Invitation Article

# A Network Approach to Neighborhoods, Cities, and Crime Based on Everyday Urban Mobility

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This article presents a theoretical framework grounded in the proposition that a neighborhood's crime rate depends not only on its own conditions, as typically studied, but also the conditions of the neighborhoods to which its residents are connected, through networks of everyday urban mobility. Based on this framework, I highlight three arguments. The first is that even though residents of disadvantaged neighborhoods may travel far and wide, their relative isolation by race and class persists. Second, I argue that mobility-based socioeconomic disadvantage explains neighborhood rates of violence beyond residential-based disadvantage. Third, I argue that a city's degree of social connectedness depends on how uneven and concentrated the networks of everyday mobility are among its neighborhoods, which in turn are hypothesized to predict rates of crime across cities beyond that expected by their residential-based segregation. For evidence, I describe individual-, neighborhood- and city-level research my colleagues and I have conducted to test these propositions using geocoded networks of movement throughout the 50 largest American cities. The results offer a new way of thinking about neighborhood effects, spatial models, and structural theories of crime.

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## Theoretical Motivation

One of the most respected traditions in criminology is the study of variations in crime rates across neighborhoods and cities. In countries around the world, researchers have long examined how the socioeconomic conditions of neighborhoods and cities predict crime rates. My own research on neighborhoods and cities has taken this approach, showing how poverty, inequality, and racial isolation, especially when co-occurring, are strong predictors, and arguably causes, of violence (e.g., Sampson 1985, 2012). But neighborhoods do not exist in social or physical isolation, in large part because of strong patterns of residential spatial segregation, especially in the United States (Massey & Denton 1993). The result is that neighborhoods are often surrounded by other neighborhoods that are socioeconomically similar. These extra-local but proximate spatial processes matter —the socioeconomic conditions of nearby neighborhoods have been shown to be important predictors of violence in a given neighborhood (Morenoff et al 2001, Peterson & Krivo 2010).

The fact that neighborhoods are not isolated islands challenges the implicit assumption of independence typically made in traditional neighborhood-level theories of crime. Although spatial interdependence has been well studied and methods have been adapted to deal with its presence (Hipp & Williams 2020), in this article I explore the explicit implications of a “higher-order” network perspective motivated by the connections among neighborhoods originating from individual mobility across the metropolis. Cross-neighborhood ties created by everyday mobility are distinct from both internal neighborhood processes and spatial processes induced by proximity to adjacent or nearby neighborhoods.

In Great American City: Chicago and the Enduring Neighborhood Effect (Sampson 2012), I started to advance this theoretical view by examining how individual-level actions created network structures in the city of Chicago through inter-neighborhood residential mobility and city-wide ties among organizational leaders. The idea was that moving from one neighborhood to another creates a tie, as does one leader consulting with another leader in a different community to address a problem, even a problem that is local in nature. A city can be further defined by the extent to which its neighborhoods are structurally tied together through the many connections these actions forge. In this sense, the individual,

neighborhood, and city levels are united analytically through neighborhood networks (Sampson, 2012, 312, 323). A growing literature in criminology is examining this "neighborhood network" logic based on urban mobility (e.g., Browning et al 2020, Graif et al 2017, Papachristos & Bastomski 2018). My colleagues and I have recently advanced this line of inquiry further by analyzing large-scale social media data to estimate travel patterns for large populations, examining the everyday movement of residents throughout multiple cities. We use these data to examine hypotheses at the individual, neighborhood, and city levels of analysis. I describe each in turn, beginning with the question of individual urban mobility and neighborhood isolation.[1)]

## Urban Mobility and Neighborhood Isolation

Living in disadvantaged neighborhoods is widely assumed to undermine life chances because residents are isolated from middle-class or "mainstream" neighborhoods with greater resources and opportunities (Wilson 1987). Concentrated poverty and social isolation are thus hypothesized to lead to higher crime rates in many theories of crime (Sampson & Wilson 1995). Yet, people do not just live in their neighborhoods. Common experience and research from travel diaries verify that over the course of a typical day or week, people often leave their neighborhoods of residence and travel throughout the city (Browning & Soller 2014). Despite this fact, research testing the role of concentrated poverty and social isolation from this "extra local" or neighborhood networks perspective is relatively sparse.

