Neighborhood Social Isolation and Spatial Exposure Heterogeneity Among Urban Youth[1]

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Abstract

Foundational urban sociological theories emphasize the role of heterogeneity of exposure to spatial contexts and associated social environments as an essential feature of the urban experience. Yet the development of “neighborhood effects” research has largely focused on the residential context as the (single) relevant non-home urban exposure space. We explore the extent to which the everyday activity locations of urban youth vary with respect to racial composition and socioeconomic status using unique geospatial data on the travel paths of a large sample of youth from the *Adolescent Health and Development in Context* study. Contrary to the expectations of the neighborhood social isolation model, findings indicate that increases in the percent African American of the residential neighborhoods youth reside in is associated with greater dispersion in the racial composition of the locations they encounter. Implications for the conduct of “neighborhood effects” research are discussed.

Urban heterogeneity by factors such as race, ethnicity, and socioeconomic status has been a central preoccupation of population researchers since the inception of urban social science. In the US context, research attention has focused on patterns of residential spatial sorting among heterogeneous urban populations, observing stark patterns of racial and socioeconomic residential segregation at the neighborhood level. In particular, the concentration of black populations within highly segregated neighborhoods has been a durable feature of US cities. Despite modest evidence of deconcentration by race, residential segregation remains pervasive.

The contrast of city-level compositional diversity combined with relative neighborhood-level homogeneity informs an extensive literature examining neighborhood inequalities across a range of dimensions and the consequences of these inequalities for the life prospects of residents – particularly youth. A critical assumption motivating "neighborhood effects" research on diversity, segregation and their impact is the expectation that neighborhoods constitute a dominant everyday exposure context for urban youth. The vast and expanding literature examining multilevel determinants of wellbeing among youth investigates features of residential neighborhoods as consequential proxies for individual-level non-home contextual exposures. Yet, the validity of this assumption has, to date, not been subject to empirical evaluation. To the extent that urban youth venture beyond the boundaries of segregated neighborhood contexts into larger and significantly more socially heterogeneous urban areas, use of home neighborhoods as a proxy for sociospatial exposures may result in an excessively homogenized view of everyday urban experience.

Using unique geospatial data on the daily spatial trajectories of a sample of urban youth from the *Adolescent Health and Development in Context* study, we investigate the extent to which the actual exposures of urban youth deviate from the average characteristics of their home neighborhoods. Specifically, we hypothesize that, consistent with the focus of early urban researchers, heterogeneity of exposure to urban areas by racial and economic composition is far more common than a focus on residential characteristics alone would suggest. Drawing on the often neglected implications of extant neighborhood theory for everyday mobility, we also consider the hypothesis that youth residing in increasingly African American segregated and economically disadvantaged neighborhoods experience heightened levels of exposure heterogeneity in their everyday routines.

The implications of a revealed pattern of more extensive exposure heterogeneity for research on neighborhood effects are considerable. Evidence suggesting the detrimental impact of residing in poor and racially segregated neighborhoods on a range of outcomes (e.g., health, educational outcomes, behavioral development (Landrine and Corral 2009; Kim 2010; Sharkey and Elwert 2011; White and Borrell 2011; Kershaw, Albrecht, and Carnethon 2013; Anderson, Leventhal, and Dupéré 2014)) has not definitively established the mechanisms through which such effects are transmitted (Leventhal 2018). Most hypothesized mechanisms assume that high levels of exposure to compromised social climates *within* the residential neighborhood accounts for the link to individual-level outcomes. Theoretical approaches to mechanisms, however, must be consistent with the actual everyday spatial experiences of urban youth, which may involve more complex exposure patterns than conventional neighborhoods models presume.

Background

NEIGHBORHOOD CONTAINMENT: EXPOSURE PROCESSES IN THE NEIGHBORHOOD SOCIAL ISOLATION APPROACH

Early Chicago School of Sociology researchers such as Shaw and McKay (1942) and others in the social disorganization tradition focused attention on the consequences of neighborhood variation in poverty, residential turnover, and compositional heterogeneity by race/ethnicity for neighborhood functioning. The emphasis on heterogeneity identified the presence of diverse groups *within* a neighborhood as a factor complicating communication across residents and the development of shared values and institutions. This hypothesis identified heterogeneity in the aggregate as consequential for outcomes such as rates of crime and poor health.

Subsequent extensions and applications of the social disorganization perspective maintained a focus on the residential neighborhood as a critical context for youth. Notably, Wilson's (1987) theory of neighborhood social isolation drew on the insights of social disorganization theory to highlight the negative consequences of residence in concentrated poverty neighborhoods – a condition to which African American youth are disproportionately exposed. In this view, the social isolation of concentrated poverty neighborhoods refers to the absence of high quality institutions and behavioral role models that could offer youth viable pathways out of poverty. Resident youth are highly vulnerable to the conditions of concentrated poverty neighborhoods because their circumference of turf is presumed to be largely restricted to the neighborhood boundary. This *neighborhood containment* model of exposure has, with few exceptions, characterized most subsequent research on the developmental consequences of disadvantaged residential environments.

The field of "neighborhood effects" research emerging largely in the aftermath of Wilson's (1987) *The Truly Disadvantaged* has been characterized by a vigorous, cross-disciplinary effort to investigate the major claims of the neighborhood social isolation model as well as a number of other emerging neighborhood theories. The advent of readily available statistical packages for the analysis of multilevel data (individuals nested within neighborhoods) precipitated a rapid acceleration in the number of studies estimating associations between neighborhood characteristics such as poverty and racial composition and individual outcomes. Subsequent recognition that urban neighborhoods are embedded in clusters of adjacent areas led to the incorporation of expectations that spatial spillover into, and from, nearby neighborhoods could also shape contextual effects. However, the emphasis on proximal – and likely demographically and socioeconomically similar – areas in this literature has resulted in an expectation of limited spatial exposure variability beyond the characteristics of home neighborhoods.

