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AWARENESS × OPPORTUNITY: TESTING INTERACTIONS BETWEEN ACTIVITY NODES AND CRIMINAL OPPORTUNITY IN PREDICTING CRIME LOCATION CHOICE

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*According to crime pattern theory, offenders likely commit crimes in areas where their awareness space overlaps with criminal opportunity. If both are necessary conditions for crime to take place somewhere, their influence on crime location choice likely depends upon one another. Interactions between two activity nodes—residential area of (1) offenders, (2) offenders' family—and two criminal opportunity indicators—number of bars/restaurants/hotels, collective efficacy—were tested and found (*N = *13,088 any-crime-type offences committed by 5377 offenders): both residential area types were more often targeted than areas where offenders/family did not live, with no/lesser difference between low versus high criminal opportunity. Areas where offenders/family did not live were statistically significantly least often targeted when criminal opportunity there was low.*

Keywords: crime location choice, crime pattern theory, activity nodes, criminal opportunity, interactions

Introduction

According to crime pattern theory, crime location choice most likely happens in an area that is part of an offender's awareness space *and* that contains criminal opportunity for the crime to be successfully committed, for example many suitable targets and no surveillance (Brantingham and Brantingham 1981, 1993, 2008). Crime location choice research over the last decade has incorporated both types of factors as predictors of where crime takes place, simultaneously tested with discrete spatial choice models (Bernasco and Nieuwbeerta 2005; for an overview, see Ruiter 2017). However, in previous crime location choice studies their effects are merely tested additively, whereas the condition that both knowledge and opportunity should be present suggests that their effects likely depend on the presence or absence of one another. For example, a well-known area within an offender's awareness space may have a disproportionally higher chance of being targeted when the criminal opportunity in that area is good, compared to when the criminal opportunity in that area is poor. If an area is not known by an offender, the level of criminal opportunity likely has less effect on the chance of committing a crime there.

Therefore, this study aims at testing interactions between two relevant and distinctive activity nodes of offenders: their own residential area at the time of the offence and the residential area of their family; and two different environmental characteristics as indicators of criminal opportunity in an area: the number of bars/restaurants/

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hotels and collective efficacy. Using discrete spatial choice models, main effects, and interactions are tested in a total sample of 13,088 any-crime-type offences committed by 5377 offenders in three municipalities in the The Hague area in the Netherlands. Supplementary, it is explored whether any-crime-type interaction patterns also applied to violence and property crime separately. Multiple data sources are used to obtain information on the offences, residential histories of the offenders and their family, and criminal opportunity in 76 postal codes in the study area.

Crime Pattern Theory: Awareness × Opportunity

Crime pattern theory states that offenders more likely commit crimes in an area that is part of their awareness space *and* that contains sufficient opportunity for the crime to be successfully committed. Both are thus theorized to be a condition for a crime to take place in a certain area. The awareness spaces of individuals, including offenders, are developed during routine activities. Activity nodes are prominent places within an individual's awareness space where a significant amount of time is spent, such as the residential area, work, school, and shopping areas. Together with the travel paths between them and everything within visual range, activity nodes form an individual's awareness space. Offenders most likely search for suitable targets within their awareness space because they have knowledge of these areas. This includes knowledge of the presence or absence of suitable targets and surveillance in an area; knowledge they likely have less or not at all for areas outside their awareness space. The perceived quality of such indicators of criminal opportunity influences the decision process of an offender whether or not to commit a crime in an area (Brantingham and Brantingham 1981, 1993, 2008).

Following this reasoning, the level of criminal opportunity is expected to be more influential in well-known parts of an offender's awareness space compared to areas that are not (well-)known. That is, an area that is well-known by the offender and that has a high level of criminal opportunity likely has a disproportionally higher risk of being targeted compared to areas that are less known and/or where criminal opportunity is low. Brantingham and Brantingham explicitly theorized an example of this hypothesized interaction in their crime pattern theory work. They stated that crime should increase disproportionally if entertainment complexes that attract clusters of victims and targets are located close to residential areas of potential offenders, due to the strong awareness spaces and the easy access to the cluster of potential targets (Brantingham and Brantingham 1981: 52). Although previous crime location choice research has taken aspects of awareness space and opportunity characteristics into account, this study is the first to empirically test the theorized interaction between them.

Awareness: offenders' residential areas, and their family members' residential areas

This study focuses on two distinct activity nodes to indicate whether an offender is aware of a certain area. The first is a very prominent part of most offenders' awareness spaces: their own residential area. Not only is much time spent in or around the house, it is usually also the start and end point of travels to other places, such as school or work. Potential offenders gain knowledge of the environment and of the criminal

opportunity by spending much of their time in the area around their home. In addition to the increased knowledge, committing crimes close to home also saves time and effort. Both theory (Brantingham and Brantingham 1981, 1984, 1993, 2008) and empirical research underscored the importance of the residential area with respect to crime location choice: offenders were consistently found of being more likely to commit crimes in or close to their residential area (e.g. Bernasco and Nieuwbeerta 2005; Bernasco 2010; Baudains *et al.* 2013; Townsley *et al.* 2015; Ruiter 2017).

The second activity node is the residential area of family of the offender. Most individuals, including offenders, likely visit their family members at least occasionally (Verbakel and De Graaf 2004; Menting *et al.* 2016). This makes their residential area also part of an offender's awareness space, and consequently more likely of being targeted by the offender compared to areas where no family lives. However, because offenders usually spend less time in familial residential areas than in their own, and at least some travel effort is required, familial residential areas are likely less often targeted than their own. A recent study supported this reasoning by showing that residential areas of parents, siblings and/or children indeed influenced crime location choice (any-crime-type), with smaller effects for familial compared to the offender's own residential area (Menting *et al.* 2016). Since this study aims to test the interaction hypothesis for two distinctive activity nodes, effects are tested for familial residential areas where the offender did not also live at the time of the offence (while also taking offenders' former residential areas into account).

Opportunity: bars/restaurants/hotels and collective efficacy

Criminal opportunity is not evenly distributed in space: some areas are more attractive to target than others (Brantingham and Brantingham 1984). An area is theorized of being more attractive to target when suitable targets or victims are present and the risk of being caught, for example by a capable guardian or surveillance, is low (Cohen and Felson 1979; Brantingham and Brantingham 1984). The presence of some area characteristics can thus increase the risk of crime, while others reduce it. One of each is examined in this study.