The first goal of our research project, therefore, was to provide a revised conceptualization and test of neighborhood isolation that improves on static measures from census data on home neighborhoods and small-sample studies based on time diaries. To do so, Ryan Wang, Nolan Phillips, Mario Small, and I

1) In the spirit of the lecture on which this article is based, I sketch an overview of major findings and make no attempt to provide a comprehensive review of the literature. I refer readers to the original research papers highlighted in this article for further details, including the measurement of key concepts, analytic methods, and results. For an independent and recent review on urban mobility and crime that is comprehensive in nature, see Browning et al. (2020). I would also like to acknowledge the ideas and partial excerpts from Sampson (2019), Sampson and Levy (2020), and Levy, Phillips, and Sampson (2020) that I draw from and extend in this article.

leveraged fine-grained dynamic data on the everyday movement of residents from over 650 million geocoded Twitter messages (Wang et al 2018). We used machine learning techniques on these large-scale data to estimate the home locations of almost 400,000 residents of America's 50 largest cities, and in turn we estimated their travel to neighborhoods throughout a city's entire commuting zone over the course of eighteen months. This strategy expands the argument in Great American City by directly estimating inter-neighborhood contact based on everyday travel patterns rather than the much rarer act of changing one's home neighborhood by moving out.

We found surprisingly high consistency in patterns of travel from residents of neighborhoods of different race and income characteristics in the average travel distances (in meters) and the numbers of unique neighborhoods visited in the metropolitan region. This similarity seems to contradict the logic of Wilson's (1987) social isolation thesis and the corresponding hypothesis of the constraining effects of concentrated poverty, while supporting theories on the regularity of urban dwellers' mobility patterns based on a small set of basic urban principles that operate locally (see e.g., González et al 2008).

However, we uncovered notable differences in the race and class composition of the neighborhoods visited. Residents of poor neighborhoods are substantially isolated from contacts with non-poor neighborhoods when they travel. We also found that residents of primarily black and Hispanic neighborhoods—whether poor or not—are far less exposed to either non-poor or white middle-class neighborhoods than residents of primarily white neighborhoods. This result means that race is more important than economic status in shaping the mobility patterns of exposure to non-poor white neighborhoods that command resources, even though there are minimal to no differences in distances traveled and the numbers of neighborhoods visited by race.

## Neighborhood Networks and Crime

My study with Wang and colleagues (2018) established a method for estimating everyday urban mobility, but its focus was on individual patterns of movement across neighborhood types. We were mainly interested in how individuals living in neighborhoods defined by race and class were exposed to other neighborhoods, similarly, defined by race and class. In a series of

laterpapers, we built on this approach to develop network-based measures and test hypotheses at the neighborhood and city levels of analysis. I now provide a brief overview of this approach and our findings at the neighborhood level, and then in the following section of the paper I extend the approach to the next higher unit of analysis, the city.

A long body of research highlights residential disadvantage as an important predictor of neighborhood violent crime (e.g., Peterson & Krivo 2010, Sampson 2012). At the neighborhood-level, Brian Levy, Nolan Phillips, and I set out to examine how urban mobility flows (by socioeconomic disadvantage) carry consequences for neighborhood rates of violence (Levy et al 2020). To accomplish this goal, we extended Wang et al. (2018) to estimate the extent to which visits outside one's home neighborhood are to disadvantaged neighborhoods in the metropolitan region, as well as the average frequency of visits to one's home neighborhood by residents from other disadvantaged neighborhoods. We used these metrics to introduce a concept we call double disadvantage. Here, a neighborhood is considered doubly disadvantaged if it is poor and either visits mostly poor neighborhoods or disproportionately receives visits from poor neighborhoods. In network terminology, these last two quantities represent disadvantage based on a neighborhood's "outdegree" and "indegree," respectively. Most neighborhood effects research considers a neighborhood to be socioeconomically disadvantaged if it scores highly only on one measured trait, commonly indexed by measures like residential poverty, unemployment, and public assistance receipt. We consider a neighborhood that scores highly on such a residential socioeconomic disadvantage measure, as well as on the two other metrics of mobility-based disadvantage, to be triply disadvantaged.

