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Utility or Futility? A provisional examination of the utility of a geographical decision support system.

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The current study tested the extent to which the use of a geographical profiling system (GPS) represents an increase in utility. Students were compared to a GPS known as 'Dragnet' in their ability to predict the home location of 10 serial offenders from the information on the locations of the first five crimes. In the control group (n=21) students were asked to place an x on the map corresponding to where they thought the offender lived. A few minutes later the students were asked to complete the task again. In the experimental group (n=21) students were asked to place an x on the map corresponding to where they thought the offender lived. Then the subjects in the experimental group were informed about two decision rules which geographical profiling systems utilise - distance decay and circle hypothesis, and were then asked again to complete the task. Results confirmed that students with no previous knowledge of geographical profiling were able to use the two decision rules in order to improve the accuracy of their decisions. Furthermore, the findings supported the idea that providing students with the decision rules enabled them to make geographical decisions that were as accurate as Dragnet.

KEY WORDS: geographical profiling, utility, single case experimental design, decision rules

1. INTRODUCTION

A substantial amount of progress has been made over the last decade towards modelling individual offender spatial behaviour. One outcome of this progression has been the emergence of a new area of crime mapping research known as geographical profiling. Perhaps the most identifiable feature of geographical profiling has been the development of models that attempt to predict the home location of serial offenders (Canter & Larkin, 1993; Canter & Gregory, 1994; Rossmo, 1993). The development of these predictive models have advanced from simple spatial typologies such as the marauder/commuter distinction (Canter & Larkin, 1993) to more complex computerised *geographic profiling systems* (GPS) (Rossmo, 1993, 2000; Canter, Coffey, Huntley, & Missen, in press, Ned Levine & Associates, 1999). Along with the development of these 'sophisticated' systems came an increased emphasis on the potential to use computerised systems to assist geographical decision-making in police investigations (Shapiro, 2000). However, the shift towards the use of geographical decision support systems seems to have been made without any empirical evidence of an increase in decision-making accuracy due to their implementation. Few studies have examined the extent to which other methods lead to decisions that are as accurate as those provided by sophisticated decision support systems.

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2. MEASURING EFFECTIVENESS

A study by Ned Levine and Associates (1999) was perhaps the first to compare sophisticated methods of spatial analysis to simpler methods to determine whether increased sophistication necessarily leads to more accurate results. The comparison was made between spatial distribution methods (mean centre, median centre, directional mean, triangulated mean, geometric mean and harmonic mean) and journey to crime methods (mathematical and Kernel Density models) in a task which involved using crime locations to identify the home location of 50 serial offenders. To compare the methods, Levine and his colleagues calculated the distance (miles) between the estimated home base and the actual home location. Although no statistical tests were made, all methods produced similar results leading Levine *et al* to conclude that the simple methods were just as good (or as bad) as the more sophisticated ones. Furthermore, they suggested to crime analysts "who are trying to detect a pattern in the distribution of the incidents of a serial offender" to "do exactly what they have been doing" which was "basically looking at the data and making subjective guesses about where the offender may be residing". Although Levine and his associates were able to illustrate that simpler mathematical methods were as effective as the more sophisticated ones in identifying an offender's home location, they did not take steps to show how the 'subjective guesses' made by crime analysts compared to those methods used in their study. It might be the case that individuals with knowledge of the methods can make decisions that are as accurate as decisions made by geographical profiling systems, thus calling into question the utility of these systems.

This issue becomes even more interesting when one considers that despite the fact that the effectiveness of geographical profiling systems has not yet been clearly established researchers have suggested that certain criteria should be met in order for individuals to be qualified to produce geographic 'profiles' (Rossmo, 2000). Some of these criteria include having 3 years experience investigating interpersonal crimes, a superior level of investigative skill, computer literacy, self-motivation and ability to grasp abstract, psychological and geographical concepts. It appears that these guidelines have emerged without an examination of the extent to which individuals without these skills are able to produce geographical profiles. Furthermore, no study of the comparison between geographical decisions made by individuals using simple methods and those produced by a GPS has been undertaken. Before a great deal of confidence is placed into sophisticated geographical systems and before resources are invested for training on these systems, it is necessary to verify that these systems offer a substantial increase in decision-making effectiveness.

