It's no riddle, choose the middle: The effect of number of crimes and topographical detail on police officer predictions of serial burglars' home locations

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Abstract

This study examined the effect of the number of crimes and topographical detail on police officer predictions of serial burglars' home locations. Officers were given 36 maps depicting three, five, or seven crime sites and topographical or no topographical details. They were asked to predict, by marking an X on the map, where they thought each burglar lived. After making their predictions on half of the maps, officers randomly received either no training or training in one of two simple decision-making strategies. The accuracy of predictions at baseline and re-test was measured as the distance between the predicted and actual home locations and these accuracy scores were compared to a commonly used geographic profiling system. Results showed that training significantly improved predictive accuracy, regardless of the number of crime locations or topographical detail presented. Trained participants were as accurate as the geographic profiling system.

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Geographic profiling is defined as "…an information management strategy for…crime investigations that analyses crime site information to determine the most probable area of offender residence" (Rossmo, 2000, p. 259). According to Rossmo (2000), geographic profiling helps police officers prioritize suspects by comparing where suspects live in relation to the predicted area of offender residence. Predictions are typically obtained through geographic profiling systems, which utilize computationally expensive algorithms to produce probability surfaces that indicate the area most likely to contain the offender's home (e.g., Canter, Coffey, Huntley, & Missen, 2000). The algorithms are referred to as distance decay functions because it is assumed that the probability of an offender residing at a particular location generally decreases with increasing distance from an offense. The small amount of research that has examined the accuracy of such systems indicates that they reduce the overall area that the police have to search by roughly 90 percent (Canter et al., 2000; Rossmo, 2000).

Despite the popularity of these systems, researchers have recently examined alternatives to geographic profiling systems, along with the possibility of training people to make accurate profiling predictions (e.g., Levine & Associates, 2004; Paulsen, 2004; Snook, Canter, & Bennell, 2002; Snook, Taylor, & Bennell, 2004; Snook, Zito, Bennell, & Taylor, 2005). Much of this research has focused on the use of simple rules of thumb for predicting the home location of serial offenders. At a conceptual level, these studies are based on a growing body of research showing that people use simple cognitive heuristics to make accurate decisions across a range of domains (e.g., Gigerenzer, Todd, & The ABC Research Group, 1999; Gigerenzer & Selton, 2001). Heuristics, in this case, refer to "[cognitive] mechanisms that allow decisions to be arrived at quickly and with little mental effort" (Todd, 1999, p. 463). This research has demonstrated that heuristic-led decisions can be as accurate as more computationally expensive methods, such as multiple regression, because they are able to exploit natural regularities in decision environments (e.g., Martignon & Hoffrage, 1999). Recent geographic profiling research has followed this trend by showing that many individuals use simple heuristics, or can be trained to use, to accurately predict the home location of serial offenders.

For example, in a study by Snook et al. (2002), two groups of students were provided with maps depicting the location of 5 crimes committed by 10 different serial murderers. The participants were asked to predict where they thought the serial offenders lived by marking an X on each map. Before the students were asked to make predictions on another set of maps, the experimental group was given some simple training. This training consisted of informing participants about two heuristics that are based on empirical regularities of serial offender spatial behavior. Participants were informed about the *Circle* heuristic, which involves predicting that serial offenders often live within a circular area, with the diameter of the circle defined as the distance between the two crimes in a series that are furthest from each other (see Canter & Larkin, 1993), and the *Decay* heuristic, which involves predicting that the majority of serial offenders live near their crimes (see Rengert, Piquero, & Jones, 1999). The accuracy of all predictions was measured and compared to the accuracy of a computerized geographic profiling system called *Dragnet* (Canter et al., 2000).[1] The results indicated that training had a significant impact on predictive accuracy, with participant performance in the experimental group improving to a point where their predictions were as accurate as *Dragnet*.

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[1]Dragnet uses a negative exponential function, which assumes that the probability of locating a serial offender's home decreases exponentially with increasing distance from his crime location.

In a more recent study, Snook et al. (2004) extended previous research by separating out the impact of the two heuristics provided to participants by Snook et al. (2002), and by identifying the heuristics that participants used before receiving training. Student participants received 10 maps depicting the first three crime sites for solved serial murders. After making predictions on these maps, one third of the participants received training on the *Circle* heuristic, another third received training on the *Decay* heuristic, and the last third received no training. Every participant then made predictions on another 10 maps. Results showed that many participants (approximately 50%) used appropriate heuristics (i.e., they would allow for reasonably accurate predictions to be made) even before they received the heuristic training. Moreover, providing participants with training on either the *Circle* or *Decay* heuristic allowed those who did not use appropriate heuristics to improve their performance. These participants, along with those that were originally using appropriate heuristics, made predictions that were as accurate as the geographic profiling tool in *CrimeStat*[2]. Some of them made predictions that were actually more accurate than this system (especially those participants who received training on the *Decay* heuristic).

These experiments demonstrate the value of the heuristic approach for geographic profiling because it potentially provides a quick, cost-effective, and accurate means for predicting where a serial offender may be living. This is particularly important for police agencies who must deal with serious serial offending problems but do not have access to the financial and/or technical resources that are needed to run some computerized geographic profiling systems (e.g., police agencies in developing countries or rural areas). However, despite

[2]*CrimeStat* allows the user to select from five distance decay functions: linear, negative exponential, normal, lognormal, and truncated negative exponential. Snook et al. (2004) used a negative exponential function.

the promising results that have been reported in the aforementioned geographic profiling experiments, there are at least three potential limitations with that research.

