CRIMINOLOGY

BITING ONCE, TWICE: THE INFLUENCE OF PRIOR ON SUBSEQUENT CRIME LOCATION CHOICE*

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Properties, victims, and locations previously targeted by offenders have an increased risk of being targeted again within a short time period. It has been suggested that often the same offenders are involved in these repeated events and, thus, that offenders' prior crime location choices influence their subsequent crime location choices. This article examines repeated crime location choices, testing the hypothesis that offenders are more likely to commit a crime in an area they previously targeted than in areas they did not target before. Unique data from four different data sources are used to study the crime location choices of 3,666 offenders who committed 12,639 offenses. The results indicate that prior crime locations strongly influence subsequent crime location choices. The effects of prior crime locations are larger if the crimes are frequent, if they are recent, if they are nearby, and if they are the same type of crime.

Targets of crime have an increased risk of being targeted again. The risk typically returns to its previctimization level over a couple of weeks or months (Farrell and Pease, 1993; Johnson, Bowers, and Hirschfield, 1997; Pease, 1998). When the same target is targeted multiple times, it is often referred to as "repeat victimization." It has been argued that in most cases of repeat victimization, the same offender is responsible for both the initial and the subsequent crime (Farrell, Phillips, and Pease, 1995). In the wake of a crime, not only the initial target is characterized by an increased risk of victimization, but also potential targets nearby the initial target are faced with a higher risk (Baudains, Braithwaite, and Johnson, 2013; Bowers and Johnson, 2005; Townsley et al., 2014; Townsley, Homel, and Chaseling, 2003). This "near-repeat victimization" has also been attributed to the involvement of the same offenders in both the initial and subsequent crimes (Johnson and Bowers, 2004; Townsley, Homel, and Chaseling, 2003).

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Empirical research has confirmed that multiple crimes committed in a short time span against the same or a nearby target often involve the same offender (Bernasco, 2008; Johnson, 2013; Johnson, Summers, and Pease, 2009). Changing the perspective from victims to offenders, this finding does suggest that prior crime location choices influence subsequent crime location choices possibly because offenders' experiences during prior offenses teach them something about criminal opportunities, risks, and rewards that is useful in the follow-up.

Although the research on repeat offending is widespread, systematic research on repeated crime location choices is nonexistent. All previous research on crime location choice has ignored repeat offending. It has thus also ignored the possibility that offenders' current crime location choices could be affected by their prior crime location choices. Previous studies either selected only a single crime per offender (e.g., Bernasco and Nieuwbeerta, 2005) or they analyzed multiple crimes per offender as if they had been committed by different individuals (e.g., Bernasco, 2010b; Bernasco and Block, 2009). Ignoring prior crime locations could result in the incorrect attribution of their effects to other causes. For example, the finding that offenders tend to commit crimes near areas where they previously lived (Bernasco, 2010b) might be mediated by prior crime locations. Maybe they only return to locations near their past homes because that is where they offended before.

In this study, repeated crime location choice is examined, taking different crime types into account. The main hypothesis being tested is that offenders are more likely to commit crimes in areas where they offended before than in areas not previously targeted. To test this hypothesis, we studied repeated crime location choices of 3,666 offenders who lived in the greater The Hague area, the Netherlands, and for whom at least one offense had been recorded by the police in this area between 2006 and 2009 and at least one offense within the 3 years prior to the 2006–2009 offense(s). This study contributes two key innovations to the literature. First, we theorize the effects of prior crime locations. This approach moves us beyond the hypothesis that prior crime locations matter and allows us to formulate and test additional hypotheses on the effects of frequency and recency of prior location choices, on the effects of proximity to prior crime locations, and on location choice consistency across different types of crime. Second, we tease out the extent to which prior crime location choices affect subsequent crime location choices while taking into account alternative explanations including the locations of current and former homes and other differences between areas.

This article is organized as follows: First, studies on same offender involvement in (near-) repeat crimes are discussed, followed by a theoretical explanation of why offenders would target the same area multiple times. The hypotheses are then formulated, followed by sections that present the data and methods used. Subsequently, the results of the study are presented. Finally, we reflect on the findings, discuss caveats, and explore avenues for future research.

SAME OFFENDER INVOLVEMENT IN (NEAR-) REPEAT VICTIMIZATION

Research has shown that repeat victimization is prevalent (e.g., Johnson, Bowers, and Hirschfield, 1997; Pease, 1998) and so is near-repeat victimization (Bowers and Johnson, 2004; Morgan, 2001; Townsley, Homel, and Chaseling, 2003). Farrell, Phillips,

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and Pease (1995) argued why offenders might offend against the same target or victim multiple times, and a small number of qualitative studies included the topic of repeat offending in offender interviews (Ashton et al., 1998; Ericsson, 1995; Shaw and Pease, 2000). The reasons given by these offenders to commit multiple burglaries close to each other were similar across the three studies: The first crime provided them with knowledge about 1) the area and the targets, 2) any valuable goods not taken away during the first crime, and 3) which targets were easily accessible. Ashton et al. (1998) also asked about (near-) repeat vehicle crimes and violent offenses. For vehicle crimes, the reasons given by the offenders were comparable with those for (near-) repeat burglaries. Having a troubled relationship with the victim was a reason mentioned for repeated violent offenses.

So far, five studies have systematically and empirically investigated the amount of same offender involvement in (near-) repeat crimes. Everson (2003: 190) concluded that "the majority of repeat or multiple offenses committed against the same victim or location, where the perpetrator was known, were the responsibility of the same offender." Bernasco (2008) demonstrated that both repeat and near-repeat burglaries were much more likely to involve the same offender than burglaries that were spatially or temporally unrelated. Johnson, Summers, and Pease (2009) showed similar results for burglaries and theft of and from motor vehicles. Johnson (2013) concluded that "offender analysis (...) provides further evidence that serial offenders commit spatially and temporally clustered crime" (p. 145). Johnson (2014) also found that most offenses committed by the same offender tend to be near each other.

