THE SPACE AND TIME DIMENSIONS IN THE CRIMINAL BEHAVIOUR OF LUST MURDERERS

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ABSTRACT. The criminal behaviour over space and time of four European lust murderers (Whitechapel Ripper, Gloucester Monster, Yorkshire Ripper, Florence Monster) was investigated. The spatial analysis, based on the geographical distribution and spatio-temporal evolutions of the crime scenes, allowed to hypothesize that these serial killers were of organized type, presumably psychopathic, followed rigid models in the elaboration of their mental maps of the crimes, and cyclical phases in the periods of emotional cooling and security distances with some exceptions. Serial killers moved near the comfort zones within buffer zones with spokes, in relation to the diameter of the criminal circle, ranging from 3% and 21%. In particular, among the examined serial killers, the results of investigations on the Florence Monster and the Yorkshire Ripper resulted particularly significative. The Florence Monster distinguished for his high coefficient of awareness and experiential depth. The increasing trend of emotional cooling times could have been due to a significant form of self-control in dominating himself during the cyclical phases in which the serial killer returns to live the desire of killing. The criminal behaviour of the Yorkshire Ripper experienced an escalation in his criminal activity, being characterized by low experience and insecurity in himself in the first crimes followed by an acquired experience and security in the commission of the criminal acts with the time. The results obtained in the present research confirmed how useful and profitable may be the application of an inter- and transdisciplinary approach, based on principles and methods of investigative psychology, criminal and geographical profiling, and Geographical Information Systems technology, in dealing with investigations related to immaterial evidence, criminal behaviour, and the resulting crime patterns from serial lust murders.

1. Introduction

The "International Workshop on Advances and Applications in Geoforensics: Unraveling Crimes with Geology" (Messina, Italy, 26/09/2022) gave the opportunity to gather eminent experts in both criminology and criminalistics, from Europe and USA. A broad overview on the earth and natural science contribution to criminology was particularly focused, in order to stress the overlaps that may exist between criminological (Canter 2022) and criminalistic issues (Byrd and Sutton 2023; Marra 2023; Marra, Di Silvestro, and Somma 2023; Morabito, Mondello, and Somma 2023; Morabito and Somma 2023; Somma 2023a,b; Somma and Maniscalco 2023; Somma *et al.* 2023d; Somma, Sutton, and Byrd 2023; Spoto 2023; Spoto,

Barone, and Somma 2023; Tagliabue *et al.* 2023). This aspect was especially underlined in criminalistic research presented at the workshop and involving the study of the spatial aspect of the crime scenes (Baldino *et al.* 2023; Somma *et al.* 2023a,b,c; Somma and Costa 2023). Spatial analysis is very used in criminology. It may be devoted to search for the general patterns and regularities existing among serial crimes. Most Serial Killers (SKs) are psychopathic individuals living with unstoppable homicidal impulses (Jaspers 1913; Cleckley 1941; Fornari 1995; B. Jones 1996; De Pasquali 2001; S. T. Holmes and R. M. Holmes 2002; Bruno *et al.* 2010; Hare 2018; Meloy 2018). Many factors influence serial crimes, including the psychological aspect, opportunism, and geographical location (Canter 2003; Ruffell and McKinley 2008). The SK of Florence, Foligno, Turin, Whitechapel, Yorkshire, and Green River are only a few examples of the link existing between SKs and geography. This close correlation led to the birth of the Geographical Profiling (GP) (P. J. Brantingham and P. L. Brantingham 1981; Canter and Heritage 1990; Canter 2003; Rhodes and Conly 2017; Berezowski *et al.* 2023). In criminology, the GP applies the principles of investigative and environmental psychology to criminal investigation. The birth of the GP can be attributed to the biologist Stuart Kind (Kind 1987a,b; Canter 2003). Stuart Kind was called by the police to assist them in the search for the Yorkshire Ripper in the 1970s. On this occasion he applied principles that would become the pillars of the GP (Canter 2003). The GP is a methodology applied in criminal investigations mainly in order to identify the area where the base/residence of the serial perpetrator is most likely to be present. The application of the GP can also lead investigators to understand much of the criminal behaviour of the offender; the interpretation of the spatio-temporal aspect of a serial crime assumes fundamental importance in order to better understand the *Modus Operandi (MO)* and sometimes also the emotions experienced by the perpetrator of serial crimes. The geographic crime analysis with his spatio-temporal information, such as the dates when the serial crimes were committed and the respective geographical coordinates, can therefore provide useful data for criminal investigation purposes (Canter 2009). The application of the GP to criminal investigations achieved encouraging results in the past. The SK Justin Porter was discovered thanks to a geographic analysis carried out using the principles of the GP (Canter *et al.* 2000). The Dragnet software, created by David Canter, used a layered Geographic Information System (GIS) system where the crimes were traced, with attributes such as time and date, the type of incident, the "connection" hierarchy (common fingerprints, DNA, *MO*). The data of the various layers, through triangulation or the identification of the weighted centre of gravity (centroid) of the criminal circle led to the identification of the *condominium* that housed Porter (Ruffell and McKinley 2008). The serial offender Simon Wadland, known as the telephone scammer, was discovered thanks to GP using sophisticated mapping technologies of the various police forces. Canter (2003) demonstrated how, with a large database (227 calls in 1998), it was possible to trace the home of the serial offender. The Canter map showed Simon Wadland's house, in the centre of the area from which the calls originated, resulting in a bull's-eye shape. The area appeared slightly elongated in a north/south direction, probably due to the trend of the main roads (Ruffell and McKinley 2008). One case of serial crimes in which urban geography played a prominent role regarded the SK David Berkowitz, killing couples in parked cars on the dimly lit streets of the Bronx and Queens, in New York (Ruffell and McKinley 2008). The SK couple, Ian Brady and Myra Hindley, were responsible for torturing, killing and

hiding 5 young victims between 1963 and 1965. The geographical control in the crime influenced this couple in the choice of the site where to conceal the bodies, the Saddleworth Moor near Manchester (Ruffell and McKinley 2008). It is interesting to point out that the serial murders of Ted Bundy, one of the most ruthless SKs in the history of criminology, are interrupted in Seattle when he moved to Utah where a new series of murders began, thus highlighting a geographical control in the scheme of action (Ruffell and McKinley 2008). The SK Jeffrey Dahmer (Wisconsin) and the SK couple, made up of the spouses Fred and Rosemary West (England), chose their home as the geographical hub of the criminal plans (Ruffell and McKinley 2008). The SK Nikolai Dzhumagaliev (Kazakhstan), known as "Metal Fang", committed 8 of the 10 murders along the same river. Nikolai Dzhumagaliev was diagnosed with *schizophrenia*. He was found guilty of seven murders, three of which with the aggravating circumstance of cannibalism (Hall 2020). Moreover, a preponderant role on the choice of crime scenes seems to be ruled by the geographical localization of the transport network (motorways, railways or riverside routes) with respect to crime scenes. In such framework, it must be emphasized that experts of the territory may contribute for such investigation, on the base of their expertise in the field of remote sensing and GIS. An integrated management of the land from remote is able to process geographical information in geo-referenced data to be measured and evaluated (Ruffell and McKinley 2008). The geo-referenced information may be used for assisting law enforcements and judicial authority in finding the culprits as well as in understanding the SKs' criminal behaviour in space and time. In other words, a such multi-disciplinary approach, based on the GP, remote sensing, and GIS technologies applied by forensic experts, such as investigative and environmental psychologists, psychiatrists, coroners, criminal and geographical profilers, geographers, geologists, botanists, and ecologists may allow to better analyse the existing relationships between human beings (victim and perpetrators) and geography of the sites.

Another aspect to evidence is related to the fact that the SKs, between one murder and the next one, need to experience a moment in which they decompress their interior pressure and, at the same time, dedicate themselves to a phase in which they may indulge in the satisfaction and enjoyment of the deeds carried out during the committed criminal acts. Later, after a first short phase, the tension starts to increase hand in hand with the fantasies; this will lead to a new and probable more complex and risky murder. The geographical distribution of the crime scenes in the territory and the distance between a crime scene and the next one (known as security distance) may provide significative investigative information. These temporal and spatial dimensions may characterize the different criminal behaviour of SKs. Moreover, investigations may be corroborated by data from comparative statistics applied to SKs. Notwithstanding, comparing offenders with different mental illnesses or personality disorders is not appropriate because each individual might perceive the spatial dimension very differently. In any case, perpetrators of criminal actions require knowledge of the geography of the area in which they strike and these spatial data may be analyzed spatio-temporally using GIS systems (Ruffell and McKinley 2008).

With this in mind, the present paper was devoted to the characterization of the geographical and criminal behaviour in space and time of four SKs, among the most appalling described in the criminological history of the last centuries. This investigation, in particular, pointed at ascertaining:

1) any patterns used for the elaboration of the mental map of the crime and whether the SK was suffering from severe personality disorders, especially psychopathy or psychopathic personality disorders (according to the classification reported in the DSM-5) or psychotic (or schizophrenic) disorders (American Psychiatric Association 2013; Lingiardi and McWilliams 2017);

2) if the spatial and temporal characteristics associated with the serial crimes were regulated by cyclical *phenomena*;

3) if SKs were experts/elderly at the debut of a criminal career;

4) if the bases/residences of the suspects fell within the criminal circle and in what relationship with respect to comfort zones;

5) if the trend of base/residence distances could be correlated with the trend of security distances;

6) if the dimensions of the buffer zones were relevant compared to the diameter of the criminal circle.