The presence of crime generators and attractors can make an area more susceptible to crime. Crime generators are areas where many people come to for non-criminal reasons. Due to the large numbers of visitors—both locals and outsiders—present, potential offenders may notice criminal opportunity, despite their initial non-criminal intent to visit the area. The large people flows contain many potential victims. It is also more accepted to hang out in the vicinity of facilities where many people come. Crime attractors, on the other hand, are described to produce criminal opportunity. Motivated offenders intentionally visit them to commit a crime, because of the known opportunity there for the intended crime type (Brantingham and Brantingham 1995, 2008; Kinney *et al.* 2008). Following this, areas that contain many crime generating or attracting facilities are likely at increased risk of being targeted by offenders because of the criminal opportunity that arises or exists, as compared to areas with no or few of those facilities. This study focuses on one combination of facilities that generate and/or attract crime: bars, restaurants, and hotels. They all attract larger numbers of visitors including potential victims and offenders. Some are also known for their specific criminal opportunity. They include facilities

that are allowed to serve alcoholic beverages, and Dutch 'coffeeshops', where cannabis can be purchased for personal consumption. A positive association between the presence of such facilities and several types of crime has been found in empirical research (e.g. Roncek and Maier 1991; LeBeau 2012; Bernasco *et al.* 2013; Bernasco and Jacques 2015).

Areas where the risk of being caught is high are less likely targeted by offenders. Following social disorganization and collective efficacy theory, criminal behaviour is more likely to be observed by residents if social disorganization is low, and social cohesion and mutual trust among neighbours high; residents are then also expected to be more likely to intervene when they observe crime in their neighbourhood (Shaw and McKay 1969; Sampson *et al.* 1997; Sampson 2006). Thus, areas characterized by high levels of collective efficacy—i.e. high social cohesion and willingness to intervene on behalf of the common good among neighbours (Sampson *et al.* 1997)—are likely less attractive for offenders to target because of the increased risk of being caught by residents. Although not found in all studies, multiple empirical studies showed the described negative association between collective efficacy and several types of crime (e.g. Sampson *et al.* 1997; St. Jean 2007; Bernasco and Block 2009; Browning 2009; Wikström *et al.* 2012).

For both opportunity characteristics can be argued that offenders are particularly aware of their level when they know the area very well. Thus, they likely know better that there are many crime generating/attracting facilities when they are within their own residential area. Many targets close to home also saves travel effort. Moreover, large numbers of external visitors may make offenders less noticeable, even when living in that area. When being part of a residential population, offenders likely also know better how much trust and cohesion there is among their neighbours, and how actively neighbours safeguard their neighbourhood. Such knowledge helps them decide whether to target their own residential area or another area. This may also apply, though likely to a lesser extent, to activity nodes that are less frequently visited and that require at least some travel effort, like familial residential areas.

Aims and hypotheses

The current study aims to test: (1) whether the effects of two distinct activity nodes—the offender's residential area and the residential area of family of the offender—on crime location choice differs under different conditions of two indicators of criminal opportunity—the number of bars/restaurants/hotels and collective efficacy—in the area; and (2) whether the effect of the number of bars/restaurants/hotels, and the level of collective efficacy on crime location choice differs between areas that are residential areas of offenders and of their family and areas that are not.

Interactions between awareness and opportunity are expected. More specifically, it is hypothesized that residential areas of offenders with much opportunity are disproportionally more likely targeted, thus when there are many bars/restaurants/hotels, and when collective efficacy is low. Because these areas are well-known by the offenders, they know that there are many potential targets or victims due to the crime attracting/generating facilities, and that the chance that they attract attention and that their neighbours might intervene is likely low. If an offender lives in an area with less bars/restaurants/hotels and higher collective efficacy, the offender probably also knows that

the opportunity to successfully commit a crime is poorer. This knowledge makes the area relatively less attractive to target. Areas where offenders do not live are generally expected to be less often targeted than their residential areas, following previously found strong main effects. More importantly for this study, criminal opportunity is hypothesized to be less influential in areas where the offender does not live. By spending no/substantially less time in those areas, offenders have less knowledge of the environment and criminal opportunity there. A similar pattern is expected for residential areas of family, however, with smaller differences than those expected for offenders' own residential areas. Familial residential areas are likely less often visited and, consequently, knowledge of criminal opportunity there is likely less.

The hypotheses are tested with any-crime-type offences. Brantingham and Brantingham (1993) indicated that there are similarities across crime types, for example in the way offenders see their surroundings and how they learn what to see as a suitable target when spending time within their awareness space. However, they also indicated that criminal behaviour is highly varied and complex. What an offender perceives as a suitable criminal context for violent crime may not be the same for property crime. Although the presence of crime attractors/generators such as bars/restaurants/hotels and poor collective efficacy have been linked to multiple crime types, their presence or absence may have varying importance in providing or reducing criminal opportunity. Therefore, it is also explored whether the hypothesized interaction applies to two crime types that presumably share some crime location choice predictors (e.g. being the offender's residential area, see Bernasco 2010), but may differ somewhat in others (e.g. ideal criminal opportunity): violence and property offences.

Methods

Study area

The study area consisted of three municipalities in the greater The Hague area in the Netherlands: The Hague, Rijswijk, and Leidschendam-Voorburg. Four-digit postal code areas were used as spatial unit of analysis. Dutch four-digit postal code areas are designed to have minimal travel restrictions for postal delivery services that usually travel by foot or bicycle, and their size is inversely related to the level of urbanization (Bernasco 2010: 398). These postal codes are therefore well suited for a crime location choice study, because most people will be familiar with these areas when living there or (frequently) visiting the area. The three municipalities in this study contained 82 postal code areas in 2006–2009. Postal code areas were includable when community survey data were available, which applied to 76 (92.7%) of the postal codes in the area[1]. These 76 postal code areas had an average population size of around 7700 and an average area size of 1.68 km^2 (SD = 2.61, range = 0.12–22.26, median = 1.15)[2].

[1]The community survey was sent to residents of areas in which SPAN study participants (selected via their schools in The Hague, see Hoeben and Weerman 2014) lived/spent time.

[2]Statistically significantly less residents lived in the six postal codes without SPAN data than in the 76 included postal codes (note that neighbourhoods were only included in the survey if they contained sufficient residents). Excluded postal codes' surfaces did not differ from included postal codes' surfaces. Relatively few offences were committed in the 6 excluded postal codes compared to the 76 included (on average 72 and 172 offences in 2006–2009 per postal code, respectively).