Based on different data selection procedures and analytical techniques, studies on crime linkage analysis provide additional support for the claim that offenders often target the same area repeatedly. Crime linkage analysis tries to find observable characteristics of crimes that indicate the involvement of the same offender, typically based on similarities in offending behavior (when no forensic evidence is present). Case linkage compares the relative behavioral consistency and distinctiveness of pairs of crimes committed by the same offender with pairs of crimes committed by two different offenders (Markson, Woodhams, and Bond, 2010). Multiple studies showed that the most successful linkage characteristic of offending behavior was the distance between crime locations. Linked crime pairs were committed closer to each other in space than unlinked crime pairs. The second best linking characteristic was temporal proximity (Bennell and Jones, 2005; Burrell, Bull, and Bond, 2012; Goodwill and Alison, 2006; Markson, Woodhams, and Bond, 2010; Tonkin et al., 2011, 2012). In other words, proximity in both space and time seems to be one of the strongest predictors of same-offender involvement. This finding is fully consistent with those found in repeat and near-repeat victimization studies.

CRIME PATTERN THEORY

Why would offenders go back to areas they have targeted before, often shortly after their previous offense? The described qualitative studies have offered an explanation, which can be summarized as offenders gaining knowledge about the previously targeted property and using this knowledge to offend there again. The same could be true for near repeats. Johnson, Summers, and Pease (2009) argued that the knowledge gained at a first burglary is likely to reduce uncertainty about nearby homes.

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A central claim of crime pattern theory (Brantingham and Brantingham, 2008) is that offenders' knowledge of an area shapes their criminal activities. Crime pattern theory states that offenders commit crimes in areas where their awareness space overlaps with the distribution of attractive targets. Offenders, like everybody else, learn about their environment when going about their normal daily activities. All people develop routine activity spaces, in which some areas are more familiar to them than others. The activity space consists of activity nodes (e.g., home, school, workplace, shop, and gym) and the paths between these activity nodes. The awareness space consists of this activity space and the area within visual range of this activity space, and it guides the offender's search for a location to commit a crime (Brantingham and Brantingham, 1993, 2008).

Crime pattern theory thus offers several theoretical explanations for why offenders would offend multiple times in the same area. First, offenders have noncriminal reasons to travel to a particular area, for example, to visit family, friends, or a shopping mall. Once in the area, they might spot an attractive opportunity that leads them to offend (again). Second, an area could contain numerous attractive targets. For example, a shopping mall offers many opportunities for a shoplifter, whereas an area without shops does not. Offenders are thus attracted to areas because of the presence and the attractiveness of the targets. Third, offenders learn from their prior crime experiences in that particular area. For example, they learn where attractive targets are located, how they can enter and exit the area quickly, and whether active guardians are present.

Brantingham and Brantingham (1981) conceptualized awareness space as dynamic and changing over time. "New" or first-time offenders begin with an awareness space that has developed through noncriminal activities. They probably look for targets within their awareness space and are unlikely to go into areas where they have never been before. When these offenders continue to commit offenses, it is likely that they learn more detailed information about the areas in which they have found good targets. Over time, the offenders are likely to expand their awareness space to areas adjacent to the initial crime area (Brantingham and Brantingham, 1981).

Bernasco (2010b) was the first to test hypotheses empirically regarding awareness space dynamics in crime location choice. He studied Dutch offenders in the greater The Hague area who committed a burglary, robbery, assault, or theft from a vehicle. His results show that offenders were more likely to commit a crime in an area where they were living at the time of the offense and where they had previously lived than in otherwise comparable areas, and the effect was stronger for former areas of residence where they had lived more recently and for a longer time. Offenders were also more likely to commit an offense near an area where they were living or had lived than in areas farther away from their current or former residences (Bernasco, 2010b). This finding was replicated for commercial robberies (Bernasco and Kooistra, 2010).

HYPOTHESES

Some empirical evidence indicates that offenders return to previously targeted areas, and crime pattern theory provides a generic explanation why they would be more likely to offend in the same area multiple times. Therefore, our first hypothesis is as follows:

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Hypothesis 1: Offenders are more likely to commit a crime in an area where they have offended before than in an area where they have not offended before.

Bernasco (2010b) argued that offenders probably target areas close to their (prior) residential areas because they should have more knowledge on these areas than on areas farther away. We expect the same applies to prior crime locations. Therefore, our second hypothesis is as follows:

Hypothesis 2: The closer an area is to a prior target area, the more likely the offender is to target that area.

Because the knowledge of an area and therefore the awareness of attractive criminal opportunities will decrease as the time since visiting the area elapses, it is likely that the probability of reoffending in a previously targeted area also decreases over time. Therefore, our third hypothesis is as follows:

Hypothesis 3: The more recently an offender has targeted an area, the more likely the offender is to offend in that same area.

It is likely that as the number of times an offender has committed a crime in a particular area increases, so does the knowledge of the offender about that particular area. Therefore, our fourth hypothesis is as follows:

Hypothesis 4: The more crimes an offender has committed in an area, the more likely the offender is to offend in that same area.

Specific crimes require specific knowledge. An offender might have the knowledge needed to commit burglaries in a specific area but no knowledge on how to commit a robbery in that same area. Therefore our fifth and last hypothesis is as follows:

Hypothesis 5: Offenders are more likely to offend in an area where they have committed the same type of crime before than in areas where they have committed a different type of crime.