3. THE CURRENT STUDY

As a preliminary step in testing effectiveness, the current study assessed the utility of the predictive method used in a geographical profiling system known as Dragnet[2]. Although the topic of geographical profiling and its area of applicability have been reasonably defined (e.g., Rossmo, 2000), the components that make up a geographical profile have yet to be clearly outlined. At the most basic level, a geographical 'profile' consists of deciding upon a location where the search for a serial offender's home should commence. It is likely that there are other factors involved in producing a geographical profile such as temporal and behavioural analyses or providing advice concerning a search strategy that contribute to the utility of geographical profiles. For the current study, however, an increase in utility was simply defined as the extent to which the method used in a GPS provided a more accurate prediction of an offender's home location compared to individual-made decisions based on visual examination of the offence locations.

Arguably, two of the simplest methods that can be used to structure decision making in geographical profiling are the concepts of distance decay and the circle hypothesis. Distance decay relates to the decreasing frequency of offending with increased distance from an offender's home location (Turner, 1969; Capone and Nichols, 1976). Rossmo (1993) was perhaps the first researcher to incorporate the

[2] For more information see Canter, *et al* (in press). Predicting serial killers' home base using a decision support system. *Journal of Quantitative Criminology.*

distance decay idea into a geographical decision support system. He reasoned that if the probability of offending at a particular distance followed a decay function, then the probability of an offender living at a particular distance from his offence location should also follow a decay function. The probability of a serial offender's home being located around each of the offences was used to provide an indication of where the offender was likely to live. Rossmo (1993) called this package the Criminal Geographic Targeting (CGT) model. Similarly, the distance decay function has been used in other models such as Canter *et al's* Dragnet model (in press) and Ned Levine and Associates' (1999) Crimestat program.

The second concept, that the majority of offender's homes are found within a circle with its diameter defined by the distance between that offender's two furthermost offences, was first proposed by Canter and Larkin (1993). Subsequent research by Kocsis and Irwin (1997) and Tamura and Suzuki (1997) using different types of crimes have supported Canter and Larkin's (1993) contention that the circle is useful in locating an offender's home.

The present study was divided into two parts. Part one investigated the extent to which students could improve in their decision-making accuracy if provided with two decision rules. Specifically, these rules amounted to: 1) offences are often committed close to home and 2) the majority of offenders' homes may be found within a circle with its diameter defined by the distance between the two furthermost offences in that offender's series. The second part of the study examined the possibility that students given these rules would make decisions as accurate as those produced by Dragnet.

4. METHODOLOGY

4.1. The Subjects

Subjects in the control group consisted of 21 students (4 undergraduates, 17 postgraduates), without any knowledge of geographical profiling, studying a variety of disciplines at the University of Liverpool. The control group consisted of 10 males and 11 females from a variety of nationalities. The age of the subjects ranged from 19 years to 40 years with an average age of 25.90 years (SD=5.23).

The experimental group consisted of 21 students (8 undergraduate, 13 postgraduate), studying a variety of disciplines. The experimental group consisted of 13 males and 8 females from a variety of nationalities. The age of the subjects ranged from 21 years to 61 years with an average age of 27.67 years (SD=8.75).

4.2. Procedure

4.2.1. Establishing a Baseline

In phase 1 of the experiment each of the 21 subjects in the control and experimental groups was given 10 different maps that contained the first five offence locations of American serial murderers. To establish the baseline subjects in both groups were asked to indicate, by marking an x somewhere on the map, where they thought the home location of each of the serial murderers homes may be found. To measure their decision-making accuracy, the distance (mm) between the estimated and actual home location was measured (henceforth referred to as the *error distance*). Subjects were also given the opportunity to indicate the decision-making heuristics they used in reaching their conclusions.

