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Abstract

The role of criminal, social interactions occupies a central place in criminology, yet minimal research exists on the relationship between co-offender networks and dimensions of offending. Drawing on the social network literature, this investigation hypothesizes that a link exists between the level of redundancy (i.e., the extent of overlap) in an individual's co-offender network and offending versatility. Relying on longitudinal data for a random sample of delinquents from Philadelphia, this study begins by constructing egocentric co-offending networks for the respondents. Then, using Tobit regression models, it finds that higher levels of co-offender network redundancy (more dense networks) are related to higher levels of specialized offending in group crimes, but no such relationship exists with overall (i.e., solo and group) offending specialization. The discussion considers the implications of these findings and offers suggestions for future research.

Keywords

life-course, network, co-offending, specialization

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The study of how social connections and processes relate to crime occupies a central place in criminology. The pioneering work of Shaw and McKay (1931; see also Shaw, 1931), which influenced social process-oriented theorists such as Sutherland (1947) and Akers (1998), described how one of their key subjects, Sidney, appeared to be learning from his accomplices through a system of social interactions. Sidney exhibited a changing mix of offense types and seriousness that mirrored the characteristics of the social group with whom he was associating at that time. More recently, criminologists have turned their attention to criminal networks when studying the onset, maintenance, and desistence of criminal behavior (e.g., Haynie 2001; Krohn, Massey and Zielinski 1988; Mullins and Wright 2003). This work has demonstrated that the pattern of ties in the peer network, as well as the strength or quality of these ties, conditions the effect of delinquent peers on offending behavior (Agnew 1991; Haynie 2001).

Although most criminologists view group crime as a "fact" of juvenile delinquency, the nature, structure, and processes of co-offending over the life course remain underexplored (McGloin et al. 2008). This is unfortunate because co-offending networks represent a unique deviant group, based on shared offending behavior rather than nominated friendships. Examining the relationship between co-offending network structure and offending behavior has the potential to illuminate whether co-offending is simply a characteristic of a criminal event or whether it has a meaningful connection with dimensions of the criminal career.

The current investigation adopts an individual-level focus of co-offending networks, providing a distinctly different view of delinquents' deviant network structure. In an attempt to extend the current network focus in criminology, it appeals to a well-known network characteristic in economic sociology: network redundancy. Using the basic presumption that redundant networks are less beneficial because they provide access to overlapping skills, knowledge, and opportunities, we propose that juveniles with redundant co-offending networks will demonstrate greater offending specialization.

Co-Offending and Network Redundancy

Co-offending research typically includes aggregate analyses that speak to general trends within a sample or a broader population (e.g., McGloin 2005; Reiss 1986, 1988; Sarnecki 2001; Stolzenberg and D'Alessio 2008). These investigations have contributed to our knowledge, but they leave a

void regarding individual-level co-offending patterns and their potential relationship with dimensions of the criminal career. For instance, previous research has shown that offending groups get smaller as offenders age and that the typical offending group is active for only one event (Reiss 1988; Warr 2002). Such general statements may overlook individual-level relationships of interest, such as how co-offenders affect offending decisions, the availability of unconventional opportunities, and the expression of criminal behavior.

Drawing on data from 50 street offenders, Hochstetler (2001) argued that it is a critical oversight to ignore the role of the group when studying criminal decision-making processes, given the salient influence co-offenders exert on negotiating and constructing criminal opportunities. Moreover, Conway and McCord (2002) found that nonviolent offenders who co-offended with violent accomplices were likely to "switch" to violence as a consequence of this interaction. Such findings indicate that scholars should look past general features of co-offending to examine how co-offending structure may relate to dimensions of the criminal career.

Network Redundancy

Recent criminological research recognizes the role social networks play in structuring crime patterns at both the community and individual levels (e.g., Hagan 1993; Krohn et al. 1988). For example, Haynie's (2001) work applied social network measures such as centrality and popularity to differential association and social control theories, demonstrating that network structure conditions the effect of delinquent peers. Furthermore, Baker and Faulkner (2006) recently appealed to diffusion in social networks in their study of fraud among investors.

"Network redundancy," or the overlap among contacts in one's social network, is a key network characteristic in economic sociology. A person whose connections are all linked to each other has high redundancy because connections provide access to the same information, knowledge, and opportunities; a person who has a number of "unique" connections (i.e., his or her contacts are not connected to each other) has a nonredundant network. According to network scholars and empirical research (e.g., Burt 1992), individuals with nonredundant networks have entrepreneurial/occupational benefits, largely because they have access to diverse knowledge, opportunities, and skills (see also Jenssen and Greve 2002).

This concept stems from Granovetter's (1973) argument about the strength of weak ties and was clarified by Burt's (1992:18) description of

structural holes (i.e., "the separation between non-redundant contacts"). First, whereas most researchers focused on strong/intimate relationships, Granovetter considered the potential importance of weak associations, in which people typically invest less resources. He asserted that weak ties are important because "individuals with few weak ties will be deprived of information from distant parts of the social system and will be confined to the provincial news and views of their close friends" (Granovetter 1982:106). Burt refined this notion by suggesting that individuals who bridge structural holes are more likely to succeed in economic or occupational competition because they are exposed to more skills, knowledge, and opportunities.[1]

Redundant networks have few structural holes, thereby constraining an individual's exposure to information and opportunities. In contrast, individuals in nonredundant networks have greater returns for social investments because they are exposed to a larger diversity of skills, knowledge, and opportunities (see also Davern and Hachen 2006; Lin 1982, 1990; Podolny and Baron 1997). Surowiecki (2004) suggested that nonredundant groups can assist decision-making processes because they provide varied perspectives and balance out destructive processes of group decision making. Homogeneous groups run the risk of "group think" (Janus 1972), where members fail to consider alternative decisions and behavior: "Homogenous groups become cohesive more easily than diverse groups, and as they become more cohesive they also become more dependent on the group, more insulated from outside opinions" (Surowiecki 2004:36-37; see also Jenssen and Greve 2002).

