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Clinical Versus Actuarial Geographic Profiling Strategies: A Review of the Research

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Abstract

Geographic profiling predictions can be produced using a variety of strategies. Some predictions are made using an equation or mechanical aid (actuarial strategy) while others are made by human judges drawing on experience or heuristic principles (clinical strategy). We review research that bears directly on the issue of whether clinical strategies can produce geographic predictions that rival those produced by actuarial strategies. Although there are certain advantages associated with actuarial strategies, we argue that clinical predictions based on fast and frugal heuristics are useful. We support this argument with results from a meta-analysis of existing geographic profiling research. We conclude by outlining our position on the relative merits of clinical and actuarial strategies, and by proposing an agenda for future research that involves examining the relative performance of profiling strategies in operational settings.

Key words: actuarial, decision aids, geographic profiling, heuristics, meta-analysis, serial crime

Clinical Versus Actuarial Geographic Profiling Strategies: A Review of the Research

In 2000, Brent Snook delivered a paper at the 4th Annual Crime Mapping Conference in San Diego, California where he presented evidence suggesting that predictions made by students using simple heuristics were often as accurate as those produced by a computerized (i.e., actuarial) geographic profiling (GP) system. His findings have led to a debate about the relative merits of human (clinical) and actuarial strategies for GP. This debate has taken place on newsgroups, at conferences, in trade magazines, and in peer-reviewed academic journals. Since Snook's original presentation, this research has also caught the attention of a wider judgment and decision-making audience (e.g., Gigerenzer & Brighton, in press; Katsikopoulos, Pachur, Machery, & Wallin, 2006). The purpose of this paper is to: (1) review the debate and the related literature, (2) provide new analyses that shed light on the debate, (3) clarify our position on this topic, and (4) outline a research agenda that can resolve some of the remaining controversial issues.

The Geographic Profiling Debate

Simple Heuristics: Geographic Profiling the Fast and Frugal Way

Snook's (2000) conference presentation was subsequently published by Snook and his colleagues (2002). They compared the performance of students with an actuarial strategy on a GP task that required predictions of offenders' home locations based on the distribution of five crime locations (participants were asked to mark an "X" on maps where they thought each serial offender resided). Half of the participants received training on how to improve their predictions, while the other half received no training. Specifically, trained participants were introduced to two consistent observations about serial offenders' spatial behavior – the *decay heuristic* (that many serial offenders live near their crime locations; Rengert, Piquero, & Jones, 1999) and the *circle heuristic* (that many serial offenders live within a circle whose diameter is the distance between their two furthermost crime locations; Canter & Larkin, 1993). Participant performance was assessed using *error distance* (i.e., the straight-line distance on a map between the predicted home location and the actual home location). By comparing performance before and after training, Snook et al. demonstrated that trained participants were able to use these two GP principles to improve their predictive accuracy. More importantly, the participants' performance was found to be comparable to an actuarial system known as *Dragnet* (Canter, Coffey, Huntley, & Missen, 2000), when *Dragnet's* performance was also measured using error distance (i.e., the distance between the point of highest probability and the offender's actual home location).[1]

The results reported by Snook et al. (2002) were surprising. One might expect that participants provided with simple, well-established GP principles might improve their performance, but not to the extent that they perform as well as a GP system. Throughout the decade leading up to Snook et al.'s study, research on GP had largely assumed that actuarial methods were an essential way of supporting investigators' decisions (e.g., Canter & Gregory, 1994). This finding seemed to challenge that notion, suggesting that individuals were able to use simple mental rules to make accurate predictions. In trying to understand this result, we discovered research showing that simple heuristics can perform as well as complex computational techniques (e.g., Gigerenzer, Todd, & the ABC Research Group, 1999).

[1] *Dragnet* allows the user to select a distance decay function from a large number of decay functions. In the study by Snook et al. (2002), the negative exponential function identified as optimal by Canter et al. (2000) was used. It is of course possible that the results reported by Snook et al. (2002) would have been different if a different decay function had been selected. As discussed in more detail later, some have argued that the results in this study are also influenced by our decision to use error distance to determine the accuracy of *Dragnet*. The algorithms used in most GP systems, including *Dragnet*, produce probability surfaces that resemble colored topographic maps. Reducing this probability surface to a single point prediction has been cited as the most significant problem with our research (Rossmo, 2005). See Snook, Taylor, and Bennell (2005) and Levine (2005) for counter-arguments.