Data and Measures

Offenders and offences

Data on offenders and their offences were acquired from the police information system used by the The Hague Police Service. Records with information on offenders and offences they had been charged with were used to establish the location and date of the offences committed. A random sample was taken of 10,000 offenders with at least one registered crime incident in 2009 in the greater The Hague area.

Of the original sample, 4623 individuals were excluded, resulting in a final sample of 5377 offenders. Exclusion was due to: (1) 92 individuals were involved in offences that did not meet the criteria of a felony; (2) 5 individuals were younger than 12 years old in 2009 and the Dutch criminal law does not allow prosecution of children below age 12; (3) 2284 individuals had no offence committed in 2006–2009 at a valid address in one of the 76 postal codes, because offences were in another region, had an unknown/non-specific address, or were not committed in 2006–2009; and (4) 2242 individuals were dropped because they did not have a known residential address within the study area when they committed the 2006–2009 offences. The remaining 5377 offenders were on average 33.0 years old (SD = 14.0, range = 12–95, median = 30); 82.3 percent was male.

All registered offences of the 5377 offenders committed in the study area in 2006–2009 were used to construct the dependent variable. This resulted in a total of 13,088 offences committed by these offenders. Offence locations were geocoded to one of the 76 postal code areas. For each offence, the postal code in which the offence was committed scored 1, and all other remaining postal codes scored 0.

Violent and property offences were determined using the classification of Statistics Netherlands (2014).[3] Of the 13,088 offences, 2970 were violent offences (committed by 1992 offenders), such as assaults, criminal threats, homicides, sex offences, and robberies. There were 4283 (committed by 1844 offenders) property crimes, including thefts, burglaries, selling of stolen goods and forgery.

Activity nodes

To construct the two activity nodes—residential area of the offender, and residential area(s) of the offender's family (parents, siblings, and/or children)—population registration data were used from a nationwide information system (Dutch acronym BRP) that records information on all Dutch citizens. This system is continuously updated and can be extracted daily by authorized organizations. Status changes of citizens, including moving to another residential address, marriage/divorce, child birth, and death are registered and updated by municipalities. These registration data are a reliable source to obtain residential histories of individuals, and for identifying the family members of the 5377 offenders (see also Menting *et al.* 2016). All residential addresses of offenders and their family within the study area were geocoded to one of the 76 postal code areas.

Two dummy variables were constructed. *Residential area of the offender* (1 = yes; 0 = no) indicated those postal codes in the study area in which the offender lived at the time

[3]Other categories were: vandalism, traffic, environmental, drugs, weapons, and other (same subdivision as Lammers et al. 2015).

of the offence. Similarly, *residential area of family* (1 = yes; 0 = no) indicated each of the 76 postal codes in which at least one parent, sibling and/or child of the offender lived at the time of the offence. Whenever multiple family member types resided in a postal code area, the score was set to 1 for that postal code; when no family member lived in a postal code, the score was 0. Because the aim was to test interactions for two different and distinctive activity nodes, only postal code areas where family lived at the time of the offence without the offender were indicated as a residential area of family. Areas where both the offender and family lived received only the score 1 on residential area of the offender and 0 on residential area of family. For the 13,088 included offences and the 76 alternative postal codes per offence, there were 15,731 postal codes that received a score of 1 on residential area of family (parents: 5162; siblings: 11,004; children: 1842).

Criminal opportunity indicators

The *number of bars/restaurants/hotels* was assessed using LISA (Dutch: 'Landelijk Informatiesysteem Arbeidsplaatsen') data on the locations and other characteristics of all businesses and facilities in the study area in 2006–2009 (for more information, see Steenbeek *et al.* 2012). All facilities in each postal code in the study area indicated as a food and/or beverage outlet (e.g. bars, restaurants, clubs, 'coffeeshops' where cannabis can be purchased for personal consumption), and/or lodging facility (e.g. hotels, hostels, campsites) were summed. Only facilities attracting customers on a regular basis were included. Therefore, 'event catering' facilities were excluded because catering is provided somewhere else and most customers likely rarely visit the office/distribution centre. The total number of bars/restaurants/hotels within each postal code was calculated for the year in which each offence was committed. Because of the score's distribution and the interpretability of significant interactions, this score was natural log (ln) transformed (after adding 1) and z-standardized ($M = 0$, SD = 1) for the models.

Collective efficacy was measured with a community survey, which was part of the Study of Peers, Activities and Neighborhoods (SPAN) project (Bruinsma *et al.* 2013; Hoeben and Weerman 2014). The community survey was randomly distributed among residents of 110 neighbourhoods of The Hague, Rijswijk, and Leidschendam-Voorburg, covering most of the The Hague area. These neighbourhoods were selected because a substantial number of adolescents who participated in the SPAN project reported living or spending their time there. Neighbourhoods were only included if there was a sufficient number of residents to provide valid information on the ecological characteristics (excluding parks and industrial areas). 11,505 questionnaires were sent to residents in three batches in March, May, and November 2009; 3696 were returned. For this study, 3527 (31%) were includable because there was a collective efficacy score and the participant lived in a four-digit postal code in the study area.

Collective efficacy was constructed using the informal social control and neighbourhood social cohesion and trust scale (Bruinsma *et al.* 2013), a Dutch adaptation of Sampson and colleagues' scales (1997). Respondents were asked to consider an area within 5 min walking distance from their home. Informal social control consisted of six items (Cronbach's alpha = 0.79), such as 'If a fight broke out in front of your house, how likely is it that your neighbours would intervene?', and 'If you were on holiday and your window is thrown in, would your neighbours get your window repaired while you

are away from home?'. Scores were on a five-point Likert scale, ranging from 0 ('very unlikely') to 4 ('very likely'). Neighbourhood social cohesion and trust consisted of 5 items, including 'People in this neighbourhood can be trusted', and 'People in this neighbourhood do not share the same values', with scores ranging from 0 ('totally disagree') to 4 ('totally agree'). Negatively stated items were reversed, so that higher scores represent higher cohesion and trust (Cronbach's alpha = 0.79). The mean score of the 11 items from both scales was calculated (when ≥9 item scores were present; Cronbach's alpha = 0.86) to obtain the collective efficacy score of each participant (range = 0–4, higher score = more collective efficacy).

To create a collective efficacy score per postal code, the mean of the collective efficacy scores of all individual participants in a specific postal code was calculated. Of the 76 postal codes with at least one includable participant, the large majority (96%) had at least 10 participants with a collective efficacy score (M = 46.4, SD = 26.3, median = 42.5, range 1–172 participants per postal code). To ease interpretation of (interaction) effects, the z-standardized collective efficacy score (M = 0, SD = 1) was used in the models.