Morselli and Tremblay (2004) recently brought attention to the concept of criminal network redundancy. In a manner consistent with the supposed benefit of nonredundant social networks, they found that offenders with less redundant criminal networks had higher criminal earnings than did their counterparts in more redundant criminal networks. In this way, they illustrated that social structure was relevant to illegitimate occupational "success" just as it was to legitimate economic success. Although this investigation demonstrated that network redundancy may translate to criminological questions of interest, it was still limited in two important respects. First, the data on criminal networks were self-reported by the offenders. This is a favored way to identify friends or connections, but this means that the connections among the associates were based on the perception of the subject. That is, if two associates were linked but the subject was unaware of this, there would be no tie between the associates in the network. Relying on official co-offending information links

individuals based on shared behavior, not on perceptions of the subject, and therefore is an important extension. Second, Morselli and Tremblay's dependent variable was more consistent with economic inquiries than with traditional criminological interests, leaving the question of how influential network redundancy is for other dimensions of the criminal career unanswered. Therefore, expanding the outcome of interest is also a necessary next step.

Again, the basic premise underlying the supposed benefit of nonredundant social networks is that they provide access to varied skills, expertise, and opportunities (Burt 1992; Granovetter 1973; Lin 2001). This means that individuals with nonredundant co-offending networks arguably have access to an array of criminal norms, skills and knowledge, models of behavior, and opportunities, which may translate into a versatile offending profile. In contrast, an offender with a redundant network will have relatively constrained exposure, structuring a more specialized offending profile. In this way, co-offending networks become more than a simple descriptor of a criminal event and instead are seen as an important part of an individual's offending repertoire.

Empirical research provides some indirect support for this hypothesis. First, McAndrew (2000) has noted that co-offending connections "can lead to sharing new methods of committing crime, identification of potential targets, information about police activities and opportunities to be part of specific criminal enterprises" (p. 53). Therefore, individuals with nonredundant co-offending connections may benefit from more effective and varied "sharing." Next, Warr (1996) found that offenders rarely committed different offense types with the same co-offending group. Rather, offending groups were relatively specialized, and diverse offenders typically rotated through a number of these groups, thereby having nonredundant offending networks. Individuals who offended with the same people (i.e., had redundant offending networks) instead were likely to be relatively more specialized.

Shaw and McKay's (1931; Shaw, 1931) research on Sidney provides a useful case study of this notion. Sidney's offending behavior systematically corresponded with his current deviant group affiliation, culminating in a diverse offending profile as well as membership in various, distinct offending groups. Therefore, Sidney developed a nonredundant offending network over time, which was reflected in his versatile offending profile. Furthermore, McGloin et al. (2007) recently found that shifts in local life circumstances were related to within-individual changes in offending specialization/versatility. The results showed that experiencing marriage

and community supervision were related to increased offending specialization, whereas periods of drug and alcohol use were related to increased diversity. McGloin et al. suggested that marriage and supervision constrain one's social network (i.e., potentially increasing its redundancy), subsequently reducing the available types of criminal opportunities and increasing specialization. In contrast, offenders who use drugs and alcohol may consequently expand their social networks, resulting in increased criminal opportunities and supporting more diverse criminal offending.

Collectively, the above studies lend credence to the hypothesis of a positive relationship between co-offending network redundancy and offending specialization. This linkage takes on added importance given the pervasive nature of group offending during adolescence. Although most adult offenders commit crimes alone, group offending is modal in youth (Hood and Sparks 1970; Reiss 1988). If group crime is more than a "fact" of juvenile delinquency and co-offending network structure has the capacity to shape generalized antisocial behavior, this carries important implications for the remainder of juveniles' criminal careers. A delinquent who engages in diverse deviance is arguably developing/demonstrating a generalized proclivity for offending, which is more risky for later maladaptive outcomes than is a tendency to specialize in one form of deviance. Indeed, research shows that youth who engage in diverse antisocial behavior early in the life course are at greater risk for later serious, persistent, and aggressive antisocial behavior (Loeber 1988; Loeber and Schmaling 1985).

Although the previous arguments view network redundancy as criminogenically important, they do not assume that offenders purposively seek out varied accomplices or consciously construct a nonredundant network. Such a standpoint would be inconsistent with the limited research that exists on co-offending. For example, in his study of youthful offenders in Stockholm, Pettersson (2003) stated that "it seems likely that choices of co-offender are more affected by whom youths come into contact with in the course of their daily lives than by a conscious search for persons" (p. 156). Moreover, the idea of nonredundant networks influencing behavior is not contingent upon agency—one need not actively cultivate the exposure to varied information and opportunities to be influenced by it.

Data and Methods

The data used here come from a random sample of juvenile offenders selected from the population of official arrest records for individuals

younger than age 18 ($N = 60,821$) during 1987 in Philadelphia (Conway and McCord 2002). Prior to sampling, all crimes were divided into offenses committed by single offenders and by a group, and 200 subjects were drawn from each list. Complete juvenile offending histories (from ages 10-17) were gathered for all subjects by reviewing Philadelphia court records from January 1976 through December 1994. Of the original sample, 218 individuals (approximately 54%) committed at least two co-offenses during their juvenile criminal career. This subsample serves as the main data set for the current investigation (97% male, 76% Black, 9% Hispanic, and 15% White).[2] For these subjects, the data also track the criminal histories of the co-offending accomplices during the same time period (1976-1994). In doing so, the data indicate whether these accomplices co-offended with anyone else in the original sample or in the larger pool of identified accomplices during this time period.