There are several theoretical reasons to focus on the added value of triple disadvantage in explaining rates of neighborhood violence. Triple disadvantage increases the likelihood of interactions occurring among nonresidents or strangers of similar deprived status, which arguably increases the potential for conflictual interactions, or what Anderson (2000) calls "code breaches," hence increasing the kinds of interpersonal disputes that trigger violence. The ability of a neighborhood to achieve regulatory control also extends beyond these kinds of disputes and even its own institutions, including its ability to marshal crime-preventing resources from municipal and state governments. For example, Light and Thomas

(2019) argue that segregation creates a spatial divide that reduces public investment in and erodes the local regulatory capacity of low-income, majority-black communities. Beyond residential disadvantage, Levy, Phillips, and Sampson (2020) hypothesize that triple neighborhood disadvantage plays an important role in a neighborhood's ability to maintain social control, develop collective efficacy, and access crime-reducing resources. More specifically, the structural connection of a triply disadvantaged neighborhood to other similarly situated neighborhoods would amplify its lack of resources for successful crime control.

Analyzing nearly 32,000 neighborhoods and 9,700 homicides in 37 of the largest U.S. cities, Levy et al. (2020) show that triple disadvantage predicts homicide after accounting for known neighborhood correlates of violence (e.g., density, racial and age composition, residential stability), spatial proximity to disadvantage, prior homicides in the neighborhood, and a city's stable characteristics. Not only does triple disadvantage improve explanatory power over traditional measures, Levy et al. (2020) report that it explains a sizable portion of the association between residential neighborhood disadvantage and homicides. For example, we find that mobility-based disadvantage can account for roughly one-fifth of the relationship between residential disadvantage and homicide. Moreover, including indegree disadvantage (the rate of visitation from other disadvantaged neighborhoods), outdegree disadvantage (the rate of visiting other disadvantaged neighborhoods), and the traditional measure of residential disadvantage increases the explanation of neighborhood homicide counts by almost a third more than a model including only residential disadvantage and controls. We also find: "For homicides, indegree disadvantage, or the influx of visitors from other poor neighborhoods, is more salient than outdegree disadvantage. In terms of specific mechanisms, neighborhood drug activity, interpersonal friction, and gun prevalence can explain sizable portions of the association between triple disadvantage and homicides."

There are certainly several limitations to this study. The results I have described are not causal even though we show a substantive and statistically significant relationship between triple neighborhood disadvantage and homicides, controlling for city-level fixed effects, lagged homicides, and a set of theoretically chosen covariates measured with precision. Future research, perhaps using natural experiments that change the nature of interneighborhood mobility, might provide a

stronger causal design. We note in the paper that further research is also needed on data sources that can potentially overcome the limitations of social media data, such as cellphone records that capture movement based on GPS position measurement (Browning et al 2020). In the future, for example, if mobility data become publicly available from smartphones or fitness trackers consistently used by many individuals, these could provide added value This would be especially true if data exist for a representative and non-proprietary sample of people in many neighborhoods. In the meanwhile, in a supplemental analysis, Levy et al. (2020: Appendix) provide a validation test in Houston, which demonstrates that Twitter data offer a close approximation of mobility patterns estimated from cell-phone GPS tracking.

Despite the limitations of social media data and allowing for inevitable measurement error, I would argue that the results of Levy et al. (2020) indicate that the concept of triple disadvantage can be reliably measured and that it has independent explanatory power. At the least it is a novel theoretical concept that can be expanded in future research and tested with other data sources. By highlighting the added value of triple disadvantage beyond residential disadvantage for explaining neighborhood disparities in homicide, this research thus provides fresh evidence and a new theoretical framework for the importance of extra-local conditions in understanding spatial inequality in the U.S.

## City-Level Connectedness

I now turn to an overview of how a neighborhood networks approach sheds light on the connectedness of cities, which in turn has theoretical consequences for crime rates. I begin with the work of Phillips, et al. (2019), who developed two structural measures of mobility-based connectedness for the 50 largest American cities—one based on the equitability, or evenness, of everyday mobility and the other on equality in the dispersion, or concentration, of urban mobility.

Drawing on the same underlying data in Wang et al. (2018) and Levy et al. (2020) but taking a more formal network perspective and ultimately defining measures for a different unit of analysis, Phillips and colleagues (2019) conceptualized a city's connectedness (or "social integration") as the extent to which its neighborhoods are tied to one another by the movement of their residents. Here, the city itself is a network in which neighborhoods are vertices,

or nodes, and residents' travels between neighborhoods are edges, or ties (see also Sampson 2012, 311). They developed two formal measures: one based on the degree to which neighborhoods are connected to each of the others in equal proportion and one based on the extent to which travels are concentrated in a handful of receiving neighborhoods, or concentrated mobility. More specifically, the equitable mobility index (EMI, hereafter "equitable mobility") reflects the extent to which residents of each neighborhood in a city travel to all other neighborhoods in that city equally. The concentrated mobility index (CMI, hereafter "concentrated mobility") represents the extent to which residents' travels outside their residential neighborhoods are concentrated in receiving destination neighborhoods. The concentrated mobility for each city is calculated as the Gini coefficient for the distribution of normalized indegree values—the share of all visits in a city that are in each neighborhood—for all neighborhoods in the city. Ranging between 0 and 1, a low value indicates a lack of "hub" connectedness or widely shared public spaces, such as parks, downtown areas, or other places that generate a concentration of visits from residents around the city.

