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Social Science Computer Review 2007; 25; 210
DOI: 10.1177/0894439307298924

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Social Science Computer Review
Volume 25 Number 2
Summer 2007 210–238
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Integrating Distance Into Mobility Triangle Typologies

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Achieving a more complete understanding of the behavioral aspects of homicide has great potential for developing more targeted intervention and prevention strategies. One avenue to increased understanding is through the study of the spatial behavior of the parties involved. Mobility triangles have been used to describe the spatial relationships and develop a spatial typology of crime events. Mobility triangles enable the classification of crimes into types based on the relative locations of offender home address, victim home address, and homicide location. This work focuses on the crime of homicide and examines the 2,773 mobility triangles developed from homicide events in Washington, D.C. The research extends the traditional mobility triangle by defining and analyzing the explanatory power of a new type of mobility triangles based on distances. The analysis compares the output of the area-based traditional mobility triangle typology with that of a distance-based mobility triangle typology.

Keywords: *geographic information systems; spatial typology; homicide; geometry; opportunity theory*

Theoretical frameworks such as routine activity theory (Cohen & Felson, 1979; Felson, 2001, 2002; Felson & Cohen, 1980) and environmental criminology (P. J. Brantingham & Brantingham, 1978, 1984, 1981/1991; P. L. Brantingham & Brantingham, 1993) emphasize how the everyday activities of individuals either facilitate or hamper the convergence of potential victims and motivated offenders in space and time. As a group, these opportunity theories recognize the importance of places and travel behavior in understanding the phenomenon of convergence. Related work in geography and criminology has recognized the role of anchor points (e.g., home, workplace, school) in providing fixed locations from which travel patterns are generated over time (Golledge, 1978; Golledge & Stimson, 1997; Rengert, 1988).

Early researchers examining the role of human activity in facilitating the convergence of victims and offenders focused on the distance the offender traveled from the home address to the location of the crime, and only a few examined the victims' "journey to crime" (Bullock, 1955; Normandeau, 1968; Wiles & Costello, 2000).[1] These studies pointed to consistencies in the characteristics of the journey to crime for both offenders and victims.

Authors' Note: This research effort benefited from the input of a variety of individuals who made both substantive and technical contributions. George Rengert and Jerry Ratcliffe provided valuable insights regarding initial patterns of triangles and suggestions regarding the analysis plan. Deborah Weisel's questions prompted our examination of dots, lines, and triangles. Anonymous reviewers contributed comments that improved the final research. On the technical front, the work benefited from the custom programming contributions of two ESRI-Vienna staff members, James Cardona and Jo Fraley. The authors appreciate Ron Wilson's encouragement of our research. This research was supported by the Grant 2003-IJ-CX-0150 from the National Institute of Justice.

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They found that both victims and offenders are relatively close to home when crimes are committed. Taken together, these studies provide a solid empirical foundation for understanding how human behavior facilitates or impedes the commission of a crime.

Although these studies quantified distances traveled, they did not address the joint relationship between where the offender or victim lived and where the crime was committed. In an attempt to address this gap, several researchers have examined the "mobility triangles" of crime (Amir, 1971; Burgess, 1925/1967; Normandeau, 1968; Rand, 1986; Tita & Griffiths, 2005). Normandeau (1968) developed a mobility triangle typology that identified the home address of victims and offenders and the location of the crime as primary anchor points in crime events. His typology identified five configurations of events based on whether the offender home, victim home, and the location of the incident were in the same or different social areas. More recent studies demonstrate that the characteristics of homicides vary with their classification within a mobility triangle typology.

To explore the potential advantages of making explicit the role of activity spaces on the distribution of crime, we quantify the relative distances among anchor points (i.e., home and incident addresses) for each crime event and use those to create a distance-based mobility triangle typology. We then apply a social-area typology to the same data set. Finally, we use logistic regression to provide insights into whether homicide characteristics vary based on their spatial typologies.

Theoretical Background

Opportunity theories serve as the basis for mobility triangles because they emphasize the convergence of victims and offenders in space and time. Theoretical frameworks such as routine activity theory and environmental criminology fall within the rubric of opportunity theories. As a group, they recognize the importance of places and travel behavior in understanding the phenomenon of convergence. They identify routine human activity by both offenders and victims as driving convergence. Whenever the routine activity spaces of potential victims and offenders intersect, the likelihood of a crime increases.

Two opportunity theories have proven especially beneficial in developing a better understanding of spatial behavior and its relationship to crime events, environmental criminology, and routine activity theory. Environmental criminology is concerned with the place at which a victim, an offender, and a law intersect to produce a crime (P. J. Brantingham & Brantingham, 1981). The theory emphasizes the factors that bring offenders and victims together at a specific place and how victims and offenders are distributed throughout space. It also highlights that criminal events occur during the course of normal human activity, both for offenders and victims.

Routine activity theory (Cohen & Felson, 1979; Felson, 2001, 2002; Felson & Cohen, 1980) also emphasizes spatial convergence and identifies four necessary elements involved in a crime event. Three of the four must be present for a crime to occur—a motivated offender, a suitable target, and the absence of capable guardians. The fourth element, routine activity, operates as an umbrella factor that encompasses the travel behavior of the other three elements. Cohen and Felson (1979) note that changes in the routine activities of offenders or targets result in either greater or fewer opportunities for crime because they change the frequency with which offenders and victims converge in space and time.

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Geographical theory also provides information regarding the description of the activity patterns of urban residents. The concept of *activity space* is especially useful because it describes the area of the urban environment with which an individual interacts on a daily basis (Horton & Reynolds, 1971). The size and shape of activity spaces vary depending on home location (city vs. suburb), sex, socioeconomic class, and age (Chapin & Brail, 1969; Harries, 1999; Horton & Reynolds, 1971). Women and children tend to have more constrained activity spaces; men and young adults have larger activity spaces. In general, activity spaces consist of the places people visit and the routes they take to get there. Anchor points are places that appear routinely in activity spaces (Golledge, 1978; Golledge & Stimson, 1997; Rengert, 1988). Relatedly, criminologists put forward the idea that offenders develop activity spaces just like law-abiding members of society (P. J. Brantingham & Brantingham, 1981, 1984).[2] Crimes are most likely to occur where the activity spaces of the two groups overlap.

Empirical research on both victims and offenders, although not able to directly measure routine activities, provides some general information regarding the distances offenders and victims are from their residences when a crime occurs and the distance between their two homes. These distances are important because the frequency with which individuals come in contact with one another is often because of proximity of residence or type of relationship (Block, Galary, & Brice, 2004). Neighbors tend to see each other more often because they live close to one another. In general, intimates and friends have more contact than acquaintances or strangers.

In the journey to crime literature, there is broad agreement that offenders' journeys to crime are short (Capone & Nichols, 1976; Harries, 1980; LeBeau, 1987; Rossmo, 2000; Toolkits, 2001; Turner, 1969; Wiles & Costello, 2000).[3] This phenomenon has been hypothesized to reflect a preference to commit crimes in areas with which the offender has personal knowledge (P. J. Brantingham & Brantingham, 1981; Capone & Nichols, 1976). The finding also has implications for determining the crime potential for each neighborhood as a function of the number of criminals living nearby (Katzman, 1981). If, as suggested by the literature, crime journeys are short, then the crime potential of a particular block rises with the number of criminals who reside nearby.

As just reviewed, most extant research examines offender and victim travel separately and thus cannot address the joint spatial structure travel to crime events. One notable exception is the work done with mobility triangles to create a classification system based on three known locations: incident location, victim's home address, and offender's home address. Conveniently, these locations represent the origins of offender and victim travel and the convergence of the two at a crime location. Traditionally, the classification of incidents into mobility triangles has involved the assignment of each of the locations to a social-area designation, most often neighborhood or census tract. The choice to classify by neighborhoods reflects their importance as representations of relatively homogenous areas within which people are more likely to have shared acquaintances, mores, and characteristics.

