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 a key feature of social structure - racial composition. We use unique geospatial data on the travel paths of a large sample of youth from the Columbus, OH-based *Adolescent Health and Development in Context* study. Contrary to the expectations of the dominant theoretical approach to neighborhood influence – the neighborhood social isolation model – findings indicate that youth residing in segregated African American neighborhoods spend a significant proportion of their time in white-dominated areas. In addition, increases in the percent African American of the residential neighborhoods youth reside in is associated with greater variability in the racial composition of the locations they encounter. Implications for interpreting findings from decades of research on the influence of residence in segregated neighborhoods and the conduct of "neighborhood effects" research more broadly are discussed.

Urban heterogeneity by factors such as race, ethnicity, and socioeconomic status has been a central preoccupation of urban researchers since the inception of sociology. 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 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 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, and 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 neighborhood 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 racially segeregated, 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. 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 to area racial composition: 1) exposures of youth who reside in socially isolated, segregated neighborhoods to neighborhoods dominated by other race groups are likely to be negligible (e.g., black youth who live in high black composition neighborhoods will not encounter white-dominated neighborhoods with any regularity), and 2) heterogeneity of exposure to racial composition is least likely among youth who reside in socially isolated neighborhoods.

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 within individual exposure variability.

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 potentially 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 neighborhoods of comparable composition, particularly 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. In this view, residents of segregated 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) residents of segregated, African American neighborhoods will experience non-trivial levels of exposure to white-dominated areas, and 2) residents of segregated African American communities will experience significantly *larger* variability in exposures to locations by race and socioeconomic status than residents of white-dominated or integrated 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; the 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 1167 youth (with non-missing information on covariates), and 181 census tracts.

MEASURES

Dependent Variable

In the current analyses, the dependent variable is based on the Census block group proportion African American or white for the specific location encountered. We consider the proportion of time spent in block groups characterized by high proportions (>=70%) African American or white for youth during all waking hours and during non-home time over the 5-day period. We also examine the time-weighted standard deviation of the distribution of percent African American characterizing the locations youth spend time at over the course of the five-day period (see Analytic Strategy below).

Individual-level measures

At the individual level, we include measures of youth socio-demographics and caregiver socioeconomic characteristics. *Race/ethnicity* includes three categories: white (reference category), African American, other race. *Youth gender* is a two category measure: female (reference) and male. *Youth age* was left as a continuous measure. *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). *Caregiver marital status* includes four categories: married (reference), cohabitating, single, and other. *Caregiver education* measured ten categories of educational attainment, ranging from primary education to professional degree. This was left continuous in the model. *Home ownership* is a binary indicator of whether the caregiver was a home owner. *Years in neighborhood* was a continuous measure that captured the amount of time the caregiver has lived in the neighborhood.

Neighborhood-level measures

To capture residential neighborhood exposures, we use the residential census tract percent African American, also using the 2009-2013 ACS data. We use a three-category operationalization of this measure, capturing neighborhoods that are less than 30%, between 30% and 70%, and greater than or equal to 70% African American.

Analytic Strategy

To estimate the proportion of time spent in neighborhoods of differing racial composition, we employ multilevel zero-inflated beta regression models. Specifically, we model the individual level proportion of time spent in high proportion African American and white block groups as a function of individual covariates and tract-level racial composition. For proportions strictly between 0 and 1, the beta distribution is a convenient distributional assumption for the outcome, facilitating a modeling specified in the generalized linear mixed model framework (GLMM).

Since our data contains observed proportions equal to zero (i.e., no time in high proportion African American block groups), we employ a mixture model extension of the standard multilevel beta GLM as follows.

Specifically, let Y_{ij} be the proportion of time spent in >70% African-American (or White) block group for the i^{th} respondent, in the j^{th} tract. We assume that Y_{ij} | $\gamma_{ij}, \mu_{ij}, \phi$ 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

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

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

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

Conditional on $y_i \epsilon (0,1)$, we assume

$$\frac{\mu_{ij}}{1-\mu_{ij}}$$

¿

¿

ln¿ (1)

where β_{0j} is the intercept and β_p are the coefficients associated with the effects of *P* respondent-level covariates X_{pij} on the expected proportion of time spent in >70% African-American (or White) block groups.

We assume

$$\beta_{0j} = \sigma_{00} + \sum_{q=1}^{Q} \sigma_q^{(tract)} X_{qj}^{(tract)} + u_{0j} \qquad u_{0j} \quad N(0, \tau^2) \qquad (2)$$

where σ_{0j} is the intercept, σ_q are the coefficients associated with the effects of *Q* tract-level covariates X_{qj} on the expected proportion of time spent in >70% African-American (or White) block groups, and u_{0j} is an independent and identically distributed error term with mean 0 and tract level specific variance τ^2 .

Equation 3 represents the complete version of the model:

$$\frac{\mu_{ij}}{1-\mu_{ij}}$$

¿

¿

ln¿ (3)

We directly model the probability of spending zero proportion of time in segregated locations, and allow this probability to vary as a function of respondent and tract covariates, and account for clustering within tracts.