Because the data provide the accomplices with unique identifiers and track their offending history, they afford the opportunity to construct egocentric co-offending networks for the subjects. Egocentric networks, also called personal networks, are somewhat different from traditional social networks (Wasserman and Faust 1994). Social networks typically refer to the linkages within a population of interest. In egocentric networks, a single actor is the focus and the network delineates to whom he or she is connected, as well as specifies the connections among these associates. Thus, egocentric networks are more consistent with the individual-level focus of the criminal career framework; they are also the traditional level of analysis for inquiries into network redundancy and its connection to individual characteristics and behavior (Jenssen and Greve 2002; Kalish and Robins 2005). In the current case, shared co-offending incidents define the social linkages within the personal networks. It is important to note that the subject's accomplices (i.e., co-offenders) can be connected to each other via a common criminal event with the ego or via a group offense without the ego (e.g., John and Chris independently commit a crime with the subject and subsequently commit a crime together in the absence of the subject). Table 1 provides descriptive information for the sample.

Analytic Plan

We construct personal co-offending networks for the 218 subjects of focus. The links in the egocentric networks are based on co-offending

Table 1. Descriptive Information for the Sample of Subjects Who Commit at Least Two Co-Offenses ($N = 218$)

Variable	Mean	Standard Deviation	Minimum	Maximum
White	.15	—	0	1
Hispanic	.09	—	0	1
Black	.76	—	0	1
Gender (male = 1)	.97	—	0	1
Number of co-offenses	4.19	2.66	2	18
Number of arrests	6.45	4.05	2	24
Density	.52	.19	.10	1
Number of unique co-offenders	7.45	5.85	1	43
Group offending diversity index	.29	.22	0	.67
Overall offending diversity index	.35	.21	0	.67

events, and the networks have a radius of 1; they capture to whom the subject is connected and whether these accomplices are connected to each other.[3] An adjacency matrix for each subject served as the base for graphs and descriptive measures of the network. In this matrix, both the columns and rows are defined by the actors in the network. The actors are determined by reviewing every subject's co-offending history and listing the individuals with whom he or she co-offended. Therefore, the size of the matrix varies across subjects according to the number of people with whom they offended. The cells in the matrix had a value of 0 (no co-offending event in common) or 1 (the two individuals have a co-offense in common). Logically, all of the cells affiliated with the subject (ego) had a value of 1.[4]

Previous work has also constructed egocentric criminal networks. Morselli and Tremblay (2004) surveyed adult offenders and asked subjects about (a) their criminal associates and (b) whether these associates knew each other, which allowed the construction of personal networks with a radius of 1. Because the networks herein are built from collective offending over time rather than a single inquiry, their construction is somewhat more complicated. Figure 1 illustrates the manner whereby a personal network captures a series of co-offending incidents. The top part of the figure illustrates the delinquent events that make up the subject's

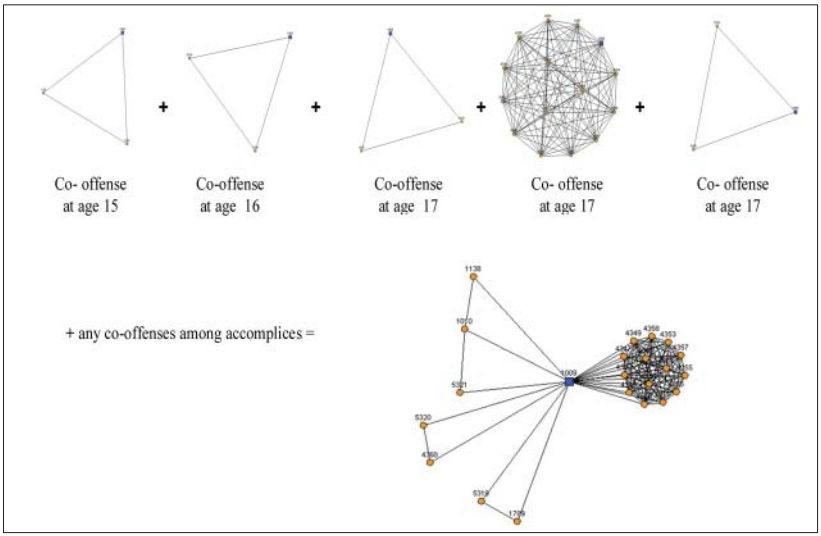

Figure 1. Building an egocentric co-offending network for the juvenile criminal career (the subject is the square and the accomplices are circles)

juvenile co-offending history. At age 15, this subject committed a crime with two co-offenders, and at age 16, he committed another crime with two other co-offenders. The subject then engaged in three delinquent acts with others when he was 17. The first was with two co-offenders, one of whom was also an accomplice in the first co-offense. The next delinquent act occurred with a large group of 14 accomplices, whereas another occurred with 2 accomplices. These events, along with any co-offending linkages among the accomplices not captured in the subject's criminal history, cumulate to the subject's juvenile egocentric co-offending network. The final graph in Figure 1 also captures the fact that an accomplice for the co-offense at age 15 was also an accomplice for the co-offense at age 17. After constructing and reviewing the egocentric networks for the subjects, the analysis turns to the potential relationship between network redundancy and offending versatility.