Burgess (1925/1967) was the first to investigate whether a crime and its perpetrators were associated with the same neighborhood. Lind (1930) extended his research and applied it to the study of juvenile delinquency triangles. It was Normandeau (1968) who created the five-category typology to describe the joint distribution of offender's address, victim's address, and crime location. He defined a neighborhood triangle as a crime in which all three locations share a common neighborhood (i.e., a local phenomenon). An offender mobility triangle characterizes situations in which the victim and incident locations are in

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the same neighborhood but the offender travels from a different neighborhood. Similarly, a victim mobility triangle occurs when a victim travels to the offender's home neighborhood and is victimized. When the victim and offender live in the same neighborhood, and the crime occurs in another neighborhood, the event is part of an offense mobility triangle. A total mobility triangle occurs when there is no overlap among the neighborhoods containing the three locations. These five categories represent a mutually exclusive classification scheme describing the sociospatial relationships among an offender's home, a victim's home, and a crime location. He then classified street robbery events in Philadelphia according to whether the pivotal locations (offender home address, victim home address, and address of the crime) were in the same social area or in different social areas.

Normandeau's (1968) mobility triangle classifications have served as the basis for investigations of rape (Amir, 1971), homicide (Tita & Griffiths, 2005), and various other crimes (Rand, 1986). Rand (1986) advanced mobility triangle research by applying Normandeau's five-category classification scheme to several different crimes in the same city. Tita and Griffiths (2005) continued using Normandeau's categories, albeit with new names, keeping the underlying criteria the same.

The body of research on mobility triangles found that the type of triangle varied with the type of crime. Robberies tended to be either victim or offender mobility triangles (Rand, 1986). Neighborhood triangle was the most frequently occurring triangle for rapes (Amir, 1971). Only two studies have examined homicide (Rand, 1986; Tita & Griffiths, 2005). Rand (1986) found neighborhood triangles were the most frequently occurring type of homicide triangle but she had only 17 observations. In contrast, Tita and Griffiths (2005) had 420 homicides in their data from Pittsburgh. They found total mobility triangles to be the most frequently occurring type of homicide (28.3%) and neighborhood triangles (26.9%) as the next most frequent. Offender mobility triangles (21.9%) and victim mobility triangles (18.3%) accounted for similar proportions, whereas offense mobility triangles accounted for only 4.5% of the homicides.

These studies demonstrate the existence of an identifiable spatial typology that describes the joint mobility of offender and victim. In addition, they show that the type of spatial typology varies by type of crime. However, the value of mobility triangles goes beyond the already substantial benefits derived from classification of events into joint distributions. Their real value is in laying the foundation for the simultaneous examination of victim, offender, place, and event characteristics (Tita & Griffiths, 2005). The results of such an analysis can inform problem-solving activities and aid in homicide investigations.

Despite the potential advantages outlined above, the validity of mobility triangles has been challenged on several fronts. One of the most serious challenges stems from the modifiable areal unit problem (MAUP)—a problem inherent in all research that aggregates individual level data to areal boundaries (Fotheringham, Brundson, & Charlton, 2000; Haining, 1990). Data aggregation is itself a type of categorization that enables large amounts of data to be summarized. The difficulty is that placement of boundaries to define an area determines which events are included in that area. The boundaries therefore influence the outcome of an analysis by placing events in one area rather than another.

One solution to these issues is to develop a new mobility typology based solely on the distance between events. However, using distance to characterize spatial coincidence has its own drawbacks. Distance is a sterile measure that fails to integrate information about the social milieu in which the homicide took place. The importance of neighborhoods and neighborhood

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boundaries on spatial behavior has been clearly demonstrated (Bursik & Grasmick, 1993). Crossing from one neighborhood to another often carries with it a significant change in housing, racial makeup, and exposure to crime. Thus, the decision to go to another place may have less to do with physical distance than with social distance. People frequent areas within which they feel comfortable. Human behavioral patterns are reflected in the spatial structure of their activities. Their activities, in turn, directly influence the convergence of victims and offenders. In addition, neighborhoods provide easily recognizable places for which analytical results can be discussed.

The advantages of a distance measurement are twofold. First, the classification is based on the distance traveled and is thus consistent for all incidents. This is in contrast to areal units, where the classification of a particular configuration is affected by the size and shape of the neighborhoods chosen. Second, distance-based measures for each side of the triangle are produced and, when taken together, provide the basis for testing the differential impact of travel to crime across victim and offender travel distance and the distance between residences.

Finally, we used a logistic regression to more fully evaluate whether social-area or distance-based typologies can be effective at capturing other homicide event, victim, or offender characteristics. Beginning with the seminal research by Wolfgang (1958), the existing body of research provides a clear description of the personal characteristics of homicide offenders and victims. Both homicide offenders and victims tend to be African American (Miethe & Regoeczi, 2004; Wolfgang, 1958). In general, males are more likely to be involved in a homicide as either victim or offender than are females (Miethe & Regoeczi, 2004). The incidence of both victimization and offending significantly varies by age (Miethe & Regoeczi, 2004). Wolfgang (1958) found that offenders tend to be younger than victims on average. In addition, he found that the highest rates of offending are among young males regardless of race, whereas victims tend to be older regardless of race or sex. Relationship between offender and victim is also important. Most homicides involve offenders and victims with some type of intimate or casual relationship (Miethe & Regoeczi, 2004; Wolfgang, 1958).[4]

In sum, both social-area and distance typologies offer important and in some ways complementary information to the study of homicides. Traditional mobility triangle research represents an initial attempt to incorporate the social intersection of a victim's home, an offender's home, and a homicide location. In this research, we first decompose the triangles into more specific geometries (i.e., dots, lines, and triangles). Next, we apply the traditional, social-area typology to homicides in Washington, D.C., and compare the results to those for Pittsburgh, Pennsylvania. Then, we develop and apply a distance-based typology to explore whether the resulting classification illuminates the same or different characteristics by type of triangle. By including both, we are able to explore the impact of physical distance versus social distance. Finally, we use logistic regression to examine whether there are characteristics of homicide offenders, victims, and/or events that discriminate among the different spatial classifications.

Data and Method

This research explores the use of spatial typologies to increase our understanding of the convergence of victims and offenders in space. Both a social-area mobility triangle

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typology and a distance-based typology are applied to homicide data in Washington, D.C., from 1990 to 2002. The homicide database, obtained from the Metropolitan Police Department of the District of Columbia, includes three essential location-related elements describing the address where the homicide occurred, the home address of the victim, and, for closed cases, the home address of the offender or offenders. It also includes the characteristics of the event, victim, and offender. For the study period, 2,311 homicides were closed, for a clearance rate of 58.4%, whereas 1,644 (41.6%) remained open. These rates are as of our cutoff date for data collection of March 2003.

Following Block et al. (2004), the unit of analysis is a triad, which is defined as the combination of a homicide location, victim's home address, and offender's home address. Multiple triads are formed when multiple offenders are associated with a homicide. For example, three triads would be developed for an incident in which there are three offenders who killed a victim. We believe it is important to include all known offenders because they have different mobility patterns. Although there were a total of 4,552 homicides during the period, all three locations were available for only 2,773 unique combinations of event location, victim home address, and offender home address.[5]

All measurements are calculated using Euclidean distances. Euclidean distance is the straight-line distance between two points.[6] The key advantages of the Euclidean distance are that it is easy to calculate through a geographic information system and it provides a convenient heuristic to describe the relative distances between locations. One criticism of Euclidean distance is that it does not take into account the transportation network of an area that might change the route taken. However, recent empirical research has demonstrated a strong and positive linear relationship between Euclidean distance and street distance (Groff & McEwen, 2005).[7] Distance from home address to an event location is only an estimate of the journey to victimization because there is no way of knowing whether victims and offenders were at home immediately prior to the event. Euclidean distances do, however, serve as good proxy measures for activity spaces of participants (Rhodes & Conly, 1981).

Although the data set assembled for this analysis is comprehensive, it has several limitations. Three factors introduce an unknown amount of bias into the study results. First, including only those cases where all three locations were known may produce a biased sample. Block et al. (2004) conjecture that homicides in which all three addresses are known might overrepresent those in which the victim and offender had some prior relationship or the distance traveled by both parties was short. Second, the process of geocoding reduces the number of observations because some data are not able to be assigned a geographic location. Limiting the analysis to geocoded events introduces an unknown level of bias because systematic bias can occur, for example, when certain types of locations are not geocoded. The large size of the sample mitigates but does not erase this potential bias. Third, the use of the home to location distance as a measure of distance traveled is a heuristic device and should not be taken as assuming that the victim or offender began at home and directly proceeded to the location of the crime (Rhodes & Conly, 1981). We recognize that it is far more likely that the trip to the location of the homicide did not start at home for either the offender or the victim and that it involved intermediate stops. However, information was not available on other locations (e.g., work, recreation, a friend's residence) from which victim's or offender's journeys may have started (Horton & Reynolds, 1971; Wiles & Costello, 2000).