Let γ_{ij} be the probability of respondent *i,* living in tract *j* reporting no time in >70% African-American (or White) block groups. We assume that

$$\ln\left(\frac{\gamma_{ij}}{1-\gamma_{ij}}\right)=\alpha_{0j}+\sum_{p=1}^{P}\alpha_p^{(respondent)}X_{pij}^{(respondent)} \quad (4)$$

where α_{0j} is the intercept and α_p are the coefficients associated with the effects of *P* respondent-level covariates X_{pij} on the expected probability of spending no proportion of time in >70% African-American (or White) block groups. We then assume

$$\alpha_{0j}=\delta_{00}+\sum_{q=1}^{Q}\delta_q^{(tract)}X_{qj}^{(tract)}+d_{0j} \qquad d_{0j}\ N\left(0,\psi^2\right) \quad (5)$$

where δ_{00} is the intercept, δ_{0q} are the coefficients associated with the effects of *Q* location-level covariates X_{qj} on the expected probability of spending no time in >70% African-American (or White) block groups, and d_{0j} is an independent and identically distributed error term with mean 0 and tract level specific variance ψ^2 . Equation 6 represents the complete version of the model:

$$\ln\left(\frac{\gamma_{ij}}{1-\gamma_{ij}}\right)=\delta_{00}+\sum_{p=1}^{P}\alpha_p^{(respondent)}X_{pij}^{(respondent)}+\sum_{q=1}^{Q}\delta_q^{(tract)}X_{qj}^{(tract)}+d_{0j} \quad (6)$$

In order to account for the temporal dimension of the GEMA location data, we generate respondent level time-weighted means and time-weighted variances for average location proportion African American. These are produced using the following equations:

$$w$$

$$\frac{\sum_{i=1}^{N}\left(\text{¿¿}\, i\, x_i\right)}{\sum_{i=1}^{N} w_i}$$

$$\hat{\mu}=\text{¿}$$

Here, let $\hat{\mu}$ represent a respondents mean location proportion African American, w_i represent the proportion of their observed time spent in location i, and x_i represent the location proportion African American.

Next, we use this time-weighted mean to calculate the time-weighted variance of location proportion African American. These are generated using the following equation:

$$\hat{\sigma}^2=\frac{\sum_{i=1}^{N} w_i\left(x_i-\mu^{\text{¿}}\right)}{\sum_{i=1}^{N} w_i}$$

Here let $\hat{\sigma}^2$ represent the respondents variance in location proportion African American, w_i represent the proportion of their observed time spent in location i, x_i represent the location proportion African American, and $\mu^{\text{¿}}$ represent the respondents time-weighted mean location proportion African American. For modeling and descriptive purposes, we take the square root of the time-weighted variance to generate the time-weighted standard deviation.

Results

Table 1 presents descriptive statistics for variables included in the analysis. For outcomes measures of exposure to racial composition, we consider both the proportion of observed *waking* time and the proportion of observed *non-home* time. The latter captures the allocation of time to place outside of time spent within the confines of the home. The average proportion of observed waking time spent in block groups >=70% African American is .15 while the comparable figure for >=70% white block groups is .53. The average time-weighted standard deviation for the proportion African American in block groups encountered is .11. Focusing on non-home time, the average proportion of time spent in African American-dominated block groups is .10, compared with .53 for white-dominated block groups. The average time-weighted standard deviation for the proportion African American in block groups encountered during non-home time is .12.

With respect to demographics, the racial distribution of the sample is roughly equally distributed across white and African American youth (47% and 43%, respectively, with 10% of the sample in a combined "Other" category - Hispanic race/ethnicity youth represent a comparatively small percentage of the sample - 6%). With respect to annual household income, 35% report income under $30,000 per year, 24% report income between $30,001-$60,000, 29% 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 tertiles - 57% reside in <30% African

American tracts, 26% in 30% - 70% African American tracts, and 17% in >=70% African American tracts.

We next turn to results of zero inflated multilevel beta regressions of time spent in high proportion African American and white block groups, presented in Table 2. The coefficients can be interpreted as an increase or decrease in the log odds of the estimated proportion of time spent in high African American block groups. Both models include measures of tract racial composition; consequently, coefficients for individual level covariates should be interpreted net of the racial composition of residential neighborhoods. Unsurprisingly, African American youth spend more time in African American-dominated block groups than white youth (African American race is negatively associated with spending no time in high proportion African American neighborhoods and positively associated with the proportion of time spent in African American-dominated neighborhoods by comparison with white youth (conditional on spending a non-zero amount of time in such neighborhoods). Other race/ethnicity youth are also more likely to spend time in high proportion African American neighborhoods (with a coefficient somewhat larger than that of African American youth). Middle income youth spend less time in high proportion African American block groups than low income youth; however, net of residential tract composition, higher income youth are not significantly less likely to spend time in high proportion African American block groups. Years resident in the neighborhood is positively associated with time spent in high proportion neighborhoods while youth age is negatively associated with this outcome.

Considering tract racial composition, model 1 offers strong evidence that increases in the proportion African American of the youth's residential tract is positively associated with time spent in high proportion African American neighborhoods. This association is expected, particularly given that the specification of the dependent variable (based on proportion of waking time) includes time spent at home. Consequently, for those youth who reside in high proportion African American tracts, time spent at home will be included in the proportion of time spent in African American-dominated neighborhoods.