DATA

This section describes the different data sources used and how we defined the study and control variables. Subsequently, our analytical strategy (discrete spatial choice modeling) is explained. The dependent variable in this study is a choice of an area j from a geographical set of alternatives J to commit a crime in. The crime had to be committed between 2006 and 2009 in the greater The Hague area, an area consisting of 142 four-digit postal code areas (with an average population size of approximately 7,000 and an average size of 2.96 km^2). As described by Bernasco (2010b), a four-digit postal code area is a useful and plausible indication of the area people are expected to be familiar with when for instance living in or (regularly) visiting that area because 1) Dutch postal code areas are designed

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to have minimal travel restrictions for postal delivery services usually traveling on foot or bicycle, and 2) the size of a postal code area is inversely related to its level of urbanization that matches the geographic coverage of residents (i.e., smaller areas are more urbanized and urban residents travel shorter distances than rural residents) (Bernasco, 2010b: 398). Most other studies on crime location choice analyzed areas of similar or larger size (e.g., Bernasco, 2010b; Bernasco and Block, 2009; Bernasco and Nieuwbeerta, 2005; Clare, Fernandez, and Morgan, 2009; Townsley et al., 2014). Only two crime location choice studies used smaller units of analysis (Bernasco, 2010a; Bernasco, Block, and Ruiter, 2013), but these were designed with very different objectives in mind (e.g., the identification of micro hot spots for robbery and the estimation of spillover effects) than the current study, in which the focus is on the personal geographic experience of offenders. Therefore, four-digit postal code areas are the spatial unit of analysis to indicate “crime locations” (crime target areas) and “areas of residence.” To reconstruct offenders’ crime history, all recorded offenses they committed in the greater The Hague area up to 3 years prior to each offense committed in 2006–2009 are included. These prior crimes are used to create the independent study variables, for example, how many crimes an offender committed in a specific area. The other independent variables are included to control for confounding effects.

OFFENDERS AND OFFENSES: POLICE RECORDS

Data on offenders and their offenses were obtained from a police information system used by the greater The Hague Police Service. Records with information on offenders and the offenses they had been charged with were used to establish the location, date, and type of offenses committed. From the electronic system, a random sample was taken of 10,000 offenders with at least one crime incident in 2009. All information on their offense history back to 2003 was also obtained, as was information on gender and the age of the offenders.

Of the 10,000 offenders from the original sample, 6,334 individuals were excluded for five reasons, resulting in a final sample of 3,666 offenders. Ninety-two individuals were dropped because they were involved only in offenses that did not meet the criteria of a felony. Five individuals were excluded because they were younger than 12 years of age in 2009 and the Dutch criminal law does not allow prosecution of children younger than 12 years of age. Because the dependent variable of this study is the location of an offense committed between 2006 and 2009, individuals had to have at least one offense committed in 2006–2009 in the greater The Hague area. This inclusion criterion resulted in a dropout of 308 individuals either because their offenses were committed in another region, at an unknown or nonspecific address within the area, or because the offenses were actually committed before 2006 or after 2009. A total of 1,685 individuals were dropped because they did not have a known residential address within the greater The Hague area at the time they committed the 2006–2009 offenses. Another 4,244 individuals were excluded because they committed only one offense in 2006–2009 and the 3 years prior to that offense, and therefore they had no crime history to predict the current offense. Descriptive statistics of the remaining 3,666 offenders are provided in table 1.

Of the 3,666 offenders included in the study sample, all their registered offenses in the period 2006–2009 in the greater The Hague area were used in the analyses, as well as

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Table 1. Offender Characteristics (N = 3,666)

Variable	Count	Percentage
Sex		
Male	3,234	88.2
Female	432	11.8
Years of Age (December 2009)		
12–18	683	18.6
19–23	815	22.2
24–30	676	18.4
31–40	679	18.5
41–50	520	14.2
51 or older	293	8.0
Number of Offenses[a]		
2	1,205	32.9
3–4	1,104	30.1
5–10	1,055	28.8
11–20	230	6.3
21 or more	72	2.0

[a] All offenses committed by each offender between 2006 and 2009 and their offenses up to 3 years before their first 2006–2009 offense.

their offense history with a maximum of 3 years prior to the 2006–2009 offense(s), thus, offenses dating back to 2003 in the greater The Hague area. In the period 2006 to 2009, these 3,666 offenders committed 15,111 offenses, with an additional 4,262 offenses (committed by 1,308 of these offenders) in the period 2003 to 2005. Only 2006–2009 offenses with at least one prior offense in the previous 3 years were used as dependent variable offenses. Therefore, 2,472 offenses in 2006–2009 were considered only as independent variable offenses, resulting in a final sample of 12,639 dependent variable offenses. All offense locations were geocoded and allocated to one of the 142 four-digit postal code areas.

To test our hypotheses, multiple study variables were constructed based on these offenses. First, for each offense and the associated 142 alternative postal code areas, a dichotomous variable *previously chosen* (0 = no; 1 = yes) was constructed to indicate whether the offender had committed a prior offense in that particular postal code area in the previous 3 years (to test hypothesis 1). Second, to test the proximity hypothesis (hypothesis 2), a *distance to prior offense* variable (continuous) was created by calculating the Euclidian distance in kilometers from the former crime location(s) to each of the 142 alternative target areas. This distance was calculated between the centroids of the areas. In case the offender had committed more than one prior offense, the shortest distance to each alternative postal code area was used per offense and per alternative. The resulting *distance to prior offense* variable was adjusted whenever the distance between the prior crime location and the alternative postal code area was zero (when the alternative target area was the same area as the area previously chosen), by replacing these zeros with the average distance between two random points in that particular postal code area (defined as .49 times the square root of the size of the area in square kilometers; following Ghosh, 1951). Third, for testing the recency hypothesis (hypothesis 3), six different dichotomous variables (*previously chosen within … days*) were created to indicate whether a postal code area was a previous crime location within 1) a maximum of 2 days, 2) 3–7 days, 3) 8–30 days, 4) 31–183 days (1–6 months), 5) 184–730 days (6 months to