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Analytical Strategy and Distance Typology Development

We begin with a descriptive analysis of the triads, which provides an overview of characteristics of the events, offenders, and victims. To better characterize the homicides, they are classified by other geometries (i.e., dots, lines, and triangles) that appear in the data. Dots represent homicides where both the victim and offender lived in the residence where the homicide occurred. Lines represent homicides that occurred in the home of either the victim or offender. Triangles consist of three noncoincident locations, that is, a victim and offender did not live together, and the homicide took place somewhere else.

Two different mobility triangle classifications are generated and compared. The traditional social-area typology is applied to the data. Then, the typology is extended through the use of distance-based measures. Distance measures may provide a more accurate picture of the relative relationships of the three locations to one another. Creation of the two typologies involves different steps. To create a social-area typology, the first step is to decide on the areal unit. We use neighborhood clusters obtained from the District of Columbia Office of Planning as our social areas because they represent easily recognizable places in the city. Neighborhood clusters are larger than census tracts, usually encompassing between 4 and 10 census tracts per cluster depending on the size of each areal unit. For each event, the clusters for offender home, victim home, and incident location are compared and a classification is made. For example, if all three neighborhoods are the same, the event is classified as a neighborhood triangle.

Creation of a distance-based typology is more complex because of the conversion from a continuous measure to a categorical one. A categorical measure is needed for the typology, so a cutoff distance is used to evaluate the distance measure for each pair of locations and to assign a value of inside or outside the distance.[8] For example, if the distance between offender home and incident location, the distance between victim home address and incident location, and the distance between victim home and offender home are all less than the cutoff distance of one fourth of a mile, then the event is classified as a neighborhood triangle. Four different cutoff distances are compared. We chose one fourth of a mile as the smallest distance because it is widely considered to be the distance an individual will walk to public transportation, shopping, and so on and thus makes a good surrogate for frequent interaction space (Calthrope, 1993; Nelessen, 1994). One fourth of a mile is just more than three blocks in Washington, D.C. The one-fourth-mile distance has also been shown to be important in criminal behavior. Research on drug-dependent criminals indicates they travel about three blocks from a drug sale location to commit property crimes (Rengert, 1996). The other three cutoffs build on the one-fourth-mile distance band and offer the ability to cut the problem into fixed-width slices.[9]

Figure 1 depicts the five types of social-area and distance-based mobility triangles. The relative proportions of homicide triangles will be computed for each type of classification. We also examine differences between the two typologies. Finally, we use multinomial logistic regression to identify the relative significance of event characteristics in differentiating cases across the five categories. For presentation purposes, only the multinomial regression results for the half-mile distance typology and the social-area typology are discussed.

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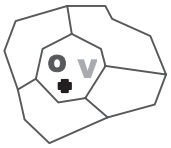
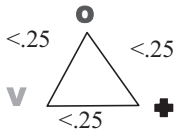
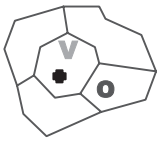
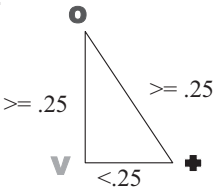
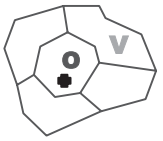
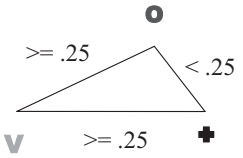
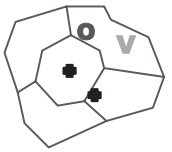
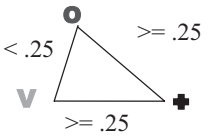
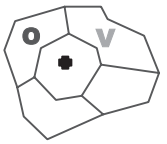
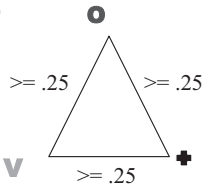
Figure 1
Traditional and Distance Mobility Triangle Typologies

Type of Homicide	*Sample Traditional Diagram* Code	*Sample Distance Diagram* Code
Neighborhood	**1** 	**1** 
Offender Mobility	**2** 	**2** 
Victim Mobility	**3** 	**3** 
Offense Mobility	**4** 	**4** 
Total Mobility	**5** 	**5** 

Findings

The descriptive analysis is provided first to provide context for the regression analysis.

Description of Triad Data

For the homicides composing the triads, Table 1 shows that victims and offenders were overwhelmingly male (88% of victims and 95% of offenders) and African American (94%

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Table 1
Demographics of Triad Victims and Offenders

	Victims		Offenders	
Characteristic	*n*	%	*n*	%
Gender				
Male	2,426	87.5	2,633	95.0
Female	347	12.5	140	5.0
	2,773	100.0	2,773	100.0
Race				
African American	2,595	93.6	2,689	97.0
White	82	3.0	20	0.7
Hispanic	71	2.6	55	2.0
Other	25	0.8	9	0.3
	2,773	100.0	2,773	100.0
Age category				
Younger than 18 years	292	10.5	443	16.0
18-24 years old	1,067	38.5	1,503	54.2
25-34 years old	781	28.2	554	20.0
35-49 years old	464	16.7	213	7.7
Older than 50 years	169	6.1	60	2.2
	Average Age (*M*)	*SD*	Average Age (*M*)	*SD*
Age	28.3	12.4	23.8	8.8

of victims and 97% of offenders). Because of the high percentage of African Americans, it was not possible to perform any meaningful comparisons with other races. The average age of victims was 28.3 years ($SD = 12.4$), and the average age of offenders was 23.8 years ($SD = 8.8$).

The characteristics of the homicide event are captured in data describing the number of offenders, setting, type of weapon used, and year of occurrence. Approximately 75% of homicide triads ($n = 2{,}096$) involved only one offender. Almost 60% ($n = 1{,}655$) occurred outdoors or on a transportation route. A firearm was used in 78.1% ($n = 2{,}166$) of the triads. With motives, argument is the most frequent ($n = 1{,}687$), followed by drug-related ($n = 946$), retaliation ($n = 751$), robbery ($n = 647$), gang-related ($n = 469$), and domestic violence ($n = 203$) homicides. In sum, the characteristics of the triads are very similar to those of all homicides over the same period (Groff & McEwen, 2006a).

Geometry of Homicide: Dots, Lines, and Triangles

Although the focus of this research is mobility triangles, triangles are not the only type of geometry that appears in the data. This section details an analysis of whether there are significant differences in homicide characteristics by type of geometry. Only about 5% of triads were dots ($n = 141$). Almost 21% ($n = 576$) of triads were lines. Triangles are the largest category, with approximately 74% of triads in the triangle category.

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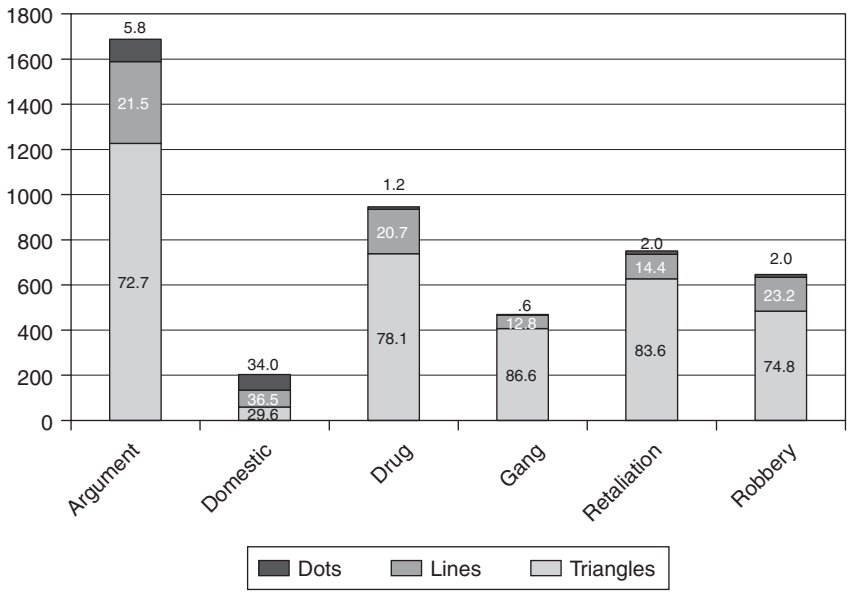
Figure 2
Dot, Line, and Triangle Homicides by Motive



The characteristics of the homicides are significantly different by dot, line, and triangle classification.[10] By motive, domestic violence homicides have the highest proportion of dots (34.0%) and the second highest proportion of lines (20.8%; Figure 2). Argument homicides have the next highest proportion of dots (5.8%). Lines account for approximately 20% of triads among argument, domestic violence, drug-related, and robbery homicides. Triangles are the most frequently occurring type of geometry for all motives except domestic violence. One interesting finding concerns the relatively high percentage of lines in robbery homicides (23.2%), indicating that the incident took place at the home of the victim or offender.