The basic assumptions of the neighborhood social isolation model (shared by most multilevel applications of neighborhood theory) generate the following expectations regarding heterogeneity of exposure: 1) individual-level exposure heterogeneity is limited: focusing on racial composition and economic disadvantage, the vast majority of the variation in spatial exposures is expected to be between neighborhoods, rather than between individuals (within neighborhoods) or within individuals; accordingly, 2) the deviation between the characteristics of actual spatial exposures of youth and those of their home neighborhoods is negligible; and: 3) exposure heterogeneity is expected to remain consistent or, possibly, increase as neighborhood economic advantage increases and minority concentration declines. The hypothesis of an increase in exposure heterogeneity as neighborhood advantage increases is consistent with the logic of the social isolation model (although not directly addressed in it) and stems from the expectation that residents of more affluent neighborhoods will have a larger number of routine activity destinations (involving e.g., employment, organizational affiliation, leisure, and network-related activities), exposing them to a greater number of potentially variable urban spaces. Affluent urban residents also have the resources to realize potentially idiosyncratic (omnivorous) tastes with respect to activities and their associated locations.

COMPELLED MOBILITY: CLASSIC AND COMTEMPORARY MODELS OF EXPOSURE HETEROGENEITY

Early sociological investigations of the city identified heterogeneity as an essential aspect of the urban experience. Wirth's (1938) focus on size, density, and heterogeneity as the key defining features of cities emphasized the relevance of these characteristics in the aggregate, but ultimately made a social-psychological argument regarding the consequences of heterogeneity. In Wirth's view, cities presented individuals with widely disparate social exposures the dynamic intensity of which generated "nervous stimulation." Simmel (1903) also highlighted the relevance of constantly changing social stimuli in the emergence of the typical affective ("blaze") detachment characterizing urban residents. Essential to both claims was the expectation of non-trivial exposure variability within individual.

Despite Simmel and Wirth's seminal work on the role of heterogeneity in shaping urban experience, the subsequent development of urban sociology increasingly focused on residential neighborhoods as relevant units for understanding the effects of non-home social environments. This approach ruled out the possibility of exposure heterogeneity by defining a single areal unit and its associated characteristics as the source of environmental influence. Emerging evidence, however, points to the substantial role of areas beyond conventionally defined neighborhoods in the lives of urban youth (Basta, Richmond, and Wiebe 2010; Robinson and Oreskovic 2013; Colabianchi et al. 2014; Browning et al. 2017). Time spent outside the residential neighborhood offers the opportunity to be exposed to settings with different structural characteristics. Yet, extra-neighborhood exposure is no guarantee of exposure variability, particularly in cities characterized by high levels of segregation. Venturing beyond the neighborhood boundary may involve minimal traversed distance and merely expose youth to comparably poor (or wealthy) areas of cities if substantial race and SES sorting has occurred regionally within cities.

We offer an alternative *compelled mobility* approach to understanding the spatial exposures of urban youth across race and class. In this view, residents of segregated, economically disadvantaged neighborhoods, including youth, are *more* likely to exhibit exposure heterogeneity due to the absence of resources, organizations, and amenities typically characterizing their residential contexts. The notion of deinstitutionalization – ironically central to the neighborhood social isolation model – describes the process by which urban African American neighborhoods gradually lost their economic and civic base during the 1960s and '70s, eventually resulting in the widespread diminution of the organizational and amenity infrastructure of these communities. Absent banks, grocery stores, shopping centers, adequate schools, safe parks, and viable sources of employment within the neighborhood, residents will be constrained to seek these resources elsewhere to the extent possible. Given the concentration of resources in wealthier and often whiter neighborhoods, residents of segregated and economically disadvantaged areas are likely to experience non-trivial levels of exposure to places that may vary substantially from their home neighborhood environments.

In contrast, residents of whiter and more affluent areas are likely to have access to organizational resources either within their own communities or in comparably advantaged areas. The long-recognized residential self-segregation of white and affluent populations within urban areas (Massey 1996) is likely to have a counterpart in patterns of activity location choice among this group. Consequently, a compelled mobility approach expects 1) exposure heterogeneity is far more common than the conventional neighborhood social isolation approach would expect, particularly for youth residing in high percentage African American neighborhoods: a substantial proportion of the variance in spatial exposures to area racial composition and socioeconomic status will be observed *within individuals* and, perhaps, between individuals within neighborhoods; 2) for African American and lower SES youth, average actual spatial exposures will be whiter and higher SES than the composition of home neighborhoods; and 3) residents of segregated African American and low-SES communities will experience significantly *larger* variability in exposures to locations by race and socioeconomic status than residents of white-dominated and more affluent communities.

Few studies have investigated the extent of variability in spatial exposures among urban residents. Wang et al. (2018) use Twitter data from the 50 largest US cities to investigate patterns of non-neighborhood exposure relying on geo-tagged Tweets. They find some evidence of exposure variability but in the context of substantial mean differences in non-neighborhood exposures across residential tract composition. Residing in a largely black neighborhood is negatively and powerfully associated with Tweeting from a white-dominated or non-poor neighborhood, offering evidence of inequality in access to "mainstream" neighborhoods in the course of daily routines. The authors interpret these findings as consistent with the essential claims of the neighborhood social isolation model regarding inequality of access to resources across space. To date, however, no studies have investigated the extent of exposure variability (whether to white and non-poor neighborhoods or not) using a representative sample of urban youth with demographic and socioeconomic data at the individual level, information on the time duration of exposures, and near continuous GPS-derived data on exposure locations.

We explore hypotheses regarding exposure heterogeneity among urban youth employing unique geospatial data on the everyday spatial trajectories of a large sample of urban youth from the *Adolescent Health and Development in Context* study. Based on smartphone GPS tracks collected over the course of a five-day period and subsequently verified for accuracy relying on respondent input, these data offer an unprecedented opportunity to investigate the extent and sources of exposure heterogeneity in a large, midwestern US city.