The Current Study

One obvious limitation of previous geographic profiling experiments has been the use of student participants. Of course, the typical student does not possess any investigative experience and will likely never be required to make a geographic profiling prediction in a police investigation. Therefore, it is important to replicate findings from previous research using participants who will have had natural exposure to the spatial behavior of offenders, and be in a position to consider geographic-type predictions as part of their daily work. Namely, a replication is needed using police officers.[3] Because geographic profilers believe that investigative experience plays a crucial role in this prediction task (e.g., Rossmo, 2000), one would expect predictions made by police officers to be as accurate as those made by participants in previous studies (or more accurate). Even if a police officer never received any formal geographic profiling training, they may still be aware of the patterns of offender spatial behavior that would facilitate accurate profiling predictions. Presumably, this awareness would originate from their observations of the relationship between offender crime site and home locations and their direct experience with serial offenders (Snook et al., 2004). However, previous research has often demonstrated that subject matter competence or experience in a domain does not always result in better decisions (Connelly, Arkes, & Hammond, 2000). In other words, having knowledge about a particular area does not automatically equate to the appropriate execution of

[3]Some professional geographic profilers may argue that active police officers, at least in North America, will also never be in a position to construct a geographic profile due to the fact that geographic profiling is supposed to be carried out by specially trained profilers. While we would agree that this is probably the case in many high profile investigations, police officers and crime

that knowledge (Hammond, 1996). Thus, the issue of whether police officers can predict the home location of serial offenders is a question that needs to be addressed empirically. The current study does this by examining the predictions made by a sample of police officers from a large police force in the United Kingdom, before and after they were provided with heuristic training.

A second potential limitation relates to whether the geographic profiling experiments conducted in previous studies are representative of the task faced by geographic profilers during police investigations. In past experiments, participants were simply provided with blank maps consisting of dots (representing crime site locations). The number of dots has always been held constant across the maps and no other information has been provided to the participants. Because human decision makers have limits on their mental capacities (Broadbent, 1957; Miller, 1956), it might be the case that providing additional information to participants for their consideration could influence their predictive accuracy. For example, having to analyze a greater amount of crime scene information, in addition to crime site locations, may increase the complexity of the geographic profiling task to a point where the decision maker's cognitive processing system becomes overloaded (Eppler & Mengis, 2004; Jacoby, Speller, & Berning, 1974). The result in such circumstances would be a plateau, or even a decrease, in predictive accuracy. The current study examines this possibility by looking specifically at how two factors influence predictive accuracy – the number of crimes and the level of topographical detail. These two factors are being examined due to the fact that professional profilers (e.g., Rossmo, 2005) have argued that both factors should be taken into account when making geographic profiling predictions.

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analysts have indicated to us that they often construct geographic profiles in lower profile cases, although they use less sophisticated techniques than professional profilers.

Lastly, previous experiments have always focused on serial homicide cases. Given that geographic profiling is used as an investigative tool across a wide variety of crimes (Laverty & McLaren, 2002; Rich & Shively, 2004; Rossmo, 2000) it is important to determine whether previous results generalize across crime types. In particular, it is important to examine the usefulness of the heuristic approach to geographic profiling for crimes such as serial burglary. Research conducted on serial murder has demonstrated the suitability of these crimes for geographic profiling purposes and, therefore, the results from previous studies are perhaps unsurprising. For example, the majority of serial murderers are marauders who reside within a circle defined by their general area of criminal activity (Canter, 2003; Godwin & Canter, 1997; Lundrigan & Canter, 2001; Snook, Cullen, Mokros, & Harbort, 2005). However, the same is not necessarily true for property offenders, as these offenders are more likely to commute to their crimes (Goodwill & Alison, 2005; Kocsis & Irwin, 1997; Kocsis, Cooksey, Irwin, & Allen, 2002; Meaney, 2004). The results from the few tests of the "marauder/commuter" distinction for property offenders suggests that the heuristics taught in previous studies might not result in significant improvements in predictive accuracy for serial burglary cases, or at least not to the same extent as what has been found for serial homicide.[4] The current study tests this possibility by focusing on serial burglaries.

Method

[4]Another reason why it is important to determine whether previous results generalize to crimes such as serial burglary is the extremely high number of burglaries that are committed in most police jurisdictions, many of which will be the work of serial burglars (and therefore able to be profiled). For example, according to the US Department of Justice (2005), the 2004 nation-wide burglary rate in the US has been estimated at 2,143,456 (comparable rates for murder and rape are 16,137 and 94,635, respectively). Similar rates have been reported in Canada (Statistics Canada, 2005) and the UK (Home Office, 2005). While it is impossible to know how many burglaries are committed by serial burglars, criminological research suggests that they constitute a sizable portion of all offences (e.g., Blumstein, Cohen, Roth, & Visher, 1986).

Participants

Participants included 91 police officers of varying ranks from a large police service in the UK who were taking part in mandatory training classes (unrelated to geographic profiling). More specifically, the sample consisted of 67 Constables, 14 Sergeants, 4 Detective Constables, 3 Detective Inspectors, 1 Chief Inspector, 1 Detective Sergeant, and 1 Community Contact Officer. The participation rate of officers taking part in the training classes was 100%.