In addition to the motives, the demographics are different for each type of geometry (Table 2). Male victims are far more likely to be involved in triangle homicides. Female victims are involved in dot homicides at 4 times the rate of males and are twice as likely to be part of a line homicide. As victims, African Americans are more likely to be part of a triangle than are Whites but less likely than Hispanics. However, racial differences were not significant. Until age 50, victims are approximately 3 times as likely to be part of a triangle; afterwards, they are more likely to be part of a line.

Characteristics of offenders are similar to victims. Males are overwhelming involved in triangles (76.4%), whereas females are most likely to be in lines, followed by triangles. As with female victims, female offenders are 7 times more likely to be part of a dot than males. Racial differences are significant for offenders. The breakdown for African American offenders matches that of African American victims. White offenders are more likely than African American offenders and White victims to be part of a line homicide (55.0%) rather

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Table 2
Person and Event Characteristics by Type of Geometry

	Victim Characteristics			Offender Characteristics		
Characteristic	Dots	Lines	Triangles	Dots	Lines	Triangles
Gender*						
Male	3.4	18.3	78.3	3.9	19.7	76.4
Female	16.7	38.3	45.0	27.9	40.7	31.4
Race						
African American	5.1	20.6	74.3	5.1	20.6	74.3
White	4.9	26.8	68.3	0.0	55.0	45.0
Hispanic	4.2	19.7	82.6	3.6	20.0	76.4
Other	0.0	24.0	76.0	11.1	0.0	88.9
Age category*						
Younger than 18 years	3.1	21.6	75.3	1.8	17.5	80.7
18-24 years old	2.1	13.9	84.1	2.1	19.5	78.4
25-34 years old	3.5	21.1	75.4	7.0	20.6	72.4
35-49 years old	10.3	26.7	62.9	19.7	34.3	46.0
50 years or older	20.7	45.0	34.3	35.0	31.7	33.3
Homicide characteristics						
Location*						
Inside	14.4	43.1	42.5			
Outside	0.6	10.1	89.3			
Weapon*						
Other	16.8	30.8	52.4			
Firearm	1.8	18.0	80.2			
Relationship*						
Intimate	41.8	36.2	21.9			
Acquaintance	2.5	20.6	76.9			
Stranger	0.0	15.3	84.7			
No. of offenders*						
One	6.3	20.1	73.6			
Two or more	1.2	22.9	75.9			

*Pearson chi-square significant at $p < .05$.

than a triangle homicide (45.0%). No White offenders were part of a dot homicide. Starting with age 35, offenders tend to be involved in fewer triangle homicides.

Event characteristics also significantly vary across the geometries. Homicide events that occur inside are evenly split between lines and triangles, whereas almost 90% of those that occur outside are triangles. Homicides in which a firearm was used (80.2%) are also overwhelmingly triangles. The number of offenders is significantly different across geometries, but, in general, multiple offenders are associated with lines and triangles.

Mobility Triangle Typologies

Social-area mobility triangle findings confirm the spatial coincidence of offenders' homes, victims' homes, and location of the incident. Of the 2,773 triads analyzed, 46.3% ($n = 1,283$) of the offenders committed murder in their home neighborhood cluster. About 50.7%

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(n = 1,405) of victims died in the same neighborhood cluster in which they lived. Victims and offenders lived in the same neighborhood in about 30.7% (n = 850) of the cases. Considerable variability was found in the relative proportion of triangles by neighborhood.[11] Some neighborhoods stood out as areas with high proportions of offender mobility triangles (i.e., where the homicide problem has been brought into the neighborhood), whereas others had high proportions of neighborhood mobility triangles, indicating a local problem with violence involving residents.

Disaggregating the homicide triads by motive offers more insight into how the spatial structure varies in DC. Argument and domestic violence homicides have the highest proportions of neighborhood triangles. More than 25% of drug-related, gang-related, and retaliation homicides are offender mobility triangles. In other words, the offender traveled to another neighborhood and killed a resident of that other neighborhood. Robbery homicides are most frequently total mobility triangles, indicating that in more than 25% of robberies there is no spatial coincidence among the residences and the location of the crime.

The analysis of homicide using a social-area typology reveals two important findings. First, there are significant differences in the spatial configurations of homicides. Neighborhood mobility triangles are the most frequently occurring type, followed by offender, victim, and total mobility triangles. Second, the spatial configurations vary by motive. Specifically, the biggest differences are between homicides that are neighborhood triangles (i.e., local in nature) and all other types. These differences hold true when a distance-based classification scheme is used.

The comparison distance classification is applied using four different cutoff points of one fourth mile, one half mile, three fourths of a mile, and one mile. Table 3 below compares the distribution of the traditional mobility triangles with each of the distance classifications. The half-mile distance cutoff produces a distribution most similar to the traditional one. As one would intuitively expect, increasing the cutoff distance increases the number of neighborhood triangles and decreases the number of total mobility triangles. Interestingly, the number of offender and victim mobility triangles remains relatively constant across distance cutoffs (especially the offender mobility).

Graphing each type of triangle across all the traditional and distance typologies reveals which types of homicide are stable across distances (Figure 3). The offender mobility triangle is the most stable across all distances. This is probably related to the longer distances that most offenders travel to commit a crime (i.e., average is greater than one mile). Both victim mobility triangles and offense mobility triangles are fairly stable, with only slight increases in their proportion of events with increasing distances. The proportion of victim mobility triangles at one fourth mile is approximately 3% lower than at other distances or under a traditional mobility triangle classification. This suggests that those additional 3% are between one fourth and one half miles away from home when the homicide occurs, which fits with the relative short distances victim travel. The neighborhood and total mobility triangles are the most sensitive to distance cutoff points. As the distance increases, the number of neighborhood triangles increases and the number of total mobility triangles decreases.

In general, MAUP occurs when data are spatially classified using areal units. If the boundaries of the areal units change, so do the numbers and types of events assigned to the areas. Specific to this study, the problem is that the number of homicides classified as belonging to particular classes (e.g., neighborhood mobility, offender mobility, etc.) changes when another set of areas is used for classification purposes (e.g., census block

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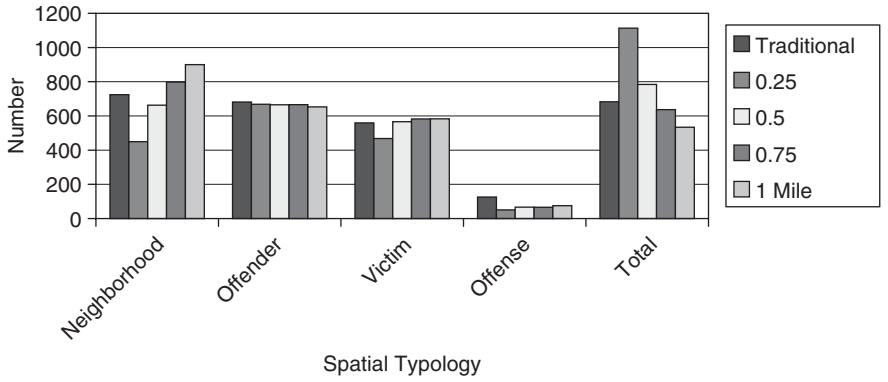
Table 3
Distribution of Traditional and Distance Mobility Triangles

				Distance Cutoff Point							
		Traditional		0.25 Miles		0.5 Miles		0.75 Miles		1 Mile	
Code	Description	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
1	Neighborhood	724	26.1	450	16.2	663	23.9	798	28.8	900	32.5
2	Offender	681	24.6	668	24.1	665	24.0	666	24.0	653	23.6
3	Victim	559	20.2	468	16.9	566	20.4	582	21.0	583	21.0
4	Offense	126	4.5	51	1.8	67	2.4	66	2.4	75	2.7
5	Total	683	24.6	1,113	40.1	784	28.3	637	23.0	534	19.3
		2,773	100.0	2,750	99.1	2,745	90.0	2,749	99.2	2,745	99.2

Figure 3
Proportion of Traditional and Distance Mobility Triangles



groups instead of neighborhood clusters). Similarly, with neighborhoods defined by distances, classifications change based on selection of the cutoff point. For example, the traditional classification resulted in 724 neighborhood triangles based on the neighborhood definitions in our study. With a cutoff distance of one-fourth mile, the distance typology has 450 neighborhood triangles. A cutoff distance of a half mile results in 663 neighborhood triangles, and with a one-mile cutoff point, there were 900 neighborhood triangles.