Model 2 estimates the proportion of non-home time spent in high proportion African American neighborhoods. The pattern of individual level associations with this outcome is comparable to that for model 1, with the exception that other race/ethnicity and age are no longer significant predictors while home ownership becomes significantly negatively associated with time spent in high proportion African American block groups. With respect to tract characteristics, model 2 indicates that increasing African American composition is negatively associated with spending no time in high proportion African American block groups and positively associated with the proportion of time spent in high proportion African block groups (conditional on spending non zero time in these areas). Although in the latter case, only residing in tracts that are 70% or greater African American is significantly associated with the outcome. Tests of interactions between residential tract racial composition and individual level race revealed no evidence that residential racial composition differentially affects the outcome by race.

Figures 1A and 1B plot the predicted proportion of time spent in high proportion African American block groups by race and residential tract composition for both waking and non-home time. Tract racial composition is the major driver of time spent in African American dominated block groups. The predicted proportions of time spent in African American dominated block groups for white and African American youth who reside in tracts with less than 30% African American residents are .02 and .06, respectively. For those residing in 30% to <70% African

American tracts, the proportions rise to .07 and .16. For those residing in 70% or greater African American tracts, the proportions of time spent in African American dominated block groups rise substantially, to .47 and .58, respectively. Despite the strong association of residential tract racial composition with proportion time spent in African American dominated block groups for both races, youth who reside in African American neighborhoods nevertheless do not spend the vast majority of their time in comparable neighborhoods. Even African American youth residing in segregated neighborhoods still spend only modestly above half of their time in areas of comparable racial composition.

Turning to non-home time shown in figure 1B, for youth who reside in high proportion African American residential tracts, the proportion of time outside the home that these youth spend in block groups with comparable racial composition is only .19 for white youth and .33 for African American youth. In the case of the latter, African American youth who live in segregated African American tracts spend only one third of their non-home time in segregated block groups, indicating that everyday exposures to non-segregated places constitute a significant majority of their exposures beyond the home.

Although African American youth living in segregated neighborhoods may experience lower levels of exposure to segregated African American areas in their everyday exposures than the neighborhood social isolation model would expect, these analyses do not address the extent of their encounters with *white-dominated* areas. Table 3 reports the results of multilevel zero-inflated beta regressions of the proportion of time spent in 70% or greater white block groups. Again, analyses are presented for both waking time and non-home time. African American youth are significantly less likely to spend time in white-dominated areas than white youth when considering both waking and non-home time. Although the models indicate some differences in individual level covariate effects on time spent in white block groups, the most powerful associations with this outcome are observed for tract racial composition effects, consistent with the analysis of exposure to African American block groups. The interaction between tract racial composition and individual race does not achieve statistical significance.

Figures 2A and 2B plot the predicted proportions of time spent in 70% or greater block groups by race and tract racial composition for both waking and non-home time. Tract racial composition exerts a powerful influence on the extent of exposure to white areas. However, even African American youth who reside in 70% or greater African American neighborhoods spend a non-trivial proportion of their waking time (.13) in 70% or greater white block groups. Considered at the day level, 13% of a 16 hour waking period (roughly the average amount of time awake for the sample) corresponds to over 2 hours of time. This indicates that black youth who live in segregated areas experience high levels of exposure to white dominated areas, not just areas with integrated racial composition (or areas with marginally lower proportions of African Americans than .70). The predicted amount of time spent in white block groups for segregated African American youth is also over twice the proportion of time these youth are expected to spend outside their home within their residential tract (about .05). Thus exposure to white-dominated areas among segregated African American youth is, on average, substantially more common than is exposure to their own residential neighborhoods. Among these youth, the proportion of time spent in white block groups rises to .25 when considering only non-home time, again demonstrating the salience of white neighborhoods for segregated African American youth.

An alternative method of capturing the extent to which youth exposures to racial composition varies across their everyday experiences focuses on the distribution of exposures to block group racial composition across all locations visited. Specifically, we consider the time-weighted standard deviation of exposure to proportion African American over the course of the five-day period considered. We test the neighborhood social isolation hypothesis that segregated African American neighborhoods are likely to experience the *least* variable exposures to racial composition contrasted with the compelled mobility expectation that youth in these neighborhoods will experience the *greatest* variability in their exposures.

Models 1 through 4 of table 4 report results of models without and without tract by race interactions for waking and non-home time, respectively. Model 1 indicates that African American youth have significantly larger standard deviations (SD) of exposure to proportion African American than white youth. Middle income status ($30k - $60k) and home ownership are also positively associated with the outcome. Considering tract racial composition, we see that residence in 30% - 70% African American tracts is positively and significantly associated with the time-weighted SD (coefficient = .06) by comparison with low percent African American neighborhoods. Residing in tracts that are 70% or greater African American, however, is also positively associated with the time-weighted SD with a coefficient that is nearly twice the size (.11) of that for integrated neighborhoods. Incorporating interaction terms in model 2 offers evidence of a significant interaction for African American youth. Analyses of non-home time reveal a weaker but nevertheless increasing impact of African American composition on the magnitude of the time-weighted SD.

Figures 3A and 3B plot the predicted time-weighted SD by residential tract proportion African American and race for both waking time and non-home. For waking time, the trend clearly indicates that variability in exposures to proportion African American increases with the proportion African American of the residential tract. Again, the pattern is also positive, but weaker for non-home time among African American youth. These analyses indicate that, for African American youth, residing in a segregated African American neighborhood is associated with *greater* variability in spatial exposures to racial composition, consistent with the compelled mobility approach and challenging those of the neighborhood social isolation model.