The participants were randomly assigned to a Control ($n = 30$), Circle ($n = 28$), or Decay ($n = 33$) group. Of the 91 participants who responded when asked their age, there was no significant difference between the Control ($M = 31.97$, $SD = 7.81$), Circle ($M = 34.07$, $SD = 8.32$), and Decay ($M = 33.84$, $SD = 8.34$) groups. Of the 91 participants who responded when asked their gender, there was no significant difference between the Control (Men = 27, Women = 3), Circle (Men = 22, Women = 6), and Decay (Men = 26, Women = 7) groups. Of the 91 participants who responded when asked how long they have served as a police officer, there was no significant difference between Control ($M = 8.1$ years), Circle ($M = 10.0$ years), and Decay ($M = 9.5$ years) groups.

To ensure officers did not have extensive prior knowledge of geographic profiling methods, they were asked to rate their familiarity with geographic profiling methods on a five-point scale ranging from 1 (very poor) to 5 (very good). None of the officers in any of the conditions felt that they had “very good” knowledge of geographic profiling, and only one officer, who happened to be in the Control group, felt he had “good” knowledge. Twenty of the officers rated their knowledge as “fair,” while the rest of the officers ($n = 70$) rated their knowledge as “poor” or “very poor.”

Materials

The maps used in the current study were randomly selected from a larger database of solved serial burglaries committed in St. John's, Newfoundland, Canada.[5] The maps were copied from MapInfo to a sheet of A4 paper (map size = 297 mm x 210 mm) and were presented in black and white. Half of the maps were presented with topographical information. One third of the maps presented three burglary locations, another third five burglary locations, with the last third displaying seven burglary locations. The maps were incorporated into a booklet that had two parts. The first half of the booklet contained, in order, on separate pages: (a) an informed consent form, (b) a questionnaire asking for demographic information, and (c) the first set of 18 maps in random order. The second half of the booklet contained: (a) heuristic training material for the experimental groups that consisted of the *Circle* or *Decay* heuristic (those in the Control group were simply instructed to continue on with the next set of maps), (b) another set of 18 maps in random order, and (c) a debriefing form. For each of the 36 maps, the participants were instructed to predict, by marking an X, where they thought the offender was most likely to live.

The same 36 maps were analyzed by the geographic profiling tool in *CrimeStat*, which is a National Institute of Justice funded spatial statistics program that has been made freely available to users (Levine & Associates, 2004). *CrimeStat* allows for five distance decay functions to be used to predict home locations. We arbitrarily used a negative exponential function because previous research has demonstrated that there are no significant differences in

[5]Although there is no other alternative in research of this type, it should be stressed that the reliance on solved crimes does potentially limit the generalizability of our findings, since solved and unsolved serial burglaries may be characterized by different geographic patterns. For example, as Maguire (1982) suggested, a marauding pattern of spatial behaviour may be more typical in solved crimes, which would allow them to be more easily profiled. Unfortunately, there is no way of testing whether these differences exist, because the location of the offender's home must be known for such a determination to be made.

predictive accuracy between the different functions (Levine & Associates, 2004; Snook, Zito, et al., 2005; Taylor, Bennell, & Snook, 2002). The negative exponential function assumes that the probability of locating an offender's residence decreases with increasing distance from an offense. This decrease occurs at an exponential rate, declining rapidly near the crime site until the likelihood of locating the offender's residence approaches zero (Snook, Zito, et al., 2005). In *CrimeStat,* a grid is superimposed over the total map area and a recursive algorithm is used to compute the straight-line distance between each cell and the crime locations. For every cell, a negative exponential function is applied to these distances, which are then summed to produce an overall score. This is then transformed into a probability and the home location is identified as the cell with the highest probability.

Procedure

The testing sessions were run with as little as eight participants to as many as 34 participants at any one time. The police officers completed all phases of the experiment in an officer training room. They were informed that they would be making predictions about the likely home location of 36 serial burglars. Officers were asked to work individually through the booklet at their own pace. They were instructed to finish each map before moving onto the next and were asked not to change any of their answers. The fifth author remained in the training room throughout the experiment to answer any questions and ensure that the task was completed individually. Completion of all tasks in the booklet took approximately 35 minutes. The predictive accuracy, or error distance, for both the participants and *CrimeStat* was measured by hand after the experimental sessions. Consistent with previous research (e.g., Snook et al., 2002, 2004), error distance was defined as the straight-line distance (in millimeters) between the predicted and actual home location. A larger error distance indicates a less accurate prediction.

Design

A 3 (control x circle x decay) by 3 (three crimes x five crimes x seven crimes) by 2 (topography x no topography) by 2 (baseline x re-test) mixed design, with counterbalancing of the within-subject variables, was used to examine predictive accuracy amongst the participants. The within-subject variables were the number of *crimes* on the map, whether or not *topography* was provided, and the *phase* of the experiment where predictions were being made. The between-subject variable was the participant's *group*. The dependent variable was *error distance*. In addition to this analysis, a series of one-sample t-tests were conducted to compare the performance of the participants to *CrimeStat*.