Control variables

Several control variables were included in the models. First, because previous residential areas of the offender were also found to have an increased chance of being targeted (Bernasco 2010), the dummy variable *former residential area of the offender* was constructed (1 = yes; 0 = no) from the BRP residential history data. Only former residential areas up to three years before the offence were included. Another control variable is *distance* between the offender's residential area and the crime location. It has consistently been found in previous crime location choice studies that offenders more likely commit crime closer to their home than further away (for an overview: Ruiter 2017), following the distance decay pattern (Brantingham and Brantingham 1984: 344–6). The Euclidian distance (kilometres) between the centroid of the offender's residential area at the time of the offence and the centroid of each alternative postal code was used. Distances of zero were replaced with the average distance between two random points in that postal code (following Ghosh 1951).

Analyses were also controlled for previous crime locations. Previously targeted areas were found to be at increased risk of being targeted again by an offender (Bernasco *et al.* 2015; Lammers *et al.* 2015). Using the police data, *previous crime location* (1 = yes; 0 = no) was constructed for each 2006–2009 offence and the associated 76 alternative postal code areas to indicate whether the offender had committed a prior offence in that particular postal code in the three years before the offence.

Several other postal code area characteristics were also taken into account. These include other types of facilities that attract people, such as shops and schools, which may also generate/attract crime (Brantingham and Brantingham 1995, 2008). Therefore, crime year specific numbers of *retail facilities, schools*, *cultural*, *health care*, and *sports/leisure facilities* in each postal code were determined with LISA data. Also the *number of employees* indicates the presence of people—who may be guardians, targets or offenders—in an area, so the sum of employees of all businesses in LISA was calculated for each postal code (part-time employee = 0.5). Furthermore, analyses were controlled for *neighbourhood disorder*, constructed for each postal code in

a similar way as collective efficacy using the SPAN community survey. Respondents were asked whether their neighbourhood had problems with 17 forms of disorder, including trash, drug trade and homeless people on the street/in public space; items ranged from 0 (*no problem*) to 2 (*large problem*) (alpha = 0.91). To control for residential population characteristics, three crime year specific variables were constructed for each postal code using census-like statistics from Statistics Netherlands: *population density* (number of residents divided by surface, obtained from the Ministry of the Interior and Kingdom Relations 2014), *proportion of single-person households*, and *proportion of residents with a non-western background*. Highly populated areas might generate crime, but may also provide more potential guardians. Many single-person households and ethnic diversity have been associated with aspects of social disorganization and less cohesion in an area.

Statistical analyses

Hypotheses were tested with discrete choice models. They test why a decision-maker chooses a specific single alternative from a distinct number of alternatives, given the characteristics of the alternatives and of the decision-maker (Ben-Akiva and Bierlaire 2003). They often follow the random utility maximization (RUM) assumptions and are statistically tested with a conditional logit model (McFadden 1974). In crime location choice studies, the offender is the decision-maker, the alternatives from which the offender has to choose are distinct spatial entities, and the choice faced by the offender is where to commit a crime. The model implies that a motivated offender evaluates the utility (gain, profits, satisfaction, risks) of each of the possible choice alternatives—in this study 76 mutually exclusive postal code areas—and selects the alternative with the largest utility. Both characteristics of the offender (e.g. residential area) and characteristics of the spatial alternatives (e.g. criminal opportunity) can be simultaneously tested. This model was applied to crime location choice and in detail explained by Bernasco and Nieuwbeerta (2005), and several crime location choice studies have followed (Ruiter 2017).

Main effects of activity nodes, criminal opportunity characteristics, and control variables were tested first. Subsequently, interaction effects were tested by adding the interaction term/product of the activity node and the opportunity characteristic to the main effects model. To decompose the direction of interaction effects, significant interaction terms were probed by estimating the effects of the offender's/familial residential area at high and low levels of criminal opportunity in the area (following Holmbeck 2002: 1 SD above and 1 SD below the mean, respectively). Vice versa, the effect of number of bars/restaurants/hotels, and collective efficacy was examined when an area was indicated as being a residential area of the offender or not, and a familial residential area or not.

The conditional logit models were estimated using a data matrix of 994,688 rows, containing 76 rows for each of the 13,088 offences (per offence, one row for each of the 76 alternative postal codes that could have been chosen). Odds ratios (OR) are reported. They indicate the multiplicative effect of a one-unit increase of the independent variable on the odds (ratio of probability p and $1 - p$) of choosing a particular target area. OR's between 0 and 1 indicate that the odds decrease (negative effect) and OR's

>1 indicate an increase (positive effect). For binary independent variables, an estimated OR of 2 would indicate that the odds of being targeted was two times larger when the score was 1 on that variable compared to similar areas with 0 on that variable. For continuous/count independent variables, an OR of 2 would imply that the odds become two times larger with a one-unit increase of the independent variable. If crimes are expected to be disproportionally more likely committed in residential areas with much criminal opportunity, the OR of the interaction terms between the activity nodes and the number of bars/restaurants/hotels are hypothesized to be >1, and <1 for collective efficacy.

Results

Descriptive statistics

Of the 13,088 any-crime-type offences, 3123 (23.9%) were committed in the residential area of the offender, and 843 (6.4%) in a residential area of the offender's family. Of the 2970 violent offences, 971 (32.7%) were in offenders' residential areas, and 271 (9.1%) in their family's residential areas. Of the 4283 property offences, 817 (19.1%) were in offenders' residential areas, and 203 (4.7%) in their family's residential areas. Table 1 shows descriptives of the two opportunity indicators for the (1) targeted versus non-targeted areas, (2) areas that were a residential area of an offender versus areas that were not, and (3) areas that were a residential area of family of an offender versus not. The median of the number of bars/restaurants/hotels was statistically significantly higher in targeted than in non-targeted areas, and in areas where the offender or the offender's family lived compared to, respectively, areas where the offender/offender's family did not live. The collective efficacy mean score was statistically significantly lower in targeted areas compared to non-targeted areas; the same applied to areas indicated as residential areas of offenders, and of their family, versus those that were not (all p's < 0.001).