2. Serial killers

The criminal behaviour sciences classify murders as serial when at least two or three people are killed, a time lapse occurs among two consecutive homicides, and a red thread links the crimes. According to the FBI, SKs (originally known as chain killers) kill because they want (Douglas 1992; Federal Bureau of Investigation 2005; Douglas *et al.* 2006). An exception would regard those killers suffering severe mental illness. Psychotic and schizophrenic SKs find the primary cause leading them to kill in the severe mental illness they suffer. Most SKs suffer psychopathy/malignant narcissism/antisocial personality (Kernberg 1984). The motivating factors underlying the criminal behaviour of most SKs are of psycho-pathological origin. One of the most significant manifestations of power for human beings is represented by giving and taking life. The killing act is for the SK a means for gaining control on another person. SKs kill to achieve psychological gratification. Killers may be motivated by sexual impulses, anger, thrill, financial gain, and attention-seeking. In lust murders, serial offenders seek erotic gratification in killing someone. They have sexual fantasies about what they did or will do in the subsequent murder; when the fantasies will be realized, the level of deviance will further increase in the next fantasies with an escalation of violence. Sexual motivation will also be driven by the offender's sexual needs/desires if there is a common lack of overt sexual contact with victims at the crime scene. The perpetrator of the crime reifies the victims by transforming them into items for their own gratification. More importance is given to the rituals accomplished during the murder than the sexual act. Tortures and mutilations may increase sexual gratification. The absolute protagonists of the lust murders are sex and death conjugated together. In sexual assaults, criminal behaviour may be accompanied by exploratory probing, regressive *necrophilia*, and object insertion. Lust killings occur either with killing during a sexual approach and mutilation of the sexual organs or other parts of the victim's body. Mutilation may include evisceration and removal of the genitals or other body parts (breast, heart) (Jaspers 1913; Cleckley 1941; Kernberg 1984; Norris 1989; Ponti 1990; Douglas 1992; Ressler and Schachtman 1992; Fornari 1995; Ponti and Fornari 1995; B. Jones 1996; De Pasquali 2001; S. T. Holmes and R. M. Holmes 2002; Massaro 2002; Federal Bureau of

Investigation 2005; Douglas *et al.* 2006; Ponti and Betsos 2008; Picozzi and Intini 2009; Bruno *et al.* 2010; Malizia 2010; Häfner 2011; Baron-Cohen 2012; Mastronardi 2012; Hare 2018; Meloy 2018). According to the FBI, most sexually motivated Sks eroticize violence during their development, and consequently, violence and sexual gratification are inexplicably intertwined in their psyche (Douglas 1992; Federal Bureau of Investigation 2005; Douglas *et al.* 2006). According to the FBI, the disorganized Sks are impulsive, improvised, and do not organize the crime in advance. They act under an uncontrollable and unstoppable *impetus*. The organized Sks are methodical and meticulous in the crime planning; they are usually pharmacologically incurable, but from a psychotherapic and clinic point of view there are divergent opinions.

Criminal profiling is particularly useful in serial crimes. According to the FBI's behavioural Science Unit (BSU), understanding the behaviour of serial criminals at the crime scene and what kind of interaction they have with the victims constitutes the "golden rules" of criminal profiling (Douglas 1992; Federal Bureau of Investigation 2005; Douglas *et al.* 2006). The GP falls within the scope of criminal profiling and aims to assist investigators in narrowing down the number of suspects and identifying the possible provenance and geographical area of the serial offender. The GP, in some circumstances, may allow to prioritize the search areas for the base/home of the offender (known as anchor point) as well as formulate various predictive hypotheses on the criminal behaviour of the offenders related to the space and time dimensions of their crimes (Canter 2003). The SK's behaviour generally undergoes an evolution during the murderous series. Initially, the onset of a criminal career manifests itself only in the imagination of the Sks, who indulge in a very intense deviant fantasy in which they commit serial crimes, finding more satisfaction in their vision than in the real world. The future SKs, before killing, will imagine the murder several times; when they will be no longer satisfied by their fantasies, the killers will kill. SKs may experience the following phases (Norris 1989):

  i auroral phase (compulsive fantasies);
 ii pointing phase (paranoid behaviour);
iii seduction phase (approach with the victim);
 iv phase of capture (victim control);
  v homicidal phase (orgasmic phase due to capturing and killing the victim);
 vi totemic phase (removal of organs and possible acts of cannibalism);
vii depressive phase.

3. Geographical Profiling

The fundamental assumption of the GP consists in considering the environment in which the human being lives as having a significant influence on human behaviour (P. J. Brantingham and P. L. Brantingham 1981; Canter and Heritage 1990; Canter and Larkin 1993; Canter and Gregory 1994; Canter 1995a,b; Canter and Fritzon 1998; Canter, Hughes, and Kirby 1998; Canter and Snook 1999; Canter *et al.* 2000; Canter and Hodge 2000; Canter and Youngs 2003; Canter and Hammond 2006, 2007; Aldershot, Canter, and Youngs 2008; Canter and Shalev 2008; Canter and Youngs 2009; Osborne and Salfati 2014; Rhodes and Conly 2017; Curtis-Ham *et al.* 2021; Spaulding and Morris 2021; Berezowski *et al.* 2023; Spaulding and Morris 2023). It seems useful to point out that even the animal world (to

which man belongs) obeys this natural "rule"; the animal behaviour studied in the context of the hunting of feline predators living within nature reserves in the savannah is characterized by hunting methods whereby the predators kill the prey close to where they have their den/base and the latter is chosen by the predators in the central area of the reserve (Canter 2003). The above suggests that the places where serial crimes are committed are deliberately chosen, consciously or latently, by the human predatory perpetrator. David Canter was the first to develop the GP methodology and also to develop dedicated software for the purpose (Dragnet and Dragnet P). This latter is an easy-to-use interactive software, developed as an aid to indicate the area most likely to host the offender's base and to determine the implications of linking crime scenes. Following Canter's studies (P. J. Brantingham and P. L. Brantingham 1981; Canter and Heritage 1990; Canter and Larkin 1993; Canter and Gregory 1994; Canter 1995a,b; Canter and Fritzon 1998; Canter, Hughes, and Kirby 1998; Canter and Snook 1999; Canter *et al.* 2000; Canter and Hodge 2000; Canter and Youngs 2003; Canter and Hammond 2006, 2007; Canter and Shalev 2008; Canter and Youngs 2009) and the development of the software, Kim Rossmo, a former police inspector who became a professor at Texas State University, developed his own approach to the GP and created a further software. Still other software dedicated to GP has been developed, such as CrimeStat by Ned Levine (Levine 2015).

Canter, after studying the spatio-temporal behaviour related to numerous cases of serial criminals, elaborated the concept of the so-called "criminal sphere". This concept corresponds bi-dimensionally to the so-called circle of the offender or criminal circle. It is a circle whose diameter corresponds to the straight line joining the places of the crime scenes of the crime series, placed at a greater distance (Canter 2003). Serial criminals tend to live within the area circumscribed by their crimes (P. J. Brantingham and P. L. Brantingham 1981; Rengert, Piquero, and P. R. Jones 1999; Canter 2003), identified by Canter and Larkin (1993) in the "criminal sphere". It has been shown that 87% of a sample of serial rapists lived within a circle defined by the diameter drawn between the two most distant places where the crimes were committed. Kocsis and Harvey (1997) showed that 82% of serial arsonists, 70% of serial rapists and 49% of Australian burglars lived within the criminal circle. Hodge and Canter (1998) found that 86% of US Sks fall within the circle. Serial predators who, immediately after committing the crime, return to their home/base are defined by Canter marauder. In the case of marauder serial predators, this circle encloses an area that contains the place where the home/base of the SK is located. Marauder behaviour is the prevalent in serial criminals (Canter 2003). The criminal sphere and the circle include the space within which the perpetrator of crimes commits his serial crimes (Canter 2003). Within the criminal circle it is possible to distinguish (Canter 2003):

i The "base" of the offender. It represents the anchor point for criminal activity (home, place of work, residence of a relative, place of recreation).

ii The "buffer" zone or free zone. It is the area close to the SK's home/base. Inside this zone the SK feels safe and does not commit crimes in order not to arouse suspicion as it is too risky.

iii The comfort zone. It is the area where the SK commits the crimes. There may be multiple comfort zones for the same homicidal streak. These are usually in places located at a certain distance from the base/home, from the place where the SK works or where relatives reside.

The scientists also observed that in most cases, over time, the space-time dimension with which the criminal series continues, undergoes variations. The marauder serial predator tends to commit two successive crimes at distance and time intervals between homicides (Osborne and Salfati 2014) increasingly greater, trying to reduce the risk to be discovered. This leads to an increase in the size of the circle over time and a decrease of the number of crimes with increasing distance from the home of the offender (Rengert, Piquero, and P. R. Jones 1999). From this observation it follows that the residence/base of the predator is located not far from the places where he committed the first serial crimes. It should be underlined that the location of the place of the first crime scene of the crime series assumes a relevant importance for investigative purposes (Canter 2003). In the GP, the more crime scene locations are examined, the more accurate and precise will be the data obtained. In this regard, if the serial predator concluded his criminal plan, the accuracy and precision of the GP results will be better. The distribution of distances that the offender travels from home to the crime scene seems to be related to a decay law. The so-called distance decay law (Rossmo 1995) is the basis of all reasoning of GP. The decay functions mathematically express the relationship between the probability of an offender hitting and the distance from home. Researchers showed as the distance from an offender's home to crime scene increases, the probability of committing a crime decreases, *i.e.* the probability of "decays" in a distance-decay function (P. J. Brantingham and P. L. Brantingham 1981; Rhodes and Conly 1981; Rossmo 1995; Rengert, Piquero, and P. R. Jones 1999; Rhodes and Conly 2017).