Data and Measures

The Adolescent Health and Development in Context study is a longitudinal study of adolescents in Franklin County, Ohio. The sample of 1,405 youth ages 11 to 17 was recruited during Wave 1 using a mix of vendor- and school-based address lists. Letters and postcards describing the study were mailed to the household. Among eligible households that were contacted, one randomly chosen child and a primary caregiver were selected to participate. The study area is a contiguous space within the outerbelt of Interstate 270, encompassing a majority of the city of Columbus and several adjoining suburbs. The sample is representative of the study area with respect to household income of families with children and race/ethnicity, with the exception that the percent of recruited participants that are African American is somewhat higher than the estimated population living in the study area.

Over the course of a weeklong period, two in-home interviews are conducted. At the first in-home visit, the Entrance Survey, interviewer- and self-administered surveys with both the youth and their caregivers are collected. This survey gathers household rosters, routine activity locations, and a host of environmental, household, and behavioral measures from both participants. The Entrance Survey is followed by a weeklong geographically-explicit ecological momentary assessment (GEMA), during which the youth carries a study-provided Android smartphone. The GEMA week collects real-time assessments of locations, activities, and experiences as well as continuous GPS tracking. The ecological momentary assessment surveys are administered up to 5 times a day before/after school and throughout the day on holidays, school breaks, and weekends. GPS data are collected prioritizing location coordinates from GPS satellites approximately every 30 seconds. If no GPS satellite location has been collected in the last 10 minutes, the location coordinates based on cell network tower connection are collected as a replacement, approximately every one minute. If location services are turned off during the week, the study application sends a prompt to remind the participant to turn services back on.

At the end of the GEMA week, a second in-home visit is conducted with the respondents, during which the youth completes a recall-aided interactive space-time budget. Prior to administering the space-time budget, the GPS data are processed using a convex hull-based binning algorithm that summarizes data points into stationary and travel periods. The space-time budget takes the output of the convex hull processing of the raw GPS data and displays these locations to the respondent. Each location is combined with labels from nearby routine location self-reports from the Entrance survey along with Google Places search results; respondent can then report whether each stable location was associated with a routine location, a Google Places result, write in other text, or change the location coordinates as needed. The youth respondents report on 5 days of location data of the GEMA week, as well as provide continuous activity and network partner presence reports for those days. The current analyses employ location data from the space-time budget, geocoding coordinates from locations encountered over the 5-day period to the Census block group level. Exposures to block group characteristics are constructed using the American Community Survey 2009-2013 five year file. For our final analytic sample, we use data on 40,017 locations nested within 1256 youth (with non-missing information on covariates), and 182 census tracts.

MEASURES

Dependent Variable

In the current analyses, the dependent variable is the Census block group proportion African American for the specific location encountered (we will investigate measures of exposure to socioeconomic status as well for the final manuscript). Our principal focus is the model-based variance in exposure to percent African American and percent in poverty over the observation period, which is allowed to vary across individuals and tracts (see Analytic Strategy below).

Individual-level measures

At the individual level, we include only measures of youth race/ethnicity and household income in preliminary models presented below.[2] *Race/ethnicity* includes four categories: white (reference category), African American, Hispanic, and other race. *Household income* is a four category measure (less than $30,000 (reference); $30,001 to $60,000, $60,001 to $150,000, and greater than $150,000).

Neighborhood-level measures

To capture residential neighborhood exposures, we use the residential census tract percent African American, also using the 2009-2013 ACS data. A unit increase in this measure corresponds to a 10-point increase in the percentage African American.

[2] Our modeling strategy, detailed below, is computationally demanding. Accordingly, for the purposes of this abstract, we present streamlined models offering preliminary evidence that bears on our hypotheses.

Analytic Strategy

To investigate the extent to which variability in exposure to proportion African American in activity locations is accounted for by residential tract, we first decompose variation in this outcome across locations, youth, and tracts. The neighborhood social isolation model would expect that the vast majority of the variance would be accounted for by residential tract under the assumption that neighborhoods largely bound youth exposures and non-neighborhood exposures are typically spatially proximate and similar in composition to the home tract. We then examine the extent to which the actual average exposures to percent African American of white and African American youth deviate from their home neighborhood racial composition. Finally, we turn to the multilevel analysis of variance heterogeneity by individual and home tract level characteristics. We employ a Bayesian variable dispersion zero-inflated beta regression model to accommodate the specific features of the outcome. The beta distribution is appropriate for the outcome (a proportion – varying between 0 and 1). The observed distribution of location percent African American exhibits some clustering at zero due the presence of block groups with no resident African Americans, requiring a zero-inflated approach. The variable dispersion component of the model incorporates the potential for random variation in the variance of locations within individual and tracts. We fit the model using a Bayesian modeling framework with non-informative priors.

Specifically, let Y_{ijk} be the proportion African American in the i^{th}location, in the j^{th}individual, and k^{th} tract. We assume that $Y_{ijk}| \gamma, \mu_{ijk}, \phi_{ijk}$ follows a mixture distribution, with density

$$g(Y, \mu, \phi, \gamma) = \begin{cases} \gamma \; if \; y = 0 \\ (1-\gamma) f(y; \; \mu, \phi) \; if \; y \, \epsilon (0,1) \end{cases}$$

Where $f(z;\ \mu, \phi)$ is the beta density parameterized such that

$$E[z|\ \mu, \phi] = \mu$$

and

$$Var[z|\mu, \phi] = \frac{\mu(1-\mu)}{\phi + 1}$$

Accordingly, μ can be interpreted as the mean and ϕ plays the role of a precision parameter. γ is an unknown constant assumed a priori to be uniformly distributed on (0,1).