Sampson and Levy (2020) extended this approach to examine whether these two measures of mobility-based disconnectedness are related to violence beyond the expected effects of traditionally measured segregation based on residence. Theoretically, social integration depends on opportunities for contact, no matter how fleeting (Blau 1977, Blau & Schwartz 1984). Opportunities for contact do not guarantee contact—but the absence of opportunities, as indicated by segregated mobility, will undermine an essential precursor of macrosocial integration, in this case of a city. In addition, spatial divisions in everyday contact are likely to reduce the identification or concern that residents in any given neighborhood have for the other neighborhoods of a city, which can translate into reluctance to support investment in public goods such as housing, schools, transportation, and substance-abuse treatment, eroding systems of social control that prevent violence (Sampson 2012).

Figure 1, from Sampson and Levy (2020, 81), visualizes a key result. The figure plots terciles of the homicide rate by equitable mobility and concentrated mobility. The vertical and horizontal lines in the plot area identify median levels of equitable mobility and concentrated mobility. The figure reveals that cities with low levels of equitable mobility and low levels of concentrated mobility—those

occupying the lower left corner of the plot—are associated with higher rates of homicide. Essentially, these are cities where many neighborhoods have limited direct mobility ties and relatively few hub neighborhoods and shared public spaces exist. Detroit, Cleveland, Baltimore, and Philadelphia, for example, have low values of both concentrated mobility and equitable mobility, indicating that the mobility network is cleaved, such that residents there neither travel to the same neighborhoods in large numbers (shared visitation) nor do they travel to many of the neighborhoods in the city overall. As we note (Sampson and Levy, 2020, 82), only one city with a homicide rate in the lowest tercile (Los Angeles) appears in the lower left quadrant of the figure, and its score on concentrated mobility barely falls below the median. Overall, the mean (unlogged) homicide rate of the cities in the lower left corner of Figure 1 is 21.48 per 100,000, which is substantially higher than, in one case more than double, the homicide rates in the other three quadrants (11.50, 10.01, and 11.64, respectively, going in a clockwise direction).

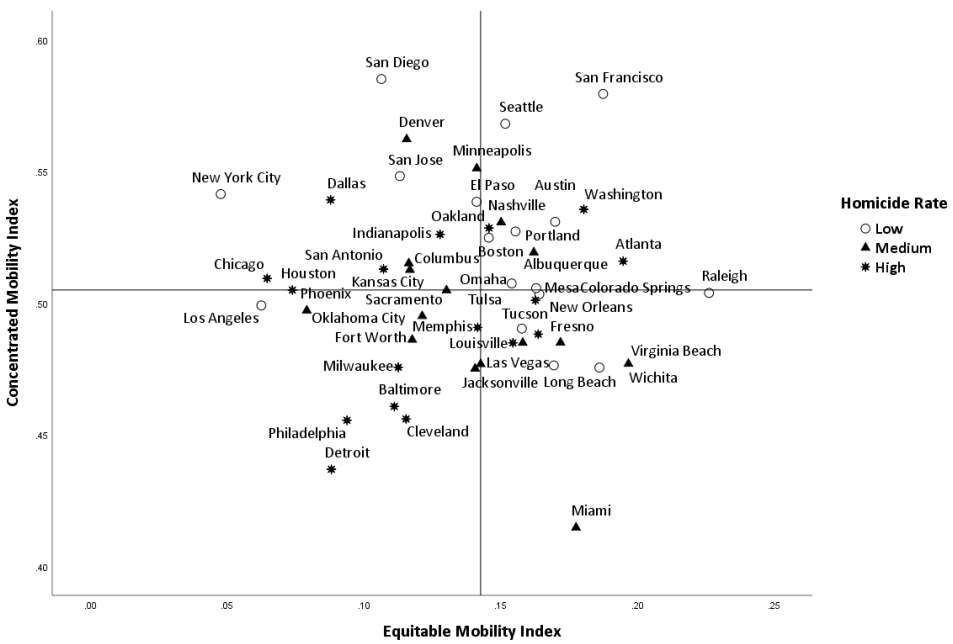


Figure 1. City homicide rates (terciles) by equitable and concentrated mobility (raw values). Adapted from Sampson and Levy (2020, 81).