4. GIS systems

The GIS system allows to map and analyze the spatial information of interest. Two types of data may be stored (Burrough and McDonnell 1998; Atzeni *et al.* 2013; Guandalini and Salerno 2013):

1) spatial information,
2) non-spatial information on attributes.

GIS system is an advanced information technology that allows for tracking, archiving, querying, comparing, manipulating, and analyzing spatial data. It is used in various fields, including demographic studies, the creation of maps, spatial planning. Thanks to GIS it is possible to correlate quantitatively data that occupy the same position or different positions in space. Conventional spatial reference systems are represented by geographic coordinates (latitude and longitude). The GIS models consist of vector and raster digital data. Vector data consist of points, lines, and polygons that have attributes. GIS can be used to delimit areas with common attributes, automatically giving rise to maps with separate features (altimetry, urbanized areas, land use, geology). Raster data represent continuous variables in the form of a grid of cells (pixels). An attribute may be assigned to each pixel. The Digital Terrain Model (DTM) and Digital Surface Model (DSM) consist of grid cells to which elevation information is assigned. GIS provides a quantitative measure of the distribution of georeferenced spatial data. GIS uses primary and secondary data. In this second case, the cartographic sources can be entered into the system in digital format, through digitization and scanning. The most used GIS systems are ArcMap, ArcGIS, and QGIS. QGIS was used in the present study. The Crime Mapping Research Center (CMRC) was established in the

United States to address the issue of the production of several competing "crime mapping" software. The CMRC is also tasked with maintaining quality control over available software products (Ruffell and McKinley 2008). GIS systems applied to criminal investigation (Hirschfield and Bowers 2003; Herrmann and Devlin 2008; Ruffell and McKinley 2008; Chainey and Ratcliffe 2013; Elmes, Roedl, and Conley 2014; Bunch, Kim, and Brunelli 2017; Somma *et al.* 2018; Somma 2022a,b; Somma and Costa 2022; Somma *et al.* 2023c; Somma and Costa 2023) allow to carry out various operations in order to obtain useful info-investigative information. GIS systems may allow to recognize potential geographical areas provided of high risk for criminal activity if showing specific characteristics or search for places in which certain conditions of interest exist (Somma and Costa 2023).

5. Case studies

The main aim of spatial analysis in criminology is to search for the general patterns and regularities existing among crimes. The present research was aimed to analyse over space and time the criminal behaviour assumed by the following four SKs:

  i the Whitechapel Ripper (London, UK),
 ii the Gloucester Monster (Gloucester, UK),
iii the Yorkshire Ripper (Yorkshire, UK),
 iv the Florence Monster (Florence, Italy).

For each one, the following factors were reported in GIS-based cartographic maps and tabular portrayals, and analyzed during their criminal career:

  i the time interval between successive crimes (period of emotional cooling),
 ii the distance between successive crime scenes (security distance),
iii the distance between the base/home and crime scene (journey to crime).

For each one of the analysed SKs, the GP context of offenders' offense sites, the activity spaces, the dates of the crime scenes, and homes/bases of perpetrators were searched in the literature, collected, and uploaded in a GIS georeferenced database (Somma 2022b).

5.1. The Whitechapel Ripper. The Whitechapel Ripper, known in the chronicle as Jack the Ripper, was responsible for the killings of at least five prostitutes (Table 1), but the number of the victims may have been much greater. The period of criminal activity was very short, being distributed in less than three months, since 31/08/1888 to 09/11/1888. The murderers were committed during the night or early in the morning of weekends in the slum area of London, known as Whitechapel (UK) (Lekh *et al.* 1992; Rossmo 1995; Feldman 1998; Eddleston 2002; Stewart and Skinner 2002; Canter 2003; Whiteway 2004; Trevor 2005; Begg 2006; Hall 2020; Jari and Miller 2020; Somma 2022b; P. Jones 2023).

The crime maps of the spatio-temporal evolution of Jack the Ripper's homicidal series were reported in Figures 1 and 2 with the spatial position of 5 crime scenes (Canter 2003) and the home of one of the main suspects (A.K.). Whitechapel was located north of the River Thames and appeared bounded to the north and south by physical barriers consisting of two sections of the ENE-OSO railway line. The criminal circle (Figure 1) was defined by identifying as extremes of the diameter, the straight line joining the two crime scenes placed at the maximum distance (crime 1 and 4). The measured diameter of the circle was equal to 1368 m. Crime scenes relapsed into all quadrants of the criminal circle with two

TABLE 1. Victims and dates of the homicides (ID of the crime scene).

ID	Date of the homicide	Victims (initials)
1	31.08.1888	P.N.
2	08.09.1888	A.C.
3	30.09.1888	E.S.
4	30.09.1888	C.E.
5	09.11.1888	M.K.

into the same quadrant. The identified comfort zone was unique. As for the pattern obtained by joining consecutive crime scenes with a broken straight line, it was possible to observe that it appeared fairly symmetrical, being characterized by straight line, almost similar in length and orientation (Figure 1, Table 2):

  i ID 1-2 and 3-4 crimes scenes, parallel to each other and with an approximately E-W trend;
 ii ID 2-3 and 4-5 crime scenes, transversal to the previous ones and with a NW-SE and NE-SW orientation.

The directions in which the locations of consecutive crime scenes were displaced in the space and the time were towards (Table 2):

  i the west in the succession of ID 1-2 crime scenes,
 ii the southeast in the succession of ID 2-3 crime scenes,
iii the west in the succession of ID 3-4 crime scenes,
 iv the north-northeast in the succession of crimes ID 4-5 crime scenes.

The first three crimes (ID 1-2-3) were placed at such a similar distance that, by joining them with straight lines, it was possible to define an approximately equilateral triangle (Figures 1, $2A_1$). After the first three crimes, the SK killed in an opposite area from the first crime, moving away from the so-called vicious triangle, probably for fear of being recognized and captured (Canter 2003) (Figures 1, $2A_2$).
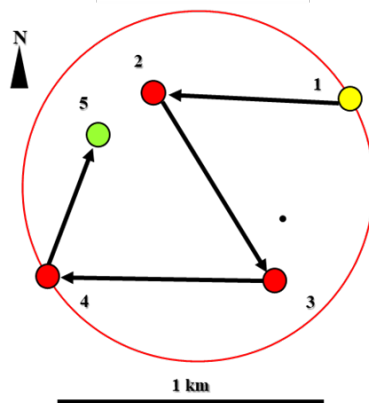
FIGURE 1. Crime scene pattern of subsequent crimes committed by the Whitechapel Ripper. Crime scenes and offender's home are reported with red and black circles, respectively; the first and last crime scenes are reported with yellow and green circles, respectively. Source: Author.

TABLE 2. Movement direction between successive crime scenes related to homicides committed by the Whitechapel Ripper.

ID	Movement direction
1-2	W
2-3	SE
3-4	W
4-5	NE

With crime scene 5, Jack the Ripper returned to strike closer to the vicious triangle, near to crime scene 2 (Figures 1, $2A_3$). It was possible that the SK did not extend further the comfort zone, moving to north or south, for the presence of the two physical (and presumably also mental) barriers constituted by the railway tracks located to the north and south of the comfort zone. The home of one of the suspects relapsed within the vicious triangle and the hull (Figure 1A). The shape of the hull evolved from a roughly equilateral triangle (Figure $2A_1$) to a roughly parallelepiped-shaped polygon (Figure $2A_{2-4}$). The measured buffer zone had a *radius* of about 275 m (*i.e.* 20% of the circle diameter). The criminal circle gradually increased in size moving south-westwards (Figure 2B). Jack the Ripper in his mental map tended to move first towards the south (Figures 1, $2B_2$) and then towards the west (Figures 1, $2B_3$).
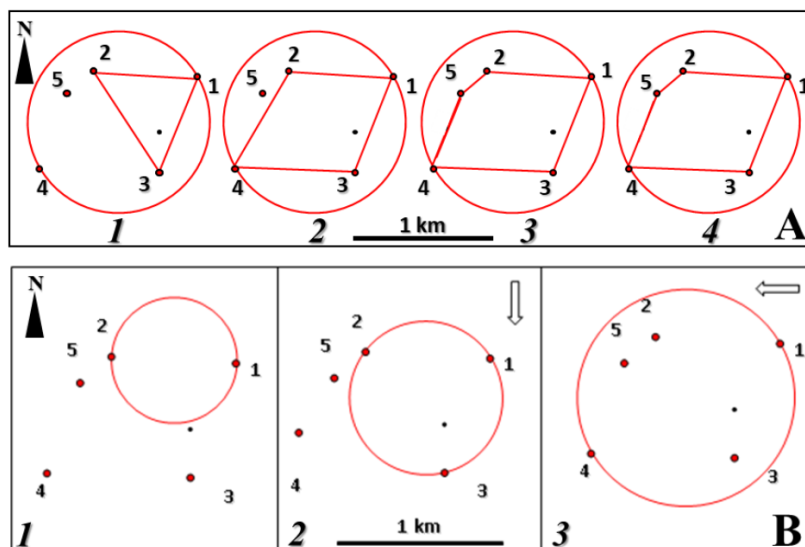
FIGURE 2. Crime maps of the spatio-temporal evolution of the serial homicides committed by the Whitechapel Ripper. A) Evolution of the hull. B) Evolution of the criminal circle. Crime scenes and offender's home are reported with red and black circles, respectively. Source: Author.

