Racial Preferences and Racial Residential Segregation:

Findings from Analyses Using Minimum Segregation Models

by

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August 2003

This paper is available through the working paper series edited and distributed by the Race and Ethnic Studies Institute at Texas A&M University. The analyses reported in this paper build on an earlier paper presented at the Annual Meetings of the Population Association of America, New Orleans, Louisiana, May, 1996 and a subsequent paper presented at the Annual Meetings of the Southwestern Sociological Society in San Antonio, Texas, April, 2003. I thank Sean-Shong Hwang for valuable comments on the first of these two papers. I also acknowledge the support of NIH Grant R43HD38199 (Simulating Residential Segregation Dynamics: Phase I) and NIH Grant R44HD038199 (Simulating Residential Segregation Dynamics: Phase II) which provided major funding supporting the analyses reported here.

Abstract

In this paper I advance theoretical understanding of the role racial preferences may play in racial residential segregation by developing new methods for calculating minimum segregation measures – model-based measures that register the theoretical minimum level of racial residential segregation that can be achieved in a city without violating the ethnic preferences of the populations residing in the city. I build on Massey and Gross' (1991) previous work for the two-group (white-black) case and extend it in several ways. First, I introduce the segregation chart – a new graphical tool that depicts residential patterns generated by minimum segregation procedures. Second, I develop three distinct formulations of minimum segregation measures: one taking account of only preferences held by whites, one taking account of only preferences held by blacks, and one taking account of both groups' preferences simultaneously. Third, I extend minimum segregation methods to situations where preferences are heterogeneous within groups. Fourth, I formulate minimum segregation measures in terms of both aversion – preferences to minimize contact with out-groups, and affinity – preferences to maximize contact with co-ethnics. Fifth, I extend minimum segregation methods so they can be used with a wide range of segregation measures (not just the index of dissimilarity). Sixth, I extend minimum segregation methods to yield minimum segregation on multiple dimensions of segregation simultaneously. Finally, I explore minimum segregation measures formulated in terms of preferences regarding a group's "willingness to mix" with out-groups.

My investigation of minimum segregation models yields the following findings: (a) the implications of a group's preferences for segregation are complex and can vary dramatically depending on the racial composition of the city, the preferences held by other groups, and the "form" (i.e., central tendency, dispersion, and shape) of the preference distributions involved, (b) rigorous assessments of the implications of preferences for segregation require model-based analysis, (c) model-based assessments suggest racial preferences may have important implications for racial segregation in American urban areas, and (d) contrary to conventional wisdom, ethnic preferences held by numerical minority populations can give rise to high levels of residential segregation even when the minority population is fairly tolerant of out-group contact.

Introduction

The last half-century marked a period of important changes relating to race and housing in America. Court decisions swept away laws, ordinances, and regulations expressly promoting racial residential segregation. Fair housing legislation (e.g., the Fair Housing Act of 1968 and the Fair Housing Amendments Act of 1988) provided a basis for challenging and dismantling many forms of informal housing discrimination. Support by whites for formal policies of racial exclusion in housing declined steadily. At the same time, support by whites for policies of equal opportunity in housing increased as did whites' expressions of willingness to accept blacks as neighbors. If informed that these changes were coming, social scientists observing the situation in 1950 would no doubt have been optimistic that substantial reductions in racial residential segregation would be evident by today. This is not the case. Modest reductions in black-white segregation have been documented for recent decades (Farley and Frey 1994; Thernstrom and Thernstrom 1997; Glaeser and Vigdor 2003), but data from the census of 2000 shows that white-black segregation remains at very high levels in most American urban areas (Logan 2003).

The question of why this is so has yet to be fully answered at this time. One factor that may be relevant to explaining the persistence of racial residential segregation is the role of ethnic preferences in residential choice. Survey evidence indicates that, while whites express greater acceptance of the presence of blacks in their neighborhoods now than in the past, the level of black representation that whites will willingly tolerate remains low. Thus, most whites express clear preferences for neighborhoods that are predominantly white and few whites say they would be willing to move into majority black neighborhoods. Survey evidence also indicates that, while blacks are much more accepting of "mixing" with whites than whites are accepting of mixing with blacks, blacks overwhelmingly prefer neighborhoods with substantial co-ethnic presence and most are reluctant to move into neighborhoods that are exclusively or predominantly white. Since both whites and blacks express an affinity for substantial residential contact with co-ethnics and both whites and blacks express aversion to "excessive" residential contact with out-groups, the question arises, "How much racial residential integration is feasible given these racial preferences?".

A definitive answer to this question is not presently available. My goal in this paper is to extend model-based methods that can be used to develop more rigorous answers to this question. I work toward this goal by advancing methods for computing minimum segregation measures – measures that register the theoretical minimum level of racial residential segregation that can be achieved without violating individual preferences. Taking the standard case of white-black segregation as the point of departure, I refine and extend previous theoretical work in this area in important ways that give rise to several new formulations of minimum segregation measures. I then examine the behavior of these measures under varying combinations of group preferences and demographic structure and consider the relevance of such investigations for broader understandings of segregation in American urban areas.

The seven sections of this paper mark a progression of steps toward fulfilling the goals of the analysis. Section I introduces the logic of using minimum segregation measures to assess the implications of whites' preferences for segregation and draws on a new graphical tool – the segregation chart – to help illustrate residential distributions generated by minimum segregation procedures. It introduces equation-based methods for calculating the values of minimum segregation measures when preferences are *homogeneous*.

Section II extends the analysis to the situation where preferences are heterogeneous. It introduces algorithm-based methods that are required to calculate the values of minimum segregation measures in this circumstance.

Section III applies the logic of minimum segregation measures to the consideration of minority preferences. It begins with a demonstration that minimum segregation measures formulated in terms of sentiments of *ethnic aversion* (preferences to avoid contact with out-groups) are mathematically equivalent to those formulated in terms of sentiments of *ethnic affinity* (preferences to achieve contact with co-ethnics), a notion that is seen by some as a more appropriate way to conceptualize minority preferences. It then shows that the methodologies used to assess the implications of whites' preferences (conceptualized in terms of ethnic aversion) for segregation can be adapted in simple and straightforward ways to assess the implications of black's preferences (conceptualized in terms of ethnic affinity) for segregation. And it shows that these implications can be substantively important under conditions that are likely to prevail in American metropolitan areas.

Section IV lays the groundwork for extending the logic to the assessment of the implications of both whites' and blacks' preferences considered together. It uses informal, graphical methods to highlight the potential importance that the combined impact of whites' and blacks' preferences may have on minimum segregation outcomes. And it provides a preliminary review of broader issues relating to the logic of considering the implications of blacks' preferences either alone or in conjunction with whites' preferences.

Section V introduces formal methods for assessing the implications of both whites' and blacks' preferences for segregation. In particular, it introduces new equation-based methods for assessing the implications of preferences when preferences are homogeneous and it introduces new algorithm-based methods for assessing the implications of preferences when preferences are heterogeneous. This section also undertakes systematic analyses documenting the nature of variation in minimum segregation outcomes and showing that these outcomes are complex (e.g., non-additive and non-linear) functions of city demographic mix and the "shapes" (i.e., central tendency, dispersion, etc.) of each group's preference distribution.

Section VI reframes the analysis of the previous chapter in terms of "willing-to-mix" preferences – preferences that reflect "minimum tolerable" residential outcomes as opposed to preferred outcomes. It extends methods of analysis introduced in previous sections to assess the implications of willing-to-mix preferences for minimum segregation outcomes. And it discusses the likely importance of tolerable-outcome preferences in shaping residential patterns.

Section VII places the findings of the earlier sections into broader perspective. It reviews the standing of preference theories of segregation and discusses the implications of the findings for minimum segregation outcomes for understanding segregation in American urban areas.

Anticipating what lies ahead, I list the key conclusions that will emerge below as follows. Prevailing understandings of the implications of preferences for segregation are grounded in discursive, "common sense" reasoning that often is flawed and inadequate. As a result, many widely held views about the implications of preferences are mistaken and indefensible. Defensible assessments of the implications of preferences should draw on more rigorous, model-based frameworks such as the minimum segregation methodology outlined in this paper. Theoretical analysis of minimum segregation outcomes indicates that preferences have potentially important implications for racial residential segregation under a wide range of theoretically and substantively interesting conditions. Some of these implications are counterintuitive and contradict conventional wisdom. For example, the preferences of numerical minority groups can lead to high levels of residential segregation even when the group is relatively tolerant of out-group contact and the preferences of numerical majority groups can be surprisingly modest in their impact even when they involve strong preferences for co-ethnic contact.

In the final analysis, the implications of any group's preferences for segregation are strongly conditioned by a variety of factors including the citywide racial composition and the nature (i.e., central tendency, dispersion, and shape) of the preference distribution for the group in question and the nature of the preferences held by other groups. Because of this, the implications of preferences for segregation are complex and difficult to summarize. Thus, further research is needed to understand more fully how minimum segregation outcomes vary across substantively interesting conditions and what implications such variation may hold for better understanding residential segregation in urban areas.

Section I
The Logic of Minimum Segregation Measures – the D* Construct

In this section I introduce the logic of minimum segregation measures and methods that can be used to calculate the values of such measures under specific conditions. I begin by discussing D* – a construct first introduced by Massey and Gross (1991). As its name would suggest, it is based on the familiar index of dissimilarity (D), the most widely used measure of residential segregation. However, where D is typically used with census or survey data to measure the level of segregation in a city or metropolitan area, Massey and Gross offer D* as an analytic tool. Drawing on a simple model of strategic residential placement, it registers the *theoretical* minimum level of segregation in a city (quantified in terms of D) needed to insure that a group's preferences to avoid unwanted residential contact with another group are never violated.[1] I adapt this measure, which I here term ${}_{W}D_{B}$, and extend the logic of its formulation to advance the goals of the present analysis.[2]

The analytic model of strategic residential placement underlying ${}_{W}D_{B}$ is a simple one. It involves two groups – whites and blacks – and a preference for neighborhood racial composition that is held uniformly by all whites. The value of ${}_{W}D_{B}$ can be obtained by either of two procedures. One approach begins with a completely integrated city where the racial mix in every neighborhood matches that for the city as a whole, but where all whites have an aversion to "excessive" residential contact with blacks and prefer to limit contact with blacks to a certain level (e.g., no more than 5%). If it is necessary, strategically move white and black households to new neighborhoods to insure that no white household lives in an area where their ethnic preference is violated. At the same time, however, require that the resulting level of segregation be held to the minimum possible (maintain the maximum possible level of integration). Alternatively, begin with a completely segregated city where all neighborhoods are either all white or all black. Then, strategically move white and blacks households to reduce segrega-

[1] Massey and Denton (1993: 110-112, 260) also call attention to this construct. They summarize key findings from Massey and Gross (1991) in the text and discuss the measure and its computing formula in reference notes. The Massey and Gross notation for the measure is $E(D_{\delta})$ where E(D) denotes the expected value of D and δ denotes the maximum level of residential contact with blacks that whites will tolerate.

[2] I use D* to refer generically to minimum segregation calculations or expressions involving the index of dissimilarity. I use ${}_{W}D_{B}$ to refer to specific minimum segregation calculations involving the index of dissimilarity and based on whites' preferences regarding residential contact with blacks. I may also use D* to refer to specific minimum segregation calculations involving the index of dissimilarity if the context makes it clear what the specific nature of the calculations is.

tion as much as possible (increase integration as much as possible) but under the constraint that no white's ethnic preference can ever be violated.

Massey and Gross conceived of ${}_{W}D_{B}$ as having the potential to register the "structural propensity" for segregation in a community – the minimum level of segregation needed for whites to attain the outcomes they desired regarding ethnic residential contact. Reasoning that whites' preferences in this area were strongly held and that, as a power majority, whites had the ability to realize their preferences by a variety of means (e.g., self-segregation, exclusion of minorities, resisting public housing, etc.), they hypothesized that ${}_{W}D_{B}$ might be helpful in explaining variation in the level of white-black segregation across metropolitan areas. To test this idea, they derived a formula for calculating the value of ${}_{W}D_{B}$. The formula required only two independent pieces of information: the proportion black in the citywide population (Q) and the maximum level of residential contact with blacks that whites will accept (δ). They measured the former using census data and speculated that the latter was a small number (i.e., 0.05) that was constant across cities. Using this approach they computed the value of ${}_{W}D_{B}$ for a sample of cities.[1] They were disappointed to find, however, that ${}_{W}D_{B}$ was not a strong predictor of cross-community variation in segregation levels.

Despite this negative result, there area several good reasons to view Massey and Gross' effort as an important contribution to the literature on residential segregation. First, the ${}_{W}D_{B}$ construct they introduced is valuable because it links aggregate segregation patterns registered by the index of dissimilarity (D) – the most widely used measure of segregation – to a model of individual-level, goal-directed behavior. Second, their formulation of ${}_{W}D_{B}$ incorporates the insight that the *structural propensity* for segregation is shaped by the way individual-level preferences for neighborhood ethnic mix express themselves under differing demographic conditions (e.g., varying percent black). Third, they set forth an *explicit model-based method* for assessing the implications of preferences for segregation under specific demographic conditions. Finally, their application of this method yielded results with potentially important substantive implications; namely, when they considered plausible values for white preferences along with commonly occurring values of proportion black, they found that ${}_{W}D_{B}$ assumed high values thus indicating that high levels of segregation would typically be needed to satisfy

[1] By assuming δ to be a constant, their estimate ${}_{W}D_{B}*$ amounted to a nonlinear, monotonic transformation of proportion black.

whites' preferences regarding ethnic residential contact. In sum, while ${}_{W}D_{B}$ did not prove to be a strong predictor of variation in racial residential segregation across metropolitan areas, the theoretical reasoning under girding Massey and Gross' ${}_{W}D_{B}$ construct is sound and deserves to be pursued further.

Two other reasons support the conclusion that minimum segregation measures warrant further development and investigation. One is that Massey and Gross' development of the computing formula for ${}_{W}D_{B}$ contained errors that caused them to *misestimate* the structural propensity for segregation. Below I show that errors in their derivation of the computing formula for ${}_{W}D_{B}$ caused them to calculate estimates that were too low and a corrected formula yields higher values of ${}_{W}D_{B}$.

This fact alone might go part way toward explaining why ${}_{W}D_{B}$ was not a strong predictor of segregation in their empirical analysis. But I believe there is a more important explanation for this fact. It is that the logic of Massey and Gross' analysis can and should be taken further than it was in their original formulation. When this is done it leads not only to a potential explanation of their negative empirical results but also to insights as to why segregation continues at high levels in most American metropolitan areas decades after *de jure* segregation has been struck down. I establish the basis for this view below by introducing extended formulations of model-based minimum segregation measures similar to ${}_{W}D_{B}$ that assess, not only the implications of whites' ethnic preferences, but also the implications of blacks' ethnic preferences and the implications of white and black preferences taken together. The results I obtain using these refined versions of minimum segregation measures suggest that, given prevailing ethnic preferences held by whites and blacks, *the structural propensity for segregation is high in most American metropolitan areas regardless of ethnic demographic mix*.

A Revised Formulation of $\mathbf{{}_{W}D_{B}}$

As a first step toward developing the basis for the view just offered, I introduce the following computing formula for the ${}_{W}D_{B}$ construct:

$${}_{W}D_{B} = 1 - P/Q \cdot \delta/(1-\delta) \text{ when } Q > \delta \text{ and 0 otherwise} \qquad [1]$$

where Q is the proportion black in the city, P is the proportion white in the city (given by 1.0 – Q), and δ is the maximum proportion black that whites will tolerate in the neighborhoods they reside in. This is a revision of the formula offered by Massey and Gross (1991). As Massey and Gross originally intended, the expression in Equation 1 registers the minimum possible value of D under the condition that whites' preferences to maintain residential contact with blacks at or below the level specified by δ are never violated. I introduce a revised formula here because the derivation of the computing formula presented in Massey and Gross (1991) contains flaws that render the formula they provide invalid. I do not review the specific errors here, but I do provide a detailed discussion in Appendix B for the interested reader.

As the first step in developing the revised computing formula for ${}_WD_B$, I introduce the familiar computing formula for the index of dissimilarity (D):

$$D = ½ \Sigma \mid w_i/W - b_i/B \mid$$

where "W" and "B" are the total numbers of whites and blacks, respectively, in the city, "i" is a neighborhood index running from 1 to N (the total number of neighborhoods in the city), and "w_i" and "b_i" are the numbers of whites and blacks, respectively, in each neighborhood.[1]

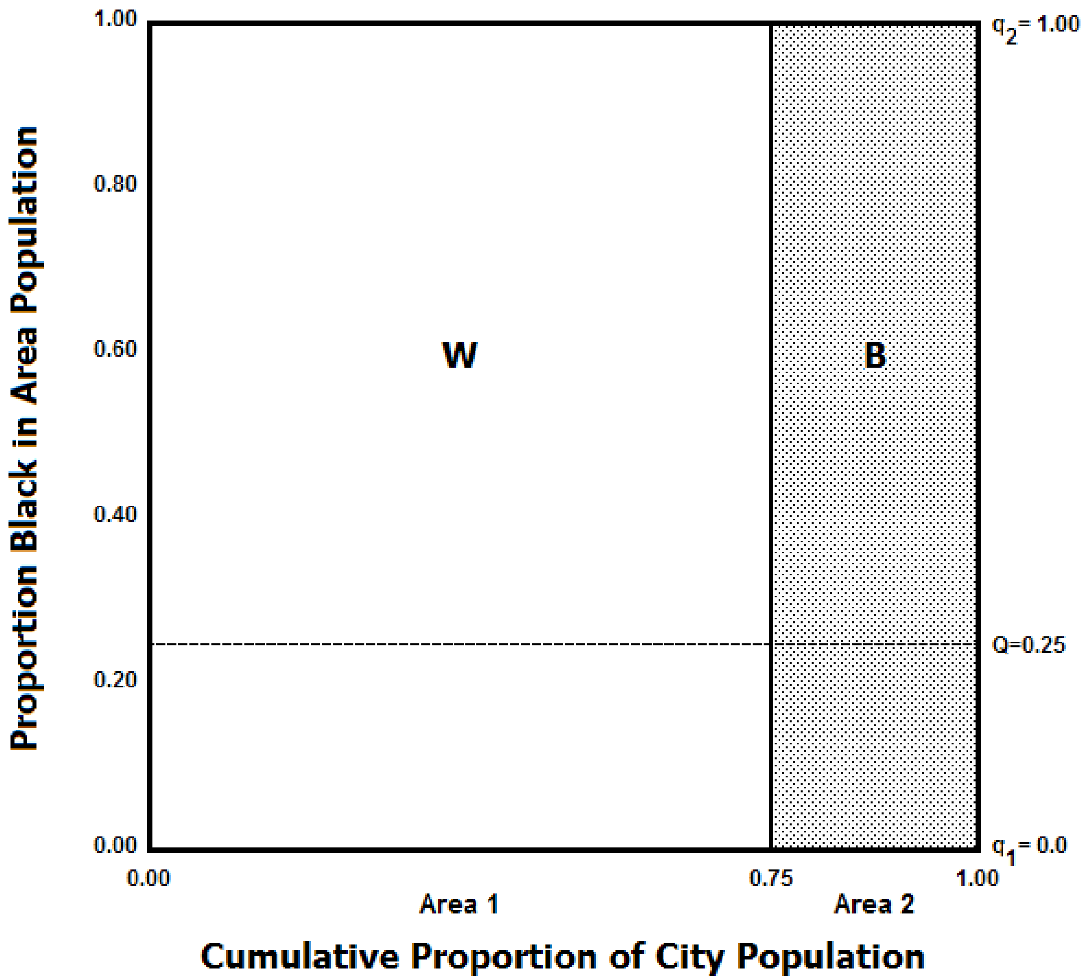
Next I introduce a graphical device I term a "segregation chart". This device serves two purposes. One is that it provides an intuitive, graphical representation of residential distributions that simultaneously registers the ethnic demography of the city as well as the extent to which groups are distributed evenly (or unevenly) across neighborhoods. In addition, the segregation chart also provides a geometric representation of the terms of a computing formula (to be introduced later) that can be used to obtain the value of ${}_WD_B$.