Conclusion

Heterogeneity of urban spatial exposure remains a woefully understudied phenomenon despite its centrality to many foundational perspectives on urban experience. In these 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 examined the extent to which youth spend time in neighborhoods of differing racial composition with a focus, in particular, on African American youth who reside in segregated African American neighborhoods. We found evidence that these youth spend a substantial amount of time outside segregated African American areas. More telling, these youth spent non-trivial amounts of time in *white-dominated* areas, suggesting the importance of white spaces for everyday spatial experiences among African American youth residing in segregated neighborhoods. These results held for both waking time and non-home time.

Second, we investigated the association between tract racial composition and the extent of variability in everyday exposures to proportion African American spaces. These analyses offered evidence that residence in high proportion African American census tracts was associated with greater variability in exposures to proportion African American areas. These findings counter the expectation of the neighborhood social isolation approach that segregated African American neighborhoods constrain exposures, limiting the extent to which exposures to places of differing racial composition will occur.

In sum, these findings offer evidence that the everyday spatial exposures of youth who reside in neighborhoods with higher percentages of African Americans are both substantially 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 considerably more variable than a "neighborhood containment" assumption 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 (1,167 Youth in 181 Tracts)

Variable	MEAN or %	SD	Min	Max
Waking Time				
Proportion Spent >70% Black Block	.15	.29	0	.99
Proportion Spent >70% White Block	.53	.42	0	.99
Time-Weighted SD Proportion Black	.11	.09	0	.44
Non-Home Time				
Proportion Spent >70% Black Block	.10	.22	0	.99
Proportion Spent >70% White Block	.58	.38	0	.99
Time-Weighted SD Proportion Black	.12	.10	0	.45
Youth Race				
White Youth	47%			
African American Youth	43%			
Other Race Youth	10%			
Caregiver Marital Status				
Married	54%			
Cohabitating	10%			
Single	20%			
Other	16%			
Household Income				
Under $30,000	35%			
$30,001 - 60,000	24%			
$60,001 - 150,000	29%			
$150,000 or more	12%			
Caregiver Education	6.01	1.67	1	10
Caregiver Owns Home	62%			
Years in Neighborhood	12.02	10.21	0	62
Youth Home Census Tract				
Tract <30 % African American	57%			
Tract 30-70 % African American	26%			
Tract >70 % African American	17%			

Table 2: Results from Beta Regression

	Model 1: Waking Time	Model 2: Non-Home Time
Variable	Proportion of Time >70% Black Estimate (SE)	Proportion of Time >70% Black Estimate (SE)
Mean Model		
Youth Race		
White Youth	REF	REF
African American Youth	0.28 (0.14)*	0.41 (0.14)**
Other Race Youth	0.38 (0.19)*	0.31 (0.20)
Male Youth	0.08 (0.09)	0.10 (0.10)
Youth Household Income		
Under 30K	REF	REF
30k-60k	-0.36 (0.12)**	-0.42 (0.13)**
60k-150k	-0.09 (0.17)	-0.18 (0.17)
150k+	0.07 (0.27)	-0.22 (0.28)
Caregiver Education	-0.04 (0.04)	0.03 (0.04)
Caregiver Marital Status		
Married	REF	REF
Cohabitating	-0.02 (0.16)	-0.04 (0.17)
Single	0.15 (0.13)	0.22 (0.14)
Other	0.03 (0.14)	0.01 (0.15)
Years in Neighborhood	0.02 (0.01)***	0.02 (0.01)***
Home Owner	-0.20 (0.13)	-0.29 (0.13)*
Youth Age	-0.07 (0.03)**	0.00 (0.03)
Youth Home Census Tract		
Tract <30 % African American	REF	REF
Tract 30-70 % African American	0.41 (0.13)**	0.02 (0.14)
Tract >70 % African American	2.15 (0.15)***	0.43 (0.15)**
Intercept	-0.91 (0.44)*	-1.73 (0.47)***
Zero Inflation Model		
Youth Race		
White Youth	REF	REF
African American Youth	-1.16 (0.22)***	-1.15 (0.21)***
Other Race Youth	-0.30 (0.29)	-0.44 (0.27)
Male Youth	0.28 (0.17)	0.29 (0.16)
Youth Household Income		
Under 30K	REF	REF
30k-60k	-0.11 (0.23)	-0.17 (0.22)
60k-150k	0.19 (0.28)	0.11 (0.27)
150k+	0.16 (0.38)	0.10 (0.37)
Caregiver Education	-0.02 (0.06)	-0.01 (0.06)
Caregiver Marital Status		
Married	REF	REF
Cohabitating	-0.05 (0.31)	-0.08 (0.29)
Single	0.03 (0.27)	0.05 (0.25)

Other	0.13 (0.26)	0.08 (0.24)
Years in Neighborhood	-0.00 (0.01)	-0.01 (0.01)
Home Owner	0.06 (0.24)	0.04 (0.23)
Youth Age	0.02 (0.05)	0.04 (0.04)
Youth Home Census Tract		
Tract <30 % African American	REF	REF
Tract 30-70 % African American	-2.01 (0.20)***	-1.84 (0.20)***
Tract >70 % African American	-4.15 (0.36)***	-3.10 (0.28)***
Intercept	1.56 (0.76)*	1.39 (0.72)
Precision-like Parameter	0.92 (0.06)***	0.75 (0.06)***
Number of Observations	1167	1167