This mixture specification implies that

$$E[y|\mu, \phi, \gamma] = (1-\gamma)\mu$$

and

$$Var[y|\mu, \phi, \gamma] = (1-\ \gamma)\frac{\mu(1-\mu)}{\phi + 1} + \gamma(1-\gamma)\mu^2$$

For level one of the model (equation 1), the stable location level, let μ_{ijk}be the exposure to proportion African American at location *i*, for respondent *j*, living in tract *k*.

$$\ln(\frac{\mu_{ijk}}{1-\ \mu_{ijk}}) =\ \beta_{0jk}\ +\ \sum_{p=1}^{P} \beta_p^{(location)} X_{pijk}^{(Location)} \qquad (1)$$

At level one, the location level, β_{0jk} is the intercept, β_p are the coefficients associated with the effects of *P* location-level covariates X_{pijk} on exposure to proportion African American.

$$\beta_{0jk}\ = \sigma_{0jk} + \sum_{q=1}^{Q} \sigma_q^{(Individual)} X_{qjk}^{(Individual)} + u_{0jk} \qquad u_{0jk} \sim N(0, \tau^2) \qquad (2)$$

At level two, the respondent level (equation 2), $\sigma_{0jk}$is the intercept, σ_q are the coefficients associated with the effects of *Q* respondent-level covariates X_{qjk} on proportion African American, and u_{0jk} is an independent and identically distributed error term with mean 0 and respondent/tract level specific variance τ^2.

$$\gamma_{0jk} = \omega_{000} + \sum_{z=1}^{Z} \omega_z^{(Tract)} \omega_{00zk} X_{zk}^{(Tract)} + t_{00k} \quad t_{00k} \sim N(0, \tau^2) \qquad (3)$$

At level three, the home tract level (equation 3), ω_{000} is the intercept, ω_z are the coefficients associated with the effects of Z location-level covariates X_{zk} on proportion African American, and t_{00k} is an independent and identical distributed error term with mean 0 and tract level specific variance τ^2.

$$\ln(\frac{\mu_{ijk}}{1-\mu_{ijk}}) = \omega_{000} + \sum_{p=1}^{P} \beta_p^{(location)} X_{pijk}^{(Location)} + \sum_{q=1}^{Q} \sigma_q^{(Individual)} X_{qjk}^{(Individual)} + \sum_{z=1}^{Z} \omega_z^{(Tract)} \omega_{00zk} X_{zk}^{(Tract)} + u_{0jk} + t_{00k} \quad (4)$$

Equation 4 represents the complete version of the model.

In order to account for variation not explained by the mean, we further allow the precision like parameter to vary as a function of location, individual, and tract covariates, in addition to allowing each youth and each tract to have a unique intercept. For level one of the model (equation 5), the stable location level, let ϕ_{ijk} be a "precision" estimate – defined as the inverse of the variance – in exposure to proportion African American at location i, for respondent j, living in tract k.

$$\ln(\phi_{ijk}) = \alpha_{0jk} + \sum_{p=1}^{P} \alpha_p^{(location)} X_{pijk}^{(Location)} \quad (5)$$

At level one, the location level, α_{0jk} is the intercept, α_p are the coefficients associated with the effects of P location-level covariates X_{pijk} on variation in exposure to proportion African American.

$$\alpha_{0jk} = \delta_{00k} + \sum_{q=1}^{Q} \delta_q^{(Individual)} X_{qjk}^{(Individual)} + d_{0jk} \qquad d_{0jk} \sim N(0, \psi^2) \quad (6)$$

At level two, the respondent level (equation 6), δ_{00k} is the intercept, δ_{0qk} are the coefficients associated with the effects of Q location-level covariates X_{qijk} on variation in proportion African American, and d_{0jk} is an independent and identically distributed error term with mean 0 and respondent/tract level specific variance ψ^2.

$$\delta_{00k} = \nu_{000} + \sum_{z=1}^{Z} \upsilon_z^{(Tract)} \omega_{00zk} X_{zk}^{(Tract)} + a_{00k} \qquad a_{00k} \sim N(0, \psi^2) \qquad (7)$$

At level three, the respondent level (equation 7), ν_{000} is the intercept, ν_{00z} are the coefficients associated with the effects of Z location-level covariates X_{zijk} on variation in proportion African American, and a_{00k} is an independent and identical distributed error term with mean 0 and tract-level specific variance ψ^2.

$$\ln(\phi_{ijk}) = \nu_{000} + \sum_{p=1}^{P} \alpha_p^{(location)} X_{pijk}^{(Location)} + \sum_{q=1}^{Q} \delta_q^{(Individual)} X_{qjk}^{(Individual)} + \sum_{z=1}^{Z} \upsilon_z^{(Tract)} \omega_{00zk} X_{zk}^{(Tract)} + a_{00k} + d_{0jk} \quad (8)$$

Equation 8 represents the complete version of the model.

Results

Table 1 presents descriptive statistics for variables included in the analysis. The average proportion African American in the locations youth visit is .27. The higher than expected value of the mean comes from the positively skewed distribution of location proportion African American. The median, which typically does a better job describing a positively skewed distribution, was .12 (12% African American). We also report the average number of locations visited (31.81, sd=16.2). The racial distribution of the sample is roughly equally distributed across white and African American youth (47% and 44%, respectively). Hispanic and other race/ethnicity youth represent comparatively small percentages of the sample (6% and 4%, respectively). With respect to annual household income, 36% report income under $30,000 per year, 24% report income between $30,001-$60,000, 28% report income between $60,001 and $150,000, and the remaining 12% of the sample report income above $150,000. Note that the sample includes both the highest poverty areas of the City of Columbus as well as three of the wealthiest suburbs in the metro area. The tract level measure of percent African American is reported in deciles (mean = 3.72).