The first segregation chart I present is shown in Figure 1. This figure depicts the condition of complete or "perfect" segregation in a hypothetical city where the proportion black (Q) is 0.25. Under the condition of complete segregation, all whites live in neighborhoods that are 100% white, all blacks live in neighborhoods that are 100% black, and the index of dissimilarity reaches its maximum value of 100. The chart depicts this pattern of residential distribution as follows.

First, the figure contains two vertical bars delimited by heavy lines found at selected points along the figure's "X" axis; specifically, at points 0.0, 0.75, and 1.0. Each vertical bar represents a distinct neighborhood "type" characterized by a unique racial mix. In the present case, there are two types of neighborhoods; all-white neighborhoods and all-black neighborhoods.

[1] A complete listing of the definitions of these and all other terms used in this paper is provided in Appendix A.

Figure 1
Proportion Black by Area Type with Homogeneous White Preferences δ=1.0 and Q=0.25



The ethnic composition of each neighborhood type is registered on the "y" axis of the figure and neighborhood types are depicted from left to right in order of increasing proportion black. The "x" axis of the figure registers the share of the city's total population that is cumulated moving from left to right through the neighborhood types; Area 1, an all-white neighborhood on the left and Area 2 an all-black neighborhood on the right. Labels appear below each area. The dotted horizontal line labeled "Q = 0.25" depicts the proportion black that would obtain in every neighborhood under conditions of complete or "perfect" integration (i.e., exact even distribution). The "W" seen in the interior of Area 1 signifies that this area contains the white population in the city (W) and the "B" seen in Area 2 signifies that this area contains the black population in the city.

The computation of D is elementary for this situation. The values of the terms w_i/W and b_i/B for the all-white neighborhood (Area 1) are W/W = 1 and 0/B = 0, respectively. Similarly, the values of the terms w_i/W and b_i/B for the all-black neighborhood (Area 2) are 0/W = 0 and B/B = 1, respectively. Thus, D is given by

$$D = ½ (|W/W–0/B| + |0/W–B/B|) = ½ (|1-0| + |0-1|) = 1.$$

The resulting value of 1 registers the fact that the city is completely segregated.[1]

The segregation chart shown in Figure 1 can be seen as depicting the residential distribution produced by the behavioral model for ${}_WD_B$ when whites have no tolerance for residential contact with blacks (i.e., when δ is 0.0). Under the guidelines for the model, it is not possible to mix white and black households in the same neighborhoods without violating whites' ethnic preferences. Thus, neighborhoods must be constructed to be either all white or all black as in Figure 1 and the resulting value of ${}_WD_B$ must be 1.0.

Figure 2 depicts the segregation chart for the opposite pattern, a completely integrated city where the index of dissimilarity registers its minimum value of 0.0. There is only one neighborhood in this city – Area 1 – and it has a proportion black that is identical to that for the city as a whole. Since all whites (W) and all blacks (B) live in this area, the calculation for ${}_WD_B$ is given by

$$D = ½ (|W/W–B/B|) = ½ (|1–1|) = ½ (|0|) = 0.$$

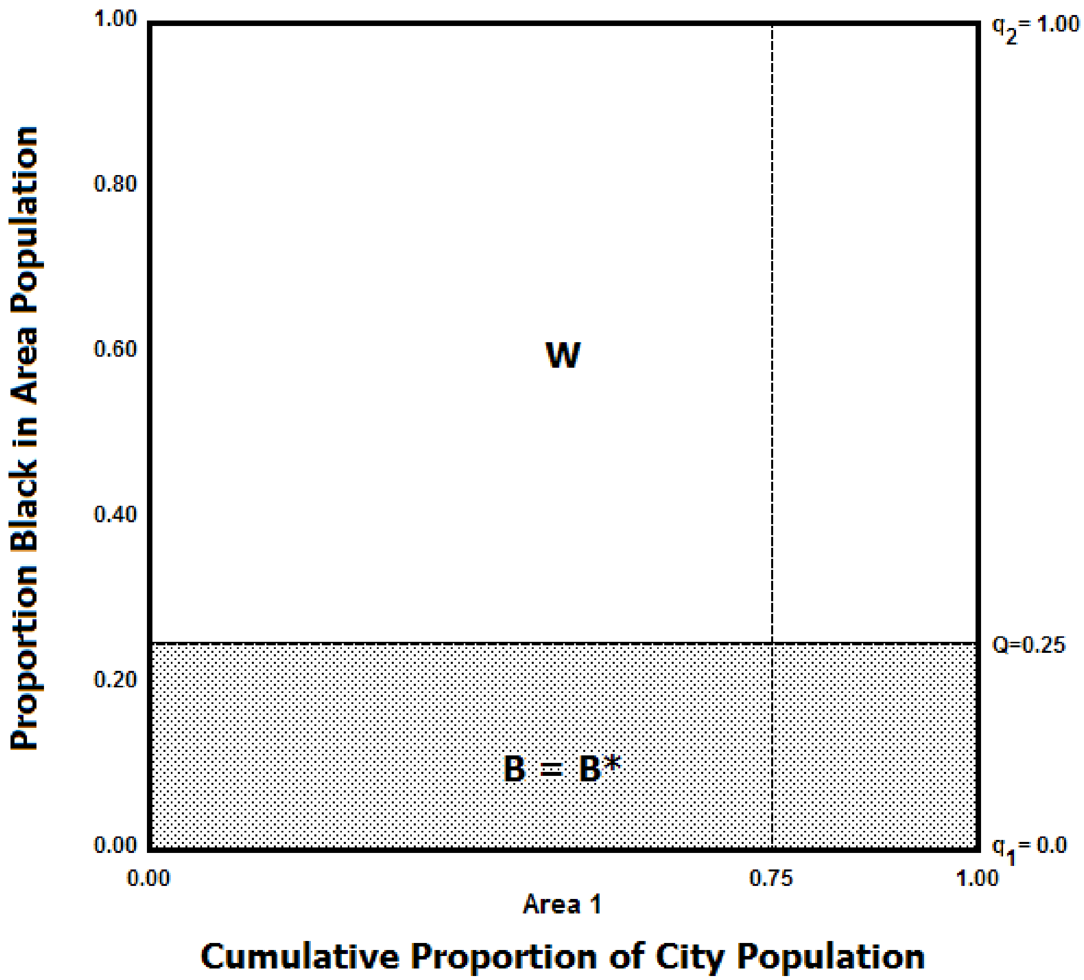
The segregation chart shown in Figure 2 depicts the residential distribution produced by the behavioral model for ${}_WD_B$ when whites' tolerance for residential contact with blacks is high enough to permit all blacks to reside with whites, that is, when $\delta \geq Q$ which in this case is 0.25. Under the guidelines for the model, it is possible to place all white and black households in the same neighborhood without violating whites' ethnic preferences. Thus, only one neighborhood need be constructed (Area 1) and the resulting value of ${}_WD_B$ is 0.0.

Figure 3 presents the segregation chart depicting the residential distribution resulting under the model when whites' maximum desired tolerance for contact with blacks (δ) is set to 0.10 – a value greater than 0.0, but lower than the citywide proportion black (Q) of 0.25.

[1] See Appendix B for further discussion of this and other formulations developed in this section.

Figure 2

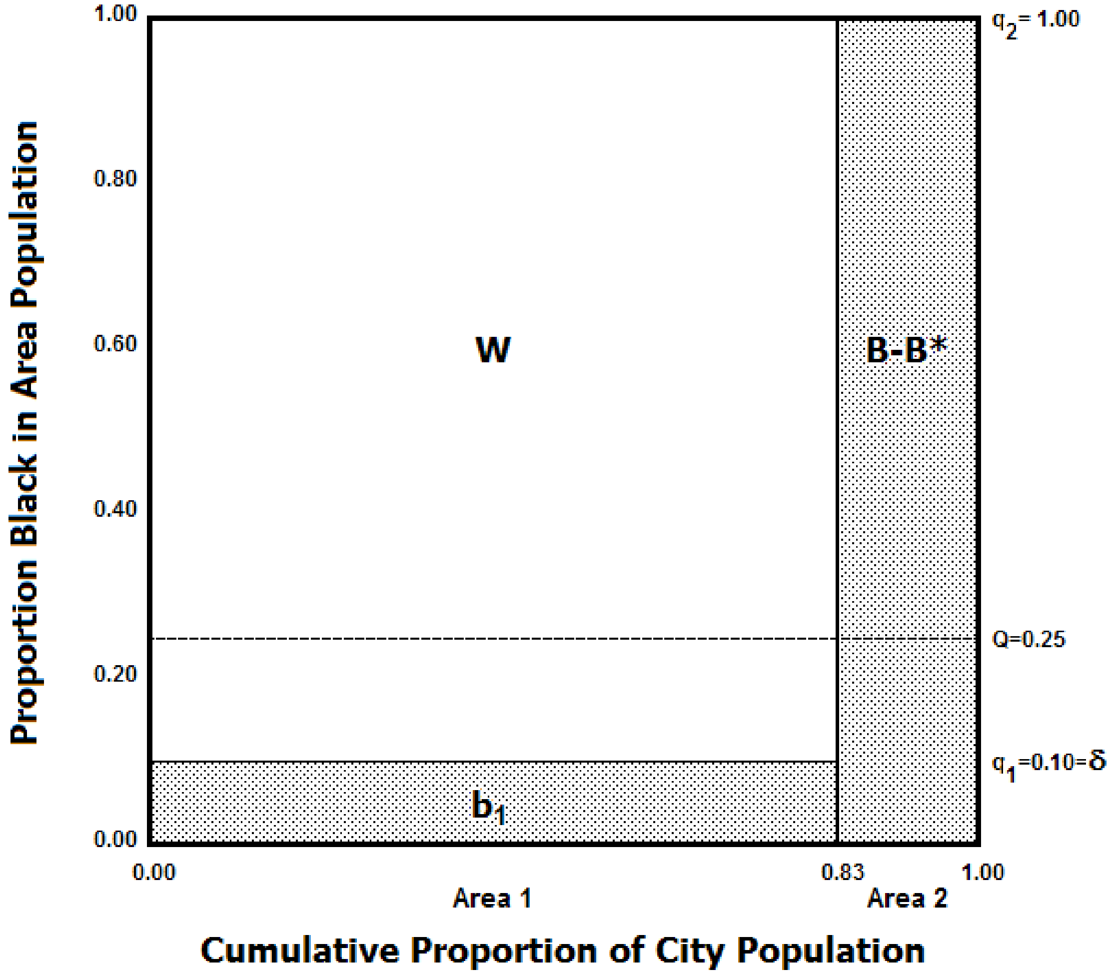
Proportion Black by Area Type with Homogeneous White Preferences δ=0.0 and Q=0.25



The figure shows that, given this combination of ethnic demography and white tolerance of contact with blacks *and* following the guidelines for computing ${}_{W}D_{B}$, white and black households can be distributed into two types of areas in order to achieve maximum integration without violating whites' ethnic preferences. The first, Area 1, is constructed by placing all white households in the area and then moving black households into the area until the proportion black in the area reaches δ. The resulting neighborhood is a "semi-integrated" area containing all whites (W) and some blacks (b_1).

Figure 3

Proportion Black by Area Type with Homogeneous White Preferences δ=0.10 and Q=0.25



A second area, Area 2 is needed to accommodate the remaining black households who cannot be placed in Area 1. Area 2 is thus an all black area containing B-B* black households where B* is the number of black households living in integrated areas. (In this case B* is simply b_1, but the B* label will be more useful at a later point when heterogeneous preferences are considered.) The ethnic mixes of the two types of neighborhoods in the city are marked on the right-hand y-axis. Proportion black in Area 1 is 0.10 (noted as "q_1") and proportion black in Area 2 is 1.0 (noted as "q_2").

A general expression for D for this situation can be developed as follows. All whites live in the semi-integrated neighborhood (Area 1), thus w_1 = W. A certain number of blacks (b_1) also live in this semi-integrated neighborhood. (Accordingly, the upper portion of the bar depicting Area 1 is labeled "W" and the lower portion is labeled "b_1".) The values of w_i/W and b_i/B for the semi-integrated neighborhood are given by $w_1/W = W/W = 1$ and b_1/B, respectively. The remaining blacks live in the all-black neighborhood (Area 2). In the figure, this number (b_2) is given by B-B* where B* is the total number of blacks residing in integrated areas (this formulation will be useful later). In this case B* is simply b_1 and thus $b_2 = B–B^* = B–b_1$. The values of w_i/W and b_i/B for this neighborhood are thus given by $0/W = 0$ and $(B–b_1)/B$, respectively. The value of D is thus given by:

$$D = ½ (|w_1 /W – b_1/B| + |w_2 /W – b_2/B|).$$

$$D = ½ (|1 – b_1/B| + |0 – (B – b_1)/B|).$$

Integration in the city in question has proceeded to the maximum extent possible without violating whites' ethnic preferences. So this expression gives the value of ${}_WD_B$ for the case in question.

Appendix C shows that this last expression can be restated as simply

$${}_WD_B = 1 – b_1/B .$$

Since $B^* = b_1$, the expression can also be stated given as

$${}_WD_B = 1 – B^*/B \qquad [2]$$

Appendix C shows that b_1 can be obtained from $w_1/(1-δ)$ and that b_1 /B (and B*/B) can be obtained from $P/Q ·δ/(1-δ)$. Based on this, Equation 2 can be stated in even more general form as

$${}_WD_B = 1 – P/Q · δ/(1-δ). \qquad \text{[introduced previously as Equation 1]}$$

Equation 2 is useful because it links ${}_WD_B$ to the generalized geometric analysis in the segregation chart. Equation 1 is useful because it is a general expression that permits calculation of ${}_WD_B$ based on knowledge of only two terms – Q and δ (remembering that P = [1-Q]).

The numerical values of these two terms are known for the example at hand (i.e., Q = 0.25, δ = 0.10). Thus, it is a straightforward matter to compute the numerical value of the index score

$${}_WD_B = 1 – (0.75/0.25 · 0.10/0.90) = 0.667.$$

Table 1 Values of ${}_WD_B$ Under Selected Combinations of Citywide Racial Mix (Q) and White Tolerance of Neighborhood Integration (δ).

Black Representation in the City Population (Q)	Maximum Black Presence in a Neighborhood Tolerated by Whites (δ)					
	1%	2%	5%	10%	20%	30%
40%	0.985	0.969	0.921	0.833	0.625	0.357
25%	0.970	0.939	0.842	0.667	0.250	0
15%	0.943	0.884	0.702	0.370	0	0
10%	0.909	0.816	0.526	0	0	0
5%	0.808	0.612	0	0	0	0
2%	0.505	0	0	0	0	0
1%	0	0	0	0	0	0

Selected Quantitative Results

Table 1 lists values yielded by this computing formula for ${}_WD_B$ under selected combinations of citywide racial mix (Q) and white tolerance for residential contact with blacks (δ). The table shows that, when whites' tolerance for residential contact with blacks is greater than or equal to the proportion black in the city (i.e., $\delta \geq Q$), ${}_WD_B$ takes the value of zero since whites' ethnic preferences are compatible with full integration and no segregation is needed to prevent whites' ethnic preferences from being violated. Thus, ${}_WD_B$ is zero in the cells falling on or below the diagonal in the table. In contrast, when whites' tolerance for residential contact for blacks drops below the proportion black in the city (i.e., when $\delta < Q$), ${}_WD_B$ takes on positive values reflecting the fact that segregation is required to insure that whites' ethnic preferences are not violated.

As the table shows, the required level of segregation varies with Q and δ as follows. Holding constant percent black in the city (Q), ${}_WD_B$ is a monotonic negative function of whites' tolerance for residential contact with blacks (δ) over the range $0 < \delta < Q$. Holding constant whites' tolerance for residential contact with blacks (δ), ${}_WD_B$ is a monotonic positive function of percent black in the city (Q). Graphical analysis presented later in the paper confirms what the table suggests, the value of ${}_WD_B$ is a complex nonlinear function of Q and δ.

Table 1 shows that ${}_WD_B$ takes high values under conditions likely to hold in US cities. For example, when δ is 0.05 (a value suggested as plausible by Massey and Gross), ${}_WD_B$ is 0.526 for a city that is

10% black and 0.702 for a city that is 15% black. If this is taken as the "structural propensity" for segregation as Massey and Gross propose, it would follow that the structural propensity for segregation is very high in most American cities.

This is an important substantive finding in itself. However, it takes on even greater significance when considered in light of the fact that *$_{W}D_{B}$ registers the theoretical minimum for segregation under strategic assignment* of households by an outside observer. One might reasonably speculate that successful goal-driven social processes geared to satisfying whites' ethnic preferences would likely *overshoot* the theoretical minimum target needed to achieve the result whites desire. After all, the theoretical minimum for $_{W}D_{B}$ is achieved by placing whites with blacks to the maximum extent permitted by whites' preferences, but whites making location decisions in the "real world" would hardly strive systematically seek to achieve *exactly* this outcome even though they would accept if they encountered it. One might imagine that either other constraints on location decisions (e.g., concerns for neighborhood quality) or the location decisions of other groups might "force" whites into systematically confronting this minimally tolerable outcome. However, I conclude later in this paper that there is no sound basis for expecting this to be the case. Thus, it is quite possible that the practical implications of $_{W}D_{B}$ for segregation might be even greater than the tabulated values would indicate.

Formulations of Other Minimum Segregation Measures

The index of dissimilarity (D) is the most widely used measure of segregation. In part this is because it has a simple and intuitive substantive interpretation – it registers the proportion of blacks that would have to move from their present neighborhood in order to achieve full integration. Furthermore, it is relatively simple to compute and explain and it has been shown to be highly correlated with other measures of "uneven distribution" in at some important empirical applications (Massey and Denton 1988).

Still, other measures of segregation also are widely used and are of interest. Some tap dimensions of segregation other than uneven distribution (e.g., "exposure" or "isolation"). Others have theoretical properties that make them arguably superior to D for the purpose of measuring uneven distribution and/or offer a substantive interpretation that may be appealing in a particular analysis. Any segregation measure can be computed from the residential distributions depicted in the segregation charts shown in Figures 1-3. Figures 1 and 2 depict minimum and maximum segregation outcomes and are not particularly interesting. But Figure 3, provides a generalized representation of the residential distributions associated with minimum segregation compatible with whites' preferences under a specific city-wide racial mix. Figure 3 depicts minimum segregation in a city with specific white ethnic preferences ($\delta = 0.10$) and racial mix ($Q = 0.25$). But the racial composition of the areas in the city are governed by general expressions (noted earlier and reviewed in more detail in the appendix) as follows:

$w_1 = W = P$,

$w_2 = 0.0$,

$b_1 = w_1/(1-\delta) = P/(1-\delta)$, and

$b_2 = B - b_1 = Q - b_1$.

At the risk of stating the obvious, these expressions hold only under the specific conditions where the city has only two groups (whites and blacks) and where all whites hold the same ethnic preference (δ).