Notes: Standard Errors are based on two tailed hypothesis tests $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 3: Results from Beta Regression

	Model 3: Waking Time	Model 4: Non-Home Time
Variable	Proportion of Time >70% White Estimate (SE)	Proportion of Time >70% White Estimate (SE)
Mean Model		
Youth Race		
White Youth		
African American Youth	-0.39 (0.09)***	-0.41 (0.10)***
Other Race Youth	0.02 (0.11)	0.03 (0.12)
Male Youth	0.09 (0.06)	0.17 (0.07)*
Youth Household Income		
Under 30K		
30k-60k	0.02 (0.09)	0.09 (0.10)
60k-150k	0.05 (0.11)	0.20 (0.12)
150k+	0.08 (0.14)	0.25 (0.15)
Caregiver Education	0.02 (0.02)	0.02 (0.03)
Caregiver Marital Status		
Married		
Cohabitating	-0.16 (0.12)	-0.29 (0.13)*
Single	-0.09 (0.10)	-0.13 (0.11)
Other	-0.01 (0.10)	-0.05 (0.10)
Years in Neighborhood	-0.01 (0.00)*	-0.01 (0.00)**
Home Owner	0.33 (0.09)***	0.25 (0.10)*
Youth Age	0.02 (0.02)	0.01 (0.02)
Youth Home Census Tract		
Tract <30 % African American		
Tract 30-70 % African American	-1.99 (0.09)***	-1.04 (0.09)***
Tract >70 % African American	-2.33 (0.11)***	-1.19 (0.12)***
Intercept	0.80 (0.28)**	0.76 (0.31)*
Zero Inflation Model		
Youth Race		
White Youth		
African American Youth	1.28 (0.41)**	1.25 (0.40)**
Other Race Youth	0.50 (0.57)	0.61 (0.54)
Male Youth	0.28 (0.22)	0.32 (0.22)
Youth Household Income		
Under 30K		
30k-60k	-0.92 (0.32)**	-0.95 (0.32)**
60k-150k	-0.46 (0.43)	-0.44 (0.42)
150k+	-0.93 (1.10)	-1.09 (1.09)
Caregiver Education	-0.10 (0.09)	-0.10 (0.09)
Caregiver Marital Status		
Married		
Cohabitating	0.41 (0.38)	
Single	0.36 (0.31)	0.49 (0.37)

Other	0.10 (0.36)	0.38 (0.31)
Years in Neighborhood	0.02 (0.01)	0.09 (0.36)
Home Owner	-0.20 (0.31)	0.02 (0.01)
Youth Age	0.04 (0.06)	-0.16 (0.30)
Youth Home Census Tract		
Tract <30 % African American		
Tract 30-70 % African American	1.60 (0.39)***	1.42 (0.37)***
Tract >70 % African American	1.91 (0.41)***	1.74 (0.38)***
Intercept	-4.56 (1.11)***	-4.36 (1.09)***
Precision-like Parameter	1.02 (0.04)***	0.68 (0.04)***
Number of Observations	1167	1167

Notes: Standard Errors are based on two tailed hypothesis tests ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 4: Results from Mixed Linear Regression Model

Variable	Model 5 Time-Weighted Waking Time SD of Proportion Black Estimate (SE)	Model 6 Time-Weighted Waking Time SD of Proportion Black Estimate (SE)	Model 7 Time-Weighted Non-Home Time SD of Proportion Black Estimate (SE)	Model 8 Time-Weighted Non-Home Time SD of Proportion Black Estimate (SE)
Youth Race				
White Youth	REF	REF	REF	REF
African American Youth	0.02 (0.01)**	0.04 (0.01)***	0.03 (0.01)***	0.05 (0.01)***
Other Race Youth	0.01 (0.01)	-0.00 (0.01)	0.00 (0.01)	-0.01 (0.01)
Male Youth	-0.01 (0.00)	-0.01 (0.00)	-0.00 (0.01)	-0.00 (0.00)
Youth Household Income				
Under 30K	REF	REF	REF	REF
30k-60k	0.02 (0.01)*	0.02 (0.01)**	0.01 (0.01)*	0.01 (0.01)*
60k-150k	0.01 (0.01)	0.01 (0.01)	0.00 (0.01)	0.00 (0.01)
150k+	-0.00 (0.01)	0.00 (0.01)	-0.01 (0.01)	-0.00 (0.01)
Caregiver Education	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
Caregiver Marital Status				
Married	REF	REF	REF	REF
Cohabitating	0.01 (0.01)	0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)
Single	-0.00 (0.01)	-0.00 (0.01)	0.01 (0.01)	0.00 (0.01)
Other	0.01 (0.01)	0.01 (0.01)	0.00 (0.01)	0.00 (0.01)
Years in Neighborhood	-0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Home Owner	0.02 (0.01)**	0.02 (0.01)**	0.00 (0.01)	0.00 (0.01)
Youth Age	-0.00 (0.00)	-0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Youth Home Census Tract				
Tract <30 % African American	REF	REF	REF	REF
Tract 30-70 % African American	0.06 (0.01)***	0.08 (0.01)***	0.06 (0.01)***	0.08 (0.01)***
Tract >70 % African American	0.11 (0.01)***	0.15 (0.03)***	0.07 (0.01)***	0.06 (0.03)*
Tract*Race Interactions				
Tract 30-70 % A.A.* A.A. Youth		-0.03 (0.01)*		-0.05 (0.02)***
Tract 30-70 % A.A.* A.A. Youth		0.01 (0.02)		0.00 (0.02)
Tract >70 % A.A. * A.A. Youth		-0.07 (0.03)*		-0.01 (0.03)
Tract >70 % A.A. * A.A. Youth		0.00 (0.03)		0.06 (0.04)
Intercept	0.06 (0.02)**	0.06 (0.02)**	0.06 (0.02)**	0.06 (0.02)**
Number of Observations	1167	1167	1167	1167