The graphics of Figure 3 showed the spatio-temporal evolution of Jack the Ripper's serial crimes. A general increase in the time interval among successive crime scenes, from 8 to 40 days, was observed (Figure 3A) with the exception related to the sequence 3-4 occurring at the same date (a few hours apart) presumably because during the crime 3 the SK failed in performing the mutilations completing his criminal plan (Canter 2003). The security distances between the first four successive crimes (1-2, 2-3, 3-4) were almost similar, being equal to about 800-900 m (Figure 3B). A significant decrease in the distances was recorded only in the sequence 4-5 (557 m, Figure 3B).

5.2. The Gloucester Monster. Fred West, known to the chronicle as the Gloucester Monster, was responsible for the kidnapping and killings of at least 14 women (including two belongings to his own family) in the Gloucestershire (UK). The SK killed with the complicity of his wife (Bennett 2006; Woodrow 2011; Boduszek and Hyland 2012; Harrison 2023). The period of criminal activity occurred from December 1972 to May 1975. The West spouses, after the kidnappings, killed their victims inside their home. Most of the bodies were buried in shallow clandestine graves dug in the garden and cellar of their house (Bennett 2006; Woodrow 2011; Boduszek and Hyland 2012). The crime maps of the spatio-temporal evolution of Fred West's serial crimes were reported in Figures 4 and 5 with the spatial position of the last sighting and kidnapping sites of only five of the victims (Table 3) and West's house (Somma 2022b).
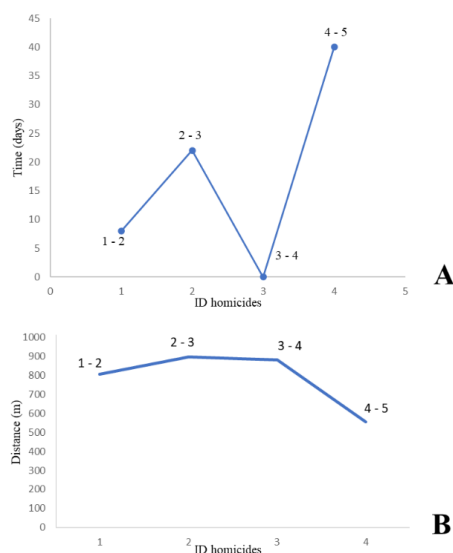
FIGURE 3. Graphs of the spatio-temporal evolution of the serial murders committed by the Whitechapel Ripper. A) Evolution of the time interval among successive crime scenes. B) Evolution of the security distances among successive crime scenes. Source: Author.

TABLE 3. Missing/abducted women and dates of disappearance related to crimes committed by the Gloucester Monster.

ID	Date of the homicide	Victims (initials)
1	12.1972	C.O.
2	11.1973	C.A.C.
3	27.12.1973	L.P.
4	11.1974	S.H.
5	05.1975	J.M.

The diameter of the criminal circle corresponded to the maximum distance between the places of disappearance/abduction 2 and 3. The circle had a diameter of approximately 33.76 km (Figure 4). The places of disappearances were distributed in all four quadrants of the circle. The pattern designed by the connection between the places of disappearance/abduction was very symmetrical (Figure 4). The offenders adopted a behaviour that involved moving from the southern to the northern quadrants, alternately, from one place of disappearance/abduction to the next one (Figure 4, Table 4). The spatio-temporal evolution of the criminal circle showed how the offenders, starting from a roughly central axis (ID 1-2), also aligned with the West house, moved first towards the east (ID 2-3; Figure $5A_2$) and then to the west (ID 3-4 and 4-5; Figure $5A_{3-4}$). The size of the criminal circle remained almost unchanged (Figure 5). The hull evolved over time and space so that its shape passed

from a roughly isosceles triangle (Figure $5A_1$) to a roughly parallelepiped-shaped polygon (Figure $5A_2$), and finally to a trapezoid (Figure $5A_3$). The offender's residence was outside the criminal circle and also outside the vicious triangle (Figure 5B). The buffer zone used by Mr and Mrs West had a *radius* of approximately 10 km.
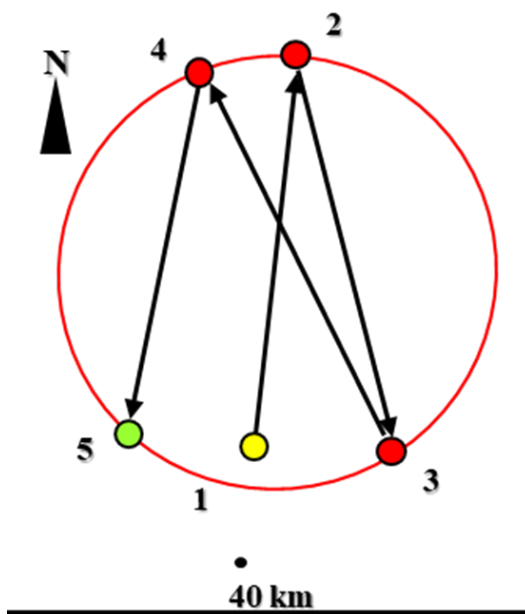

FIGURE 4. Crime scene pattern of subsequent crimes committed by the Gloucester Monster. Crime scenes and offender's home are reported with red and black circles, respectively; the first and last crime scenes are reported with yellow and green circles, respectively. Source: Author.

TABLE 4. Movement direction between successive sites of disappereance.

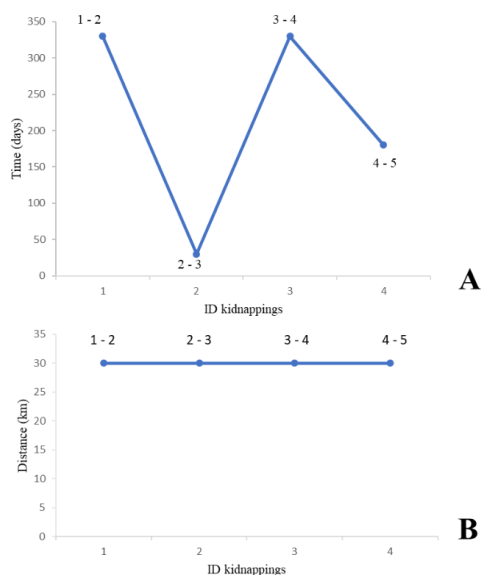| ID	Movement direction
1-2	NNE
2-3	SSE
3-4	NNW
4-5	SSW
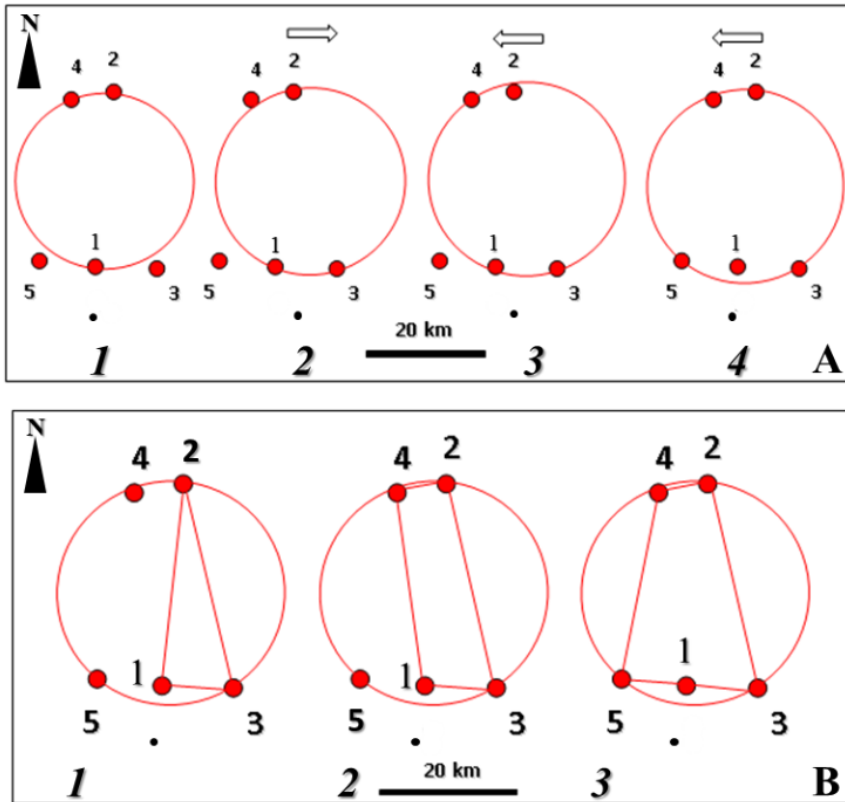
FIGURE 5. Crime maps of the spatio-temporal evolution of the serial kidnappings committed by the Gloucester Monster. A) Evolution of the criminal circle. B) Evolution of the hull. Crime scenes and offender's home are reported with red and black circles, respectively. Source: Author.

The spatio-temporal configuration of consecutive crimes was characterized by variable emotional cooling (Figure 6A) and very homogenous security distances (Figure 6B). The period of emotional cooling remained similar among crimes 1-2 and 3-4 whereas between the crimes 2-3 and 4-5 the period was shorter (Figure 6A). The series of events presented a certain cyclicity with time intervals tending to increase and decrease over time.

FIGURE 6. Graphs of the spatio-temporal evolution of the serial kidnappings committed by the Gloucester Monster. A) Evolution of the time interval among successive crime scenes. B) Evolution of the security distances among successive crime scenes. Source: Author.

