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CRIMINAL MOBILITY OF ROBBERY OFFENDERS

by

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B.S. University of Minnesota, 2002

A thesis submitted in partial fulfillment of the requirements  
for the degree of Master of Science  
in the Department of Criminal Justice and Legal Studies  
in the College of Health and Public Affairs  
at the University of Central Florida  
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## ABSTRACT

The current paper addresses the mobility and willingness to travel of robbery offenders. A five-sector robbery typology was constructed, consisting of: personal robbery, commercial robbery, carjacking robbery, home-invasion robbery, and robbery by sudden snatching. Defining mobility as the straight-line distance between the offender's home residence and the location of the robbery offense, the extent of criminal mobility for each type of robbery offense was analyzed. Using geographical information system (GIS) technologies and, more specifically, geocoding software programs, the latitudinal and longitudinal coordinates of the offender's home and offense's location was determined. It was found that a subset of robbery offenders exhibit relatively high mobility across all five robbery types. However, distinct mobility patterns also emerged between the different types of robbery offenses. Policy and research implications from these findings are discussed.

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## LIST OF NOMENCLATURE

**Robbery by sudden snatching**<sup>1</sup> - the taking of money or other property from the victim's person, with intent to permanently or temporarily deprive the victim or the owner of the money or other property, when, in the course of the taking, the victim was or became aware of the taking. In order to satisfy this definition, it is not necessary to show that:

(a) The offender used any amount of force beyond that effort necessary to obtain possession of the money or other property; or

(b) There was any resistance offered by the victim to the offender or that there was injury to the victim's person.

**Carjacking** - taking of a motor vehicle which may be the subject of larceny from the person or custody of another, with intent to either permanently or temporarily deprive the person or the owner of the motor vehicle, when in the course of the taking there is the use of force, violence, assault, or putting in fear.

**Home-invasion robbery** - any robbery that occurs when the offender enters a dwelling with the intent to commit a robbery, and does commit a robbery of the occupants therein.

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<sup>1</sup> All robbery definitions are drawn from the criminal statutes of the State of Florida.

**Commercial Robbery** - the taking of money or other property which may be the subject of larceny from the person or custody of another, with intent to either permanently or temporarily deprive the person or the owner of the money or other property, when in the course of the taking there is the use of force, violence, assault, or putting in fear, in which the owner of the money or property is a business establishment.

**Personal Robbery** - the taking of money or other property which may be the subject of larceny from the person or custody of another, with intent to either permanently or temporarily deprive the person or the owner of the money or other property, when in the course of the taking there is the use of force, violence, assault, or putting in fear, otherwise not defined as a carjacking, robbery by sudden snatching, home-invasion robbery, or commercial robbery.

## INTRODUCTION

In many respects, the spatial landscape in which we live dictates our actions and movements. Interstates, highways, streets, and roads determine where we go and how we get there. It is along these corridors that we observe our surroundings, and create mental cognitive maps of the world around us (Brantingham & Brantingham, 1993). Also, homes, work places, recreational facilities, and numerous other business establishments govern where we are going, generically referred to as destinations or nodes (Brantingham & Brantingham, 1981). Consciously or unconsciously, where we are at a specific point of time is largely influenced by these destinations. Where we live, work, and enjoy recreational activities determine our physical geographic location. If the location of these nodes change, such as by moving to a different neighborhood or changing a job, so too will our physical location. In addition, our movements along transportation routes are generally predictable and consistent, as typical travel behaviors exhibit “a very high repetition ratio” (King & Golledge, 1978, p. 307). In other words, our daily mobility patterns, defined here as physical movement through space, appear to be dependent on the structure of the surrounding environment.

The mobility patterns and spatial awareness of criminals seem to follow the same processes. Major thoroughfares become a part of an offender’s cognitive map, and potential targets along these paths may ultimately attract criminals (Duffala, 1976; Wright & Decker, 1997). Similarly, nodes may not represent destinations to the offender but rather opportunity (Bernasco & Luykx, 2003; Stangeland, 1998), in which criminal mobility reflects the structure of criminal opportunity and target availability. For example, the location of a bank will dictate the

movements of a bank robber, much the same way a university dictates the movements of its students. In essence, our travel patterns are the result of interactions between ourselves and the environment.

Underlying these mobility and travel patterns is the concept of distance, or geographic space between destinations. Travel may be limited by distance, because of the costs associated with overcoming spatial distances (Brantingham & Brantingham, 1981; Mooney Zwanziger, Phibbs, & Schmitt, 2000). The development of urban American society seems to reflect the obstacles of distance. Research has shown that the average journey-to-work commute is relatively short, with mean and median travel times less than 35 minutes (Kluger, 1998; U.S. Bureau of the Census, 2000; U.S. Department of Commerce, 2004). In general, mobility appears to be limited, in which long journeys are either undesired or unnecessary.

The research presented here analyzes the “criminal commutes” of robbery offenders (Rhodes & Conly, 1981, p. 167). The primary purpose of this study is to determine how far robbery offenders are willing to travel during the commission of their crime. The importance of understanding the travel patterns of criminals cannot be understated. Such knowledge can help guide police investigations by minimizing search spaces, thereby reducing related costs while enhancing the probability of capture (Canter, Coffey, Huntley, & Missen, 2000). Also, as mapping software becomes more available and easy to use, spatial crime analysis will become increasingly prevalent in today’s police organizations (Ratcliffe, 2004a). By enhancing our understanding of the criminal commute, mapping tools will be implemented more efficiently and effectively through the integration of computer technology and criminological theory. Research on the criminal commute will provide a backdrop in which to analyze, interpret, and respond to

spatial crime analysis. The goal of this study is to contribute to the general knowledge of criminal travel, by providing a detailed analysis of the mobility patterns of robbery offenders.

The criminal commute, also referred to as journey-to-crime, criminal mobility, or crime trip, will be defined as the straight-line distance between the offender's home and the location of the crime. Prior research has demonstrated that the home is an important point of reference of offenders, and that criminal activity tends to cluster around the home (Canter et al., 2000; Canter & Larkin, 1993; Godwin & Canter, 1997). Also, previous journey-to-crime research typically uses the offender's home as the starting point of crime trips, including studies analyzing the mobility of robbery offenders (Rhodes & Conly, 1981; Turner, 1969; Warren et al., 1998). Therefore, the home appears to be the most relevant and appropriate location for journey-to-crime research.

The current study analyzes the mobility of robbery offenders. There are several reasons why robbery was chosen for this research. First, prior research has not adequately addressed travel patterns of robbery offenders, particularly among different types of robbery. Second, because of the definition of the crime, robbery can encompass a variety of criminal behaviors (see List of Nomenclature), ranging from commercial to person victimization, armed to unarmed offenses, as well as from general to specific criminal activities (i.e. carjacking), just to name a few. This breadth of robbery may result in a mosaic of journey-to-crime patterns, some of which have been left unexplored. Third, because of the nature of the crime, robbery lends itself to multiple theoretical explanations of crime, and can serve as a basis for theoretical testing. Lastly, the act of robbery can be a very frightful and traumatic experience for the victim, and deserves research attention.

## THEORETICAL REVIEW

Previous journey-to-crime research has emphasized three theoretical perspectives when analyzing the relationship between crime and offender mobility: rational choice theory, routine activities theory, and environmental criminology. Each theory uses distinct approaches to address the concepts of offender mobility and travel distance, and offers unique frameworks in which to study journey-to-crime. As will be shown below, each perspective predicts similar criminal travel patterns and tendencies. A brief summary of each theoretical model is presented. This section then concludes with a discussion of how the concepts of these theories address criminal mobility.

### Rational Choice Theory

Although the definitions and concepts of the rational choice theory have evolved over decades of research, the basic underlying assumption that offenders make rational decisions has remained consistent. Rationality can be viewed from many perspectives, varying in complexity. Dahlbäck (2003) defines rationality as “the assumption that people’s behavior results from making deliberate choices from among different action alternatives” (p. 1). Through this working definition, an individual bases his or her decisions on a cognitive evaluation of all possible choices, as opposed to random or spontaneous decision making. Through rational thought, individuals proceed through a decision making process by first assessing each action



available to them, then determining possible outcomes of each action, and lastly by weighing the expected benefits or utility of each action (Dahlbäck, 2003). The action perceived as the most beneficial and providing the most utility will be chosen, which may include criminal actions.

Despite the seemingly straightforwardness of the rational choice theory, complications arise when applying rationality to criminal choices. One example is timing. When does rational decision making begin? In a model developed by Brown and Altman (1981), rationality is viewed as a series of decisions, in which sequential rational decisions are made over an extended period of time by the offender. A decision at one point of time will lead to a new set of choices, in which the offender must make additional decisions. Each decision made by the offender alters future choices, in which some actions and targets of crime become more likely while others do not. In sum, decisions made by the offender are linked and dependent on previous decisions. The actual criminal act is just a manifestation of a series of decisions made by the offender. Other researchers have also viewed criminal decision making as a progression of judgments as opposed to a singular choice, in which offenders exhibit an incremental decision making process (Hochstetler, 2001). Cornish and Clarke (1986) distinguish between criminal involvement and event decisions. The choice to become involved in criminal activity takes place over a period of time, characterized by a multi-step decision process, whereas event decisions are more specific and made relatively abruptly. Under this model constructed by Cornish and Clarke, the decision making process can long precede the actual criminal act, and rationality is not limited to the commission of the crime. In another construct of criminal decision making, Rengert and Wasilchick (2000) note that in addition to choosing to engage in criminal activities, offenders also need to determine how and where to commit a crime. Again, under this model, decision making extends well beyond the actual commission of the crime.

Despite its growing complexity, the rational choice theory is still characterized as the weighing of the benefits, costs, and risks of criminal activity (Dahlbäck, 2003). Decisions are then made based on this utilitarian analysis. It is also likely that the decision making process varies between different types of crime, and even within general crime categories. Cornish and Clarke (1986) define this as the “crime-specific focus” of rationality (p. 2). Using Cornish and Clarke’s rational choice model, it would be fallacious to categorize the nuances embedded in general crime types, such as robbery, under a broad conceptualization of rationality. For example, the decision making process to commit a home-invasion robbery may differ from the decision making process to commit a carjacking. Each specific crime embodies a unique decision making process, with a particular set of expected costs and benefits. Hence, the nature of rational choice among criminals depends heavily on the type of crime being considered.

### Routine Activities Theory

Like the rational choice theory, the routine activities theory has been expanded over the years with the growing body of related literature. However, the basic model set forth by Cohen and Felson (1979) has remained relatively consistent. Namely, that the necessary predicate for criminal activity is the spatial and temporal convergence of three elements: a motivated offender, a suitable target, and the lack of a capable guardian. Under this model, crime rates will be affected by changes in the daily routine activities of any of these three actors (motivated offenders, suitable targets, and capable guardians). If a change in routine activities facilitates or increases the likelihood of the convergence of motivated offenders with suitable targets without a

capable guardian, crime rates will similarly increase (Cohen & Felson, 1979). Also, victimization rates may reflect the daily travel patterns of potential targets, and may partially explain the differences in victimization by age, race, gender, and socioeconomic status (Cohen & Canter, 1980, 1981).

Subsequent research has introduced spatial concepts into the original routine activities theory developed by Cohen and Felson (1979). Proximity between potential targets and potential offenders has been shown to be a significant factor when examining the spatial component of criminal activity (Cohen, Kluegel, & Land, 1981). Through daily routine activities, motivated offenders and suitable targets are likely to converge more frequently as the proximity, or physical distance, between the two decreases. In other words, targets which are spatially closer to offenders are at greater risk of victimization. Likewise, an increase in target exposure or visibility also increases the chances of victimization (Cohen, Kluegel, & Land, 1981). An area's population structure may also play a role in criminal activity. There is evidence that as the density of capable guardians decrease, crime rates will increase due to the increase in criminal opportunity (Cohen, Felson, & Land, 1980).

The relevance of the routine activities theory to robbery offenses is unmistakable. The original routine activities theory was based on "direct-contact predatory violations," a condition easily met by the definition of robbery (Cohen & Felson, 1979, p. 589). Also, underscoring the assumptions of Cohen and Felson's original work is mobility and criminal travel. Convergence of a motivated offender, a suitable target, and the lack of a capable guardian can only occur through physical movements. Travel is a necessity of crime implied by the routine activities theory. Furthermore, by incorporating spatial hypotheses into the original premise, the routine activities model has become a theoretical framework in which to analyze journey-to-crime

patterns. Similar to the rational choice theory, opportunity is crime specific under the routine activities theory (Cohen & Felson, 1979). Criminal opportunity is shaped by the meaning of suitable targets and capable guardians. For instance, an empty home could be considered a suitable target for a burglary, but not for crimes that are defined by person-to-person contact, such as robbery or rape. In other words, *specific* crimes will be affected by *specific* routine activities patterns (Stangeland, 1998).

### Environmental Criminology

Crime needs a place to happen. Prior research has demonstrated that crime is not uniformly distributed, but rather clusters of high crime areas or “hot spots” appear when criminal activity is spatially analyzed (Weisburd, Bushway, Lum, & Yang, 2004; Weisburd & Mazerolle, 2000). Furthermore, targets of crime and potential offenders are also unevenly distributed over geographic areas (Brantingham & Brantingham, 1981). It appears that crime tends to pattern itself over space and time and, as a result, spatial and temporal dynamics are important aspects of criminal activity. Environmental criminologists argue “that the patterning of crime, and even the volume of crime, depends on motivation and opportunity, *and* mobility and perception” (Brantingham & Brantingham, 1981, p. 48). Environmental criminology is concerned with the interaction between space and crime, and shifts crime analysis towards “geographic imagination” (Brantingham & Brantingham, 1991, p. 18). Three concepts drawn from environmental criminology are especially relevant to offender mobility and journey-to-crime analysis: awareness space, search space, and nodes.

Before a crime can be committed, an offender must be able to successfully identify a potential target. Even though a target may hold characteristics that are attractive to the offender, the target will only be considered if the offender has knowledge of these characteristics (Rengert & Wasilchick, 2000). Therefore, criminal activity is shaped by the offender's familiarity with the physical environment and the targets within their surroundings. Such knowledge of geographic areas is referred to as the criminal's awareness space (Brantingham & Brantingham, 1981). Only targets falling within an offender's awareness space, by which the offender is aware of their existence, are in danger of possible exploitation. Targets lying outside an offender's awareness space will not be considered for criminal activity, since their characteristics are unknown. Hence, spatial knowledge limits the choices of potential targets rendered to motivated offenders, as unknown territories are exempt from possible victimization. Furthermore, not all awareness space is criminally enticing. Some areas that the offender has knowledge of will offer many desirable targets, while other areas will not (Brantingham & Brantingham, 1981, 1991). Search space is defined as a subset of an offender's awareness space, which is comprised of areas viewed as most attractive for criminal activity (Rengert & Wasilchick, 1985). As a result, an offender's activity over space is further limited, in which only certain areas within an offender's awareness space are considered for criminal purposes.

Nodes, also referred to as bases, are spatial reference points, which include the home, work, and recreational areas (Brantingham & Brantingham, 1981). These points are specific geographic locations that are visited frequently, and are considered to be the most familiar places in one's awareness. Because of this familiarity, an offender's awareness and search spaces will be shaped by the location of these nodes. Namely, as illustrated by Brantingham and Brantingham (1981), these spaces will be concentrated around the offender's nodes. This, in

turn, will influence criminal activity. The areas in which an offender's awareness space, shaped by his or her nodes, overlaps with areas consisting of desirable targets (i.e. the offender's search space), are the places where criminal activity will occur.

Environmental criminology postulates that space will guide an offender's decision making process. The locations of crimes and journey-to-crime patterns will reflect the nodes and search spaces of the offender. Spatial knowledge will be skewed towards the offender's nodes, which includes their home, and this knowledge will ultimately affect criminal decisions. Only targets in which an offender has some knowledge of will be considered for criminal activity. Furthermore, an offender's awareness space is shaped by their mobility. Knowledge and information is gained through exploration, which include both criminal and non-criminal travel (Brantingham & Brantingham, 1981). As the awareness space of the offender grows, shrinks, or changes due to the influxes of travel, so too will their spatial distribution of criminal activity. Hence, the interaction between the offender and the physical setting will help determine their criminal behavior and decision making process, as well as journey-to-crime patterns.

### Discussion

Whether implicitly or explicitly, the rational choice theory, routine activities theory, and environmental criminology all speak to criminal mobility. The concepts of movement and mobility can be integrated with the basic assumptions stipulated by each theoretical perspective. Through mobility, offenders may come in direct contact with potential targets (routine activities theory), alter the context in which decisions are made (rational choice theory), or enhance or

diminish knowledge of geographic areas (environmental criminology). And despite their fundamental differences, all three theories predict short journey-to-crime distances. However, the mechanisms used to reach this conclusion are very different.

Under the rational choice theory, offenders weigh the potential benefits of a crime versus its potential costs and risks (Cornish & Clarke, 1986). Rationality may also include a process of utility maximization, in which a potential offender chooses the best course of action given the circumstances and alternative choices (Dahlbäck, 2003). Crime is simply the result of this decision making process. When the criminal activity is viewed as more beneficial than non-criminal activity, or when the potential benefits of such action outweighs the perceived costs and risks, then crime will occur. To maximize utility, the rational offender tries to minimize the costs and effort of committing a crime (Potchak, McGloin, & Zgoba, 2002). Journey-to-crime can be viewed as a cost of criminal activity, since traveling requires time and energy (Brantingham & Brantingham, 1981). It would be expected that the rational offender would minimize the journey-to-crime, as overcoming distance is a cost of crime. Therefore, under the rational choice theory, short journey-to-crime distances would be preferred over long ones, and likewise criminal mobility would also be expected to be minimal. However, the attractiveness of short travel distances is tempered by the offender's perceived risks of committing crimes close to home. The criminal is more likely to be known and identified the closer the offense is to the home (Brantingham & Brantingham, 1981). Also, various criminal patterns, including the general level of criminal activity and journey-to-crime, may be shaped by the availability of targets and opportunity (Andresen, 2006; LaGrange, 1999; Sullivan, McGloin, Pratt, & Piquero, 2006; Van Koppen & Jansen, 1998). Strictly related to criminal mobility, the further potential targets are away from the home, the greater crime travel should be expected. However, all else

being equal, rational offenders would choose targets close to home over targets further away to lessen the costs of travel.

The routine activities theory also implies relatively short journey-to-crime distances. The predicate to a criminal offense is the convergence of three elements: a motivated offender, a suitable target, and the lack of a capable guardian (Cohen & Felson, 1979). Criminal mobility is therefore shaped by the mobility patterns and routine activities of these three actors. The original conceptualization of routine activities set forth by Cohen and Felson (1979) does not imply short or long crime trips. Criminal opportunity occurs when a motivated offender and a target without a capable guardian converge. This opportunity structure is independent of the offender's home. If the offender's daily routine activities transport him or her to areas far from home, then it is also possible that the convergence of a target without a capable guardian will also occur far from home.

However, research conducted by Cohen, Kluegel, and Land (1981) concluded that proximity influences criminal opportunity, in which suitable targets physically near motivated offenders are at greater risk of victimization. Using Cohen and Felson's (1979) terminology, closer spatial proximity between motivated offenders and targets without a capable guardian increases the likelihood of convergence, thereby increasing the risk of victimization. This research by Cohen, Kluegel, and Land integrate spatial variables into the original routine activities theory. The convergence of the three elements enumerated under the routine activities theory increases in frequency when offenders are physically close to suitable targets. Since criminal mobility reflects the routine activities of the offender, one would expect short journey-to-crime distances. In essence, the probability of the convergence between a motivated offender and a target without a capable guardian is skewed towards targets near the offender. As a result,



through the mechanisms of proximity and routine activities, journey-to-crime patterns should be relatively short. Additional research has supported this relationship, as the proximity of offenders to potential targets decreases, the likelihood of victimization increases (Sampson, 1985; see also Cochran, Bromley, & Branch, 2000; Fisher, Cullen, & Turner, 2002; Miethe & Meier, 1990; Mustaine & Tewksbury, 1998).

Like an increase in proximity, an increase in exposure of a target will also increase the chances of victimization (Cohen, Kluegel, & Land, 1981; Dugan & Apel, 2005). Exposure of a target is also linked to opportunity, whereby the more interaction (or exposure) between the offender and the target the greater the opportunity for crime. Similarly, Cohen, Kluegel, and Land (1981) found that familiarity of a target is also linked to criminal activity. Additional research has supported this finding that familiarity with potential targets increases their vulnerability of victimization (Boggs, 1965; Bullock, 1955; Smith, Frazee, & Davison, 2000; Wright & Decker, 1997). Both exposure and familiarity of a target should increase as proximity to the offender decreases, since the frequency of contact between offenders and targets increases as proximity decreases (Cohen, Kluegel, & Land, 1981). Hence, under the routine activities theory, journey-to-crime should be relatively moderate as the influences of proximity, exposure, and familiarity are skewed towards targets close to the offender's home.

The third theoretical perspective also predicts short journey-to-crime distances. Environmental criminologists view the home and the surrounding area as an integral part of the offender's awareness space, since "awareness spaces are primarily based on nodes centered at the home, work or school, shopping locations, recreational areas, and the paths connecting these" (Brantingham & Brantingham, 1981, p. 37). Regular activity around the home increases the offender's knowledge of the area. As such, the offender will likely have some knowledge

regarding potential targets close to home, effectively biasing search spaces near the offender's place of residence. Since targets near the offender's home are more likely to be identified and integrated in the offender's cognitive map, long crime trips associated with target searches will be unnecessary.

Other nodes and awareness spaces may also result in the identification of attractive targets. In a study on burglary, Rengert and Wasilchick (1985) conclude that in addition to the home, work and recreational locations strongly influences target selection, stating "the search behavior of the burglars is orientated, if not constrained, by the habitual, familiar journey to work" (p. 69). Depending on the proximity of these nodes to the home, offender mobility may become quite large. Nodes separated by long distances would result in greater criminal commutes, since the spatial location of the awareness spaces and the corresponding targets are relatively far away from the home. However, as Brantingham and Brantingham (1981) state, "it takes time, money, and effort to overcome distance. If any of these factors is constrained, then close locations have inherent advantages over distant locations" (pp. 30-31). Hence, because of the ease, availability, and lack of strain required for criminal activity, targets closer to the offender's home are viewed as more desirable than those further away.

Through the influences of an offender's awareness spaces, target availability, and potential costs of overcoming long distances, Brantingham and Brantingham (1981) predict a criminal mobility phenomenon known as distance decay. The distance decay model concludes that the probability of a target being victimized by an offender decreases as the distance from the offender's home increases. In other words, criminal activity is inversely related to distance from the offender's home. As a result, average journey-to-crime distances are expected to be relatively short. However, targets within the area immediately surrounding the offender's home

are less likely to be victimized, because of the increased possibility of detection and apprehension (Brantingham & Brantingham, 1981). Therefore, offender mobility patterns should reflect the balance between the risks of being identified with the costs of overcoming distance.

## LITERATURE REVIEW

Research on criminal mobility over the last thirty years has supported the distance decay prediction set forth by Brantingham and Brantingham (1981) (Van Koppen & Jansen, 1998; see also Bernasco & Nieuwebeerta, 2005; Capone & Nichols, 1976; Philips, 1980; Potchak et al., 2002; Rengert, Piquero, & Jones, 1999; Rhodes & Conly, 1981; Snook, 2004; Turner, 1969; Warren et al., 1998). Furthermore, this journey-to-crime phenomenon is supported among several crime types and through various statistical methodologies. For example, distance decay mobility patterns have been observed for: rape (Warren et al., 1998), burglaries (Rengert et al., 1999), auto-thefts (Potchak et al., 2002), and robberies (Capone & Nichols, 1976). In sum, the distance decay phenomenon has been a pervasive finding in previous journey-to-crime research.

In conjunction with distance decay, previous research has demonstrated that the typical crime trip is relatively short. Just as each theoretical model predicted, the general consensus of empirical research is that offenders commit crimes close to home. Table 1 summarizes the current literature on journey-to-crime. Regardless of the year and location the study took place, previous research has routinely shown that offenders are unlikely to travel long distances; with a mean and/or median crime trip distances of less than three miles. Furthermore, the tendency of offenders to display limited mobility traverses crime types. Both property (Phillips, 1980; Pyle, 1976; Wiles & Costello, 2000) and predatory (Canter & Larkin, 1993; Godwin & Canter, 1997; Rhodes & Conly, 1981) offenders exhibit modest mobility.