Notes: Standard Errors are based on two tailed hypothesis tests ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

A.A. = African American

Figure 1A.

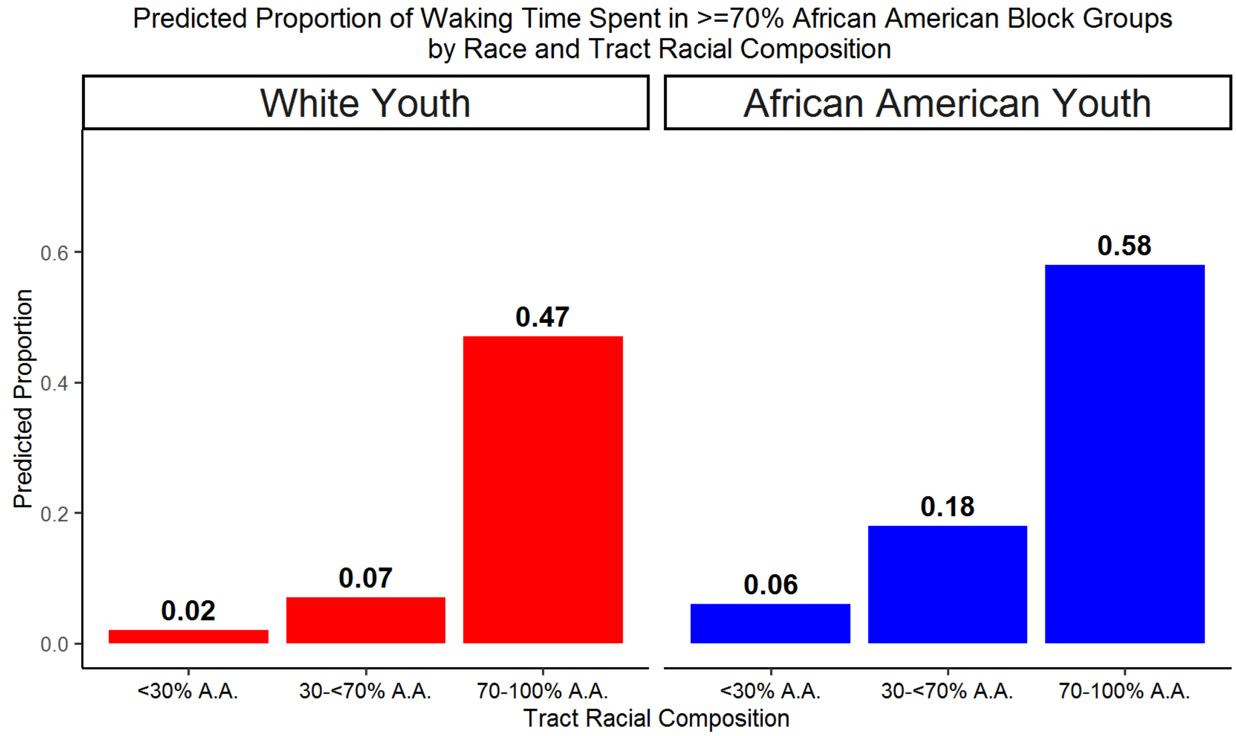

Figure 1B.