5.3. The Yorkshire Ripper.

Peter William Sutcliffe, known in the chronicle as the Yorkshire Ripper, was the author of a series of heinous and interconnected attacks and murderers took place in the West Yorkshire (UK). The period of criminal activity lasted about 11 years, since 09/15/1969 to 09/24/1980. Sutcliffe killed 13 women and assaulted 10 others, among prostitutes and ordinary women (Wattis 2018; Cobb 2019). The GP was successfully applied to this case by the expert, Stuart Kind. Thanks to the expert's experience in the military field, Kind laid the foundations of the current GP (Kind 1987a,b; Canter 2003). Kind elaborated crime maps thanks to which it was possible to establish the relationships among criminal behaviour and geography, and locate the offender's home before his arrest. Notwithstanding, Sutcliffe was arrested for a casualty by the British police during a control point on the street of his vehicle[1]. The crime map reconstructed by Canter (2003) was based on the locations of 20 crime scenes and one of the two Sutcliffe's homes (Cobb 2019). The here reported crime maps of the spatio-temporal evolution of the Sutcliffe's attacks (Figures 7 and 8) took into account the spatial position of three more crime scenes and the two perpetrator's homes (at No. 57 in Cornwall Road in Bingley, and after 09/26/1977 in Garden Lane, Heaton in Bradford). The first 11 assaults occurred when Sutcliffe lived in Bingley, whereas the successive crimes were committed when he transferred in Bradford. The criminal activity was distributed geographically in three different comfort zones, localized in the areas of

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[1]https://www.history.com/this-day-in-history/the-yorkshire-ripper-is-apprehended (Accessed online 2 January 2022).

Chapel Town in Leeds, Bradford, and Manchester. Sutcliffe knew the geography of these places well; he knew Leeds because he used to frequent the pubs where he hooked up with victims; he knew Manchester because he frequented the red-light district; he knew Bradford because he resided in this area since 1977. The diameter of the criminal circle corresponded to the maximum distance between attacks 13 and 16 and was wide approximately 69.04 km (Figure 7). The places of the criminal activity were mainly distributed in the NE quadrant of the circle. Two fell in the SW zone, whereas the other two fell in the NNW quadrant of the circle bordering the NE quadrant (Figure 7). The two Sutcliffe's residences fell in the NE quadrant, *i.e.* in the area characterized by the highest density of crimes (Figure 7). No crimes were committed in the SE quadrant (and in the NW quadrant, being the two attacks 2-4 mostly on the borderline; Figure 7). The buffer zone during the first 11 attacks had a *radius* of approximately 4.65 km, whereas during the following attacks the *radius* reduced to approximately 2 km. The *radius* of the two buffer zones was equal to 7% and 3% of the criminal circle diameter, respectively. Sutcliffe adopted a behaviour which involved moving mainly from west to east and from NE to SW, alternatively, from one site of the attack to the next one (Figure 6, Table 6, Somma 2022b).

TABLE 5. Victims of assaults and homicides with dates of the events related to the crimes committed by the Yorkshire Ripper.

| ID	Date of the homicide	Victims of assaults and homicides (initials)
1	15/09/1969	Unknown
2	05/07/1975	A.R.
3	15/08/1975	O.S.
4	29/09/1975	T.B.
5	30/10/1975	W.M.
6	20/01/1976	E.J.
7	09/05/1976	M.C.
8	05/02/1977	I.R.
9	23/04/1977	P.A.
10	26/06/1977	J.M.
11	10/07/1977	M.L.
12	01/10/1977	J.J.
13	14/12/1977	M.M.
14	21/01/1978	Y.P.
15	31/01/1978	H.R.
16	16/05/1978	V.M.
17	02/03/1979	A.R.
18	04/04/1979	J.W.
19	02/09/1979	B.L.
20	20/08/1980	M.W.
21	24/09/1980	U.B.
22	06/11/1980	T.S.
23	17/11/1980	J.H.
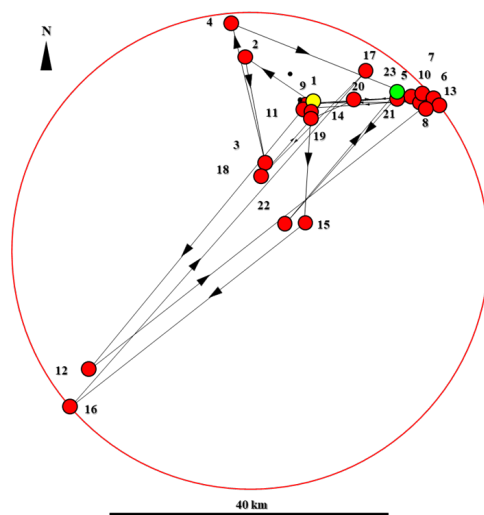
FIGURE 7. Crime scene pattern of subsequent crimes committed by the Yorkshire Ripper. Crime scenes and offender's home are reported with red and black circles, respectively; the first and last crime scenes are reported with yellow and green circles, respectively. Source: Author.

The spatio-temporal evolution of the criminal circle (Figure 8A) showed how the position of the circle and its size remained roughly unchanged until attack 4. The criminal circle moved east-wards during crime 5 and the diameter doubled compared with the criminal circle 1-2 (Figure $8A_3$). From attacks 5 to 11, the circle size remained roughly the same (Figure $8A_5$). The criminal circle moved SW-wards during crime 12 and the diameter increased in size to reach its maximum size (Figure $8A_6$). From attacks 12 to 15, the circle size remained roughly the same (Figure $8A_7$). From aggression 16 to 23, the circle did not change size and position and reached its maximum size (Figure $8A_7$). The hull appeared triangular until crime 11 (Figure $8B_{1-5}$); from crime 12 onwards the hull acquired a polygonal shape with four sides, strongly asymmetrical (Figure $8B_{6-8}$). The spatio-temporal configuration of consecutive crimes was characterized by highly variable emotional cooling (Figure 9A) and security distances (Figure 9B). The longest period of emotional cooling occurred between the first two crimes (Figure 9A) and lasted about six years (2119 days). During the successive attacks, the trend was characterized by 3 cycles in which there were phases of increase and decrease of times (Figure 9A). The largest security distances occurred between events 12-13 (63.7 km) and 16-17 (64.8 km) (Figure 9B). The trend was characterized by 3 cycles in which there were phases of increase and decrease of the security distances (Figure 9B). The distances travelled by Sutcliffe from home to the crime scenes were also analyzed (Figure 9C). The distances were calculated on the basis of the residence at the time the crime was committed. The distances travelled were comprised from about 2 km to 55 km. Two cycles were observed in the middle period of his criminal career (Figure 9C). By comparing the trends of the security distances among successive crime scenes and
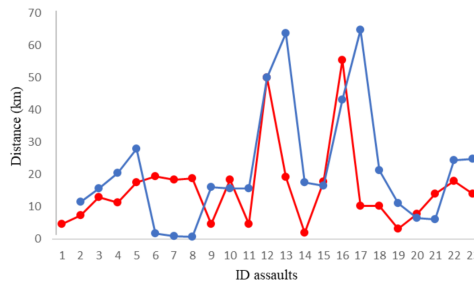
the trend of the distances among Sutcliffe's home and different crime scenes, it was possible to appreciate as the main cyclicity of the parameters roughly corresponded (Figure 10).

TABLE 6. Movement direction between two successive events of the serial crimes committed by the Yorkshire Ripper (7 times along the E-W axis, 7 times along the NE-SW axis, 3 times along the NNW-SSE axis, 2 times along the NW-SE axis, 1 time, along the WNW-ESE axis, 1 time along the ENE-WSW axis, 1 time along the N-S axis).