Since the minimum segregation residential distribution for the city is fully and exactly determined by whites' preferences (δ) and city-wide racial mix (Q), the minimum segregation value of any measure can be obtained by applying the relevant computing formula for the measure to this residential distribution. Moreover, it is possible to identify formulations that express many measures of segregation directly in terms of the parameters δ and Q. As I show in Appendix C, minimum segregation formulations for the gini index (G), the index of black exposure to whites (${}_BE_W$), the index of black isolation (I), and the correlation ratio (R) can be given as follows.

G[1] $= 1 - P/Q \cdot \delta/(1-\delta)$ when $\delta < Q$, 0 otherwise;

${}_BE_W = \delta \cdot P/Q$ when $\delta < Q$, P otherwise;

I = when $\delta < Q$, Q otherwise; and

R = when $\delta < Q$, 0 otherwise.

[1] As noted in Appendix C, this formulation shows G to be identical to D. This is true only in the special case where there are only two groups (whites and blacks) and where whites' preferences (δ) are homogeneous.

Section II
Extension to Heterogeneous Preferences

In this section I introduce algorithms for computing minimum segregation measures when preferences are heterogeneous. To begin, I modify the situation depicted in the segregation chart presented previously in Figure 3 by introducing variation in whites' tolerance of residential contact with blacks. To simplify discussion and graphical analysis, I assume only three categories of ethnic preferences within the white population.[1] I set one third of whites to have no tolerance for the presence of blacks (i.e., $\delta_1 = 0.0$). I set the next third to have a weak tolerance for the presence of blacks (i.e., $\delta_2 = 0.10$) and the last third to have a tolerance that is only slightly higher (i.e., $\delta_3 = 0.30$). In sum, no whites are open to extensive contact with blacks, but preferences are not homogeneous. Figure 4 presents the segregation chart depicting the minimum segregation distribution for this situation.

Continuing the mode of graphical analysis established earlier, Figure 4 depicts the city as having a residential distribution consisting of four neighborhood types; three based on the ethnic preferences of their white residents and a fourth all-black area. Moving from left to right in the figure, Area 1 is an all-white neighborhood populated by whites with no tolerance for black neighbors ($\delta_1 = 0.0$). Area 2 is a semi-integrated neighborhood populated by whites with a weak, but non-zero tolerance for black representation ($\delta_2 = 0.10$). Area 3 is an "exactly integrated" neighborhood populated by whites with the highest tolerance for black representation ($\delta_3 = 0.30$).[2] Finally, Area 4 is an all-black neighborhood where blacks that could not be placed in either of the two integrated neighborhoods live.

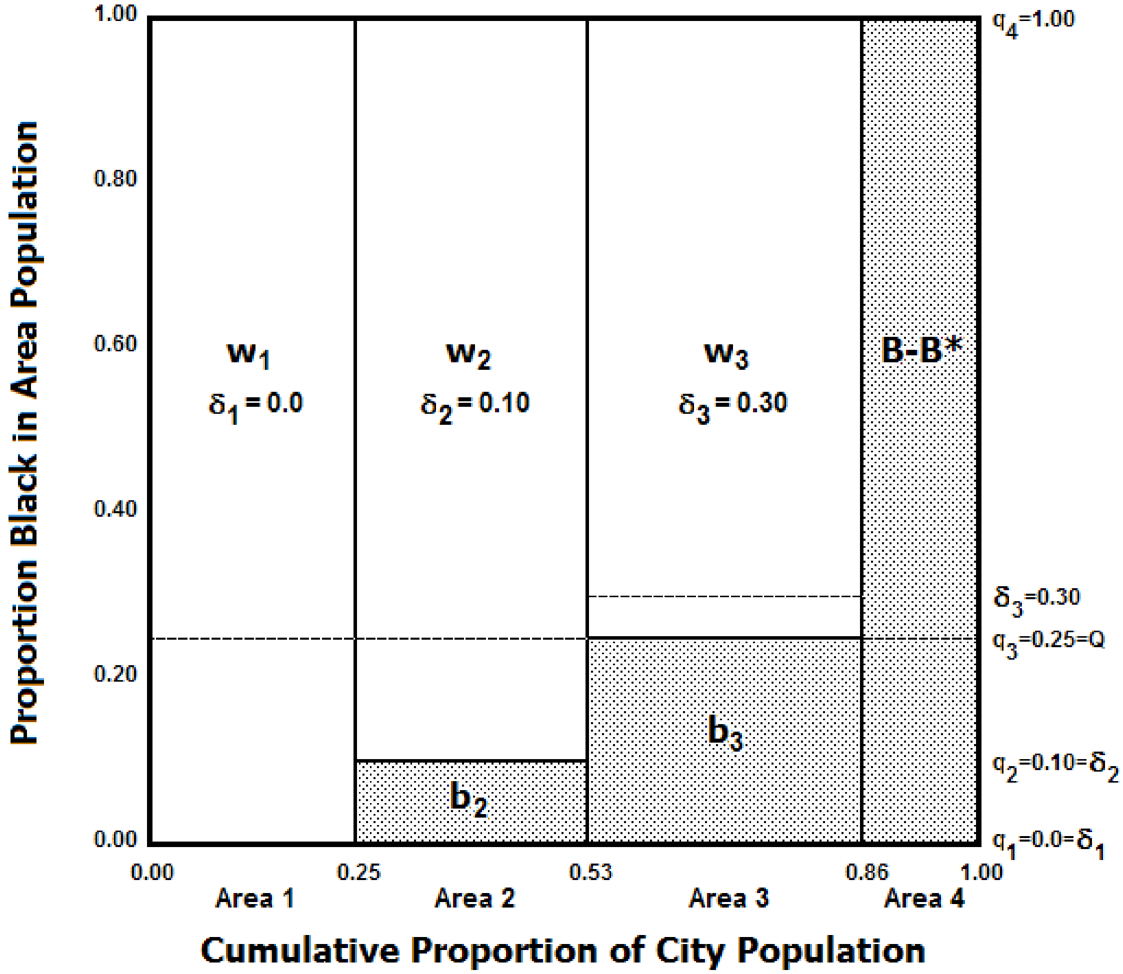
Note that the proportion black in Area 3 ($q_3 = 0.25 = Q$) is lower than the maximum that whites in the area would tolerate (based on $\delta_3 = 0.30$). The reason for this rests with the nature of the index of dissimilarity (D) as *any* deviation (positive or negative) of proportion black in the neighborhood (q_i) from the citywide proportion black (Q) promotes segregation as measured by D. Consequently, once blacks have been moved into Area 3 up to the point that proportion black has reached Q, the placement of additional blacks in this area will not lower the value of D. So proportion black in Area 3 is set to 0.25 instead of 0.30 (as whites' preferences would permit). (More on this point later.)

[1] The relatively simple analysis presented here is extended to more complicated preference distributions in later sections.

[2] The neighborhood is "exactly" integrated from the point of view of even distribution. That is, q_i for the area is equal to Q for the city.

Figure 4

Proportion Black by Area Type Using Rule I with Heterogeneous White Preferences $\delta_1 - \delta_3$ and Q=0.25



Building on previous notation, I signify the number of whites and blacks in each area by w_i and b_i and the total population in each area by $t_i = w_i + b_i$. Appendix C shows that whites (w_i) with an ethnic preference $\delta_i \leq Q$ can be placed into areas where the black population (b_i) is given by $b_i = \delta_i \cdot t_i$ where $t_i = w_i / (1-\delta_i)$. The minimum segregation distribution for the city can be generated by taking the least tolerant whites first and placing them into a neighborhood that is integrated to the extent possible (given their preferences) and then continuing on to the next group of whites until all whites and any remaining blacks are placed.

As Figure 4 shows, this procedure yields three areas where whites reside and a fourth all-black area. Area 1 is an all-white area, based on $t_1 = w_1/(1\text{-}\delta_1) = w_1/(1\text{-}0) = w_1/1 = w_1$ and $b_1 = \delta_1 \cdot t_1 = 0 \cdot w_1 = 0$. Area 2 is a semi-integrated area with $t_2 = w_2/(1\text{-}\delta_2) = w_2/(1\text{-}0.1) = w_2/(0.9)$ and $b_2 = \delta_2 \cdot t_2 = (0.1) \cdot w_2/(0.9)$.

Based on these example, some might expect that Area 3 would be given by $t_3 = w_3/(1\text{-}\delta_3) = w_3/(1\text{-}0.1) = w_3/(0.7)$ and $b_3 = \delta_3 \cdot t_3 = (0.3) \cdot w_3/(0.7)$. However, this is not needed to minimize segregation as measured by the index of dissimilarity. Instead, Q can be substituted for δ_3 and the population in Area 3 can be given by $t_3 = w_3/(1\text{-}Q) = w_3/P = w_3/0.75$ and $b_3 = Q \cdot t_3 = w_3 \cdot Q/P = w_3 \cdot (0.25/0.75)$. The reason for this is that D registers *all* departures from even distribution and the tolerance level for whites in this area (δ_3) exceeds Q (i.e., $0.30 > 0.25$), the proportion black that would result under even distribution. Consequently, placing blacks with whites in Area 3 lowers D only until q_3 for Area 3 reaches Q (i.e., 0.25). Moving additional blacks into Area 3 is still possible, but it will not reduce D any further because it creates departure from even distribution in a new way (i.e., by q_i exceeding Q rather than falling short of it). Thus, the minimum value of D can be achieved with *minimal movement* by moving blacks residing in all-black areas into areas where q_i is $< Q$ until q_i in each area reaches δ_i or Q, whichever is *lower*.

I term the assignment strategy just outlined "Rule I". This algorithm achieves the minimum possible value for D using the minimum possible movement. It can be stated more carefully as follows. Begin with a city that is completely segregated. Then move blacks from all-black areas into integrated and semi-integrated neighborhoods when it is possible to do so subject to two restrictions. First, moves cannot cause the ethnic composition in an area to become incompatible with whites' tolerances of contact with blacks. Second, moves cannot cause the proportion black in an area to exceed Q, the overall proportion black in the city. The first restriction insures that whites' preferences are never contradicted. The second restriction insures that the minimum D is achieved with minimum movement; additional moves may be possible, but they will not reduce D and need not implemented. This possibility did not come up in the earlier discussion of computing ${}_W D_B$ under homogeneous preferences because, if whites' tolerance of contact with blacks (δ) exceeds Q, q_i for the integrated area will automatically be capped at Q because all blacks will be moved into one area with all whites.

Interestingly, the value of ${}_W D_B$ under this algorithm is varies depending on the distribution of whites with tolerances (δ) below Q. The greater the proportion of whites with $\delta < Q$, and the lower their tolerances, the higher the value of ${}_WD_B$. In contrast, the distribution of whites with tolerances (δ) equal to or greater than Q does not matter. Since neighborhood proportion black (q_i) is capped at Q regardless of the value of whites' tolerances (δ), the value of ${}_WD_B$ produced under Rule I is the same regardless of whether whites with tolerances $\delta \geq Q$ hold tolerances that are all simply equal to Q or whether they hold tolerances that are all equal to 1 (the maximum possible).

Rule I achieves the objectives originally set forth by Massey and Gross (1991) and extends them to the analysis of heterogeneous preferences. Rule I is also straightforward to describe and relatively easy implement. Unfortunately, while it generates the lowest possible value for ${}_WD_B$, it suffers from an significant problem – it does not implement all of the possible moves that segregation theorists (e.g., James and Taeuber 1985) would classify as integration-promoting. The problem traces to a flaw in the index of dissimilarity itself. Specifically, D does not register transfers of blacks from area i to area j where $q_i > q_j \geq Q$ *before* the move and $q_i \geq q_j \geq Q$ *after* the move. Segregation measures *should* register such transfers because they increase black's residential "exposure" to whites and reduce blacks' residential exposure to other blacks closer to the levels that would result under exact integration (i.e., under even distribution).[1]

In view of this, I now introduce "Rule II", a second algorithm for achieving the minimum possible D under conditions of heterogeneous white preferences. This algorithm is attractive because it implements transfers of the type just described whenever possible. This will not produce lower scores for D. But, in addition to yielding the minimum value of D, it will also yield the minimum possible values of two other segregation measures; the index of black isolation (I) and the correlation ratio (R). The isolation index (I) is a specific case of the more general "exposure" index (${}_XE_X$). In this instance, it registers the average black's residential "exposure to" (i.e., contact with) other blacks (${}_BE_B$).[2] The correlation ratio (R) can be obtained from (I-Q)/(1-Q) and hence is also known as the "revised index of isolation". Since the index of isolation (I) takes the value Q under conditions of perfect integration, R can be understood as scaling the increase in black isolation resulting from *observed* segregation (I-Q)

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[1] Measures that do not register these moves do not meet the "Lorenz criterion" which holds that a measure should yield a lower score whenever a segregation curve is somewhere within and nowhere outside of a comparison segregation curve.

[2] In the two group case involving only whites and blacks, the isolation index (I) is also equal to $1 - {}_BE_W$ where ${}_BE_W$ is the average black's residential contact with whites. Thus, Rule II maximizes black residential contact with whites.

as a proportion of the maximum amount it could be raised under conditions of *perfect* segregation (1-Q).[1]

The algorithm for implementing Rule II requires two steps. In the first step, the Rule I algorithm is applied. If no white holds a tolerance (δ_i) that is less than Q, all whites and blacks will be placed together in an exactly integrated neighborhood and the procedure terminates at this point; maximum integration will be achieved and no further action is needed. Similarly, if no white holds a tolerance (δ_i) that is greater than Q and some whites hold a tolerance that is less than Q, the Rule I algorithm will generate the maximum level of *partial* integration and the procedure terminates at this point; no further integrating moves are possible. However, if some whites hold a tolerance (δ_i) that is less than Q and other whites hold a tolerance (δ_i) that is greater than Q, the Rule I algorithm will generated partial integration along the lines of that depicted in Figure 4. This is a situation where additional integrating moves are possible and step two of the algorithm for Rule II is required.

At the end of step one, the application of the Rule I algorithm will have created semi-integrated areas where $q_i < Q$, an exactly integrated area where $q_i = Q$, and an all-black area where $q_i = 0$. (This is the pattern seen in Figure 4.) At least some whites in the exactly integrated area hold preferences (δ_i) that exceed Q. Blacks residing in the all-black area could be moved and placed with these whites to form a new semi-integrated area where $q_i > Q$. This would constitute an integration-promoting transfer of blacks from area i to area j where $q_i > q_j \geq Q$ *before* the move and $q_i \geq q_j \geq Q$ *after* the move. Thus, these moves should be implemented to achieve maximum integration.

Step two accomplishes this according to the following process. Examine the population residing in the exactly integrated area where $q_i = Q$ and identify the group of whites holding the lowest tolerance (δ_i) that is greater than Q but has not yet been used to create a neighborhood (remember that at the end of step one no areas with $q_i > Q$ have been created). To the extent possible, take these whites, plus the blacks they are currently paired with, and place them with additional blacks taken from the all-black area to form a new area where $q_i = \delta_i$. Repeat this procedure until either all blacks have been moved out of the all-black area or until no more blacks can be moved.

[1] The correlation ratio (R) is also known as eta squared (Duncan and Duncan 1955). James and Taueber (1985:7) note that R can be expressed in a variety of ways based on exposure measures. There appear to be typographical errors in the expressions they give (specifically those found in footnote 7), but I have verified that R can be given by either $1 - {}_W E_B / Q$ or $1 - {}_B E_W / P$. Both expressions quantify the degree to which cross-group contact departs from the maximum that would be achieved under even distribution (full integration).

Note that under Rule I neighborhoods with different racial mixes (as defined by q_i) can be created in any order. This is not the case under Rule II. Instead, neighborhoods with $q_i > Q$ must be created in ordered sequence with q_i running from low to high over the range Q to 1 (excluding the end points of this range).

Also note that step 1 of Rule II is crucial and cannot be bypassed. If the logic of step 2 is applied without first applying the Rule I algorithm – for example, if blacks are placed with whites to the maximum extent permitted by δ_i beginning with the least tolerant whites and proceeding until all whites and blacks are placed – the index of dissimilarity will not reach its minimum possible value in some situations. This problem will occur when all blacks are placed *before* all whites with $\delta_i > Q$ are placed. When this happens, some whites with preferences compatible with even distribution (i.e., with $\delta_i \geq Q$) will be residing in areas where $q_i < Q$. This is a certainty when whites hold heterogeneous preferences where all $\delta_i \geq Q$. In this case, some whites will be placed in areas where $q_i > Q$ before all whites are placed in areas with $q_i = Q$. At some point then, some whites with $\delta_i > Q$ will be placed in areas where $q_i < Q$ because there will not be "enough" blacks remaining to build more areas where qi ≥ Q. Obviously, this will produce uneven distribution even though whites' preferences are compatible with exact even distribution. The same thing *can* happen when whites hold heterogeneous preferences that include $\delta_i < Q$, but it is not a certainty.

The segregation chart resulting from the application of Rule II is shown in Figure 5. The key change in the residential distribution depicted here (over that that depicted in Figure 4) is that the population in Area 3 is expanded and it now accommodates more blacks and the population of Area 4 is reduced by a corresponding amount. Thus, in Figure 4 the population of Area 3 is given by

$t_3 = w_3/(1\text{-}Q) = w_3/P = w_3/(0.75)$ and

$b_3 = Q \cdot t_3 = w_3 \cdot Q/P = w_3 \cdot (0.25)/(0.75)$.

In Figure 5 the population of Area 3 is given by

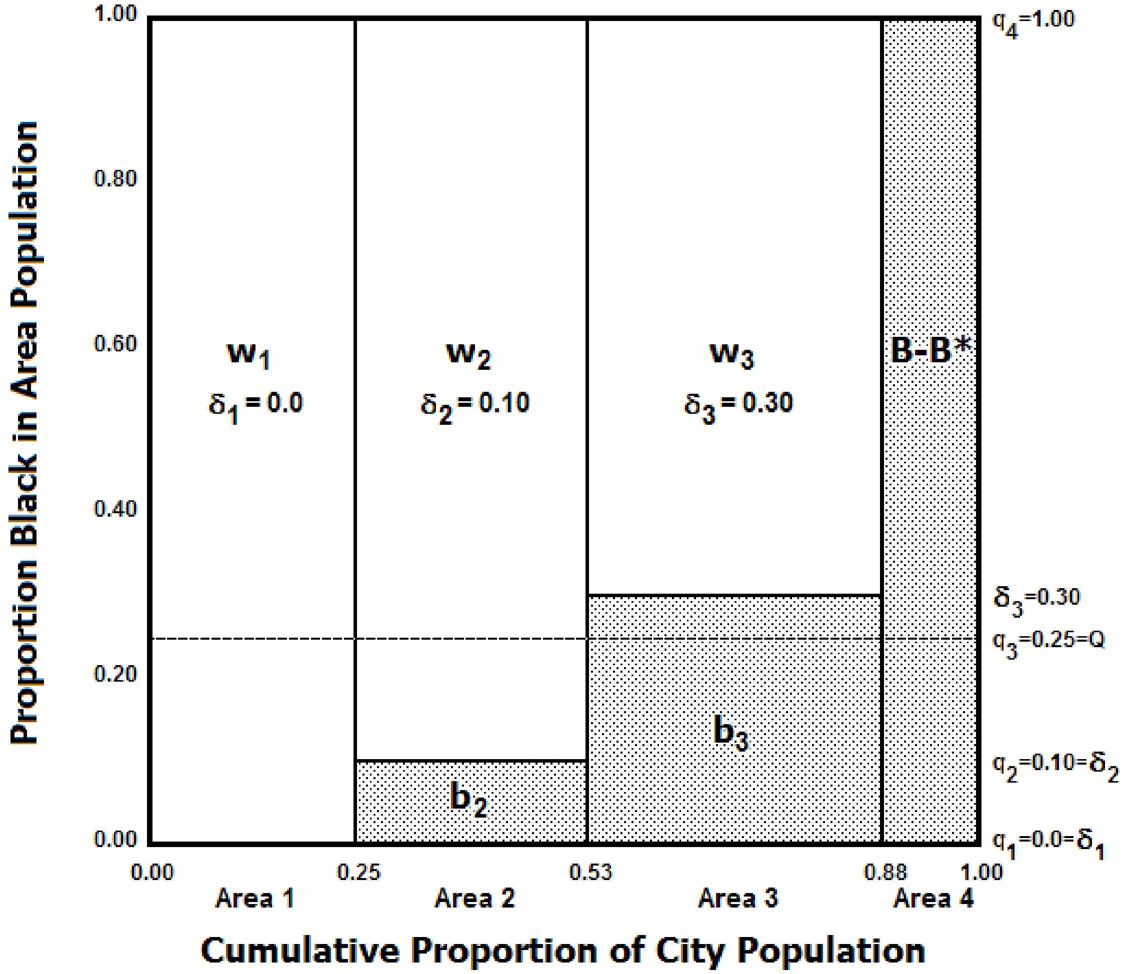
$t_3 = w_3/(1\text{-}\delta_3) = w_3/(1\text{-}0.30) = w_3/(0.70)$ and

$b_3 = \delta_3 \cdot t_3 = w_3 \cdot (0.3)/(0.7)$.