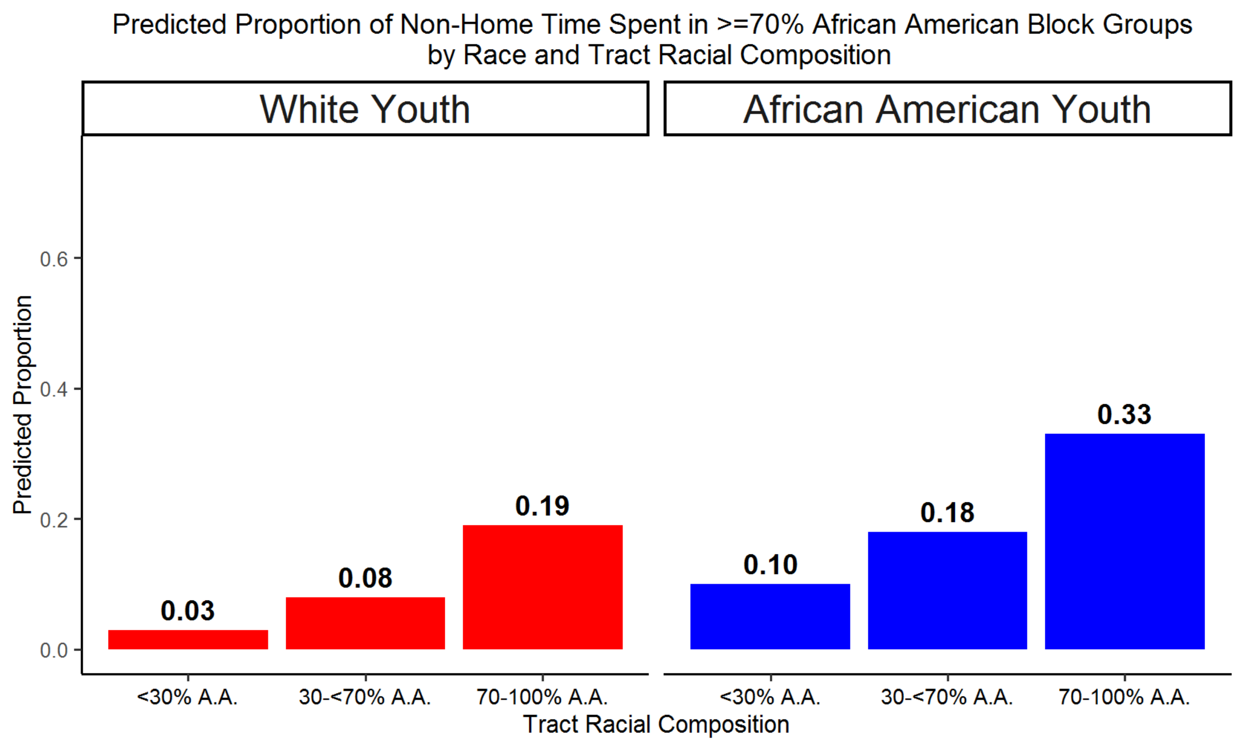

Figure 2A

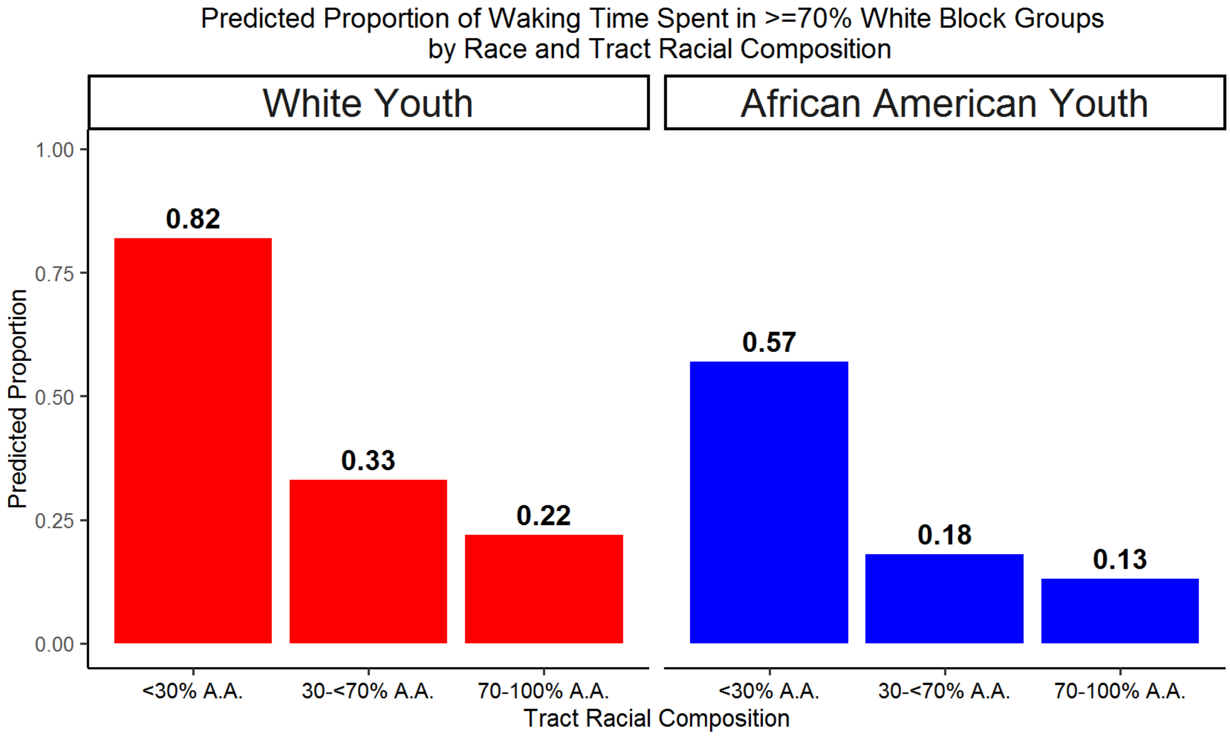

Figure 2B