4.2.2. The Control Group

In phase 2 of the experiment, subjects in the control group were given the same maps as those used in establishing a baseline and were again asked to indicate where they thought the offenders' home was likely to be located.

4.2.3. Experimental Group

To test the extent to which students were able to improve their decision-making accuracy the subjects in phase 2 of the experimental group were provided with the two pieces of information. In phase 2, the subjects were told that: 1) the majority of offenders commit offences close to home and 2) the majority of offenders' homes could be located within a circle with its diameter being the distance between the offenders two furthermost crimes. After being presented with this information subjects in the experimental group were given the same maps again and were asked to indicate where they thought the serial offenders' homes were located. They were also asked to indicate the heuristics used to make their decisions.

If, after providing the students with the decision rules, a significant reduction in the error distance is found, when compared to the results in phase 1, then a positive effect of providing the two decision rules could be assumed. That is, a significant reduction in error distance after being provided with the two decision rules would be indicative of the ability of students to use the rules to improve and structure their geographical decision-making.

4.2.4. Dragnet

To answer the second research question, that students given the decision rules would make decisions as accurate as Dragnet, the error distance produced by the students after phase 2 were compared to the error distances produced by Dragnet. The Dragnet model uses pre-set distance decay functions, applied around crime locations, to predict the likely home location of unknown serial offenders. The end product of Dragnet is a coloured map where the colour of each pixel on the map is determined by the probability that the offender resides there. Using the highest point of probability (i.e., the most likely pixel to contain the offender's home location) produced by Dragnet, the error distance was measured (mm). A significant difference (i.e., Dragnet providing more accurate decisions) would negate the ability of the students to make investigative geographical decisions that are as accurate as Dragnet.

5. RESULTS

5.1. The Control Group

The mean error distance for the control group in phase 1 was 35.30 mm (SD=22.66). The average error distance in phase 2 was 34.22 mm (SD=21.65). Figure 1 presents the results of the mean error distances for the control group. The figure shows that there was minimal change in the mean error distance in the two phases. A related-samples t-test confirmed that no significant difference existed between the two phases (t_{207}=1.626, n.s.).

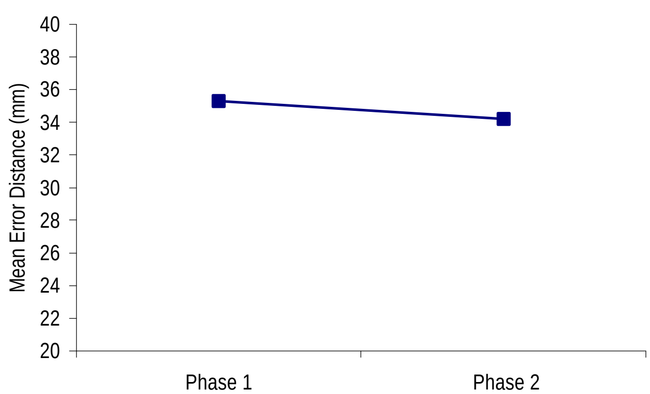

Figure 1. The mean error distance for the control group in the phase 1 (n=210) and phase 2 (n=210)

5.2. Experimental Group

The results of the mean error distances before and after the students were given the decision rules are shown in Figure 2. The mean error distance in phase 1 was 33.94 mm (SD=23.45). After the students were informed about the decision rules the average error distance was 25.65 mm (SD=15.17). A related-samples t-test established that these error distances were significantly different (t_{209}=5.449, $p<0.05$). That is, students did make more accurate predictions when they have been provided with two relevant decision rules.