The difference traces to the fact that when $Q < \delta_3$, Rule I uses Q to determine t_3 and Rule II uses δ_3. See Appendix D for additional discussion of how residential distributions generated by Rule II differ from those generated by Rule I.

Figure 5

Proportion Black by Area Type Using Rule II with Heterogeneous White Preferences δ_1 - δ_3 and Q=0.25



In both figures, the number of blacks (b_4) residing in the all-black neighborhood (Area 4) is obtained by taking the total number of blacks in the city (B) and subtracting out the number of blacks who reside in integrated or semi-integrated neighborhoods. Thus, it is given by B – B* where B* is given by Σb_i for areas that are not all-black (i.e., where $q_i < 1.0$). The expressions that give the residential distributions depicted in Figures 4 and 5 are summarized in Table 2. The resulting calculations for neighborhood ethnic distributions are shown in Table 3 based on city-wide population assignments of T = 1.0, W = 0.75, and B = 0.25. The values of selected segregation indexes computed from the neighborhood population assignments reported in Table 3 are shown in Table 4.

Table 2 Expressions for Obtaining Neighborhood Population Assignments Under Heterogeneous White Preferences

Type of Neighborhood	Proportion Black = q_i = δ_i or Q	Whites = w_i	Total = $t_i = w_i/(1-\delta_i)$	Blacks = $b_i = t_i\delta_i$
All White Neighborhoods				
Area 1 ($\delta_1 = 0.00$)	$\delta_1 = 0.00$	w_1	$t_1 = w_1$	$b_1 = 0$
Integrated Neighborhoods				
Area 2 ($\delta_2 = 0.10$)	$\delta_2 = 0.10$	w_2	$t_2 = w_2/(1-\delta_2)$	$b_2 = t_2 \cdot \delta_2$
Area 3 ($\delta_3 = 0.30$)				
Rule I ($q_i = \min[\delta_i, Q]$)	Q = 0.25	w_3	$t_3 = w_3/(1-Q)$	$b_3 = t_3 \cdot Q$
Rule II	$\delta_3 = 0.30$	w_3	$t_3 = w_3/(1-\delta_3)$	$b_3 = t_3 \cdot \delta_3$
All-Black Neighborhoods				
Area 4	1.00	$w_4 = 0$	$t_4 = B - B^*$	$b_4 = B - B^*$

Note: B* is given by $\Sigma\, b_i$ over areas where $q_i < 1.0$.

When Rule I (minimum D with minimum movement) is in effect, it is relatively easy to obtain ${}_WD_B$ from the terms in Table 2 because D is equal to the fraction of blacks residing in all-black areas.[1] The fraction of blacks living in all-black areas is obtained by dividing the total number of blacks in all-black areas ($b_4 = B - B^* = B - \Sigma\, b_i$) by the total number of blacks in the city (B). Thus,

$${}_WD_B = (B - \Sigma\, b_i) / B$$

$${}_WD_B = 1 - \Sigma\, b_i / B.$$

This last expression can be restated in a form that closely parallels Equation 1 which gives the formula for ${}_WD_B$ under *homogeneous* preferences as $1 - P/Q \cdot \delta/(1-\delta)$ when $Q > \delta$ and 0 otherwise.

[1] D is given by $\frac{1}{2}\, \Sigma\, | w_i/W - b_i/B |$. It is well known that the sum of the positive values of the difference term ($w_i / W - b_i / B$) will exactly offset the sum of the negative values for the difference term. Thus, D is given by either the sum of the positive differences or the absolute value of the sum of the negative differences. Under Rule I, the difference term ($w_i / W - b_i / B$) is negative for only one area – Area 4, the final, all-black area. Since w_4 is 0, the difference term is $-b_4 / B$ and D is thus given by b_4 / B.

Table 3 Resulting Population Assignments and Group Population Shares for Neighborhoods Under Heterogeneous White Preferences (As Depicted in Figures 4 and 5)

Type of Neighborhood	Prop. Black (q_i)	Whites (w_i/T)	Blacks (b_i/T)	Total (t_i/T)	Share w_i/W	Share b_i/B
			Assignments Under Rule I			
Area 1 (δ_1 = 0.00)	0.00	0.2500	0.0000	0.2500	0.3333	0.0000
Area 2 (δ_2 = 0.10)	0.10	0.2500	0.0278	0.2778	0.3333	0.1112
Area 3 (δ_3 = 0.30)	0.25	0.2500	0.0833	0.3333	0.3333	0.3332
Area 4	1.00	0.0000	0.1389	0.1389	0.0000	0.5556
Sum over All Areas		0.7500	0.2500	1.0000	1.0000	1.0000
			Assignments Under Rule II			
Area 1 (δ_1 = 0.00)	0.00	0.2500	0.0000	0.2500	0.3333	0.0000
Area 2 (δ_2 = 0.10)	0.10	0.2500	0.0278	0.2778	0.3333	0.1112
Area 3 (δ_3 = 0.30)	0.30	0.2500	0.1071	0.3571	0.3333	0.4284
Area 4	1.00	0.0000	0.1151	0.1151	0.0000	0.4604
Sum over All Areas		0.7500	0.2500	1.0000	1.0000	1.0000

Note: Figures for areas may not sum to total due to rounding.

A formula similar to this can be obtained for the situation where white preferences are *heterogeneous* as follows. First, start with the expression

$${}_WD_B = 1 - \Sigma\, b_i / B$$

and substitute $\min(\delta_i, Q)\cdot w_i/(1-\min(\delta_i, Q))$ for b_i. This yields

$${}_WD_B = 1 - \Sigma \min(\delta_i, Q)\cdot w_i/(1-\min(\delta_i, Q)) / B .$$

Next rearrange terms to obtain

$${}_WD_B = 1 - \Sigma\, (w_i/B)\cdot(\min(\delta_i, Q) / (1-\min(\delta_i, Q))) .$$

Then multiply w_i/B by 1 in the form of (1/T)/(1/T) to obtain

$${}_WD_B = 1 - \Sigma\, (P_i/Q)\cdot(\min(\delta_i, Q) / (1-\min(\delta_i, Q))) . \qquad [3]$$

Table 4 Selected Segregation Index Scores Computed from Neighborhood Ethnic Mixes Under Heterogeneous White Preferences (As Depicted in Figures 4 and 5)

Segregation Index	Computed Using Rule I (Figure 4)	Computed Using Rule II (Figure 5)
Index of Dissimilarity (D*)	0.5556	0.5556
Gini Index (G*)	0.7778	0.7460
Correlation Ratio (R*)	0.5333	0.4667
Black Isolation (I* or ${}_{B}E_{B}$*))	0.6500	0.6000
Black Exposure to Whites (${}_{B}E_{W}$*)	0.3500	0.4000

For computation formulas see James and Taeuber (1985) or Massey and Denton (1988).

where P_i represents the proportion of the total population that is both white *and* holds the preference δ_i.

When Rule II is used, the algorithm for calculating ${}_{W}D_{B}$ is sufficiently complicated that it cannot be represented by a compact expression such as Equation 3.[1]

The calculations reported in Table 4 show that the value of the index of dissimilarity is the same for the residential distributions depicted in both Figure 4 and Figure 5. Thus, the algorithms for Rules I and II are *both* correctly described as minimum D* algorithms. But the algorithm for Rule II goes further and executes all integration-promoting transfers of blacks that can be achieved without violating whites' preferences. That is, after Rule II has been implemented, it is not possible to implement any additional integration-promoting transfers of blacks from area i to area j where $q_i > q_j \geq Q$ *before* the move and $q_i \geq q_j \geq Q$ *after* the move. Consequently, while Rule I and II yield identical scores on D, Table 4 shows that Rule II yields equal or higher scores for blacks' residential exposure to whites (${}_{B}E_{W}$) and equal or lower scores for black residential exposure to blacks (${}_{B}E_{B}$) also known as black isolation (I), equal or lower scores for the correlation ratio (R), and equal or lower scores for the gini index (G).

I speculate that Rule II achieves the maximum possible value of ${}_{B}E_{W}$ and the minimum possible values for I, R, and G. I have not tried to develop a formal proof to show that this "hunch" is true (it is

[1] This appears to be one advantage that Rule I has over Rule II – it is a bit more convenient to represent and explain since its computation can be expressed in a form that is relatively easy to manipulate.

beyond the scope of this paper). But, it seems likely to be correct. The Rule II algorithm terminates only when it is no longer possible to move any black into an area where their contact with whites will be higher. Thus, ${}_{B}E_{W}$ is apparently maximized and I (i.e., ${}_{B}E_{B}$) is apparently minimized. Since R is given by (I-Q)/(1-Q), it also is apparently minimized. The gini index (G) meets James and Taeubers' (1985) principle of transfers so its value may also be minimized.[1] Whether these speculations are confirmed by future theoretical work remains to be seen. For now, however, I can safely state that the Rule II algorithm produces lower minimum segregation scores than any other known algorithm.

An Aside Regarding Certain Practical Considerations

The application of Rules I and II to create the residential distributions presented in Figures 4 and 5 and in Tables 2 and 3 is greatly simplified by the fact that the population distributions and areas involved in this exercise are theoretical abstractions. Areas can assume any racial mix (i.e., any q_i necessary to accommodate whites' tolerances [δ_i]) and whites and blacks can be placed into areas in "fractional" parts as necessary. This allows Rules I and II to generate the maximum level of integration (minimum level of segregation) possible under their respective procedures.

A variety of departures from this theoretical idealization can make the implementation of these rules more complicated. Suppose, for example, that the population is defined as finite (e.g., 100,000 residents) and that individuals can only be placed into areas in integer amounts (i.e., people cannot be divided into fractional parts). Then certain area racial mixes (q_i) that might be feasible in principle based on whites' tolerances (δ_i) might not be attainable when population assignments involve integer counts. In these kinds of situations, Rules I and II may have to be adjusted to accommodate various practical constraints. The resulting residential distributions would then produce *less* residential integration than could be achieved under the abstract idealization used in the analyses presented to this point here.

This issue is not entirely hypothetical. Analytic exercises I report in later sections of this paper place whites and blacks into areas with racial mixtures (q_i) that must be exact multiples of 0.0025. Imposing a finite set of allowable values for area racial mix has the practical benefit of facilitating the

[1] Reardon and Firebaugh (2002) note that G responds to transfers in very complex ways. But intuitive reasoning suggests it may be minimized by the algorithm since it must decline with each integration-promoting black move and, when Rule II terminates, no more such moves are possible.

implementation, and speed of execution, of computer algorithms for computing D*. But there is a "cost" in that D* calculations will be less exact than would be possible if areas could be created with racial mixes optimal for permitting integration. In the analyses reported below, the "coverage" of possible racial mixtures (q_i) is sufficiently "fine-grained" (i.e., it delimits a total of 401 possible racial mixes distributed evenly from 0 to 1) that the practical impact on D* calculations (and other minimum segregation calculations) is probably negligible. More generally, however, the question of whether the impact of departures from the idealized implementation of Rules I and II is large enough to "matter" must be assessed on a case-by-case basis.

Section III
Assessing the Implications of Minority Preferences

In this section I consider the implications that minority preferences may have for residential segregation. As a preliminary step, I show that the measure ${}_{W}D_{B}$ can be expressed in an alternative form than the one presented to this point; one that emphasizes whites' preferences for co-ethnic contact rather than whites' aversion to contact with blacks. I then adapt this formulation to create a new measure ${}_{B}D_{W}$ which represents the minimum value of D required to insure that blacks' ethnic preferences are never violated and use this to assess the implications minority preferences for co-ethnic contact may have for segregation.

An Alternative Formulation and Interpretation of ${}_{W}D_{B}$

The value of ${}_{W}D_{B}$ can be interpreted in way that emphasizes whites' preferences for co-ethnic contact rather than whites' intolerance of other groups. Specifically, the measure can be defined as the minimum value of D required to insure that whites' preferences for residential contact with other whites are always realized. For simplicity of exposition, I return to the simple situation where whites' ethnic preferences are homogeneous. Let α represent the minimum proportion white in an area that whites prefer. In the simplified, two-group situation assumed in this analysis, α is equal to 1-δ. Likewise, δ is equal to 1-α.

When Equation 1 for ${}_{W}D_{B}$ is modified by substituting α for 1-δ and substituting 1-α for δ, the result is

$${}_{W}D_{B} = 1 - P/Q \cdot (1-\alpha)/\alpha \text{ when } \alpha > P \text{ and 0 otherwise.} \quad [4]$$

Since it is a straightforward matter to extend this formulation to the situation of heterogeneous preferences, I forego a review of that exercise. Rules I and II can be applied (with appropriate adjustments) to obtain values of D, I, ${}_{B}E_{W}$, R, and G based on whites' heterogeneous preferences for co-ethnic contact.

This alternative formulation of ${}_{W}D_{B}$ is useful for several reasons. First, it is sometimes appropriate to hypothesize that segregation is produced by the efforts members of a group make to achieve certain levels co-ethnic contact. It is not unusual for members of an ethnic group to seek out co-ethnic contact for a variety of reasons stemming from positive desires to experience, affirm, or reproduce ethnic culture.

Second, this formulation of $_WD_B$ highlights the fact that the distinction between intolerance of and aversion to out-group contact, on the one hand, and ethnic solidarity and affinity for in-group contact, on the other hand, can be quite slippery. Indeed, in the present example, *the two are exact mathematical transformations of each other*. Furthermore, as will become evident shortly, their respective implications for residential segregation are identical.

A third reason for emphasizing the notion that individuals may actively *seek out* minimum levels of co-ethnic contact is that this conceptualization fits nicely with two important perspectives on segregation that highlight the role of preferences in *choice* rather than exclusion. One is the urban ecological perspective which in its earliest statements stressed the role of "social distance" in shaping segregation patterns and identified the process of "congregation" (e.g., Burgess 1928; Cressy 1938; McKenzie 1926; Park 1926; 1936). Another perspective, first set forth by Schelling (1969; 1971; 1972) and revisited by Taylor (1984) and Granovetter and Soong (1988) among others, draws on micro-economic choice theory attempting to understand its macro-level implications for residential segregation and neighborhood "tipping" .

These perspectives stress social dynamics that are neglected in conventional theorizing about the impact of preferences. Conventional treatments focus on *white* intolerance of (aversion to) minorities and whites' efforts to minimize contact with blacks or other ethnic groups via exclusion and discrimination. These are obviously important dynamics and they deserve attention. However, the literature's overwhelming emphasis on these dynamics can foster an incorrect impression that ethnic preferences can have implications for segregation *only* by causing power majorities to exclude minority groups from majority residential areas. In fact, social distance theory and micro-economic choice theory both suggest that preferences can have important implications for segregation even in the absence of exclusion and discrimination. They also suggest that a group need not be a power majority for its preferences to have implications for segregation.

This last point leads to the final reason why the formulation of D* in terms of preferences for in-group contact is useful. Namely, this formulation established the conceptual foundations for considering how *minority* preferences may affect segregation by promoting "congregation".

An Alternative Formulation and Interpretation of ${}_{W}D_{B}$

To explore the implications minority preferences may have for residential segregation I introduce a new measure – ${}_{B}D_{W}$ – which represents the minimum value of D required to insure that blacks' ethnic preferences are never violated. This can be developed in two ways. One is from the point of view that blacks may desire to keep residential contact with whites from exceeding a certain level (e.g., at or below 50%). Using the term π to represent the maximum proportion white that blacks will tolerate in a neighborhood and assuming homogeneous preferences, the measure ${}_{B}D_{W}$ can be given as

$${}_{B}D_{W} = 1 - Q/P \cdot \pi/(1-\pi) \text{ when } P > \pi \text{ and 0 otherwise.} \quad [5]$$

This is a straightforward adaptation of Equation 1 for ${}_{W}D_{B}$ with δ being replaced by π and the roles of P and Q being adjusted accordingly.

The second way to develop ${}_{B}D_{W}$ is from the point of view that blacks may hold preferences to achieve a certain level of co-ethnic contact. Using the term λ to represent the minimum representation of blacks that blacks desire in a neighborhood, the measure can be given as

$${}_{B}D_{W} = 1 - Q/P \cdot (1-\lambda)/\lambda \text{ when } \lambda > Q \text{ and 0 otherwise.} \quad [6]$$

This is a straightforward adaptation of Equation 4 for ${}_{W}D_{B}$ with α being replaced by λ and the roles of P and Q being adjusted accordingly.[1]

Table 5 gives a sampling of combinations of racial mix and black preference for co-ethnic contact and the values of ${}_{B}D_{W}$ that result under these structural conditions. It shows that, when Q is greater than or equal to λ, no segregation is needed to insure that blacks' preferences for co-ethnic contact are satisfied – blacks' preferences are compatible with complete integration and thus ${}_{B}D_{W}$ is zero. However, as Q falls below λ, increasingly high levels of segregation are needed to insure that blacks achieve the minimum levels of co-ethnic contract they seek and ${}_{B}D_{W}$ rises to higher and higher values.

The substantive implications of this last pattern are potentially important. The pattern suggests that, because blacks are a numerical minority in most metropolitan areas, their preferences for co-ethnic contact have the potential to generate surprisingly high scores on ${}_{B}D_{W}$ even when the level of co-ethnic contact sought by blacks is moderate or low. This important possibility receives more attention at the end of this section.

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[1] I do not present derivations for either Equation 5 or Equation 6. Both are straightforward adaptations of the derivations used earlier to establish Equations 1 and 4 for ${}_{W}D_{B}$ for whites.

Table 5. Values of ${}_{B}D_{W}$ Under Varying Combinations of City-Wide Racial Mix and Black Preference for Co-Ethnic Contact.

	Minimum Black Representation in a Neighborhood Desired by Blacks (λ)					
Black Representation in the City Population (Q)	2%	5%	10%	20%	30%	40%
1%	0.505	0.808	0.909	0.960	0.976	0.985
2%	0	0.612	0.816	0.918	0.952	0.969
5%	0	0	0.526	0.789	0.877	0.917
10%	0	0	0	0.556	0.741	0.833
15%	0	0	0	0.294	0.588	0.735
20%	0	0	0	0	0.417	0.6250
25%	0	0	0	0	0.222	0.500
30%	0	0	0	0	0	0.357
35%	0	0	0	0	0	0.192
40%	0	0	0	0	0	0

Figure 6 depicts a semi-integrated city where $\lambda > Q$.[1] In this city, all black households (B) reside in the semi-integrated area (Area 2). The proportion white in this area is $1-\lambda$. The number of white households residing in this area (w_2) is given by $B\cdot(1-\lambda) / \lambda$. White households that cannot be accommodated in the integrated area without violating blacks' preferences reside in the white area (Area 1). Their number is given by W-W* where W* is the number of whites living in integrated areas (i.e., w_2).