An examination of the distance typologies by motive for the homicide yields some interesting contrasts (Figure 4). As with the traditional typology, the domestic violence homicides have more neighborhood triangles. Neighborhood triangles account for almost the same proportion of events as do total mobility triangles under the distance typology. In addition, for drug-related, gang-related, and retaliation homicides, the most frequently occurring type is the total mobility triangle, followed by the offender mobility triangle. Robbery remains the same, with total mobility triangle as the most frequent.

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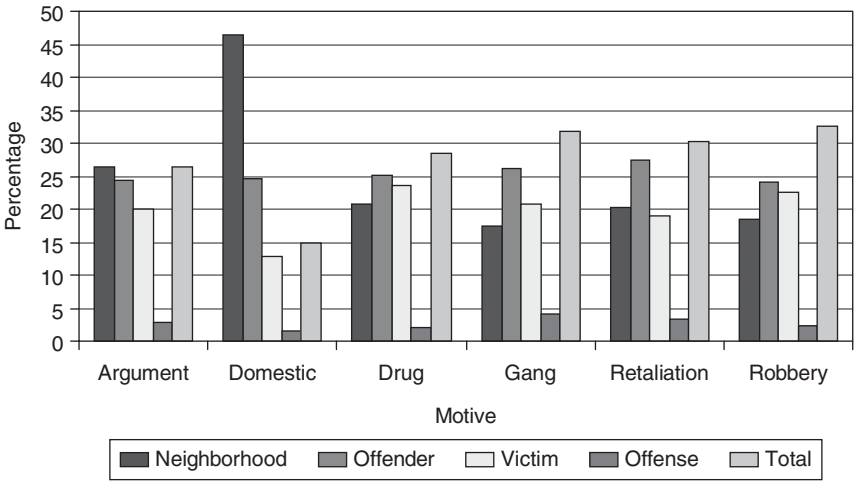
Figure 4
Half-Mile Distance Typology Classification by Motive Type



Traditional mobility triangles show similar patterns but with one interesting difference in the number of total mobility triangles (Figure 5). There is a striking reduction in total mobility triangles as compared with the distance classification for argument, drug-related, gang-related, retaliation, and robbery homicides. This occurs even though the relative proportions of triangles in each spatial typology type remain consistent across motives. In sum, the descriptive analysis has provided a wealth of information about the spatial configuration involved in homicide events. Next, we use multinomial logistic regression to determine which characteristics of the homicide events are associated with specific types of triangles.

Regression Analysis

Our approach to the regression analysis is based on past efforts by Tita and Griffiths (2005) and Rand (1986). Tita and Griffiths performed a standard multinomial logistic regression with independent variables for participant characteristics, event characteristics, victim-offender relationship, and motives. Our analysis employs similar variables based on the data collected during our study. A multinomial logistic regression was used to differentiate key variables across the five categories in our distance typology.

The results of two multinomial logistic regressions, one for traditional and the other for distance mobility triangle typologies, provide insights into whether homicide characteristics vary based on their spatial typologies. Because our dependent variable, mobility triangle type, is nominal, we use a multinomial logistic regression. In a multinomial logistic regression, a single regression applies to the five categories in a typology (i.e., neighborhood, victim, offender, offense, and total). The regression determines the most significant variables that differentiate cases across the five categories. Only the half-mile distance typology is examined for this analysis.

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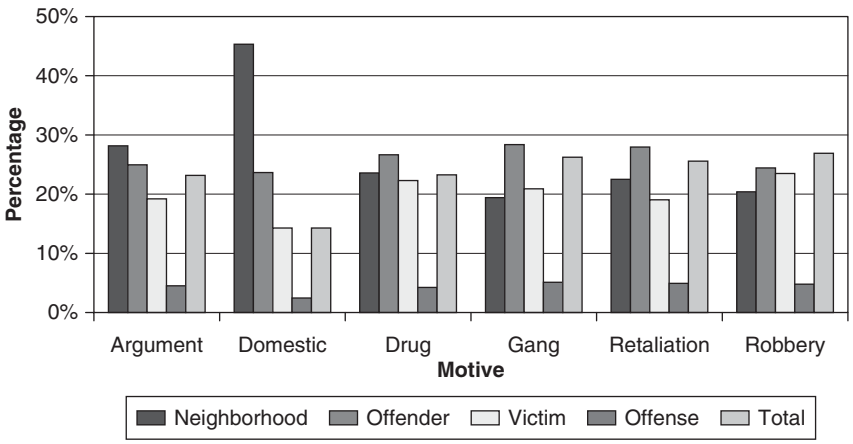
Figure 5
Traditional Typology Classification by Motive Type



The independent variables for the regressions were as follows,

- Victim Variables
  - Race (African American = 1, other = 0)
  - Sex (female = 0, male = 1)
  - Age (younger than 18 years old = 1, 18 to 24 years old = 2, 25 to 34 years old = 3, 35 years or older = reference category)
- Offender Variables
  - Race (African American = 1, other = 0)
  - Sex (female = 0, male = 1)
  - Age (younger than 18 years old = 1, 18 to 24 years old = 2, 25 to 34 years old = 3, 35 years or older = reference category)
- Motives
  - Argument (no = 0, yes = 1)
  - Domestic violence (no = 0, yes = 1)
  - Drug related (no = 0, yes = 1)
  - Gang related (no = 0, yes = 1)
  - Retaliation (no = 0, yes = 1)
  - Robbery (no = 0, yes = 1)
  - Firearm (no = 0, yes = 1)
- Relationship
  - Intimate (no = 0, yes = 1)
  - Acquaintance (no = 0, yes = 1)
  - Stranger (reference category)

Table 4 shows the values for the significant variables resulting from the regressions that were found to be statistically significant. The multinomial regression gives results for each

(*text continues on p. 229*)

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Table 4
Multinomial Logistic Regression Results for Traditional and Distance Mobility Triangle Typologies

	Neighborhood Versus Victim		Neighborhood Versus Offender		Neighborhood Versus Offense		Neighborhood Versus Total		Victim Versus Offender	
Variable	a	b	a	b	a	b	a	b	a	b
Victim variables										
African American									–0.53**	–0.48*
Male	–0.39*	–0.66***	0.31*	0.30*	–1.06**			–0.47**	0.70***	0.95***
Age										
Younger than 18 years old		0.65***		0.48**	0.90**			0.47***		
18-24 years old	0.43**	0.43**			0.89***		0.49***	0.61***	–0.35**	
25-34 years old	0.72***	0.91***					0.56***	0.69***	–0.67***	–0.69***
Offender variables										
African American				0.71*			0.66*	0.79**	0.74*	0.74*
Age										
Younger than 18 years old										
18-24 years old	0.56**	0.49**	0.75***	0.58***	0.95*			0.40*		
25-34 years old	0.53**	0.59**	0.88***	0.83***	1.03**		0.50*	0.63***		
Motives										
Argument							0.28**	0.32**		
Domestic violence									0.58*	
Drug-related		–0.31**								
Gang-related						–0.68**				
Retaliation			–0.32**	–0.37***					–0.26*	–0.34**
Robbery										
Firearm used			–0.45***	–0.43***		–0.90**	0.56***	–0.56***		
Relationship										
Acquaintance	1.27***	1.41***	0.83***	1.03***	1.22***		1.18***	1.47***	–0.44***	–0.38**
Intimate	2.23***	2.27***	0.85***	1.20***	0.99*		2.54***	2.48***	–1.39***	–1.07***