Furthermore, the predictions of the rational choice theory, routine activities theory, and environmental criminology appear to be statistically supported. In fact, several studies on

Table 1: Summary of Research on Journey-to-Crime

Offense	Source	Findings
Homicide	Bullock (1955)	Over 74% of homicides occurred less than two miles from the offender's home
Delinquent Events <sup>1</sup>	Turner (1969)	Median distance traveled from the offender's home: 2,152.5 feet (3.5 "units") 75% of all offenses occurred within one mile from the offender's home
Robbery	Capone and Nichols (1976)	33% of robberies occurred within one mile of the offender's home Over 50% of robberies occurred within two miles of the offender's home Almost two-thirds of robberies occurred within three miles of the offender's home Mean distance traveled by vehicular robbers: 2.68 miles Mean distance traveled by residential robbers: 2.47 miles
Property Crime	Pyle (1976)	Mean distance traveled from the offender's home: 2.30 miles
Robbery	Nichols (1980)	Mean distance traveled from the offender's home: 2.02 miles by offenders less than 20 years old 4.98 miles by offenders 20 years old and older 3.56 miles by male offenders 2.45 miles by female offenders 2.29 miles by black offenders 6.67 miles by white offenders
Assault	Phillips (1980)	Mean distance traveled from the offender's home: 0.70 miles
Burglary	Phillips (1980)	Mean distance traveled from the offender's home: 1.05 miles
Auto Theft	Phillips (1980)	Mean distance traveled from the offender's home: 1.15 miles
Petty Larceny	Phillips (1980)	Mean distance traveled from the offender's home: 2.46 miles

Offense	Source	Findings
Drug Related	Phillips (1980)	Mean distance traveled from the offender's home: 1.93 miles
Burglary	Pope (1980)	52% of burglaries occurred less than or equal to one mile from the offender's home
Robbery	Rhodes and Conly (1981)	Mean distance traveled from the offender's home: 2.10 miles Median distance traveled from the offender's home: 1.62 miles
Burglary	Rhodes and Conly (1981)	Mean distance traveled from the offender's home: 1.62 miles Median distance traveled from the offender's home: 1.20 miles
Rape	Rhodes and Conly (1981)	Mean distance traveled from the offender's home: 1.15 miles Median distance traveled from the offender's home: 0.73 miles
Robbery	Feeney (1986)	Over one-third of offenders robbed within the neighborhood in which they lived Over 70% of offenders robbed within the town in which they lived
Rape <sup>2</sup>	Canter and Larkin (1993)	Mean minimum distance traveled by serial rapists: 1.53 miles
Murder <sup>2</sup>	Godwin and Canter (1997)	Mean distance traveled to abduct victims: 1.46 miles
Robbery	Van Koppen and Jansen (1998)	Mean distance traveled from the offender's home: 19.2 km Median distance traveled from the offender's home: 3.5 km 31% (270 out of 876) of robberies occurred within two km from the offender's home
Rape <sup>3</sup>	Warren et al. (1998)	Mean distance traveled from the offender's home: 3.14 miles 48% (40 out of 83) of rapists raped within a half-mile from their home

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Offense	Source	Findings
Burglary	Rengert et al. (1999)	46% (51 out of 112) burglaries occurred within one mile from the offender's home
Vehicle Theft	Wiles and Costello (2000)	Mean distance traveled from the offender's home: 1.97 miles
Domestic Burglary	Wiles and Costello (2000)	Mean distance traveled from the offender's home: 1.88 miles
Shoplifting	Wiles and Costello (2000)	Mean distance traveled from the offender's home: 2.51 miles
Auto Theft	Potchak et al. (2002)	Mean distance traveled from the offender's home: 1.68 miles
Burglary	Snook (2004)	Median distance traveled from the offender's home: 1.7 km 33% of targets selected were within one km from the offender's home 84% of targets selected were within five km from the offender's home 13% of targets selected were between five and ten km from the offender's home 3% of targets selected were over ten km from the offender's home
Assortment <sup>4</sup>	Sarangi and Youngs (2006)	Mean distance traveled from the offender's home: 1.62 km Over two-thirds of crimes were committed within 2 km of the offender's home

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<sup>1</sup> Refers to offenses resulting in injury to victims and/or property loss or damage

<sup>2</sup> Study of serial offenders

<sup>3</sup> Results reflect travel distances of local serial rapists

<sup>4</sup> Study is based on thirty serial burglary offenders in India, of which committed burglary, theft, robbery, dacoity (robbery involving five or more offenders), rape, and grievous bodily harm

criminal mobility conclude that more than one of these theories may be reflected in criminal mobility behavior. Feeney's (1986) study on robbery offenders indicated that criminal travel decisions are not only rational, but are also guided by the hypotheses set forth in the routine activities theory. For the most part, robbers traveled relatively short distances, limiting their activities to the town in which they resided. However, there were indications that those who did travel out-of-town did so because of the availability of suitable targets. As reported by Feeney, one offender robbed in a neighboring town because "most of the motels in the area were outside the town where he lived" (p. 63). In another study on robbery, Van Koppen and Jansen (1998) studied journey-to-crime travel patterns of commercial robbers. Offenders who traveled the shortest distances lived and robbed in areas that were most densely populated by targets. Conversely, longer crime trips were associated with more rural regions, as "trip traveled was also related to the density of targets" (Van Koppen & Jansen, 1998, p. 241). Lastly, Potchak et al. (2002) analyzed offender mobility and auto-theft in Newark, New Jersey. The authors investigated the relationship between auto-theft and the opportunity structure of the city, which was defined by four variables: land use, public housing, roadways, and Penn Station. Not only were journey-to-crime distances fairly short, but the findings also indicated a strong correlation between auto-theft occurrences and general opportunity (Potchak et al., 2002).

Therefore, crime trips appear to be governed by the offender's goal to minimize the costs of committing the crime, including distance, and the availability of potential targets. In addition, exploitation of potential targets will be dictated by the offender's knowledge of the area (Brantingham & Brantingham, 1981, 1991; Rengert & Wasilchick, 1985, 2000). The influences of these factors may act in unison, as opposing forces, or somewhere in between. Following Brantingham and Brantingham's (1981) assumption that offender's prefer nearby targets as



opposed to ones further away, criminal travel will be indicative of target availability. Journey-to-crime distances will merely reflect the spatial distribution of targets. If a cluster of targets exists near the offender's home, and the offender is cognitive of such targets, crime trips will be short. However, targets are not always immediately available to the offender, especially commercial or spatially fixed targets (Capone & Nichols, 1976). Under these circumstances, longer crime trip distances would be expected, as shown by Feeney (1986) and Van Koppen and Jansen (1998). In sum, it appears that the interplay between target availability and the rationality of offenders shape the criminal commute.

Despite the attention given to criminal mobility, several limitations are apparent in the existing body of research. The first limitation relates to how mobility and distance are measured. A handful of studies do not directly measure offenders' journey-to-crime, in which criminal travel was not calculated as the distance between the offender's home address and the specific location of the offense. Rather, mobility is inferred from aggregated data. Geographical units, such as zones, neighborhoods, towns, zip codes, or other like areas are analyzed and compared. Mobility is then defined as the movement from one zone to another (Feeney, 1986; Hesseling, 1992; Pettiway, 1982, 1985). In these types of studies, mobile offenders are defined by those who traverse the geographic boundaries constructed by the researcher, in which the offender's home and the location of the offense are located in two different units. Although such methodologies may indicate the relative attractiveness of an area relative to crime (Bernasco & Luykx, 2003; Bernasco & Nieuwbeerta, 2005; Rengert, 1980), they are ill-suited for measuring journey-to-crime distances. The major drawback of such a research design is that the findings on criminal mobility may be misleading. Offenders who cross these jurisdictional boundaries are implied to display greater mobility than those who do not. However, this assumption that those

who cross a geographical boundary travel further than those who do not may lead to inaccurate conclusions. Offenders living near the edges of these zones or units may cross these spatial boundaries with minimal travel. Conversely, offenders who do not cross jurisdictional boundaries may in fact travel comparatively further, depending on the size of the geographic areas analyzed by the researcher. To accurately gauge the level of criminal mobility, point analysis is needed to determine the true criminal commute of offenders. Namely, street-level address data, which reflects the most specific location of the offender's home and crime location, should be obtained and compared.

Several methodologies used in prior research studies have encouraged the distance decay phenomenon, as well as small mean and median journey-to-crime distances. In a study on juvenile delinquency, Phillips (1980) analyzed various offenses occurring in Lexington-Fayette County, Kentucky. The average distance of all crime trips, which included all juvenile offenses included in the study, was 1.43 miles. However, the data set and methodology that was used eliminated the possibility of long crime trips. Data was obtained from the Lexington-Fayette Urban County Police Department. Only juveniles residing within the county were used for the study, which excluded offenders who traveled into the county from neighboring areas (Phillips, 1980). Although it is probable that offenders arrested but not residing Lexington-Fayette County would display greater mobility, these juveniles were not included in the study.

In another example, Rhodes and Conly (1981) studied journey-to-crime distances of rape, robbery, and burglary offenders in Washington, D.C. The offender mobility analysis also included aspects of opportunity, in which land use of the city was also studied. Like Phillips' (1980) research on juvenile delinquency, the Rhodes and Conly study was limited to the geographic area of the city. Only criminals who resided in Washington, D.C. and who

committed their crime in the city were included in their data set. Hence, the more mobile offenders traveling into or out of Washington, D.C. were excluded, skewing the findings towards shorter journey-to-crime distances.

In a more recent study, Warren et al. (1998) examined the mobility patterns of serial rapists. The study researched the mobility patterns of numerous rape-related characteristics, such as the time (day/night) and location (inside/outside) the rape occurred. The mean travel distances reported by the authors tended to stay within the two to four mile range, with the decaying effect described by Brantingham and Brantingham (1981). However, it is difficult to determine if the mobility of serial rapists is indeed limited, as indicated by the study, or if the research design used by the authors artificially produced short journey-to-crime patterns. As stated in their paper, “sixteen cases [out of 108] were removed from the main analyses, as they involved rapes occurring over 20 mi (i.e., 21 to 620 mi) from the rapist’s residence” (Warren et al., 1998, p. 45). Nearly 15 percent of the original sample was ignored for the bulk of their analysis, simply because the offenders exhibited greater travel. When these offenders were included in the analysis, the mean distance traveled by serial rapists jump from 3.14 to 14.54 miles (Warren et al., 1998). This result is glossed over by the authors, and the mobile rapists (those that traveled over twenty miles) are not included in their ensuing analyses. In essence, only rapists who supported the distance decay phenomenon were included in the study, severely biasing the results.

One last example comes from the Potchak, McGloin, and Zgoba’s (2002) study on auto thefts in Newark, New Jersey. The authors utilized mapping software and included a detailed spatial analysis of the Newark area, attempting to control for criminal opportunity. However, not only were offenders who lived in the city but traveled elsewhere to commit their crime excluded

form the study, so too were offenders who resided outside of the city limits but stole a car in Newark. As a result, the original sample of 277 auto-theft incidents resulting in an arrest, obtained by the Newark Police Department, was reduced to 228 cases (with 201 of those cases being successfully mapped) (Potchak et al., 2002). Again, a substantial subset of offenders, over 17 percent of the original sample, was not included in the research study because of their enhanced mobility.

The preceding examples illustrate a major problem in journey-to-crime research, in which offenders who travel, or who are more likely to travel relatively long distances to commit their crime, are systematically excluded from the research study. In the studies previously discussed, the data set is defined by offenders who travel short distances. It is difficult to determine to what extent the results reported from prior research reflects the true mobility patterns of criminal offenders, and how much of these findings are artifacts of past research methodologies. The empirical support of the distance decay phenomenon is particularly troublesome. Previous research has demonstrated that the number of offenses wane as distance from the offender's home increases. However, by excluding the very offenders who violate the distance decay trend and travel long distances, the conclusions of past journey-to-crime studies are inherently biased. Furthermore, the general consensus that the typical crime trip is short is tempered by journey-to-crime distance limitations imposed by researchers. Studies that include only offenders who reside and commit their crime within the same geographical entity (such as a town, neighborhood, or city) restrict the maximum travel possible. Using Rhodes and Conly's (1981) study as an example, the furthest a criminal can travel, and still be included in the analysis, is from one edge of Washington, D.C. to the other. Hence, the mean and median journey-to-crime distances that are reported should be interpreted relative to this maximum possible mobility. For

instance, is the average criminal commute by robbery offenders of 2.10 miles “short,” given that the District of Columbia consists of 61 square miles of land area (U.S. Bureau of the Census, 2000)? Without a detailed frame of reference, the findings from prior journey-to-crime research are difficult to interpret.

The final limitation derives from the definitions of crimes used in previous research. Prior studies have lumped similar criminal behaviors under broad general categories, such as burglary or robbery, thereby creating a one-dimensional viewpoint of offenses. However, the aggregation of like crimes into a single, generically defined behavior may hide important differences within crime types. In a recent paper, Tita and Griffiths (2005) analyzed mobility and homicides occurring in Pittsburgh, Pennsylvania between 1987 and 1995. Several mobility-related factors were explored in the study, which consisted of “participant characteristics” and “event-specific characteristics” (Tita & Griffiths, 2005, p. 280). Participant characteristics refer to the age, gender, and race of the offender and victim, while event-specific characteristics relate to the individual nuances of each homicide that occurred. Such event-specific characteristics included: motive and location of the homicide, type of weapon used, and nature of the victim-offender relationship. The study results in an analysis based on a spatial typology of homicide, which considers both the characteristics of the offenders and victims, as well as the characteristics associated with each homicide. The authors conclude that “event characteristics shape the mobility patterns of victims and offenders to homicide incidents” (Tita & Griffiths, 2005, p. 302).

The findings of the Tita and Griffiths (2005) study illustrates that mobility differences do not only exist *between* different types of crime, but also *among* specific crime types. Although such a crime typology is limited in journey-to-crime research, studies that do disaggregate

general crime categories also indicate travel variability within crime types. Snook's (2004) study on serial burglars discovered that average crime trip distances vary depending on the characteristics of the burglar and the nature of the burglary. Statistically significant mobility differences were found relative to the method of transportation used to commit the burglary and the value of the property stolen. Additional travel differences were observed for other variables as well, such as the age of the offender and the type of target chosen. Warren et al. (1998) found significant differences in mean crime trips among serial rapists. Specifically, rapists who used restraints, were ritualistic in nature, and obtained their restraints at the scene of the crime tended to travel further than their counterparts. Relative to robbery, Capone and Nichols (1976) discovered mobility differences between armed and unarmed robbers. Also, the authors found that the journey-to-crime involving open space robberies were typically shorter than commercial robberies, in which the authors alluded to the influence of target availability.

As mentioned above, the term robbery embodies an array of criminal activity. Many different types of robbery can occur (see List of Nomenclature), each signifying different criminal processes and, possibly, different criminal mobility patterns. As such, it is imperative that research on robbery offenses is broken down into its component parts, reflecting the breadth and variability of the crime. The current literature on offender mobility does not sufficiently examine travel differences among the various types of robbery, such as carjacking, home-invasion robbery, and robbery by sudden snatching. Tita and Griffiths' (2005) research demonstrated that a more stringent representation of criminal definitions and conceptualization is needed, as journey-to-crime trends can become lost when a single, general definition for crime is used.

This paper attempts to address three prevalent gaps in the current body of criminal mobility literature. First, specific robbery offenses will be analyzed relative to the criminal commute. By breaking down the generic crime category of robbery into smaller subgroups, a more in-depth, inclusive review of journey-to-crime could be conducted. Second, as previously shown, mobile offenders have been systematically excluded and ignored in prior research studies. The current paper addresses criminal mobility with an unbiased perspective, in which all offenders, regardless of their respective mobility, will be included in the ensuing mobility analyses. Third, whether due to lack of technology, data availability, or research conceptualization, very few studies have directly examined the distance from an offender's home to the crime site for a large data set. One notable exception is the Wiles and Costello (2000) study on burglars in Sheffield, England, which analyzed several thousand crime trip distances based on the x, y coordinates of the offender's home and crime location. More typically, prior journey-to-crime research falls into one of two categories. Either the geographic scope of the study is limited to a single city, county, or police jurisdiction while examining the specific address of the offender and offense (Capone & Nichols, 1976; see also Nichols, 1980; Phillips, 1980; Potchak et al., 2002; Rhodes & Conly, 1981; Warren et al., 1998). Or, criminal travel between geographical units such as zip codes and neighborhoods, as opposed to individual addresses, are analyzed (Feeney, 1986; Hesseling, 1992; Pettiway, 1982, 1985; Van Koppen & Jansen, 1998). The current study attempts to combine spatial robustness with accurate journey-to-crime measurements.

## METHODOLOGY

To conduct a mobility analysis on various types of robbery offenses, the current study implemented a five-step research design process. First, the research questions and hypotheses of the study are presented. Next, a robbery typology was constructed. The purpose of the robbery typology is to further refine the generic crime category of robbery into smaller, more homogeneous parts. This will aid in the general understanding of mobility exhibited by robbery offenders, and avoid some of the shortcomings of prior journey-to-crime research; namely, the overgeneralization of criminal definitions. Third, data which contains the necessary elements for journey-to-crime research had to be collected. Specifically, the address of the offense and the offender's home, as well as the type of robbery that occurred, had to be collected. Fourth, after obtaining the necessary data, the physical location of the robbery and the offender's home address had to be determined. The spatial locations of these two addresses were estimated through the use of geographic information system (GIS) technology, and more specifically a process termed geocoding. And fifth, after the offender's residence and location of the robbery were approximated, the distance between the two addresses had to be measured. The straight-line distance calculation would represent the crime trip of each offender.



### Hypotheses of the Current Study

Over the past several decades, a fair amount of journey-to-crime research has been produced. However, less attention has been given to the crime of robbery, and little attention has been given to the mobility patterns of specific types of robberies. The current research addresses the shortcomings in the literature by examining the criminal commute of different types of robbery offenders. Diverging from prior research, a robbery typology was constructed, based around Florida's state criminal statutes. Journey-to-crime trends for each robbery type were then analyzed. The primary goals of the current study are two-fold: to determine how far different types of robbery offenders travel to commit their crime, and to ascertain any significant differences in criminal mobility among different types of robbery offenses and offenders.

Previous journey-to-research has discovered mobility differences among demographic characteristics of offenders. In a study on robbery offenders, Nichols (1980) found statistically significant mobility differences between black and white, male and female, and young (twenty years old and younger) and old (over twenty years old) offenders. Nichols concludes by stating, "age, sex, and race distributions in a region can be thought of as partial predictors of robbery movement behavior" (p. 165). In a study on ten different offense categories, Phillips (1980) also discovered mobility variability between gender and age groups. Contradicting Nichols' (1980) study, female offenders were found to travel further than their male counterparts. In Pettitway's (1982) study on robbery and burglary offenders, he concludes that "both race and offense type have independent effects on destination" (p. 265), and that black robbers were more likely to traverse ghetto boundaries than white robbers. Two more recent studies have also found statistically significant mobility differences among offender demographic characteristics.

Warren et al. (1998) found that white rapists on average traveled farther than minority rapists, and that older rapists exhibited greater mobility than their younger counterparts. Finally, Snook's (2004) research on burglary found similar results to that of the serial rapist study by Warren et al., in which older burglary offenders (those over twenty years of age) traveled further than younger burglars.

Target selection also appears to impact criminal mobility. In their study on robbery offenders in Miami, Capone and Nichols (1976) found journey-to-crime variation between offenders who victimized open space targets to those who robbed fixed premises, such as business establishments. In their comprehensive study on commercial robbers, Van Koppen and Jansen (1998) conclude that the level of security and target difficulty is positively correlated with the criminal commute. This was evidenced by a comparison between bank and gas station robberies. Robbers who targeted banks traveled further than those who robbed gas stations (Van Koppen and Jansen, 1998).

The current study addresses these significant findings of previous journey-to-crime research. Specifically, five independent variables were analyzed: age, race, gender, robbery type, and target characteristics. The effects of these variables were tested against the dependent variable of crime trip distance. Offender demographic data was obtained from the arrest reports, and the robbery typology that was constructed includes both open space and fixed targets. For the ensuing analyses, commercial and home-invasion robberies are classified as fixed target robberies, while personal robbery, robbery by sudden snatching, and carjacking are labeled as open space robberies.

The following hypotheses are stated as follows:

H<sub>1</sub>: Mobility differences will exist among the different types of robbery offenses.

H<sub>2</sub>: Crime trips will tend to be longer for fixed targets than open space targets.

H<sub>3</sub>: White arrestees will travel further than black arrestees.

H<sub>4</sub>: Male arrestees will travel further than female arrestees.

H<sub>5</sub>: Older arrestees will travel further than younger arrestees.

### Conceptualization of Robbery Typology

To enhance the understanding of robbery offenders' level of mobility, a five-section typology was created. The five robbery types used for the ensuing analyses mirror the State of Florida's robbery criminal statutes, which served as a template for the categorization of robbery offenses (West's Florida Statutes Annotated § 812, 2006). The robbery typology is comprised of: personal robbery, robbery by sudden snatching, home-invasion robbery, carjacking, and commercial robbery. The classification of robbery offenses was fairly straightforward, as three of the robbery categories included in the typology are synonymous with specific criminal statutes; robbery by sudden snatching (Florida Statute § 812.131); carjacking (Florida Statute § 812.133); and home-invasion robbery (Florida Statute § 812.135) (also see List of Nomenclature). Offenders which were arrested under one of these three robbery statutes were classified accordingly. However, the criminal statutes of Florida do not distinguish between commercial robbery and robbery of persons, which are both embodied under Florida statute § 812.13. For the current study, two criteria had to be met for an offense to be labeled a commercial robbery. First, the offender must have been arrested under robbery statute § 812.13, and not under the sudden snatching, carjacking, or home-invasion statute. Second, the money or property which

was taken during the commission of the robbery must have belonged to or owned by a business establishment. Similarly, personal robbery is defined as the taking of money or property belonging to an individual, otherwise not defined as any of the other four robbery types. Figure 1 illustrates the relationships between Florida’s robbery statutes and the robbery typology used for this study. To determine whether statute § 812.13 robberies were either commercial or personal, the description of each robbery occurrence was reviewed and coded. If the ownership of the property taken belonged to a business, then the robbery was classified as a commercial robbery. All other robberies not classified as either a sudden snatching, home-invasion, commercial, or carjacking robbery were defined as a personal robbery.

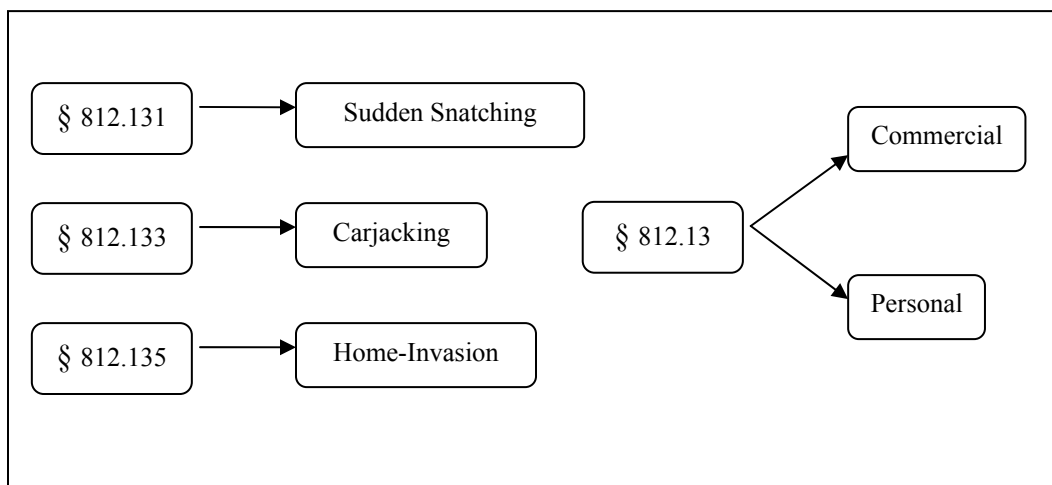


Figure 1: Relationships between Florida’s Robbery Statutes and the Robbery Typology

To ensure that the five robbery categories were mutually exclusive, two decisions regarding the classification of offenses had to be made. First, robberies by sudden snatching are generally viewed as purse-snatching or other equivalent behaviors in which an individual is deprived of property. However, sudden snatching robberies can also occur within a business

establishment, sometimes referred to as a smash-and-grab, in which a business is the victim of the robbery. To reconcile this ambiguity, all robberies by sudden snatchings, as indicated by the corresponding criminal statute, were treated as such. Therefore, the robbery by sudden snatching category includes both commercial and personal victims. Although a case can be made to treat sudden snatchings that occur within a business as commercial robberies, the actual behavior exhibited by these offenders was thought to be better represented under the sudden snatching definition, as opposed to the commercial robbery definition.

Second, from the brief description included on typical arrest reports, it is impossible to determine if the victim of a robbery is exclusively a person or a commercial enterprise. One particular scenario is especially troublesome; the robbery of a pizza delivery driver. The sample used for this research project included a handful of cases in which a pizza delivery carrier was robbed while making a delivery (usually to the offender's home). The property taken during the commission of these robberies, i.e. the pizza, of course belongs to the pizza establishment. However, the money taken may belong to the business (in the form of sales from previous deliveries), or the delivery driver (as tips or general cash). The information included on the arrests reports collected for this study do not identify what was taken from whom, and how much. For purposes of this study, if the primary target of the robbery was a business and the defendant was charged under the general robbery statute, then the crime is defined as a commercial robbery. Generally, the robbery occurrences defined as commercial robberies were apparent, in which an offender entered a place of business. In the cases of the pizza delivery robberies, the delivery person is seen as an extension of the pizza parlor, and these robberies were therefore labeled as commercial robberies.

The decision to use Florida's criminal statutes as a guide in constructing the robbery typology was made for three primary reasons. First and most importantly, the criminal statutes reflect possible offender mobility difference. Although the underlying premise of each robbery statute is the same, namely the taking of property or money by force or threat of force, the hypothesized journey-to-crime characteristics of these robberies are inherently and fundamentally different. Opportunities to commit different types of crimes, and even subsets of general crime types, may vary over time and space (Cohen & Felson, 1979; Lynch & Cantor, 1992; Van Koppen & Jansen, 1999). As stated by Felson and Clarke (1998), "the opportunity for crime must be evaluated for very specific categories of offence" (p. 14). The opportunity structure for various robbery offenses also appears to vary within the crime category, particularly between robberies of fixed and open space premises (Capone & Nichols, 1976). As the opportunity structure varies among robbery types, it seems logical that travel patterns to reach these opportunities would vary accordingly. The robbery statutes and the similarly constructed robbery typology used for the current study include both fixed premises (homes and businesses) and open space targets (persons and automobiles). As such, the Florida statutes easily lend themselves to criminal mobility-related research.