We now consider the decomposition of variance across locations, youth, and home Census tracts for exposure to percentage African American in the locations youth encounter over the five-day period of observation. Table 2 reports variance decompositions for the total sample, white, and African American youth. The first column reports the decomposition for all waking time. Here, we see that 53 percent of the variation in exposure to percentage African American is accounted for by the home census tract. Although a majority of the variance is explained by the home neighborhood, a substantial percentage of the variance (39%) is explained by the location level. The youth level accounts for only a modest proportion of the variance (8%). Columns 2 and 3 report comparable variance decompositions by race, indicating the neighborhood level explains significantly more of the variation for white youth (55%) than African American youth (38%). The percentage of the variability at the location level is higher for African American youth (52%) than for white youth (40%), offering evidence that non-neighborhood exposures are more variable for the former. Columns 4-6 report variance decompositions for the total sample, white, and African American youth considering only waking time *not at home.* This approach captures the period at risk of (non-home) residential neighborhood and extra-neighborhood exposures. The percentage of the variance explained by the neighborhood level in columns 4-6 declines significantly – 37%, 34%, and 22% for the total sample, white youth, and African American youth respectively – while the percentage explained by the location level is substantially higher – 50%, 58%, and 63%, respectively. These findings indicate that the neighborhood social isolation expectation that the neighborhood level will explain the vast majority of the variance in exposure to racial composition does not characterize the observed variation in such exposures.

Decomposition of variance does not capture the magnitude of variation in exposures youth actually experience. We next consider the comparison between youths' average non-home exposures to percent African American and the comparable value for their residential block group. For white youth, the average deviation of the non-home location percent African American from the comparable residential neighborhood value is small (median=.156%, mean=-.32). However, for African American youth, comparable deviations are considerable larger and in the direction of whiter spaces in activity locations (median=-11.5%, mean=-13.4%). These figures indicate that the activity locations[3] of African American youth are substantially *less* African American, on average, than their home neighborhoods, consistent with the compelled mobility approach.

We next turn to results of the variable dispersion zero inflated beta regression, presented in Table 3. We begin by considering the model for the mean exposure to proportion African American. The model for the mean uses a logit link function, and coefficients can be interpreted as an increase or decrease in the log odds of the estimated proportion African American. These results indicate that the mean location proportion African American is higher for African American youth relative to white youth (log odds of .31, with a 95% credible interval of .27 to .34). We find no meaningful difference between white youth (the reference category) by comparison with Hispanic and other race youth, as the 95% credible interval for both of these estimates contain zero. In terms of household income, we find that the average proportion African American decreases as household income increases; the log odds for youth in \$30k-\$60k households decreases by .12 relative to under 30k households. Similar differences are found for youth living in \$60k-150k (log odds -.15) and \$150k+ households (log odds -.23). All 95%

[3] For this analysis, the location percent African American is time-weighted to reflect the duration of exposure. Bayesian multilevel models reported below use non-time weighted data. Subsequent models will employ time-weighted data on locations.

credible intervals for household income differences did not contain zero, indicating a non-zero effect. The key covariate of interest in this preliminary model is the home tract percent African American. Consistent with expectations, we find that a 10 percent increase in residential tract percent African American is associated with a .39 increase in the log odds of exposure to proportion African American at activity locations. The 95% credible interval for this effect does not include zero.

We now interpret the model for the parameter representing precision. The model uses the log link function; coefficients can be interpreted as an increase or decrease in log(phi), where negative values of phi indicate more variability and positive values of phi indicate less variability in exposure to proportion African American. These results suggest no difference in the average phi between African American youth and white youth, conditional on household income and tract racial composition (95% credible interval -.05 to 0.16). Results do suggest racial differences in the precision between Hispanic youth and white youth (log .33, 95% credible interval .14 to .69), as well as between other race youth and white youth (log .10, 95% credible interval .04 to .18). We find no difference in log phi between different household income brackets and those under 30k, with the exception of the contrast between those in the $30k-$60k range and those making less than 30k (log -.19, 95% credible interval -.30 to -.09).

Turning to the tract racial composition effect on the precision, we find that a 10 percent increase in the residential tract percent African American leads to a .16 decrease in log phi (95% credible interval does not include zero). This finding indicates that the variability in location average proportion African American increases as neighborhood percent African American increases. The association is consistent with the expectation that the locations youth encounter in their daily routines exhibit greater variation in racial composition as the level of African American segregation of the youth's home neighborhood increases.

We provide model based predictions of the mean location proportion African American (Figure 1) and the standard deviation in proportion African American (Figure 2). These estimates are for an African American youth with a household income of under $30,000, varying the tract percent African American from less than 10% to >90%. Figure 1 plots the increase in the average location proportion African American across different levels of home tract African American. The estimated average location proportion African American is lower than the residential percent African American, particularly at higher levels of the latter. In Figure 2, we see a similar increase in the standard deviation of the average proportion location African American across different levels of home tract percent African American, with youth in the most segregated census tracts experiencing the most variability in terms of the location proportion African American.

In the context of the beta distribution, the standard deviation does not provide easily interpretable information on the estimated distribution of the outcome at varying levels of tract racial composition. In order to further our understanding of how the distribution of location proportion African American (both the mean and the precision of the distribution) changes across tract percent African American, we simulate raw data from several beta distributions in order to visualize the expected distribution of locations (simulated distributions are for an African American youth with less than $30,000 in annual household income, varying tract percent African American). Figure 3 presents ridge plots that allow for comparison of the simulated distributions across levels of tract percent African American. At the lowest levels of tract percent African American, the location proportion African American tends to be low, with a relatively low spread of values. However, across tract percent African American, we see that the dispersion of location proportion African American increases.[4] The dispersion shrinks somewhat at the highest levels of tract percent African American, but remains considerably larger than the spread observed at low levels of percent African American. Thus African American youth living in high percent African American neighborhoods experience substantial variability in the racial composition of the locations they visit.