Results

The effect of training

Figure 1 shows the mean error distances for predictions made before and after training for the three groups, and the mean error distances for *CrimeStat*. Overall, predictive accuracy across the three groups improved from baseline to re-test, as indicated by a significant main effect for phase, $F\ (1, 88) = 21.03$, $p < .001$. However, a significant two-way interaction was also found between phase and group, $F\ (2, 88) = 4.43$, $p < .05$. This interaction occurs because the decrease in mean error distance from baseline to re-test was not of the same magnitude across the groups. More specifically, the change in mean error distance for the Control group from baseline (M = 39.56 mm, SD = 5.85) to re-test (M = 38.91 mm, SD = 5.92) does not represent a significant decrease. In contrast, the decrease in mean error distance for the Circle group is significant from baseline (M = 38.65 mm, SD = 4.53) to re-test (M = 35.53 mm, SD = 1.56), $t = 3.74$, $df = 27$, $p < .001$, as is the decrease for the Decay group from baseline (M = 40.92 mm, SD = 8.39) to re-test (M = 35.48 mm, SD = 1.68), $t = 3.79$, $df = 32$, $p < .001$. The between-subject comparisons showed there was no significant overall effect of group.

[Insert Figure 1 about here]

Participants versus CrimeStat

As illustrated in Figure 1, a number of surprising results emerge when comparing the performance of participants to *CrimeStat* at baseline and re-test. At baseline, there were no significant differences found between *CrimeStat* (M = 37.70 mm, SD = 28.48) and the Control (M = 39.56 mm, SD = 5.85) or Circle group (M = 38.65 mm, SD = 4.53). However, *CrimeStat* performed significantly better than the Decay group (M = 40.92 mm, SD = 8.39; t = 2.21, df = 32, p < .05). At re-test, there was still no significant difference found between *CrimeStat* and the Control group (M = 38.19 mm, SD = 5.92). However, at re-test, *CrimeStat* performed significantly worse than the Circle (M = 35.53 mm, SD = 1.56; t = 7.34, df = 27, p < .001) and Decay groups (M = 35.48 mm, SD = 1.68; t = 7.55, df = 32, p < .001). No significant differences were found in the performance of *CrimeStat* across maps consisting of three (M = 43.83, SD = 8.60), five (M = 34.00 mm, SD = 13.33) or seven crimes (M = 34.00, SD = 13.95).

The effect of number of crimes

Figure 2 shows the mean error distances for the three groups across maps consisting of three, five, or seven crimes, at baseline and re-test. As evident in this figure, a significant main effect was found for crimes, F (2, 176) = 221.5, p < .01, with officers having a significantly lower error distance on maps containing five crimes (M = 31.69 mm, SD = 5.38) compared to either three (M = 43.05 mm, SD = 3.99; t = 22.06, df = 90, p < .001) or seven crimes (M = 39.86 mm, SD = 6.24; t = 14.41, df = 90, p < .001). A significant two-way interaction between crimes and phase was also found, F (2, 176) = 3.47, p < .05, indicating that the change in error distance across phases varied depending on whether the maps consisted of three, five, or seven crimes. In this case, the decrease in error distance was smallest, but still significant, in the three crime condition from baseline ($M = 44.02$ mm, $SD = 6.63$) to re-test ($M = 42.09$ mm, $SD = 3.78$; $t = 2.54$, $df = 90$, $p < .05$), slightly larger in the five crime condition from baseline ($M = 33.15$ mm, $SD = 7.91$) to re-test ($M = 30.24$ mm, $SD = 5.03$; $t = 3.57$, $df = 90$, $p < .01$), and largest in the seven crime condition from baseline ($M = 42.16$ mm, $SD = 9.64$) to re-test ($M = 37.56$ mm, $SD = 6.68$; $t = 4.02$, $df = 90$, $p < .001$). No other interaction effects were significant.

[Insert Figure 2 about here]

The effect of topography

Figure 3 shows the mean error distances for the three groups across maps consisting of topographical or no topographical details, at baseline and re-test. A significant main effect for topography was not found, nor were there any significant interaction effects.

[Insert Figure 3 about here]

Discussion

A number of recent studies have examined the ability of individuals to predict where an offender lives from information about their crime locations. The current study focused on extending the validity of these previous studies in three ways. One development was in the use of experienced police officers rather than University students as participants. This provided an opportunity to verify that the conclusions of previous student-based studies apply to those individuals who are most likely to produce and use geographic profiles. It also enabled the study to investigate whether experience in policing had an effect on profiling performance. The second development was to provide participants with additional information about the crime series, which is something that professional profilers often highlight as critical to the profiling task (Rossmo, 2000). Specifically, this study examined the effect of changing information quantity, by varying the number of crime sites shown, and information quality, by altering whether or not the participants saw topographical information. Finally, in an effort to increase the generality of previous findings, this study tested individuals' ability to predict the home location of serial burglars rather than serial murderers. This change in crime type was predicted to be consequential given recent suggestions that the prevalence of marauding behavior for burglars is lower than serial murderers (Goodwill & Alison, 2005; Kocsis & Irwin, 1997; Kocsis et al., 2002; Meaney, 2004).