Second, prior research has analyzed several relationships relative to criminal mobility, including age (Nichols, 1980), gender (Phillips, 1980), and criminal experience (Snook, 2004). Among robbery-related research, such variables as the use of a firearm by the robber (Capone & Nichols, 1976), the number of perpetrators used to commit the robbery, and the seasonal variations in robbery offenses (Van Koppen & Jansen, 1998, 1999) have been investigated. However, previous research on criminal mobility has not addressed specific criminal statutes. Analyzing specific statutes seems particularly important in the case of robbery, as the robbery

statutes encompass a variety of criminal activity, and police and community responses may vary among specific robbery types. Third, by using the Florida criminal statutes, delimiting robbery offenses by type was relatively easy, as the corresponding offense statute is included on arrest and charging reports.

### Data Collection Methods

After creating the robbery typology, data had to be obtained which contained the necessary elements to analyze journey-to-crime. Namely, the location of the robbery occurrence, the offender's last known or reported residence, and the type of robbery that occurred had to be collected. Arrest reports fill these criteria. In addition, arrest reports also include a short narrative of the crime. Through this narrative, offenders charged under the § 812.13 robbery statute could be classified as either commercial or personal robbers.

Traditionally, research on criminal mobility has analyzed arrest data from an urban city or county police department (Capone & Nichols, 1976; Hesselning, 1992; Phillips, 1980; Potchak et al., 2002). Although convenient, collecting data from a single city or county police department for this study would have been problematic for three reasons. First, the scope of this research project must be geographically robust. If mobile offenders are to be identified, then data sources from multiple police jurisdictions have to be collected. The reason is that arrest data is compartmentalized, in which police agencies typically only store and have access to criminal data occurring within their jurisdiction. For instance, the sheriff's offices of Florida serve the unincorporated areas of their respective county, and also provide police services to the

smaller cities and towns within the county which do not maintain a police force. As a result, data obtained from most county sheriff's office will not include offenses occurring within a municipal police department's jurisdiction, even if the city that the municipal police department serves lies within the county. Although data obtained from a single police department will capture offenders who live in and are imported into the jurisdiction, it will fail to identify offenders who reside within the city or county boundary and commit their crimes in other jurisdictions; even in neighboring jurisdictions. As expected, prior research has demonstrated that offenders who commit their crimes in jurisdictions other than the one in which they live travel further than those who do not (Wiles & Costello, 2000). Ideally, data would be collected from several adjacent police jurisdictions to aid in identifying offenders who traverse jurisdictions. By collecting data from numerous data sources, offenders who cross jurisdictional boundaries, namely those who are likely to display greater mobility, are more likely to be represented in the data set. For example, if data was collected from every police department within a county, criminal movement within the entire county would be captured. Expanding this methodology, if data was collected from every police department in several counties, offenders who cross county lines would also be obtained. The importance of collecting data from multiple police sources cannot be understated. More so than other criminal research topics, journey-to-crime research is particularly sensitive to the spatial dimension of the data that is collected. Data which is geographically restricted may have significant consequences on the amount of observed criminal mobility. Thus, it is imperative to ensure that offenders who travel have an opportunity to be included in the sample. This can be achieved, in part, by collecting criminal data over a relatively large spatial area.



The second reason for collecting data from multiple sources is volume. Although robbery counts that occur in Florida are easily accessible (Florida Department of Law Enforcement, 2005), it is unclear how many of these are home-invasion robberies, sudden snatching robberies, and etc. To obtain enough cases for each robbery type to conduct statistical testing, multiple data sources were needed. And finally, prior research has shown that criminals residing in more rural areas tend to travel further than those living in urban areas (Van Koppen & Jansen, 1998). Previous journey-to-crime research which analyze data from an urban police departments, such as the Potchak et al. (2002) study in Newark and the Capone and Nichols (1976) study in Miami, are therefore inherently biased towards shorter criminal commutes. A more representative sample would include both rural and urban areas.

Data for the current study was collected from two sources: the State Attorney's Office of the Eighth Judicial Circuit, and Seminole County Sheriff's Office. Using Dillman's (1978) total survey design methodology, every State Attorney's Office in the State of Florida were contacted and asked to participate in the mobility study (N = 20). Specifically, each state attorney in Florida was identified and a database with their contact information, which included the state attorney's address and fax and telephone numbers, was compiled. One week after mailing formal letters requesting their participation, callbacks to each non-respondent were made to reiterate the importance of the study. Approximately one week later, letters were re-mailed to all non-participants. Although the general response to the data request was positive, only the State Attorney's Office serving the Eighth Judicial Circuit provided the necessary data. In total, six counties comprise the Eight Judicial Circuit: Alachua, Baker, Bradford, Gilchrist, Levy, and Union.

Requesting data from the State Attorney's Offices was the most logical choice for the purposes of this study. Data retained by state attorneys are derived from arrest reports that are collected from every police agency within their jurisdiction. In essence, police arrest reports from multiple agencies and jurisdictions are funneled to the State Attorney's Office, and therefore provide a one-stop-shop for data collection. By using the State Attorney's Office as the source of information, data from several police agencies were collected simultaneously. As a result, the volume of data collected was much higher than could have been achieved by approaching individual police departments. As an additional advantage, the Eighth Judicial Circuit of Florida consists of both rural and urban areas, as illustrated below in Table 2. Hence, criminals residing in both rural and urban areas are represented in the current study. As mentioned above, the inclusion of rural areas is important to criminal mobility research, as the length of crime trips appear to vary according to the area's level of urbanization (Van Koppen & Jansen, 1998). By including both rural and urban areas in the study, the results should be more representative of the typical criminal commute.

The Seminole County Sheriff's Office offers a unique opportunity for research on criminal mobility. The police departments within Seminole County have undertaken a data-integration initiative, in which arrest data across the county is shared among the various agencies serving Seminole County. Currently, all municipalities share the same Records Management System designed and used by Seminole County Sheriff's Office (Summer Harms, personal communication, October 10, 2006). Furthermore, arrest data can be retrieved electronically. This provided relatively easy accessibility to robberies occurring throughout the county, regardless of the arresting police organization.

Table 2: Selected Demographic and Economic Characteristics by County

Characteristic	Alachua	Seminole	Baker	Bradford	Gilchrist	Levy	Union
<u>Population and Urbanization</u> <sup>1</sup>							
Total population	217,955	365,196	22,259	26,088	14,437	34,450	13,442
Urban population	162,514	349,836	7,972	8,803	0	0	6,428
Rural population	55,441	15,360	14,287	17,285	14,437	34,450	7,014
Population in urban areas	74.6%	95.8%	35.8%	33.7%	0%	0%	47.8%
Persons per square mile of land	249.3	1,184.9	38.0	89.0	41.4	30.8	55.9
<u>Demographics</u> <sup>1</sup>							
Percent of population: male	48.8%	49.0%	52.5%	55.9%	52.9%	48.4%	64.7%
Percent of population: minority	26.5%	17.6%	16.0%	23.7%	9.5%	14.1%	26.4%
Median age (in years)	29.0	36.2	34.0	37.2	35.4	41.1	35.7
<u>Employment, Income and Poverty</u> <sup>1</sup>							
Percent of population <sup>2</sup> in labor force	63.3%	70.1%	58.3%	47.8%	53.0%	50.4%	38.5%
Unemployment rate	7.0%	3.7%	4.5%	4.8%	4.4%	6.1%	4.0%
Median household income (in dollars)	\$31,426	\$49,326	\$40,035	\$33,140	\$30,328	\$26,959	\$34,563
Per capita income (in dollars)	\$18,465	\$24,591	\$15,164	\$14,226	\$13,985	\$14,746	\$12,333
Percent of population below poverty	22.8%	7.4%	14.7%	14.6%	14.1%	18.6%	14.0%
<u>Housing units</u> <sup>1</sup>							
Total housing units	95,113	147,079	7,592	9,605	5,906	16,570	3,736
Urban housing units	71,711	141,377	2,786	2,996	0	0	994
Rural housing units	23,402	5,702	4,806	6,609	5,906	16,570	2,742
Housing units in urban areas	75.4%	96.1%	36.7%	31.2%	0%	0%	26.6%
Housing units in multi-unit structures	35.5%	25.5%	3.3%	4.8%	1.7%	3.7%	5.2%
Median value of homes <sup>3</sup> (in dollars)	\$97,300	\$119,900	\$80,900	\$71,700	\$78,000	\$75,800	\$71,700
Mean travel time to work (in minutes) <sup>1</sup>	21.1	27.0	32.7	27.9	33.5	31.4	28.6

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Characteristic	Alachua	Seminole	Baker	Bradford	Gilchrist	Levy	Union
<u>Education</u> <sup>1</sup>							
Percent of population <sup>4</sup> with:							
A high school diploma	88.1%	88.7%	71.9%	74.2%	72.4%	73.9%	72.5%
A Bachelor's degree	38.7%	31.0%	8.2%	8.4%	9.4%	10.6%	7.5%
<u>Business establishments</u> <sup>5</sup>							
Retail trade	924	1,658	65	84	29	141	29
Arts, entertainment, and recreation	77	142	2	2	1	17	0
Health care and social assistance	649	902	29	41	18	54	17

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<sup>1</sup> Data obtained from the U.S. Bureau of the Census (2000)

<sup>2</sup> Percentage based on the population of those sixteen years old and older

<sup>3</sup> Applies only to single-family owner-occupied homes

<sup>4</sup> Percentage based on the population of those twenty-five years old and older

<sup>5</sup> Data obtained from the U. S. Economic Census (2002)

The data used for this study primarily consisted of robbery offenses occurring from January 1, 2003 to mid-2006. Data received from the State Attorney's Office includes arrests up to mid-June of 2006, while data received from Seminole County extends through August of 2006. However, a handful of robbery cases used in the study occurred in the years 2001 and 2002. In these cases, the robberies occurred prior to 2003, but charges were not brought against the defendant by the state attorney until 2003 or later. Due to privacy provisions in the state of Florida, not all arrest records of juvenile offenders are considered public data. As a result, the data received from the State Attorney's Office of the Eighth Judicial Circuit includes adult offenders, and cases involving juvenile offenders which have been transferred to adult courts. Conversely, data received from the Seminole County Sheriff's Office includes all robbery arrests, of both adult and juvenile offenders (Summer Harms, personal communication, January 2, 2007). In total, a sample of  $N = 1,020$  crime trips was collected, with crime trips serving as the unit of analysis for the current study. Each crime trip was treated independently. Therefore, if a robbery occurrence consisted of more than one offender, the journey-to-crime distance by each perpetrator was analyzed. Likewise, if one offender committed multiple robberies, each individual crime trip was included in the study.

In sum, the study includes robberies which occurred in seven Florida counties: Seminole, Alachua, Levy, Bradford, Gilchrist, Union, and Baker. In general, the counties from which data was collected represent two diverse groups. Baker, Bradford, Gilchrist, Levy, and Union County are predominantly rural, as evidenced from the relatively low percentage of citizens living in urban areas, as well as the low population and housing densities. These areas can also be characterized as having relatively low economic activity, as indicated by: the percent of population in the labor force, per capita income, median value of single-family owner-occupied

homes, and the number business establishments. Alachua and Seminole County are, by comparison, urban areas, with much higher populations and business activity. The percentage of the population living in urban areas is much higher for Alachua and Seminole County, topping over 95 percent for Seminole County. In addition, the comparatively high population and housing densities, and the lower travel times to work also indicate higher levels of urbanization in Alachua and Seminole County. And in general, Alachua and Seminole County are associated with higher levels of education.

Demographically, some variability also exists, although not necessarily between rural and urban counties. The median age of Alachua County residents is relatively young at just twenty-nine years. The youthfulness of Alachua may be an effect of the University of Florida, located in the city of Gainesville. With a large population of college students, the median age of the county would predictably be low. The influence of the University of Florida may also explain the relatively high unemployment and poverty rate in Alachua. On the other end of the age spectrum, Levy residents are the oldest, with a median age of over forty-one. The prevalence of minorities also varies between counties. Over one-quarter of all residents in Alachua and Union County are minorities, compared with only 9.5 percent in Gilchrist. Finally, from a gender perspective, the percentage of the population which is male is relatively consistent throughout the seven counties, with the noticeable outlier of Union County.

Figure 2 displays the spatial location of these counties, shaded in gray. As shown in Figure 2, the counties used for the current study range from the Florida-Georgia border to the north (Baker County), to the Gulf of Mexico to the West (Levy County). Also, by collecting data from the State Attorney's Office of the Eighth Judicial Circuit and Seminole County, robbery arrest data from every police agency located within these counties was collected. In

total, the sample includes robberies occurring within the jurisdiction of twenty-one independent police departments; seven county sheriff's offices and fourteen municipal police departments.

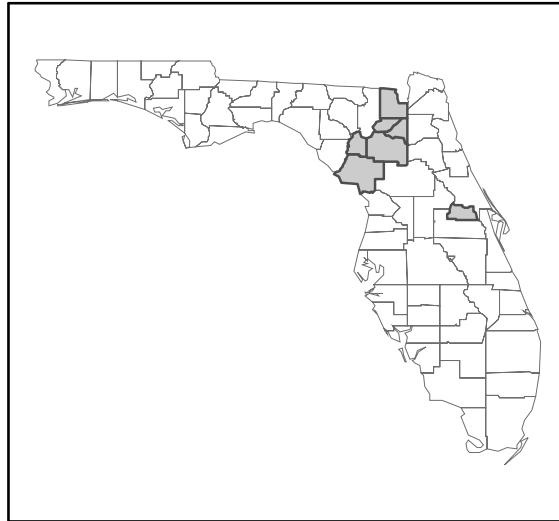


Figure 2: Illustration of the Seven Counties in Which Data Was Collected

### The Geocoding Process

In general, the term GIS refers to a computer system “designed to store, retrieve, manipulate, and display geographic data” (Broda & Baxter, 2003, p. 158). Because of its diversity, the use of GIS technology is not limited to the criminal justice field. Rather, numerous disciplines have realized the usefulness of GIS capabilities, including: public health (Kriger, Waterman, Lemieux, Zierler, & Hogan, 2001), engineering (Karimi, Durcik, & Rasdorf, 2004), epidemiology (Nuckols, Ward, & Jarup, 2004), education (Mulvenon, Wang, McKenzie, & Airola, 2006), medicine (Chung, Yang, & Bell, 2004), and environmental science (Jiménez-

Horrnero, Giráldez, Gutiérrez de Ravé, & Moral, 2007) just to name a few. Over the past fifteen years GIS technologies, and more specifically crime mapping technologies, have come to the forefront of criminal justice research. Furthermore, GIS systems have become an integral part of crime analysis and policy decision-making among police agencies. The use of crime mapping technologies among police agencies with over 100 sworn officers grew exponentially during the 1990s (Weisburd & Lum, 2005). In a recent survey conducted by the U.S. Department of Justice (2003), 19 percent of all local police departments used some form of crime mapping. Also, the majority of departments serving over 50,000 residents utilize crime mapping systems (U.S. Department of Justice, 2003).

Crime mapping technology has enjoyed this recent renaissance due to its capability and applicability in the criminal justice field. In a recent paper, Vann and Garson (2001) articulated the potential and functionality of crime mapping for both academic research projects and police operations. In sum, twenty different functions were identified, which included: pin mapping, hot-spot mapping, pattern detection, proximity mapping, and spatial modeling. Not only are these tools useful for crime prevention strategies, but can also serve as a tool for testing criminal theory. Among the functions mentioned by Vann and Garson, hot-spot analysis appears to have been given the most attention by criminological researchers (Bowers, Johnson, & Pease, 2004; Gore & Pattavina, 2004; Gorman, Zhu, & Horel, 2005; Grubestic, 2006).

For the purposes of the current study, GIS software was used for geocoding purposes. Geocoding is the process of converting postal addresses into their equivalent latitudinal and longitudinal coordinates, which can then be mapped on electronic mapping software (Gilboa et al., 2006). Essentially, the address to be geocoded is compared with a spatial database maintained by the GIS software program. Once the address is identified, or “matched,” by this



database, the software can then map the address and produce the corresponding x, y coordinates. The level of accuracy needed from geocoding software varies according to the research being conducted. Many commercial geocoders, such as the US Census Bureau TIGER/Line files and Tele Atlas, can produce results ranging from street-level accuracy to zip code or county centroid accuracy (Whitsel et al., 2004).

As one deviates from street-level accuracy, the results become more generalized. For example, when a geocoder matches an address to a zip code centroid, the latitude and longitude coordinates that are produced reflect the center of the address' corresponding zip code, not the specific street address. An example of this type of methodology is illustrated by Hesseling's (1992) study on vandalism, residential burglary, and violent and property crimes. In this study, Hesseling analyzed offender mobility based on neighborhood centroids, in which offender travel distances were measured from the neighborhood centroid of the offender's residence to the neighborhood centroid of the offense location. Although useful, these centroids do not represent the true location of the offender's home or the location of the offense, and thereby do not represent the true mobility of the offender. The current study attempts to obtain the most accurate measurements of journey-to-crime. Therefore, only point-level data could be used, in which the geocoding results represent a specific postal address. The highest degree of specificity a geocoder can produce is street-level accuracy, in which an address is identified and geocoded along a street segment. Only robbery trips in which the offender's home address and the address of the robbery occurrence were geocoded along a specific street segment were included in the study.

Geocoding systems typically use two processes to geocode an address. The first is known as parsing. During parsing, the address string is broken into its component parts, which

facilitates in the standardization of address information (Yang, Bilaver, Hayes, & George, 2004). An example of the parsing process is illustrated in Table 3. After an address is parsed, the geocoder will treat each segment of the address as an independent entity, and attempt to match to each individual element of the address with the geocoder’s reference data (i.e. the database) (Yang et al., 2004, p. 362). By parsing the address, the geocoder is able to compare the individual components of an address as opposed to the total string. As a result of the parsing process, making corrections, matching, and standardizing the data becomes easier (Yang et al., 2004).

Table 3: Example of a Parsed Address

Address string (before parsing)	Address Parsed			
	House number	Street name	Street suffix	Post-direction
7113 Bryant Avenue North	“7113”	“Bryant”	“Avenue”	“North”

The second process used in geocoding is known as interpolation. As described in Ratcliffe (2001), geocoding software is comprised of a collection of street segments, with a range of house numbers assigned to each segment. Two examples of this construct are shown in Table 4. When the street name of an address is identified by the geocoder’s reference data, the next step is to place the address in the most logical position along the corresponding street segment. This technique, of estimating the most probable location of an address along the geocoder’s street segment, is known as interpolation (Maguire, Batty, & Goodchild, 2005). When interpolating, the geocoder compares the address’ house number with the From node and To node of the corresponding street segment. The address must first fall within the street segment’s

house number range, as indicated by the From and To nodes. Then, the most likely location of the address along the specific street segment is estimated, or interpolated (Ratcliffe, 2001). An example of interpolation is shown in Figure 3.

Table 4: Examples of a Geocoder’s Line Segment

<u>Line Segment Elements</u>							
From left	To left	From right	To right	Pre-direction	Name	Suffix	Post-direction
1301	1399	1300	1398	East	Altamonte	Drive	
924	954	925	955		Orlando	Blvd	West

Current academic research utilizes a plethora of available mapping and geocoding software (Bartkowski, Howell, & Lai, 2002; Craglia, Haining, & Wiles, 2000; Srivastav et al., 2000; Tong, Hayes, & Dale, 2005). However, ArcGIS software, and its corollaries ArcView and ArcInfo<sup>2</sup> seem to have emerged as the most popular mapping programs among academics, and have been utilized extensively (Groff & LaVigne, 2001; see also Fall, Niyogi, & Semazzi, 2006; Grubestic, 2006; Jago & Boyd, 2003; Koohzare, Vaníček, & Santos, 2006; LaGrange, 1999; Poulson & Kennedy, 2004). Furthermore, in a survey conducted by the U.S. Department of Justice (1999), ArcView and ArcInfo, along with MapInfo, were the three most frequently used mapping programs by law enforcement agencies. For the current research project, two geocoding systems were available. First, the data obtained from the State Attorney’s Office and Seminole County was geocoded through ArcGIS 9.1, which uses the 2005 StreetMap USA street network database produced by ESRI. Next, address data was geocoded

<sup>2</sup> ArcGIS, ArcView, and ArcInfo are all products offered by the Environmental Systems Research Institute, Inc. (ESRI) company, based out of Redlands, California.

using a web-based geocoder provided by Centrus, a geocoding database operated by Group 1 Software, Inc.

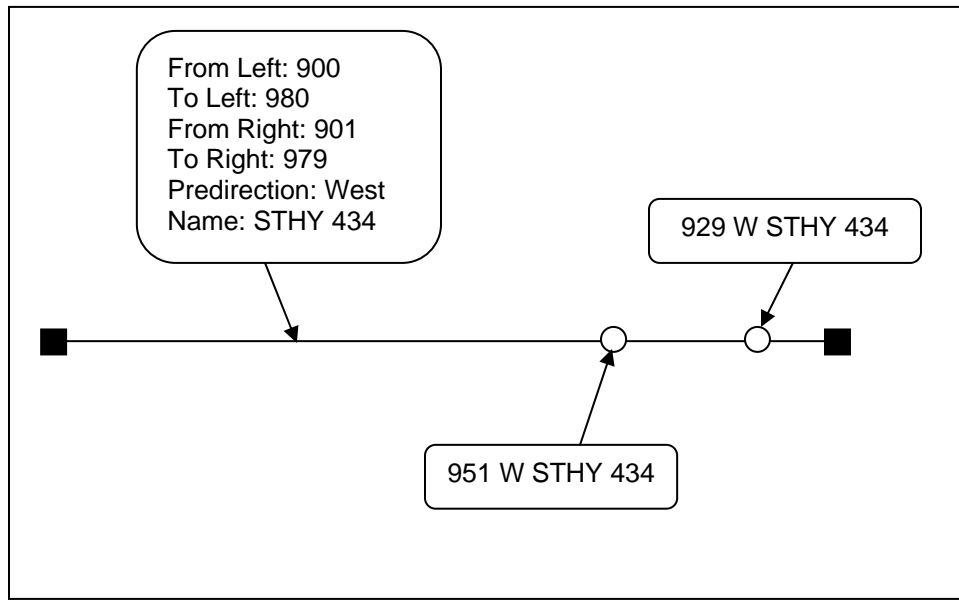


Figure 3: Example of Interpolation along a Street Segment

Before addresses can be geocoded in ArcGIS 9.1, certain parameters need to be stipulated by the user. The ArcGIS 9.1 mapping software offers several different methodologies of geocoding, which can then be selected via the “address locator.” The address locator defines the database to be used to run the geocoding. In ArcGIS 9.1, this database is the file that contains the street segments and associated address information; the 2005 StreetMap USA street network. If multiple street databases are available, the address locator allows the user to choose which database will be used to geocode. After a street database is selected, the user can then choose from a number of geocoding techniques. One problem with obtaining data from numerous cities and counties is the increased possibility of misgeocoding an address. An address is misgeocoded

when the geocoder matches an address to a wrong street segment. In essence, misgeocoding results in a disparity between the location represented by the address string, and the spatial placement of the address by the geocoder. This is most likely to happen when cities share common street names, such as “Main Street.” The geocoder identifies the street name and house range that is consistent with the address string, but the geocoder’s street segment lies in a different city or county than the address being geocoded. To control for this possibility, ArcGIS 9.1 offers several geocoding options which can be chosen based on the information of the input addresses (i.e. the address strings to be geocoded). For the current study, the “US Streets with Zone [US File]” geocoding option was selected. Using this technique, in addition to the appropriate street segment, the geocoder must also successfully match to a “zone.” For this study, the corresponding city of the address was designated as this zone. Defining the zone as the city in which the address lied was the most logical choice, as the data received from the State Attorney’s Office and Seminole County included both the city where the offender lived and the city where the robbery occurred. Also, the street network built by ESRI included the corresponding city for each street segment. Therefore, the related city of the addresses reported in the arrest data, and the associated city of the street segments in ArcGIS 9.1 could be directly compared. Only addresses in which the house range, street name, and city matched that of the geocoder’s street segment were successfully geocoded.

The second decision that has to be made by the user when using ArcGIS 9.1 is to define the matching threshold, also via the program’s address locator. As described by Zhan, Brender, De Lima, Suarez, and Langlois (2006), the geocoder identifies and ranks possible matching locations, or candidates, according to the level of similarity between the parsed address information and the geocoder’s street segment. A numerical value, known as the match score, is

assigned to each candidate. Each candidate receiving a score greater than “the minimum candidate score” is displayed, and these potential candidates can then be compared by the user. The higher the score, the more similar the street segment information matches the parsed address information. The scoring system is a continuum based on the likelihood that a potential candidate represents the correct location, ranging from zero (or the minimum candidate score) to one-hundred (perfect similarity and most likely candidate) (Ormsby, Napoleon, Burke, Groessl, & Feaster, 2004). The user can then decide at what level to allow the geocoder to automatically match and geocode potential candidates, referred to as the “minimum match score.” This means, that if a candidate receives a match score at or above the minimum match score, the candidate will be matched without any further intervention by the user. Although the highest possible scores are desired, it appears that setting a one-hundred matching threshold may not only be unwieldy, but also unnecessary. In a recent article, Ratcliffe (2004b) took an in-depth analysis at geocoding hit rates; the percentage of successfully geocoded addresses of a data set. Here, Ratcliffe articulates some of the more common, mundane errors that prevent addresses from being geocoded. Some of these errors include: minor misspellings, incorrect directional prefixes or suffixes (i.e. East instead of West), unknown abbreviations, and incorrect street types (i.e. avenue instead of street). Any variability between the address string and street segments, including those common errors depicted by Ratcliffe, would result in the address being left ungeocoded with a one-hundred scoring threshold.