Equation 2 established that ${}_{W}D_{B}$ can be given as 1.0 – B*/B where B* represents the number of blacks living in integrated or semi-integrated areas (i.e., areas where $q_i < 1$). In like manner, ${}_{B}D_{W}$ can be given as 1.0 – W*/W where W* represents the number of whites residing in integrated or semi-integrated areas and where W* is 0 if $\lambda > Q$. The equivalence of this expression and Equation 6 introduced above can be shown as follows. Start with

$${}_{B}D_{W} = 1 - W^*/W \text{ when } \lambda > Q \text{ and 0 otherwise.}$$

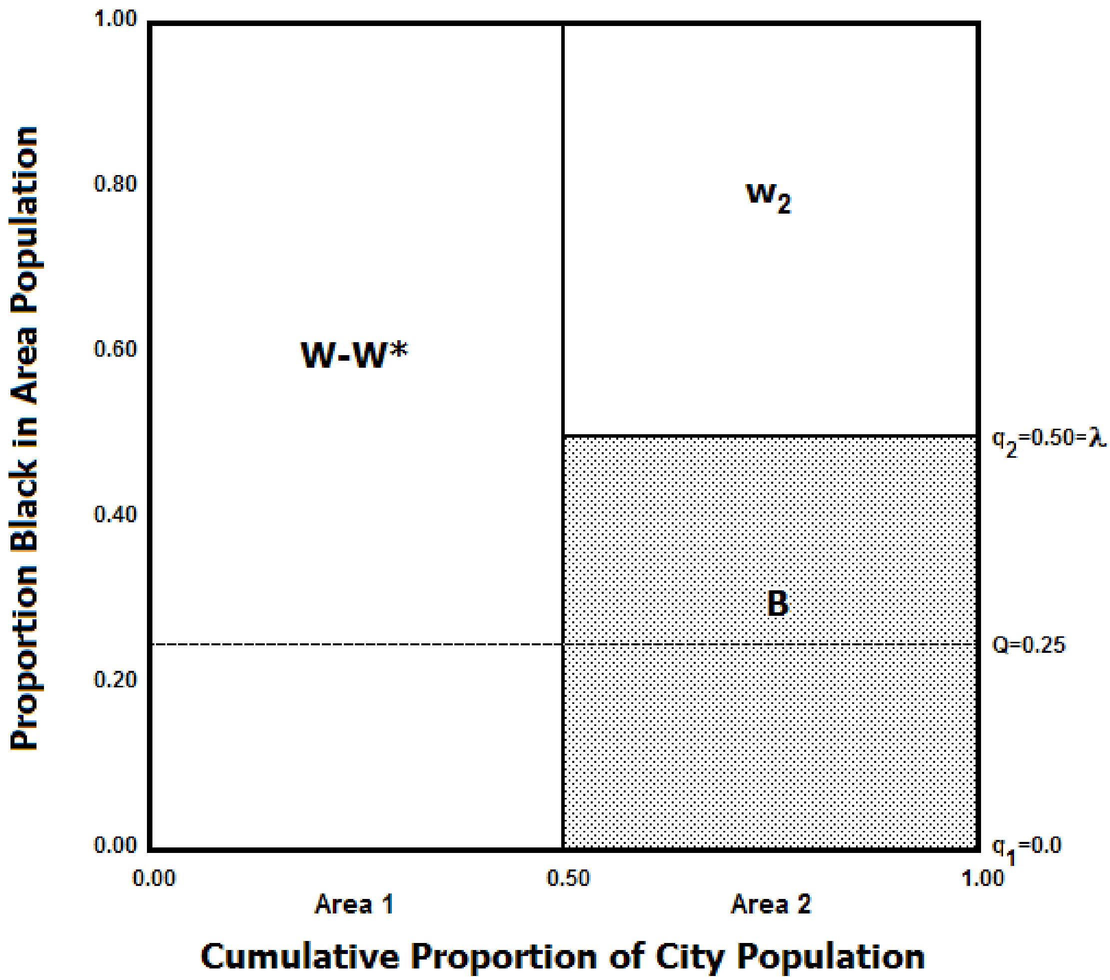
Then substitute $B\cdot(1-\lambda) / \lambda$ for W* to obtain

$${}_{B}D_{W} = 1 - [B\cdot(1-\lambda) / \lambda] /W.$$

[1] If $\lambda \leq Q$, then blacks' preferences are compatible with even distribution and the value of ${}_{B}D_{W}$ will be zero.

Figure 6

Proportion Black by Area Type with Homogeneous Black Preferences λ=0.50 and Q=0.25



Next rearrange terms and regroup to obtain

$$_{B}D_{W} = 1 - B\cdot(1-\lambda) / (\lambda /W)$$

$$_{B}D_{W} = 1 - B/W\cdot(1-\lambda) / \lambda\, .$$

Finally, multiply B/W by 1 in the form of (1/T)/(1/T) to obtain

$$_{B}D_{W} = 1 - Q/P\cdot(1-\lambda)/\lambda \text{ when } \lambda > Q \text{ and 0 otherwise.}$$

Maintaining citywide proportions white and black at the values used in the earlier examples (i.e., Q=0.25 and P=0.75), and assuming blacks' minimum requirement for black representation in their neighborhoods (λ) is 0.50, the proportion of white households residing in semi-integrated neighborhoods (P^*) is $Q/P \cdot (1-\lambda)/\lambda = 0.333$. The proportion of white households residing in all-white neighborhoods is 1.0 minus this amount or 0.667. Thus, the minimum level of segregation (as measured by ${}_{B}D_{W}$) needed to insure that black preferences are not violated in this city is 0.667.

Note that if we consider the issue from the point of view that blacks wish to avoid neighborhoods where proportion white exceeds blacks' maximum tolerance for white representation (π), the result is identical. The proportion of white households residing in semi-integrated neighborhoods (P^*) is $Q/P \cdot \pi/(1-\pi) = 0.333$. The proportion of white households residing in all-white neighborhoods is 1.0 minus this amount or 0.667. Thus, the minimum level of segregation (as measured by ${}_{B}D_{W}$) needed to insure that black preferences are satisfied in this city is 0.667.

Heterogeneous Minority Preferences

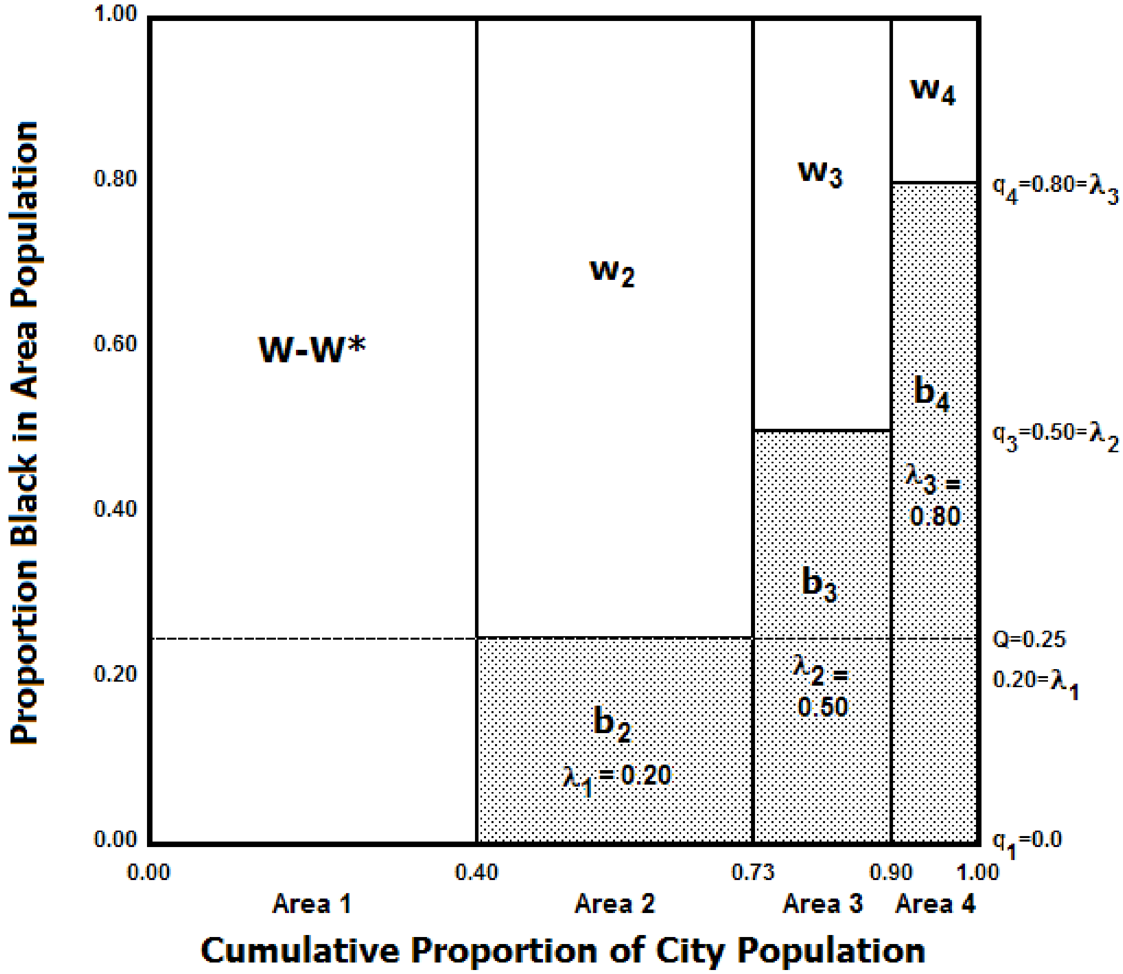
As earlier in the discussion of the implications of whites' preferences for segregation, I consider two algorithms for obtaining the minimum possible value of D under conditions of heterogeneous black preferences. Under Rule I, the city begins completely segregated and whites are strategically moved from all-white areas into integrated and semi-integrated neighborhoods when it is possible to do so under two restrictions. The first is that moves cannot cause the ethnic composition of the area to become incompatible with blacks' preferences for in-group contact. The second restriction is that moves cannot cause the proportion white in the area to exceed the overall proportion white in the city (P). This insures that the minimum value of D is achieved with minimum movement (i.e., additional moves may be possible, but will not reduce D any further).

Figure 7 presents the segregation chart resulting under Rule I when the black population is subdivided into three equal-sized groups with minimum in-group preferences (λ_i) of 0.20, 0.50, and 0.80, respectively. Notice that, while blacks in Area 2 would tolerate whites at up to a maximum of 80% of the area population, Rule I halts the movement of whites into the area when the area reaches 75% white (the proportion white in the city as a whole).

Rule II goes further and not only produces the minimum possible D, but also produces minimum values of black isolation (I or ${}_{B}E_{B}$) and the correlation ratio (R), and lower values of the gini index (G). Figure 8 presents the segregation chart resulting under Rule II.

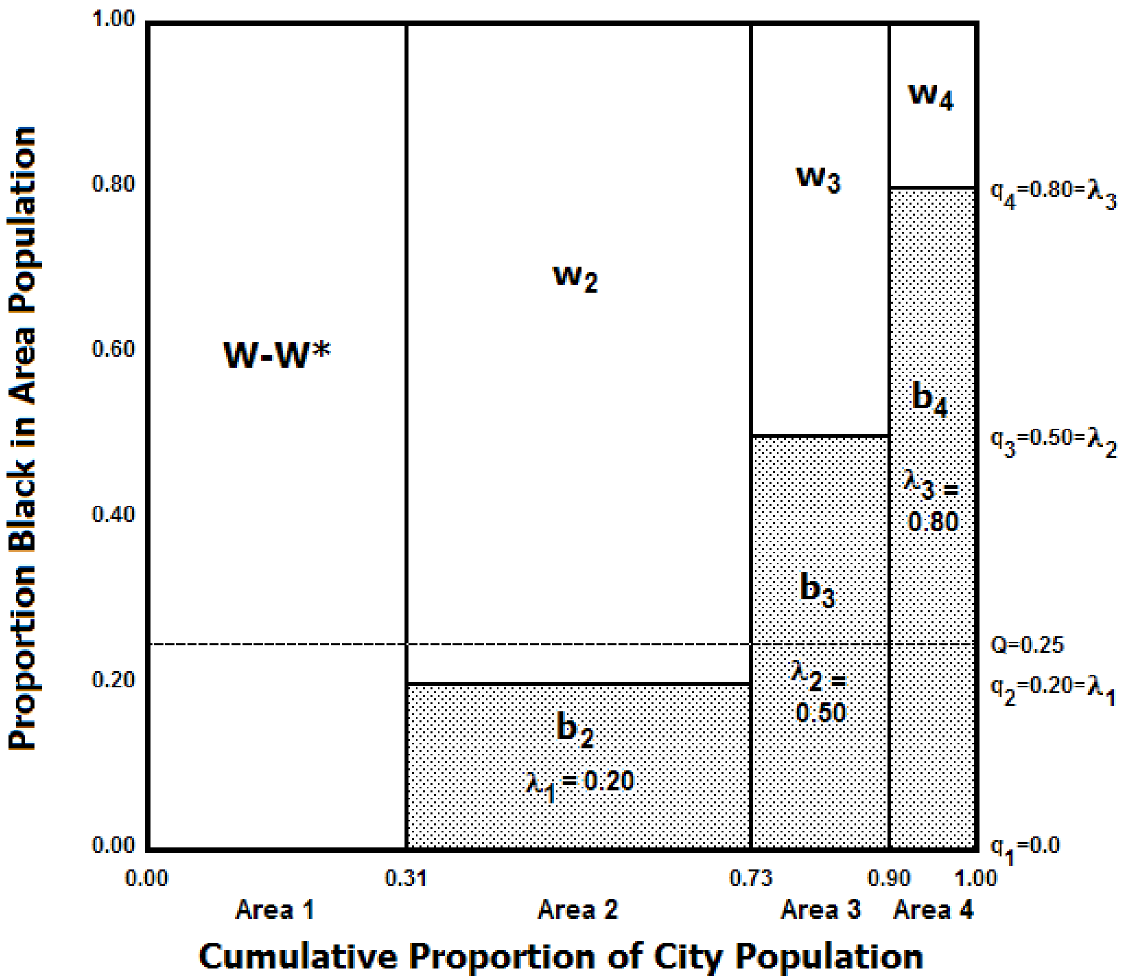
Figure 7

Proportion Black by Area Type Under Rule I with Heterogeneous Black Preferences λ_1 - λ_3 and Q=0.25



The algorithm that produces the segregation chart shown in Figure 8 involves two steps. First Rule I is applied. This creates integrated and semi-integrated areas where p_i is capped at P. If all blacks have preferences for co-ethnic contact (λ_i) that are no greater than the proportion black in the city (Q), all whites and blacks will be placed in integrated areas at the end of this step and the process terminates. If some blacks have preferences for co-ethnic contact (λ_i) that exceed the proportion black in the city (Q), some whites will not yet be moved out of the all-white area and an additional set of operations may be possible.

Figure 8
Proportion Black by Area Type Under Rule II with Heterogeneous Black Preferences λ_1 - λ_3 and Q=0.25



This next step proceeds as follows. Examine the population in the exactly integrated area (where $p_i = P$) and identify blacks who hold the preference for co-ethnic contact (λ_i) that is closest to Q but less than Q. To the extent possible, move some or all of these blacks, plus the whites they are currently paired with, plus an appropriate number of additional whites from the all-white area, and place them in a newly created area where $q_i = \lambda_i$ (or, alternatively, $p_i = 1 - \lambda_i$). Repeat this procedure until all whites are placed or until it is no longer possible to move more whites out of the all-white area.

The key difference between Figure 7 and Figure 8 is in the way the population is distributed across Areas 1 and 2. As shown in Figure 7, Rule I limits the movement of whites into Area 2 after the proportion white in the area (p_i) reaches the level for the city as a whole (P). In contrast, as shown in Figure 8, Rule II allows the proportion white in Area 2 to grow to the limit imposed by the preference for co-ethnic contact held by blacks in the area (i.e., λ_1). The result is that fewer whites reside in the all-white area in Figure 8 and the blacks that reside in Area 2 have greater levels of contact with whites in Figure 8 than in Figure 7. Since the number of blacks residing in Areas 2 is the same in both cases, visual comparison of the two figures makes it clear that Rule II produces higher levels of black exposure to whites (${}_BE_W$) and lower levels of black isolation (I or ${}_BE_B$). This intuition is confirmed in calculations reported below.

Under Rule I, the following equation

$${}_BD_W = 1.0 - W^*/W$$

(originally introduced as the formula for D under homogeneous black preferences regarding the desire for co-ethnic contact) is a good starting point for obtaining a generalized expression for ${}_BD_W$ when blacks have heterogeneous preferences.

In this equation, W* is the number of whites who reside in integrated or partially integrated neighborhoods. This term can be stated in terms of blacks' preferences (λ_i), the proportion of the city population that is black *and* holds a given preference (Q_i), and the proportion white in the city (P). To do this, take the last expression and substitute $B_i \cdot (1-\lambda_i)/\lambda_i$ for W* to obtain

$${}_BD_W = 1.0 - \Sigma\, (B_i \cdot (1-\lambda_i)/\lambda_i) / W.$$

Then modify this result to reflect the fact that Q should be used in place of λ_i if $\lambda_i \leq Q$. This yields

$${}_BD_W = 1.0 - \Sigma\, (B_i \cdot (1-(\max(\lambda_i, Q))/\max(\lambda_i, Q)) / W.$$

Next rearrange terms to obtain

$${}_BD_W = 1.0 - \Sigma\, (B_i / W) \cdot (1-(\max(\lambda_i, Q))/\max(\lambda_i, Q))$$

Then multiply B_i / W by 1 in the form of (1/T)/(1/T) to obtain

$${}_BD_W = 1.0 - \Sigma\, (Q_i/P) \cdot (1-(\max(\lambda_i, Q))/\max(\lambda_i, Q))$$

This expression for ${}_BD_W$ under the condition of heterogeneous black preferences directly parallels the formula

$${}_BD_W = 1.0 - Q/P \cdot (1-\lambda)/\lambda \quad \text{when } Q < \lambda \text{ and 0 otherwise,}$$

given earlier as Equation 5 for the condition where black preferences are homogeneous.

Table 6 Resulting Population Assignments and Group Population Shares for Neighborhoods Under Heterogeneous Black Preferences (As Depicted in Figures 7 and 8)

Type of Neighborhood	Prop. Black (q_i)	Whites (w_i/T)	Blacks (b_i/T)	Total (t_i/T)	Share w_i/W	Share b_i/B
		Assignments Under Rule I				
Area 1	0.00	0.3959	0.0000	0.3959	0.5279	0.0000
Area 2 (λ_1 = 0.20)	0.25	0.2500	0.0833	0.3333	0.3333	0.3333
Area 3 (λ_2 = 0.50)	0.50	0.0833	0.0833	0.1667	0.1111	0.3333
Area 4 (λ_3 = 0.80)	0.80	0.0208	0.0833	0.1042	0.0277	0.3333
Sum over All Areas		0.7500	0.2500	1.0000	1.0000	1.0000
		Assignments Under Rule II				
Area 1	0.00	0.3125	0.0000	0.3125	0.4167	0.0000
Area 2 (λ_1 = 0.20)	0.20	0.3333	0.0833	0.4167	0.4444	0.3333
Area 3 (λ_2 = 0.50)	0.50	0.0833	0.0833	0.3571	0.1111	0.3333
Area 4 (λ_3 = 0.80)	0.80	0.0208	0.0833	0.1151	0.0277	0.3333
Sum over All Areas		0.7500	0.2500	1.0000	1.0000	1.0000

Note: Figures for areas may not sum to total due to rounding.