(*Continued*)

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Table 4
(Continued)

Variable	Neighborhood Versus Victim		Neighborhood Versus Offender		Neighborhood Versus Offense		Neighborhood Versus Total		Victim Versus Offender	
	a	b	a	b	a	b	a	b	a	b
Victim variables										
African American							0.55**	0.47*		
Male					–1.37***		–0.61***	–0.77***		
Age										
Younger than 18 years old					0.70*				–0.87**	
18-24 years old					0.81***		0.41**	0.44***		
25-34 years old		–0.99**					0.50***	0.48***		0.77*
Offender variables										
African American	–1.11*		0.81**	0.82**						
Age										
Younger than 18 years old							–0.53**			
18-24 years old							–0.47**			
25-34 years old										
Motives										
Argument							0.31**	0.25**		
Domestic violence										
Drug-related		–0.55*	0.34**	0.29**			0.29**			
Gang-related		–0.64*				–0.58*				
Retaliation										
Robbery										
Firearm used		–0.70*	–0.35**	–0.35**						
Relationship										
Acquaintance		–0.74*					0.35**	0.43***		0.80**
Intimate	–1.24**	1.97***					1.69***	1.28***	–1.55**	2.18***

Note: For victim and offender's age, the reference category is 35 years or older. For relationship, the reference category is stranger-to-stranger.
a. Significant variables for traditional typology.
b. Significant variables for distance typology.
*$p < .10$. **$p < .05$. ***$p < .01$.

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Table 5
Multinomial Logistic Regression Summary

	Victim	Offender	Offense	Total
Neighborhood	Less likely to be male victim.[c] More likely victim is 18-34 years old.[a] More likely victim is younger than 35 years old.[b] More likely offender is 18-34 years old.[c] Less likely to be drug-related motive.[b] More likely to be acquaintance or intimate relationship.[c]	More likely to be male victim.[c] More likely victim is younger than 18 years old.[b] More likely offender is African American.[b] More likely offender is 18-34 years old.[c] Less likely to be retaliation motive.[c] Less likely to involve firearm.[c] More likely to be acquaintance or intimate relationship.[c]	Less likely to be male victim.[a] More likely victim is younger than 25 years old.[a] More likely offender is 25-34 years old.[a] Less likely to be gang-related.[b] Less likely to involve firearm.[b] More likely to be acquaintance or intimate relationship.[a]	Less likely victim is male.[b] More likely victim 18-34 years old.[a] More likely victim is younger than 35 years old.[b] More likely African American offender.[c] More likely offender is 25-34 years old.[a] More likely offender is 18-34 years old.[b] More likely to be argument motive.[c] Less likely to involve firearm.[c] More likely to be acquaintance or intimate relationship.[c]
Victim	—	Less likely victim is African American.[c] More likely victim is male.[c] Less likely victim is 18-34 years old.[a] Less likely victim is 25-34 years old.[b] More likely offender is African American.[c] More likely domestic violence motive.[a] Less likely retaliation motive.[c] Less likely to be acquaintance or intimate relationship.[c]	Less likely victim is 25-34 years old.[b] Less likely offender is African American.[a] Less likely to be drug-related motive.[b] Less likely to be gang-related motive.[b] Less likely to involve firearm.[b] Less likely to be intimate relationship.[a] Less likely to be acquaintance or intimate relationship.[b]	More likely offender is African American.[c] More likely drug-related motive.[c] Less likely to involve firearm.[c]

(*Continued*)

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Table 5
(Continued)

Victim	Offender	Offense	Total
Offender	—	Less likely to be male victim[a] More likely victim is younger than 25 years old.[a] Less likely to be gang-related motive.[b]	More likely victim is African American.[c] Less likely victim is male.[c] More likely victim is 18-34 years old.[c] Less likely offender is younger than 25 years old.[a] More likely to be argument or drug-related motive.[a] More likely to be argument motive.[b] More likely to be acquaintance or intimate relationship.[c]
Offense		—	Less likely victim is younger than 18 years old.[a] More likely victim is to be 25-34 years old.[b] More likely to be intimate relationship.[a] More likely to be acquaintance or intimate relationship.[b]

a. Significant at the .10 level for traditional typology only.
b. Significant at the .10 level for distance typology only.
c. Significant at the .10 level for both typologies.

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pairwise combination of outcomes. With 5 possible outcomes, there are 10 possible combinations (neighborhood vs. victim, neighborhood vs. offender, etc.). These combinations form the columns in the table, with the first column providing the list of variables (Table 5 provides an explanation of the parameters for those variables). Values in the *a* columns are from the multinomial regression based on the traditional mobility triangle typology, whereas values in the *b* columns are from the regression using the distance mobility triangle typology with a half-mile distance.[12] To improve readability of the table, relationships are reported in only one direction. For example, on the male victim variable, neighborhood versus victim for the traditional typology is –.39. Only the sign would change if victim mobility triangles were being compared to neighborhood mobility triangles (i.e., the value would be .39).

Results in Table 5 show similar results in several instances for the two regressions. For example, for victim versus total categories, the same three variables are identified as significant in the two regressions—African American offender, drug-related motive, and use of firearm—and the parametric values are almost identical. On the other hand, there are several differences with the two approaches, such as the following:

- For neighborhood versus victim, the distance typology includes two significant variables (victim younger than 18 years and drug-related motive) not included in the traditional typology.
- Two additional variables (victim younger than 18 years and African American offender) are also identified in the neighborhood versus offender categories.
- For the neighborhood versus offense categories, the two regressions identified completely different variables, with the traditional typology having seven significant variables and the distance typology only two significant variables.
- For the neighborhood versus total categories, the distance typology includes three more significant variables—male victim, victim younger than 18 years, and offender's age 18 to 24 years.
- For the victim versus offender categories, the traditional typology has two additional significant variables—victim's age 18 to 24 years old and domestic violence motive.
- For victim versus offense, the two regressions identified different variables, with the exception of intimate relationship.
- For offender versus offense, the regression for the traditional typology lists three significant variables, whereas the distance typology yielded only one variable (gang-related motive).
- For offender versus total, the traditional typology has two additional significant variables (victim younger than 18 years and victim's age 18 to 24 years).

The results for each type of triangle are discussed in detail in the next few sections. In addition, our results are compared to those reported by Tita and Griffiths (2005) to offer some idea of the consistency of characteristics across cities. Table 5 summarizes the numeric results to show the direction that the significant variables take the odds when comparing two categories. The upper-left corner is for neighborhood versus victim and indicates, for example, that neighborhood incidents are less likely to be male victims than those in the victim category.

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Neighborhood Triangles

Neighborhood triangles significantly differ from other types of triangles on victim, offender, and event characteristics. Only the statistically significant differences are discussed here. Both sex and age of the victim are significantly different from other triangles. Neighborhood triangles are more likely than victim, offense, or total mobility triangles to have a female victim. The victim is more likely than all other types of triangles to be younger than 18. Offenders are more likely to be 18 to 34 years of age. The homicide events are less likely than all other types of triangles except victim mobility triangles to involve a firearm. The largest differences between neighborhood and other types of triangles are in the relationship between victim and offender. Neighborhood triangles are more likely to involve intimates or acquaintances than any other triangle type.

These findings are consistent with the literature on activity spaces. Women and young people tend to have the smallest activity spaces, so they are more likely to be close to home when killed. In addition, people tend to have the greatest amount of interaction with close friends, family members, and neighbors near or in their own homes, so the predominance of close relationships and close distances is reasonable.

Motive did not consistently differentiate among the triangle types. This was an especially surprising result given the predominance of domestic violence motives among neighborhood triangles. We agree with Tita and Griffiths's (2005) assessment that the relationship variable (i.e., intimate and acquaintance categories) is mediating the effect of motive. Neighborhood triangles had three significant differences related to motive; they were less likely to be drug related than were victim mobility triangles, gang related than were offense mobility triangles, and retaliation related than were offender mobility. Homicides with drug-related, gang-related, and retaliation-related motives had some of the longest travel distances, especially between victim and offender home addresses, making them unlikely to fit the definition of a neighborhood triangle.