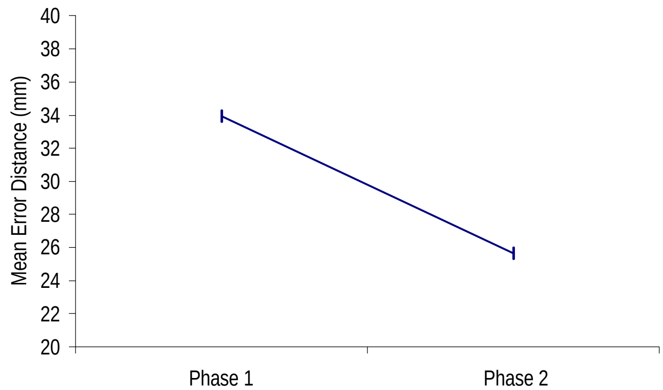

Figure 2. The mean error distance for the experimental group in phase 1(n=210) and phase 2 (n=210)

5.3. Experimental Group & Dragnet

The average distance from the area of highest probability, as indicated by Dragnet, to the actual home was 25.30 mm (SD=14.83). Figure 3 depicts a comparison of the error distance of the experimental group after the two phases with the results produced by Dragnet. A one-sample t-test verified that no significant difference existed between the mean error distances for the experimental group in phase 2 and Dragnet (t_{20}= 0.400, n.s.). This result indicates that the students provided with two relevant decision rules were as accurate as Dragnet in indicating a location where a search for an unknown offender's home should commence. Figure 3 also shows a significant change in accuracy between students with no previous knowledge of the methods used in geographical profiling systems and Dragnet. A one-sample t-test confirmed that there was a significant difference in the error distances between the mean error distance for the experimental group in phase 1 and Dragnet (t_{20}=2.306, $p<0.05$).

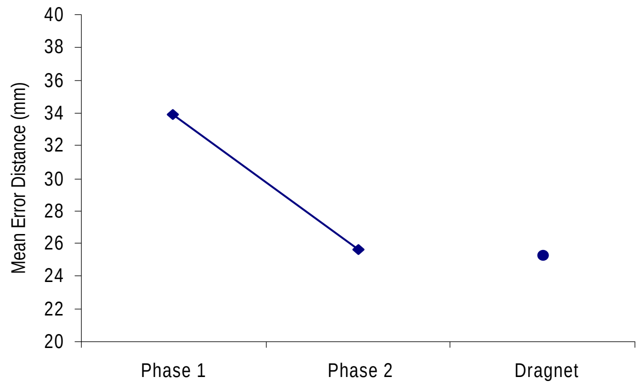

Figure 3. The mean error distance for the experimental group in the two phases (n=210x2) and Dragnet (n=21)

5.4. Control Group, Experimental Group & Dragnet

The error distances for the control group, experimental group, and Dragnet are shown in Figure 4. The figure shows a stable baseline measure in phase 1 for both the control and experimental groups. An independent t-test did not reveal any significant difference between the mean error distance between the control group and the experimental group in phase 1 of the experiment (t_{418}= -0.605, n.s.).

Figure 4 also shows that a significant difference existed in the error distance between the control and the experimental groups in phase 2 of the experiment (t_{416}= -4.694, $p<0.05$). This difference can be explained by the fact that subjects in phase 2 of the experimental group were provided with and used the two decision rules. A one-sample t-test revealed that the error distances for the subjects in phase 1 of the control group were significantly larger than those produced by Dragnet (t_{20}=3.137, $p<0.01$) as were the error distance for the subjects phase 2 of control group (t_{20}=2.943, $p<0.01$). That is, Dragnet was more accurate than students at both stages in the control group.

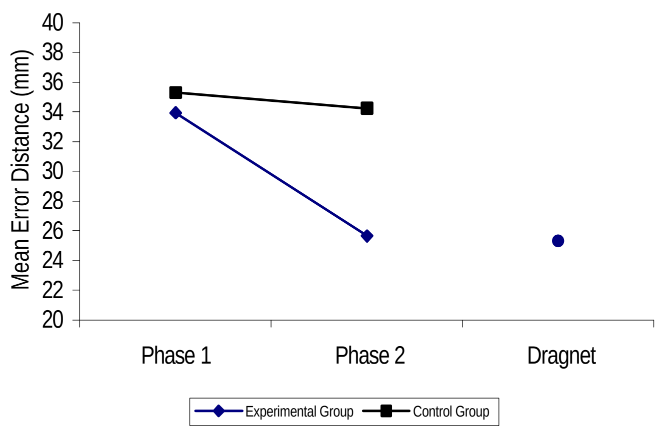

Figure 4. Mean error distance for the experimental (n=210) and the control group (n=210) in phase 1 and phase 2 and Dragnet (n=21)