Interaction analyses any-crime-type offences

First, main effects were tested; results are presented in Table 2. All study variables were statistically significant predictors of crime location choice. As expected, both types of activity nodes—residential areas of offenders and those of their family—increased the risk that an area would be targeted compared to areas in which, respectively, offenders or their family did not live. More bars/restaurants/hotels in an area also increased the risk that it was targeted. In line with expectations, higher collective efficacy protected against crime in that area. The pseudo R^2 was 0.25, which indicates that the model fits the data well (McFadden 1978).

Subsequently, interactions were tested between the two activity nodes and the two opportunity indicators in separate models (models 2–5, Table 3). Effects of control variables are not shown for reasons of parsimony; they were similar to those reported in Table 2.

The interaction between residential area of the offender and the number of bars/restaurants/hotels was statistically significant and negative (see model 2, Table 3). Probing

TABLE 1 *Descriptives of opportunity indicators in targeted areas (yes/no), in residential areas of offenders (yes/no), and in residential areas of family member(s) (yes/no) (N = 994,688)*

Opportunity indicator	Area with any-crime-type offence(s)					
	Yes (n = 13,088)			No (n = 981,600)		
	M	SD	Median	*M*	SD	Median
# Bars/restaurants/hotels	47.4	45.2	31	27.1	30.5	16
Collective efficacy	2.30	0.27	2.20	2.41	0.27	2.47
	Residential area offender					
	Yes (n = 13,099)			No (n = 981,589)		
	M	SD	Median	*M*	SD	Median
# Bars/restaurants/hotels	32.7	28.6	28	27.3	30.9	16
Collective efficacy	2.25	0.26	2.16	2.41	0.27	2.47
	Residential area family member(s)					
	Yes (n = 15,731)			No (n = 978,957)		
	M	SD	Median	*M*	SD	Median
# Bars/restaurants/hotels	31.0	28.8	26	27.3	30.9	16
Collective efficacy	2.25	0.25	2.16	2.41	0.27	2.47

#Bars/restaurants/hotels, non-transformed sum; collective efficacy, not z-standardized; *M*, mean; SD, standard deviation.

of the direction of the interaction shows that more bars/restaurants/hotels present in an area increased the risk of a crime being committed in that area in both conditions, but stronger ($\chi^2(1) = 46.0$, $p < 0.001$) when that area was *not* the residential area of the offender, see also Figure 1a. Offenders' residential areas were consistently more likely targeted than areas where they did not live regardless of the number of bars/restaurants/hotels. However, the difference in effect size between being an offender's residential area versus not reduced with increasing numbers of bars/restaurants/hotels in the area.

Model 3, Table 3 also shows a statistically significant, but positive, interaction effect between offender's residential area and the level of collective efficacy. Probing shows that collective efficacy was only a statistically significant protector against crime in areas that were *not* indicated as a residential area of the offender, see also Figure 1b. The collective efficacy effect sizes in both conditions differed significantly ($\chi^2(1) = 13.4$, $p < 0.001$). Offenders' residential areas were consistently more often targeted than areas where they did not live regardless of the level of collective efficacy, but the residential area (yes/no) effect size difference was larger when collective efficacy in that area was high due to the absence of a protective effect of collective efficacy in offenders' residential areas.

Interaction effects between residential area of family members and the two opportunity indicators were similar to those of the offender's residential area (Table 3,

Table 2 *Results from the main effects conditional logit model in predicting crime location choice (13,088 offences committed by 5377 offenders)*

Crime location choice	OR	*B*	SE	*z*
Study variables				
Residential area offender	5.285***	1.665	0.030	55.0
Residential area family	2.904***	1.066	0.044	24.5
# Bars/restaurants/hotels	1.295***	0.258	0.024	10.7
Collective efficacy	0.883***	–0.125	0.024	–5.21
Control variables				
Former residential area offender	2.028***	0.707	0.057	12.5
Former crime location	5.423***	1.691	0.030	55.9
Distance residence offender	0.691***	–0.369	0.007	–51.2
Neighbourhood disorder (z-standardized)	0.976	–0.024	0.027	–0.89
Density (per 1000)	0.992***	–0.008	0.002	–4.37
Proportion non-western residents	1.019	0.018	0.115	0.16
Proportion single-person households	0.645**	–0.438	0.129	–3.39
# Employees (per 1000)	1.027***	0.027	0.003	9.32
Retail businesses (per 10)	1.023***	0.023	0.003	8.28
Schools (per 10)	0.965	–0.035	0.023	–1.57
Health-care facilities (per 10)	0.963**	–0.037	0.011	–3.41
Cultural facilities (per 10)	1.019***	0.019	0.003	6.74
Sport and leisure facilities	1.016***	0.016	0.004	4.19

Bars/restaurants/hotels, natural log (ln) transformed, z-standardized; collective efficacy, z-standardized; OR, odds ratio; SE, robust standard error of *B* coefficient.
$^{**}p < 0.01$, $^{***}p < 0.001$.

models 4 and 5): both were statistically significant, in the same direction and of a similar magnitude. Probing of these interactions also showed largely similar results, see Figure 2. The number of bars/restaurants/hotels and collective efficacy were only influential in areas were family did not live, and residential area of family was influential regardless the number of bars/restaurants/hotels and the level of collective efficacy.

Violence and property offences

The same steps were repeated for violence (Table 4, models 6–10) and property offences (Table 4, models 11–15). The two main effects models (models 6 and 11) showed statistically significant main effects of the four study variables in the hypothesized direction for both crime types. Both models fitted the data well (violence: pseudo $R^2 = 0.30$; property offences: pseudo $R^2 = 0.25$).

For violence, three of the four interactions were statistically significant (models 7, 8 and 9), with interaction effects in the same direction as those in the any-crime-type models. The interaction between familial residential area and collective efficacy did not reach statistical significance. Probing of the significant interactions showed a largely similar pattern as reported for any-crime-type offences, with only statistically significant effects of the opportunity indicator in areas where the offender/family did not live.