Simple heuristics for a simple task

The results of this study show that police officers are able to accurately predict an offender's home location, with their performance matching that observed in previous studies of the geographic profiling task. Even without any training, many police officers made predictions that were as accurate as those provided by a computerized geographic profiling system. In the pre-training phase, participants in the Control and Circle groups (but not the Decay group) made predictions that did not significantly differ in accuracy from the predictions of *CrimeStat*. The evident ability of police officers to make accurate predictions prior to training is consistent with previous research (Snook et al., 2004), and suggests that officers, like students, may have available implicit knowledge (e.g., heuristics) that they apply to the crime locations.[6] However, the range of observed predictions suggests that these heuristics are not universally available before training. Some participants are either unaware of heuristics that allow others to make accurate predictions, or they favor a different, inappropriate heuristic. The result of not using an appropriate heuristic, or not having one available, is worse performance, as this study observed in the Decay group before training.

Perhaps more important from a policing perspective is the finding that brief training on either the *Circle* or *Decay* heuristic was sufficient to increase officers' predictive accuracy. The introduction of heuristics in this manner had a remarkable impact on officers' performances. Both groups achieved an average accuracy that was better than the accuracy of computationally expensive methods. This finding underlines the value of briefly exposing individuals to simple heuristics, and supports Snook et al.'s (2002, 2004) suggestion that these two cognitive heuristics are effective for this particular real-world prediction task. More generally, the capacity of the heuristics to work with those who do and do not have a background in policing, combined with the observation that individuals complete the profiling task rapidly and without deliberation, places question marks around the assertion that complex and detailed knowledge of offender behavior is needed to perform well on this task. The prediction of an offender's home location may be quite a simple task that requires only the application of an often-known, simple to teach, decision strategy.

The finding that participants trained in the *Circle* and *Decay* heuristics had better, as opposed to equal, predictive accuracy when compared to the computerized system is not

[6]Interestingly, experience in policing (including the various training that police officers undergo) does not appear to enhance pre-training performance on this task. University students

consistent with previous research. One likely explanation for this finding comes from the strict basis on which geographic profiling systems make their predictions. The algorithm we used adheres to the assumption that the probability of locating an offender's home location decreases with increasing distance from the crime locations. As a result, they reliably predict that offenders live central to their crimes, which on most occasions turns out to be correct. In contrast, participants tend to locate the approximate center of a distribution of crimes that they consider "good enough".[7] While this strategy has allowed participants to perform as well as geographic profiling systems in previous studies, it turned out to be a particularly effective strategy in the current study. This is almost certainly because marauding behavior is less prevalent amongst property offenders than it is amongst the interpersonal offenders that we have examined in previous studies (Goodwill & Alison, 2005; Kocsis et al., 1997, 2002; Meaney, 2004). This finding suggests that the *Circle* and *Decay* heuristics are potentially more robust than the more computationally expensive algorithms employed by geographic profiling systems when dealing with serial burglars who do not strictly meet the assumptions underlying geographic profiling.

Why is it that property offenders often exhibit a higher rate of commuting behaviour compared to interpersonal offenders? Potential answers to this question might come from environmental criminology, where crime is thought to occur at locations where motivated offenders encounter criminal opportunities in environments with low levels of associated risk (Brantingham & Brantingham, 1981). Although motivational level may be constant across offender types, factors related to opportunity and risk will vary, and this would likely result in

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participating in a different study performed as well these police officers during the pre-training phase when they were exposed to the maps used in the current study (Wilkinson, 2004).

[7] It may also be the case, as one anonymous reviewer suggested, that police officers (or human decision-makers more generally) consciously or unconsciously ignore spatial outliers, whereas

different spatial patterns when offenders commit their crimes. For example, the fact that serial burglars exhibit more commuting behavior than serial murderers is likely due in part to the fact that their targets are immobile. As Goodwill and Alison (2005) note, a burglar can locate potential targets while committing a crime by observing other dwellings in the area and, therefore, he can travel into the same area to commit more crimes in the future. Serial murderers, on the other hand, may observe other targets while offending, however, it is less likely that these potential victims will be in the same place for long. In addition, the level of perceived risk associated with committing crimes in the same geographic area will likely have an impact on whether an offender exhibits commuting or marauding behavior (Goodwill & Alison, 2005). Serial burglars appear largely unaffected by the risks associated with committing multiple offenses in close proximity to one another, and therefore they would not be dissuaded from repeatedly commuting into the same area to commit their crimes (Clarke & Hope, 1984). The same would not be true of serial murderers, given the attention their crimes receive. They would typically have to exhibit marauding behavior in order to avoid detection.

The effect of more information

The results of this study provide only mixed support for the assertion that effective geographic profiling requires the use of a range of different crime information (Rossmo, 2005). On the one hand, performance was found to vary according to the number of crime locations that participants observed on a map. Participants consistently made more accurate predictions on maps consisting of five crime locations than maps consisting of three or seven crimes and this effect was magnified after participants were trained in heuristics. On the other hand, there were no significant differences in the performance of participants presented and not presented with

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computerized systems force the profile to fit every point. While we could not locate any evidence topographical information. The availability of topographical information slightly improved performance in some conditions and slightly decreased performance in other conditions, but there was no systematic pattern to these variations and they were not significant.