5.5. Individual-Map-Level Analyses

While there was a general trend for students provided with decision rules to improve in their decision making and to make decisions as accurate as Dragnet there was still a need to consider the influence of the distribution of points (i.e., individual maps) upon the decision-making task. Table 1 contains the mean error distances for each of the maps for the control and experimental groups in relation to the two phases of the experiment. At the individual-map-level, there were no significant differences (reduction in error distance) between phase 1 and phase 2 for the control group. In the experimental group a significant reduction in error distance was found between phase 1 and phase 2 for half of the maps (see Table 1).

Table 1
The mean error distance (mm) and standard deviations for each map for the control and experimental group in the two phases

Map No.	Control Phase 1 (n=21)	Control Phase 2 (n=21)	Experimental Phase 1 (n=21)	Experimental Phase 2 (n=21)	Dragnet
Map 1 (SD)	23.86 (20.17)	26.10 (25.86)	21.30 (20.88)	15.76 (8.87)	19.00
Map 2 (SD)	37.33 (21.72)	35.07 (21.07)	35.76 (20.75)	26.00 (7.27)*	21.00
Map 3 (SD)	43.24 (17.99)	41.38 (17.55)	39.38 (17.89)	39.67 (13.52)	51.00
Map 4 (SD)	23.62 (17.00)	22.81 (16.19)	25.38 (20.38)	13.85 (7.07)*	20.00
Map 5 (SD)	37.57 (28.50)	35.05 (26.54)	33.48 (27.67)	19.24 (11.60)*	14.00
Map 6 (SD)	27.52 (22.12)	25.67 (15.70)	28.29 (19.75)	20.43 (6.11)	23.00
Map 7 (SD)	29.67 (25.88)	27.57 (25.89)	30.43 (32.64)	13.24 (14.88)*	2.000
Map 8 (SD)	32.05 (25.56)	33.00 (24.23)	33.43 (25.30)	19.95 (8.39)*	17.00
Map 9 (SD)	46.05 (12.75)	42.67 (9.23)	41.05 (17.15)	42.67 (8.77)	49.00
Map 10 (SD)	52.10 (14.31)	52.10 (12.32)	50.86 (17.61)	45.62 (7.31)	37.00
Mean	**35.30**	**34.22**	**33.94**	**25.65**	**25.30**

*Denotes a significant difference ($p<0.05$) between the phase 1 and phase 2 for that group in relation to that map.

When the mean error distances in each of the phases were compared with Dragnet using Spearman's rank-order correlation only the results in phase 2 for the experimental group and Dragnet was significant (r_s=.830, $p<0.01$). Thus, when the students provided with the decision rules produced inaccurate (or accurate) predictions Dragnet also produced inaccurate (or accurate) decisions.

5.6. Reducing Deviations

An examination of the standard deviations provided an indication of the impact of the decision rules in structuring student decision-making. Table 2 contains the mean standard deviations for the control and experimental groups under the two phases. A paired samples t-test revealed that there was no significant difference in the standard deviations between phase 1 and phase 2 for the control group (t_9=1.184, n.s.). For the experimental group, however, a statistically significant difference existed in the standard deviations between the results in phase 1 and phase 2 (t_9=9.753, $p<0.001$).