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2 years), and 6) 731–1,096 days (2–3 years) before the dependent variable offense. For example, in case an offender committed an offense in a specific area 4 and 50 days prior to the current offense, the variables "between 3 and 7 days" and "between 31 and 183 days" would score 1 for that specific offense-area combination and 0 on all other dichotomous time interval variables. Fourth, for each alternative target area, the total number of prior offenses committed in that particular alternative was calculated (*number of prior offenses*). The maximum number of times a chosen area was previously targeted by an offender was 65 times. Because of the skewed distribution of this variable and because the relationship between the number of prior offenses and the probability that an offender would target the area again was not expected to be entirely linear, the following dummy variables were created: two prior offenses (20 percent of all offenses were committed in a previously targeted area), three or four prior offenses (16 percent), five to eight prior offenses (7 percent), or more than nine prior offenses (4 percent) committed in an area. These variables were used to test the frequency hypothesis (hypothesis 4). Fifth, two dichotomous variables were created to indicate whether the prior offense was of the same or different crime type as the dependent variable offense (*same type* and *different type*, to test hypothesis 5). The offenses were categorized into eight different crime type categories: violence, property, vandalism, traffic, environmental, drugs, weapons, and other (based on Statistics Netherlands, 2014). For a final multivariate model, the recency and crime type variables were combined (i.e., by subdividing each of the six *previously chosen within … days* variables into two different sets of variables: *same type previously chosen within … days* and *different type previously chosen within … days*).

RESIDENTIAL HISTORIES: NATIONWIDE CITIZEN INFORMATION SYSTEM

The offender's residential area has been found to influence crime location choice (e.g., Baudains, Braithwaite, and Johnson, 2013; Bernasco and Nieuwbeerta, 2005; Johnson and Summers, 2014; Townsley et al., 2014), and so do former areas of residence (Bernasco, 2010b). Disregarding these effects would potentially lead to biased results because the hypothesized effects of prior crime locations are most likely confounded by a (former) home location effect. Therefore, several variables measuring former and current residential location were used as control variables in this study. These variables were derived from population registration data held in a nationwide information system (the Dutch acronym is BRP). This continuously updated system records information of all Dutch citizens including their residential addresses, and the information can be extracted on a daily basis. Major status changes (e.g., moving to a new address, marriage or divorce, and childbirth) of citizens are registered and updated by municipalities in this system, while keeping all historical information of each person such as former addresses and migration information. Using these registration data, residential histories were reliably reconstructed. Because our area of interest and choice set of postal code areas is the greater The Hague area, home addresses outside this area do not lead to scores on any of the 142 target areas. All (former) home addresses inside the study area were geocoded and allocated to one of the 142 postal code areas.

Several variables were constructed following the findings and methods described by Bernasco (2010b). Residential areas in which the offender lived at the time of the

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offense were indicated, divided into two separate variables to indicate areas in which the offender had lived for a shorter period (since <2 years) at the time of the offense or for a longer period (since >2 years). In addition, four variables were created to indicate former residential areas, taking into account the duration of living: lived long (>2 years) versus short (<2 years) at a former address; and the recency of moving: lived in the area until recently (<2 years) versus until long ago (>2 years). A last variable concerning the home location was the distance from the area in which an offender lived at the day of the offense to all potential target areas that could have been chosen to commit the offense. The Ghosh (1951) correction was also applied to this distance measure: All zero distances (when the potential target area was the same as the residential area) were replaced with the average distance between two random points inside the area.

POSTAL CODE AREA CHARACTERISTICS: STATISTICS NETHERLANDS AND BUSINESS DATABASE

Specific target area characteristics were included as control variables in our study because they are described as indicators of crime attractors and crime generators (Brantingham and Brantingham, 1995) or of guardianship (Cohen and Felson, 1979), and several studies have found that they influenced crime rates in an area (Bernasco and Block, 2011; Bernasco and Nieuwbeerta, 2005; McCord et al., 2007; Nieuwbeerta et al., 2008; Reynald, 2011). Because both the dependent variable and the independent variables in this study are based on crime locations, it is necessary to control for these area characteristics to minimize omitted variable bias.

For each postal code area in the Netherlands, census-like statistics (sociodemographic and socioeconomic information) are regularly recorded by Statistics Netherlands. For each postal code area in the greater The Hague area, information was obtained on the number of residents (total number and number of residents with a non-Western ethnic background), and households (total number and number of single-person households) for the years 2006–2009. Three crime year-specific variables were constructed using this information: 1) population density, calculated by dividing the number of residents in each postal code area by the surface of the area (postal code surface information was obtained from the Ministry of the Interior and Kingdom Relations [2014]; 2) proportion of single-person households (number of single-person households divided by number of households); and 3) proportion of residents with a non-Western ethnic background (number of non-Western residents divided by the number of residents).

The LISA database (in Dutch: *Landelijk Informatiesysteem Arbeidsplaatsen*; for more information, see Steenbeek et al., 2012), which contains information on businesses and other facilities where paid work is done, was used to obtain crime year-specific information about several area characteristics in each postal code area in the greater The Hague area. These include the number of retail stores; hotels, restaurants, and bars; schools; culture; health care; and sports and leisure facilities. In addition, we ascertained the number of people working, scored as the sum of the number of full-time employees and ½ × the number of part-time employees.