As compared to the findings from the earlier study in Pittsburgh, there are some general similarities but more differences (Tita & Griffiths, 2005). The variable that is consistent between the studies is the nonstranger relationship. All other findings vary by either the variable found significant or the pairings that are significant. Although both cities have similar proportions of offense mobility triangles, more of the neighborhood triangle characteristics significantly differ from offense triangles in DC than in Pittsburgh.

Victim Mobility Triangles

Victim mobility triangles have several significant differences from events in both neighborhood and offender triangles. As compared to neighborhood triangles, victim triangles are more likely to have male victims, but both are less likely to have older victims. The larger activity spaces of men make it more likely that they will be outside their neighborhood if involved in a homicide. In addition, victim triangles are less likely than neighborhood ones but more likely than total mobility triangles to involve drugs as a motive. In other words, victims in drug-related homicides tend to be killed either in their own neighborhoods or in the neighborhood of the dealer. Both neighborhood and victim triangles are less likely to involve a stranger.

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The differences with offender triangles involve mostly victim characteristics, although victim triangles are more likely to have an African American offender than offender triangles. When compared with offender triangles, victim triangles are less likely to have an African American victim but more likely to have a male victim. They are also less likely to involve victims in the 18 to 35 age group, although they are more likely to involve strangers than are offender mobility homicides. As far as motive, victim triangles are less likely to be retaliation related than offender triangles. There were no significant differences on firearm use between victim and offender triangles. However, victim triangles are less likely to involve a firearm than are total mobility triangles. On the whole, these findings differ from the Pittsburgh study in that more variables differentiated between the spatial classifications and the identities of those variables were not consistent across the two studies. Relationship was the only characteristic that consistently discriminated.

Offender Mobility Triangles

Offender mobility homicides also differ on victim, offender, and event characteristics. They are less likely to involve male victims than any other type of triangle. Victims are more likely to be African American than in either victim or total mobility triangles but less likely than offense mobility triangles. In general, the age of victims in offender triangles is more likely to be between 18 and 35 years of age than neighborhood or victim mobility triangles but more likely to be younger than 25 in offense triangles and between 18 and 34 in total mobility triangles.

Offender characteristics also differ, although the differences are not as consistent for victims. Offender mobility offenders are less likely to be African American than neighborhood or victim mobility triangles. Offenders in offender mobility triangles are also less likely to be between 18 and 34 than are neighborhood triangles and less likely to be younger than 25 years old than are total mobility triangles.

Event characteristics also differentiate offender mobility triangles. As far as motive for the homicide, offender triangles are more likely to be retaliation related than are neighborhood triangles but less likely than victim triangles. They are less likely to be domestic violence related than are victim mobility triangles. Finally, offender mobility triangles are more likely to be argument or drug related than are total mobility and more likely to be gang related than offense mobility triangles. Relationships also significantly differ among offender triangles. Offender mobility triangles are less likely to be intimate or an acquaintance than are neighborhood triangles but more likely than are victim triangles and total mobility triangles. These results are somewhat puzzling, especially the relationship between victim mobility and offender mobility, as it relates to offender-victim relationship and motive. On one hand, offender mobility tends to be less likely to have a domestic violence motive but on the other hand more likely to be acquaintance or intimate relationship.

As compared to the Pittsburgh study, there are only two common characteristics. Offender mobility triangle homicides are more likely to involve female victims and to result from some predatory activity. In the case of Washington, D.C., it is retaliation related. In Pittsburgh, gang felony and drug motives are often involved.

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Offense Mobility

Offense mobility triangles are the only type for which no significant relationships are identified by both mobility triangle classifications. This may be in part because of the small number of triads classified as offense mobility. Thus, the results should be interpreted with care and are not further elaborated on to develop a separate profile.

Total Mobility

Total mobility triangles have significant differences as compared with neighborhood, victim, and offender triangles. As far as victim characteristics, both sex and race differ. Total mobility triangles are more likely to have a male victim than are neighborhood triangles but less likely than are offender triangles. African Americans are less likely to be victims in a total mobility triangle than neighborhood, victim, or offender triangle homicides. The victims are less likely to be 18 to 34 years of age than neighborhood or offender homicides.

Offenders, however, are universally less likely to be African American in total mobility triangles. They are also more likely to be male than neighborhood or offender triangles. Their ages are less likely to be between 18 and 34 than neighborhood or offense triangles but more likely to be younger than 25 than offender homicides.

Related to event characteristics total mobility triangles, their motives are less likely to be drug related than victim or offender. Total mobility triangles are also less likely to be argument than are neighborhood or offender mobility triangles. Firearms are more likely to be involved than in neighborhood or victim mobility triangles. The relationship between offender and victim is less likely to be acquaintance or intimate than neighborhood, offender, or offense triangles. These findings fit with opportunity theory's view of convergence as a consequence of the intersection of routine activity spaces. Strangers are less likely to have overlapping activity spaces (i.e., and thus familiarity with a place) as are found in total mobility triangles. This attribute also explains the greater frequency of gun use in total mobility triangles because people who are unfamiliar with a place are more likely to carry a gun to compensate for their lack of knowledge.

Discussion

Although many studies have examined the distances that offenders travel to commit crime, only a few have incorporated victim travel and examined the joint mobility involved in criminal events. Our research builds on and extends the existing body of work in several ways. First, we disaggregate homicide triads into dots, lines, and triangles to identify any differences that may be important to our understanding of homicide. Second, we develop a new mobility triangle typology based on distance rather than social areas and in doing so offer a more robust option for characterizing the spatial typology of criminal events. Third, we use logistic regression to provide insights into whether homicide characteristics vary based on their spatial typologies.

Using even the simplest spatial typology of strict spatial coincidence (i.e., dots, lines, and triangles), we found evidence that there are significant differences in homicide characteristics

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by spatial classification. As expected, dot homicides are most likely to be domestic violence because they involved intimates. Robbery, argument, and drug-related motives are most frequently lines in which the homicide occurred at the victim's or offender's home address. The least spatial coincidence is found among homicides with gang-related and retaliation motives, which are predominantly triangles. Differences in gender of the victim and offender also vary by geometry. Males are more likely to be part of triangles, but females are more likely to be involved in line homicides. These results fit with empirical research showing that men have larger activity spaces than women. Two areas where victims and offenders differ are as follows. White offenders are more likely than African American offenders or White victims to be part of a line rather than a triangle. Older offenders tend to be part of dots, whereas older victims are more likely to be part of lines. In keeping with earlier observations, these findings are consistent with what is known about how activity spaces vary with age and sex and lend empirical support to the validity of using routine activities to explain crime patterns.

Our replication of Tita and Griffiths's (2005) research using Pittsburgh homicides yielded remarkably similar results, with just a few differences. Despite different periods, study area sizes, and durations (all of which contributed to very different numbers of observations between the two studies), the proportions of neighborhood and offense mobility triangles were almost identical. Washington, D.C., had greater proportions of offender and victim mobility homicides, which may have been because of the inclusion of victims and offenders who lived outside of the District of Columbia. Pittsburgh had more total mobility triangles than the District of Columbia, indicating larger activity spaces for the residents of Pittsburgh within the city itself. Although not directly addressed in this research, the size of the social areas used as boundaries will affect the triangle classification. Larger social areas will produce more neighborhood triangles and fewer total mobility triangles, whereas smaller social areas will produce the inverse. Rather than test different sizes of social areas, we chose to develop a new classification scheme based on the conceptual definitions of traditional mobility triangles but using distance as the classification mechanism.

Our experiments with distance mobility triangles demonstrate the greater sensitivity gained by using distance to classify events. However, they do not in themselves provide clear evidence of the superiority of a distance-based classification scheme versus one that is based on social areas. Like social-area typologies, distance-based triangles that use a cutoff are sensitive to the size of the distance cutoff point used in the classification scheme. We tested four different distances, one fourth mile, half mile, three fourths of a mile, and one mile. The half-mile scheme yielded results roughly comparable to traditional triangles. The results for the other distance cutoffs differed from each other and from the traditional triangles.