ID	Movement Direction
1 2	NW
2 3	SSE
3 4	NNW
4 5	ESE
5 6	E
6 7	W
7 8	SSE
8 9	W
9 10	E
10 11	W
11 12	SW
12 13	NE
13 14	W
14 15	S
15 16	SW
16 17	NE
17 18	SW
18 19	NE
19 20	ENE
20 21	E
21 22	SE
22 23	NE
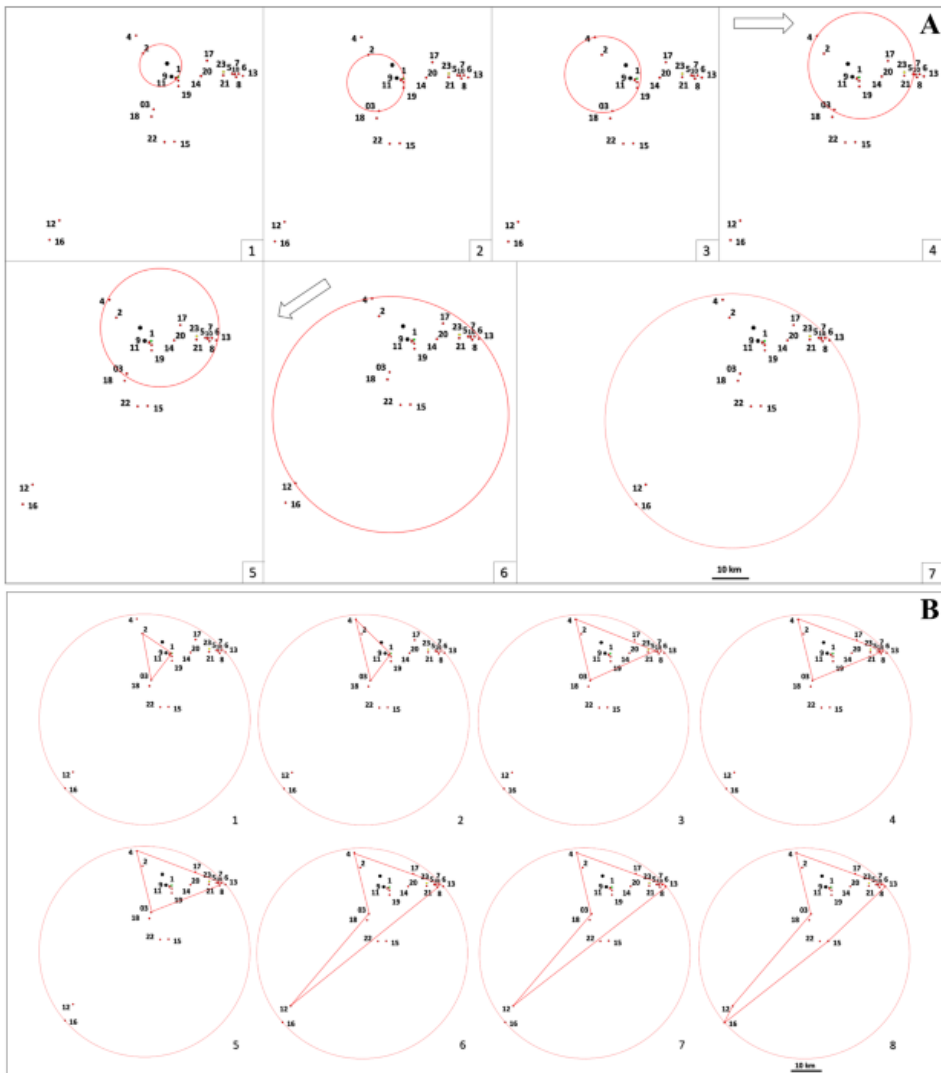
FIGURE 8. Crime maps of the spatio-temporal evolution of the serial assaults and killings committed by the Yorkshire Ripper. A) Evolution of the criminal circle. B) Evolution of the hull. Crime scenes and offender's home are reported with red and black circles, respectively. Source: Author.
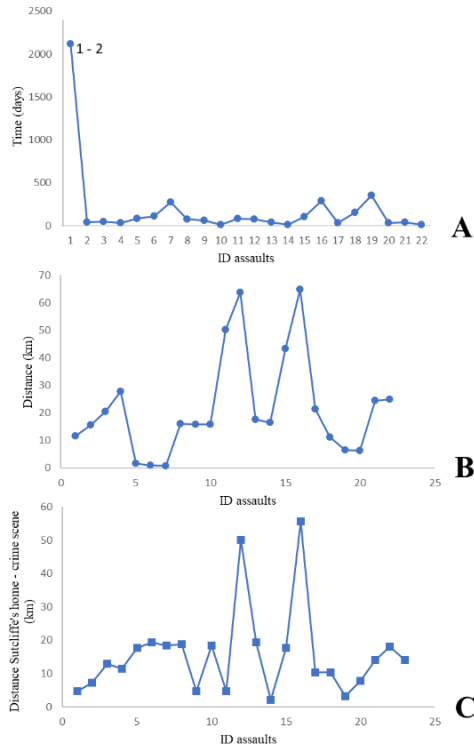
FIGURE 9. Graphs of the spatio-temporal evolution of the serial kidnappings committed by the Yorkshire Ripper. A) Evolution of the time interval among successive crime scenes. B) Evolution of the security distances among successive crime scenes. C) Evolution of the distances among Sutcliffe's home and different crime scenes ("journey to crime", Rengert, Piquero, and P. R. Jones 1999). Source: Author.

FIGURE 10. Comparison among the trend of the of the security distances among successive crime scenes (blue line) and the trend of the distances among Sutcliffe's home and different crime scenes (red line) - "journeys to crime" of Rengert, Piquero, and P. R. Jones (1999). Source: Author.

5.4. The Florence Monster. The Italian SK, known in the chronicle as the Florence Monster (or the Monsters of Florence, Giuttari 2022), had a very long criminal career, lasted almost 17 years (6227 days), since 21/08/68 to 09/08/1985 (Table 7), or 11 years (4013 days) if the first double homicide of 1968 is excluded, as supposed by some investigators (Giuttari 2022 and references therein). The SK killed 16 individuals (Table 7), among secluded couples looking for intimacy in isolated areas, during the night of new moon, inside their vehicle or camping tend in one case (Mascia 1983; De Fazio, Galliani, and Luberto 1984; De Fazio *et al.* 1985; Dunn *et al.* 1989; Bruno 1994; R. Perugini 1994; Bruno 1995; Catani 1997; Bruno and Marrazzi 2000; Pezzan and Brunoro 2011; Cochi 2020; Giuttari 2022; R. Perugini and Palmegiani 2022; M. Perugini and Cochi 2023). The murders usually involved a dual means of injury. Both victims were reached by multiple gunshot wounds (caliber 22), followed in most cases also by *post-mortem* stabbings (Giuttari 2022). In an escalation of violence, the SK started to accomplish also genital mutilation/cutting of the *pubis* and left breast of most of the women. Physical evidence left at the crime scenes was very limited. Notwithstanding, some experts observed and considered some immaterial traces left on the scenes, allowing to partly understand some aspects of his criminal behaviour and mental map (De Fazio, Galliani, and Luberto 1984; De Fazio *et al.* 1985; Bruno 1994; R. Perugini 1994; Bruno 1995; Giuttari 2022).

TABLE 7. Victims and dates of the homicides committed by the Florence Monster.

ID	Date	Victims (couple component 1; initials)	Victims (couple component 2; initials)
1	21.08.1968[a]	A.L.B.	B.L.
2	14.09.1974	P.G.	S.P.
3	06.06.1981	G.F.	C.D.N.
4	22.10.1981	S.B.	S.C.
5	19.06.1982	P.M.	A.M.
6	09.09.1983	W.F.H.M.	J.U.R.[b]
7	29.07.1984	C.S.	P.G.R.
8	08.09.1985	J.M.K.	N.J.M.

[a] It was hypothesized that the crime of 1968 was committed by Francesco Vinci and the husband of B.L. (Giuttari 2022). [b] It was hypothesized that the German man was mistaken for a woman, because of his long hair (Giuttari 2022).

According to what was reported in the rich existing literature, the sites chosen by the Monster all fell within the hilly countryside of the province of Florence (Chianti and Mugello) and were represented by isolated and rural areas, away from busy roads, in order to guarantee privacy to the couples. It was hypothesized that the Monster had to know very well the sites where he hit for previous experiences or inspections of the state of the places before the crimes (Giuttari 2022 and references therein). Most experts hypothesized the SK had very likely live or work in the areas where he decided to hit (Snook *et al.* 2005). Some references to the geographical aspect of the crimes were reported by the equipe of coroners (De Fazio, Galliani, and Luberto 1984; De Fazio *et al.* 1985) responsible for

most of the autopsies of the victims in their criminological and criminalistic report on the first seven double homicides (1968-1984). The coroners reported as *"The evaluation elements examined agree with what emerges from the scientific literature as regards some basic characteristics of the author of lust murderer; a subject who acts by choosing the places and situations but not the victims, who are generally unknown to him, under the pressure of an abnormal sexual impulse in which deep sexualized aggressive charges (sexual sadism) and a sexual desire (almost always heterosexual) converge, not finding other ways of satisfaction than those of sadistic action and sadistic masturbatory fantasies, within which his extra-criminal sexuality often ends* (De Fazio, Galliani, and Luberto 1984). Hundreds of suspects were identified during the complex investigations still today active (Giuttari 2022). Some of the suspects have been taken to trial (Pietro Pacciani - P.P., Giancarlo Lotti - G.L., Mario Vanni - M.V., known in the chronicle as the "*amici di merende*") (Giuttari 2022 and references therein). Two of them were convicted (G.L., M.V.), whereas P.P., thought to be the physical author of the crimes, deceased before the new trial (R. Perugini and Palmegiani 2022).

The life of P.P. (born the 7 January 1925 at Vicchio, in the Mugello) was not easy since he was a child, due to the life poor conditions, the mental illness of the mother, and the alcoholism problems of the father. His life was punctuated by some tragic events. On 13 April 1951 P.P. committed a homicide (passionate murder), for having found his girlfriend in profusion of love with another man in the countryside of Tassinaia of Vicchio. In the sentence in which P.P. was convicted in 1952, it was reported that P.P. declared to have seen her lover showing her left breast to the man. P.P., instigated by his girlfriend, brutally killed the man with a double injurious means. After 12 years in prison, he was released in 1964 (Giuttari 2022). He married in 1966 and had two daughters, but his wife went into *coma* after giving birth and woke up with a permanent disability[2]. P.P. returned again to prison in May 1987 for almost five years, for maltreatment of his wife and raping of his daughters since they were minors[3] (Giuttari 2022). On January 1993, P.P. was arrested on suspicion of being the Florence Monster. On November 1994, P.P. was sentenced to life imprisonment for the serial murders occurred from 1974 to 1985 but acquitted for the 1968 crimes. On February 1996, P.P. was acquitted by the Court of Assizes of Appeal, but on December 1996, the Supreme Court canceled the previous appeal sentence, ordering a new appeal process because the judgment was vitiated by technical errors. On the eve of the process-bis (5 October 1998), P.P. was found dead on February 22 in his home[3] (Giuttari 2022).