These findings go against the arguments put forward by professional profilers about the need for information. For example, Rossmo (2005) suggests that geographic profilers are most effective when information about five or more crime locations is available, and that accuracy will increase as additional crime locations are incorporated into the prediction. Our analysis of *CrimeStat's* performance across maps with varying numbers of crimes does not support this assumption. In addition, while the findings of this study show an increase in participant performance from three to five crimes, this increase vanishes when making predictions from seven crimes. Thus, the improvement in accuracy found with five crime locations is not evidence of a large positive correlation between the number of crime locations and predictive accuracy. It is instead a localized improvement in performance that does not increase as more crime locations are added to the information used to make a prediction.

There are a number of explanations for this more nuanced change in performance over number of crimes. One relates to the possibility that performance on the geographic task is characterized by an inverted-U, with three crimes not providing participants with enough information to derive accurate predictions, and seven crime locations overwhelming participants with too much information. Such an explanation would be consistent with evidence of information overload in other areas of social science (e.g., Eppler & Mengis, 2004; Jacoby et al., 1974).

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to support or reject this possibility, it may help to explain this result.

However, a second, more likely explanation comes from examining the relationship between where the offender lived and where they committed their crimes for each of the maps. For those maps consisting of five crime locations, offenders happened to live within the general area covered by their criminal activity (this occurred for five out of the six maps containing five crime locations). This pattern occurred less often in the three and seven crime conditions (on three out of six maps and four out of six maps, respectively). Future research is required to determine whether this pattern is unique to the offender's examined in this study or whether it is one that can be found more generally. While it could simply be a random event, such a pattern could also reflect a decision-making process on the part of offenders, whereby they shift their movements in space at regular intervals to maximize potential gains (e.g., exploiting valuable new targets) while minimizing potential risks (e.g., being recognized in an area). Regardless of how common this finding is, it provides support for the idea that the most critical factor that will determine the success of prediction strategies in the geographic profiling task is the degree to which the strategies match the pattern of serial offender spatial behavior.

The finding that topographical detail has no impact on performance is also not consistent with the importance placed on this information by geographic profilers (e.g., Rossmo, 2000). There are three potential explanations for this finding. First, it could be the case that topographical information is simply not as important as profilers have previously argued. Indeed, it may be that the quantitative prediction made by geographic profiling systems cannot be improved by considering features of the environment, such as topography. Second, it may be that topographical details are important for constructing accurate profiles but the limited topographical information we provided to our participants in this study was not sufficient for it to have a significant impact. Expert profilers may utilize very specific aspects of topographical information that were not available in the general maps provided in this study (such as land use indicators) or they may combine this information with other unavailable behavioral information (such as the value of the property stolen) when making their prediction. Finally, it could be argued that topographical information is important, and that adequate details were provided to participants in this study, but that they lacked the knowledge or skills that are needed to apply this information effectively.

Conclusion

The current findings are encouraging because police officers made significant improvements in their predictive accuracy on a more representative geographic profiling task compared to previous studies. This finding supports earlier geographic profiling experiments, which suggest that police agencies without access to professional geographic profiling services may be able to suffice with a fast and frugal training exercise that teaches their officers simple decision rules. The results also extend that conclusion by showing that police officers may not need to take the number of crimes or topographical details into consideration when trying to predict the home location of serial offenders. In the end, it may be that geographic profiling is no riddle, police officers can simply choose the middle!

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Figure Captions

Figure 1. Mean error distances (mm) after baseline and re-test for the Control, Circle, and Decay groups, as well as *CrimeStat*.

Figure 2. Mean error distance (mm) at baseline and re-test for maps consisting of three, five, and seven crimes.

Figure 3. Mean error distance (mm) at baseline and re-test for maps with and without topographical detail.