This second stage of analysis relies on two regression models to determine whether co-offending structure is related to offending specialization/versatility. One model investigates whether more redundant egocentric co-offending networks predict co-offending specialization, and the other investigates whether network structure is related to overall offending

specialization (i.e., both solo and co-offenses). Distinguishing between specialized co-offending and specialized offending is important because of its lack of attention in the extant literature on redundant networks (in criminology) and also because, just like the research on the correlates of criminal career dimensions, the factors that relate to one form of (co-)offending may be different from the factors that relate to others (Blumstein et al. 1986; Osgood et al. 1989). These models are simple, which coincides with the exploratory nature of the analysis. Specifically, there is only one control variable: the number of unique co-offenders. Accounting for this measure will shed insight on whether it is the pattern of linkages in the network that is important (i.e., redundancy) or the network size.[5]

Measures

Dependent Variable

Specialized co-offending/offending. We construct two measures—one for specialized group offending and one for specialized offending overall. Both measures are diversity indices, a measure increasingly used in specialization research (Mazerolle et al. 2000; McGloin et al. 2007; Sullivan et al. 2006). The diversity index is an individualized measure and does not require similar offenses to be sequential to capture specialization, as does the forward specialization coefficient (Osgood and Schreck 2007). It is based on the following formula, in which p equals the proportion of offenses in crime category m (Agresti and Agresti 1978):

$$D = 1 - \sum_{m=1}^{M} p_m^2$$

Under this formula, values range from 0, which indicates a complete lack of diversity (i.e., complete specialization), to a maximum that is defined by $k - 1/k$, in which k represents the number of offense categories. In the current case, there are three offense categories: violence (e.g., robbery, assault), property (e.g., larceny, auto theft), and drug (e.g., drug-related crimes, driving while intoxicated [DWI]). Accordingly, the maximum score possible is .667, which indicates complete diversity. For this analysis, every subject has a diversity index score that captures the (a) diversity of his or her co-offending and (b) the diversity of his or her overall juvenile offending (i.e., both solo and group offending). Among the 218 subjects, the average diversity index is .29 for co-offending and .35 for overall offending.[6]

Independent Variables

Network density. Burt (1992) states that "cohesion is an empirical indicator of redundancy. Contacts strongly connected to each other are likely to have similar information and so provide redundant benefit to the player" (p. 47). Density is a traditional measure of network cohesion and therefore also measures the extent of network redundancy. A density score captures the proportion of present links compared to the number of possible links among the actors in the network (Wasserman and Faust 1994). Density values range from 0 to 1, with 0 meaning no density (i.e., there are no links among the actors) and 1 meaning complete density (all actors are directly connected to each other). Higher density values indicate more redundancy, whereas values closer to 0 reflect nonredundant networks. Within the sample, the average density for the egocentric co-offending networks was .52 ($SD = .19$).[7]

Although the density score and the co-offending diversity index are both derived from the subjects' co-offending history, they are conceptually and mathematically distinct. Density scores come from the pattern of linkages, whereas the diversity index comes from the link "type" (i.e., the type of crime). For example, how many people are involved in a group crime, whether the person offends with the same accomplice(s) more than once, and whether the accomplices are linked to each other all influence the density score but have no impact on the co-offending diversity index. Moreover, the offending history of accomplices has no impact on the subjects' diversity indices, yet it does affect the density scores (i.e., accomplices who offended together will result in a higher density score for the subject).[8]

Number of unique co-offenders. Some scholars may assert that simply being exposed to larger numbers of offenders carries the same benefit as a nonredundant network. To address this, we include a measure that captures the number of *unique* co-offenders (i.e., it does not overcount accomplices who are "reused"). This ensures that any emergent relationship between density and offending versatility is not due to the former variable serving as a proxy for network size. Among subjects who co-offend at least twice, the average number of unique co-offenders is 7.45 ($SD = 5.85$).

The premise of nonredundant networks focuses attention on the pattern of links/connections in the network, not the size of the network. From this view, a greater number of unique co-offenders could, on occasion, actually predict lower offending versatility (i.e., a greater tendency for specialization). If a subject co-offended with the same six accomplices three times, for example, then he or she would have a completely

redundant network (i.e., a density of 1). As Burt (1992) would argue, because all six alters are linked to each other, five of these accomplices are essentially wasted connections because being connected to one of them provides the same "benefit" as being connected to all of them. Conversely, a person who offends with a different person three times (i.e., three separate dyads) has a nonredundant network, although obviously fewer unique co-offenders in his or her network. In this way, viewing the relationship between density and offending versatility, while holding the number of unique co-offenders constant, provides a more conservative assessment of the current research question.

Results

Egocentric Network Graphs

To our knowledge, this is the first investigation to construct egocentric co-offending networks for the entire juvenile career. Therefore, we first describe the variety of social structures that emerged (see Figure 2). After all, "when shown in graph forms data are displayed without assumption" (Maltz, 1998:400). First, the networks for five subjects were dyads—these subjects committed their co-offenses with the same accomplice for every event. Next, the networks for two subjects were closed triads and for another two were closed quads. Thus, these subjects must have either "reused" the co-offenders and/or the individuals with whom they co-offended are all linked to each other.