According to some authors, the motive for the homicidial series would be to be found in the circles of black magic, satanic sects, and exotorism. "Untouchable subjects" would have requested the fetishes to the "*amici di merende*" and other accomplices (Giuttari 2022 and references therein).

The here presented crime maps of the spatio-temporal evolution of the homicidal series of the Monster took into account the spatial positions of the crime scenes related to the murders carried out from 1968 to 1985 (Table 7; Figures 11, 12, 13) and homes of G.L., M.V., and P.P. (Figures 12, 13).

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[2]http://insufficienzadiprove.blogspot.com/2009/03/pietro-pacciani-memoriale-del-7-marzo_04.html
[3]https://www.poliziaedemocrazia.it/archivio/live/index-6305.html?domain=archivio&action=articolo&idArticolo=153 (Accessed online 10 December 2022)
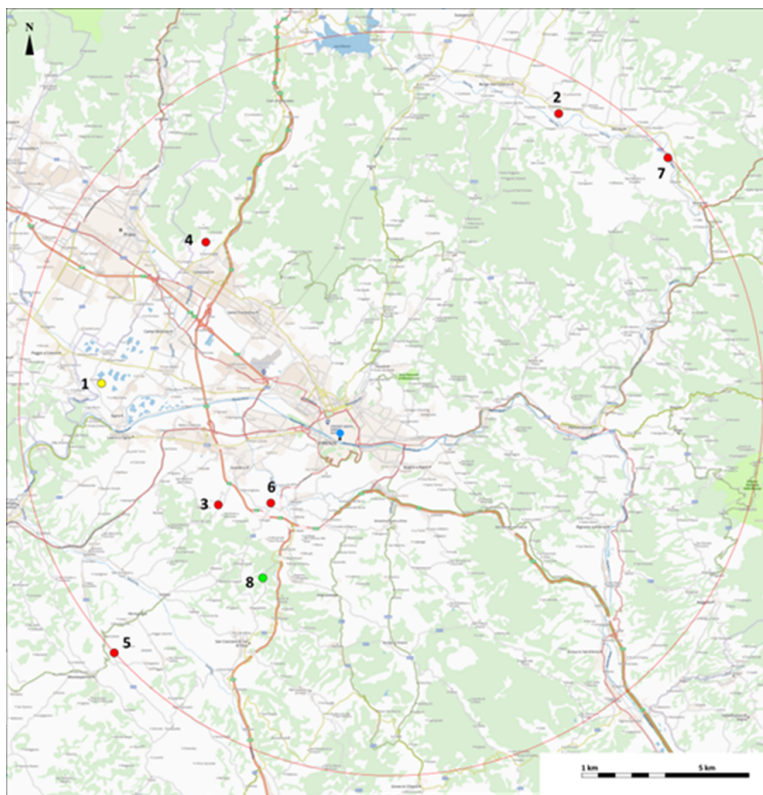
FIGURE 11. Crime map of the crimes committed by the Florence Monster between 1968 and 1985. Crime scenes are reported with red circles; the first and last crime scenes are reported with yellow and green circles, respectively. Source: Author.

The comfort zones fell within the area extending from Chianti (to the south) to the western Arno valley (to the north) and the Mugello area (to the NE). The diameter of the criminal circle corresponded to the maximum distance between attacks 5 and 7, equal to about 44 km (Figure 11). The crime scenes were mainly distributed in the SW quadrant of the circle. Two fell in the NE quadrant of the circle, whereas the other two fell in the NW quadrant (of which No. 1 was borderline with the SW quadrant, Figure 11). No crimes were committed in the SE quadrant as evidenced by Prof. Francesco Bruno (Bruno 1994, 1995). The area in which the residences of the perpetrators/suspects fell were all located in the SW quadrant, *i.e.* in the area where the density of crimes was higher. The buffer zone of M.V.'s home in San Casciano Val di Pesa, in Chianti, had a *radius* of approximately 4.4 km. The buffer zone of G.L.'s home in Ponterotto, in Chianti (during 1980s) had a *radius* of approximately 6.16 km. P.P. lived during his youth in Bovino, in Mugello. It would seem that P.P. moved to Montefiridolfi approximately between 1972/1973 where he lived until 1982, before moving to Mercatale. The buffer zone of P.P.'s home in Mercatale Val di Pesa,
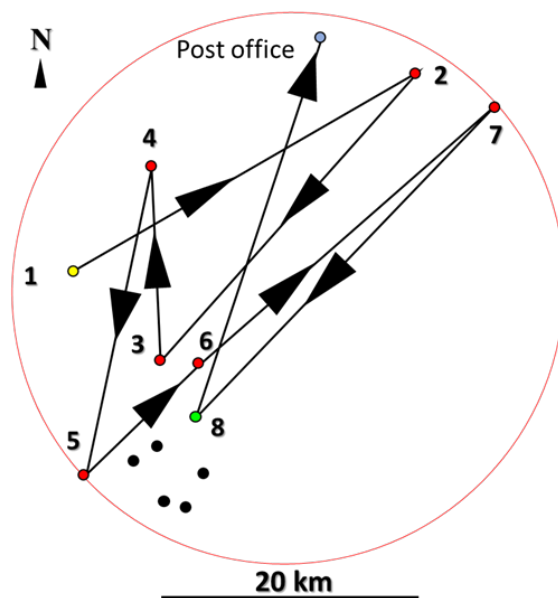
FIGURE 12. Crime scene pattern of subsequent crimes committed by the Florence Monster. Crime scenes and offenders' homes are reported with red and black circles, respectively; the first and last crime scenes are reported with yellow and green circles, respectively. The post office is reported with blue circle. Source: Author.

in Chianti (where he inhabited since about 1982), had a *radius* of about 7.1 km. The pattern drawn by the connection between successive crime scenes showed a general symmetry according to the NE/SW trend (Figure 12, Table 8). This characteristic was originally highlighted by Prof. Bruno (Bruno 1994, 1995). As intuited by this eminent criminologist, the Monster adopted a criminal behaviour according to which he moved alternately, from the southern to the northern quadrants, mainly along approximately NE/SW directions (from SW to NE and from NE to SW), each time he moved from one crime scene to the next one (Figure 12).

These trajectories included also the displacements from the scene of the last crime 8 to the post office in San Piero a Sieve (Mugello), where the SK posted to the magistrate S.D.M. an envelope containing a letter and part of the breast tissue of N.J.G.M. (Figure 12). The only exception to this pattern of alternating displacements was constituted by crime scene 6 which therefore acquired a particular criminological significance in the context of the present research. It was highlighted how the position of the place of the crime 6 was peculiar, if compared with the previous and successive scene, as it was the only crime scene to fall on the same straight line, linking crimes 5 to SW and 7 to NE, with crime 6 in the middle. The spatio-temporal evolution of the criminal circle showed how the position of the circle and its size remained roughly unchanged until crime 4 (Figure 13A_{1-2}). The criminal circle moved to SE during crime 5 and the diameter increased considerably in size until
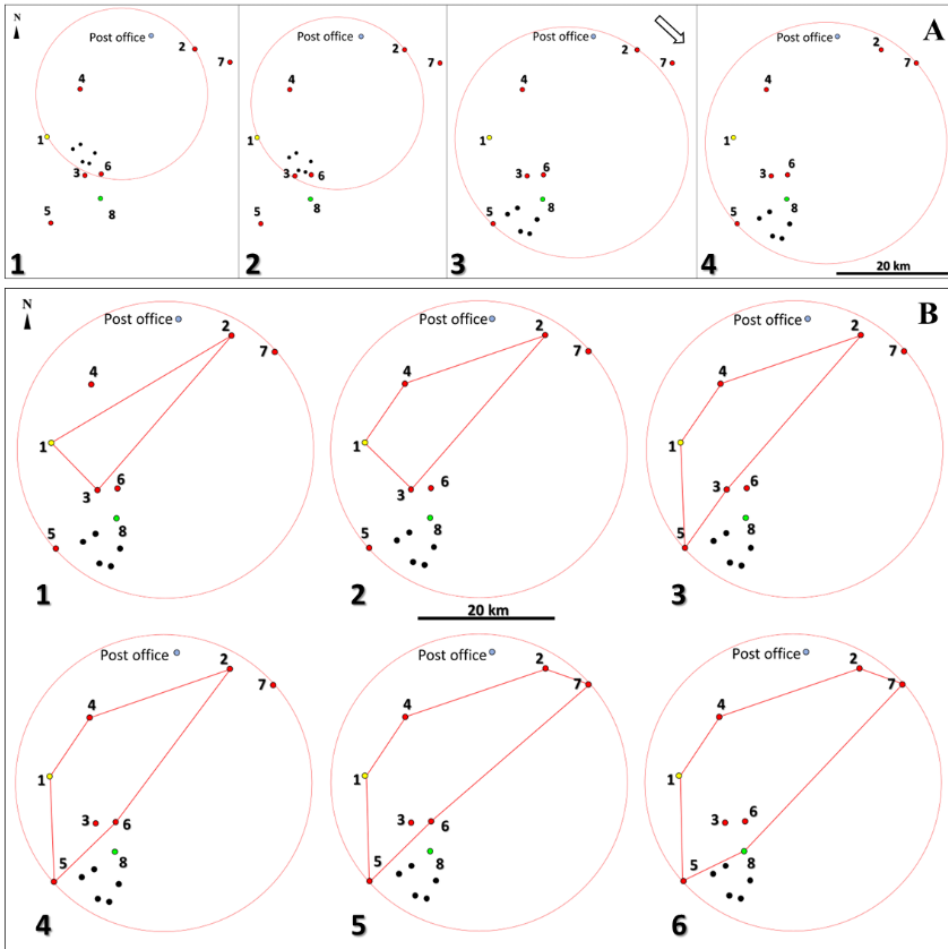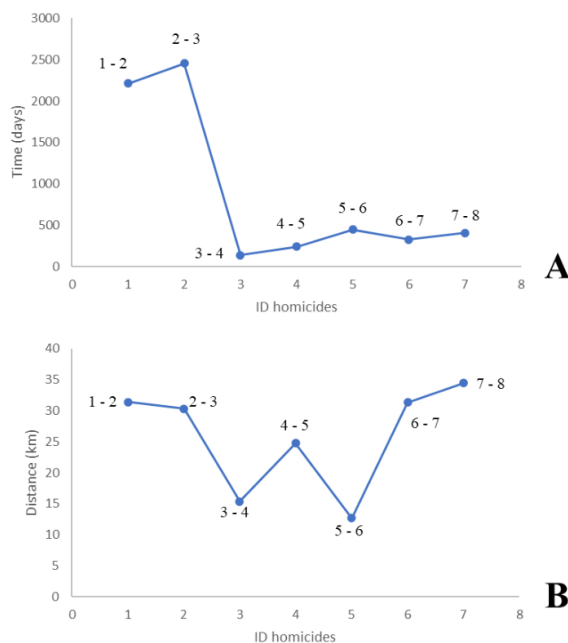
FIGURE 13. Crime maps of the spatio-temporal evolution of the serial homicides committed by the Florence Monster. A) Evolution of the criminal circle. B) Evolution of the hull. Crime scenes and offender's home are reported with red and black circles, respectively; the first and last crime scenes are reported with yellow and green circles, respectively. Source: Author.