The combination of these measures therefore reveals distinct insights about the nature of a city's structural integration based on mobility and its potential importance for the incidence of violent crime. In the full paper, we also showed that racial residential segregation is negatively correlated with both measures of mobility-based connectedness and that the negative relationships maintain when education, income segregation, city size, and density are controlled (see also Phillips et al. 2019: Table 2).[2] Yet, the correlations among residential segregation and mobility-based connectedness are not so strong as to suggest that the measures are duplicative. To further assess the associations of our network-based variables with homicide rates, Sampson and Levy (2020) conducted a multivariable regression analysis. Controlling for racial segregation, education, income segregation, city size, and density, the interaction shown in Figure 1 still obtains. Cities with low levels of equitable mobility and low levels of concentrated mobility are associated with higher rates of homicide.

Like the neighborhood-level analyses, these city-level results have limitations. The results are not causal, and the sample size of cities is very small, at 50. And once again, the Twitter measures contain selection biases and need to be more widely replicated with other data sources, such as cell phone records. I thus consider the results suggestive and would emphasize foremost their theoretical value in generating new research.

## Toward a Future Research Agenda

Racial and economic differences in social isolation are notable given recent declines in racial segregation, the increasing diversity of American cities (Firebaugh and Farrell, 2016), and the perception that modern urbanites travel far and wide. As Wang et al. argue (2018), a previously unrecognized form of social isolation is nonetheless occurring, whereby residents of disadvantaged neighborhoods

2) In another analysis, Candipan et al. (2020) go further to propose a dynamic measure of mobility-based racial segregation—the segregated mobility index (SMI)—that captures the degree to which neighborhoods of given racial compositions are connected to other types of neighborhoods in equal measure. They find that the SMI captures a distinct element of racial segregation, one that it is related to, but not solely a function of, residential segregation. A city's racial composition also matters—minority group threat, especially in cities with large black populations and a troubled legacy of racial conflict, appears to reduce movement across neighborhoods in ways that produce previously undocumented forms of racial segregation.

travel well beyond their home residence and yet their relative isolation and segregation by race and class persist within the wider metropolis. This finding, based on a population that is technologically connected and likely more mobile than the general population, implies that segregation and more generally, social isolation, operate at a higher-order level than typically appreciated or systematically measured by urban scholars. Put differently, racial and economic segregation are manifested not only where people live, but also where they travel throughout a city and to whom they are exposed to by visits from others. The inevitable conclusion is that although the U.S. is becoming increasingly diverse, interactions across race and class groups that ultimately contribute to societal integration (Blau and Schwartz, 1984) are not taking place (Candipan et al 2020).

In this article, I have emphasized research building on this mobility- based approach to advance our understanding of crime rates among neighborhoods and cities. Considering the limitations and considerations above, I view the results of this research project as a kind of "proof of concept." Indeed, despite the data being limited to geocoded social media data, it is perhaps surprising just how much added value there is in using triple disadvantage and structural connectedness to predict a hard outcome like violence at the neighborhood- and city-level, respectively. Triple neighborhood disadvantage improves our understanding of variation in homicide rates, and the interaction of equitable mobility and the concentration of travel to common areas adds substantially to the prediction of homicide and overall violence across cities, after controlling for racial segregation, economic inequality, and several other traditional factors. In Sampson and Levy (2020), there is also little evidence that patterns of everyday mobility mediate the influence of residential racial or economic segregation. Both dimensions of the connectedness of cities—one rooted in place of residence, and the other encompassing interneighborhood exposure based on travel throughout the metropolis—are implicated in violence. In this sense, social connectedness is a multi-layered force that yields an enduring higher-order structure (see also Sampson 2012, 375-377), one that is potentially more consequential than original neighborhood-based theories of crime ever anticipated.

An important question is whether patterns of higher-order segregation exist in global cities such as Seoul, London, Mumbai, Shanghai, and São Paulo, and whether or how they are related to crime. My prediction is that neighborhood

networks forged by urban mobility have general properties with consequences for the explanation of crime rates even in cities that vary widely in cultures, populations, diversity and other features of urban life. I look forward to future research that can test these ideas and advance the field of criminology further.

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