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METHOD

DISCRETE CHOICE MODELS APPLIED TO CRIME LOCATION CHOICE

Discrete choice models are used to explain why an individual chooses a specific single alternative when presented with a distinct number of alternatives (Ben-Akiva and Bierlaire, 2003), given attributes of the alternatives and attributes of the individual. Applied to location choice, the alternatives from which the individual has to choose are spatial entities. When applied to *crime* location choice, the choice faced by the offender (the decision maker) is where to commit a crime (see also previous crime location choice studies, e.g., Bernasco and Nieuwbeerta, 2005; Clare, Fernandez, and Morgan, 2009; Johnson and Summers, 2014). Discrete choice models often follow the random utility maximization (RUM) approach and are statistically tested with a conditional logit model (McFadden, 1974, 1978a). In the case of crime location choice, this RUM model implies that a motivated offender (i.e., the decision maker) evaluates the utility (gain, profits, and satisfaction) of each of the possible choice alternatives, and selects the alternative with the largest utility and gain (for a comprehensive explanation of this model applied to crime location choice, see Bernasco, 2010b).

When presenting the results of the conditional logit models, odds ratios are used. In this case, these should be interpreted as the multiplicative effect of a unit increase of the independent variable on the odds of choosing a particular target area. The effects of the study variables are hypothesized to be positive with odds ratios >1, except for distance to prior crime location (proximity hypothesis), which is expected to be negative with an odds ratio between 0 and 1.

To estimate the different conditional logit models, a large data matrix of almost 1.8 million rows was created. This matrix contained 142 rows (i.e., a row for each of the 142 alternative postal code areas that could have been chosen in the greater The Hague area) for each of the 12,639 offenses committed in 2006–2009. The dependent variable is dichotomous, with a value of 1 indicating the area that was chosen by the offender to commit the offense, and 0s for all other postal code areas.

FINDINGS

In this section, descriptive statistics are shown first in table 2. Then, the five hypotheses are tested separately with discrete spatial choice models, with the results shown in table 3. Furthermore, to examine how all aspects of prior crime locations influence subsequent crime location choice, an integrated model (table 4) is shown in which all hypotheses are jointly tested. It is important to note that all models displayed in table 3 were controlled for the residential (history) variables described previously as well as for all postal code area characteristics variables. To save space, the parameter estimates for these control variables are shown not in table 3 but in table 4, in which the results of the combined model are presented. Both the directions and levels of statistical significance of the effects of the control variables were largely consistent across models.

Descriptives

Table 2 presents the number and percentages of offenses committed in 2006–2009 in the same postal code area as a previously committed offense. Separate figures are presented

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Table 2. Number and Percentage of Crimes Committed in the Same Postal Code Area as Previous Crime(s) (2006–2009 Offenses)

Crime Location	Count	Percentage
Prior Offense in Same PC4, Same Type	**3,268**	**25.86**
Within 2 days	877	6.94
3–7 days	282	2.23
8–30 days	362	2.86
31–183 days	634	5.02
184–730 days	816	6.46
731–1,096 days	297	2.35
Prior Offense in Same PC4, Different Type	**2,621**	**20.74**
Within 2 days	235	1.86
3–7 days	86	.68
8–30 days	200	1.58
31–183 days	644	5.10
184–730 days	1,066	8.43
731–1,096 days	390	3.09
Elsewhere	**7,627**	**60.34**
Total	12,639	100.00

for same or different type of crime, committed within 2 days, 7 days, 1 month, 6 months, 2 years, and 3 years. Approximately 40 percent of the offenses were committed in a postal code area that was previously targeted within the past 3 years. This finding means that 60 percent of the offenses were committed elsewhere.

Hypothesis 1: Former Crime Location Choice

The first model in table 3 (labeled "Chosen") displays the results for the test of the *former crime location choice* hypothesis (hypothesis 1). The effect of "previously chosen" was highly statistically significant, with an estimated odds ratio of 7.17. This result indicates that the odds that an offender reoffended in an area that he or she previously targeted were 7.17 times the odds of offending in an area that he or she had never targeted before (the reference category). This finding corroborates the first hypothesis that offenders are more likely to return to prior crime locations than to offend in a new area. The pseudo R-squared of this model was .32, which shows that a considerable part of the variation in crime location choice was explained by the variables included in this model. Actually, pseudo R-squared values between .2 and .4 "represent an excellent fit" (McFadden, 1978b: 307) to the data.

Hypothesis 2: Proximity

The second hypothesis states that areas closer to a prior crime location are more likely to be targeted. The results in the second model of table 3 indeed show that the effect of distance to prior crime location on subsequent crime location choice was strongly statistically significant and negative. The odds ratio of .69 indicates that for every kilometer that an area was located farther away from the prior crime location, the odds that an offender chose that area to offend decreased with .31 (1–.69) percent.

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Table 3. Conditional Logit Models (Presented Row-Wise) Testing the Five Hypotheses on Effects of Previous on Subsequent Crime Location Choice (12,639 Offenses by 3,666 Offenders)

Model	OR	*Z*	*B*	SE	Pseudo R^2
Model 1: Chosen					.32
Previously chosen	7.17***	71.0	1.97	.03	
Model 2: Proximity					.30
Distance to prior offense (km)	.69***	−44.2	−.38	.01	
Model 3: Recency					.34
Previously chosen within					
0–2 days	59.94***	62.3	4.09	.07	
3–7 days	28.76***	35.4	3.36	.09	
8–30 days	12.11***	37.4	2.49	.07	
31–183 days	6.18***	40.8	1.82	.04	
184–730 days	4.36***	39.4	1.47	.04	
731–1096 days	3.43***	22.6	1.23	.05	
Model 4: Frequency					.32
Previously chosen					
At least once	5.82***	57.0	1.76	.03	
Additional increment for:					
Two times	1.62***	9.9	.48	.05	
Three or four times	2.25***	14.1	.81	.06	
Five to eight times	2.95***	12.8	1.08	.08	
Nine or more times	8.63***	15.1	2.15	.14	
Model 5: Type					.32
Type previously chosen					
Same	7.25***	59.5	1.98	.03	
Different	3.07***	33.0	1.12	.03	