In sum, there is a balance that must be reconciled by the user of ArcGIS software. If the matching threshold is set too high, addresses with minor spelling or other errors will not be matched, and otherwise good data will be lost. On the other hand, if the matching threshold is set too low, suspect addresses will be matched, even though a certain amount of ambiguity or

uncertainty exists as to the likelihood that the matched candidate is indeed correct. Previous researchers using ESRI products have set the candidate and matching thresholds below one-hundred, in part to allow for spelling errors (Gilboa et al., 2006; Zhan et al., 2006). Following this trend, the current research set the following geocoding thresholds: 80% for the “spelling sensitivity,” 10% for the “minimum candidate score,” and 60% for the “minimum match score.” In words, candidates that received a match score of 60 or greater were automatically geocoded. Candidates receiving a match score of at least 10 but below 60 were stored, and could be reviewed through interactive matching. Although chosen somewhat arbitrarily, these thresholds were similar to those used in prior research (Yang et al., 2004; Zhan et al., 2006).

One of the advantages of using ArcGIS software is the amount of control given to the user as it pertains to geocoding. Not only are the geocoding techniques chosen, but the candidate and matching thresholds are also at the discretion of the user. In addition, unmatched addresses can be reviewed interactively on a case-by-case basis, and manipulated if deemed necessary. These options are not available for the second geocoder used in this study; the Centrus web-based geocoder.

The web-based geocoder offered by Centrus<sup>3</sup> served as the second geocoding alternative for the current study. For address matching purposes, two international street databases are utilized by the software program: Dynamap and NAVSTREETS. Dynamap is a database created and maintained by the Tele Atlas mapping company, who have also aided in the development of selected ESRI software programs (Environmental Research Systems Institute, Inc., n.d; Zhan et al., 2006). NAVSTREETS is a Navteq product. The functionality of Centrus’ geocoder is minimal compared to ArcGIS 9.1. Unparsed address strings are simply entered into the

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<sup>3</sup> The geocoding program can be found at <http://www.centrus.com>.

appropriate fields, and the geocoding engine matches the address to the greatest degree of accuracy as possible; which may or may not be street-level accuracy. After an address is geocoded, the level of accuracy (street-level, zip code, etc.) and the corresponding latitudinal and longitudinal coordinates are displayed.

Of the many on-line and proprietary geocoders available, the utilization of Centrus' web-based geocoding program was chosen for several reasons. First, unlike other web-based geocoders, Centrus reports the level of accuracy of each geocoded address, a necessity for the current study. The geocoder's accuracy ranged from the specific interpolation to an exact street address, to the general location of a county centroid. By reporting the level of accuracy, cases in which both the offender's home address and robbery location were geocoded to a specific point along a street segment were easily distinguishable from those that were not. Second, the databases used by the geocoder are expansive, and are able to identify and geocode addresses across the country. Also, the street networks maintained by Centrus are independent from the ArcGIS 9.1 database. Therefore, the reliability of the geocoding results produced by ArcGIS 9.1 could be checked. Lastly, the program is easily accessible and user friendly. The geocoding results are produced in a matter of seconds, and are easy to interpret.

Table 5 displays the hit rates of each geocoder. Three geocoding results are reported in Table 5. The Count column reports the number of crime trips that were successfully geocoded. That is, cases in which both the offense and offender address were matched to a specific location along a street segment. In addition, two matching percentages, or hit rates, were calculated for each geocoder. The Percentage column in Table 5 reports the hit rate of each geocoder based on the entire sample of 1,020 crime trips. The Adjusted Percentage column removes the robbery cases in which the offender's or offense's address information was unusable. This consisted of



cases in which: address data was either missing, incomplete, or not formatted as an address string, a P.O. Box number was reported rather than a valid street address, and offenses committed by the homeless. After removing these cases, the remaining sample consisted of 888 crime trips.

From the results shown in Table 5, the web-based geocoder offered by Centrus appears to be more robust, successfully geocoding nearly 44% more crime trips than ArcGIS 9.1. After reviewing the unmatched addresses of the ArcGIS geocoder, two systematic problems appear to have limited its hit rate. Before an address can be interpolated and mapped using ArcGIS 9.1, the address' house or business number must fall within the range of a specific street segment (see Figure 3). However, several street segments in ArcGIS' database are incomplete, with From nodes and To nodes equal to zero. Hence, any addresses along these street segments will not be geocoded, since no numerical address range is available for interpolation. Second, many streets go by multiple names, or aliases. For instance, Colonial Drive, a major thoroughfare in Orange County, Florida, is also known as State Road 50. Unless the same nomenclature is used in the arrest reports and the geocoder's database, the address will not be geocoded, since the street name on the arrest report will not match the corresponding street segment. To overcome this obstacle, ArcGIS 9.1 includes several alias fields within its street database, in which multiple street names can be documented and referenced if needed. However, these fields are sparsely used. Unless the user is aware of the multiple monikers a street may have, potentially valid addresses will remain ungeocoded due to labeling disparities.

Unlike ArcGIS 9.1, Centrus' web-based geocoder is only a geocoding engine, not a mapping program. Also unlike ArcGIS mapping software, Centrus' web-based geocoder has not been utilized in previous academic research. Rather, ESRI products are much more prevalent

among recent academic literature (Fall, Niyogi, & Semazzi, 2006; Grubestic, 2006; Koohzare, Vaniček, & Santos, 2006). This poses two problems with relying on Centrus' geocoding results. First, the geocoder has not been tested nor accepted among the academic community. This is in direct contrast with ESRI's geocoding software programs. Second, since the Centrus data points<sup>4</sup> are not displayed on a map, the spatial locations of the successfully geocoded addresses could not be visually compared with ArcGIS 9.1. To address these shortfalls, two techniques were devised to determine the consistency between the two geocoders.

Table 5: Hit rates for Centrus and ArcGIS 9.1

Geocoder	Crime Trips Successfully Geocoded		
	Count	Percentage	Adjusted Percentage
ArcGIS 9.1	578	56.67%	65.09%
Centrus	832	81.57%	93.69%

After the data set was geocoded using both ArcGIS 9.1 and Centrus, crime trip distances were calculated using the results from both geocoders and compared on a case-by-case basis. Specifically, both geocoders produced an independent set of latitudinal and longitudinal coordinates, with each x, y coordinate pairing representing a street address. The distance between the x, y coordinates of the robbery location, and the x, y coordinates of the offender's home were calculated using the coordinates produced from each geocoder. The result is two distance calculations for each crime trip, one using the x, y coordinates produced from ArcGIS 9.1 and the other using the coordinates from Centrus' web-based geocoder. If the difference

<sup>4</sup> "Data points" refer to the visual display of successfully geocoded addresses, which is represented by a dot on an electronic street map.

between these two distance calculations is other than zero, then the two geocoders produced different x, y coordinates for the same address. The level of inconsistency between the two geocoders can then be estimated by the differences in crime trips distances. Greater distance discrepancies indicate greater variability between the geocoders. In total, 560 crime trips were successfully geocoded by both ArcGIS 9.1 and Centrus. The crime trip distances, one calculated using the x, y coordinates produced by ArcGIS and the other by Centrus' web-based geocoder, of these cases were compared. Both geocoders use North American Datum, 1983 as their coordinate projection system, making direct coordinate comparisons possible. Table 6 reports the results.

Two conclusions can be drawn from the results shown in Table 6. First, the two geocoders are not equivalent, and report different latitudinal and longitudinal coordinates for the same addresses. In an additional analysis, in no instance were the x, y coordinates between the two geocoders identical. However, this is to be expected, as the databases used for each geocoder are independently produced and, therefore, are likely to display some variability. Second, and most importantly, the two geocoders are fairly consistent. As shown in Table 6, over 64% of the crime trip distances that were analyzed were very similar between the two geocoders, deviating less than five-hundredths of a mile. In addition, nearly 90% of the 560 crime trip distances that were compared deviated less than half a mile. In sum, although the two geocoders do not produce identical coordinates, they are very similar, as illustrated by the consistent distance calculations in Table 6.

Of the 560 crime trips that were calculated and compared, 44 of them (roughly 8%) deviated by more than one mile. These cases were investigated further. As mentioned above, Centrus' web-based geocoder does not visually display its data points. However, the ArcGIS 9.1

mapping software includes a function in which data points can be manually entered or “mapped” based on latitudinal and longitudinal coordinates. Hence, the x, y coordinates produced by the Centrus geocoder could be mapped and visually displayed on ArcGIS’ street map. This was done for the 44 crime trips (88 addresses) which varied by more than one mile between the two geocoders. The result is two sets of data points, one representing locations derived from the ArcGIS 9.1 geocoder and the other representing Centrus’ web-based geocoder. Then, the street segments where both the Centrus and ArcGIS 9.1 data points were mapped were viewed. Since the x, y coordinates produced by both ArcGIS and Centrus are now mapped, the street segment in which each data point lies can be compared, and then cross-referenced with the original arrest report. Through this comparison, it is possible to determine which geocoder is more likely to have placed the address on the correct street segment, and which geocoder may have misgeocoded the address. The data point which lies on the street segment that best matches the original arrest report, is more likely to be the correct location than the data point that doesn’t. Figure 4 illustrates an example of this comparison.

Using the process described above, the 44 cases in which the crime trip distance calculated by the two geocoders differed by more than one mile were analyzed. It was determined that in 41 out of the 44 cases, the Centrus data point was more likely to represent the actual location of the address than the corresponding ArcGIS data point. A detailed report of this analysis is displayed in the Appendix. Two conclusions can be drawn from the preceding analyses. First, the Centrus and ArcGIS geocoders produce relatively consistent results. Second, cases in which there does exist substantial variability between the two geocoders, it is usually the result of ArcGIS misgeocoding the address to the wrong street segment. This is largely due to

discrepancies in street type (i.e. avenue versus street) or street direction (north versus south) between the address string and corresponding street segment.

Table 6: Difference in Crime Trip Distance Calculations Using ArcGIS 9.1 and Centrus<sup>1</sup>

Difference in Distance (in miles)	Count	Percentage <sup>2</sup>	Cumulative Percentage
Less than .05 mi	360	64.29%	64.29%
.05 to .1 mi	71	12.68%	76.96%
.1 to .5 mi	71	12.68%	89.64%
.5 to 1.0 mi	14	2.50%	92.14%
1.0 to 1.5 mi	10	1.79%	93.93%
1.5 to 2.0 mi	6	1.07%	95.00%
2.0 to 3.0 mi	10	1.79%	96.79%
3.0 to 4.0 mi	14	2.50%	99.29%
4.0 to 5.0 mi	2	0.36%	99.64%
Over 5.0 mi	2	0.36%	100.00%

<sup>1</sup> Based on 560 crime trips

<sup>2</sup> Percentages may not total 100%, due to rounding

A second method was used to supplement the above comparative analysis, and to further determine the consistency between the two geocoders. All robbery locations in Seminole County that were successfully geocoded by Centrus were mapped in ArcGIS 9.1, again using the manual mapping techniques described above. In total, 433 data points were mapped. The street segments in which these points lied were reviewed and checked against the address documented

on the arrest report. Specifically, the information stored by the street segment (see Table 4) was compared with the address string in the arrest report. The result is a direct comparison between the two geocoders, in which the data point represents Centrus, and the street segment represents ArcGIS 9.1. All 433 Centrus points that were mapped lied either directly on or immediately adjacent to the appropriate street segment.

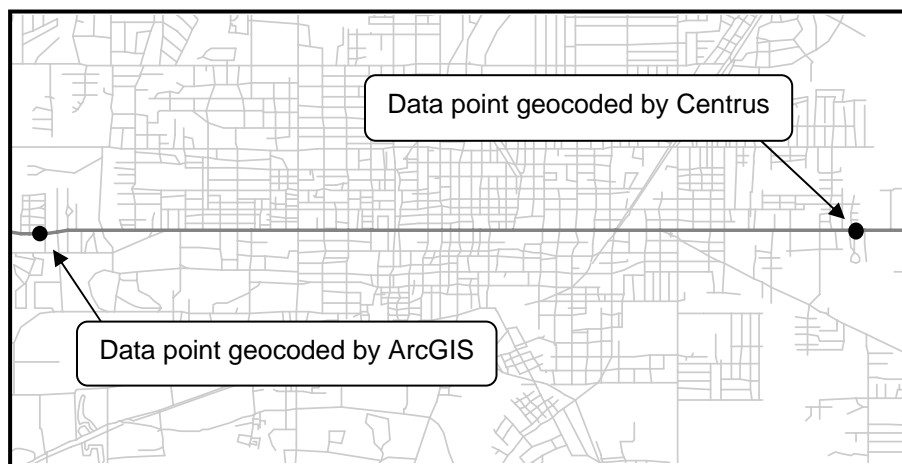


Figure 4: Visual Comparison between Geocoders: An Example (2626 E University Ave)

In sum, the geocoders provided by ArcGIS 9.1 and Centrus are remarkably similar. For the most part, the coordinates produced by both ArcGIS and Centrus were consistent, reliable and generally equivalent. This is demonstrated in Table 6, as crime trip distance calculations displayed moderate variation. When the geocoding results of ArcGIS and Centrus did diverge, misgeocoding on the part of ArcGIS 9.1 was usually the culprit, as shown in the Appendix. Hence, not only is the hit rate for Centrus' web-based geocoder higher than ArcGIS', but it also appears to be less problematic and less prone to errors. This mirrors the findings by Zhan et al. (2006), which reviewed geocoded results between ArcGIS 9.1 and a different Centrus owned

software program. The authors found that the geocoding program of Centrus Geocoder for ArcGIS produced a higher match rate and less positional errors than ArcGIS 9.1. Due to its higher hit rate and overall equivalency to ArcGIS 9.1, the Centrus geocoder was used for this study.

### Distance Calculation

By geocoding address information, and converting addresses strings into their equivalent latitudinal and longitudinal coordinates, spherical trigonometry could then be used to calculate the straight-line distance between the two points. Whether due to convenience or lack of technology, prior journey-to-crime research studies have calculated crime trip distances by using the Pythagoras theorem, which measures the shortest distance between two points on a flat surface (Capone & Nichols, 1976; Godwin & Canter, 1997; Nichols, 1980; Van Koppen & Jansen, 1998). The primary disadvantage of using Pythagoras' theorem for journey-to-crime research is that the mathematical formula is designed for a two-dimensional shape. The Pythagoras theorem fails to take into account the round curvature of the Earth. For comparing two points on the Earth's surface, spherical trigonometry is more appropriate. Prior journey-to-crime literature has not addressed the inherent inaccuracies of using the Pythagoras theorem, nor has any mobility study utilized spherical trigonometry. For this study, the haversine formula was used to measure crime trip distances (Ayers, 1954; Center for Economic Studies, 1998; Sinnott, 1984). Similar to other spherical trigonometric formulas, such as the Spherical Law of Cosines

(Law of Great Circles) and Vincenty's formula, the haversine formula is easily applicable when latitudinal and longitudinal coordinates are analyzed.

The haversine formula offers two advantages over other spherical formulas used for distance calculations. First, when compared with the Spherical Law of Cosines, the haversine formula has been proven to be more accurate at measuring short distances (Sinnott, 1984). Since prior research has demonstrated relatively moderate criminal mobility (Potchak et al., 2002; Warren et al., 1998; Wiles & Costello, 2000), it is imperative to obtain accurate calculations for short distances. Second, the haversine formula is easy to use. Although Vincenty's formula is more accurate at calculating the distance between two points on the Earth's surface, it is also much more mathematically intense (Vincenty, 1975). However, the additional accuracy afforded by Vincenty's formula is minimal, as displayed in Table 7, and unnecessary for the purposes of this study. In addition, the haversine formula is also adept to measuring relative long distances between two points. Although the variability between the haversine and Vincenty's formula becomes greater as the distance calculation increases, for purposes of the current research, the haversine formula still affords the level of accuracy needed to conduct the study. Because of its ease, accuracy, conduciveness to x, y coordinates, and applicability to a spherical three-dimensional shape, the haversine formula is the most logical choice for calculating crime trip distances.



Table 7: Comparison Between the Haversine Formula and Vincenty's Formula<sup>1</sup>

Formula	Distance Between Address A <sup>2</sup> and Address B <sup>3</sup>	Distance Between Address A <sup>2</sup> and Address C <sup>4</sup>
Haversine	1.3061 miles	1,327.5263 miles
Vincenty's	1.3068 miles	1,326.4323 miles
Difference	.0007 miles (.0536%)	1.0940 miles (.0825%)

<sup>1</sup> Addresses geocoded using Centrus

<sup>2</sup> The U.S. postal address of Address A is 7113 Bryant Avenue North, Brooklyn Center, MN 55430, with latitudinal and longitudinal coordinates 45.083766, -93.293232

<sup>3</sup> The U.S. postal address of Address B is 6301 Shingle Creek Parkway, Brooklyn Center, MN 55430, with latitudinal and longitudinal coordinates 45.068357, -93.308735

<sup>4</sup> The U.S. postal address of Address C is 23 Broad Street, Titusville, FL, 32796, with latitudinal and longitudinal coordinates 28.613431, -80.805992

## FINDINGS

The findings of this study are broken into three sections. The first section reports the journey-to-crime results by robbery type. Descriptive statistics, as well as the distribution of crime trip distances, are reported for the total sample and for each of the five robbery types. Also, the prevalence of relatively long crime trips is also reported. This section concludes with the testing of the first two hypotheses listed above. Namely, that mobility differences will exist among different types of robbery offenses, and that crime trips will be, on average, longer for fixed targets than open space targets. The second section describes the demographic characteristics of the offenders used in the sample, consisting of age, race, and gender analyses. Correlations between these demographic characteristics and criminal activity are presented. Also, potential mobility differences by age, race, and gender are explored, and the related hypotheses (H<sub>3</sub>, H<sub>4</sub>, and H<sub>5</sub>) are tested. Following the hypothesis testing, the interactive effects between these demographic variables are explored. Here, the interrelationships between age, race, and gender on criminal mobility are reviewed. Lastly, the prevalence of inter-county criminal travel is examined. Specifically, robbery offenses which occur in a different county than where the offender lives are explored.

As will be seen in the following sections, the distributions of crime trip distances across all robbery types are non-normal. Two tests, the Kolmogorov-Smirnov Lilliefors and Shapiro-Wilk test, rejected the assumption of normality. Hence, for hypothesis testing, parametric statistical techniques would have been inappropriate, as the requirement of normality is violated (Mazerolle, Brame, Paternoster, Piquero, & Dean, 2000; Snook, 2004; Sullivan et al., 2006).

Therefore, nonparametric tests were used. Namely, the Mann-Whitney *U* and Kruskal-Wallis *H* tests were used to determine statistical significance.

### Mobility by Robbery Type

In total, 832 crime trips were successfully geocoded, and serve as the basis for the ensuing analyses. Each crime trip represents a robbery arrest, in which an offender is arrested for a distinct robbery offense. Again, this means that: (a) a single robbery event may be linked to more than one crime trip if multiple perpetrators were involved; and (b) the sample includes offenders arrested for and charged with multiple robberies. Therefore, all results should be interpreted in respect to robbery arrests and crime trips, and not robbery offenders.

Two findings have been generally consistent throughout the literature pertaining to criminal mobility and journey-to-crime. First, the average criminal commute is relatively short, with mean and median travel distances typically within the two to three mile range (Phillips, 1980; Potchak et al., 2002; Rhodes and Conly, 1981; Wiles & Costello, 2000). Second, the distance decay function articulated by Brantingham and Brantingham (1981) has been routinely reinforced, as criminal activity has been skewed towards the offender's home (Van Koppen & Jansen, 1998; see also Bernasco & Nieuwbeerta, 2005; Capone & Nichols, 1976; Snook, 2004; Turner, 1969). The current study focuses solely on robbery offenders, and investigates possible journey-to-crime differences among various types of robbery. Figure 5 reports the distribution of crime trips by robbery type, based on the sample of 832 successfully geocoded criminal commutes. As expected, the most prevalent robbery types observed in the study were personal

and commercial robbery, representing 364 and 243 crime trips, respectively. Completing the robbery typology used in the study, robbery by sudden snatching constituted 103 crime trips, followed by home-invasion robbery (67) and carjacking (55).

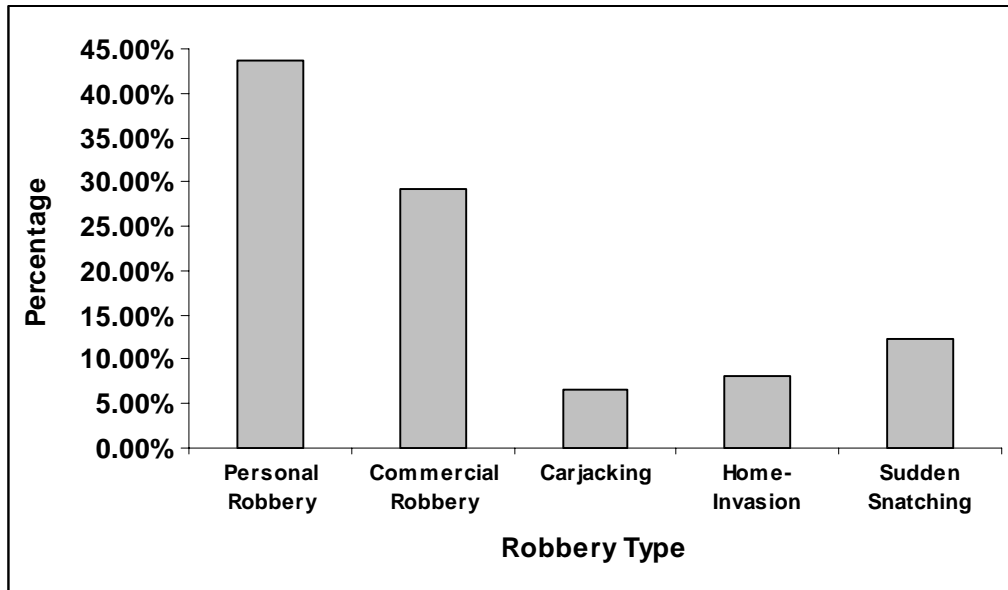


Figure 5: Percentage of Crime Trips by Robbery Type

Table 8 reports the mean and median crime trip distances for each robbery type, as well as the corresponding standard deviation (SD). For each robbery type, the distribution of journey-to-crime distances is skewed to the right, as indicated by much higher means than medians. This is to be expected, as a handful of robberies were committed over one-hundred miles from the offender's home, thereby inflating the mean distances. Additionally, each robbery type displays a wide range of crime trip distances, as indicated by the relatively large standard deviations. Each robbery type included at least three crime trips of over one-hundred miles, and at least seven percent of each robbery type's total crime trips were over twenty miles. In general, Table

8 supports the findings of prior research, as the median criminal commute for four of the five robbery types fell under three miles. Commercial robbers exhibited the greatest mobility, with a median crime trip distance of nearly four miles. Conversely, personal robbers stayed the closest to home, with a typical criminal commute of just over one-and-a-half miles.

For each robbery type, the distribution of crime trip distances was analyzed. Similar to the Rhodes and Conly (1981) study, step diagrams with half-mile intervals were used to illustrate journey-to-crime distance distributions. For each step diagram, the x-axis indicates the number of miles the robbery took place from the offender’s home, using half-mile intervals, up to ten miles. The final interval, denoted as “over 10,” groups all crime trips greater than ten miles. The y-axis reports the percentage of crime trips within each interval. The step diagrams for each robbery type are displayed in Figures 6 through 10.

Table 8: Summary of Journey-To-Crime Distances by Robbery Type<sup>1</sup>

Statistic	Robbery Type				
	Personal	Commercial	Sudden Snatching	Carjacking	Home-Invasion
Mean	11.89	44.36	60.65	23.33	26.54
Median	1.60	3.99	2.28	2.26	2.83
SD	62.17	244.30	195.46	86.88	123.77

<sup>1</sup> Reported distances are in miles

The presentation of crime trip distributions has been a source of ambiguity among prior journey-to-crime research. Many different graphical designs have been used to illustrate the distance decay phenomenon and distribution of criminal travel. Most notably, the intervals and

range used to present distance and criminal travel patterns has varied substantially across journey-to-crime literature. Typically, this involves the manipulation of the x-axis, which represents crime trip distances. Many techniques have been used, such as: limiting the range of the x-axis to less than ten miles (Potchak et al., 2002; Rhodes & Conly, 1981; Warren et al., 1998), extending the range of the x-axis to over one-hundred miles (Van Koppen & Jansen, 1998), using distance intervals of two-tenths of a mile (Warren et al., 1998), or intervals of half-kilometers (Snook, 2004). In sum, there does not appear to be an agreed method for presenting crime trip distributions.