Next Steps

We will investigate a number of extensions to the current models. The final analyses will incorporate variability in exposure to areas of different socioeconomic composition as well as racial composition. In addition, these preliminary models include only a subset of the covariates we will ultimately consider. Clearly, including a larger array of controls will be necessary to establish the robustness of any residential neighborhood effects on variability in location exposures. We will also explore the potential for interactions in the impact of residential tract characteristics by race as well as time-weighted versions of the dependent variable. With respect to modeling strategy, we will consider alternative approaches that minimize model complexity without compromising the quality of estimates. In particular, we will explore non-zero-inflated variable dispersion models that facilitate model interpretation and speed model fitting. Finally, we will incorporate models of exposure to particular kinds of neighborhoods by race and tract composition. For instance, estimates of the likelihood that youth who reside in segregated African American and low-SES neighborhoods spend a non-trivial amount of time in white-dominated and affluent residential areas would shed additional light on the extent of exposure heterogeneity among urban youth.

[4] Note that the precision varies as a function of the mean as well as covariates in this non-linear model.

Conclusion

Heterogeneity of urban spatial exposure remains a woefully understudied phenomenon despite its centrality to many foundational perspectives on urban experience. In these preliminary analyses, we investigated the extent to which youth from a large urbanized area in and around Columbus, OH encountered variability in exposures to racial composition in the course of their daily routines. Using data from a novel, smartphone-based study of the GPS tracks of a large sample of urban youth, we found evidence challenging the assumption that youth from African American segregated neighborhoods were isolated from neighborhoods of differing racial composition.

First, we found evidence of non-trivial within-individual variability in the racial compositions of locations to which youth were exposed. Perhaps more telling, considering only *non-home* time – the time during which youth are at risk of exposure to residential neighborhood and broader urban environments – the proportion of the variance in exposure to proportion African American at the location level rose substantially. This finding points to the significant role of time spent at home in accounting for the total time youth spend "in the neighborhood." Although time at home is geographically located within the home neighborhood, the experience of time at home is likely fundamentally different than non-home time (Furstenberg et al. 1999). The role of the location level in the variance decomposition also points to the potential for high levels of variability in the actual exposures of youth on an everyday basis.

Second, we presented simple calculations on the average deviation of the exposure to proportion African American in activity locations by comparison with home neighborhood racial composition for African American and white youth. Here, we observed that actual exposures tended to be significantly whiter for African American youth while those for white youth were comparable across residential neighborhoods and activity locations.

Finally, we explicitly modeled variation in exposure heterogeneity by fitting models that incorporate random effects for variance terms. These models corroborated our expectation that, net of individual level race/ethnicity and income, residential tract percent African American was positively associated with location heterogeneity.

In sum, these preliminary findings offer evidence that the everyday spatial exposures of youth who reside in neighborhoods with higher percentages of African Americans are both whiter than their home neighborhoods and more variable than neighborhoods with smaller percentages of African Americans. The implications of the findings for neighborhood effects research generally are significant. Findings pointing to the (typically) negative outcomes of residence in segregated African American neighborhoods assume that exposures are dominated by the home neighborhood. To the extent that average everyday experiences are both whiter and substantially more variable than a "neighborhood containment" approach would expect, the impact of residence in a segregated neighborhood cannot be unproblematically attributed to characteristics of the home neighborhood. To the extent that residence in a segregated neighborhood is associated with greater exposure variability – as opposed to isolation – the mechanisms translating segregation into negative outcomes must be revisited. Among African American youth, exposures to compositionally distinct neighborhoods no doubt offer access to otherwise unavailable resources; however, there may be significant downsides to substantial exposure heterogeneity in the form of perceived threat of harassment, the burdens associated with regularly required code-switching, and associated stress. To date, however, empirical research on the consequences of exposure heterogeneity for mental health, physiological stress, and other aspects of development is limited.

Despite the unprecedented nature of the data on exposure used in the current analyses, the approach is nevertheless limited in several respects. First, the observed exposure window is limited to five days. Observation over a longer period of time would help to corroborate findings presented here. Second, although the data collection effort employed a respondent-driven data cleaning approach to ensure the accuracy of the smartphone-based GPS data, the validation of the GPS data relied on the subject's recall of activities and travel patterns. The space-time budget approach incorporated a recall-aided component (using the respondents reports on EMAs and contextual data on travel paths to trigger memory); however, we cannot rule out the possibility of error in instances where the respondent chose to correct the GPS-derived information on time spent at locations. Third, the study is based on only one metropolitan area. The Columbus area is highly segregated and therefore unlikely to be a context in which variability in exposures to areas of different racial and socioeconomic compositions is inflated by comparison with other large US cities. Comparable data on a variety of urban areas, however, is needed to understand how exposure heterogeneity varies by context.

With the advent of new technologies for the measurement of mobility – particularly smartphone-based passive data collection on travel paths and minimally invasive EMA – population research on the spatial experiences of urban dwellers has entered a new era of possibility. These data offer the potential to shed unprecedented light on foundational questions in urban spatial demography.

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Table 1: Descriptive Statisics for Analytic Sample (i = 40,017 Locations, j = 1,256 Youth, k = 182 Tracts)

