Unequal Segregation

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Residential segregation is a persistent problem in cities across the U.S. Despite the passage of civil rights legislation, designed to end discriminatory practices in housing, employment, education, and other areas of social life, residential patterns continue to show often stark separation between racial and ethnic groups. In recent decades, increasing income segregation has accompanied growth in income inequality (Reardon and Bischoff 2011). Further, numerous studies have established that where a person lives is associated with a wide variety of life-course outcomes related to education, health, employment, crime, and poverty (for recent reviews, see Charles 2003; Sampson 2012; Sharkey and Faber 2013).

Most studies of residential segregation describe and compare segregation for cities and metropolitan areas. However, there has been little attention to how the level of segregation varies among the neighborhoods or blocks within a city. In this paper, I analyze spatial variation in levels of racial and income segregation within cities. Results reveal that cities previously thought of as comparable, are actually quite different. Even cities with similar overall segregation scores can have different local variation in the level of segregation. The experience of segregation within some cities is highly unequal. Some residents experience completely segregated local environments, while others live in areas as diverse as the city. In these cities of extremes, local segregation is simultaneously better and worse than indicated
Findings about the extent and spatial patterning of local variation provoke further questions about the divergent experience of segregation in these cities. There may be different consequences to living in a highly segregated local area if all areas of the city are similarly segregated, compared to if segregation is low in the rest of the city. I analyze the association between multiple forms of spatial inequality, including the levels of racial and income segregation, as well as exposure to crime and violence. I also examine which level of geography exhibits the strongest relationship between segregation and other outcomes. The way that segregation affects certain outcomes may depend on the city’s level of segregation, while others depend on local segregation.

My emphasis on spatial variation and local context reframes our understanding of segregated environments. My results provide deeper insight into the segregation of even the most studied U.S. cities, including Philadelphia and St. Louis.

**Local Segregation**

Despite a growing body of scholarship on the spatial dimensions of residential segregation, there has been little attention to the local context of segregation within cities or metropolitan areas. Few studies have analyzed how the level of segregation varies within cities, instead focusing on the overall level of segregation in cities or metropolitan areas. But overall segregation may tell us relatively little about the local conditions. A city where segregation varies greatly across local areas can have the same overall segregation as a city where all local areas have a similar level of segregation.\(^1\)

For example, Figure 1 shows the distribution of segregation levels for blocks within two

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\(^1\)City segregation is measured as the weighted mean of local segregation throughout the city, weighted by the population density of each local area.
hypothetical cities. In the first city, there is low segregation in half of the blocks and high segregation in the other half. The distribution of local segregation in the first city is bimodal. No blocks experience the mean level of segregation. On the other hand, all blocks in the second city are similarly segregated. The variance among the blocks is low. The city mean is more representative of local segregation in the second city than in the first.

Figure 1: The Distribution of Local Segregation for Two Hypothetical Cities with the Same Mean but Different Variance

There are good reasons to care about differences in the distribution of local segregation. First, city segregation is a better indicator of local conditions if the variance within a city is low. In cities with high variance, like the second city, local conditions are both better and worse than indicated by the city-level mean. This is second order segregation – the segregation of segregation.

Second, if local areas are not equally segregated it provides an opportunity to more closely examine reasons for the variation. For instance, what are the mechanisms that create or sustain local diversity in an otherwise highly segregated city? How can cities support the diversity of unsegregated areas, and mitigate the high segregation in other parts of the city? The magnitude of second order segregation likely has implications for the segregation of other social environments as well, such as schools, workplaces, libraries, and parks. For example,
neighborhood schools are likely more diverse in areas of a city with lower segregation.

Third, it can enrich our understanding of how segregated local environments matter for individual and community outcomes. There is a growing body of knowledge on the ecological context of neighborhoods and metropolitan areas (Raudenbush and Sampson 1999; Sampson and Raudenbush 1999), including the physical conditions, economic and political dynamics, and social interactions that occur within them (Bader and Ailshire 2014; Crowder, Pais, and South 2012; Papachristos, Hureau, and Braga 2013; Savitz and Raudenbush 2009; Timberlake and Iceland 2007). Numerous studies have established that where a person lives is consequential for a wide variety of life-course outcomes related to education, health, employment, crime, and poverty (for recent reviews, see Charles 2003; Sampson 2012; Sharkey and Faber 2013). The way that segregation affects certain outcomes may depend on the city’s level of segregation, while others depend on the degree of local segregation. Further, there may be different consequences associated with living in a highly segregated local area if all areas of the city are similarly segregated than if segregation in the rest of the city is low.