NOTES: OR = odds ratio coefficient and SE = robust standard error of B coefficient. Control variables of each alternative postal code area in each model not shown [i.e., current area of residence (longer and shorter than 2 years), former area of residence (longer and shorter than 2 years; until recently (<2 years) and long ago (>2 years)]; distance to current home; density; proportion single-person households; proportion non-Western residents; number of employees; retail businesses; hotels, restaurants, and bars; schools; health-care facilities; cultural facilities; and sport and leisure facilities).
***$p < .001$ (two-tailed).

Hypothesis 3: Recency

The third hypothesis to be tested is the recency hypothesis, stating that the more recent a prior crime was committed in a particular area, the more likely it is that this area is targeted again. The results in the third model of table 3 show that the effects of all six time interval variables were statistically significant and positive. This finding implies that an area in which an offense was committed before, even if it happened 2–3 years ago, had a statistically significantly higher odds of being targeted again than other areas that were not targeted before. In line with hypothesis 3, the size of the odds ratios decreased rapidly when the time between prior and subsequent offense increased, that is, from 59.94 for crimes committed within the first 2 days after the prior offense to 3.43 for crimes committed 2–3 years apart. We also tested whether the effects of the consecutive pairs of variables differed (i.e., 2 vs. 7, 7 vs. 30, 30 vs. 183, 183 vs. 730, and 730 vs. 1,096 days). All these tests showed statistically significant differences ($p < .001$). This result indicates that the odds that an area was chosen again when targeted shortly before were larger than when targeted longer ago, confirming our hypothesis.

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Hypothesis 4: Frequency

Fourth, whether an increase in the number of crimes committed in an area also increases the probability that an offender targets that area again is tested in the next model (labeled "Frequency" in table 3). The results are shown for the four dummy variables as well as for the "previously chosen" variable (also used to test hypothesis 1) that was added to this model. The results for the dummy variables should be interpreted as the increase in odds of reoffending in a particular area over and above the increased odds of a previously targeted area. In line with our hypothesis, the results show that offenders are more likely to target an area again if they had committed more crimes in that area before. When an offender had committed two crimes in an area, the odds increased with a factor 1.62, three or four crimes caused an increase with a factor 2.25, five to eight crimes an increase with a factor 2.95, and nine or more crimes an increase with a factor 8.63. Also in line with our hypothesis, the effect was statistically significantly larger when the number of crimes increased ($p < .001$ for two crimes vs. three or four crimes, five to eight crimes vs. nine or more crime; $p < .01$ for three or four crimes vs. five to eight crimes).

Hypothesis 5: Same Type of Offense

The fifth hypothesis tested is whether a previously targeted area has an increased probability of being targeted again when the prior offense is of the same type as the subsequent offense. The results of the fifth model in table 3 show indeed that when a prior offense was of the same type, the odds that the area in which the prior crime was committed was chosen again were 7.25 times larger than the odds of choosing a previously nontargeted area. When the prior crime was of a different type, the odds increased with a factor 3.07 compared with the odds of a nontargeted area. More importantly, in line with our hypothesis, the effect was statistically significantly larger when prior and subsequent offenses were of the same type compared to when they were of a different type ($p < .001$).

Combined Model

Testing the five hypotheses separately showed that prior crime locations affect subsequent crime location choice. It is, however, important to test simultaneously the effects of the different aspects of prior crime location choices. Therefore, a conditional logit model was estimated with all independent variables in a single model. Table 4 presents the results of this model and the effects of all control variables.

In this combined model, all effects of the study variables to test the five hypotheses were statistically significant and in the expected direction: The effects of the variables testing hypotheses 1, 3, 4, and 5 were all statistically significant and positive, and the effect of the variable testing hypotheses 2 (distance to prior crime location) was statistically significant and negative. Similar to the findings in the models described earlier, effects at each of the six time intervals were larger when the prior offense was of the same type as the subsequent offense than when they were of different types ($p < .001$). Testing for effect differences between the time intervals when the offenses were of the same type showed that effects decreased statistically significantly when the time between prior and subsequent offense increased up to 2 years ($p < .001$), but no statistically significant difference was found between the .5–2-year and 2–3-year intervals ($p = .33$). When the prior and current offense type were different, the effect differences were statistically

Table 4. Testing the Five Hypotheses on Repeated Crime Location Choice in a Combined Model, Including Control Variables (12,639 Offenses by 3,666 Offenders)