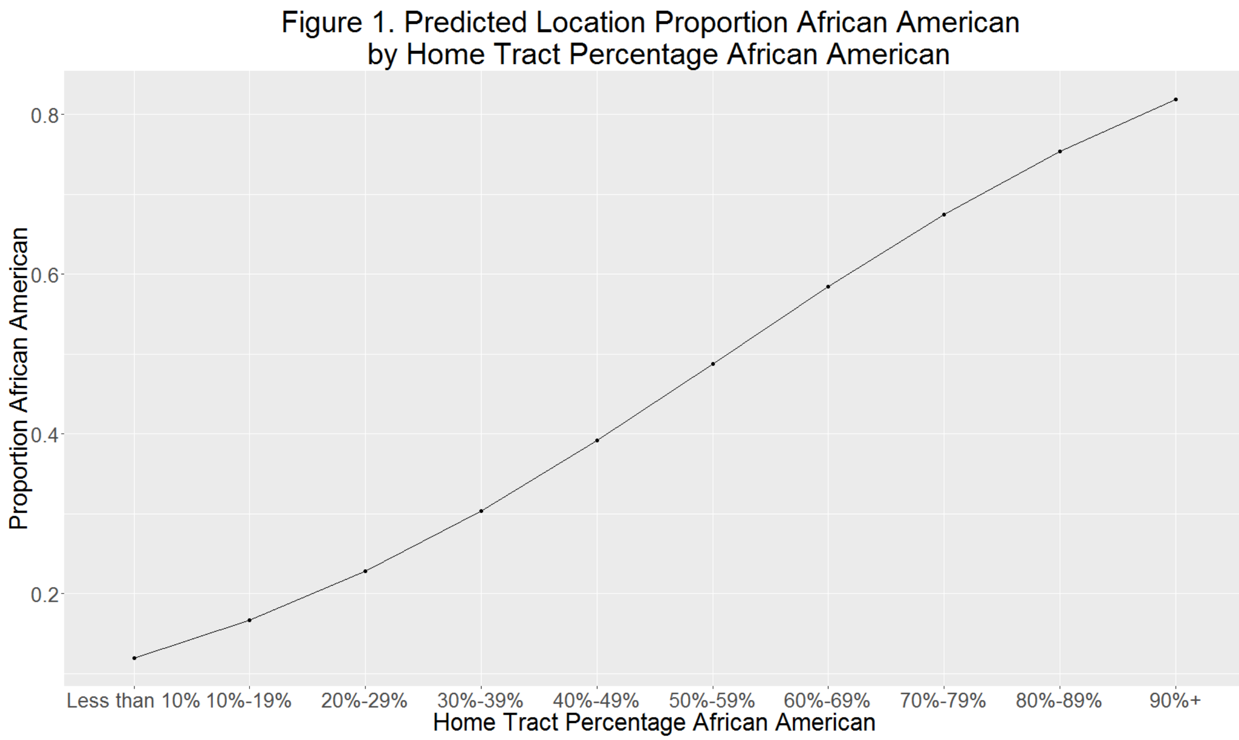
Variable	MEAN or %	SD	Min - Max	
Location Proportion African American	0.27	0.3	0	0.99
Youth Number of Locations	31.86	16.22	1	103
Youth Race				
White Youth	0.465			
Black Youth	0.436			
Hispanic Youth	0.056			
Other Race Youth	0.043			
Youth Household Income				
Under $30,000	0.361			
$30,001 - 60,000	0.241			
$60,001 - 150,000	0.283			
$150,000 or more	0.115			
Youth Home Census Tract				
Tract % Black (10% Interval)	3.72	2.92	1	10

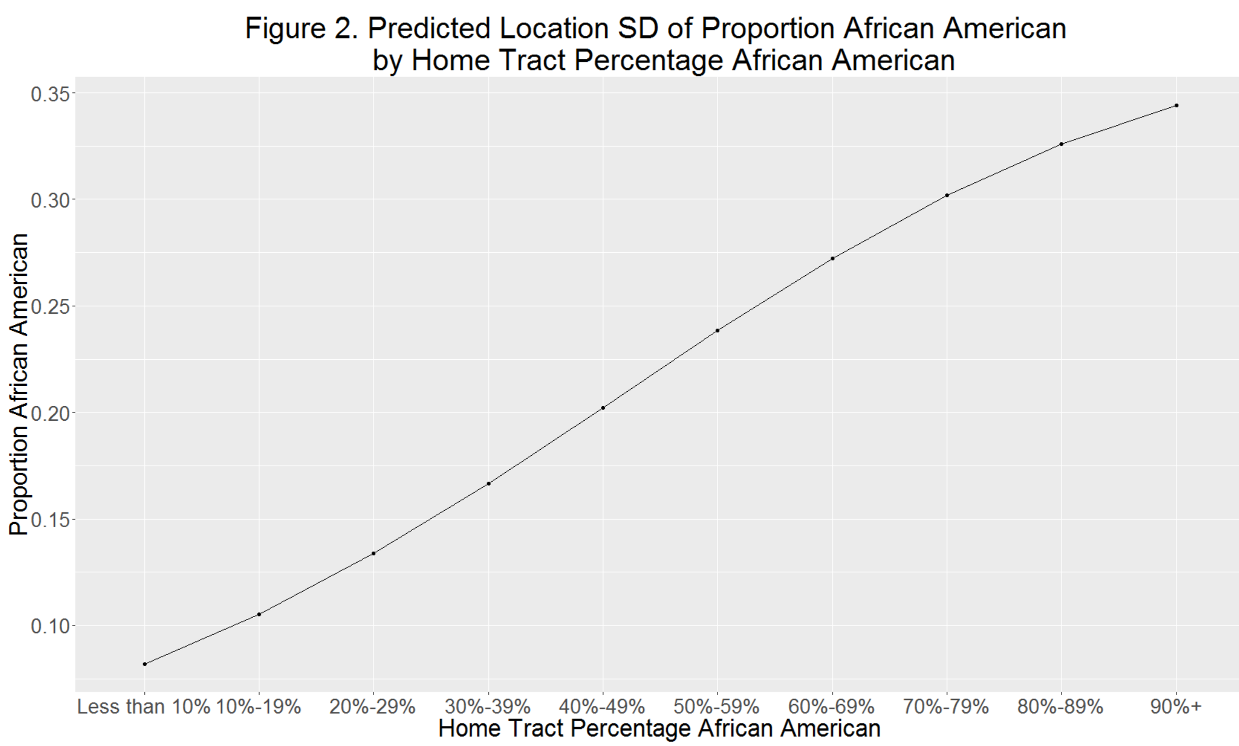
Table 2. Decomposition of Variance from Three-Level Models of Waking Time on Proportion Black at Activity Locations