When Rule II is used, the algorithm for calculating ${}_{B}D_{W}$ is sufficiently complicated that it cannot be represented by a compact expression.[1]

Table 6 reports the residential distributions that are generated when Rules I and II are implemented. Table 7 reports the segregation index scores computed from these distributions. Three findings are evident from this table. The first is that Rule I and Rule II yield identical values of D*. Thus, as seen before Rule I and Rule II both produce minimum values of D*.

[1] Recall that this was also the case for ${}_{W}D_{B}$.

Table 7 Selected Segregation Index Scores Computed from Neighborhood Population Assignments Under Heterogeneous Black Preferences (As Depicted in Figures 7 and 8 and Listed in Table 6)

Segregation Index	Computed Using Rule I	Computed Using Rule II
Index of Dissimilarity (D)	0.5278	0.5278
Gini Index (G)	0.7315	0.6945
Correlation Ratio (R)	0.6889	0.6667
Black Isolation (I or ${}_{B}E_{B}$)	0.5167	0.5000
Black Exposure to Whites (${}_{B}E_{W}$)	0.4833	0.5000

For computation formulas see James and Taeuber (1985) or Massey and Denton (1988).

The second finding is that Rule II yields lower values on the other segregation measures considered here (i.e., G, I, and R) and higher levels of black residential exposure to whites (${}_{B}E_{W}$). This also parallels the findings from the earlier analysis where Rule II was used to assess the implications of whites preferences for segregation. It confirms the conclusion set forth earlier, that Rule II should be preferred over Rule I when assessing the implications of heterogeneous preferences for residential segregation.

The third and final finding I note here is by far the most important. It is that the minimum levels of segregation resulting under Rule II are high. I suspect this result would surprise many because the preferences blacks hold in this example would strike most as being less of an obstacle to integration than the preferences whites held in the earlier examples (i.e., where D* was computed based on whites' tolerances for contact with blacks). Yet the minimum levels of segregation achieved under strategic assignment are only slightly lower here. The explanation for this is found in the dramatic impact that ethnic demography has on the implications that a group's preferences have for segregation. In the examples considered here the city is 25% black. This is significant because, even though blacks' preferences for co-ethnic contact are markedly *lower* than those seen previously for whites, most blacks seek co-ethnic contact at levels *exceeding* the representation of blacks in the city population. Consequently, substantial levels of segregation are required to avoid violating blacks' preferences. This important finding is explored in greater depth in the next sections.

Section IV
A First Assessment of the Implications of White and Black Preferences Considered Jointly

In this section I consider the implications of whites' and blacks' preferences for segregation when they are considered together. The simplest case to consider is when each group holds homogeneous preferences. Equations 2 and 6 presented earlier are appropriate in this case. They reveal that ${}_{W}D_{B}$ and ${}_{B}D_{W}$ are nonlinear functions of the proportionate representation of whites and blacks in the city and each group's preferences for co-ethnic contact. Calculations based on these equations presented in Tables 1 and 5 gave evidence of this earlier. Figures 9 and 10 offer further illustration of the complex nature of the relationships the two measures have with citywide racial mix.

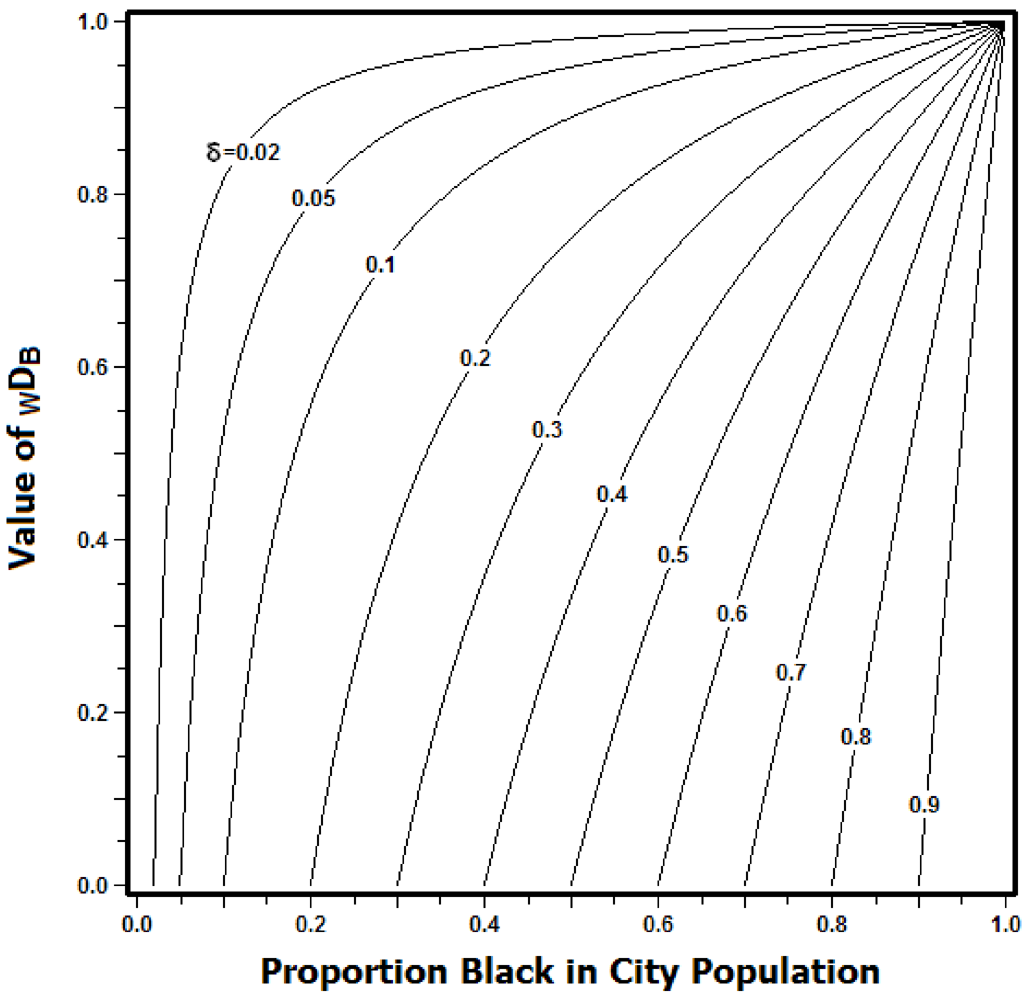
Figure 9 graphs the value of ${}_{W}D_{B}$ by percent black in the city for selected values of whites tolerance of contact with blacks (δ). It is apparent from this figure that whites' preferences can be satisfied without segregation so long as the proportion black in the city is less than the maximum level of black contact tolerated by whites (i.e., when $Q < \delta$). However, as percent black (Q) begins to exceed δ, the minimum level of segregation needed to satisfy whites' preferences begins to climb, rapidly at first and then at a slowing rate as percent black approaches 100. The onset and initial steepness of this curve are dictated by whites' tolerance of contact with blacks (δ). When the tolerance (δ) is small, ${}_{W}D_{B}$ turns non-zero at low levels of percent black and reaches high levels very quickly as percent black increases further.

It is worth noting, even at the risk of stating the obvious, that Figure 9 also illustrates the relationship between ${}_{W}D_{B}$ and percent black in the city at selected values of whites' preference for co-ethnic contact (α). The reason for this is that, in the case of homogeneous preferences, α is given by $1-\delta$. The only change needed to facilitate this interpretation is to replace the numeric values for δ with the values $1-\delta$ and then replace the symbol for whites' tolerance of contact with blacks (δ) with the symbol for whites' preference for co-ethnic contact (α).

Figure 10 graphs the relationship between ${}_{B}D_{W}$ and percent black under different values of blacks' preference for co-ethnic contact (λ). The pattern depicted is a near mirror image of that seen in Figure 9. The figure shows that blacks' preferences can be satisfied without segregation so long as the proportion black in the city exceeds blacks' preference for co-ethnic contact (i.e., $Q > \lambda$). However, as

Figure 9

Values of $_WD_B$ by Proportion Black in the City for Selected Values of δ for Whites (Homogeneous Preferences)

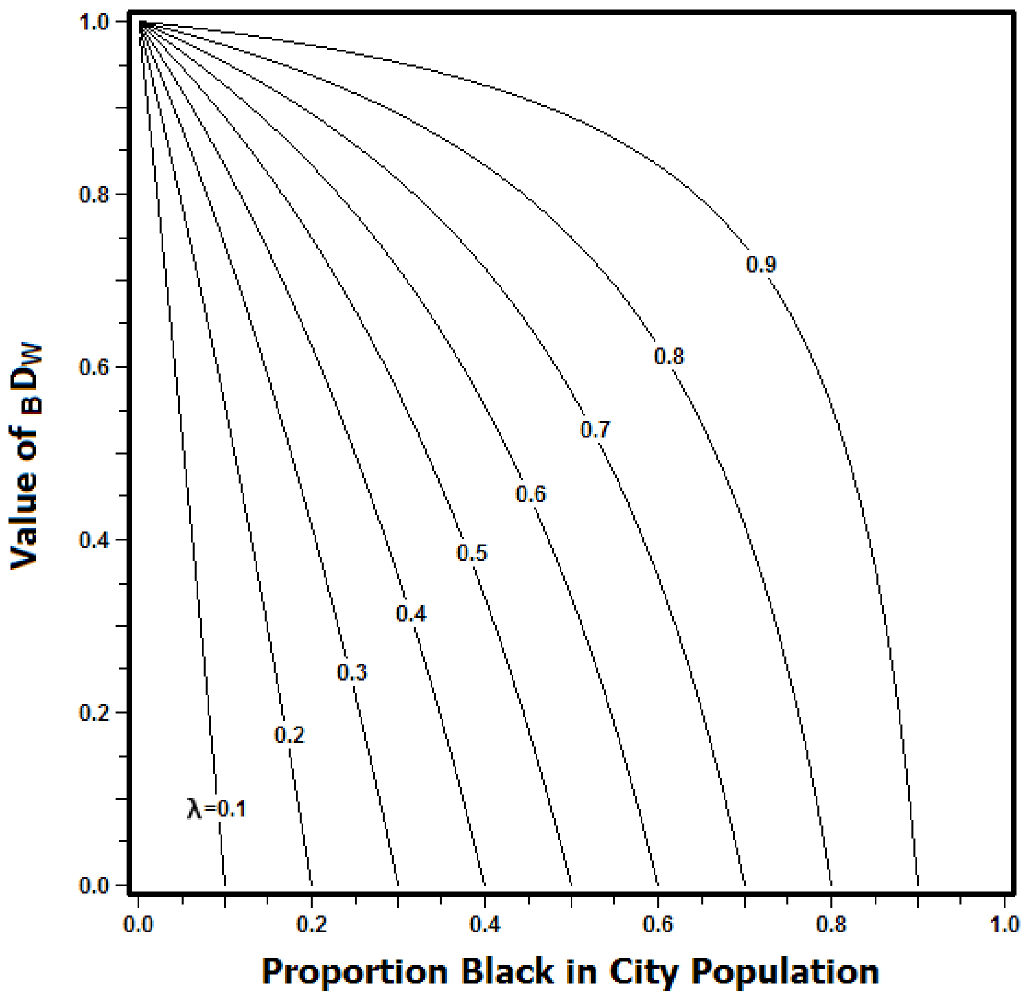


soon as percent black in the city falls below λ, the minimum level of segregation needed to satisfy blacks' preferences climbs very rapidly as percent black approaches 0. Significantly, when the proportion black in the population is low (e.g., below 0.2) the levels of $_BD_W$ tend to be high when λ takes non-negligible values (e.g., 0.2 or higher).

Figure 10 also illustrates the relationship between $_BD_W$ and percent black in the city at selected values of blacks tolerance of contact with whites (π). Again, this is because, in the case of homogeneous preferences, π is given by 1-λ. The only changes needed to facilitate this interpretation is to

Figure 10

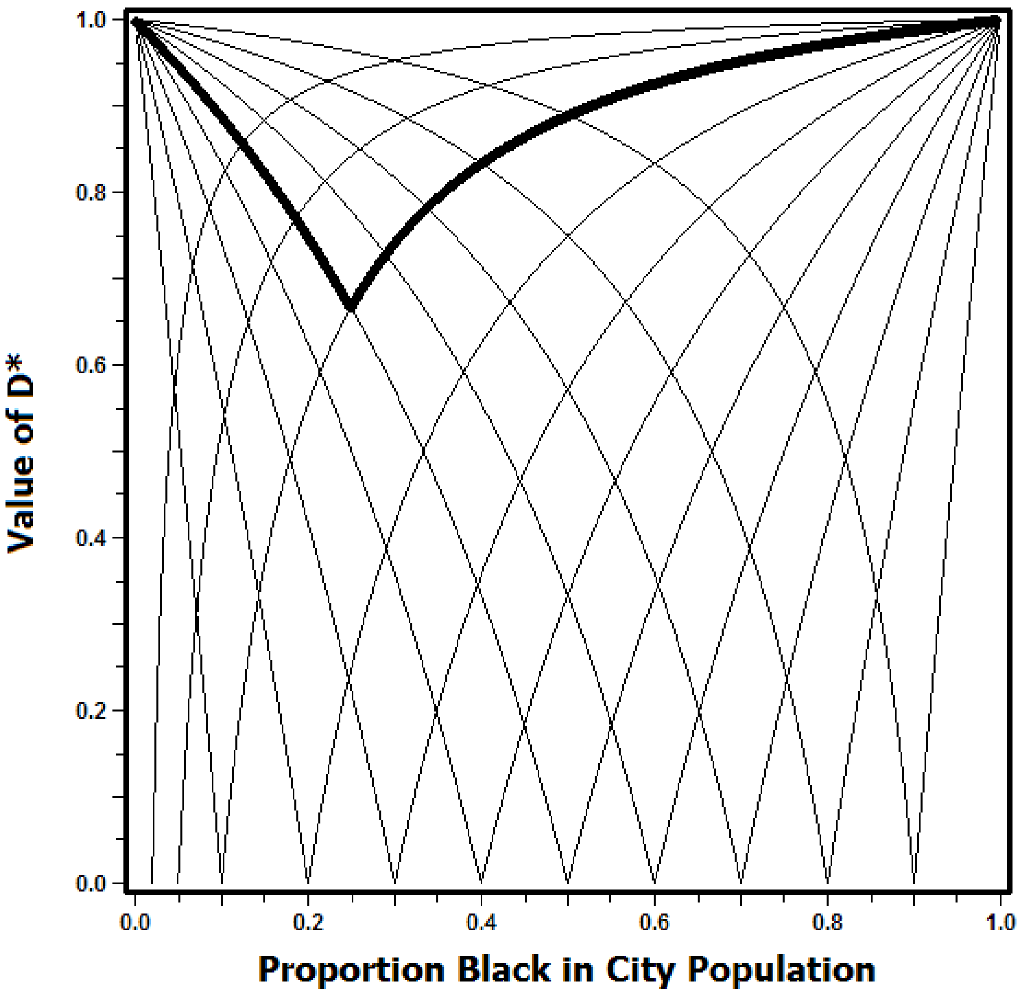
Values of $_{B}D_{W}$ by Proportion Black in the City for Selected Values of λ for Blacks (Homogeneous Preferences)



replace the numeric values for λ with the values 1-λ and then replace the symbol for blacks' preference for co-ethnic contact (λ) with the symbol for blacks tolerance of contact with whites (π).

Figure 11 superimposes the relationships shown in the two previous graphs in a single figure. An important substantive implication emerges when attention is directed to two of the curves. The first is the curve resulting when whites have limited tolerance for contact with blacks (i.e., $\delta = 10$). (Or, alternatively, this may be described as the curve resulting when whites have strong preferences for co-ethnic contact [i.e., $\alpha = 90$ percent].) The second is the curve resulting when blacks have moderate

Figure 11
Values of $_{W}D_{B}$ and $_{B}D_{W}$ by Proportion Black in the City for Selected Values of δ and λ (Homogeneous Preferences)



preferences for co-ethnic contact (e.g., λ = 50 percent). (Alternatively, the curve resulting when blacks have moderate tolerance of co-ethnic contact with whites [e.g., π = 50 percent].). The finding that emerges when the two curves are examined together is the following: *there is no city-wide racial mix for which both $_{W}D_{B}$ and $_{B}D_{W}$ have low values*.

The controlling values of the two curves (i.e., the higher value) are highlighted in the figure. The result is a bold surface that first traces the curve for $_{B}D_{W}$ and then shifts and traces the curve for $_{W}D_{B}$ when the curves cross. At low levels of percent black, $_{W}D_{B}$ is low but $_{B}D_{W}$ is high because the numerically small black population cannot achieve even the modest level of in-group contact it prefers under conditions of even distribution of whites and blacks across neighborhoods. At higher levels of percent black, ${}_{B}D_{W}$ begins to drop off to low levels but at this point ${}_{W}D_{B}$ begins to climb to high levels because the white population's strong preference for in-group contact cannot be realized when ethnic groups are evenly distributed across areas of the city.

The choice for which two curves are highlighted in Figure 11 is hardly arbitrary. Research on white and black preferences for ethnic composition of neighborhoods reviewed in Clark (1991) suggests that a consistent pattern is found in American cities. Namely, most white respondents report that they prefer neighborhoods where black representation does not exceed 10 percent and most black respondents report that they prefer neighborhoods where black representation is 50 percent or higher. If residential choices are guided by these preferences, the results clearly suggest the combination is not conducive to extensive integration.

Bear in mind three things when considering this conclusion. First, low values for the two D* measures do not occur together at any racial mix. Second, the measures register minimum segregation (maximum integration) feasible under *strategic* assignment. Third, changing the choice of curves to combinations that are more congenial to promoting integration (e.g., δ =80 and λ = 40) does not call the main conclusion into question. The new "controlling" surface would be higher than 50 over the range of values for percent black most common in American metropolitan areas (e.g., 5 to 25 percent black).

The bold line traced in Figure 11 provides a first exploratory consideration of the *joint* impact of both majority and minority preferences on segregation in cities with differing ethnic compositions. The approach is partly formal, but still substantially intuitive. In the next section I introduce extensions to the logic of this analysis that permit more rigorous assessment of the combined impact of white and black preferences on segregation, not only for the case of homogeneous preferences (as explored in Figure 11), but also for the case of heterogeneous preferences. This analysis will show that the "structural propensity" for segregation (as registered by minimum segregation measures) based on consideration of both groups preferences is even greater than this exploratory analysis would suggest.

Are Minority Preferences Relevant?

Before moving on to the next section, I first pause to introduce the question of how the model-based calculations of minimum segregation measures such as D* should inform the broader theoretical debate about the role of ethnic preferences, especially minority preferences, in residential segregation. I address this question at greater length in the last section of the paper. I make a preliminary foray here because I suspect that these substantive questions are already weighing on the minds of the reader who has had the patience to make it to this point.