Specifically, this research demonstrates that heuristics work well when they match the structure of the decision environment (i.e., ecologically rational heuristics; Gigerenzer & Selton, 2001). Thus, if people utilize a heuristic (e.g., search for crime locations that are farthest apart and predict that the offender lives at a midway point) that matches the patterns found in serial offender behavior (e.g., most serial offenders live within their criminal activity space), they are likely to perform well on the GP task.

Armed with knowledge of this research, Snook, Taylor, and Bennell (2004) considered explicitly the role of heuristics in clinical strategies for GP. By examining individuals' explanations of how they reached their predictions before and after training, Snook et al. found that a substantial portion of people utilized "appropriate" heuristics even before training, while others only did so when given instructions about how to make GP predictions. Specifically, the Snook et al. (2004) experiment required individuals to make predictions on a set of maps (each consisting of three crime locations of a different serial offender) while stating how they made each prediction. After this task, one third of the participants received training on the circle heuristic, another third received training on the decay heuristic, and the last third were not trained. Every participant then made predictions again on the same set of maps. Snook et al.'s (2004) results showed that approximately 50% of participants used ecologically rational heuristics even before they received training. Moreover, providing participants with training on either the circle *or* decay heuristic allowed those participants who did not use ecologically rational heuristics to significantly improve their performance as indicated by a reduced error distance. These participants, along with those that were originally using ecologically rational heuristics, made predictions that were as accurate as one of the actuarial GP strategies in

CrimeStat (Levine & Associates, 2000).[2] Some participants even made predictions that were more accurate than this actuarial strategy.

Rossmo Responds: The Other Side of the Debate

While the two studies just reviewed suggest that clinical strategies for GP hold merit, this view is not accepted by all. Kim Rossmo, one of the original developers of GP systems, has voiced the most concern over these studies. In response to Snook et al.'s (2004) article, Rossmo (2005) highlighted the following criticisms:

(1) The data selected for analysis does not meet the GP assumptions outlined by Rossmo (2000), which include the fact that GP works best when the crimes are committed by a single offender, no movement of residence has taken place during the crimes series, the offender is not a commuter, and the victim backcloth is uniformly distributed around the offender's anchor point.

(2) The number of crimes used to make GP predictions was lower than what Rossmo (2000) recommends (i.e., some of the maps used in previous studies included only three crimes, whereas Rossmo recommends five or more crimes).

(3) Performance was measured using error distance rather than an area-based measure such as *hit percentage*, which more closely reflects how GP systems work (area-based measures of accuracy involve rank ordering the locations where an offender could live [e.g., based on probabilities assigned by the actuarial system] and calculating the percentage of the area that needs to be searched before finding the offender's anchor point).

In a different forum, Rossmo and Filer (2005) highlighted additional concerns about the Snook et al. studies and their conclusions:

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[2] *CrimeStat*, another actuarial system, is more flexible than *Dragnet*. For example, it allows the user to choose from a wide variety of decay functions and to adjust these functions by calibrating them to solved samples of offences. Snook et al. (2004) used the same negative exponential function as Snook et al. (2002).

(4) Because Snook, Taylor, and Bennell have no experience as police officers, investigators, or geographic profilers, the credibility of the advice emerging from their studies is questionable.

(5) The use of students as participants means the results cannot be generalized to “real-world” investigative settings.

(6) The predictions considered in the experiments fail to incorporate information that is routinely used by professional geographic profilers (e.g., arterial routes), thereby making the results invalid.

(7) The studies do not compare participants’ performance to commonly used GP systems.

Responses to These Criticisms: More Support for Simple Heuristics

We have addressed many of the conceptual and methodological aspects of these criticisms in previous articles (e.g., Snook et al., 2005). Rather than reiterate these arguments here, we instead focus on the results from recent published studies that have dealt with issues raised by these criticisms. Two studies in particular warrant attention.

The first of the two studies, published by Paulsen (2006), deals with criticisms (2), (3) and (7). This study examined the accuracy of GP procedures across a range of crime types by determining whether simple actuarial strategies and clinical judgments are as accurate as complex actuarial strategies. Importantly, in Paulsen’s study, the number of crimes in a series all exceeded Rossmo’s (2000) minimum recommendation of five crimes, profile accuracy was measured in multiple ways,[3] and the procedures that were tested included commonly used complex actuarial systems, such as *Rigel Analyst*. Using a random sample of solved serial

[3] In addition to error distance, Paulsen (2006) employed three other accuracy measures: (1) a dichotomous determination as to whether the home location of the offender was within the top profile area (defined as a search point-centered, 1-mile diameter circle for the simple actuarial strategies and human participants), (2) the distance between the actual home location of the offender and the nearest part of the top profile area, and (3) the degree to which the criminal offence area of the offender was reduced by the final profile.

crimes, Paulsen reported that simple actuarial strategies and clinical predictions were as accurate as predictions made by complex actuarial methods. This was found regardless of the way profile accuracy was measured and regardless of the length of the crime series under consideration.