Crime Location Area	OR		Z	B	SE
Previously Chosen Within, Same Type					
2 days	33.68	***	45.3	3.52	.08
3–7 days	15.34	***	24.0	2.73	.11
8–30 days (week–month)	7.21	***	22.9	1.97	.09
31–183 days (month–.5 years)	3.46	***	20.1	1.24	.06
184–730 days (.5–2 years)	2.31	***	15.7	.84	.05
731–1,096 days (2–3 years)	2.12	***	9.8	.75	.08
Previously Chosen Within, Different Type					
2 days	10.96	***	17.4	2.39	.14
3–7 days	6.42	***	9.9	1.86	.19
8–30 days (week–month)	3.28	***	10.5	1.19	.11
31–183 days (month–.5 year)	2.01	***	10.9	.70	.06
184–730 days (.5–2 years)	1.82	***	12.4	.60	.05
731–1,096 days (2–3 years)	1.51	***	6.2	.42	.07
Distance to Prior Offense (3 years)	.78	***	−34.1	−.25	.01
Number of Prior Offenses					
Two	1.34	***	5.2	.29	.06
Three or four	1.48	***	5.7	.39	.07
Five to eight	1.56	***	4.5	.44	.10
Nine or more	2.58	***	6.1	.95	.16
Current residence					
Longer than 2 years	4.57	***	36.8	1.52	.04
Shorter than 2 years	4.01	***	29.0	1.39	.05
Former Residence					
Long (>2 years) until recently (<2 years)	2.76	***	10.8	1.01	.09
Short (<2 years) until recently (<2 years)	2.24	***	9.9	.81	.08
Long (>2 years) long ago (>2 years)	2.53	***	8.9	.93	.10
Short (<2 years) long ago (>2 years)	1.72	***	5.6	.54	.10
Distance to Current Residence (km)	.82	***	−33.3	−.20	.01
Density (×1000)	.99	***	−6.4	−.01	.00
Proportion of Single-Person Households	1.09		.7	.08	.12
Proportion of Nonwestern Residents	2.12	***	12.9	.75	.06
Number of Employees (×1,000)	1.02	***	5.7	.02	.00
Retail Businesses (×10)	1.05	***	22.5	.05	.00
Hotels, Restaurants, and Bars (×10)	1.39	***	12.0	.33	.03
Schools (×10)	1.17	***	6.1	.16	.03
Health-Care Facility (×10)	.89	***	−8.9	−.12	.01
Cultural Facility (×10)	1.01	*	2.2	.01	.01
Sport and Leisure Facility	1.01		1.3	.01	.01
Pseudo R^2		.35			

NOTES: OR = odds ratio coefficient and Z values with robust standard errors.
$^{*}p < .05$. $^{***}p < .001$ (two–tailed).

significant between most of the consecutive time intervals (i.e., 2 vs. 7, 7 vs. 30, 30 vs. 183, and 730 vs. 1,096 days; $p < .02$); the effects did not statistically significantly differ between the 30–183-day and 184–730-day intervals ($p = .16$).

The pseudo R-squared of this full model was .35, which again shows that a large part of the variation in crime location choice can be explained by prior crime locations, former and current residential locations, and the area characteristics included in the model. To test which of these variables had the most explanatory power, three groups of variables were tested separately. The first model only included the 10 area characteristics (density – sport and leisure facilities) and had a pseudo R-squared of .07. The second

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model only included seven variables measuring residential histories (current residence – distance to current residence) and had a pseudo R-squared of .23. Bernasco (2010b) reported the same model fit in his study on the effects of residential history on crime location choice. The final model contained our 17 crime location history variables and had a pseudo R-squared of .29. These results indicate that the model with crime location history variables had the highest explanatory power for crime location choice.

DISCUSSION

Crime location choice refers to an offender's decision on where to commit a crime. Although many offenders are repeat offenders, the research on crime location choice has ignored repeat offending. As a result, no systematic evidence is available on whether and how offenders' crime location choices are conditioned by their prior location choices. Previous crime location choice studies either selected only a single crime per offender (e.g., Bernasco and Nieuwbeerta, 2005) or analyzed multiple crimes by the same offender as independent observations (e.g., Bernasco and Block, 2009). The key advantage of the current study is that we assess whether and how offenders, as a result of their own experiences, learn about attractive and unattractive places to offend.

In line with our hypotheses, the findings give rise to the following five conclusions. First, offenders are more likely to offend in areas where they offended before than in areas where they did not offend before. Second, this effect is stronger when the prior and subsequent crimes are of similar type than when they are different. Third, the further away an area is to an area where the offender committed a crime before, the smaller the odds the offender would target that area. Fourth, the more recent their prior offense in an area, the more likely they are to target that area. Fifth, as the number of an offender's prior crimes in area increases, so do the odds of him or her targeting that area during the next offense.

The explanatory power of the variables included in our study was fairly high, with pseudo R-squared values between .30 and .34 in the models where the hypotheses were separately tested, and .35 in the final model with all independent variables included. We found that the variables measuring an offender's crime location history have more explanatory power than those that measure either residential history or area characteristics. Thus, it is recommended that future studies on crime location choice take the individual's crime location history into account.

Because prior home locations and prior crime locations tend to overlap due to the fact that offenders often commit crimes nearby their homes, our findings suggest that the effects that Bernasco (2010b) and Bernasco and Kooistra (2010) attributed to prior home locations might in part be effects of prior crime locations that were not included in these two studies. In fact, their models as well as ours do not contain unsolved crimes, which might also bias some of the estimated effects of prior home locations.

The results presented, in particular the finding that repeat offenders are attracted to locations in the proximity of where they recently committed a crime, is consistent with the finding that the same offenders are involved in the majority of (near-) repeat cases (Bernasco, 2008; Johnson, Summers, and Pease, 2009). They are also in line with the finding that crimes committed by the same offender cluster more in time and space than crimes that are committed by different offenders (e.g., Tonkin et al., 2012).

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According to crime pattern theory (Brantingham and Brantingham, 1993), offenders commit crimes within their awareness space. So far, studies have shown that offenders indeed commit crimes close to where they live (and the home location is of course an important activity node in one's awareness space). Brantingham and Brantingham (1981) argued that an offender also learns about criminal opportunities by committing crimes, and that the area in which an offender commits crimes might expand as the number of committed crimes increases, probably to adjacent areas. We derived several new hypotheses from crime pattern theory. Our results show that offenders do return to prior crime locations, which indicates that crime locations become part of an offender's awareness space. Crime locations might be considered as activity nodes in a criminal awareness space. As such, our study puts some of the ideas of Brantingham and Brantingham (1981) to a test for the first time. Still, many crimes are committed in areas where offenders have not offended before, so they must also expand their "offending area." As the proximity effects show, these areas tend to be close to the initial offending area.