The current study adds another construct to these designs by aggregating all crime trips over ten miles. These crime trips were aggregated to divide the sample into two groups; crime trips which reinforce the theoretical predictions and empirical findings of prior research (i.e. short crime trips) from those that do not (i.e. long crime trips). In addition to testing the distance decay phenomenon, the distributions presented in Figures 6 through 10 attempts to separate “short” criminal commutes from “long” ones, with long crime trips defined as those over ten miles. Since the research designs used in prior research has routinely excluded mobile offenders from the analysis (see Phillips, 1980; Potchak et al., 2002; Warren et al., 1998), relatively little is known about the prevalence of lengthy crime trips. The current study attempts to add to the sparse literature on mobile offenders (Porter, 1996; Wiles & Costello, 2000). It was therefore necessary to define which crime trips would represent relatively high criminal mobility. The ten mile threshold was deemed an appropriate benchmark to aggregate crime trips. Prior research has found that the typical journey-to-crime distance is around two to three miles (Hesseling, 1992; Phillips, 1980; Pyle, 1976; Snook, 2004; Warren et al., 1998). Comparatively, a ten mile criminal commute would be relatively long.

In general, each robbery type exhibits similar mobility patterns. Robbery offenses tend to wane as the distance from the offender's home increases, as predicted by the distance decay function. With the exception of commercial robbery, this decaying effect is both pronounced and drastic. Criminal activity drops substantially immediately following the first interval, defined as crime trips ending within a half-mile of the offender's home. For personal robbery, carjacking, and robbery by sudden snatching, more than twice as many crime trips ended within the first half-mile of the offender's home than the second (as displayed in the first and second intervals in Figures 6, 8, and 10). Commercial robbery exhibits a more gradual decaying effect, as shown in Figure 7.

Also, each robbery type displays a similar bimodal distribution of robbery trips. In each instance, the two most populated intervals are the first, crime trips less than half-a-mile in length, and the last, or crime trips greater than ten miles. For two of the five robbery types, commercial robbery and carjacking, the over ten mile interval is the most populated<sup>5</sup>. Furthermore, for commercial robbery, carjacking, and robbery by sudden snatching, over twenty percent of the corresponding crime trips were defined as long, or greater than ten miles.

In their groundbreaking book *Environmental Criminology*, Brantingham and Brantingham (1981) state that "while criminals know more of the area close to home and are more likely to locate a target easily, they are also more likely to *be* known and increase their risks close to home. One would expect that there would be an area right around the home base where offenses would become less likely" (p. 32). Due to this increased risk, criminals are deterred from committing crimes within the immediate area of their residence. As a result, the

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<sup>5</sup> In the case of carjacking, the over ten mile interval is tied with the first interval (crime trips less than a half-mile) for most crime trips, with 14 crime trips each.

distance decay curve should peak following this buffer of limited criminal activity. Prior research has supported this buffer prediction (Potchak et al., 2002; Turner, 1969; Warren et al., 1998). However, the travel patterns displayed in the current study do not support this hypothesis, as illustrated in Figures 6 through 10. Instead, robbery offenders appear willing to take the added risk of offending within this buffer in favor of shorter criminal commutes. Yet, it is possible that the half-mile intervals used in these step diagrams are too large, encompassing both the buffer as well as the mobility peak. To adjust for this possibility, the first interval was broken into five equal subintervals, with each subinterval representing one-tenth of a mile. By analyzing crime trips in smaller intervals, the offending buffer may emerge, reinforcing the theoretical predictions on criminal mobility.

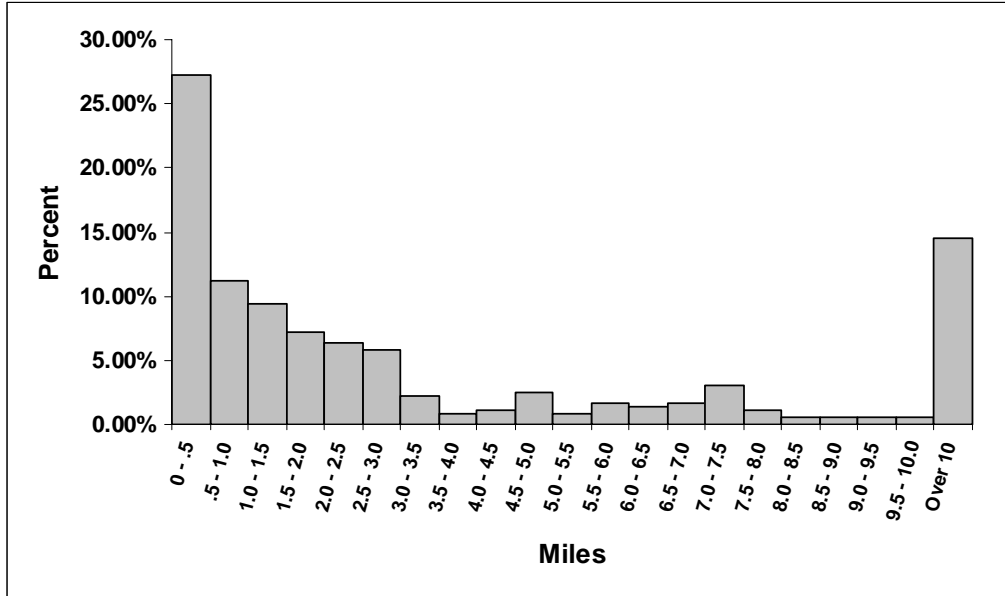


Figure 6: Distribution of Crime Trips by Distance: Personal Robbery



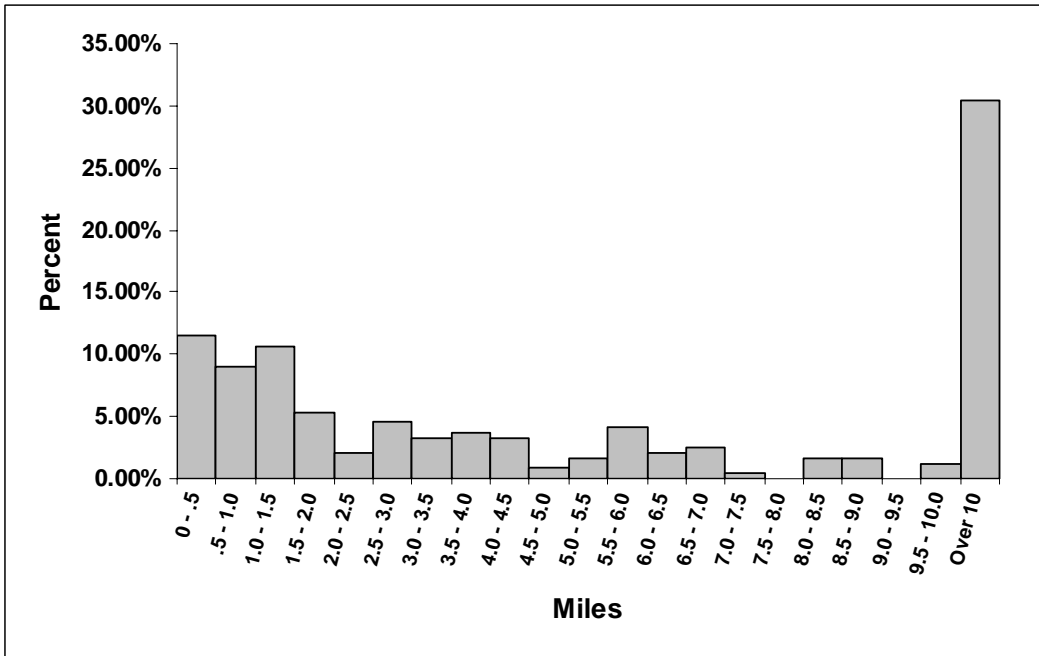


Figure 7: Distribution of Crime Trips by Distance: Commercial Robbery

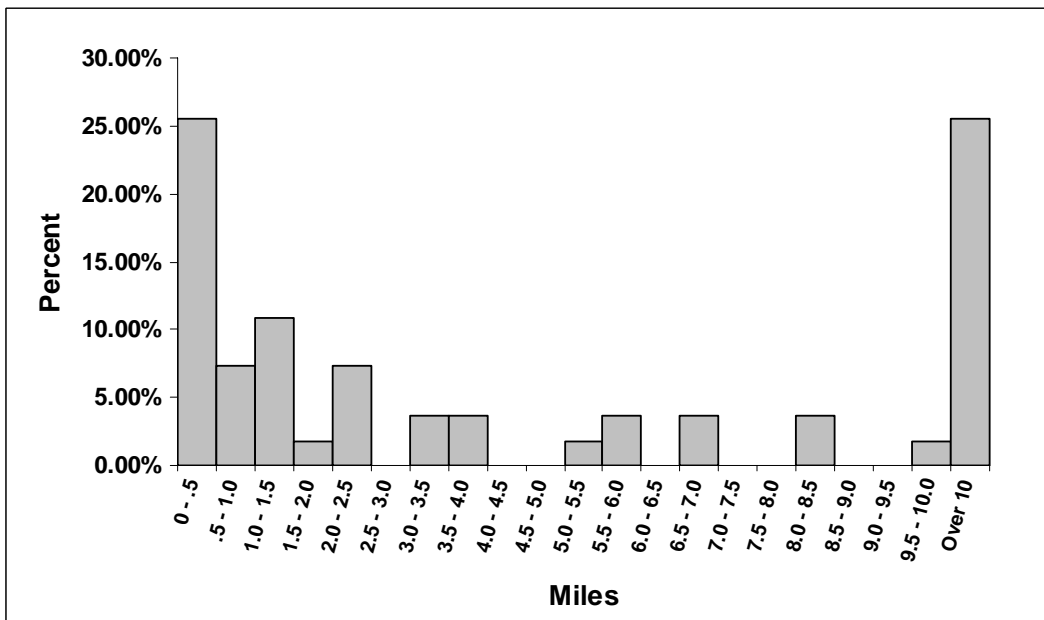


Figure 8: Distribution of Crime Trips by Distance: Carjacking

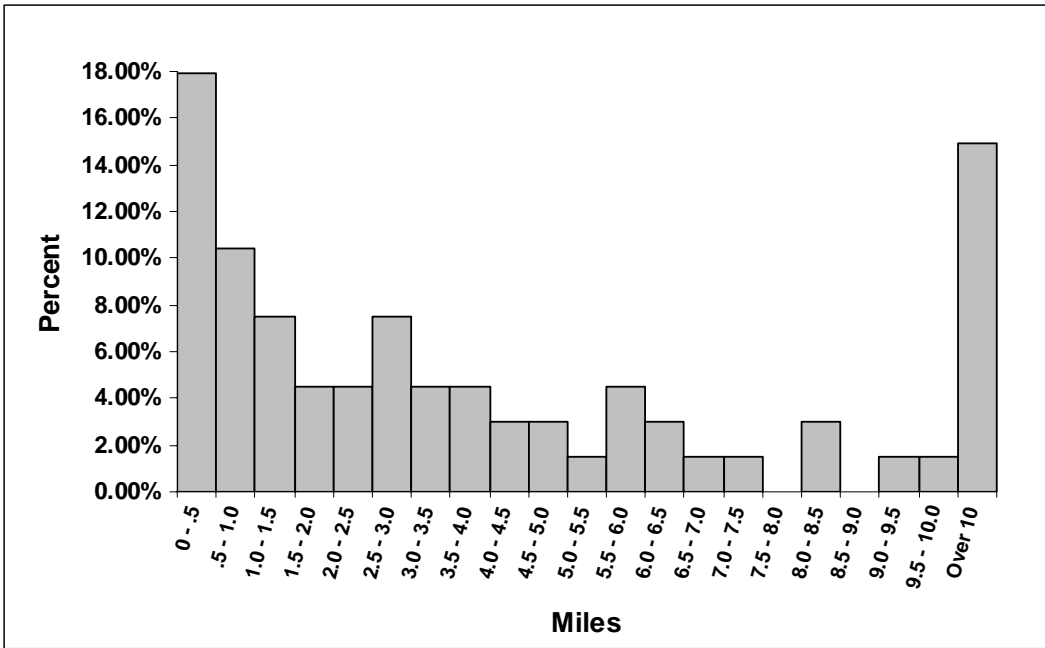


Figure 9: Distribution of Crime Trips by Distance: Home-Invasion Robbery

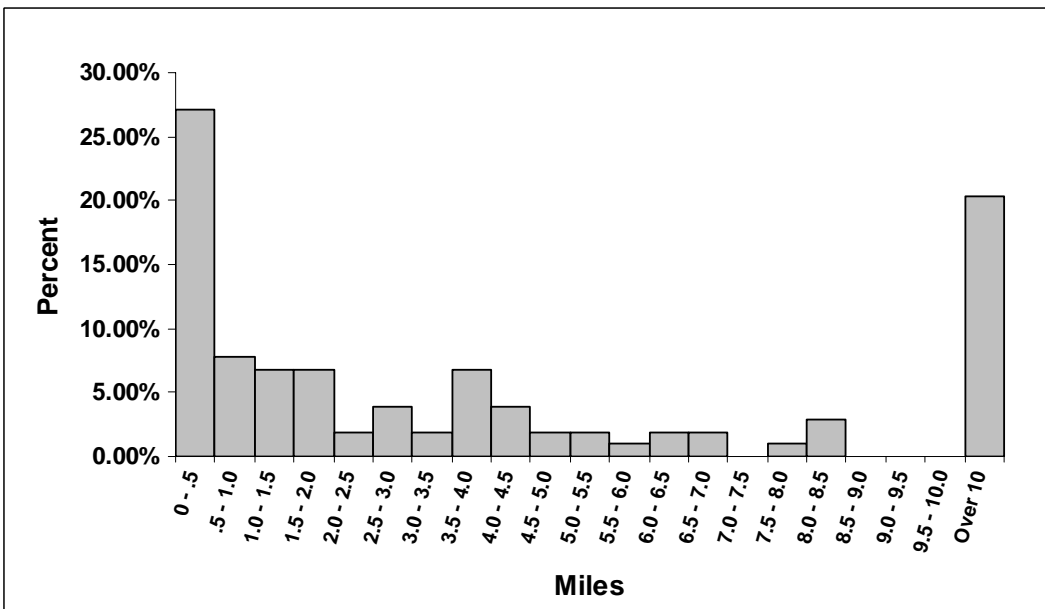


Figure 10: Distribution of Crime Trips by Distance: Robbery by Sudden Snatching

The results are reported in Table 9. For each robbery type, the subinterval analysis resulted in a microcosm of the general distance decay trend, in which the first tenth-mile distance interval housed the most crime trips, followed by a general decrease in crime trips as the distance increased. This contradicts the assumptions by Brantingham and Brantingham (1981) and the empirical findings of prior research. It appears that the lack of the typical crime buffer can be partially explained by offender/victim relationships. Table 10 reports the number of crime trip distances equal to zero for each robbery type. The offenders represented in Table 10 exhibited no travel, in which the robbery was perpetrated at the offender's place of residence. In other words, the victims of these robberies were, at the time of the robbery, in the offender's home. Therefore, with the exception of commercial robbery, it seems plausible that the crime trips depicted in Table 10 may represent robberies in which the offender has some prior relationship with the victim, such as a family member; boyfriend/girlfriend; roommate; or acquaintance. This would explain why the victim was in the offender's home. Table 10 also reports the percentage of crime trips less than one-tenth of a mile which were equal to zero. For personal robbery, carjacking, and robbery by sudden snatching, the majority of crime trips occurring within the first tenth-mile interval had a distance of zero.

The findings in Tables 9 and 10 illustrate the willingness of robbery offender's to offend close to home, and in many cases, in their home. These results contradict the Brantingham's (1981) prediction of a reduced crime activity buffer around the offender's home. As hypothesized here, the relationships between victims and offenders may skew journey-to-crime even closer to home. Therefore, the proposed buffer of reduced offending articulated by the Brantingham and Brantingham may only apply to offenses in which the offender and victim are strangers.

Among commercial robberies, the prevalence of crime trip distances of zero may indicate the changing availability structure of commercial targets. Many businesses, restaurant chains in particular, offer delivery service to their customers. Unfortunately, this feature also makes the business vulnerable to robbery attacks outside of the physical structure of their establishment, via the delivery personnel. Rather than requiring the offender to travel to the business to commit a commercial robbery, delivery service has made it possible to bring the business to the offender. It is now possible to dial-up prospective targets, possibly explaining the phenomenon displayed in Table 10.

Table 9: Distribution of Crime Trips by Distance by Tenth-Mile

Distance	Robbery Type					Overall
	Personal	Commercial	Sudden Snatching	Carjacking	Home-Invasion	
0.0 – 0.1	30	8	12	4	6	60
0.1 – 0.2	25	3	9	3	5	45
0.2 – 0.3	16	7	4	2	0	29
0.3 – 0.4	16	5	1	3	1	26
0.4 – 0.5	12	5	2	2	0	21

Table 10: Prevalence of No Criminal Mobility: Crime Trip Distances of Zero

Variable	Robbery Type					Overall
	Personal	Commercial	Sudden Snatching	Carjacking	Home-Invasion	
Crime Trips	19	4	9	4	2	38
Percentage	63%	50%	75%	100%	33%	63%

Figure 11 and Table 11 summarizes the journey-to-crime patterns of robbery crime trips. Figure 11 aggregates the distribution of all crime trip distances by collapsing the robbery types. The results, as expected, following the general distance decay trend illustrated in Figures 6 through 10, with a subset of offenders displaying relatively high mobility. Table 11 provides a detailed tabular analysis of robbery crime trip distances. For each robbery type, the number of robbery trips falling within each half-mile interval is reported, along with the corresponding percentage listed in parentheses.

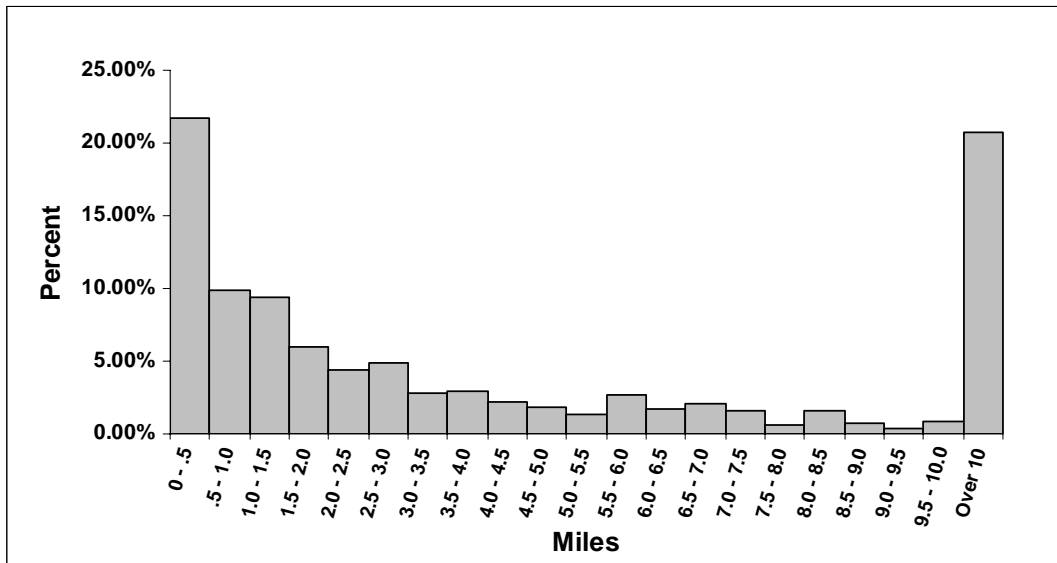


Figure 11: Distribution of Crime Trips by Distance: All Robbery Offenses

Two hypotheses were presented relative to criminal mobility among robbery types. Specifically, it is predicted that mobility differences will exist between robbery types, and that offenders who target fixed premises will travel further than those who victimize open space targets. To test for statistically significant differences, the Mann-Whitney *U* and Kruskal-Wallis

Table 11: Summary of Journey-to-Crime by Robbery Type<sup>1</sup>

Distance <sup>2</sup>	Robbery Type					Total
	Personal	Commercial	Sudden Snatching	Carjacking	Home-Invasion	
0.0 – 0.5	99 (27.2%)	28 (11.5%)	28 (27.2%)	14 (25.5%)	12 (17.9%)	181 (21.8%)
0.5 – 1.0	41 (11.3%)	22 (9.1%)	8 (7.8%)	4 (7.3%)	7 (10.5%)	82 (9.9%)
1.0 – 1.5	34 (9.3%)	26 (10.7%)	7 (6.8%)	6 (10.9%)	5 (7.5%)	78 (9.4%)
1.5 – 2.0	26 (7.1%)	13 (5.4%)	7 (6.8%)	1 (1.8%)	3 (4.5%)	50 (6.0%)
2.0 – 2.5	23 (6.3%)	5 (2.1%)	2 (1.9%)	4 (7.3%)	3 (4.5%)	37 (4.5%)
2.5 – 3.0	21 (5.8%)	11 (4.5%)	4 (3.9%)	0 (0.0%)	5 (7.5%)	41 (4.9%)
3.0 – 3.5	8 (2.2%)	8 (3.3%)	2 (1.9%)	2 (3.6%)	3 (4.5%)	23 (2.8%)
3.5 – 4.0	3 (0.8%)	9 (3.7%)	7 (6.8%)	2 (3.6%)	3 (4.5%)	24 (2.9%)
4.0 – 4.5	4 (1.1%)	8 (3.3%)	4 (3.9%)	0 (0.0%)	2 (3.0%)	18 (2.2%)
4.5 – 5.0	9 (2.5%)	2 (0.8%)	2 (1.9%)	0 (0.0%)	2 (3.0%)	15 (1.8%)
5.0 – 5.5	3 (0.8%)	4 (1.7%)	2 (1.9%)	1 (1.8%)	1 (1.5%)	11 (1.3%)
5.5 – 6.0	6 (1.7%)	10 (4.1%)	1 (1.0%)	2 (3.6%)	3 (4.5%)	22 (2.6%)
6.0 – 6.5	5 (1.4%)	5 (2.1%)	2 (1.9%)	0 (0.0%)	2 (3.0%)	14 (1.7%)
6.5 – 7.0	6 (1.7%)	6 (2.5%)	2 (1.9%)	2 (3.6%)	1 (1.5%)	17 (2.0%)

Distance	Robbery Type									
	Personal		Commercial		Sudden Snatching		Carjacking		Home-Invasion	
7.0 – 7.5	11 (3.0%)	1 (0.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (1.5%)	13 (1.6%)		
7.5 – 8.0	4 (1.1%)	0 (0.0%)	1 (1.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (0.6%)			
8.0 – 8.5	2 (0.6%)	4 (1.7%)	3 (2.9%)	2 (3.6%)	2 (3.0%)	13 (1.6%)				
8.5 – 9.0	2 (0.6%)	4 (1.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (0.7%)				
9.0 – 9.5	2 (0.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (1.5%)	3 (0.4%)				
9.5 – 10.0	2 (0.6%)	3 (1.2%)	0 (0.0%)	1 (1.8%)	1 (1.5%)	7 (0.8%)				
Over 10.0	53 (14.6%)	74 (30.5%)	21 (20.4%)	14 (25.5%)	10 (14.9%)	172 (20.7%)				

<sup>1</sup> Percentages may not total 100%, due to rounding

<sup>2</sup> Measured in miles

*H* tests were used. The skewness and distribution of the crime trip distances observed in this study violated the assumptions of parametric analysis. Namely, both the Kolmogorov-Smirnov Lilliefors and Shapiro-Wilk tests for normality resulted in a rejection of normality for each robbery type ( $p = 0.000$ ). Hence, nonparametric testing methods would be more appropriate. The Mann-Whitney *U* test is used when two samples are being analyzed, and is the nonparametric equivalent of the independent samples *t*-test (Carver & Nash, 2005). Here, the distance of criminal commutes are ranked and compared between the two groups. The Mann-Whitney *U* test will show statistical significance if the crime trip distances associated with one robbery type is consistently higher than the other (Bryman & Cramer, 1999). The Kruskal-Wallis *H* test extends this same process to circumstances in which three or more groups are being compared (Norušis, 2005; Sullivan et al., 2006). For each robbery type, the crime trip distances are ranked, summed, and then averaged, producing a mean rank for each type (Green, Salkind, & Akey, 2000). These mean ranks are then evaluated using a chi-square statistic. Prior research has used the Mann-Whitney *U* and Kruskal-Wallis *H* tests when parametric analyses would have been inappropriate; namely, when the distribution of data was non-normal (Mazerolle, Brame, Paternoster, Piquero, & Dean, 2000; Snook, 2004; Sullivan et al., 2006).

Analyzing the five robbery types, the Kruskal-Wallis *H* test revealed statistically significant differences in crime trip distances ( $\chi^2 = 35.317$ ,  $df = 4$ ,  $p = 0.000$ ) by type of robbery. In an attempt to isolate how and to what extent mobility differences exist between robbery types, each robbery type was tested independently with each of the other types; also referred to as “pairwise comparisons” (Green et al., 2000, p. 368). In total, ten pairings were analyzed and tested using the Mann-Whitney *U* test. Table 12 reports the results. Comparing fixed premises and open space targets, statistically significant differences were found using the Mann-Whitney



*U* test ( $U = 63095.0$ ,  $N = 832$ ,  $p = 0.000$ ), in which robberies of fixed targets were associated with longer crime trips than open space targets. This analysis is summarized in Table 13.