Next, 25 subjects had networks that were open triads. As Figure 2 illustrates, these individuals co-offended with one accomplice for each event, and these two accomplices (who may or may not have been reused) have no social connection to each other. Thus, regardless of how often these subjects co-offended, they all have a density score of .667 (two out of a possible three links are present). Next, 8 subjects illustrate "star" networks (see Wasserman and Faust 1994). In these data, this network "type" reflects subjects who co-offend in a series of dyads over their juvenile criminal career, but these accomplices did not co-offend with each other. If not for the subject, the accomplices would have no social connection to each other. Because these individuals have a range of offending frequency and extent to which they "reuse" offenders, their density scores vary, but they are all very low, reflecting nonredundant networks. The next 34 subjects have a network type that we have termed a "kite." These networks reflect a dyad in combination with a larger group

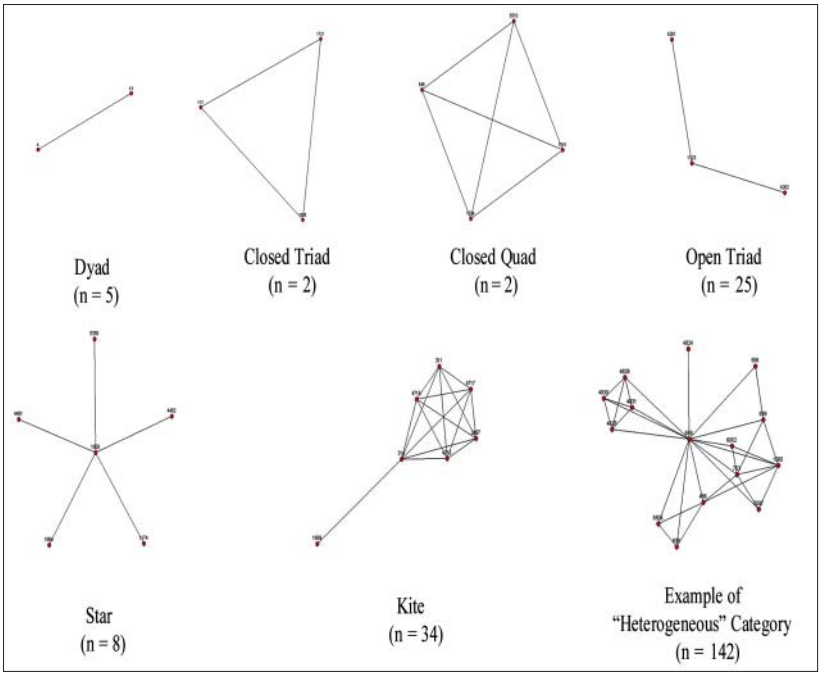

Figure 2. "Types" of egocentric co-offending networks for the juvenile criminal careers of the 318 subjects who co-offend at least twice

of accomplices, indicating subjects who have no clear affinity for the size of the group with which they offend. Finally, the majority of subjects (n = 142) belong to a category that we labeled "heterogeneous." Simply, the level of variation in this type prevented further parsing or categorizing based on visual inspection. For these last two categories, the density scores range from .10 to .81, given the variation in network structures.

Regression Analyses

Table 2 illustrates the basic bivariate relationships among the two diversity indices, density and the unique number of co-offenders. Density has a correlation of –.159 with the group offending diversity index and a correlation of –.083 with the overall offending diversity index. Although this suggests a stronger relationship with group offending, these relationships are considered without controlling for the number of co-offenders.

Table 2. Correlations among the Diversity Indices and Network Measures

Variable	1	2	3	4
1. Density	—			
2. Number of unique co-offenders	–.499	—		
3. Group offending diversity index	–.159	.085	—	
4. Overall offending diversity index	–.083	.043	.796	—

Because the outcomes are censored, we rely on Tobit regression for our multivariate analyses (Greene 1997; Tobin 1958).[9] Tobit regression models provide coefficient estimates for the unobserved, latent y^*, which is assumed to be normally distributed. Model 1 in Table 3 determines whether network density predicts group offending specialization, net of the number of unique co-offenders. Density is a significant predictor of specialized co-offending in the hypothesized direction—as networks become more dense (i.e., more redundant), the diversity index *decreases*, indicating higher levels of specialized co-offending. Model 2 illustrates that, unlike group offending, network density does not predict the diversity index for overall offending, net of the number of unique co-offenders. Approximately 63% of the variation in these two outcomes is shared ($r = .79$), yet the key independent variable does not necessarily predict related outcomes in similar ways. This underscores the decision to treat these two outcomes as distinct under a criminal career framework.[10] Importantly, these findings endure even when controlling for the frequency of offending and onset age (see appendix).

Discussion

In recent years, research in criminology has acknowledged (again) the importance of social organization in understanding crime and criminal behavior (Haynie 2001; Waring and Weisburd 2001). Even so, voids exist with regard to the types of social networks that may or may not relate to deviance, the precise attributes of these networks that "matter," and the spectrum of criminal career characteristics related to one's network. This article sought to address these gaps by investigating co-offending networks among a sample of juvenile offenders in Philadelphia. Although the data are limited in some respects, to our knowledge, they form the basis of the only existing longitudinal study that permits an exploratory examination of egocentric co-offending networks. In particular,

Table 3. Tobit Regression Models Predicting Diversity Index for Group Offending and Overall Offending ($N = 218$)

	Model 1: Group Offending Diversity Index	Model 2: Overall Offending Diversity Index
Variable	Est. (*SE*)	Est. (*SE*)
Density	−.280* (.110)	−.101 (.083)
Number of unique co-offenders	.002 (.003)	.006 (.003)
Constant	.318 (.075)	.311 (.058)
Log likelihood	−77.644	−22.723
Pseudo-R^2	.063	.050

*$p < .05$.

we examined a criminological extension of the literature on the impact of nonredundant networks—namely, whether individuals with nonredundant co-offending networks also had more diverse offending profiles.