Figure 1

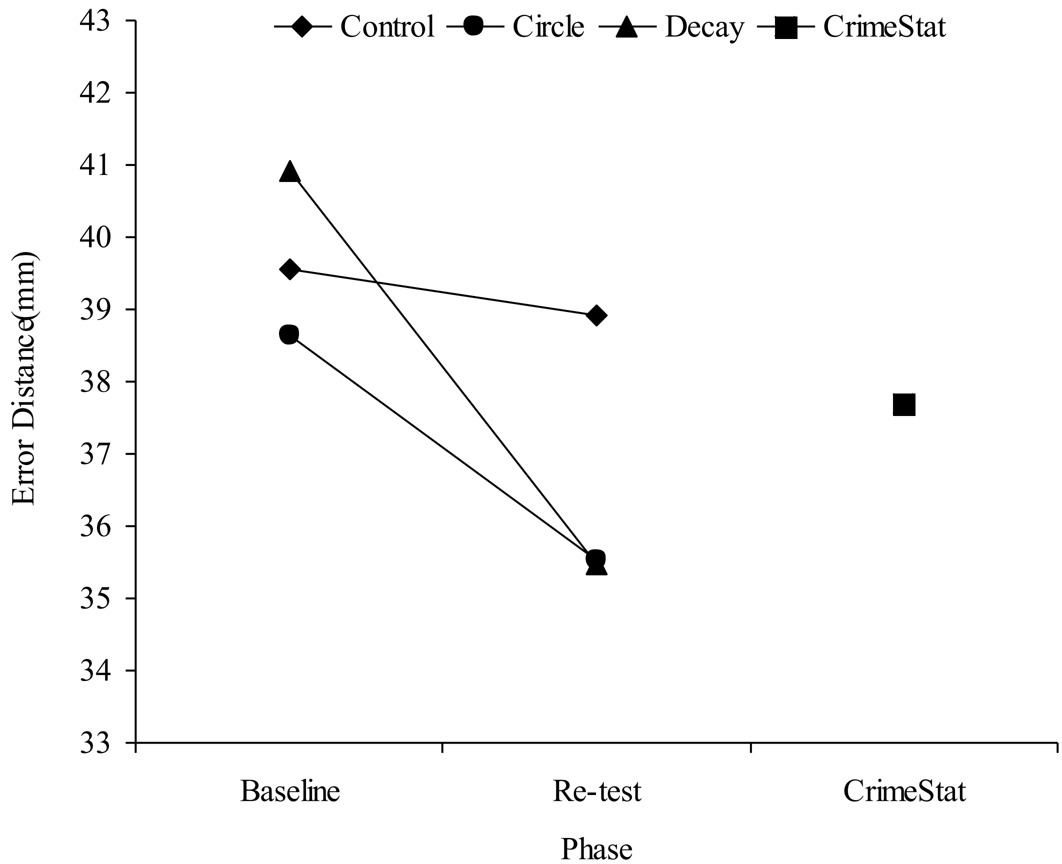
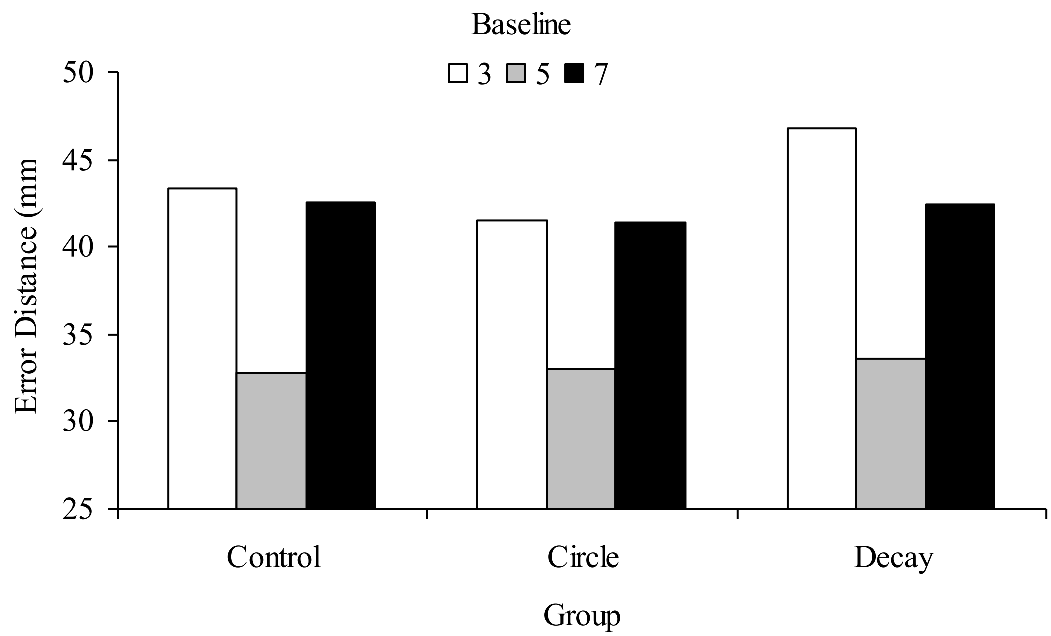

Control
Circle
Decay
CrimeStat
43
42
41
40
39
38
37
36
35
34
33
Error Distance (mm)
Baseline
Re-test
CrimeStat
Phase