Table 12: Pairwise Testing of Criminal Mobility by Crime Type<sup>1</sup>

Robbery Type	Robbery Type				
	Personal	Commercial	Sudden Snatching	Carjacking	Home-Invasion
Home-Invasion	.068	.044 <sup>2</sup>	.548	.887	****
Carjacking	.122	.125	.469	****	****
Sudden Snatching	.314	.004 <sup>3</sup>	****	****	****
Commercial	.000 <sup>3</sup>	****	****	****	****
Personal	****	****	****	****	****

<sup>1</sup> Based on the Mann-Whitney *U* test

<sup>2</sup>  $p < .05$ , <sup>3</sup>  $p < .005$

In general, there is partial support for the first two hypotheses set forth in this study. A Kruskal-Wallis *H* test found significant criminal travel differences among the five robbery types. However, it appears that any mobility differences are due to the disparities between commercial robbery trips and the other robbery types. As indicated by the pairwise analysis in Table 12, three of the ten robbery pairings were found to be statistically significant; all three were related to commercial robbery. Interestingly, journey-to-crime differences were found between commercial and home-invasion robbery, the two robbery types comprising the fixed targets category. It is possible that the opportunity structure of home-invasion robbery is more analogous of personal robbery than commercial robbery, even though the target is stationary. Relevant to the second hypothesis presented in the study, significant travel differences were

found between fixed and open space targets. This reinforces previous theoretical and empirical journey-to-crime findings, although muddled by the significant mobility differences between home-invasion and commercial robbery.

Table 13: Summary of Criminal Mobility and Target Types

Target Type	Mean	Median	Standard Deviation	Percentage of Crime Trips Over Ten Miles
Fixed	40.51	3.79	223.76	27.10%
Open Space	19.29	1.77	91.39	16.86%

### Demographic Analysis

The following demographic analyses are divided into four parts. First, a general overview of the demographic characteristics of the robbery arrestees is presented. Specifically, the age, race, and gender distribution of arrestees for each robbery type is reported. Second, possible correlations between age, race, and gender characteristics by robbery type are examined. The third section reports the results of hypothesis testing pertaining to the sample's demographic characteristics. Namely, mobility variations by age, race, and gender are addressed and statistically tested. Finally, the interrelationships of demographic data and robbery mobility are examined, in which mobility findings based on the totality of the arrestees' demographic characteristics are reported.

## General Overview of Demographic Characteristics

Table 14 summarizes the gender characteristics of the sample by robbery type. Both the percentage and number of robbery trips (in parentheses) by male and female arrestees are reported. In concert with prior findings, the majority of offenses appear to have been committed by a male offender, in which males represented over 87% of the robbery trips (DeComo, 1998; Federal Bureau of Investigation, 2004; Lo & Zhong, 2006; Steffensmeier & Haynie, 2000). Comparing the robbery types, sudden snatching is the most gender-diverse, in which over 22% of arrests for robbery by sudden snatchings involved a female perpetrator. Conversely, less than 6% of robbery trips related to home-invasion robberies were associated with a female offender.

Table 15 reports the race analysis of arrests by robbery type. For each robbery category, the majority of arrests involved a black offender. However, as shown in Table 15, the “other” category included in arrest reports, which denotes an offender’s race other than black or white, was rarely used. This may have skewed the race results, as all minority arrestees may have been lumped under the black category. An age analysis was also conducted. Despite the general completeness of the arrest reports, a handful of these reports did not record the offender’s date of birth. These records were excluded from the ensuing age analyses, since the offender’s age was unknown. Therefore, the results, as displayed in Figure 12 and Table 16, are based on a sample of 801 arrests. Also, as described earlier, not all juvenile offenders were included in the current study due to privacy constraints on data sharing. Specifically, robbery arrests of juvenile offenders in the Eighth Judicial Circuit, which were not subsequently transferred to adult courts, were not included. The findings articulated below should be viewed in light of these limitations.

Table 14: Robbery Arrests by Gender

Gender	Robbery Type					Overall
	Personal	Commercial	Sudden Snatching	Carjacking	Home-Invasion	
Male	90.93% (331)	83.54% (203)	77.67% (80)	89.09% (49)	94.03% (63)	87.26% (726)
Female	9.07% (33)	16.46% (40)	22.33% (23)	10.91% (6)	5.97% (4)	12.74% (106)

Table 15: Robbery Arrests by Race

Race	Robbery Type					Overall
	Personal	Commercial	Sudden Snatching	Carjacking	Home-Invasion	
Black	69.50% (253)	57.20% (139)	58.25% (60)	58.18% (32)	76.12% (51)	64.30% (535)
White	29.40% (107)	40.33% (98)	39.81% (41)	40.00% (22)	23.88% (16)	34.13% (284)
Other	1.10% (4)	2.47% (6)	1.94% (2)	1.82% (1)	0.00% (0)	1.56% (13)

One of the most consistent findings in criminological research is the relationship between age and crime. In general, previous research has demonstrated that criminal activity peaks during the teenage/early adult years, and subsequently drops sharply through the mid to late-twenties; a phenomenon known as the age-crime curve (Hirschi & Gottfredson, 1983; see also Cohen & Land, 1987; Farrington, 1986; Francis, Soothill, & Ackerley, 2004; Kirk, 2006; Steffensmeier & Streifel, 1991). Figure 12 reports the age-crime curve of the current study. Table 16 reports three age related descriptive statistics for each robbery type: the mean and median ages of the arrestees, as well as the percentage of arrestees younger than twenty-six.

Overall, the age findings mirror that of prior research. Figure 12 is similar in shape and distribution of the age-crime curves depicted by Hirschi and Gottfredson (1983), Cohen and Land (1987), and Francis, Soothill, and Ackerley (2004). The mean and median ages for all five robbery types are relatively young. Typically, prior research and national statistics on age and crime has found similar results, with the mean and median ages of offenders for an assortment of crimes falling within the early to mid-twenties range (Federal Bureau of Investigation, 2003; Steffensmeier, Allan, Harer, & Streifel, 1989; Steffensmeier & Streifel, 1991). However, some age variability does appear to exist between the robbery types. Of the five robbery types, commercial robbers appear to be generally older than other types of robbery offenders, with nearly half of all arrests pertaining to commercial robberies involving an offender twenty-six years old or older. Conversely, carjacking robberies were most associated with young offenders, with nearly 80% of carjacking arrests involving an offender younger than twenty-six.

Table 16: Age Analysis of Arrests

Robbery Type	Mean	Median	Percentage of Arrestees Under the Age of 26
Personal	24.40	22.00	65.43%
Commercial	28.53	24.00	53.42%
Sudden Snatching	28.01	23.00	56.57%
Carjacking	23.33	20.00	78.43%
Home-Invasion	23.84	22.00	64.18%
Overall	25.94	22.00	59.25%

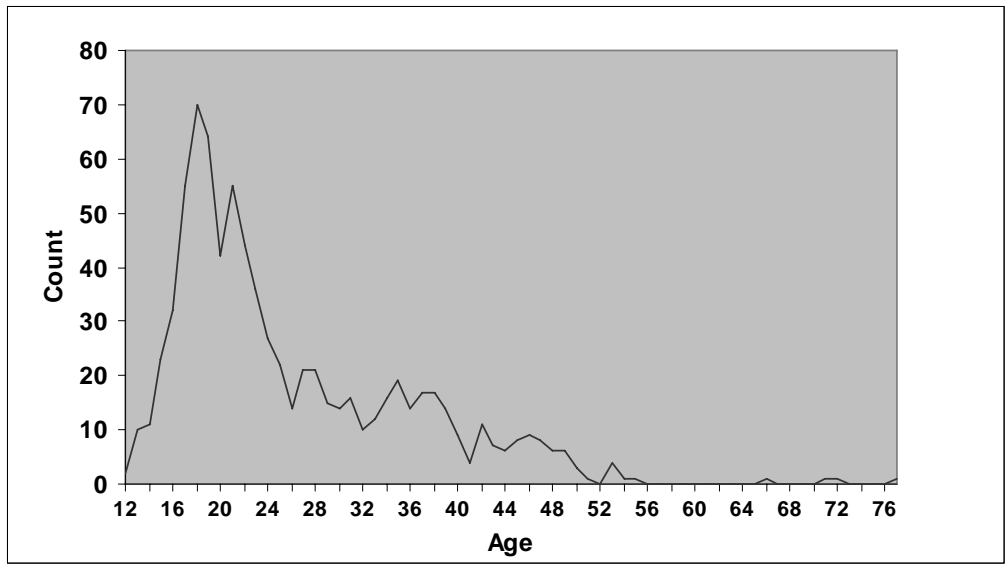


Figure 12: Age-Crime Curve

Correlations of Demographic Characteristics and Robbery Type

To further describe the demographic characteristics of arrestees by robbery type, a series of cross-tabulations were conducted. For each robbery type, three interactive demographic relationships were examined: gender with race, gender with age, and race with age. Before these analyses were conducted, two revisions were made to the original data set. First, since the “other” category included in the race field of the arrest and charging reports was barely used, these cases were excluded from the cross-tabulations. Hence, only arrestees designated as black or white were included. Second, age was aggregated into three groups, consisting of arrestees: younger than twenty, twenty through twenty-five, and twenty-six and older.

Tables 17, 18, and 19 report the results of the age, race, and gender cross-tabulations. The patterns displayed in Tables 17 through 19 are generally uneventful, and do not violate the

trends reported in the preceding section. Namely, the relationships between age, race, and gender do not seem to contradict the findings in Tables 14 through 16. However, a few findings do deserve to be mentioned. First, from the cross-tabulation of gender and age groups shown in Table 18, gender differences appear to exist relative to personal robbery. While male arrestees of personal robbery were most likely to be young, female arrestees were more likely to be older. A similar trend applies to robbery by sudden snatching. Male sudden snatchers were roughly evenly divided between the youngest and oldest age categories, in which roughly 36 percent of male arrestees were younger than twenty. However, females arrested for robbery by sudden snatching were more likely to be older. While roughly 10 percent of female sudden snatching arrestees were younger than twenty, approximately 52 percent were at least twenty-six years old.

Table 17: Cross-tabulation of Gender and Race by Robbery Type

Robbery Type	Gender	Race	
		Black	White
Personal (N = 360)	Male	235 (65.3%)	92 (25.6%)
	Female	18 (5.0%)	15 (4.2%)
Commercial (N = 237)	Male	113 (47.7%)	85 (35.9%)
	Female	26 (11.0%)	13 (5.5%)
Sudden Snatching (N = 101)	Male	47 (46.5%)	31 (30.7%)
	Female	13 (12.9%)	10 (9.9%)
Carjacking (N = 54)	Male	30 (55.6%)	18 (33.3%)
	Female	2 (3.7%)	4 (7.4%)
Home-Invasion (N = 67)	Male	50 (74.6%)	13 (19.4%)
	Female	1 (1.5%)	3 (4.5%)

Table 18: Cross-tabulation of Gender and Age by Robbery Type

Robbery Type	Gender	Age		
		Younger than 20	20 through 25	26 and Older
Personal (N = 350)	Male	127 (36.3%)	91 (26.0%)	100 (28.6%)
	Female	4 (1.1%)	7 (2.0%)	21 (6.0%)
Commercial (N = 234)	Male	54 (23.1%)	57 (24.4%)	87 (37.2%)
	Female	6 (2.6%)	8 (3.4%)	22 (9.4%)
Sudden Snatching (N = 99)	Male	28 (28.3%)	18 (18.2%)	32 (32.3%)
	Female	2 (2.0%)	8 (8.1%)	11 (11.1%)
Carjacking (N = 51)	Male	22 (43.1%)	15 (29.4%)	10 (19.6%)
	Female	1 (2.0%)	2 (3.9%)	1 (2.0%)
Home-Invasion (N = 67)	Male	22 (32.8%)	19 (28.4%)	22 (32.8%)
	Female	1 (1.5%)	1 (1.5%)	2 (3.0%)

Table 19: Cross-tabulation of Race and Age by Robbery Type

Robbery Type	Race	Age		
		Younger than 20	20 through 25	26 and Older
Personal (N = 346)	Black	99 (28.6%)	69 (19.9%)	74 (21.4%)
	White	29 (8.4%)	29 (8.4%)	46 (13.3%)
Commercial (N = 228)	Black	42 (18.4%)	34 (14.9%)	56 (24.6%)
	White	18 (7.9%)	26 (11.4%)	52 (22.8%)
Sudden Snatching (N = 97)	Black	17 (17.5%)	18 (18.6%)	21 (21.6%)
	White	12 (12.4%)	7 (7.2%)	22 (22.7%)
Carjacking (N = 50)	Black	15 (30.0%)	9 (18.0%)	5 (10.0%)
	White	7 (14.0%)	8 (16.0%)	6 (12.0%)
Home-Invasion (N = 67)	Black	16 (23.9%)	14 (20.9%)	21 (31.3%)
	White	7 (10.4%)	6 (9.0%)	3 (4.5%)



Three findings related to race and age should be noted. Extrapolated from Table 19, for personal robbery and robbery by sudden snatching, white offenders were more likely to be older than their black counterparts. Relative to personal robbery, 31 percent of black arrestees were twenty-six years old or older, compared with 44 percent of white arrestees. Similarly, while the distribution of black arrestees across the age groups is roughly equivalent for robberies by sudden snatching, more than half of white arrestees were twenty-six years old or older. Also, disparities exist among carjacking robberies. More than half of black arrestees for carjacking were less than twenty years old, while only one-third of white arrestees were similarly aged.

Due to these age-based findings, the mean and median ages were calculated based on the race and gender of the arrestee. Like Tables 17 through 19, the results for each robbery type are reported. Table 20 displays the results. Comparing the mean and median ages across robbery types, two consistent race and gender findings emerge. First, with the exception of home-invasion robbery, white arrestees were, on average, older than their black counterparts. Furthermore, the mean age differences found between black and white arrestees were always greater than two years, across robbery types. Second, the mean and median ages of female arrestees were higher than male arrestees, for each robbery type<sup>6</sup>. In addition, the average age of female arrestees tops thirty for two robbery types, personal and commercial robbery. In comparison, males arrested for commercial robbery were the oldest among the five robbery types, with an average age of under twenty-eight.

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<sup>6</sup> For carjacking robberies, the mean ages between male and female offenders were almost identical. However, the mean age of female offenders was slightly higher.

Table 20: Mean and Median Age Calculations by Race and Gender

Robbery Type	Statistic	Gender		Race	
		Male	Female	Black	White
Personal	Mean	23.77	30.72	23.80	25.93
	Median	21.00	29.50	21.00	23.00
Commercial	Mean	27.83	32.36	27.58	29.97
	Median	24.00	32.00	23.00	28.50
Sudden Snatching	Mean	27.72	29.10	26.39	30.68
	Median	23.00	27.00	21.00	28.00
Carjacking	Mean	23.32	23.50	22.07	25.48
	Median	20.00	21.50	19.00	21.00
Home-Invasion	Mean	23.57	28.00	24.55	21.56
	Median	22.00	27.50	23.00	20.00
Total	Mean	25.30	30.57	25.04	27.74
	Median	22.00	29.00	22.00	24.00

### Statistical Testing of Mobility and Demographic Data

Thus far, the demographic analyses have focused on the prevalence of age, race, and gender characteristics of robbery arrestees among the five robbery types. However, the concern of the current study is the mobility of robbery offenders. Tables 21 and 22 report the median crime trip distances by race and gender for each robbery type, respectively. In general, it appears that white offenders travel further than their black counterparts, supporting Nichols' (1980) findings. For four of the five robbery types, the median crime trip distance is greater for white arrestees than black arrestees, as shown in Table 21. Looking at gender, the median crime trip

distances of female arrestees is greater than males for three of the robbery types. Overall, female arrestees were likely to travel an additional mile than male arrestees. Similarly, white arrestees were likely to travel nearly one-and-a-half miles longer than black arrestees.

Table 21: Median Crime Trip Distance by Race and Robbery Type

Race	Robbery Type					Overall
	Personal	Commercial	Sudden Snatching	Carjacking	Home-Invasion	
Black	1.55	3.33	1.68	1.27	3.21	1.89
White	1.71	5.22	3.55	7.51	1.40	3.18

Table 22: Median Crime Trip Distance by Gender and Robbery Type

Gender	Robbery Type					Overall
	Personal	Commercial	Sudden Snatching	Carjacking	Home-Invasion	
Male	1.64	3.78	2.63	1.76	2.83	2.25
Female	1.52	4.96	2.19	10.44	4.80	3.25

Guided by the findings of previous research, the relationships between journey-to-crime and race and gender were statistically tested. Again, nonparametric tests were used due to the non-normal distribution of crime trip distances; namely, the Mann-Whitney *U* test. Analyzing the total sample, a Mann-Whitney *U* test revealed statistically significant differences ( $U = 68528.5$ ,  $N = 819$ ,  $p = 0.021$ ) of crime trip distances between black and white arrestees. Conversely, a Mann-Whitney *U* test showed no significant differences ( $U = 35882.5$ ,  $N = 832$ ,  $p = 0.261$ ) between the mobility of male and female arrestees.

To determine if these findings are consistent across the five types of robbery, each robbery type was tested individually in relation to race and gender. Table 23 reports the results of mobility and race for each robbery type. As illustrated in Table 23, only carjacking displays statistically significant mobility differences between black and white arrestees, in which white arrestees traveled further than black arrestees. Similarly, Table 24 reports the corollary analysis on mobility and gender by robbery type. Interestingly, statistically significant differences were found between male and female carjacking arrestees, in which female arrestees traveled further than their male counterparts, consistent with Phillips’ (1980) study on criminal mobility. However, this could be a function of the lack of data points, as only six female arrests for carjacking were included in the sample.

Table 23: Statistical Testing of Criminal Mobility by Race and Crime Type

Statistic	Robbery Type				
	Personal	Commercial	Sudden Snatching	Carjacking	Home-Invasion
p-value <sup>1</sup>	.635	.165	.296	.004 <sup>2</sup>	.476

<sup>1</sup> Based on the Mann-Whitney *U* test

<sup>2</sup>  $p < .005$

In general, the statistical findings do not support the third hypothesis presented in this study. Although statistically significant mobility differences were found between black and white arrestees, further analysis revealed that racial mobility differences were not significant across robbery types. Among the five robbery types, race-related mobility differences were only significant for carjacking arrests. Hence, it would be erroneous to conclude that offender travel varies by race. The fourth hypothesis was also not supported. Although Table 22 indicates that

female offenders travel further than males for three robbery types, these differences were only significant for carjacking offenses. However, the weak statistical difference found between male and female carjackers could be a statistical artifact, as the sample size of female carjackers was very small.

Table 24: Statistical Testing of Criminal Mobility by Gender and Crime Type

Statistic	Robbery Type				
	Personal	Commercial	Sudden Snatching	Carjacking	Home-Invasion
p-value <sup>1</sup>	.891	.306	.131	.040 <sup>2</sup>	.828

<sup>1</sup> Based on the Mann-Whitney *U* test

<sup>2</sup>  $p < .05$

Prior research has consistently shown that older offenders tend to travel further than their younger counterparts (Nichols, 1980; see also Phillips, 1980; Rhodes and Conly, 1981; Snook, 2004; Warren et al., 1998). Several theoretical explanations have been presented to account for these age-based mobility differences, including accessibility to an automobile; level of impulsivity; and differences in geographic and spatial knowledge (Phillips, 1980; Snook, 2004; Warren et al., 1998). For the current research, a Kruskal-Wallis *H* test was conducted to determine statistical mobility differences across the three age groups. Despite the limitation on public accessibility to juvenile arrest records, the current sample included a fairly even distribution of crime trips by age group. Of the 801 crime trips in which the offender's age was known, 267 (33%) were committed by arrestees under the age of twenty, 226 (28%) were committed by those aged twenty to twenty-five, and 308 (39%) were committed by arrestees twenty-six years old and older. Using the total sample of 801 crime trips, the Kruskal-Wallis *H*

test revealed statistically significant differences ( $\chi^2 = 19.264$ ,  $df = 2$ ,  $p = 0.000$ ) between the age groups.

Further analysis indicates that significant mobility age differences were not universal across robbery types. Table 25 reports the results of the age-based mobility testing for each robbery type. As shown in Table 25, a statistically significant relationship between age and journey-to-crime was only observed for carjacking and commercial robberies. Unexpectedly, older offenders do not display the greatest level of criminal travel, contradicting previous findings (Nichols, 1980; Phillips, 1980; Snook, 2004; Warren et al., 1998). Table 26 reports the median travel distances by age group for each robbery type. As illustrated in Table 26, the youngest arrestees (those under twenty years old) traveled the least, while the twenty to twenty-five year olds traveled the most. The only exception is robbery by sudden snatching, in which arrestees younger than twenty actually traveled the furthest. In sum, there is no support for the fifth hypothesis presented in this study. While moderate age-related mobility differences do exist, it does not appear to be a linear relationship. Young arrestees tended to stay closer to home. However, the oldest arrestees, defined as those twenty-six years old and older, did not display the greatest mobility.

Table 25: Statistical Testing of Criminal Mobility by Age Group and Crime Type

Statistic	Robbery Type				
	Personal	Commercial	Sudden Snatching	Carjacking	Home-Invasion
p-value <sup>1</sup>	.239	.008 <sup>2</sup>	.646	.015 <sup>2</sup>	.205

<sup>1</sup> Based on the Kruskal-Wallis  $H$  test

<sup>2</sup>  $p < .05$

Table 26: Median Crime Trip Distance by Age Group and Robbery Type

Robbery Type	Age		
	Younger than 20	20 through 25	26 and Older
Personal	1.25	2.26	1.65
Commercial	1.77	5.94	4.28
Sudden Snatching	3.52	1.48	2.58
Carjacking	0.94	14.07	1.45
Home-Invasion	1.59	3.60	2.77
Overall	1.52	3.22	2.65

#### Interrelationships of Demographic Characteristics and Mobility

Despite the attention given to the relationships between criminal mobility and demographic characteristics, few studies have addressed the interactive effects of demographic variables on the criminal commute. In other words, while age, race, and gender have been found to be statistically related to criminal mobility, much less is known about how these variables work in concert to shape criminal travel. Theoretically, the routine activities theory has been used to explain the differences in travel patterns by the interrelationships of age, race, and gender. Prior research has shown that the characteristics of routine activities are influenced by demographic features, and has been used to explain variability in victimization by demographic types (Felson, Baumer, & Messner, 2000; Wittebrood & Nieuwbeerta, 2000). Additionally, other studies have discovered interactive effects of demographic variables and mobility patterns

(Cohen & Cantor, 1980, 1981). The underlying premise is that daily travel patterns vary by age, race, and gender, thereby altering the chances of victimization and opportunity structure enumerated under the routine activities theory (Cohen & Cantor, 1980; Cohen & Felson, 1979; Cohen, Kluegel, & Land, 1981). The same premise can be applied to the routine activities of offenders. In a study on deviance, Osgood, Wilson, O'Malley, Bachman, and Johnston (1996) found significant explanatory relationships between offenders' routine activities and criminal behavior. Integrating demographic characteristics into their model, the authors found that age and gender related changes in criminal activity could be explained by the offender's routine activities. In other words, the relationship between age, gender, and deviance were, to some extent, a function of routine activities.

Under the routine activities theory, journey-to-crime is inherently linked to the daily travel patterns of both victims and offenders. It is along these routine activity paths which bring the offender in contact with a victim (Cohen & Felson, 1979). The criminal commute is subsequently borne out of these mobility patterns. Hence, variables which influence the routine activities of offenders and victims, such as demographic characteristics, will also invariably affect criminal mobility. However, little research has been conducted which addresses criminal travel and the interactive effects of demographic variables. One exception is a recent study conducted by Tita and Griffiths (2005) on homicide. Using logit regression analysis, the authors were able to determine the interdependence of race, age, and gender on offender mobility patterns. However, the study does not measure journey-to-crime directly, but rather offender mobility between census tracts.

Thus far, the influences of age, race, and gender on criminal mobility have been analyzed independently. In other words, each demographic variable has been viewed without regard to the



others. However, as shown by the routine activities literature, the interaction effects between demographic variables influence daily travel patterns (Cohen & Cantor, 1980, 1981), and thus, criminal mobility. The following section examines possible interactive effects of arrestees' demographic characteristics on criminal mobility. Specifically, the age, race, and gender of arrestees are viewed simultaneously, and then analyzed in conjunction with crime trip distances.

In total, the age, race, and gender of 788 arrestees were known. Again, arrestees that were not defined as either black or white were excluded from the analyses. Table 27 reports the number of crime trips (in parentheses) and median crime trip distance for each demographic category. A few interesting results emerge from the interrelationship effects displayed in Table 27. The range of mobility across demographic types is relatively large. Young, black males exhibit the least amount of criminal mobility, with a corresponding median crime trips distance of 1.34 miles. On the end of the spectrum, young, black female arrestees exhibit the greatest mobility with a median criminal commute of 6.88 miles, over five times as long as their male counterparts. Comparatively large mobility differences also exist within genders. White males, who are at least twenty-six years old, travel over three times as far as young, black males, with median crime trip distances of 4.81 and 1.34 miles, respectively. For females, the disparity is even greater. Interestingly, black females who are at least twenty-six years old travel the least among female arrestees, with a median crime trip distance of less than four times that of young, black females.

The importance of analyzing demographic interaction effects on criminal mobility can be seen from the general inconsistency between the demographic variables and criminal travel. Namely, none of the three demographic characteristics included in this study correlates uniformly with greater criminal mobility. Starting with gender, female arrestees tended to travel

further than their male counterparts. However, this relationship was reversed for those twenty-six years old and older. Controlling for race and gender, other disparate patterns emerge. Among black female arrestees, criminal mobility decreased with age, as indicated by the drop in median crime trip distances. For white males, the pattern is reversed. The median crime trip commute of the twenty-six and older age group was over three times as long as the younger than twenty age group. Finally, mobility differences between the races also varied. Pertaining to offenders younger than twenty, black male arrestees traveled less than whites, while black female arrestees traveled further than white female arrestees. For the twenty through twenty-five age group, the opposite is true, as black male and white female arrestees traveled further than their respective counterparts.