We can better understand second order segregation by analyzing the both the mean and the variance of local segregation. Two strategies are ideal for accomplishing this task: decomposition analysis and spatial mapping.

Decomposition analysis allows us to compare how segregation within and between different levels of geography contributes to overall segregation. Several recent studies have decomposed the segregation of regions and compared the segregation occurring within and among municipalities (Bischoff 2008; Farrell 2008; Fischer 2008; Fischer et al. 2004; Hipp 2007; Lichter, Parisi, and Taquino 2012; Parisi, Lichter, and Taquino 2011). They report the results for the aggregate components, for example, how much of the overall segregation occurs at the level of tracts, counties, or regions.

Unfortunately, most segregation indexes are not additively decomposable. The information theory index (Reardon and Firebaugh 2002; Reardon and O’Sullivan 2004; Theil
and Finizza 1971; White 1986) has become the gold standard for decomposing spatial segregation. However, as I have shown elsewhere (Roberto 2015), it can produce misleading results. I developed a new index – the Divergence Index – that is additively decomposable and intuitive to interpret for each local area or the region as a whole.

Maps provide a medium for both visualization and analysis. To quote Logan: “The most powerful spatial tool is the simplest – creation of a map that allows visualization of a spatial pattern.” (Logan 2012:509) Mapping local segregation values allows patterns emerge that would not be obvious in summary tables or statistical graphics.

**Data and Methods**

Better measurement of residential environments is critical for explaining how and why local context matters for individual and community outcomes. For several decades, the most popular measure of residential segregation has been the dissimilarity index (Duncan and Duncan 1955; Jahn, Schmid, and Schrag 1947; Taeuber and Taeuber 1965). Although the dissimilarity index and other summary indexes allow researchers to describe certain characteristics of residential segregation, they do not integrate the fundamentally spatial concepts of proximity and geographic scale into the measurement of segregation. Further, results can not be decomposed to compare the segregation occurring within and between local areas in a city. The summary indexes fail to capture key aspects of how segregation is locally experienced.

Recent years have seen heightened interest in studying the spatial dimensions of residential segregation (Bischoff 2008; Fischer 2008; Grannis 1998, 2002; Hipp 2007; Lee et al. 2008; O’Sullivan and Wong 2007; Reardon and Bischoff 2011; Reardon et al. 2009, 2008; South, Crowder, and Pais 2011; Spielman and Logan 2013). Studies have incorporated information about the contiguity of census tracts or blocks and the proximity of racial or ethnic clusters, and have analyzed the geographic scale of segregation patterns. For example, Reardon and
O’Sullivan (2004) developed the spatial information theory segregation index, which they used to measure and compare the geographic scale of racial residential segregation in large metropolitan areas in the U.S. (Lee et al. 2008; Reardon and O’Sullivan 2004; Reardon et al. 2009, 2008).

Data

I use publicly available population data from the 2010 decennial census (U.S. Census Bureau 2011), and the corresponding shapefiles for blocks, roads, and municipalities (U.S. Census Bureau 2012). Studies of residential segregation typically use data aggregated at the level of census tracts, which are intended to approximate neighborhoods and have an average population of 4,000 individuals. However, tract-level data are often too blunt to capture fine-grained segregation patterns in cities. Instead, I use census blocks, which are nested within tracts. Blocks are the smallest unit of census geography for which data are publicly available. In urban areas, most blocks resemble a typical city block. The population of blocks varies, as does the number of blocks within a tract. By using the smallest unit of census geography, I capture more nuance in the spatial topology and segregation patterns of cities.

Measure

In previous research (Roberto 2015), I introduced the divergence index, a conceptually intuitive and methodologically rigorous measure of inequality and segregation. It addresses the limitations of existing measures and accurately represents the inequality and segregation across contexts and nested levels of geography.

The Divergence Index is based on relative entropy, an information theoretic measure of

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2 The spatial information theory segregation index is a measure of residential segregation that incorporates information about geographic proximity.
the difference between two probability distributions (Cover and Thomas 2006). As an index of residential segregation, it measures the difference between the composition of individuals’ local environments and the overall population composition.