For property crimes, residential area of the offender interacted only significantly with collective efficacy, and familial residential area with the number of bars/restaurants/

TABLE 3 *Interaction effects between two activity nodes and two opportunity indicators in predicting crime location choice (N = 13,088 offences)*

	Model 2			Model 3		
	OR	*B* (SE)	*z*	OR	*B* (SE)	*z*
ResArOff	**5.687*** **	**1.738 (0.033)**	**53.0**	**5.587*** **	**1.720 (0.034)**	**50.3**
ResArFam	2.903***	1.066 (0.044)	24.5	2.886***	1.060 (0.044)	24.3
#BRH	**1.364*** **	**0.310 (0.026)**	**12.0**	1.294***	0.258 (0.024)	10.6
CollEff	0.878***	–0.131 (0.024)	–5.42	**0.871*** **	**–0.138 (0.024)**	**–5.67**
ResArOff × #BHR	**0.837*** **	**–0.178 (0.026)**	**–6.78**			
ResArOff × CollEff				**1.104*** **	**0.099 (0.027)**	**3.66**
	Model 4			Model 5		
	OR	*B* (SE)	*z*	OR	*B* (SE)	*z*
ResArOff	5.294***	1.667 (0.030)	55.1	5.280***	1.664 (0.030)	55.1
ResArFam	**3.217*** **	**1.169 (0.047)**	**24.6**	**3.122*** **	**1.138 (0.051)**	**22.3**
#BRH	**1.312*** **	**0.271 (0.024)**	**11.1**	1.294***	0.258 (0.024)	10.6
CollEff	0.884***	–0.123 (0.024)	–5.14	**0.880*** **	**–0.127 (0.024)**	**–5.32**
ResArFam × #BRH	**0.828*** **	**–0.189 (0.043)**	**–4.41**			
ResArFam × CollEff				**1.121***	**0.114 (0.045)**	**2.55**

Bold results are main effects plus interaction term of focus in that model. All control variables were taken into account; effects were similar to those in Table 2. OR, odds ratio; SE, robust standard error of *B* coefficient; ResArOff, residential area offender; ResArFam, residential area family; #BRH, number of bars/restaurants/hotels (ln–transformed, z-standardized); CollEff, collective efficacy (z-standardized).
*$p < 0.05$; ***$p < 0.001$.

hotels (models 13 and 14). These interactions showed again a similar effect pattern as found for any-crime-type offences.

Discussion

Following crime pattern theory's premise that crimes are most likely committed in areas where the awareness space of an offender overlaps with the presence of criminal opportunity, it is expected that the effect of an activity node depends on the level of criminal opportunity in that area and vice versa. By merely examining additive effects of both types of predictors, as previously done in crime location choice research, this potential dependency between both is ignored. Therefore, this study examined interactions between two activity nodes and two indicators of criminal opportunity. Areas that are a well-known activity node of the offender and that contain much criminal opportunity were expected to be disproportionally likely of being targeted compared to areas that were either less/not known by the offender and/or that had no/less criminal opportunity (cf. example by Brantingham and Brantingham 1981, p. 52).

The findings showed a number of things. The main effects of both activity nodes and both opportunity indicators were present in the expected direction: residential areas of offenders, residential areas of family, and areas with many bars/restaurants/hotels had an increased risk of being targeted, and areas with high collective efficacy a lower risk. More importantly for this study, interaction effects were

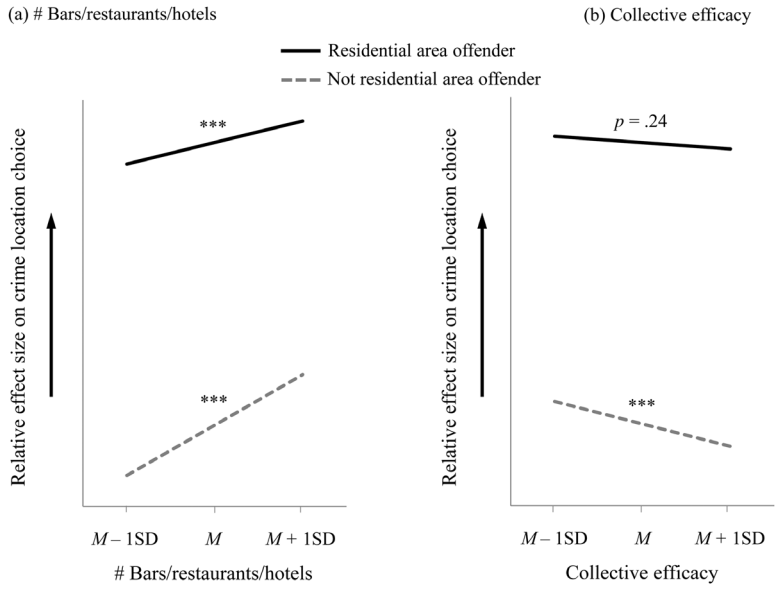

FIG. 1 Relative differences in effect sizes (*B*) on crime location choice of residential area of the offender versus not when (a) the # bars/restaurants/hotels was low (*M* – 1SD), average and high (*M* + 1SD); and (b) collective efficacy was low (*M* – 1SD), average and high (*M* + 1SD). *Note*. Controlled for other study and control variables; # bars/restaurants/hotels = ln-transformed. ***$p < 0.001$.

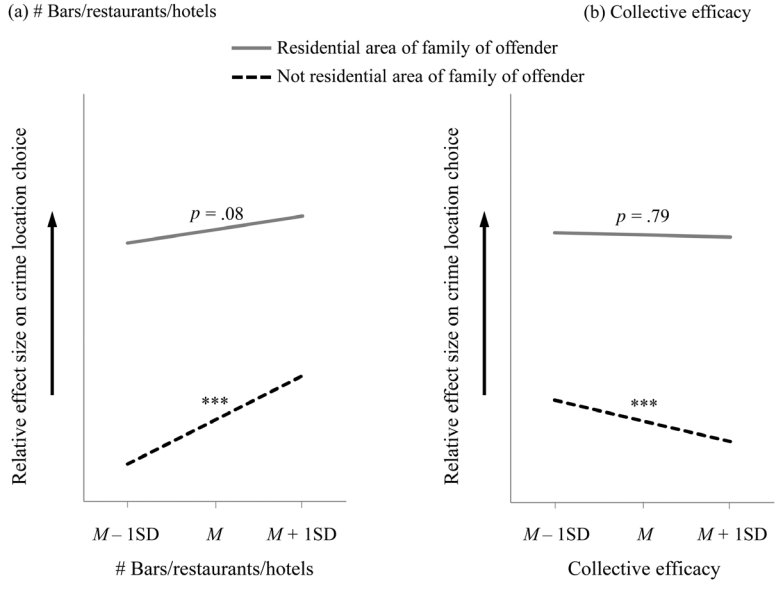

FIG. 2 Relative differences in effect sizes on crime location choice of residential area of family of the offender versus not when (a) the # bars/restaurants/hotels was low (*M* – 1SD), average and high (*M* + 1SD); and (b) collective efficacy was low (*M* – 1SD), average and high (*M* + 1SD). *Note*. Controlled for other study and control variables; # bars/restaurants/hotels = ln-transformed. ***$p < 0.001$.