The second study that investigated Rossmo's (2005a) criticisms is an article by Bennell, Snook, Taylor, Corey, and Keyton (2007), which dealt with criticisms (2), (5) and (6). This study examined the effect of the number of crimes and topographical detail on police officers' 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 serial burglar lived. After making their predictions on half of the maps, officers randomly received either no training or training on the decay or circle heuristic. Performance at baseline and retest were measured using error distance, and then compared to predictions produced using *CrimeStat* (implemented in the same manner described above). Results showed that training significantly improved predictive accuracy, regardless of the number of crime locations or topographical detail presented. In addition, the trained officers substantially outperformed *CrimeStat*.

The Current Status of Empirical Evidence

The results emerging from these two studies are consistent with results from the Snook et al. studies. To assess the overall body of evidence produced by the combination of these studies, we conducted a meta-analysis. Our aim in conducting this analysis was to determine, in statistical terms, the extent to which training improves performance on the GP task and whether clinical strategies perform as well as actuarial GP strategies. Eligible studies for the analysis were those that:

(1) Used an experimental scenario (i.e., contained an independent variable) in which both the crime locations and home location were known to the experimenter.

(2) Compared the predictive accuracy of a trained participant group to a comparison group of untrained participants, an actuarial GP system, or both.

(3) Reported information regarding the relationship between the predicting group and the accuracy of prediction in a form that could be converted into a common effect size (*r*).

A search of the published and unpublished GP literature revealed 7 potential studies, of which 6 met the above criteria (Bennell et al., 2007; Paulsen, 2006;[4] Snook et al., 2002; Snook et al. 2004; Snook, Ennis, Bennell, Johnson, Taylor, & Campbell, 2006; Taylor, Bennell, & Snook, 2007). The excluded study (van der Kemp, van Ruth, Blokland, & Snook, 2005) did not provide adequate statistical information.

Pearson correlation coefficients (*r*) were calculated across the relevant groups for each accuracy measure. When statistics other than *r* were reported in a study (e.g., *t*), the appropriate formulae were used to convert them to *r* values (Rosenthal, 1991). Effect size (ES) magnitudes were assessed by examining the mean *r* values and their respective 95% confidence intervals (*CI*s) for each outcome. Results were also assessed using Rosenthal and Rubin's (1982) Binomial Effect Size Display (BESD). This statistic allows one to examine changes in success rates that are attributable to the predictor variable, assuming a base rate of 50%. To illustrate how BESDs can be interpreted in the present context, a value of $r = -.30$ would translate into a 30% difference in predictive ability between experimental (e.g., human predictions, 65%) and comparison groups (e.g., actuarial systems, 35%).

[4] While Paulsen's (2006) publication did not provide adequate statitical information related to his accuracy measures he was able to provide the authors with the neccesary information for error distance. Unfortunately, statistical information related to the other measures used by Paulsen was unavailable.

Results of the Meta-Analysis

Table 1 contains the meta-analytic results. In relation to the effect of heuristic training (Bennell et al., 2007; Snook et al., 2002; Snook et al., 2004), 14 ESs sampled from 826 participants in predicting offender home locations indicated that training produces significantly more accurate predictions (r = .27, SD = .15, 95% CI = .18 to .36). In terms of the BESD, the accuracy rate of trained participants was 63.5%, which compares with a 36.5% accuracy rate for untrained participants. For the trained participant-actuarial system comparison (Bennell et al., 2007; Paulsen, 2006; Snook et al., 2002; Snook et al., 2004; Snook et al., 2006; Taylor et al., 2007), 29 ESs sampled from 1005 participants indicated that trained participants and actuarial strategies produce predictions that are almost equally accurate (r = -.01 , SD = .39, CI = -.16 to .14).[5] In terms of the BESD, the accuracy rate of human predictions was 50.5% compared to 49.5% for actuarial methods.