Table 2. The mean standard deviations (mm) for the control and experimental group in the two phases

	Phase 1	**Phase 2**
Control	20.60	19.46
Experimental	22.00	9.379

5.7. Heuristics

The use of inappropriate heuristics that were reported by the subjects was likely to have contributed to the large error distances. For example, some subjects said that “the individual seems to choose his victims on the basis of encounters or sporadic interaction” and “I guess the perpetrator lives away from the averaged position of victim’. Subjects in the control group were asked to repeat the same task again under the same stages and reported continued use of the same inappropriate heuristics, which resulted in inaccurate decisions. However, a correction phase was provided to the experimental group, after the baseline, where they were told about appropriate heuristics based on journey-to-crime research. The correction phase resulted in a decrease in error distance (i.e., they become more accurate) as a result of the subjects being provided with more appropriate heuristics. Subjects were able to adopt these appropriate heuristics when choosing a location and forget about the inappropriate ones they had previously used.

6. DISCUSSION

The fact that students provided with the two decision rules significantly improved their accuracy of indicating the likely home location of serial murders provides preliminary evidence that individuals without any knowledge of geographical profiling can use relevant information to make more accurate decisions. This finding has potential positive implications for police organisations. It indicates that police organisations may be able to correct the use of inappropriate geographical decision-making heuristics or instruct officers on more appropriate ones. Once the officers use the appropriate heuristics their ability to make effective geographical decisions could significantly be enhanced. Related, is the finding that agreement between the students provided with the decision rules about the location most likely to contain the offenders’ home increased as revealed by a significant reduction in error distance variability. The significance of these results increases when smaller police agencies are considered. Such agencies will likely have limited resources and technological capabilities making low-cost easy-to-implement alternatives to GPS systems beneficial.

The second finding, that students were able to make as accurate decisions as the geographical profiling system Dragnet, challenges the need for specialised profilers (as defined by Rossmo, 2000) and geographical profiling systems. It is plausible that some specialised qualifications may be required to understand the operation of complex decision support systems. However, the results of this study indicate that if the basic underlying processes are understood it is less likely that these qualifications would be required to make accurate geographical decisions in an investigation of a serial offender. Unfortunately, the students in the current study were not directly asked questions regarding their investigative experience of interpersonal crimes or of their level of investigative skill. Assuming that the students lacked these requirements, they were able produce those accurate decisions without the aid of a computer. Moreover, the results from the present study suggest that individuals with some knowledge of geographical profiling can make these accurate decisions relatively quickly. In the present study, all students completed the task, including the follow-up questionnaires within 20 minutes.

Another issue was highlighted by the consistent rank ordering of the error distances between the experimental intervention and Dragnet at the individual-map-level. That finding indicates that when decision rules were ineffective for the students, they were also ineffective for Dragnet. Due to the fact that the two decision rules provided in the study did not work in some instances for both the students and Dragnet suggests that there may be other decision rules that need to be identified and implemented. For example, there may be some factors that relate specifically to commuting offenders (whom are particularly difficult to locate) that need to be identified. Those maps in the present study where a significant reduction in error distance did not occur contained commuting offenders. Once an effective decision rule has been identified for commuting offenders it may be employed to increase the accuracy in both individual-made and Dragnet-made decisions.

While the results from this study can not be generalised to other GPS's, they do suggest that it may be necessary to take a step backward to evaluate and define more clearly the role that geographical profiling systems can play in police investigations of serial offenders. In particular, the current findings suggest a need to consider whether or not 'sophisticated' geographical profiling systems significantly increase utility or whether or not it is an exercise in futility.

FUTURE RESEARCH

There are a number of issues relating to the utility of decision support systems that need clarification. Some of these issues are currently being explored as part of a doctoral thesis on the effectiveness and applicability of geographical profiling systems at the University of Liverpool. For example, a number of other studies are being considered that will test the extent to which factors such as the type of subject used, type of crime, the number of crime locations, and the number and type of decision rules provided affect utility. In some instances in this study students did not seem to use the decision rules as indicated by their inability to improve in their decision making. To ensure that the students realise the benefit of the rules, they may need to be provided with a training/feedback session to illustrate the effectiveness of the decision rules. It is hypothesised that providing individuals with feedback will further improve their decision-making accuracy. Experiments exploring decision-making heuristics and whether the judgements made by subjects and different methods used in GPS systems are accurate in locating offender's home are being designed.

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