To provide some sense of the relationship between distance and social-area classifications, the results from the half-mile typology are discussed in relation to the social-area typology. The half-mile distance mobility triangles had fewer neighborhood triangles and more total mobility triangles. Neighborhood mobility and total mobility classifications were the most sensitive to distance although in opposite directions. As the distance cutoff increased, the proportion of neighborhood triangles increased and the proportion of total triangles decreased. The proportion of offense mobility triangles is insensitive to changes in the size of the distance bands, reflecting the longer distance that offenders tend to travel to the location of the homicide. Victim mobility triangles show an increase between one

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fourth mile and one half mile but are stable at one half mile and above. Similarly, this may be a function of the shorter distances most victims travel. Finally, offense mobility triangles made up a smaller proportion, at all distances, than was observed in the traditional typology, and their proportion increased with increasing distance. Thus, the use of distance triangles provides a more nuanced view of relationships between the anchor points, but the variations between the two typologies were not extreme. One additional benefit of distance triangles is that because the classification is attached to the location of the event, they can be aggregated to any boundary for display purposes (e.g., to summarize neighborhood homicide problems) or shown as points by type of triangle to examine their relationship to neighborhood boundaries (e.g., a point map of all neighborhood triangles).

The application of multinomial logistic regression to identify person and event characteristics that differentiated among the spatial types was illuminating but ultimately unsatisfying from a policy view. Related to the comparison of social-area and distance typologies, they perform about equally as far as identifying significant differences between triangle types with a high level of agreement between the two techniques. They disagreed in sign only two times and often had very similar values. The conflicting signs involved the relationship variable, specifically intimate relationships. In both cases, the traditional typology predicted it was less likely to be an intimate relationship for victim mobility versus offense mobility and for offense mobility versus total mobility, whereas the distance typology predicted it was more likely that they would involve intimates in victim mobility versus offense mobility and for offense mobility versus total mobility. These results could be because of the small number of offense mobility triangles. Further study is necessary to determine whether the differences between the two typologies are significant enough to advocate for the use of one typology over the other.

Implications for Practice

Much attention has been focused on the crime of homicide because of its severity for the victim, its impact on the victim's family and friends, and its affect on the ability to maintain a viable community (Wilson, 1975). These factors make the results of this research endeavor important to police, community members, and violence-prevention practitioners. Although the ability of police to prevent homicide has been hotly debated, results of a recent quasiexperimental study show a link between the implementation of problem-oriented policing strategies and dramatic reductions in homicides (White, Fyfe, Campbell, & Goldkamp, 2003).

We anticipate two major uses for these findings in practice: (a) informing the problem-solving activities of patrol and (b) aiding in homicide investigations. Disaggregating problems is an essential component of problem solving (Eck & Spelman, 1987; Goldstein, 1990). Application of a spatial typology aids in the problem-solving process by providing unique information concerning the joint mobility distribution and characteristics of homicide events.[13] Different types of homicide triangles suggest different intervention and prevention strategies. In neighborhoods with high proportions of neighborhood triangles, violence-reduction strategies that would concentrate on the residents of the neighborhood could be organized. If the neighborhood were dominated by victim mobility homicides that

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are drug related, a variety of strategies would be available to implement depending on the nature of the drug trade. If abandoned buildings are havens for drug dealing and drug use, then partnerships with code enforcement officials will aid in securing those buildings. Routine police tools such as license check points and drug task forces may be used to reduce both demand and supply. The license checkpoints deter both potential customers and dealers, whereas the drug task force reduces supply by arresting dealers. Whatever the initial type of triangle identified, it is critical that further analysis of the character of the homicides is conducted before deciding on a strategy.

Mobility triangle analysis has the potential to provide important information to homicide detectives, especially when they are investigating homicides with no witnesses, where there is no prior relationship between the victim and the offender, and when there is very little physical evidence. These cases are especially challenging to solve. Development of offender lists is a primary area where the geographic analysis of homicide case information may be particularly helpful. The relationship of the joint mobility pattern in closed cases and the associated characteristics of victims and events can be used to predict likely characteristics in open cases. For example, homicides with female victims who are killed in their own neighborhood are likely part of a neighborhood triangle, so the offender may live in the same neighborhood. The age of the victim is also an important discriminator. Homicides with victims older than 35 are more likely to be victim or offense mobility triangles, both of which involve an offender who resides near the homicide location. The distance of the victim's home to the location of the homicide can be used determine which type of triangle it is. The relationship between victim travel to crime and distance between the two homes will enable investigators to predict the likely distance the offender traveled to commit the crime. In sum, there is a whole host of potential applications for both investigations and problem-oriented policing from data generated to look at the joint mobility patterns of victims and offenders.

Conclusion

This research takes the first steps at using improved computing available through geographic information systems to develop and apply new methods of spatial classification. Although this research examines several aspects of mobility triangles, there is still much to be done. Further research on homicides should test the results of different distance band sizes as compared to traditional mobility triangles to determine if they produce classifications that are stronger discriminators among the characteristics of the offender, victim, and event by classification. In addition, the data should be disaggregated by periods to test whether the use of shorter periods would provide greater clarity.

Mobility triangles have application beyond homicide events. More work that addresses other crime types (e.g., rape, robbery, and aggravated assault) in addition to homicide is needed. A more comprehensive examination of additional crime types would provide the first in-depth exploration of anchor points as they relate to violent crime. One particularly interesting line of research that could be conducted involves the examination of the relationship between homicides and aggravated assaults. Other researchers have noted that homicides may be thought of as aggravated assaults in which the victim died rather than as

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premeditated attacks with the specific goal of death. Answers to these questions are now within technical reach and need to be addressed by future research endeavors.

Notes

1. Several reviews of the offender journey to crime literature exist, including ones by Harries (1980), Rossmo (2000), Wiles and Costello (2000), and Groff and McEwen (2006a).

2. P. J. Brantingham and P. L. Brantingham (1981) developed drawings of paths and nodes under different assumptions (e.g., uniform distribution of targets, one criminal, one node) to describe a wide range of situations in which criminal travel behavior may be modeled. Earlier work by Lynch (1960), in which he described the routine activities of people in terms of several elements (i.e., edges, paths, nodes, districts, and landmarks), provided the basis for the Brantinghams' notions of nodes and pathways used in their diagrams. Most important to this discussion is Lynch's formulation of nodes (i.e., home, work, recreation, etc.) and paths (i.e., roads, bus routes, etc.) to describe the physical environment in which movement occurs.

3. Please see Groff and McEwen (2006a) for a more extensive review of the journey to crime literature.

4. Please see Groff and McEwen (2006a) for a more extensive review of the homicide research underlying the multivariate model.

5. Approximately 99.6% of the homicide locations (n = 4,534), 95.3% of the victims' home addresses (n = 3,955), and 96.2% of the offenders' home addresses (n = 3,304) were successfully geocoded. For a complete description of the data and the geocoding process, please see Groff and McEwen (2006b).

6. The routine for calculating Euclidean distances in Arcview 3.1 is named pt2pt_distance.ave and is available from http://support.esri.com.

7. For more discussion of the effect of street networks on crime locations, please see Lu and Chen's (in press) evaluation of network- versus distance-based K functions.

8. Classification required the use of a cutoff distance. See Groff and McEwen (2006a) for a more complete description of the classification schemes tried and discarded. Unfortunately, the use of a larger cutoff distance resulted in more triads being classified as neighborhood mobility triangles, whereas a smaller cutoff distance produced more total mobility triangles. Thus, the resulting classification of an incident may be influenced by the cutoff distance chosen.

9. Previous researchers have pointed out that the area under each distance band exponentially increases away from the center (e.g., the area under a 0.50-mile buffer is more than twice the area under a 0.25-mile buffer; Rengert, Piquero, & Jones, 1999; Turner, 1969). However, in this research, we are using the actual distances between pairs of points to classify the event rather than summarizing a distribution of events within some distance cutoff.

10. Pearson chi-square tests were performed to determine significant differences in motive, demographics (for both suspects and victims), and event characteristics across geometry types.

11. See maps in report at http://www.ilj.org/publications/SpatialConfigurationofPlaces.pdf.

12. Odds ratios were not computed because the tables only show significant variables.

13. Please see Groff and McEwen (2006b) for a more in-depth examination of cartographic techniques related to the visualization of mobility data.

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