Our Position in the Geographic Profiling Debate

Having now had ample opportunity to reflect on the ongoing GP debate, we believe it is reasonable to draw seven tentative conclusions:

(1) Many people have access to GP strategies that allow them to make relatively accurate GP predictions, although it is currently unclear where these heuristics come from.

(2) Exposing people to ecologically rational GP strategies improves their performance, regardless of whether people are exposed to single or multiple heuristics.

(3) Heuristic training does not allow everyone to perform equally well. This is likely due to one of any number of factors, including inadequate training delivered by the experimenters,

[5] Of these 29 ESs, 21 relate to error distance (r = -.12, SD = .36, 95% CI = -.29 to .04), four relate to an area-based measure of accuracy calculated from uniform search strategies (r = .50, SD = .09, 95% CI = .36. to .63), and four relate to an area-based measure of accuracy calculated

confusion on the part of some participants as to how to apply the heuristics, a lack of sustained effort when participants make predictions, etc.

(4) Heuristic training often allows people to perform as well as a range of actuarial GP strategies.

(5) The above conclusions appear to hold true even when predictions are based on different numbers and types of crimes, and different processing conditions, such as when topographic information is made available.

(6) When people perform poorly as a group on the GP task, GP systems also perform poorly, and this tends to occur when standard GP principles do not apply (e.g., in cases where the offender commutes into the area where they commit their crimes).

(7) In some circumstances, specifically when making predictions about serial burglars, clinical judgments can outperform actuarial strategies. This appears to be due to the fact that GP systems rigidly adhere to GP principles in situations where a more relaxed application (such as shown by human participants) is better suited to the actual pattern of offender behavior.

So, what can be said if these conclusions are correct? We believe the research we have reviewed suggests that heuristics are a viable alternative to complex actuarial strategies, and that the use of such heuristics may allow police officers themselves to generate geographic profiles that can aid their investigation. Where actuarial strategies are difficult to implement (e.g., for financial or technological reasons), this is an important finding.[6] For example, if a police agency in a developing country faces problems with serial offending, but does not have the capacity to implement an actuarial GP system, then a clinical strategy would allow these agencies to make relatively accurate predictions. How about in agencies where there are no restrictions (i.e.,

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from directed (i.e., irregularly shaped) search strategies (r = .06, SD = .34, 95% CI = -.48 to .60). For more details of these area-based measures please contact the authors.

[6] The cost of GP systems currently ranges from no charge through to $60,000 (Rich & Shively, 2004).

agencies that have a choice between clinical and actuarial strategies for GP)? What should these agencies take away from research in this area? This is a difficult question to answer based on the research that is currently available. However, what is clear is that, even if the above conclusions are accepted as valid, there remain several advantages to using actuarial GP systems.

One obvious advantage is that analyses performed by actuarial systems will always be more reliable than human predictions.[7] Better training may decrease the variance exhibited by human participants, but it will never be possible to reduce this variance to a level that matches an actuarial system. This may not be a crucial issue for a police agency relying on the advice of a crime analyst who can implement the sorts of principles we have used in our training, but the result could be disastrous if the agency relies on an analyst who cannot, or does not, implement the training appropriately. A second advantage is that actuarial GP strategies may allow the user to avoid the *cognitive overload* that is likely to exist when he or she is inundated with investigative information (Rossmo, 2006). For example, actuarial methods can communicate with other databases (e.g., databases that track previous convictions) in order to more efficiently manage investigative information and prioritize suspects (Rossmo, 2000). This is something that our trained participants may have serious difficulty doing.

Despite these (and potentially other) advantages, we feel it is important to emphasize that, even if investigators had a desire to use actuarial GP techniques, it is still not clear that complex actuarial strategies are fully justified. Since they are not susceptible to variability, we believe that simple actuarial techniques (e.g., centroids) may be useful. Indeed, the results of previous research clearly indicate that these types of strategies hold promise (Levine & Associates, 2000; Paulsen, 2006; Snook, Zito, Bennell, & Taylor, 2005). With simple actuarial

[7] Remember, however, that satisficing has been shown to be more accurate than actuarial predictions under certain conditions.

techniques, police agencies can minimize the disadvantages of both the clinical (e.g., low reliability and cognitive overload) and complex actuarial approaches (e.g., potentially high costs and specific software requirements). At the very least, it would appear that the relative merits of simple versus complex strategies warrants further investigation.