To measure segregation spatially, the index is calculated as:

\[ \tilde{D}_i = \frac{\sum_{m=1}^{M} \pi_{im} \log \frac{\pi_{im}}{\pi_m}}{\tau_i} \]

where \( \pi_{im} \) is group \( m \)'s proportion of the proximity weighted population in the local environment of location \( i \), and \( \pi_m \) is group \( m \)'s proportion of the overall population. To summarize for all locations \( i \) in the city:

\[ \tilde{D} = \frac{1}{T} \sum_{i=1}^{N} \tau_i \tilde{D}_i \]

where \( T \) is the overall population count, and \( \tau_i \) is the population count in location \( i \).

The divergence index can be interpreted as a measure of surprise – how surprising is the composition of local environments given the overall population composition? If all local environments have the same composition as the overall population, then \( \tilde{D} = 0 \), indicating no segregation in the city. More divergence between the local and overall population composition indicates more segregation.

Like entropy, relative entropy is additively decomposable. We can aggregate residential locations into districts, or groups into supergroups and calculate the inequality within and between these districts or supergroups. The sum of the inequality within and between the aggregate units is identical to overall inequality for individual units.

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3Relative entropy is also frequently called Kullback–Leibler (KL) divergence (Kullback 1987).

4In contrast, the recently developed Spatial Information Theory Index (Reardon and O'Sullivan 2004) is a ratio of local population diversity to overall diversity.

5Following standard usage, I define \( 0 \log 0 = 0 \), because \( \lim_{x \to 0} (x \log x) = 0 \).
Method

In previous research (Roberto 2015), I developed a new method for studying the spatial context of residential segregation. I measure the proximity of residential locations and the reach of local environments around each location using road distance. This is more realistic than straight line (“as the crow flies”) distance, because it captures the connectivity of roads and the distance imposed by physical boundaries. My approach overcomes the limitations of current methods, and captures the spatial relationships and structured patterns that we commonly recognize as segregation.

This approach generates results that reveal additional local context, including intra-city variation in segregation levels. I use this approach to analyze residential segregation by race and income in several U.S. cities. I map the local segregation values, which provides a medium for both visualization and analysis. Mapping local segregation values allows patterns to emerge that would not be obvious in summary tables or statistical graphs. Maps deepen our understanding of the local context of segregation patterns.

Results

I find substantial spatial variation in the degree of local segregation within cities. Figure 2 maps White-Black segregation for residential locations within Philadelphia. The map shows results for local environments at a reach of 0.5 kilometers. Each residential location appears as a point on the map. Darker colors indicate higher segregation, and lighter colors indicate lower segregation values. Areas of the map that are White have no population (e.g. industrial or commercial areas, parks, cemeteries, etc.).

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6I use census data for mutually exclusive race categories, combined with Hispanic or Latino ethnicity. The Hispanic category includes all individuals who identified Hispanic or Latino as their ethnicity, along with any category of race. The remaining categories of race include only individuals who identified their ethnicity as Not Hispanic or Latino.
Figure 2: White-Black Segregation in Philadelphia, PA in 2010
(Extended Local Environments, Reach = 0.5 km)

Looking at the same area in the map of the White, Black, and Hispanic population of Philadelphia in Figure 3, we can see that the population of the area is predominantly Black, and the population of surrounding areas is mostly White. This contrast in the population composition is responsible both for the high and low segregation results we observe in the map. Areas that are predominantly of one race or the other have high segregation values. Locations along the boundary of segregated clusters have lower segregation because the groups are in close proximity.
In some cities, the areas of high and low segregation are not bright lines that mark a boundary between segregated clusters, they are entire neighborhoods or large sections of the city. Overall city segregation is the weighted mean of local segregation throughout the city, weighted by the population density of each location. In cities with high spatial variance, the city-level mean reveals relatively little about the local context of segregation. This is second order segregation – the segregation of segregation.

The map of White-Black segregation in St. Louis, MO shows that about half of the city’s population experience very high levels of segregation, and half live in areas that are about
as diverse as the city as a whole (see Figure 4). Like the map for Philadelphia, it shows local segregation results for extended local environments at a reach of 0.5 kilometers.