The minimal research that has investigated graphical patterns in co-offending network structure instead has tended to use a population-based or aggregate approach (Sarnecki 2001; see also McGloin 2005). Accordingly, we thought it was important first to carefully describe the individual-level, co-offending structures, which served as a complement to population-focused work. These structures were also unique because they were based on objectively measured behavior, rather than self-reports of friendship links. Although our knowledge about deviant network structure certainly is growing, criminologists have not paid enough attention to the actual joint participation in activities among deviant associates (Krohn et al. 1988). Some subjects had similar, if not identical, co-offending network structures, but the majority of individuals had webs of relations that were too complex to visually categorize. At a minimum, this suggests that co-offending does not take on the same shape for all offenders—it can be quite varied. With variation comes the potential for uncovering patterns that may shed insight into offending. This study specifically determined whether variations in network redundancy were related to offending versatility.

Findings point to two main conclusions. First, there is a relationship between the level of redundancy in a delinquent's co-offending network and offending versatility. Consistent with predictions, offenders whose

co-offending networks were less redundant also tended to engage in a variety of crime types when offending with others. In contrast, juveniles who had more redundant co-offending networks were more likely to engage in the same kind of offense type when committing group crimes. Moreover, this relationship emerged when controlling for the number of accomplices to whom the subject was exposed. Thus, it is not the *size* of the criminal network that matters for offending versatility but rather the *pattern* of linkages within this network.

According to the social network literature, nonredundant networks provide access to varied information, skills, and opportunities, providing individuals with broader social options and experiences (Burt 1992; Lin 1982, 1990). In this way, subjects who co-offend with the same people or with people who are part of the same offending circles potentially have relatively constrained exposure to criminal skill sets and opportunities. In contrast, individuals who co-offend with an array of people who are not part of each other's immediate co-offending circles are potentially exposed to a diverse range of skill sets, knowledge, and opportunities. Thus, co-offending is not simply a characteristic of the criminal act; even if group offending reflects spontaneous gatherings at offender convergence spaces (see Felson 2003) rather than some instrumental or purposive decisions, the connections forged during criminal acts can shed insight on dimensions of the criminal career. This view coincides nicely with the extant literature. Mullins and Wright (2003) found that the deviant social relations of residential burglars provided access to particular offending opportunities and Hochstetler (2001) found that interactions among street offenders were vital to constructing criminal opportunities and collective behavior.

Still, the data did not allow a fine-grained investigation of the precise mechanism whereby nonredundant networks influence versatility. Ideally, this should prompt future research in this area with a focus on socialization and opportunity structures. This is especially important because work on economic sociology, the area in which the network redundancy concept emerged, has become less sure about the precise reason why nonredundant networks serve as a benefit. For example, Davern and Hachen (2006) recently found that, although nonredundant networks were related to better job mobility among television station managers, none of the following emerged as mediators: the amount of information gathered from contacts, the number of job offers made via such contacts, or the prestige of social resources offered by these contacts. Therefore, data rich in details about the potential mechanisms whereby nonredundant co-offender links

specifically influence offending would be greatly welcome. For instance, in-depth data about the unconventional values, behaviors, and routines of the accomplices could provide insight on whether nonredundant networks provide access to more diverse information, thereby promoting versatile group offending. Although it may be rare, it would also be of interest to examine whether a nonredundant network composed of similar "specialists" (e.g., all accomplices specialized in burglary) still promotes versatile offending.

This investigation was unable to specify the precise direction of this relationship. Both the egocentric co-offending network and the juvenile offending profile were "constructed" over the same eight-year period and are, therefore, like much other cross-sectional research on criminal networks and offending (Haynie 2001; Morselli and Tremblay 2004; Sarnecki 2001). In all likelihood, however, this is not a simple, unidirectional pathway; instead, the relationship between network redundancy and offending versatility is likely reciprocal in nature. As juveniles interact and commit delinquent acts with accomplices from different co-offending circles, they are likely to commit a diverse set of group offenses. Because of this diversity, they may, in turn, expand their social connections or visibility, thereby increasing the likelihood of forming more nonredundant connections. This cycle can easily repeat as the network and offending activity interact and mutually influence each other over time. This is ultimately an empirical question, one that would also benefit from in-depth data on offending histories.

The second main conclusion is that group offending may be a more distinct form of criminal activity than traditionally conceived. Podolny and Baron (1997) have argued that "the standard practice of aggregating disparate kinds of ties when relating network structure to . . . outcomes seems ill-conceived" (p. 689). By heeding this advice and looking at a specific criminal network rather than aggregating across types (i.e., deviant peers and co-offenders), this investigation has uncovered a specific relationship that otherwise may have gone unnoticed. Some scholars have suggested that offenders have varying proclivities for solo and co-offending (Moffitt 1993; Warr 1996). The results here, however, hint that, *within individuals*, predictors of delinquency may vary according to whether such acts are committed alone or in a group.

Although the criminal career perspective has prompted researchers to attend to various offending dimensions, relatively little discussion exists about potential distinctions between group and general (i.e., solo) offending (Piquero, Farrington, and Blumstein 2003). This is interesting because

early criminological research differentiated between collective and solo offending, considering them as reflective of different etiologies and posing different problems for local communities (Cloward and Ohlin 1960). By distinguishing between group and overall offending, this analysis uncovered distinctions that may be informative. Perhaps, for instance, the varied information and opportunities offered by a nonredundant co-offending network are specific to group action. In contrast, whether one evinces specialization across the complete offending profile may be influenced by the larger peer network. Even further, some scholars argue that the immediate situational context helps to shape offending behavior (Cornish and Clarke 1986; Wikstrom, 2006)—because accomplices are present in group offenses but not in solo offending, their impact may be constrained to collective behavior.