I begin by noting that the results presented in this section of the paper are consistent with Schelling's (1969; 1971, 1972) theoretical and simulation analyses of segregation under conditions of voluntary location. Schelling argued that integration is an unstable condition when groups differ in relative size and have preferences for non-proportional co-ethnic association. These segregation-promoting dynamics are rarely emphasized in sociological reviews. When they are mentioned, their potential importance is usually discounted (e.g., Massey and Denton 1993; Yinger 1996) especially when compared to the segregation-promoting impact of institutional forces such as discrimination. The results introduced above would suggest that the role of preference dynamics should not be discounted, but should instead be given more careful consideration. For example, the results presented to this point suggest that, even if discrimination were somehow eliminated completely, rapid movement toward markedly lower levels of residential segregation might not necessarily follow *unless* white and black preferences for co-ethnic contact shifted from their present (non-proportional) configurations.

The theoretical debate regarding the importance of preferences for segregation touches on many issues. One that is especially crucial is the question of how to assess the implications of minority preferences. For the most part, the sociological literature portrays minorities' preferences regarding neighborhood ethnic composition as a nonfactor in residential segregation. Two major points of view are associated with this position. The first argues that, because blacks are a power minority subject to discrimination, their preferences are irrelevant because blacks cannot realize preferences that are incompatible with preferences held by whites. The second point of view argues that blacks are more accepting of mixed neighborhoods than whites and thus blacks' preferences promote *integration* not segregation (Bobo and Zubrinsky 1996; Farley et al 1976; Farley et al 1994; Zubrinsky and Bobo 1996).

I consider the second point first. Is it correct to assume that minority preferences are integration-promoting? The evidence already reviewed gives a clear answer – *not necessarily*. Blacks do express greater acceptance of mixed race neighborhoods than do whites. However, the realization of blacks' preferences would not promote proportionate ethnic distributions within neighborhoods (the dimension of integration registered by the most popular measures of segregation). Indeed, careful consideration of the issue reveals an interesting general finding. Under conditions of voluntary choice, in-group preferences held by a numerical minority group can be equally or more segregation-promoting as the in-group preferences held by a numerical majority group, even when the minority group is *more* accepting of out-group contact than the majority group.

To see this, consider a city where, consistent with survey results, whites seek to avoid neighborhoods that are more than 10 percent black while blacks will accept neighborhoods that are up to 50 percent white. If the city is 15 percent black, the more intolerant white preference is only 5 points short of supporting even distribution while the more tolerant black preference is 35 points away from supporting even distribution. Massey and Gross argued that the segregation- promoting *potential* of whites' preferences can be indexed by ${}_{W}D_{B}$. Its value in this situation is 0.370. Applying the same logic to assess the segregation-promoting *potential* of blacks' preferences with ${}_{B}D_{W}$ yields a value of 0.823. On this basis, blacks' preferences are not only *not* integration-promoting, their segregation-promoting potential can be *greater* than that of whites' preferences in some demographic contexts. This example illustrates what I term the *"paradox of weak minority preferences"*.

The paradox of weak minority preferences arises from the fact that the implications of individual-level preferences for segregation are profoundly conditioned by macro-level demographic structure. Strong preferences for co-ethnic contact on the part of a numerically large group may be only weakly segregation-promoting because members of the group may realize their preferences under conditions approaching even distribution. In contrast, moderate and weak preferences for co-ethnic contact on the part of a numerically small group can be strongly segregation-promoting because members of the group cannot realize their preferences under conditions of even distribution. Demographic structure requires that smaller groups must congregate (i.e., self-segregate) to a greater degree than larger groups to achieve a given level of co-ethnic contact.[1]

This paradox is not a mere analytic curiosity. When percent black is in the range typical for American urban areas (e.g., 2-25 percent), ${}_{B}D_{W}$ computed under an assumed mild black preference for co-ethnic contact of 50 (i.e., maximum tolerance of whites of 50 percent) is not only nonzero, it equals or exceeds ${}_{W}D_{B}$ computed under a strong white preference for co-ethnic contact of 90 (i.e., maximum

[1] "Degree of congregation" refers to the degree of departure from a distribution expected under evenness (or alternatively random assignment). It does not refer to the level of co-ethnic contact achieved (that would be the same for both groups).

tolerance of blacks of 10 percent). Based on this, it is incorrect to conclude that minority preferences are integration-promoting and it is incorrect to conclude that they are less segregation-promoting than whites' preferences.

Minority preferences for co-ethnic contact will be segregation-promoting when four conditions are met. (1) Minority preferences for co-ethnic contact exceed the level that would obtain under proportionate or "even" distribution. (2) Minority preferences for co-ethnic contact have behavioral consequences (i.e., they have the potential to influence residential choices). (3) Minority movement into disproportionately minority areas is not constrained. (4) Housing that is acceptable to minority households is available in disproportionately minority areas. These conditions may well hold in many American cities. In view of this, black preferences for co-ethnic contact should not be casually dismissed as irrelevant for racial residential segregation.

This brings us back to the other major reason people give to discount the relevance of blacks' ethnic preferences; namely that blacks are a power minority subject to discrimination. Does this fact imply in and of itself that minority preferences have little relevance for segregation and can be ignored? In a word, no. The key reason for this answer is that discrimination restricting minority access to predominantly white neighborhoods is not monolithic and it is not certain to endure. Given this, it is important to understand the impact that minority preferences may exert on segregation *as one among multiple contributing causes*. It is not implausible to hypothesize that segregation is *overdetermined* by virtue of having multiple contributing causes *each one of which is potentially a sufficient cause*. If this is the case, and it is not recognized, observers could easily overestimate the degree to which segregation is due solely to the impact of discrimination and raise unrealistic expectations regarding the impact that reducing discrimination is likely to have on segregation.

Section V
Considering the Joint Implications of Heterogeneous Preference Distributions for Whites and Blacks

In this section I extend the minimum segregation measure approach for assessing the implications of ethnic preferences for residential segregation in the case where preferences are heterogeneous and thus vary considerably within groups. This refinement is significant because it provides a basis for addressing a point that some critics of preference theories have raised; namely, that previous analyses of the implications of preferences have been too simplistic because they have not considered the implications of heterogeneity in the preference distributions of minority and majority populations. For example, Yinger (1995) suggested that heterogeneity in the preference distributions for whites and blacks is potentially an important factor. He argues that it encourages integration by creating possibilities for whites and blacks with compatible preferences to reside together in neighborhoods with different racial mixtures. As is often the case in this literature, Yinger does not offer any formal theoretical analysis to justify this "hypothesis", but it has an intuitive appeal and strikes many as a highly plausible speculation.

In this section I offer a more rigorous, model-based exploration of the hypothesis. I move toward this by first considering more carefully how the joint combination of the white and black preference distributions affects the possibilities for integration in the simpler case where preferences are *homogeneous*. I use minimum segregation measures to quantify the possibilities for integration and introduce a new formulation where these measures (D*, I*, G*, etc.) are defined as *the minimum level of segregation needed to insure that, in the combined population of whites and blacks, no individual's ethnic preferences are ever violated*.

As noted previously, preferences regarding minimum co-ethnic contact imply a maximum tolerance for (i.e., limit on) out-group contact and vice versa. Thus, D* in this formulation can be understood as the minimum level of segregation needed to insure that any of the following combinations of white and black preferences are never violated: (a) whites' and blacks' preferences regarding maximum tolerance of out-group contact; (b) whites' preferences regarding maximum tolerance of out-group contact and blacks' preferences regarding minimum co-ethnic contact; (c) white's preferences regarding minimum co-ethnic contact and blacks' preferences regarding maximum tolerance of out-group contact; and (d) whites' and blacks' preferences regarding minimum co-ethnic contact. It is a bit tedious to list all the possible combinations of interpretations. But I do so to again emphasize the important point that out-group aversion and in-group affinity are closely tied and, in the two-group case, define each other.

The last analysis of the previous section (based on Figure 11) offered an exploratory consideration of the implications of the joint impact of white and black preferences for segregation. The approach involved calculating the impact of each group's preferences for segregation separately for a city with a specified racial mix and then highlighting the higher of the two values $_{W}D_{B}$ and $_{B}D_{W}$. As it turns out, this approach provides an overly optimistic view of the impact of preferences. In fact, the structural propensity for segregation (as reflected in minimum segregation measures) is *greater* than that suggested by the procedure of simply taking the higher of $_{W}D_{B}$ and $_{B}D_{W}$.

This can be illustrated by considering a simple example where the following conditions are in place: preferences are homogeneous within groups, whites seek a minimum of 90 percent contact with whites (i.e., $\delta = 90$), blacks seek a minimum of 50 percent contact with blacks (i.e., $\lambda = 50$), and the city is 25 percent black. As shown earlier, assessment of the implications of these preferences for segregation when whites' and blacks' preferences are considered separately yields values of $_{W}D_{B}$ and $_{B}D_{W}$ of 0.370 and 0.823, respectively.

The value of D* for the joint consideration of whites' and blacks' preferences taken together is not merely the higher of these two scores (as implied by the exploratory analysis based on Figure 11). Instead, it is 1.0. That is, complete segregation is required to insure that no individual's preferences are violated. The value of D* must be 1.0 in this case because it is not possible for any combination of individuals from both groups to live together and realize their preferences. That is, no neighborhoods that can attract white residents can also attract black residents and vice versa.

This result is inevitable under the following approach for establishing the value of D* for joint consideration of homogeneous preferences for whites and blacks. Start with a completely segregated city where all whites reside in all-white areas and all blacks reside in all-black areas. Attempt to create an integrated neighborhood with a racial mix that is compatible with both group's preferences *and* is as close to the city-wide racial mix (Q) as possible. Then, if such an area can be created, move as many whites and blacks into this area as is possible.

Table 8: Values of D*, ${}_{W}D_{B}$, and ${}_{B}D_{W}$ Under Possible Combinations of Whites' Preferences, Blacks' Preferences, and Relative Minority Size When Racial Preferences are Homogenous within Groups.

Preference Conditions and Racial Mix	D*	Value of ${}_{W}D_{B}$	${}_{B}D_{W}$
$\delta < \lambda$			
1) $Q \leq \delta < \lambda$	100	0	${}_{B}D_{W}$
2) $\delta < Q < \lambda$	100	${}_{W}D_{B}$	${}_{B}D_{W}$
3) $\delta < \lambda \leq Q$	100	${}_{W}D_{B}$	0
$\delta = \lambda$			
4) $Q < \delta = \lambda$	${}_{B}D_{W}$	0	${}_{B}D_{W}$
5) $\delta = Q = \lambda$	0	0	0
6) $\delta = \lambda < Q$	${}_{W}D_{B}$	${}_{W}D_{B}$	0
$\delta > \lambda$			
7) $Q > \delta > \lambda$	${}_{W}D_{B}$	${}_{W}D_{B}$	0
8) $\delta \geq Q > \lambda$	0	0	0
9) $\delta > \lambda \geq Q$	${}_{B}D_{W}$	0	${}_{B}D_{W}$

Notes: δ represents whites' tolerance of contact with blacks (i.e., the maximum proportion black whites will accept in a neighborhood), and λ represents black's desire for co-ethnic contact (i.e., the minimum percent black that blacks seek in a neighborhood).

Under this procedure, no neighborhood racial mix is compatible with both whites' and blacks' preferences. So no integration can be achieved. At the end of the exercise, all whites remain in all-white areas where percent white is slightly higher than the minimum required by their preferences (i.e., 100 instead of 90) and all blacks remain in all-black areas where percent black is substantially higher than the minimum required by their preferences (i.e., 100 instead of 50).

Table 8 summarizes the values of D* that obtain when the rule introduced above is implemented under various conditions. For comparison, the table also shows whether ${}_{W}D_{B}$ and ${}_{B}D_{W}$ take the value of 0 or whether they will take some nonzero value based on their respective computing formulas (introduced earlier as Equations 2 and 5, respectively). Several findings emerge from this table. One is that, in general, the joint consideration of both groups' preferences will produce maximum segregation whenever whites' maximum tolerance for contact with blacks (δ) is less than blacks' minimum preference for co-ethnic contact (λ). That is, D* will be 100 when $\delta < \lambda$ (rows 1-3 of Table 8).

Joint consideration of preferences will permit *complete* integration (i.e., D* of 0) only when all whites tolerate blacks at a level equal to or surpassing the proportionate representation of blacks in the city population *and* when all blacks seek co-ethnic contact at a level that does not exceed the proportionate representation of blacks in the city population. That is, D* can be 0 if and only if $\delta \geq Q \geq \lambda$ (rows 5 and 8 of Table 8).

Situations other than those just described will generate D* values above 0 but less than 100. The value of D* in these situations will equal ${}_{W}D_{B}$ or ${}_{B}D_{W}$ depending on the specific demographic circumstance (rows 4, 6, 7, and 9 of Table 8). Thus, the exploratory analysis based on Figure 11 was not entirely off-base. It accurately reflected the values of D* under some, but not all circumstances.

A First Consideration of Joint Combinations of Heterogeneous Preferences

The results in Table 8 reveal that, even in the simple case where preferences within each group are homogeneous, the implications of preferences for segregation are complicated when both groups' preferences are jointly considered. The situation becomes even more complex when preferences are heterogeneous within each group. This can be highlighted by noting that in this situation the possibility of achieving full integration is controlled by extreme values in each group's preference distribution, not by "typical" values (e.g., the median or mode). Thus, full integration is possible only when the *minimum* value in the distribution of whites' tolerances for contact with blacks (δ) is no lower than the proportionate representation of blacks in the city population (Q) and the *maximum* value in the distribution of blacks' preferences for co-ethnic contact (λ) is no greater than the proportionate representation of blacks in the city population. That is, D* can equal 0 if and only if $\min(\delta_i) \geq Q \geq \max(\lambda_i)$. Alternatively, this can be restated in terms of whites preferences for co-ethnic contact (α) in which case D* can equal 0 if and only if $P \geq \max(\alpha_i)$ and $Q \geq \max(\lambda_i)$.[1]

Full integration is harder to achieve when preferences are heterogeneous, but partial integration can be achieved more easily. This is because variation in preferences increases the possibility that some combinations of preferences held by whites and blacks will be compatible. For example, whites that prefer a 90 percent white neighborhood can reside in a partially integrated neighborhood if there

[1] I will use this mode of describing whites' preferences in this section to simplify discussion and graphing (e.g., it permits white and black preferences to be presented on the same scale).

also exist blacks that seek only 10 percent black in a neighborhood. When such combinations exist, at least some integration is feasible. However, it is very difficult to judge in advance exactly how much integration can be achieved because this will depend in complex ways on the "shapes" of the separate preference distributions for whites and blacks and on the ethnic composition of the city.

The powerful conditioning effect of city racial mix has already been shown for situations where preferences are homogeneous. Thus, it should come as no surprise that it also plays a similar role when preferences vary within groups. For example, if preferences are heterogeneous with the "typical white" seeking a 90 percent white neighborhood and the "typical black" seeking a 10 percent black neighborhood, substantial integration should be possible in a city that is 10 percent black. But the level of feasible integration would not be as great in a city that is 30 percent black.

The impact of "dispersion" in preferences on segregation also is complicated; its impact depends on, among other things, whether whites' and blacks' "typical" preferences are compatible or not. Consider, for example, the situation where preferences are homogeneous with whites seeking neighborhoods that are 90 percent white and blacks seeking neighborhoods that are 50 percent black. These preferences are incompatible and thus D* will be 100 (indicating complete segregation) regardless of the ethnic mix in the city. It is obvious, however, that if sufficient heterogeneity is introduced into each groups' preference distribution, the possibilities for integration will be improved. Thus, if the values 90 and 50 are specified as "typical" values (e.g., medians) and whites' and blacks' preferences are sufficiently dispersed around these typical values, *some* whites and blacks will have compatible preferences and it will be possible to place them together to create neighborhoods that are at least partially integrated. Thus, D* would fall from 100 under homogeneous preferences to some lower value under heterogeneous preferences.

In this case, the introduction of heterogeneity clearly *improves* the prospects for integration as anticipated by Yinger (1995). Unfortunately, this is not a necessary outcome. Consider a different situation where preferences are homogeneous with whites seeking neighborhoods that are 70 percent white and blacks seeking neighborhoods that are 20 percent black. These preferences are compatible and thus complete integration is feasible in a city that is 25 percent black; all white and black preferences can be comfortably satisfied by placing everyone in neighborhoods that are exactly integrated (i.e., 25 percent black). D* for this residential distribution would be 0 indicating complete integration. It is easy to see, however, that if sufficient heterogeneity is introduced into each group's respective preference distribution, the possibilities for integration will be diminished. Thus, if the values 70 and 20 are specified as "typical" values (e.g., medians) and whites' and blacks' preferences are sufficiently dispersed around these typical values, it will no longer be possible to place all whites and all blacks in exactly integrated neighborhoods that are 25 percent black. Instead, many will have to be placed in partially integrated neighborhoods where percent black deviates from the citywide racial mix of 25 percent black.[1] Accordingly, D* will necessarily rise from 0 to some higher value indicating that the introduction of heterogeneity in preferences *reduces* the prospects for integration.

These examples illustrate that the impact of heterogeneous preferences for both groups is difficult to anticipate and easily summarize. In view of this, I have not found a way to express the value of D* resulting from the consideration of the joint combination of heterogeneous preferences for whites and blacks – at least not in terms of a set of simple, equation-based computing rules. I have, however, developed a computing algorithm that can be used to calculate the values of minimum segregation measures under strategic placement strategies that maximize integration while simultaneously respecting both whites' and blacks' preferences.[2] This algorithm for computing the values of minimum segregation measures (e.g., D*, I*, G*, etc.) involves the following steps.

1. Establish a total of 401 possible neighborhood "types" based on values of percent black (q_i) ranging from 0.0 to 100.0 at equal intervals of 0.25 percentage points (i.e., 0.0, 0.25, 0.50, 0.75, 1.00, 1.25 ... 99.75, 100.00).[3]
2. Establish the proportion black (Q) and the proportion white (P) for the city, restricting the possible values of Q and P to the middle 399 values on the 401 point scale just described (i.e., on the values 0.0025, 0.0050, 0.0075, ... 0.9950, 0.9975).[4]

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[1] It may even be the case that it will be impossible to place all whites and blacks in *any* kind of integrated neighborhood and thus some white and/or some blacks may end up residing in all-white or all-black areas, respectively.

[2] I characterize the result as an approximation from the point of view an theoretical analysis where heterogeneous preferences are drawn from a continuous distribution, neighborhood ethnic mixes can take any fractional value, and individuals can be placed in neighborhoods in fractional amounts. If preferences and neighborhood ethnic mixes are restricted to an arbitrary number of specific values (401 in the present case), the algorithm yields the *exact* value for the minimum level of segregation required to simultaneously satisfy both whites' preferences and blacks' preferences.

[3] The large number of neighborhood types used here is not crucial to the substantive findings, but it does permit "fine-grained" calculations that better approximate results that would be obtained using continuous distributions. It also yields figures that are "smoother" and thus more visually appealing.

[4] The end points of the scale are not used because the concept of segregation is obviously irrelevant for cities that are all white or all black.

3. For whites, establish the relative frequency distribution for α – the minimum percentage white a white household seeks in their neighborhood. Use values of α that correspond to the values for q_i set in step 1 (i.e., 401 values ranging from 0.0 to 100.0).
4. For blacks, establish the relative frequency distribution for λ – the minimum percentage black a black household seeks in their neighborhood. Use values of λ that correspond to the values for q_i set in step 1 (i.e., 401 values ranging from 0.0 to 100.0).
5. Create an initial residential distribution that is completely segregated with all whites placed in an all-white neighborhood type and all blacks placed in an all-black neighborhood type.
6. Attempt to create integrated neighborhoods starting with the exactly integrated neighborhood where $|Q - q_i|$ is equal to 0.0 and populate it with as many whites and blacks as is feasible taking the most "reluctant" members of each group first.
   a. When feasible, take whites with the highest values of α first.
   b. When feasible, take blacks with the highest values of λ first.
7. Identify the next as yet unpopulated neighborhood type with the lowest value on $|Q - q_i|$ and repeat Step 6. Continue this process until all possible neighborhood types are processed. (Note that when this process concludes some, perhaps many or even most, of the 401 neighborhood types may not be populated.)
8. Compute D*, G*, I*, R*, $_BE_W$*, and other measures from the final residential distributions of whites and blacks across the 401 neighborhood types.