TABLE 4 *Main effects and interaction models for violence (N = 2970) and property (N = 4283) offences separately*

Violence	Model 6		Model 7		Model 8		Model 9		Model 10	
	OR	*B* (SE)	OR	*B* (SE)	OR	*B* (SE)	OR	*B* (SE)	OR	*B* (SE)
ResArOff	10.39***	2.341 (0.062)	**11.81*** **	**2.469 (0.068)**	**12.29*** **	**2.509 (0.071)**	10.39***	2.341 (0.061)	10.38***	2.340 (0.061)
ResArFam	5.080***	1.625 (0.082)	5.078***	1.625 (0.082)	4.980***	1.605 (0.082)	**5.537*** **	**1.711 (0.089)**	**5.485*** **	**1.702 (0.097)**
#BRH	1.343***	0.295 (0.052)	**1.491*** **	**0.400 (0.056)**	1.347***	0.298 (0.052)	**1.366*** **	**0.312 (0.052)**	1.341***	0.293 (0.052)
CollEff	0.801***	–0.222 (0.052)	0.784***	–0.243 (0.053)	**0.764*** **	**–0.269 (0.053)**	0.803***	–0.220 (0.052)	**0.798*** **	**–0.226 (0.052)**
ResArOff × #BRH			**0.747*** **	**–0.292 (0.052)**						
ResArOff × CollEff					**1.312*** **	**0.271 (0.054)**				
ResArFam × #BRH							**0.840***	**–0.175 (0.079)**		
ResArFam × CollEff									**1.120**	**0.113 (0.084)**
Property	**Model 11**		**Model 12**		**Model 13**		**Model 14**		**Model 15**	
	OR	*B* (SE)	OR	*B* (SE)	OR	*B* (SE)	OR	*B* (SE)	OR	*B* (SE)
ResArOff	3.538***	1.264 (0.056)	**3.587*** **	**1.277 (0.061)**	**3.870*** **	**1.353 (0.067)**	3.543***	1.265 (0.056)	3.536***	1.263 (0.056)
ResArFam	1.983***	0.684 (0.085)	1.983***	0.684 (0.085)	1.967***	0.677 (0.084)	**2.259*** **	**0.815 (0.089)**	**2.155*** **	**0.768 (0.107)**
#BRH	1.221***	0.200 (0.040)	**1.231*** **	**0.208 (0.043)**	1.217***	0.197 (0.041)	**1.236*** **	**0.212 (0.041)**	1.222***	0.200 (0.041)
CollEff	0.823***	–0.195 (0.042)	0.822***	–0.196 (0.042)	**0.812*** **	**–0.209 (0.042)**	0.825***	–0.192 (0.042)	**0.821*** **	**–0.197 (0.042)**
ResArOff × #BRH			**0.968**	**–0.033 (0.049)**						
ResArOff × CollEff					**1.146** **	**0.136 (0.052)**				
ResArFam × #BRH							**0.790** **	**–0.236 (0.081)**		
ResArFam × CollEff									**1.127**	**0.119 (0.093)**

Bold results are main effects plus interaction term of focus in that model. All control variables were taken into account, but not reported for reasons of parsimony. OR, odds ratio; SE, robust standard error of *B* coefficient; ResArOff, residential area offender; ResArFam, residential area family; #BRH, number of bars/restaurants/hotels (ln-transformed, z-standardized); CollEff = collective efficacy (z-standardized).

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

found, but not in the hypothesized direction. Residential areas of offenders and of family members were consistently found to have a substantially increased risk of being targeted compared to areas where the offenders/family members did not live, and the effect was only moderately (i.e. number of bars/restaurants/hotels in offenders' residential areas) or not statistically significantly (i.e. number of bars/restaurants/hotels in familial residential areas, and collective efficacy in both types of residential areas) influenced by the level of criminal opportunity in that area. Criminal opportunity, however, appeared to be consistently (more) influential in the areas that were no residential area of offenders or of their family: areas where the offender/family did not live with many bars/restaurants/hotels or with lower collective efficacy were more likely targeted by offenders than such areas with few bars/restaurants/hotels or higher collective efficacy, respectively. Although interactions terms did not always reach statistical significance when tested separately for violent and property crimes, their direction was the same as for any-crime-type offences.

There are several potential explanations for the initially unexpected direction of the interactions. First, the smaller/absent effects of criminal opportunity in residential areas of offenders and of their family are discussed. Because of the higher level of knowledge of specific targets in residential areas of offenders and of their family, a large number of crime generating/attracting facilities such as bars/restaurants/hotels may actually be less required to make it substantially more attractive. As long as there is at least some criminal opportunity in a well-known own/familial residential area, it is likely attractive enough to target. Less obvious criminal opportunity may also be particularly visible for offenders who live or visit family there. For example, one well-known local bar can be enough to provide suitable targets for a residing offender, so that additional crime generating/attracting facilities have less additional effect compared to in areas where they have less knowledge of. Almost all offenders (99.9%) and their family (99.6% of their residential areas) in this study's sample lived in areas with at least one bar/restaurant/hotel, and relatively often the number of bars/restaurants/hotels was even rather high in offenders'/familial residential areas. Although the number of bars/restaurants/hotels was less influential in offenders' residential areas than in areas where they did not live, offenders did commit more any-crime-type offences close to their home when there were many bars/restaurants/hotels compared to when there were few. This did not apply to familial residential areas with many bars/restaurants/hotels, perhaps because offenders knew these areas less well and more effort was required to go there.

The absence of a protective effect of collective efficacy in offenders' residential areas may be explained by the negotiated-coexistence model (Browning *et al.* 2004): the protective effect of collective efficacy against crime is weakened if offenders are integrated into dense networks within their neighbourhood. The social capital provided by such networks then buffers against neighbours' social control (Browning 2009). Collective efficacy was found to be less protective against crime when the network density among neighbourhood residents was higher (Browning *et al.* 2004, 2009). Neighbours may thus be more tolerant towards crime when their social network includes their offending neighbour. Another explanation could be that offenders prefer areas where they feel comfortable and where they have knowledge of what could happen (Brantingham and Brantingham 1993). When offenders live in

neighbourhoods with relatively higher collective efficacy, the higher social trust may make them feel more comfortable and less conspicuous. Non-offending residents may also be less careful guarding their property when they think they can trust and rely on their neighbours. Although theoretically more plausible for offenders' own residential area, such mechanisms might also explain why an increase in collective efficacy does not further protect against crime committed by offenders in their family's neighbourhood. If collective efficacy is higher there, the neighbours of the family members may also recognize and trust the visiting offender. For both opportunity characteristics, it may also be argued that the lifestyle of (particularly prolific) offenders binds them more to particular places such as the area in which they live. Also their criminal activities would then likely take place in these areas, irrespective of the area's objective level of opportunity.