We view this investigation as a contribution to the growing literature on social networks in criminology, as well as the underdeveloped research on co-offending more broadly. Even so, it does have data limitations. As mentioned, the data do not contain information on the precise mechanisms whereby co-offending network characteristics are related to offending versatility. Second, the data only captured the juvenile criminal career. Group offending is most frequent during adolescence, which both supports this focus and suggests some caution. This is a logical phase of the criminal career to begin an investigation of co-offending network structure because group offending tends to decrease substantially with age (Piquero, Farrington, and Blumstein 2007), but the fact that peers are most influential during adolescence may indicate that the influence of these networks degrades over time, even among offenders who persist in group crime. And although deviant peer groups retain their role as a salient risk factor over the life course, and Morselli and Tremblay (2004) found that criminal networks affected illegitimate earnings among adult offenders, it would still be informative to assess the generalizability of these findings across the life course.

Third, because the data come from official records, they are potentially vulnerable to the "group hazard hypothesis" (Erikson 1971). Hindelang (1976) argued that law enforcement records are more apt to capture group than solo offending and suggested that scholars potentially overestimate the relative frequency of co-offending. Still, this investigation was interested in constructing and studying egocentric networks, not in estimating the incidence of co-offending compared to solo-offending. Still, to the extent that individuals in these data differ in their (co-) offending patterns, summary conclusions based on official

arrest records may not be completely accurate. Nevertheless, given the difficulty of obtaining network-oriented data, the use of these data begins to address some of these important questions and arrives at some very interesting findings that are unique, important, and relevant to the extant literature. Going forward, it will be of particular interest to examine the extent to which network redundancy may be related to the probability of arrest. Co-offending with many different people might increase the probability of arrest (and hence the probability of inclusion in samples that employ official records) not only because the probability of arrests tends to increase with increasing offending frequency (Brame, Paternoster, and Bushway 2004; Cohen 1986) but also because co-offenders and offender networks tend to be a selective target of enforcement among police departments. For instance, several police departments have instituted patrols that focus on co-offenders and criminal organizations (e.g., Baltimore City Police Department).

With the limitations of official records in mind, self-report data would provide an important and informative complement to the current analysis.[11] Such data would also provide an important opportunity to study the overlap between the deviant peer and co-offending networks.[12] Presumably, co-offenders are drawn from the peer group (Warr 2002), but no study has yet investigated the process whereby offenders "choose" their accomplices from this larger network. Such data would also afford the opportunity to further investigate the argument by Krohn et al. (1988) that greater role multiplexity in a social network (i.e., when an individual participates with another person in more than one domain of social life) constrains behavior. For example, is it the case that a person who is strongly tied to deviant friends and whose ties involve offending together (i.e., the friends are part of the deviant peer network and the co-offending network) is also apt to be a serious, persistent offender because he or she is more embedded in an interdependent criminal network?

Finally, it would be interesting to expand the personal networks beyond immediate contacts to include nonimmediate contacts (i.e., accomplices of the subject's accomplices). Recent work has suggested that indirect deviant peer connections, steps away from the ego, can influence a subject's behavior (see Payne and Cornwell 2007). Whether this generally holds true for co-offending networks or specifically for the issues of redundancy and versatility is an empirical question. Future work could investigate whether having a nonredundant network comprising accomplices who also have nonredundant networks amplifies the likelihood of versatile group offending.

Appendix

At least two theoretical perspectives would suggest that the relationship between network redundancy and offending versatility is spurious: the general theory of crime (Gottfredson and Hirschi 1990) and Moffitt's (1993) dual taxonomy. Moffitt (1993, 2006) argues that, compared to adolescence-limited (AL) offenders, life course persistent (LCP) offenders demonstrate more diverse antisocial behavior, largely because their offending stems from a pathological origin that has pervasive and enduring effects over the life course. At the same time, during adolescence, LCP offenders serve as behavioral models and magnets for AL offenders. Because of their poor social skills and a tendency to exploit AL offenders for their own gain (e.g., using them as drug customers, fences, lookouts), LCP offenders should serve as the core for revolving, transient networks of AL offenders, which is another way of stating that they will have nonredundant co-offending networks. Such networks hold no criminogenic or etiological role for LCP offenders, however (Moffitt 1993, 1994). Next, Gottfredson and Hirschi (1990) posit that individuals with greater criminal propensity (i.e., lower self-control) are also the most versatile. Furthermore, individuals lowest in self-control (a) typically exhibit the highest offending frequency and (b) also lack the capacity to form lasting or enduring relationships. Together, this suggests that persons with low self-control will be relatively high-rate co-offenders who rarely use the same accomplices across criminal incidents. These individuals would, therefore, build nonredundant co-offending networks over their criminal career.

Under these premises, once accounting for a measure of propensity and/or a measure indicative of an LCP offending pattern, the relationship between network redundancy and versatility should no longer be statistically significant. Following other work (McGloin et al. 2007; Paternoster et al. 1997), we used offending frequency as a proxy for criminal propensity. For the group offending outcome, the measure was the number of co-offenses, whereas it was overall offending frequency for the general diversity index. Next, Moffitt (1993, 1994) argues that one of the primary distinguishing characteristics of LCP offenders is that they demonstrate an earlier onset than AL offenders. We used age of first arrest as a proxy for this concept (e.g., Patterson, Crosby, and Vuchinich 1992; Tibbetts and Piquero 1999). The analyses revealed that the pattern between density and the diversity indices remained consistent, even when accounting for these measures. Specifically, density was

(continued)

Appendix (continued)

not a predictor of overall offending diversity, but including both of these measures in the model predicting group offending diversity did not strip density of its significance or reduce its magnitude. These results are available from the authors upon request.