The current findings are important for police surveillance and criminal investigations. First, and in line with recommendations based on findings about repeat victimization and the contagion of victimization risk, future offenses may be prevented by increasing surveillance in the targeted area in the wake of an offense. Second, our results confirm what is often implicitly assumed in police investigations, namely that it is generally useful to consider as potential suspects offenders who have recently been arrested in the area for other crimes.

LIMITATIONS

It is important to discuss some limitations of the current study. First, it relies exclusively on cleared offense data from police records, and it might suffer from detection bias, that is, bias caused by the fact that solved crimes are not representative for all (both solved and unsolved) crimes. For example, the probability of arrest might be elevated for offenders who reoffend in the same area or in their former or current area of residence. If so, this could have inflated our estimates of the effects of prior crime locations and of prior and current home locations. Two recent studies, however, suggested that detection bias is not very likely. Using data on DNA traces secured at Dutch crime scenes, Lammers (2014) demonstrated that no statistically significant differences existed between the intercrime distances of arrested and nonarrested offenders. Another study (Johnson, Summers, and Pease, 2009) showed that solved and unsolved offenses displayed similar spatiotemporal patterns, which would not be the case in case of detection bias. Thus, the findings from these two studies suggest that it is not very likely that the patterns observed in the current study are strongly affected by detection bias.

Second, our data are geographically limited to the greater The Hague area. This region is largely urban. The results could be different in other, more rural parts of the country. Furthermore, we did not take crimes into account that the offenders in the sample could have committed outside the study area. Excluding crimes committed outside the study area could inflate distance decay parameters for offenders living close to the boundary (real decay could be less strong than the estimates). We examined this issue with a method used by Bernasco, Block, and Ruiter (2013). First, we calculated the shortest distance from the offender's residence at the time of the offense to the boundary of the greater The Hague area on land (thus excluding the North Sea coast line). The

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average shortest distance from residence to boundary was 7.1 km, which is much larger than the mean and median distance between residence and crime location (2.9 and 1.9 km, respectively), suggesting that a bias caused by edge effects is unlikely. Next, the effects of distance to current residence were estimated separately for residence-boundary distances above and below thresholds of 2, 5, and 10 km. No statistically significant differences were found above and below the thresholds in the combined model (p values > .18), indicating that distance decay does not depend on the location where offenders live relative to the boundary of the greater The Hague area.

A third and final limitation is the size of the unit of analysis, the four-digit postal code area. Most studies on crime location choice have used areas of similar or larger size in their analyses and it is reasonable to assume that people are familiar with an area of this size. However, the four-digit postal code area could be considered to be a large unit of analysis. A smaller unit of analysis that could have been used is, for example, a six-digit postal code area. These areas are roughly the size of a football field and contain 18 residential properties and 40 residents on average. However, using this smaller unit of analysis has its own downsides. For example, smaller units of analysis increase issues of spatial interdependence between observations, which calls for models that take this spatial interdependence into account (Bernasco, 2010a). Choosing the right level of aggregation and determining how this choice affects study results are well-known problems in the field of geography. Discussing this problem, which is known as the modifiable areal unit problem, is beyond the scope of this article, but for an example of a criminological study on this problem, see Ouimet (2000).

FUTURE RESEARCH

The previously described limitations and other considerations give rise to suggestions for future research. First, to increase the generalizability of the findings, it would be necessary to study a larger area and hence a larger choice set. This approach would then also include information on the location choices of offenders who offend farther away from home, and it would include more rural regions.

An offender's awareness space includes many more activity nodes than just residences and crime locations. These other nodes might be important in the decision of where to commit a crime. Various other Dutch data registers might provide additional opportunities for examining some other, possibly important nodes, for example, the home locations of family members of the offender or employment locations. However, these sources could still only provide information on a limited number of other nodes. To learn more about the impact of many more activity nodes, it is important to conduct offender-based research in which offenders are asked about their daily spatial routines and the locations of their crimes. Such a design would provide an alternative and arguably better way to tap into the richness and diversity of offenders' activity spaces. Summers, Johnson, and Rengert (2010) explored how the awareness space of offenders and its relation to their offending behavior could be measured empirically by asking a sample of convicted offenders to draw sketch maps and to mark the areas known to them on regular printed maps. Although it is resource intense to conduct, we believe the further development of such an approach to data collection holds considerable promise.

The current study's findings indicate that offenders do return to prior crime locations even though they had been arrested for these crimes. This raises the question why

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offenders would return to an area in which they committed a crime for which they had been arrested. Maybe the pros of knowing an area outweigh the cons of (the possibility of) getting arrested. We expect that the effects found in the current study might be even larger when taking unsolved crimes into account as well: Offenders might be even more likely to return to an area they have targeted before and for which they were not arrested. Taking both solved and unsolved crimes into account when studying crime location choice could also show the extent of bias in studies that analyze solved crimes only.

We believe that an important aspect of our study is its link to other literatures and lines of research in environmental criminology, in particular to the proliferating literature on near-repeat victimization and prospective crime mapping. The number of studies that have replicated the near-repeat phenomenon has grown rapidly over the last few years, and its potential for predictive policing is being widely exploited already. Because most research on space-time patterns in crime events has been based on plain event data (mainly location, date and time, crime type), the mechanisms underlying the observed patterns remain poorly understood. By providing a behavioral model of individual crime location choices that are informed by prior location choices (as well as other information), our study demonstrates how aggregate space-time crime patterns can be studied and interpreted at the individual level. Following Coleman (1987), we stress that a proper understanding of macrolevel outcomes necessitates the study of microlevel decision making.

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