Figure 2


Baseline
3
5
7
50
45
40
35
30
25
Error Distance (mm
Control
Circle
Decay
Group

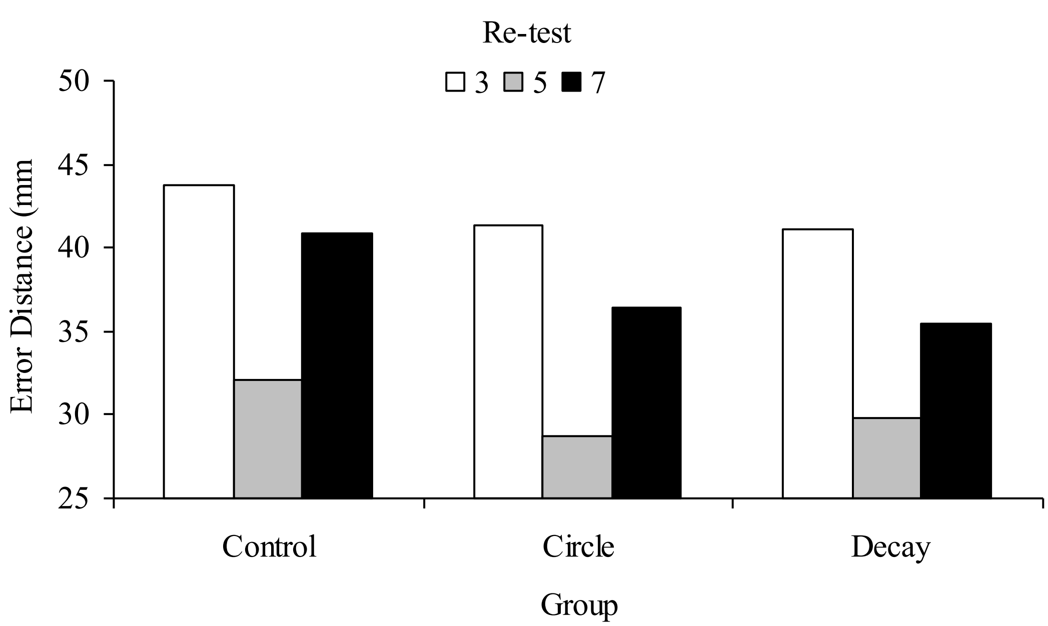
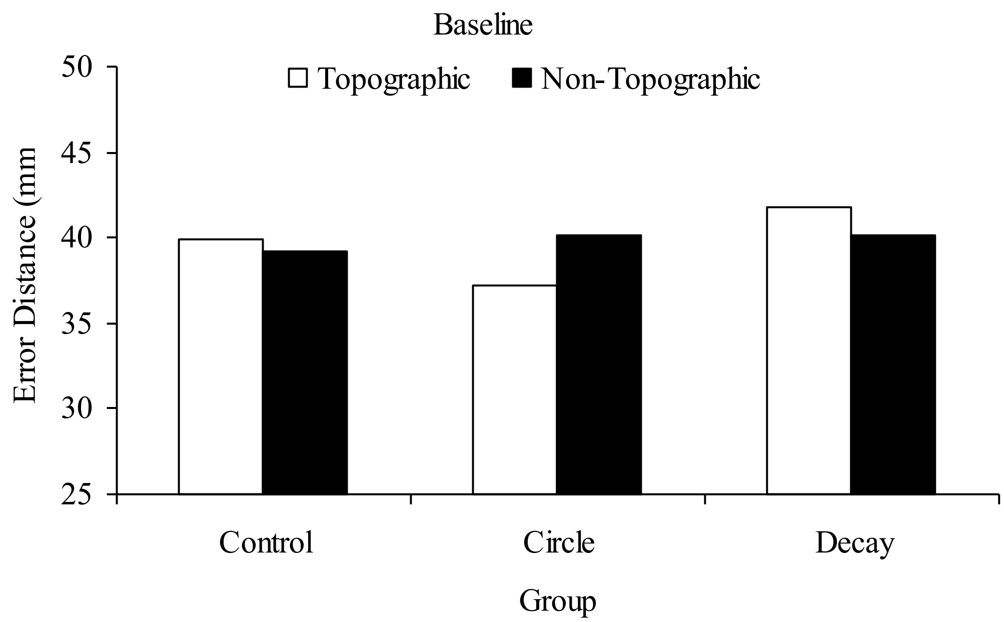
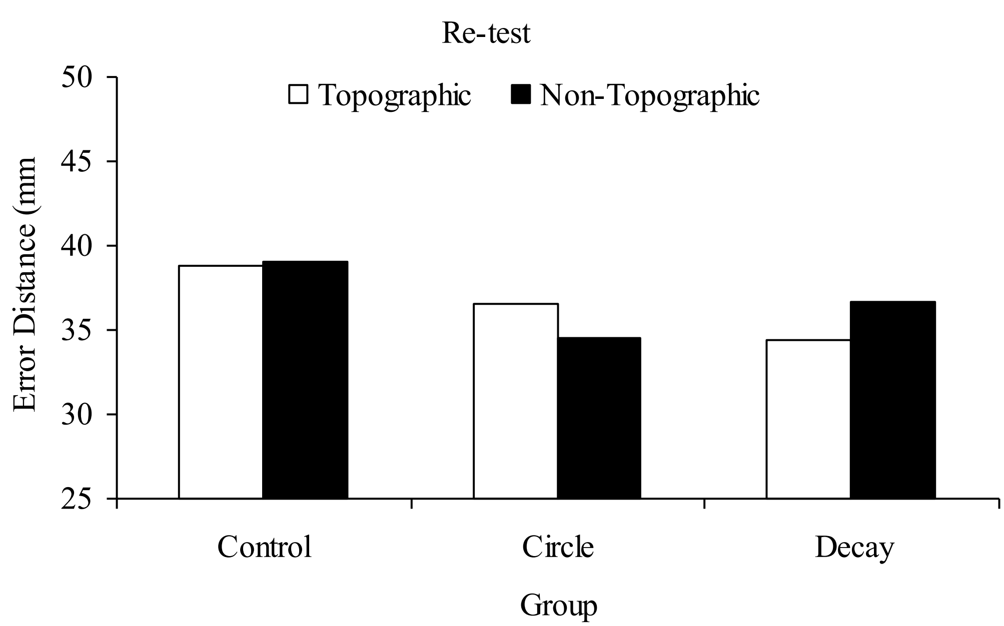

Re-test
3
5
7
50
45
40
35
30
25
Error Distance (mm
Control
Circle
Decay
Group

Figure 3


Baseline
Topographic
Non-Topographic
Error Distance (mm
50
45
40
35
30
25
Control
Circle
Decay
Group


Re-test
Topographic
Non-Topographic
Error Distance (mm
50
45
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Control
Circle
Decay
Group