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Notes

1. Although certainly related, Burt (1992) argues that his concept of structural holes is distinct from Granovetter's (1973) notion of weak ties. Whereas Granovetter (1973) spoke of weak ties as being important both because of their location in the network and their strength (i.e., level of attachment, involvement, etc.), Burt asserts that the former, not the latter, characteristic is the causal agent.
2. One of our outcomes is the level of co-offending versatility. Our measure, the diversity index, requires at least two offenses, which limits the sample to these 218 subjects.
3. By focusing on personal networks with a radius of 1, we are therefore asserting that individuals with whom an ego has direct contact may shape his or her offending. Although social influence also operates through indirect alters (Leenders 2002; Payne and Cornwell 2007), direct contacts are likely to exert the greatest impact and are typically the focus with investigations on network redundancy.
4. Accordingly, the links are not valued, despite the fact that some subjects "reuse" offenders. One could construct valued graphs to capture this characteristic, but the focus of this investigation (i.e., network redundancy) is based on the presence or absence of links, not necessarily their strength. In this way, the networks and the density measure are consistent with recent conceptions of network redundancy. As Burt (1992) states, "The causal agent in the phenomenon is not the

weakness of a tie but the structural hole it spans . . . whether a relationship is strong or weak, it generates information benefits when it is a bridge over a structural hole" (pp. 27-28).

5. As discussed in the appendix, we also estimated a supplemental analysis that controlled for offending frequency and the age of onset. The results remain consistent with those presented here (i.e., density predicts group offending specialization).
6. As with any measure of specialization, the diversity index has potential limitations (Osgood and Schreck 2007). Some scholars may be concerned with a potential confound between the diversity index and offense frequency. Subjects who offend fewer times than the number of possible offending category types cannot actually obtain the maximum score. Previous work has addressed this (see McGloin et al. 2007; Sullivan et al. 2006) and agrees with Agresti and Agresti's (1978:208) assertion that researchers should not standardize the diversity index to account for this issue. Even so, we (a) controlled for offense frequency in supplemental analyses discussed in the appendix and (b) operationalized specialization in a number of alternative ways (i.e., sensitivity analyses). First, we constructed a simple binary measure that assessed whether the subject engaged in only one form of offending (i.e., violent, property, or drug). Under this measure, individuals who co-offend two times can have the same "maximum" score as those who co-offend more often. For both co-offending and overall offending outcomes, the logistic regression results were substantively the same as those presented here. Second, we also measured specialization on a scale. This outcome ranged from 1 to 3, with 1 representing a single crime category across offending (i.e., all violence, all property, or all drug), 2 representing two categories, and 3 reflecting involvement in all three crime types. Ordered regression models also revealed the same substantive findings as the models presented in the text. Finally, we also expanded the number of categories for the diversity index to four by transferring crimes such as fraud, embezzlement, and criminal trespassing from the property category. Under this calculation, the diversity indices logically increase slightly across subjects, but the results remain substantively the same.
7. Morselli and Tremblay (2004) measured network redundancy with Burt's (1992) "effective size" in their investigation of criminal achievement. Effective size is another measure of network redundancy and essentially captures the number of non-redundant contacts in the network. Borgatti (1997) argues that density, a less complicated and more readily interpretable measure, can substitute for effective size. Furthermore, effective size is more strongly correlated with co-offending frequency ($r = .82$) and raises concerns about multicollinearity for the supplementary models discussed in the Appendix.
8. Some readers may question whether the density score is completely dependent on offending frequency. Although subjects who engage in high co-offending are

likely to have lower density scores (the correlation coefficient for these two measures is –.62), this is not always the case, both conceptually and in the current data. A person who commits five offenses but reuses an accomplice could easily have a higher density score than someone who commits only two co-offenses with a number of people yet never reuses an accomplice(s). The density score is derived from a number of factors, including co-offending frequency, the number of people involved in each criminal event, whether the accomplices are connected to each other, and whether the subject reuses accomplices. Still, offending frequency and density are related. Furthermore, this relationship is likely nonrecursive because nonredundant networks can also facilitate more offending by affecting opportunity structures. The supplemental models discussed in the appendix control for offending frequency and subsequently allowed for a more precise measure of density.

9. The diversity indices were transformed to their natural log form for these analyses.
10. Again, various sensitivity analyses revealed similar substantive findings. We also ran the current models with ordinary least squares (OLS) regression, and the results were substantively the same (see Sullivan, McGloin, and Piquero 2008). Given concerns about using OLS with censored variables (Osgood, Finken, and McMorris 2002), however, we rely on Tobit regression for our main models.
11. Earlier, we criticized the use of self-reports in constructing a measure of network redundancy. Although we believe self-reports would be a useful way to generate a list of one's accomplices, we do not suggest that a subject's perceptions should be the sole basis for links among the alters (i.e., whether or not the subject believes his or her alters are also linked), which was the focus of our criticism. Instead, one should rely on the associates' reports of their own offending. We recognize that such data would be extremely difficult to collect, however.
12. Replicating this investigation with a focus on redundancy in peer networks and its relation to offending versatility would be more complicated by the fact that most "deviant" peer groups are a mixture of antisocial and prosocial youth (Haynie 2002). Although the notion that nonredundant networks provide access to more knowledge, opportunities, skills, and so forth would sustain, this broader access may be to both delinquent and prosocial opportunities. Therefore, the hypothesis presented herein would not translate easily or directly because co-offending networks are by definition criminal in nature.

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