Future Directions

To resolve the debate about clinical and actuarial strategies for GP, it will be important to pursue several lines of future research. First, replication and expansion of our research is required; in part to further address the criticisms highlighted above. In this regard, several factors (e.g., type of crime) should be examined to determine how they influence the performance of both types of GP strategies. In addition, future research of this sort should aim to compare clinical judgments to a wider variety of simple and complex actuarial strategies across varied conditions, and to include a range of accuracy measures. Of particular interest will be research relating to whether humans can make area-based predictions that are comparable to the probability surfaces produced by actuarial systems (e.g., Taylor et al., 2007). Overlaid on top of all this research should be attempts to develop more accurate GP heuristics and actuarial methods (e.g., by considering the psychological processes involved in spatial decision-making).

Second, researchers should evaluate the various assumptions that arguably must be met before GP systems can be used effectively (Rossmo, 2005). As indicated above, Rossmo (2005) asserts that our previous tests of GP methods are invalid because we do not pre-screen our data for these assumptions. However, we believe that to test GP methods using data that is selected on the basis of post-investigation criteria (e.g., whether the offender is a commuter) is to not test them at all. Before criteria such as these are used to restrict the data examined, it is necessary to determine whether or not it is possible to identify empirically the existence or otherwise of such conditions during an ongoing criminal investigation.

Third, the qualitative component of GP needs to become a priority. Our GP experiments have focused solely on the quantitative component of GP (with the exceptions of Bennell et al., 2007 and Snook et al., 2006) and have ignored how the consideration of such things as physical barriers, arterial routes, land use, and offender types can influence these quantitative predictions. According to Rossmo (2000), the qualitative aspect of GP is important because it potentially increases the accuracy of GP as was the case, for example, when police officers in one jurisdiction refined the search strategy produced by a GP system based on a belief that the offender was likely residing in a motel (Rossmo, Filer, & Sesely, 2006). If this is the case, the results reported in our experiments may underestimate the true value of GP. Whether or not the qualitative component of GP enhances the accuracy of profiling is an empirical question. While professional profilers are confident that they have something to add to quantitative profiling, we are concerned with this self-assessment because research in other areas has shown that such input often fails to improve actuarial predictions (Dawes, Faust, & Meehl, 1989).

Fourth, and perhaps most importantly, GP research needs to be taken into the operational arena. To date, there have been surprisingly few reports of how successful GP strategies are in criminal investigations, despite the frequency with which these methods are used. Developing measures of operational success (e.g., the proximity of the offender’s base to the predicted home location) is certainly one way to begin deriving some understanding of how useful various GP strategies are to the police (see Rich & Shively, 2004, for other measures that could be used to evaluate GP in an operational setting). However, if such attempts prove too difficult, further experimental studies could be beneficial, if these studies are characterized by acceptable levels of external validity. To accomplish this, greater cooperation between academic researchers, the police community, and professional geographic profilers is necessary.

Conclusion

While future research of the type we have recommended in this article may ultimately indicate that the results of our previous studies do not hold up under field-compatible conditions, it is currently our contention that humans often have access to simple heuristics that allow them to make relatively accurate GP predictions. In addition, for those who do not have access to these heuristics, our research clearly demonstrates that they can easily be taught them and that this training translates into enhanced performance. However, given their advantages, if future research demonstrates that sophisticated actuarial GP systems are effective in criminal investigations there seems to be little reason not to use them, so long as time, knowledge, and resources are plentiful. The choice then, between whether a clinical versus an actuarial approach to GP is most appropriate in a specific criminal investigation will likely be context dependent. Fortunately, at the moment, both strategies appear to hold some merit.

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Brent Snook, Ph.D. is an Assistant Professor and Director of the Bounded Rationality and the Law Laboratory at Memorial University of Newfoundland, Canada. His research primarily involves the study of bounded rationality and the law. He is particularly interested in the types of simple heuristics that people use to make consequential decisions in legal settings, when and why those heuristics succeed and fail, and the conditions under which simple heuristics are used. His research interests also include pseudoscience in the criminal justice system.

Table 1

Effect Sizes for Experimental versus Comparison Groups

Outcome (*k*)	*N*	Mean *r* (*SD*)	95% CI_r
Pre-Training vs. Post-Training (14)	826	.27 (.15)	.18 to .36
Human vs. Actuarial (29)	1005	-.01 (.39)	-.16 to .14

Note. *k* = number of effect sizes; *N* = number of participants; mean *r* (*SD*) = mean Pearson correlation coefficient with standard deviation; 95% CI_r = confidence intervals about *r*.