Second, there are possible explanations for why the effects of criminal opportunity were more visible in areas where offenders/family did not live. While offenders are expected to have much knowledge of their own residential area and at least some knowledge of their family's residential areas, these two activity nodes do not provide a complete picture of the awareness space of most offenders. The areas with many bars/restaurants/hotels may also be visited by the offenders in this study. Despite being theorized as being part of an individual's awareness space (Brantingham and Brantingham 1993), there is no crime location choice study, however, that included a measure for each individual offender indicating which bars/restaurants/hotels were visited by this person. Only more general measures such as the city centre or the number of such facilities have been included, with the assumption that most people are familiar with the city centre (Bernasco and Nieuwbeerta 2005; Townsley *et al.* 2015). Also in this study, there was unfortunately no measure available that indicated favourite leisure locations of individual offenders. The current findings underscore the relevance of including such areas as separate activity nodes, as offenders generally also seem to be attracted to areas with many bars/restaurants/hotels when they are not located in their own or family's residential area. They might have visited these specific areas, but they can also have general knowledge of opportunity in areas with many bars/restaurants/hotels based on common characteristics of such areas. Therefore, similar to crime location choice research in general, more information is needed in future research about the actual activity patterns of each individual offender when disentangling the role of awareness, opportunity, and their interdependence.

The presence of an effect of collective efficacy in areas where offenders/family did not live might also be explained by an additional elucidation. Although particularly people who know an area well know to what extent residents trust one another and are willing to intervene, higher collective efficacy has also been described to discourage all potential offenders (Bernasco and Block 2009). There are indicators of physical and social disorganization related to collective efficacy that are more visible also to outsiders, for example neglected properties. The relationship between collective efficacy and more observable signs of disadvantage in the neighbourhood has indeed been found (Sampson *et al.* 1997; O'Brien and Kauffman 2013). Based on these more visible characteristics, offenders with no/less ties with a neighbourhood may also estimate the likelihood of residents' intervention before deciding to commit a crime there or not (cf. Bernasco and Block 2009). A recent study also showed that when offenders targeted an

area with different ecological characteristics than their own residential area, they more often targeted more disadvantaged areas presumably because of the associated lower social control and lower risk of being caught in those areas (Chamberlain and Boggess 2016). Such mechanisms might thus also explain why areas where the offender/offender's family did not live with lower levels of collective efficacy are more likely targeted than such non-residential areas with higher collective efficacy. It suggests that higher levels of knowledge of an area may not be necessarily required for potential offenders to estimate what the chance of being caught by residents is.

Limitations

This study also has limitations. First, the study area consisted of three urban municipalities. The role of awareness, opportunity and their interaction may not be the same for offenders in rural areas. For example, aspects of social disorganization and community organization may be differently related to crime in rural compared to urban areas (Kaylen and Pridemore 2013). Mechanisms may also differ between countries. Therefore, inclusion of a larger and more diverse geographical area in future studies is needed to increase the findings' generalizability.

Second, although it is reasonable to assume that people are relatively familiar with four-digit postal codes when living there or (frequently) visiting them, this spatial unit of analysis could be considered as being rather large, whereas smaller areas may better fit theoretical models of crime location choice. However, smaller spatial units of analysis also yield several computational and theoretical challenges (e.g. very large datasets and spatial spillover; Ruiter 2017). Multiple previous crime location choice studies used areas similar to or larger than this study's postal codes, and their findings were not contradictory to findings from those that used smaller areas (Ruiter 2017).

Third, despite the inclusion of two distinct activity nodes expectedly known by an offender to a different extent, there were no data available to more precisely and more completely map awareness spaces of individual offenders. More complete and direct measures are needed in future research, not only to include other theorized parts of the awareness space in order to more precisely map well-known, less-known versus unknown areas, but also to confirm individuals' assumed time-spending patterns (e.g. whether offenders indeed visit their family). The expected difference in knowledge-level of the two activity nodes was indeed visible in the main effects of offenders' and familial residential areas, but interaction patterns were largely similar.

Fourth, the hypothesized interaction pattern might be found for other types of criminal opportunity than used in this study. For example, although collective efficacy has characteristics similar to guardianship, it does not indicate actual guardianship, but perceptions of potential interventions by neighbours against potential forms of deviancy (Hipp and Wo 2015). Actual (formal) guardianship might have more deterrent effects in an offender's residential area than a higher level of collective efficacy. There may also be other types of opportunity specifically relevant for (well-)known own/familial residential areas than for areas in general. Although the consistent interaction pattern across the activity node-opportunity indicator combinations for any-crime-type, violent and property crimes suggests a more general pattern (or no significant

interaction), further scrutiny is warranted to examine the findings' robustness by also including other, more complete and precise measures of offenders' activity spaces and criminal opportunity in future research, not only for crime in general but also for other and more specific crime subtypes.

Conclusion

In sum, this was the first crime location choice study to explicitly test interactions between offenders' awareness and opportunity, two requirements for a crime to take place somewhere, using measures from multiple different sources. Interactions were found, but not in the hypothesized direction: in areas that are expected to be (well-) known areas by the offender because of living there or because family lived there, criminal opportunity was less/not influential, but opportunity did (more strongly) increase the chance that an offender targeted an area where the offender or family did not live. These findings again confirm that both awareness and opportunity are important in predicting crime location choice. They also indicate, however, that their joint influence seems to be more complex than just being additive predictors, which has implications for both research and practice. For example, effects of awareness and/or opportunity might be over- or underestimated when their interdependence is not taken into account, providing a somewhat distorted picture of the actual chance that a crime is committed in a certain area. The better the risk can be estimated that an offender targets a specific area based on offender as well as area characteristics, the more directed surveillance and criminal investigation efforts can be applied by the police to areas at risk. Because this is the first study to test interactions between awareness and opportunity, the robustness of these findings warrants further scrutiny in future research, using similar and different (more complete and precise) measures for both awareness and opportunity. Both are thus influential, but supposedly not only in predicting where crime takes place, but also to what extent the other influences crime location choice.

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