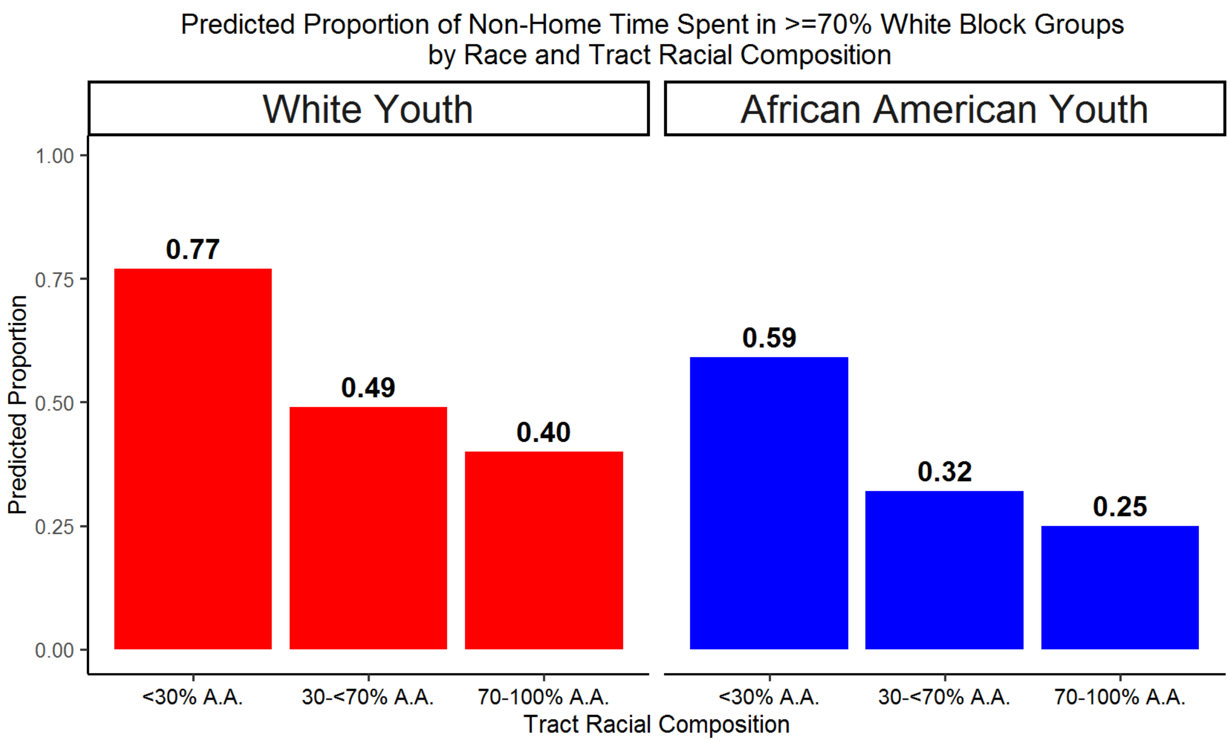

Figure 3A

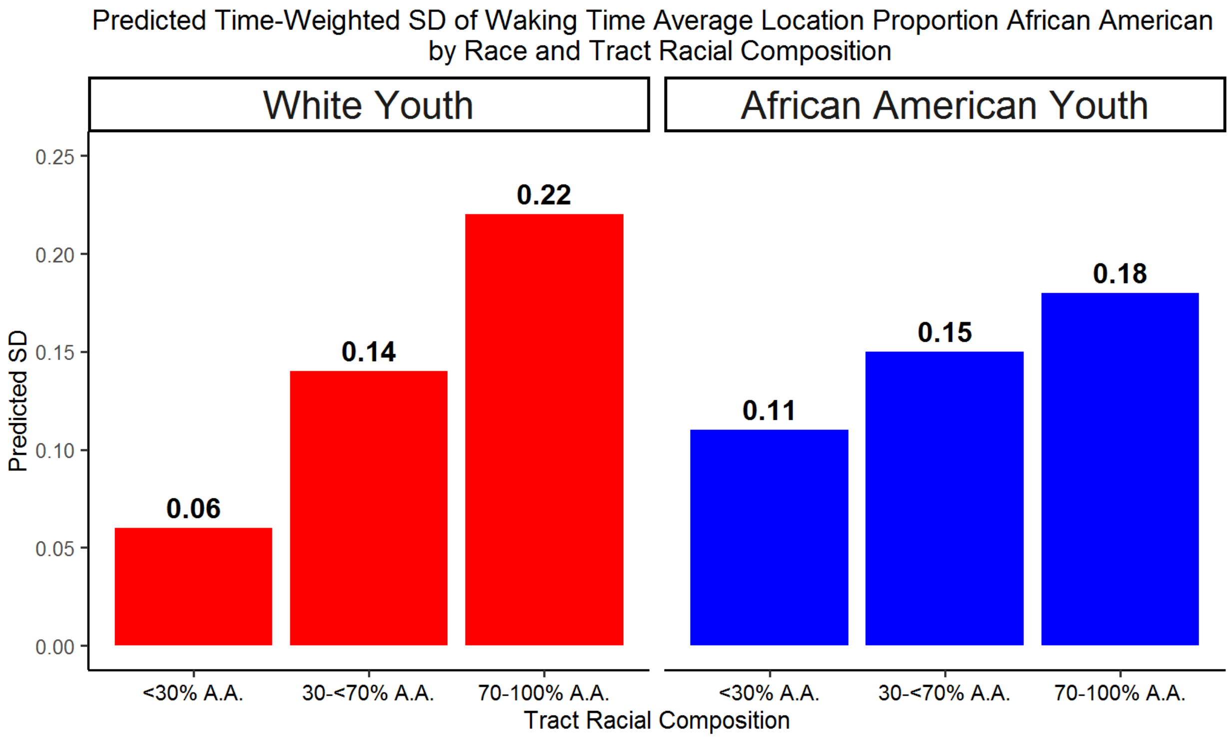

Figure 3B