it almost reached the maximum dimension (Figure 13A_3). Since crime 6 to 7, the circle remained roughly the same, reaching its maximum size (Figure 13A_4). The spatio-temporal evolution of the comfort zones evolved over time and space so that the hull increased in size and changed from a roughly isosceles triangular shape during the first three killings (Figure 13B_1), to a trapezoid-like polygon (up to attack 6, Figure 13B_{2-4}), and finally to an irregular six-sided polygon (Figure 13B_{5-6}).

The longest doldrums (Figure 14A) occurred between the first three homicides. The cooling periods were similar, ranging from just over 6 and 7 years. During subsequent

TABLE 8. Movement direction between two successive homicides committed by the Florence Monster (5 times along the NE-SW axis, 2 times along the NNE-SSW axis, 1 time along the N-S axis). Source: Author.

ID Homicides	Movement direction
1 - 2	NE
2 - 3	SW
3 - 4	N
4 - 5	SSW
5 - 6	NE
6 - 7	NE
7 - 8	SW
Post office	Displacement direction
8 - Post office	NNE

murders there was a general trend of increasing times. The *stasis* between crimes 5 and 6 was an exception, since subsequently between crimes 6 and 7, there was a decrease in the *stasis* followed by an increase between crimes 7 and 8 (Figure 14*A*). The spatio-temporal configuration of consecutive crimes was characterized by highly variable security distances between successive scenes (Figure 14*B*). The largest security distances occurred between crimes 1-2 and 7-8. During the homicides there was a decrease in the distances between crimes 1 and 4 and an increase from 6 to 8. The sequence 4-5 was an exception in which there was an increase in the distances compared to sequences 3-4 and 5-6 (Figure 14*B*).

FIGURE 14. Graphs of the spatio-temporal evolution of the serial homicides committed by the Florence Monster. A) Evolution of the time interval among successive crime scenes. B) Evolution of the security distances among successive crime scenes. Source: Author.

6. Discussion and conclusions

The investigated space and time criminal behaviour of four European lust murderers (Whitechapel Ripper, Gloucester Monster, Yorkshire Ripper, and Florence Monster) allowed to:

i Confirm that these SKs had a marauder behaviour, falling the bases/residences of the suspects within the criminal circle. An exception was represented by the Gloucester Monster; it is likely that this different result could simply depend on the fact that the considered crimes in the investigation were only 5 on the total number of 14 victims.

ii Recognize how SKs moved near the comfort zones within buffer zones with spokes, in relation to the diameter of the criminal circle.

iii Understand that these SKs followed rigid models of the criminal spatial behaviour in the elaboration of their mental maps.

iv Identify cyclical phases of the periods of emotional cooling in all the examined SKs' behaviours, except in the Florence Monster. Decreasing and increasing trends presumably could depend on stages in which the desire to kill and avoid getting caught would have alternatively prevailed, respectively, but it cannot be excluded that they could simply depend on the cycles that SKs usually live from the auroral to depressive phase. Cycles could be related also to the type of pathology, criminogenesis, and criminodynamics.

v Hypothesize that these SKs were presumably of organized type and with severe personality disorders, especially psychopathic personality disorder or psychopathy. SKs suffering of mental illnesses (*psychosi*s or *schizophrenia*) should have presumably perceived the spatial dimension of the crimes in a very different way.

In particular, among the examined SKs, the results of investigations on the Florence Monster and the Yorkshire Ripper resulted particularly significative. In both SKs' behaviours:

i Cyclical phases of the security distances were identified. As evidenced for the cyclicity of emotional cooling, decreasing and increasing trends could depend on analogous motivations.

ii The first crimes were characterised by times of emotional cooling peculiar for their long periods and for being at the beginning of their criminal career.

In the case of the Florence Monster, in particular, this research allowed to:

i Identify a peculiar almost constant increasing trend of emotional cooling times, after the commission of the first crimes. This trend could be interpreted in terms of a more significant form of self-control in dominating himself during the phases in which the SK lived the desire of killing. The marauder serial predators tend to commit two successive crimes with periods of "emotional cooling" increasingly greater, trying to reduce the risk to be discovered. Notwithstanding, also the complexity of the fantasy, increasing in the time, could contribute to determine this trend. The SK (especially the psychopath) raises the bar of his fantasy, being no longer enough for satisfying his desire, makes it more complex and therefore also its realization needs more time.

ii Identify some mistakes made by the SK and the consequent spatial-temporal behavioural responses. The criminal behaviour of the SK consisting in the scheme of choosing the successive crime scene in a site located into the northern quadrants, if the previous site was in the southern quadrants, and *vice versa* had only one exception. Crime 7 was located to north of crime 6. This could be dependent on the fact that the SK killed the couple of German men for a mistake, and the SK cancelled this site from his mental map, "relacing" with crime 7 the previous crime 6 (Figure 12), being crimes 5-6-7 perfectly aligned.

iii Evaluate high his coefficient of awareness and "experiential depth".

iv Recognize a criminal pattern very similar to that characterizing the serial crimes committed by the so-called Shankhill butchers in west Belfast (Northern Ireland) during the 1970s (Figure 15) (Ruffell and McKinley 2008).
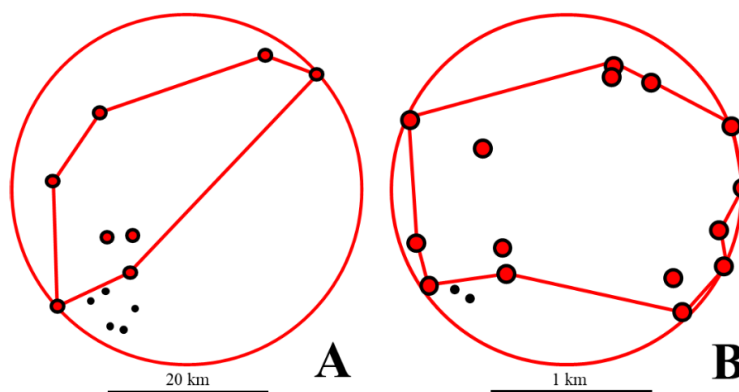
FIGURE 15. Comparison between the hull of the serial homicides committed by the Florence Monster (A) and the Shankhill butchers in west Belfast (Northern Ireland) (B). In both cases, the homes of the suspects were localized outside the hull, near the perimeter. Crime scenes and offender's home are reported with red and black circles, respectively. Source: Author.

Finally, in the case of the Yorkshire Ripper, this research allowed to:

i Identify how the trend of the distance between the home of the offender and the crime scene ("journey to crime") had a pattern similar to that of the security distance. This observation may suggest that the security distance could have a predictive role in identifying the home/base of the offender.

ii Recognize how much experienced/elderly was the SK in the "debut of his criminal career". Criminal circles, very reduced in size in the early crimes, strongly increasing in the time, could suggest a SK with low experience and insecurity in the first crimes followed by acquired experience and security in the commission of the criminal acts.

The analysis of emotional cooling and security distances may provide evidence of similarities but especially differences between the various offenders' behaviours. These results can prove useful for the purpose of profiling and investigating their personality, specifically being indicators of the trend of psychopathology, its severity, and type. In reflecting aspects of the personality, they are therefore useful for the identification of SKs (personal communication of Sarah Margherita Silvera).

In conclusion, the results obtained in the present research confirmed how useful and profitable might be the application of an inter- and transdisciplinary approach, based on principles and methods of investigative psychology, criminal and GP, and GIS technology, in dealing with investigations related to immaterial evidence from serial lust murders. The approach used in the present research could be also used for more widespread serial crimes, such as rape, theft/robbery, and arson. At the same time, as evidenced tens of years ago, it is necessary to underline that researchers should be aware of the assumptions and complexities in dealing with modeling of criminal behaviour (Rengert, Piquero, and P. R. Jones 1999) and take care of some caution.

Acknowledgments

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