There are large areas of high segregation in the north half of the city and the southwest portion of the city. Through the middle of the city and in the southeast portion of the city, there is lower segregation. Very few areas experience the mean level of segregation. There is high local variance – local conditions are both better and worse than indicated by the city mean (0.50).

In some areas of St. Louis, the local population is in close correspondence with the city’s composition, and in other areas the population is nearly monoracial. The map in Figure 5 shows that there is a prominent north-south divide in the city. The population in the north is mostly Black and the population in the south is mostly White. There is also an area with considerable diversity in the southeast portion of the city. The large, nearly monoracial clusters in the north and south of the city explain the large clusters of high segregation in Figure 4. The diversity of the area in the southeast, as well as through the middle of the city align with the areas of low segregation in Figure 4.

To better understand the local variation observed in St. Louis and Philadelphia, I use the divergence index to calculate the segregation of segregation. I measure the difference between local segregation values and the overall city mean. If there is no segregation of segregation, then all residential locations will have the same value as the mean and the divergence index will equal 0. Larger differences between the mean and the local segregation values indicate more divergence, i.e. high local variation.

Figure 6 shows that both cities have about the same mean level segregation. Segregation is quite high in small local environments and it decreases as their reach increases. Second order segregation is also quite high in both cities, as shown in Figure 7. This indicates high divergence between the mean and local segregation values. Results are similarly high for both cities when local environments have a reach of about 6 to 8 kilometers. Otherwise,
Figure 4: White-Black Segregation in St. Louis, MO in 2010
(Extended Local Environments, Reach = 0.5 km)
Figure 5: White, Black, and Hispanic Population in St. Louis, MO in 2010

City Composition
White: 42%
Black: 49%
Hispanic: 3%

Population Size
- < 5
- < 25
- < 100
- < 250
- < 1000

City Boundary
Water
Roads
Population
there is considerably more divergence in St. Louis than in Philadelphia.

St. Louis is often listed as one of the most segregated cities in the U.S., but the city mean is actually much lower than the segregation of many local environments. The experience of segregation is highly unequal across locations in the city. Some residents experience
completely segregated local environments, while others live in areas as diverse as the city. To a large extent, this is also true in Philadelphia.

[ This paper is a work in progress. I will add an analysis of the association between multiple forms of spatial inequality, including the levels of racial and income segregation, as well as exposure to crime and violence. I include have results on the association for multiple levels of geography to examine if certain outcomes are associated with the city’s level of segregation, while others are explained by local levels of segregation. ]

Discussion

There is a rich literature on the complex social interactions that occur in places: cities, neighborhoods, blocks, street corners (Anderson 1990, 1999; Deener 2010; Jacobs 1961; Papachristos 2009; Papachristos et al. 2013; Pattillo 2003, 2007; Rae 2003; Suttles 1968; Zorbaugh 1929). This work motivates my interest in studying the heterogeneity of segregation within cities. This paper attempts to bridging qualitative insight on the local experience of unequal social environments and how we measure segregation for city populations.

I argue that segregation cannot be adequately described without attention to how it locally varies within cities. I use a new approach that incorporates spatial context into the measurement of segregation. It captures the spatial relationships and structured patterns that we intuitively recognize as segregation.

By examining spatial variation in the level of segregation within several U.S. cities, I identified areas of high and low segregation in a map of White-Black segregation in Philadelphia, including a bright line of low segregation surrounding the high segregation of the Point Breeze neighborhood. In some cities, the areas of high and low segregation are not bright
lines, they are entire neighborhoods or large sections of the city. The segregation of segregation leads to an unequal experience of segregation within cities. In St. Louis, the White-Black segregation of many local environments is considerably higher than the city mean.

These findings point to further questions about the divergent experience of segregation in these cities. For instance, what are the mechanisms that create or sustain local diversity in an otherwise highly segregated city? How can cities support the diversity of unsegregated areas, and mitigate the high segregation in other parts of the city? Moreover, why is there such high inequality in the level of segregation across areas of a city?

The magnitude of second order segregation likely has implications for the segregation of other social environments as well, such as schools, workplaces, libraries, and parks. For example, we might expect neighborhood schools to be more diverse in areas of a city with lower segregation?

This work attempts to bridge qualitative insight on the local experience of unequal social environments and how we measure segregation for city populations. It lights a path forward for studying local variation in the level of segregation as a source of social and spatial inequality, and suggests multiple paths for future work.
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