Level	Pooled Sample	White Youth	Black Youth	Pooled Sample Non-Home Time	White Youth Non-Home Time	Black Youth Non-Home Time
Tract	53%	55%	38%	37%	34%	22%
Individual	8%	5%	10%	13%	8%	16%
Location	39%	40%	52%	50%	58%	63%

Table 3: Results from Bayesian Variable Dispersion Beta Regression Predicting Location Proportion African American as a function of Youth and Tract Level Covariates

Variable	Model 1			
	Estimate	Error	95% Credible Interval	
Mean Model				
Youth Race				
White Youth	REF	REF	REF	REF
Black Youth	0.31	0.03	0.27	0.34
Hispanic Youth	-0.01	0.02	-0.04	0.02
Other Race Youth	0.04	0.08	-0.04	0.17
Youth Household Income				
Under 30K	REF	REF	REF	REF
30k-60k	-0.12	0.03	-0.16	-0.08
60k-150k	-0.15	0.04	-0.19	-0.1
150k+	-0.23	0.04	-0.28	-0.17
Youth Home Census Tract				
Tract % Afr Am (10% cat)	0.39	0.01	0.38	0.39
Intercept	-2.7	0.03	-2.75	-2.67
Precision Model				
Youth Race				
White Youth	REF	REF	REF	REF
Black Youth	0.04	0.08	-0.05	0.16
Hispanic Youth	0.33	0.21	0.14	0.69
Other Race Youth	0.10	0.06	0.04	0.18
Youth Household Income				
Under 30K	REF	REF	REF	REF
30k-60k	-0.19	0.07	-0.30	-0.09
60k-150k	-0.01	0.16	-0.23	0.19
150k+	0.28	0.16	0.00	0.44
Youth Home Census Tract				
Tract % Black (10% Interval)	-0.16	0.02	-0.19	-0.14
Intercept	2.99	0.18	2.71	3.22
Random Effects (SD)				
Tract (Mean)	0.52	0.05	0.47	0.61
Youth (Mean)	0.56	0.04	0.49	0.60
Tract (Precision)	0.42	0.40	0.00	0.92
Youth (Precision)	1.55	0.06	1.45	1.62
Zero Inflation	0.17	0.00	0.17	0.18





Note: SD=Standard Deviation

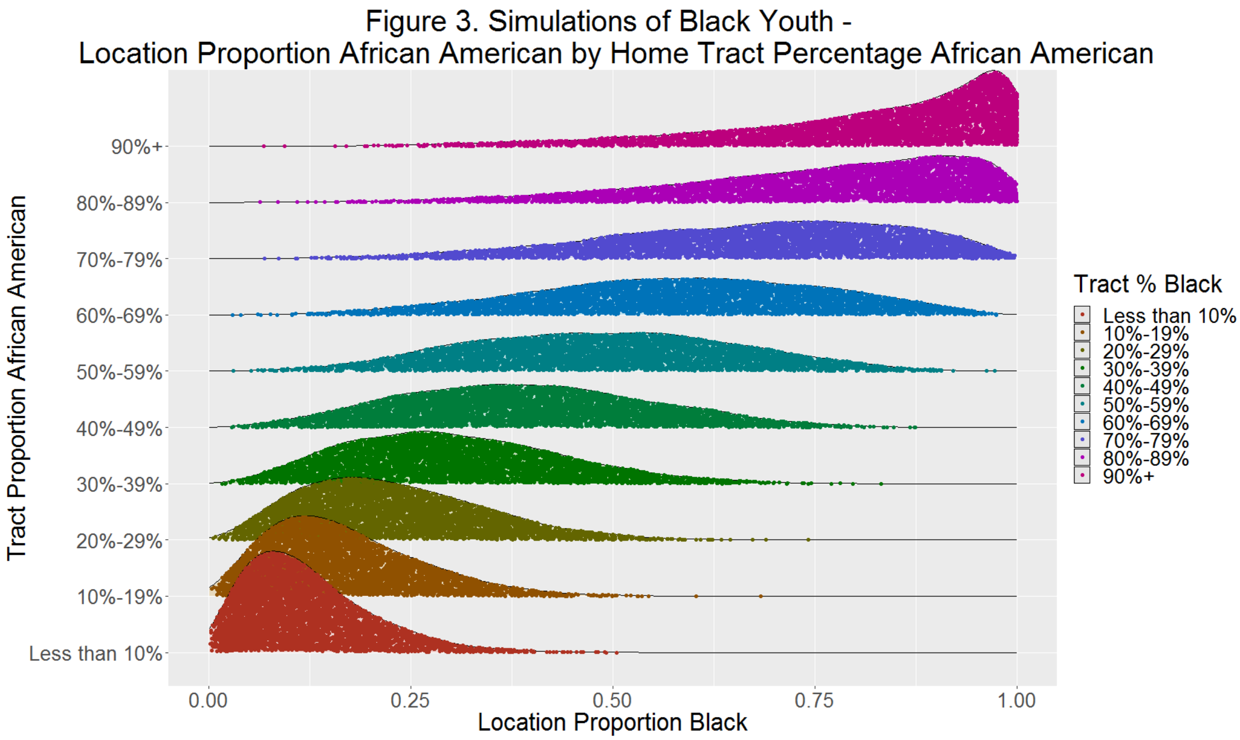


Figure 3. Simulations of Black Youth -
Location Proportion African American by Home Tract Percentage African American
Tract Proportion African American
90%+
80%-89%
70%-79%
60%-69%
50%-59%
40%-49%
30%-39%
20%-29%
10%-19%
Less than 10%
0.00
0.25
0.50
0.75
1.00
Location Proportion Black
Tract % Black
Less than 10%
10%-19%
20%-29%
30%-39%
40%-49%
50%-59%
60%-69%
70%-79%
80%-89%
90%+