Table 27: Median Crime Trip Distance by Demographic Type

Gender	Race	Age		
		Younger than 20	20 through 25	26 and Older
Male	Black	1.34 (181)	3.16 (128)	1.71 (146)
	White	1.57 (67)	2.57 (66)	4.81 (104)
Female	Black	6.88 (8)	3.56 (16)	1.60 (31)
	White	2.40 (6)	4.36 (10)	3.13 (25)

Table 27 illustrates an important finding of the current research study. Namely, that no one demographic characteristic is better equipped at explaining criminal mobility. Rather, the interrelationships between demographic variables create an assortment of correlations with criminal travel. For instance, the effects of age on journey-to-crime vary by race and gender. In sum, there does not appear to be simple correlations between criminal mobility and demographic

characteristics of offenders, adding to the complexity of journey-to-crime research. Next, we turn our attention to the prevalence of crime trips exceeding ten miles by demographic category.

As depicted in Table 11, over twenty percent of crime trips in the current sample were over ten miles, indicating a subset of offenders who are willing to travel. This finding runs contradictory to previous research, in which little criminal travel has been the norm (Nichols, 1980; Phillips, 1980; Rhodes & Conly, 1981; Sarangi & Youngs, 2006; Warren et al., 1998). This section reviews the demographic characteristics of mobile offenders; those who traveled more than ten miles from their residence to commit their crime. The purpose of this section is to provide some insight into offenders willing to travel, and to identify possible interrelated demographic variables that correlate with criminal mobility.

In sum, out of the 172 crime trips which exceeded ten miles, age, race, and gender information was known for 159 of the corresponding arrestees. Table 28 breaks down these mobile offenders by demographic type. Both the number of crime trips exceeding ten miles within each demographic category is reported, as well as the corresponding percentage out of the 159 crime trips. However, Table 28 does not describe the prevalence of mobile offenders by demographic types. To fill this void, Table 29 reports the percentage of crime trips exceeding ten miles by the interrelationships of age, race, and gender. Specifically, this percentage is calculated by dividing the number of crime trips over ten miles for each demographic type, by the total number of crime trips within each demographic type, reported in parentheses. Unlike the findings from Table 27, age seems to be more of a contributory factor to criminal mobility than other demographic characteristics. Arrestees aged twenty to twenty-five were the most likely to travel over ten miles, regardless of race or gender. However, limited correlations of race and gender can still be seen. Consistent with Table 27, 26 percent of crime trips by white

males who were at least twenty-six years old exceeded ten miles. Also, one-quarter of black female arrestees younger than twenty years old traveled over ten miles.

Table 28: Arrestee Characteristics of Crime Trips Exceeding Ten Miles

Gender	Race	Age		
		Younger than 20	20 through 25	26 and Older
Male	Black	22 (13.8%)	39 (24.5%)	26 (16.4%)
	White	8 (5.0%)	18 (11.3%)	27 (17.0%)
Female	Black	2 (1.3%)	4 (2.5%)	6 (3.8%)
	White	1 (0.6%)	3 (1.9%)	3 (1.9%)

Table 29: Prevalence of Crime Trips Exceeding Ten Miles by Demographic Type

Gender	Race	Age		
		Younger than 20	20 through 25	26 and Older
Male	Black	12.0% (183)	31.0% (126)	17.8% (146)
	White	11.9% (67)	27.3% (66)	26.0% (104)
Female	Black	25.0% (8)	25.0% (16)	19.4% (31)
	White	16.7% (6)	30.0% (10)	12.0% (25)

### Inter-Jurisdictional Criminal Travel

Unlike the findings of previous journey-to-crime research, it appears that a substantial subset of offenders exhibit a willingness to travel. In total, over 20 percent of all robbery trips were over ten miles in length. Another aspect of criminal travel is whether offenders cross

police jurisdictional boundaries, sometime referred to as the spillover effect of criminal activity (Hakim, 1980). The prevalence of inter-jurisdictional travel carries unique policy implications, and as will be shown later, is an important aspect of crime prevention policies. The following section reports a conservative estimation of police inter-jurisdictional travel; specifically, robbery offenders who cross county boundaries.

Table 30 reports the prevalence of inter-county and inter-state crime trips by robbery type. Inter-county robbery trips are defined as those in which the offender lived in a different county than where the robbery occurred. Similarly, inter-state robbery trips are those in which the offender traveled from another state to commit a robbery. As shown in Table 30, 172 crime trips crossed county boundaries. An additional analysis was conducted to determine the character of inter-county travel. Inter-county crime trips were divided into two segments; those which begin and end in two adjacent counties and those that do not. For two counties to be considered adjacent, they must share a common geographic border, as illustrated in Figure 13. Two statistics pertaining to inter-county, inter-state, and adjacent county crime trips are reported in Table 30. First, for each robbery type, the number of inter-county, inter-state, and adjacent county crime trips are reported. Second, the percentage of crime trips represented by these three categories within each robbery type is also reported. These percentages are calculated by dividing the number of crime trips in each category, by the total number of crime trips for the corresponding robbery type. For example, 48 out of the 364 personal robbery trips crossed county lines, accounting for roughly 13 percent of all personal robbery trips. The totals then represent the number and percentage of inter-county, inter-state, and adjacent county crime trips out of the total sample of 832 robbery trips.

As expected, commercial robbery trips were the most likely to cross county jurisdictions, with over 30 percent of these crime trips ending in a different county than where the offender lived. In addition, inter-county mobility among carjacking and robbery by sudden snatching were also quite pervasive, as over 24 percent of these crime trips ended in a different county than where it began. In total, over 20 percent of all robbery trips crossed county lines. Also, the majority of inter-county crime trips began and ended in two adjacent counties, representing 113 of the 172 (65.7 percent) inter-county crime trips.

Table 30: Prevalence of Inter-County Crime Trips by Robbery Type

Robbery Type	Inter-County Crime Trips	Inter-State Crime Trips	Adjacent County Crime Trips
Personal	48 (13.2%)	4 (1.1%)	31 (8.5%)
Commercial	75 (30.9%)	4 (1.6%)	52 (21.4%)
Sudden Snatching	25 (24.3%)	1 (1.0%)	18 (17.5%)
Carjacking	15 (27.3%)	3 (5.5%)	8 (14.5%)
Home-Invasion	9 (13.4%)	2 (3.0%)	4 (6.0%)
Total	172 (20.7%)	14 (1.7%)	113 (13.6%)

Prior research has demonstrated that some areas may attract offenders more than others, such as areas of higher opportunity or general criminal attractiveness (Bernasco & Luykx, 2003; Bernasco & Nieuwebeerta, 2005; Hakim, 1980). Table 31 reports, by county, the number of arrestees imported from other areas. As expected, Seminole County, with its proximity to Orlando and level of urbanization, experienced the highest gross importation of robbery arrestees

in which 88 had traveled from other counties. However, each county witnessed a significant percentage of robbery arrests of non-county residents. Interestingly, while the two most urban counties, Alachua and Seminole, were nearly equivalent relative to the number of arrestee home locations (380 and 378, respectively), Seminole County made over 50 percent more arrests of non-county residents than Alachua County.

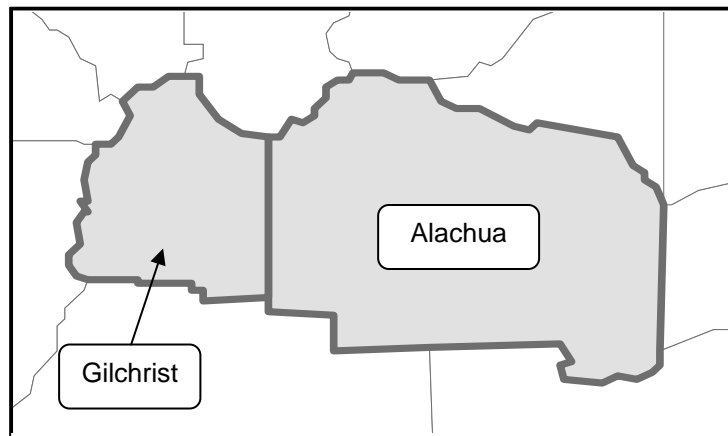


Figure 13: Illustration of Two Adjacent Counties

Table 31: Inter-County Robbery Arrests by County

County							Total
Alachua	Seminole	Union	Gilchrist	Levy	Baker	Bradford	
56 (14.7%)	88 (23.3%)	3 (42.9%)	1 (20.0%)	6 (28.6%)	7 (50.0%)	11 (40.7%)	172 (20.7%)

## DISCUSSION

The goal of this study was to investigate the mobility of robbery offenders, and to determine if criminal travel varies by robbery type. In total, 832 robbery arrests and corresponding crime trips were analyzed. A robbery typology was constructed, mimicking the robbery statutes of the State of Florida. By further refining robbery offenses into smaller, more homogeneous categories, it would be possible to identify distinct mobility differences among criminal offenders that would otherwise be lost under the broad, generic definition of robbery. In addition, criminal mobility by various demographic and target characteristics were evaluated. For each robbery type, possible significant differences in offender mobility among these demographic and target characteristics were explored.

In general, while the overall distributions of crime trip distances across the five robbery types were similar, a closer analysis revealed offender mobility differences among the robbery types. With varying degrees, each robbery type displayed the distance decay phenomenon, as offenders appeared to prefer targets closer to home. However, there also appears to be a subset of offenders across robbery types who are willing to travel, as indicated by the volume of crime trips over ten miles. When viewed as a whole, over 40% of all robbery commutes can be defined as either very short, in which crime trips ended less than a half-mile from the offender's home, or relatively long, in which crime trips exceeded ten miles. In addition, the prevalence of very short and comparatively long criminal commutes is relatively even. While nearly 22% of all robbery trips were minimal and shorter than a half-mile, roughly 21% ended over ten miles from the



offender's place of residence. This polarization of crime travel can be seen across all five robbery types.

Commercial robbery may provide a possible exception to this general uniformity of criminal mobility. As a robbery type, commercial robbery sticks out for a few reasons. First, commercial robbery is associated with both the lowest percentage of crime trips less than a half-mile, and the highest percentage of crime trips exceeding ten miles (11.5 and 30.5 percent, respectively). Second, the distance decay effect for commercial robbery is the most gradual out of the five robbery types. The sharp drop in criminal activity does not occur until the fourth distance interval<sup>7</sup>, in which the number of crime trips is cut in half from the preceding interval. Similar drops occur for the other four robbery types, but closer to the offender's home, following the first half-mile interval. And third, hypothesis testing revealed that commercial robbery is atypical from other types of robberies when it comes to criminal mobility. Through a pairwise analysis of the five robbery types, commercial robbery arrestees were found to travel significantly further than home-invasion, personal, and carjacking arrestees. No other statistically significant mobility differences were found. Overall, the criminal commutes related to commercial robbery were generally longer than those of other robbery types.

The overall shape and distribution of crime trip distances for each robbery type generally support prior research on criminal mobility. Namely, it appears that robbery offenders prefer targets close to home, as proven by the distance decaying effect for all five robbery types. However, the current study does not fully reinforce the empirical findings of previous journey-to-crime research. Criminal activity was skewed too far towards the offender's home, as the number of crime trips ending within the immediate vicinity of the offender's residence was

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<sup>7</sup> The fourth interval is defined as crime trips greater than a mile-and-a-half but not exceeding two miles.

greater than theoretically predicted. Specifically, the buffer of reduced criminal activity described by Brantingham and Brantingham (1981) was not found. Several arguments may explain the prevalence of robbery offenses occurring within the high-risk zone around the offender's home. As hypothesized here, the offender/victim relationship may partially explain criminal activity in and around the offender's home. These offenders may have simply underestimated the probability that the victim of the robbery would contact the police. Knowledge of the victim based on a previous or current relationship may provide the offender with a sense of security or comfort, drawing the criminal to look inward rather than outward.

However, other mechanisms may explain the lack of this buffer. For example, it is possible that these offenders simply do not act rationally, or place a high cost on travel. The routine activities of these offenders may be limited, and are heavily based around his or her home. Also, offenders who commit crimes in or around their home may act more spontaneously than those who exhibit greater amounts of travel. Travel requires planning or, at a minimum, deferment of gratification. Those who exhibit no travel may act more impulsively on immediate stimuli. Also, robbery targets themselves may be becoming more accessible to criminals, such as deliver drivers, in which travel by the offender is unnecessary.

The most significant finding of the current study, which contradicts previous theoretical and empirical research, is that a substantial subset of offenders appears willing to travel. Over twenty percent of all robbery trips evaluated exceeded ten miles. Although, the presence of mobile criminals is prevalent across each of the five robbery types, some variability between the robbery types does exist. As a percentage, the prevalence of crime trips over ten miles was highest for commercial robberies at 30.5 percent, and the lowest for personal robbery at 14.6 percent. In other words, it appears that commercial robbers are more than twice as likely to

travel over ten miles as personal robbers. Variability also existed among fixed and open space targets. Commercial robbers were also twice as likely to travel over ten miles as home-invasion robbers. Similarly, the prevalence of crime trips exceeding ten miles was greater for carjackers and sudden snatchers than personal robbers.

Two design methodologies may have contributed to this anomaly among journey-to-crime research. First, the geographical area analyzed in this study was more expansive than prior research. Rather than investigating a single urban city or county, which inherently skews criminal mobility towards shorter commutes, arrest data from seven counties and nearly two dozen police agencies were collected and reviewed. This allowed for a more robust analysis, which included both urban and rural areas. Second, mobile offenders were not systematically excluded from the mobility analyses, which has been a pervasive methodological flaw in prior journey-to-crime research (Nichols, 1980; Phillips, 1980; Potchak et al., 2002; Warren et al., 1998). All crime trips which were successfully geocoded were used in the current study, which offers an unbiased look into criminal mobility.

In total, five hypotheses were tested in this study. Relative to criminal mobility and robbery type, two hypotheses were presented. Specifically, that mobility differences would exist among the five robbery types, and offenders who target fixed premises will travel farther than those who victimize open space targets. Limited support for both of these hypotheses was found. While statistically significant mobility differences were found between robbery types, these significant differences appear to be limited to commercial robbery. As shown through a pairwise analysis, no significant differences were found between the other four robbery types. Supporting prior research, statistical testing revealed that offenders who victimized fixed targets were more likely to travel greater distances than those who chose open space targets. It seems plausible that

these mobility differences are caused by target availability, in which open space targets are more densely available across space than fixed targets. However, it appears that a portion of all types of robbery offenders are willing to travel, for each of the five robbery types.

Three hypotheses presented in the current research addressed criminal mobility and the demographic characteristics of arrestees. Specifically, possible age, race, and gender correlates of criminal mobility were examined. Statistical testing revealed very little racial and gender based mobility differences. A Kruskal-Wallis  $H$  test reported significant mobility differences between white and black arrestees. However, further analysis revealed that out of the five robbery types, significant racial mobility differences were confined to carjacking arrestees. A similar result was found between male and female arrestees. Although statistical testing did not find significant mobility differences based on gender for the entire sample, gender-based differences were found pertaining to carjacking robberies. Therefore, the hypotheses that criminal mobility varies by race and gender were not supported.

The mobility findings related to race and gender may illustrate the necessity to analyze narrowly defined crime types. Prior research has shown mobility differences between male and female, and black and white offenders (Nichols, 1980; Phillips, 1980; Warren et al., 1998). However, these previous findings may be a function of the overgeneralization of crime definitions. For instance, the gender and racial analysis conducted by Nichols (1980) was based on all robbery offenses, not specific robbery types. It is possible that mobility similarities between genders and races were masked due to the aggregation of robbery offenses, and the significant findings were a function of a specific robbery activity like carjacking. Likewise, differences in criminal travel by gender were also found by Phillips (1980). However, the analysis lumped together ten offense categories, and gender-based mobility findings by crime

type were not presented. The current study deviates from the Nichols (1980) and Phillips (1980) study in that specific crime types were examined. This may partially explain why these previous studies concluded that mobility varies by gender and race, and why the current study does not.

Conversely, the analysis on age and mobility was more robust. In the current study, three age groups were constructed, consisting of arrestees aged: younger than twenty, twenty to twenty-five, and twenty-six and older. A Kruskal-Wallis  $H$  test found significant differences between the three age groups across the five robbery types. Analyzing each robbery type independently, statistically significant age-based differences were found among carjacking and commercial robbery arrestees. However, the hypothesis that older arrestees would travel further than younger arrestees was not supported. For all five robbery types, in no instance did the oldest age group travel the furthest, as indicated by the median travel distances of the age groups. Additionally, older offenders were not the most likely to travel over ten miles to the robbery site.

These findings contradict prior research, which have demonstrated that older offenders traveled further than their younger counterparts (Nichols, 1980; Snook, 2004; Warren et al., 1998). It is possible that the age-related mobility findings of the current research are artifacts of the age groupings. Namely, that age-based travel differences have been created by how arrestees were aggregated. While three age groups were constructed here, prior research has typically dichotomized age into two groups; usually separating those younger than twenty from those twenty and older (Nichols, 1980; Snook, 2004). However, in a study on serial rapists, Warren et al. (1998) also constructed three age groups, and found that distance traveled by offenders increased as age increased.

There are several possible explanations to the observed curvilinear relationship between age and mobility. For instance, differences in routine activities between the age groups may

explanation variation in criminal travel. The routine activities of twenty to twenty-five year olds may be more spatially disperse when compared to the other age groups. In other words, the daily travel patterns and lifestyle of young adults may be the most geographically robust, leading to longer crime trips. Entertainment venues, such as bars and sporting/concert events, or commercial areas may be more attractive to young adults. These places may even become nodes of their mental map. As a result, the awareness spaces of young adults may grow and ultimately exceed that of older adults, and likewise, so too does the number of potential robbery targets away from home.

Also, in a study by Cohen and Cantor (1980), those who lived in single-adult households were more likely to be a victim of a crime. Following the routine activities theory, the authors concluded that these individuals are less likely to spend time at home and more time in public places, thereby increasing their chances of converging with an offender. Similarly, Hindelang, Gottfredson, and Garofalo (1978) propose that marital status will affect the likelihood of victimization, as “married persons would be expected to spend proportionately more time within the home than would single persons” (p. 249). This same concept can be extended to offenders. Offenders who are single should also exhibit daily travel patterns which are likely to bring them to areas away from home, as their “keeping house” responsibilities should be diminished (Cohen & Cantor, 1980, p. 140). Of the three age groups defined in the current study, twenty to twenty-five year olds should be the least restricted. Younger offenders, particularly juveniles, would predictably be more likely to live with their parents, and therefore may be accountable for some household responsibilities. Older offenders may be more likely to be married or have children, in which keeping house becomes a greater daily necessity. Twenty to twenty-five year olds, however, are more likely to be in transition, in which they have moved out of their parent’s home

but have not yet married. Hence, we should expect that young adults, including offenders, spend more time away from home. Therefore, a greater percentage of criminal activity can be expected to take place in areas away from the offender's home, and as a result, the crime trip distances would be relatively long.

Concluding the demographic analysis, possible interrelationships between age, race, and gender and criminal mobility were explored. Specifically, the median crime trip distances by demographic type were calculated and compared. The findings here emphasize the importance of analyzing the interrelationships between demographic variables. Neither age, nor race, nor gender appears to be any better at predicting criminal mobility. In addition, distinct travel differences emerged when all three arrestee demographic characteristics were considered. From a routine activities perspective, it is possible that travel patterns and lifestyles may not only vary between age, race, and gender types, but also within these demographic characteristics. For example, the factors which influence the routine activities of young adults may vary by race and gender, directly influencing journey-to-crime patterns.

### Policy Implications

The current study analyzed the criminal mobility patterns among five robbery types. To conduct this research, GIS and geocoding software was utilized to standardize offender and offense addresses. Through these computer technologies, distance measurements were made using the x, y coordinates that were produced. Crime trip distances were then examined for each of the five robbery types. Distributions of crime trip distances were reported, as well as

measures of the typical criminal commute. Through these analyses, various mobility differences between robbery types were found.

The following section summarizes the policy and research implications arising from the current study. These implications are varied in nature, ranging from recommendations for future journey-to-crime research, to GIS and geocoding suggestions applicable to all disciplines. Specifically, the influence of criminal definitions, and the future needs of criminal mobility research are discussed. This is followed by a discussion on data sharing, and concluded with recommendations pertaining to GIS and geocoding technologies.

#### Crime Research Should Focus on Narrow Definitions of Crime

As illustrated in this study, while each robbery type exhibited a similar distribution of crime trip distances, some important differences among the robbery types did emerge. Crime trips related to commercial robberies were more than twice as likely to exceed ten miles as personal or home-invasion robberies. Similarly, commercial robbery crime trips were also the most likely to cross county borders, followed closely by carjacking and robbery by sudden snatching. Furthermore, more than one-fifth of all commercial robbery crime trips began and ended in adjacent counties, the highest percentage out of the five robbery types. The measures of central tendency further depicted journey-to-crime discrepancies among the robbery types. For example, the median criminal commute of commercial robberies was more than twice as long as that of personal robberies. In essence, while each robbery type displayed similar distributions of crime trips by distance, the median criminal commutes, and the prevalence of inter-jurisdictional



and long crime trips (defined as those over ten miles) varied considerably between the robbery types.

The mobility findings described above would have been lost without the construction of the robbery typology. The general robbery definition encompasses a vast array of behaviors and activities (see List of Nomenclature). Because the definition of robbery is so robust, unique offender patterns by specific types of robbery can become glossed over. To adequately investigate criminal activity, definitions of crime must be limited in scope. Both crime analysis and academic research should focus on narrow definitions of crime. Likewise, crime prevention strategies should be constructed and directed towards specific illegal activities, reflecting narrowly-defined criminal activity.

For example, from the results of the current study, policies designed to address commercial robberies should emphasize a cooperative approach among police agencies. Out of the five robbery types, the commutes of commercial robbers appear to be the most likely to originate in a jurisdiction other than the robbery's location. Similarly, policies directed towards carjacking and robbery by sudden snatching should also be multi-jurisdictional, as the current study found that over twenty percent of those arrested for these crimes resided in a different county than where the robbery was committed. Conversely, of the five robbery types, personal robbery and home-invasion robbery were the most localized. While criminal mobility was not entirely lacking among these two types of robberies, responses to home-invasion and personal robbery should reflect the diminished role of inter-county mobility by offenders. Therefore, prevention strategies may be orientated towards specific communities or neighborhoods. The current study also makes an argument for greater detail in criminological research. Generally, recent research on the criminal commute has been increasingly focused, analyzing a variety of

sub-groupings of a general crime category (Snook, 2004; Tita and Griffiths, 2005; Van Koppen and Jansen, 1998; Warren et al., 1998). This trend must continue across all aspect of related research.

### More Attention Is Needed Towards Mobile Criminals

In the current study, over twenty percent of crime trips exceeded ten miles. Prior research has garnered scant attention to the mobile criminal and motivations for travel, and therefore, little is known about these offenders. However, a few studies do offer a glimpse into the mobile criminal. Through interviews with robbery offenders, Feeney (1986) was able to ascertain the prevalence and rationale behind the travel patterns of robbery offenders. In total, thirty percent of robbers interviewed stated they had robbed in a different town than which they lived. Of these, a minority of robbers indicated that they had made a conscious, rational decision to travel to the crime site with the explicit purpose of committing a robbery. More typical was offender displacement, in which the robber “just happened to be in the other town” (Feeney, 1986, p. 62). Similarly, a Wiles and Costello (2000) study on burglars found that “travel associated with crime is not primarily driven by plans to offend” (p. 43). However, in interviews with offenders who lived in the city of Sheffield, the authors found that the primary reason why these offenders traveled outside of the city was to offend.

In another study based on offender interviews, Kock, Kemp, and Rix (1996) examined the patterns and distributions of stolen electrical goods. Part of the authors’ analysis focused on burglars’ mobility patterns and willingness to travel. Through discussions with informants, they

found that a few burglars would travel up to two hours to commit a burglary. In a similar study, Porter (1996) interviewed 21 known offenders, ten of whom were convicted of robbery offenses. Several reasons for travel were reported by Porter, in which the offender: was attracted to crime-conducive target characteristics such as lower levels of security and higher expected payouts (see also Van Koppen & Jansen, 1998), happened to be in the area, and had to commute for drug-related purposes. In addition, rational decision-making also seemed to dictate offender travel, as “one third traveled to offend in order to minimize the chances of being detected” (Porter, 1996, p. 17).

In general, the availability of targets, the routine activities of offenders, and rational decision-making all seem to, at least partially, explain criminal mobility. However, more research is needed to determine how such influences as criminal opportunity, target availability, decision-making, spatial knowledge, and offender displacement shape the robber’s criminal commute. The current body of literature which investigates the decision-making process of mobile offenders is largely limited by sample size and crime type. Specifically, sample sizes of prior research have been relatively small, with interviews of a few dozen offenders (Feeney, 1986; Porter, 1996), or have analyzed burglary offenders (Kock, Kemp, & Rix, 1996; Wiles & Costello, 2000). More work is needed to address the motivations behind the willingness-to-travel by different types of robbery offenders. Furthermore, other correlates of long crime trips, such as demographic or socioeconomic variables, should be further explored.

## The Need for Intra- and Inter-County Data Sharing

The current study found that over 20 percent of all robbery arrests can be considered inter-county, in which the offender lived in a different county than where the robbery was committed. The importance of analyzing inter-county mobility is derived from the way data and information are stored among police agencies. Every police agency works under sharply defined geographic areas in which they are responsible for police services, known as the agency's jurisdiction. Crime data, such as arrest data, is then collected by these agencies based on the geographic location of the crime. Namely, only crime related information which occurs within an agency's jurisdiction is obtained, stored, and available for analysis. As a result, crime data becomes spatially fragmented and decentralized, as crime information is pigeonholed based on police jurisdictional boundaries. Unfortunately, the overemphasis on jurisdictional responsibilities can cause police officers and administrators to ignore more general crime trends, or what Steven Egger (2002) defines as "linkage blindness" (p. 241). Under the current construct, "law enforcement investigators do not see, are prevented from seeing, or make little attempt to see beyond their own jurisdictional responsibilities" (Egger, 2002, p. 241).

From the results of this study, a disparity exists between the traditional method of collecting and storing data, and the nature and extent of criminal mobility. While the majority of crime trips were localized around the offender's home, exhibiting distance decay, more than one-fifth of all crime trips crossed county, and therefore, police jurisdictional boundaries. In other words, counties can expect one out of every five robbery arrests to come from an offender who does not live within the county. To address the mobile offender, police agencies should broaden their geographic scope of crime analysis, and emphasize inter-jurisdictional data sharing; in

particular, intra- and inter-county data sharing. Data sharing between police organization will enhance their investigative abilities, by making accessible information from other police agencies which may be important (see Reynolds, Griset, & Scott, Jr., 2006). Data sharing would also allow policy decision-makers to better respond to crime spikes in neighboring counties and areas. As crime rates increase in one county, adjacent counties may encounter similar, although less drastic increases in crime, as offenders may extend their range of operation. Ideally, each police agency within a county and between adjacent counties would share a common records management system, like the system being used in Seminole County. Currently, all arrest data is shared among each police department in Seminole County, and electronically stored at the Seminole County Sheriff's Office. Police data originating from anywhere in the county can then be extracted and analyzed, thereby enhancing the level of crime analysis. This allows easy access to potentially important data, and provides all police agencies with a more comprehensive picture of criminal activity. It should be noted that the prevalence of inter-jurisdictional travel presented in this study are conservative estimations of police jurisdictional spillover. While over 20 percent of crime trips crossed county boundaries, it is likely that a greater percentage crossed municipal police jurisdictional boundaries.

### Understand the Limitations of Geocoding Software

Thus far, the policy implications discussed have emphasized the mobility findings of the current study. Two findings are of particular importance. First, it appears that a relative large subset of offenders is willing to travel. Second, criminal mobility, and the prevalence of long

journeys-to-crime<sup>8</sup>, vary by robbery type. These two findings have direct consequences on crime analysis methodologies and future journey-to-crime research, as well as the need for greater accessibility of data. However, driving the current study is the geocoding software. In essence, the entirety of this study hinges on the geocoding results. Specifically, the latitudinal and longitudinal coordinates produced by Centrus directly influenced the crime trip distance calculations, in which these crime trips distances ultimately served as the basis for the ensuing analyses. The current section concludes with comments on GIS and, more specifically, geocoding software, and the implications of using these technologies.

Geocoding and GIS software programs have revolutionized spatial and temporal analyses, by offering technologies which can quickly and easily organize, manipulate, and map large amounts of data. The two geocoders used for this study demonstrate the capabilities of current geocoding technology, and the advantages of using geocoding software for academic research. Specifically, three aspects of these technologies are of particular importance. First, by converting postal address strings into their latitudinal and longitudinal equivalences, address data is effectively standardized. Because of this standardization, data points can be directly compared and contrasted using the universal language of x, y coordinate systems. This becomes imperative in spatial analysis, as the context in which the data is analyzed must be consistent for comparability. Second, geocoding programs have the ability to interpret and map large data sets that would otherwise be impossible. For example, ArcGIS 9.1 can display thousands of addresses on a map in a matter of seconds. This capability opens the door to more expansive and generalizable studies, furthering our understanding of spatial patterns and trends. Third, data can be quickly and efficiently updated by the user. Subsets of data can be easily extracted if

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<sup>8</sup> Long journeys-to-crime are defined here as crime trips exceeding ten miles.

necessary, new information can be added, and multiple analyses can be conducted simultaneously that would be cumbersome without the use of geocoding and mapping tools. For the current research, this characteristic of geocoding and GIS software became especially helpful as five different robbery types were examined.

However, as also shown in the current research, the process of geocoding is not a perfect science. Errors can occur which could greatly influence the final results. In general, the process of geocoding exhibits two primary limitations. First, not all geocodable addresses, i.e. those with valid address strings, will be successfully geocoded. In other words, the hit rate will be less than 100 percent. This shortcoming stems from the database referenced by the geocoder. After the address is parsed, the geocoder then compares this parsed information with the geocoder's street map. Once the most appropriate street segment is identified, the address is then interpolated along this segment, and ultimately geocoded. However, streets are continually being updated, in which streets are moved, added, deleted, and renamed. Databases stored by geocoding programs can become quickly outdated, as the various modifications to street networks occurring after the development of the database will not be reflected by the geocoder. This can cause two problems. First, the hit rate of the geocoder will drop, as newly formed addresses are not reflected in the geocoder's database. Second, the spatial location of the street segment itself may be obsolete. This occurs when the physical location of a street is moved. Figure 14 illustrates an example of this scenario. Hence, while the geocoder may successfully match an address to a street segment, the street segment itself may not reflect the true geographic position of the street. As a result, the actual physical location of the address and the geocoded location of the address will not be equivalent, possibly contaminating the ensuing analyses. Therefore, users of geocoding software should strive to attain the most recent versions of geocoding programs to maximize the hit rate,

and minimize spatial disparities of street networks. Also, if possible, a sample of the geocoded results should be checked for validity from an additional source.

The second primary limitation of the geocoding process is the possibility of misgeocoding, in which an address string is matched to a wrong street segment. Misgeocoding becomes more of a problem as data is obtained over wider geographical areas. Users of geocoding programs must be aware of the possibility of misgeocoding addresses, and the steps which can be taken to minimize this risk. Although the geocoding results from ArcGIS 9.1 were not used, the current study illustrates how the user can guard against misgeocoding. Specifically, the ArcGIS geocoder not only had to match to a street segment, but also a “zone.” If the city of the address recorded in the arrest report did not match the street segment in ArcGIS 9.1, the address was not geocoded. Depending on the purpose and methods of the analysis, other techniques can be employed to minimize misgeocoding. In general, geocoding results should be reviewed for potential inaccuracies. Also, programs which allow the user to interactively modify address data, such as ArcGIS 9.1, should be used with caution. The purpose of geocoding is to accurately portray the physical location of addresses on a virtual map, not to maximize the hit rate. Simply changing an address string to match a geocoder’s street segment is fraught with peril, and can lead to misleading results. Before any policies are implemented based on geocoded information, the integrity of the results must be reviewed. While GIS and geocoding software can greatly enhance any spatial analysis, including crime-related questions, they can also be misleading if precautionary steps are not taken to preserve the accuracy of the data. Understanding the potential for error is the first step to well-guided decision-making based on GIS and geocoding output.



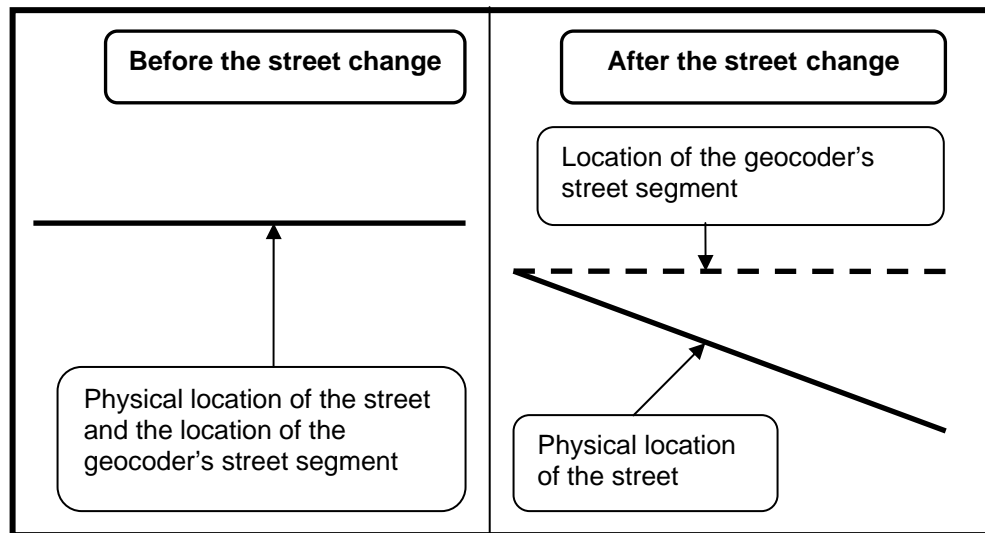


Figure 14: Example of Street Modifications and Possible Geocoding Effects

### Use GIS Software Which Best Fit Your Needs

The utilization of GIS technologies has rapidly increased, and can be seen in many diverse industries. Numerous sectors of society, both public and private, are using GIS and geocoding software programs. Some of these sectors include: police and fire departments (Liu, Huang, & Chandramouli, 2006; Ross, 1999; Woodby & Sherman, 2003), school administration and planning (“School District,” 2005), public works and transportation departments (Chang, Long, & Hewitt, 2004; Isaacs, 2004; Wagner, 1998), waste and recycling departments (“County,” 2000), the legal system (Jordan & Graves, 2000), insurance companies (Meckbach, 1999), the U.S. postal system (Gates 1997), retail chains (Hickey, 1999), and even the National Aeronautical Space Administration (NASA) (Hobish, 1999), just to name a few. With such an

amalgam of uses, GIS software programs have been implemented to achieve a variety of industrial and research goals.

To address this growing market, a wide range of GIS and geocoding software packages are readily available, varying in specialization, capabilities, and cost. The benefits of utilizing GIS software have been well documented (Bowers & Hirschfield, 1999; see also Karikari & Stillwell, 2005; Kiernan, 2005; Miranda et al., 2005; Sementelli, McDonald, & Gardner, 2002; Wu, Miller, & Hung, 2001). However, before any investment in GIS technologies should be undertaken, several computer programs should be explored. Given the goals of the user, the capabilities, potential benefits, and expected costs of various GIS programs should be analyzed and reviewed before implementation, to ensure that the GIS technologies which are ultimately adopted serve the purposes of the organization (Chan & Williamson, 1999). The same can be said for Criminological research. As demonstrated in this study, simply because a software program is more expensive does not necessarily mean it is better equipped to address the purposes of the research. Throughout the literature, different mapping schematics have been used based on the research question(s) of the study. For this project, point accuracy was needed so that the best estimations of the offender's home and the robbery location were obtained. However, other research designs have analyzed various geographic areas in which street-level point accuracy would have not been needed, such as: environmental zones, residential areas, ghetto zones, suburbs, postal codes, and neighborhoods (Hesseling, 1992; see also Bernasco & Luykx, 2003; Bernasco & Nieuwbeerta, 2005; Brown, 1982; Pettit, 1982, 1985; Rengert, 1981; Van Koppen & Jansen, 1998). As future spatial and geographic studies are conducted, an assortment of GIS products should be reviewed to ensure that the most appropriate software program is being used, at the least expense to the researcher.

## Limitations

To conduct this research, several assumptions had to be made at the onset of the study. First, it was assumed that criminal commutes begin at the offender's home. The methodology used in the current research can not verify the accuracy of this assumption. It is possible that the genesis of crime trips may be some other node or place, and the offender's home has little bearing on journey-to-crime characteristics. By assuming the offender resides at the address recorded in the arrest reports, and that this is the origin of the criminal commute, possible discrepancies may exist between the offender's actual criminal commute and how journey-to-crime was measured. A study conducted by Wiles and Costello (2000) addressed this very issue in journey-to-crime research. Through interviews with burglary offenders, they discovered that criminal mobility was overestimated using the offender's recorded address. Alternatively, by using the location of where the offender had slept the night before the offense rather than the documented home address in police data, the mean travel distances dropped, implying that the willingness to travel was less than that reflected in official data (Wiles & Costello, 2000). Additionally, in interviews with active armed robbers, Wright and Decker (1997) found that robbery offenders may travel frequently between living places, rarely settling at a fixed residential location. The true journey-to-crime for these nomadic criminals may not be reflected in official arrest reports, as the documented address for these types of offenders may be just one of many resting places.

The current study also assumes that criminals travel directly from their home to the target with the intention to commit a robbery. Prior research has produced ambiguous results when addressing criminal planning. While some research has demonstrated that offenders first decide

to commit a crime, then search for potential targets (Nee & Meenaghan, 2006), other research has shown that crime, including robbery, are functions of opportunity, in which the offender acts spontaneously to the current environment (Feeney, 1986; Wiles & Costello, 2000). Still, other offenders may have a specific target in mind prior to deciding to commit a crime (Wright & Decker, 1994). The level of criminal planning, or lack thereof, poses a problem for journey-to-crime research. If criminal offenses are not planned, in which the mobility displayed by the offender is not directly related to committing a crime, crime trips would be merely incidental to the other purpose(s) of travel. Hence, crime trip distances would not reflect the offender's willingness to travel to engage in criminal behavior, but rather the non-criminal routine activities of the offender. Conversely, it is possible that robbery offenders may conduct rigorous and expansive searches of his or her awareness space before offending. The actual robbery location would simply be the end result of this search. Under this scenario, journey-to-crime would be underestimated, as it was assumed that offenders commuted directly from their home to the robbery site, ignoring any search-related travel. In sum, the current study measured journey-to-crime as the straight-line, or as the crow-flies, distance from the offender's home to the robbery location. However, this may or may not represent the true criminal commute, or the travel associated with the explicit purpose to offend.

Relying on official arrest data may also skew mobility findings. As mentioned above, Wiles and Costello (2000) illustrated how official data may overestimate criminal mobility. However, it is possible that official data marginalizes criminal mobility. In Porter's (1996) study on inter-jurisdictional crime, he concludes that crossing police boundaries may both frustrate the police and reduce the probability of being apprehended. Therefore, official records may be inherently linked to localized crime events, in which the possibility of police apprehension is

greater. Under this hypothesis, arrest data may be biased towards short criminal commutes, as mobile offenders are less likely to be processed by the criminal justice system.

To determine the location of both the robbery occurrences and offender addresses, geocoding software was used. Despite the overall reliability between Centrus' web-based geocoder and ArcGIS 9.1, the accuracy of the results is difficult to estimate. The purpose of geocoding is to obtain latitudinal and longitudinal coordinates that accurately represent the ground truth or physical location of an address (Nuckols, Ward, & Jarup, 2004). However, several aspects of the geocoding process can compromise this accuracy, and ultimately the quality of the data. As articulated by Ratcliffe (2001), street databases may be out-of-date, or line segments may be oversimplified and not represent the true typology of the land. Other problems, such as inaccurate block sizes and misleading assumptions as to the physical construct of residential locations may also reduce the accuracy of the geocoder (Wu, Funk, Lurmann, & Winer, 2005). To overcome these deficiencies, prior researchers have utilized GIS programs in conjunction with global positioning systems (GPS) capabilities (Wu et al., 2005; Zhan et al., 2006). GPS technologies may produce more accurate results, but are also more costly to use and less efficient (Karimi et al., 2004). The primary benefit of using GPS devices is that they can serve as an accuracy check on the geocoder's results. Unlike geocoders, that must estimate the location of an address through interpolation, a GPS device can measure the same location more directly. Due to the lack of GPS technologies available, no such method was used in the current study, and therefore, the accuracy of the geocoded results was not tested

## CONCLUSION

The purpose of the current study was to examine the level of mobility among various robbery offenders. To achieve this purpose, a robbery typology consisting of five categories was constructed, mirroring Florida's state criminal statutes. By requesting data from the State Attorney's Offices, rather than from the more traditional urban police department, a relatively large and diverse sample of arrest data was collected. In total, data was obtained from seven counties in the State of Florida, ranging in levels of urbanization and the prevalence of robbery crimes. After the arrest data was collected, a web-based geocoder offered by Centrus was used to estimate the latitudinal and longitudinal coordinates of the offenders' residential addresses and robbery locations. In total, 832 crime trips were successfully geocoded and analyzed.

The distance traveled, defined as the straight-line distance from the offender's home to the robbery location, was examined for each of the five robbery types. The analysis showed that for each robbery type, a subgroup of arrestees exhibited high levels of mobility, defined as criminal commutes exceeding ten miles. Furthermore, the buffer zone around the offender's home, as described by Brantingham and Brantingham (1981), was not observed. Despite the overall similarity in the distribution of crime trip distances across the different types of robberies, some specific robbery-type mobility patterns did emerge. Hypothesis testing revealed three findings related to criminal mobility by robbery type, using the Kruskal-Wallis  $H$  test. First, statistically significant differences in crime trip distances were found among the five robbery types. Second, in a pairwise analysis, statistically significant mobility differences were restricted to commercial robberies, in which commercial robbery arrestees traveled further than their

counter parts. Third, significant differences were found between fixed and open space robbery targets. As expected, those arrested for open space robberies (carjacking, personal robbery, and robbery by sudden snatching) traveled less than those who victimized fixed targets (commercial and home-invasion robbery).

The demographic characteristics of the arrestees were also examined relative to journey-to-crime. Specifically, the variables of age, race, and gender were analyzed. In general, race and gender was found to be unrelated to criminal mobility. Although statistically significant differences were found between black and white, and male and female, carjackers, the other four robbery types displayed no significant mobility differences by race or gender. However, age does appear to be linked to criminal mobility. Based on the sample of 832 robbery trips, a Kruskal-Wallis  $H$  test revealed significant differences between the three age groups. Of the five robbery types, statistically significant mobility differences among the age groups were observed for commercial and carjacking robberies. Supporting prior research, young offenders generally showed the most limited mobility. But contrary to previous studies, the twenty to twenty-five year olds, rather than the oldest offenders, traveled the furthest.

The current study illustrates some of the modern dilemmas in criminological spatial analysis. While GIS technologies are becoming more integrated across academic fields and industry sectors, the processes behind geocoding software should be well understood before directing policy decisions. The integrity and accuracy of the spatial data should be analyzed and tested. Furthermore, geocoding results and analyses are only as good as the supporting street databases, and these databases should be updated frequently. Also, by reviewing the geocoded results, policies which are based on misgeocoded or inaccurate results can be avoided. As more

proprietary products are introduced, geocoding software programs should be explored for applicability, to ensure that the needs and goals of the user are met.

The current study found greater criminal mobility than has been reported in prior research. Namely, over twenty percent of crime trips were greater than ten miles. More research is needed to address the mobile robbery offender. While a collection of studies has offered theoretical insights into the general factors explaining journey-to-crime, more attention is needed towards those who travel. Specifically, more research is needed to better understand the relationships between mobile criminals and opportunity structures, rational-decision making processes, and target availability functions.



APPENDIX  
COMPARISON OF GEOCODERS

Table 32: Comparison of ArcGIS 9.1 and Centrus Data Points

Street Segment <sup>1</sup> Corresponding to the Centrus Data Point	Street Segment Corresponding to the ArcGIS 9.1 Data Point	Address	Geocoder Likely Accurate
2701-3006 SW 23 <sup>rd</sup> Street	14-3010 SW 23 <sup>rd</sup> Terrace	2930 SW 23 <sup>rd</sup> Terrace	ArcGIS 9.1
0000-0000 NE 39 <sup>th</sup> Boulevard	1301-1599 NW 39 <sup>th</sup> Avenue	1320 NE 39 <sup>th</sup> Avenue	Centrus
1500-1899 SE 4 <sup>th</sup> Street	1500-1599 NW 4 <sup>th</sup> Street	1516 SE 4 <sup>th</sup> Street	Centrus
6323-10636 SE 96 <sup>th</sup> Terrace	1270-13319 SE 9 <sup>th</sup> Place	10630 SE 96 <sup>th</sup> Terrace	Centrus
5100-5299 NW 43 <sup>rd</sup> Street	5200-5299 NW 4 <sup>th</sup> Place	5200 NW 43 <sup>rd</sup> Street	Centrus
0000-0000 SW 55 <sup>th</sup> Terrace	800-817 SW 5 <sup>th</sup> Terrace	816 SW 55 <sup>th</sup> Terrace	Centrus
0000-0000 SE 8 <sup>th</sup> Avenue	1700-1799 NW 8 <sup>th</sup> Avenue	1721 SE 8 <sup>th</sup> Avenue	Centrus
3901-3999 SW 20 <sup>th</sup> Avenue	3814-3999 SE 20 <sup>th</sup> Avenue	3930 SW 20 <sup>th</sup> Avenue	Centrus
2112-4099 SW 23 <sup>rd</sup> Street	3661-4098 NW 23 <sup>rd</sup> Avenue	4000 SW 23 <sup>rd</sup> Street	Centrus
0000-0000 SW 42 <sup>nd</sup> Street <sup>2</sup>	3426-3699 NW 42 <sup>nd</sup> Terrace	3500 SW 42 <sup>nd</sup> Street	Centrus
0000-5865 NW 23 <sup>rd</sup> Terrace <sup>3</sup>	5700-5753 NW 23 <sup>rd</sup> Avenue	5700 NW 23 <sup>rd</sup> Terrace	Centrus
0000-0000 SW 39 <sup>th</sup> Boulevard <sup>4</sup>	3400-4399 NE 39 <sup>th</sup> Boulevard	3415 SW 39 <sup>th</sup> Boulevard	Centrus
486-599 50 <sup>th</sup> Boulevard	500-599 NE 5 <sup>th</sup> Street	501 SE 50 <sup>th</sup> Street	Centrus
2646-2699 E University Avenue	2600-2699 W University Avenue	2626 NE University Avenue	Centrus

Street Segment <sup>1</sup> Corresponding to the Centrus Data Point	Street Segment Corresponding to the ArcGIS 9.1 Data Point	Address	Geocoder Likely Accurate
2200-2299 SE 36 <sup>th</sup> Street	2072-2299 NW 36 <sup>th</sup> Terrace	2201 SE 36 <sup>th</sup> Terrace	Centrus
2601-3308 SW 33 <sup>rd</sup> Place	300-3699 SW 3 <sup>rd</sup> Place	2620 SW 33 <sup>rd</sup> Place	Centrus
6312-6687 SW 13 <sup>th</sup> Street	6300-6499 NW 13 <sup>th</sup> Street	6315 SW 13 <sup>th</sup> Street	Centrus
123-10486 NE 131 <sup>st</sup> Place	0000-12657 131 <sup>st</sup> Place	10291 NE 131 <sup>st</sup> Place	Centrus
0000-3999 SW 20 <sup>th</sup> Avenue	3814-3999 SE 20 <sup>th</sup> Avenue	3900 SW 20 <sup>th</sup> Avenue	Centrus
123-10486 NE 131 <sup>st</sup> Place	0000-12657 131 <sup>st</sup> Place	10291 NE 131 <sup>st</sup> Place	Centrus
000-498 NW 6 <sup>th</sup> Street	222-499 NW 46 <sup>th</sup> Street	401 NW 6 <sup>th</sup> Street	Centrus
1900-2099 SE 4 <sup>th</sup> Street	1900-1938 NW 4 <sup>th</sup> Street	1900 SE 4 <sup>th</sup> Street	Centrus
0000-0000 SW 27 <sup>th</sup> Street	3622-3951 SE 27 <sup>th</sup> Street	3700 SW 27 <sup>th</sup> Street	Centrus
Near 900-999 SE 43 <sup>rd</sup> Street	823-1049 NW 41 <sup>st</sup> Drive	975 SE 41 <sup>st</sup> Drive	Ambiguous
2646-2699 E University Avenue	2600-2699 W University Avenue	2626 E University Avenue	Centrus
0000-0000 W Newberry Road	1766-18199 Newberry Road	6200 Newberry Road	ArcGIS 9.1
1301-1499 SE 1 <sup>st</sup> Street	1200-1398 NE 1 <sup>st</sup> Street	1308 SE 1 <sup>st</sup> Street	Centrus
0000-0000 W Newberry Road	1766-18199 Newberry Road	6910 W Newberry Road	Centrus
0000-3999 SW 20 <sup>th</sup> Avenue	3814-3999 SE 20 <sup>th</sup> Avenue	3900 SW 20 <sup>th</sup> Avenue	Centrus

Street Segment <sup>1</sup> Corresponding to the Centrus Data Point	Street Segment Corresponding to the ArcGIS 9.1 Data Point	Address	Geocoder Likely Accurate
17100-18009 SW 30 <sup>th</sup> Avenue	4500-46519 NW 30 <sup>th</sup> Avenue	18511 SW 30 <sup>th</sup> Avenue	Centrus
2400-2499 1 <sup>st</sup> Street	2823-2899 W 1 <sup>st</sup> Street	2851 E 1 <sup>st</sup> Street	Centrus
0000-0000 N Orange Blossom Trl.	5200-5284 S Orange Blossom Trl.	5242 N Orange Blossom Trl	Centrus
0000-7299 W University Avenue	7200-7307 E University Avenue	7300 W University Avenue	Centrus
486-599 50 <sup>th</sup> Boulevard <sup>4</sup>	500-599 NE 5 <sup>th</sup> Street	501 SE 50 <sup>th</sup> Street	Centrus
4105-4499 E 25 <sup>th</sup> Street, Sanford	3700-4299 E STHY 46, Geneva	4140 E STHY 46, Sanford	Centrus

<sup>1</sup> Occasionally, the From node and To node are unknown due to the shortcomings of the ArcGIS 9.1 street map

<sup>2</sup> Represents five data points, i.e. five robbery trips ended at 3500 SW 42<sup>nd</sup> Street

<sup>3</sup> Represents four data points

<sup>4</sup> Represents two data points

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