I have authored a computer program – which I term "D-Star" – to implement this algorithm.[1] The program has several capabilities. First, it generates model-based preference distributions for each group. Second, it assesses the implications of these preferences for residential segregation under the strategic-assignment algorithm just described. In addition, the program also can implement the strategic assignment algorithms introduced in earlier sections (e.g., Rules I and II) and thus can be used to assess the implications of one or both group's preferences for segregation.

The algorithm the D-Star program implements makes certain concessions to the practical requirements of computing minimum segregation measures. Specifically, the algorithm requires that preferences (δ and λ), area racial mix (q), and city-wide racial mix (Q) take values from a limited number

[1] The D-Star program is written in Delphi, an object-oriented variant of the Pascal programming language.

(401) of evenly spaced points between 0 and 100 inclusive. As a consequence, the values of minimum segregation measures that the program yields result are approximations of "exact" values that could in theory be obtained in an analysis where preferences, area racial mix, and city-wide racial mix could take any values from an infinitely divisible continuum.[1] For example, the "Rule II" procedure outlined earlier can conclude with the final area receiving blacks having a proportion black (q_i) that is lower than that for the next-to-last area receiving blacks.[2] When this happens, the last area receiving blacks must be combined with the next-to-last area receiving blacks and this action should be repeated, if necessary, until the proportion black (q_i) for the last area created is greater than that for the next-to-last area created. This assures that black contact with whites is maximized and that black isolation is minimized.

As a practical matter, the concessions the D-Star program makes to the practical requirements of computing minimum segregation measures are minor. The 401 discrete values the program draws on are relatively "fine-grained" and thus allow it to register substantively interesting changes in minimum segregation outcomes that result when assumptions about preference distributions and city-wide demographic mix are varied in even minor ways.

I now review an example which illustrates how the D-Star program can be used to assess the joint combination of whites' and blacks' preferences. First, I use the D-Star program to generate relative frequency distributions for white and black preferences. In this example, the frequency distribution for whites' preferences has a median preference for co-ethnic contact (α) of 90 and the frequency distribution for blacks' preferences has a median preferences for co-ethnic contact (λ) of 50.

Next I use the D-Star program to generate heterogeneity in these preference distributions (i.e., dispersion around the central tendency) by applying normal theory to the logit-transformed values of α and λ. This involves the following specific steps. First, the median value in the "raw" or percentage version of the preference distribution is subjected to a logit (log-odds) transformation. Then normal theory is used to generate dispersion in the logit-score preference distribution.[3] Finally, the resulting

[1] I say "in theory" because it is possible to imagine this even though the necessary methods have not yet been developed.

[2] This will occur if the number of blacks available to place in the area (i.e., the number of blacks remaining in the all-black area) is less than the maximum number of blacks the area can receive.

[3] Normal theory cannot be used with the original "untransformed" preference scores because the infinite tails of the normal distribution would extend beyond the valid range of the bounded distribution of raw preference scores. In contrast, normal theory can be used with the logit-transformed preference scores because they are not bounded (i.e., their values can extend outward from the center of the distribution toward positive and negative infinity).

preference distribution is converted back to the original raw-score or percentage scale. When I apply normal theory to generate dispersion in the logit-score preference distributions, I give attention to two practical considerations. I use standard deviations for the logit-score distributions that are calibrated to yield substantial spread in the raw score distributions.[1] At the same time, however, I restrict these standard deviations so the resulting raw score preference distributions will be unimodal.[2]

Under this procedure, cases in the distribution of logit-transformed preference scores are symmetrically distributed around the median case in the distribution. When the scores are converted back to "raw" or percentage values, the distribution is symmetrical only if the "raw" score median is 50. If the median preference is above 50, the distribution will be left-skewed; if it is below 50, the distribution will be right skewed.

The distributions that are generated for the present example are shown in Figure 12. The relative frequency distributions for whites' and blacks' preferences are depicted using lighter and darker shading, respectively. The figure reveals that the distribution of raw scores for black preferences is symmetric with equal numbers of blacks with preferences for co-ethnic contact above and below the group median of 50. There are also equal numbers of whites with preferences for co-ethnic contact above and below the group median of 90. However, the distribution is highly skewed because cases above 90 "pile up" in the interval 90-100 while the cases below 90 are distributed widely over the range 0-90. (This pattern of dispersion is typical for variables that are distributed within a bounded range.)

Consideration of the figure suggests that the heterogeneity within each of the two group's preference distributions creates opportunities for *at least some* integration. If preferences were homogeneous (i.e., if all individuals had preferences equal to their respective group medians), no integration would be feasible even under strategic placement because whites' preferences and blacks' preferences would be incompatible and could not be simultaneously satisfied. In contrast, the figure suggests that the heterogeneity in preferences present is sufficient to insure that at least *some* whites and blacks will have preferences for co-ethnic contact that are compatible thus making it possible to place them together under strategic assignment into neighborhoods that are integrated to some degree.

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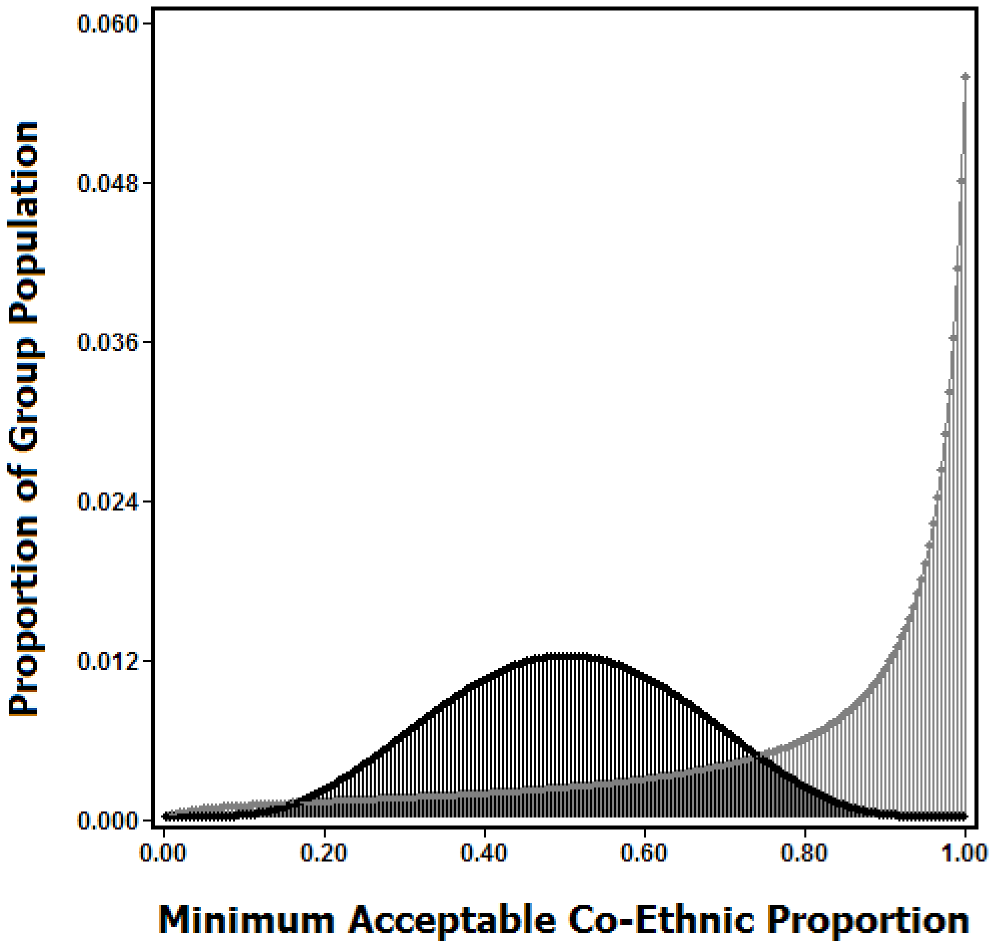
[1] The interdecile range for α is over 50 points and the interdecile range for λ is over 40 points.

[2] If the standard deviation for the normal distribution of the logit scores is set too high, it can produce a bimodal distribution when the logit scores are converted back to percentage scores.

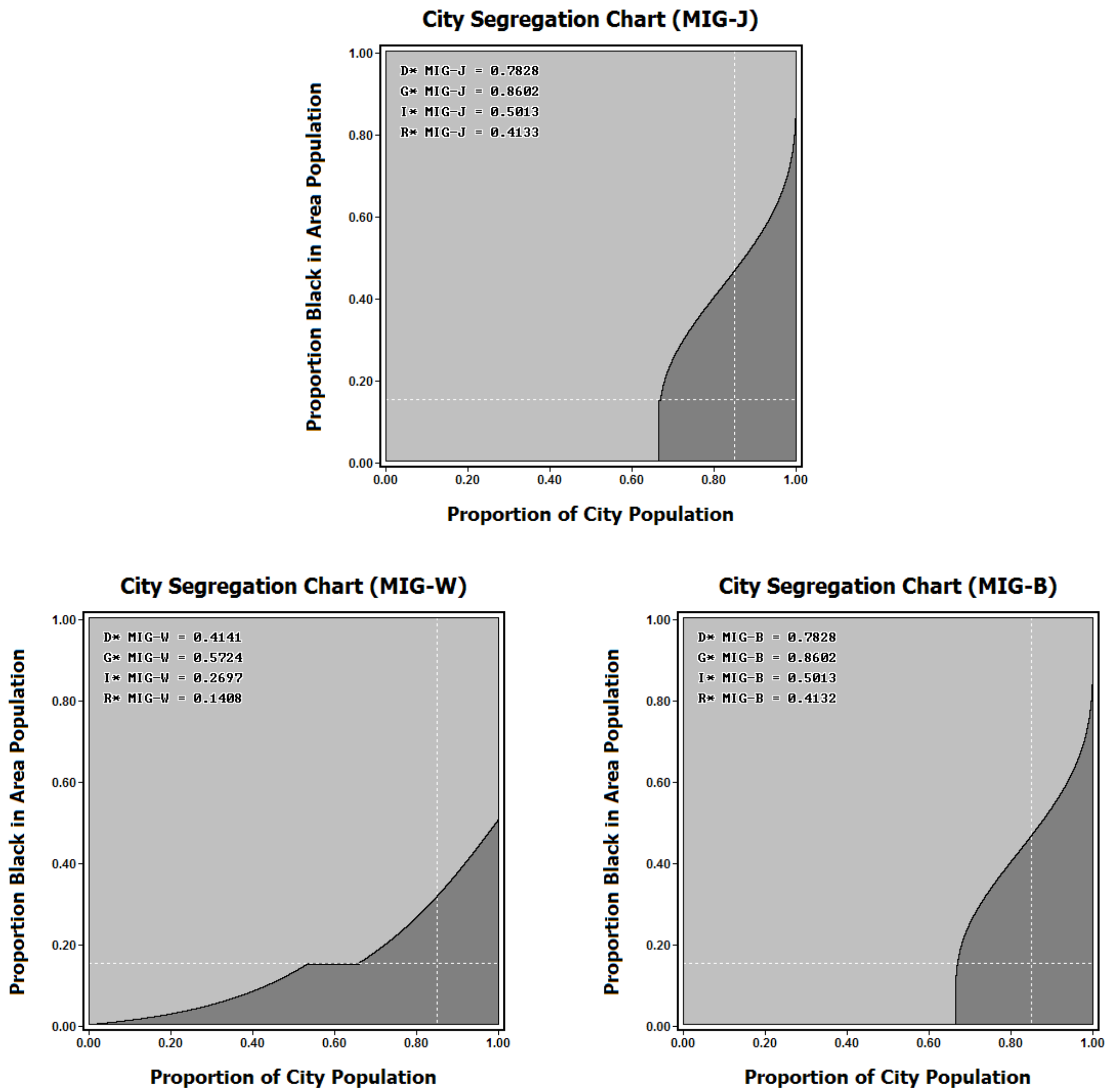
Figure 12
Distributions of Preferences for
Co-Ethnic Contact for Whites (α) and Blacks (λ)



The resulting possibilities for integration under strategic placement are illustrated in the segregation chart presented in Figure 13.[1] Since the implications of preferences for the possibilities of achieving integration depends on the ethnic mix of the city, this value must be established before minimum segregation measures can be computed. For the purposes of this example, I assume a city that is 85% white and 15% black. Thus, with Q set at 15, Figure 13 presents segregation charts based on analysis of possibilities for integration under the *heterogeneous* ethnic preferences depicted in Figure 12.

[1] Rule II is used when assessing the implications of a single groups' preferences.

Figure 13
Segregation Charts for D* Calculations (Rule II) Based on Heterogeneous Preferences for Minimum In-Group Contact (MIG) for Whites Only, Blacks Only, and Jointly



Notes: D* signifies minimum feasible segregation; MIG-W indicates only Whites' preferences were considered, MIG-B indicates only Blacks' preferences were considered, and MIG-J indicates both groups' preferences were considered jointly.

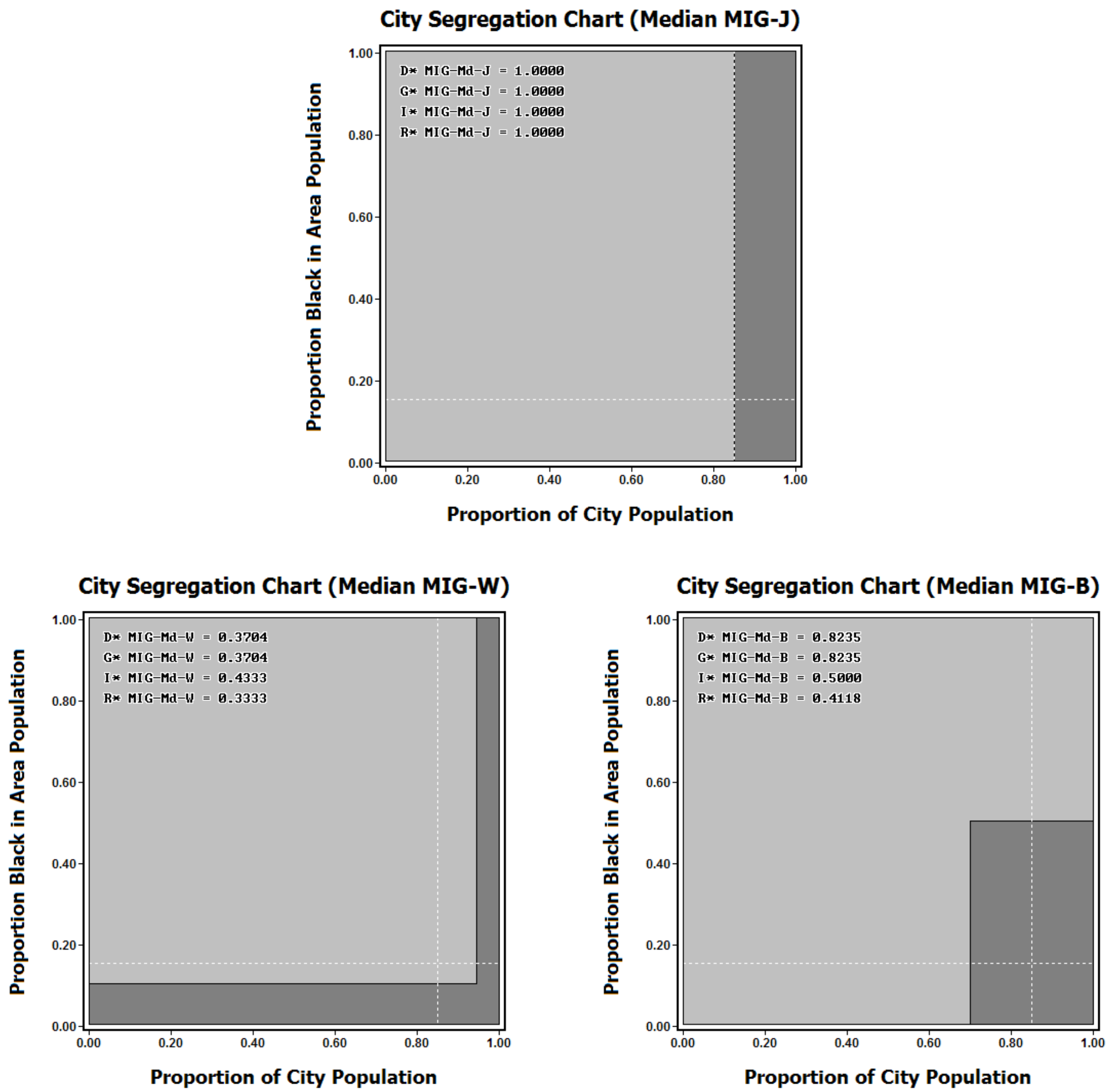
For purposes of comparison, Figure 14 presents segregation charts that are based on analysis of possibilities for integration under *homogeneous* ethnic preferences where all individuals in each group are given preferences equal to the median values in the distributions depicted in Figure 12.

Figures 13 and 14 both show three segregation charts; one based only on the implications of whites' preferences for minimum in-group (co-ethnic) contact (MIG-W, strategic placement ignoring blacks' preferences), one based only on the implications of blacks' preferences for minimum in-group contact (MIG-B, strategic placement ignoring whites' preferences), and one based on a joint consideration of the minimum in-group preferences of both groups (MIG-J). The comparison of the two figures shows that a more complex pattern of neighborhood ethnic mixtures is possible when preferences are heterogeneous.

For example, the MIG-W segregation chart reflecting whites' preferences in Figure 14 (found in the lower left-hand panel of the figure) is a simple rectangular pattern. This reflects the fact that all integrated neighborhoods have the same ethnic mix ($q_i = 1-\alpha$). In contrast, the corresponding segregation chart in Figure 13 shows a pattern indicating that integrated neighborhoods vary in proportion black from 0.0 to Q. No one lives in an exactly integrated neighborhood in the MIG-W segregation chart in Figure 14, but a significant portion of the population lives in an exactly integrated neighborhood in the corresponding segregation chart Figure 13. Note, however, that the overall level of segregation is about the same. The reason for this is straightforward; *heterogeneity cuts both ways*.

Figure 13 shows that the presence of whites with in-group preferences (α) below the median (90) permits the creation of neighborhoods where percent black *exceeds* 10 (i.e., the amount possible based on the median for α) but is less than all-black. Such neighborhoods are not present in Figure 14 and this impact of heterogeneity serves to *reduce* segregation. But the presence of whites with in-group preferences *above* the median simultaneously forces the creation of neighborhoods where percent black falls *below* 10. These kinds of neighborhoods also are not present in Figure 14 and this impact of heterogeneity serves to *increase* segregation. In this example, the two impacts largely offset one another, but the second one is slightly larger and so D* is actually *higher* under heterogeneous preferences (i.e., the resulting D* values are 41 and 37, respectively).

Figure 14
Segregation Charts for D* Calculations (Rule II) Based on Homogeneous Preferences for Minimum In-Group Contact (MIG) for Whites Only, Blacks Only, and Jointly



Notes: D* signifies minimum feasible segregation; MIG-W indicates only Whites' preferences were considered, MIG-B indicates only Blacks' preferences were considered, and MIG-J indicates both groups' preferences were considered jointly.

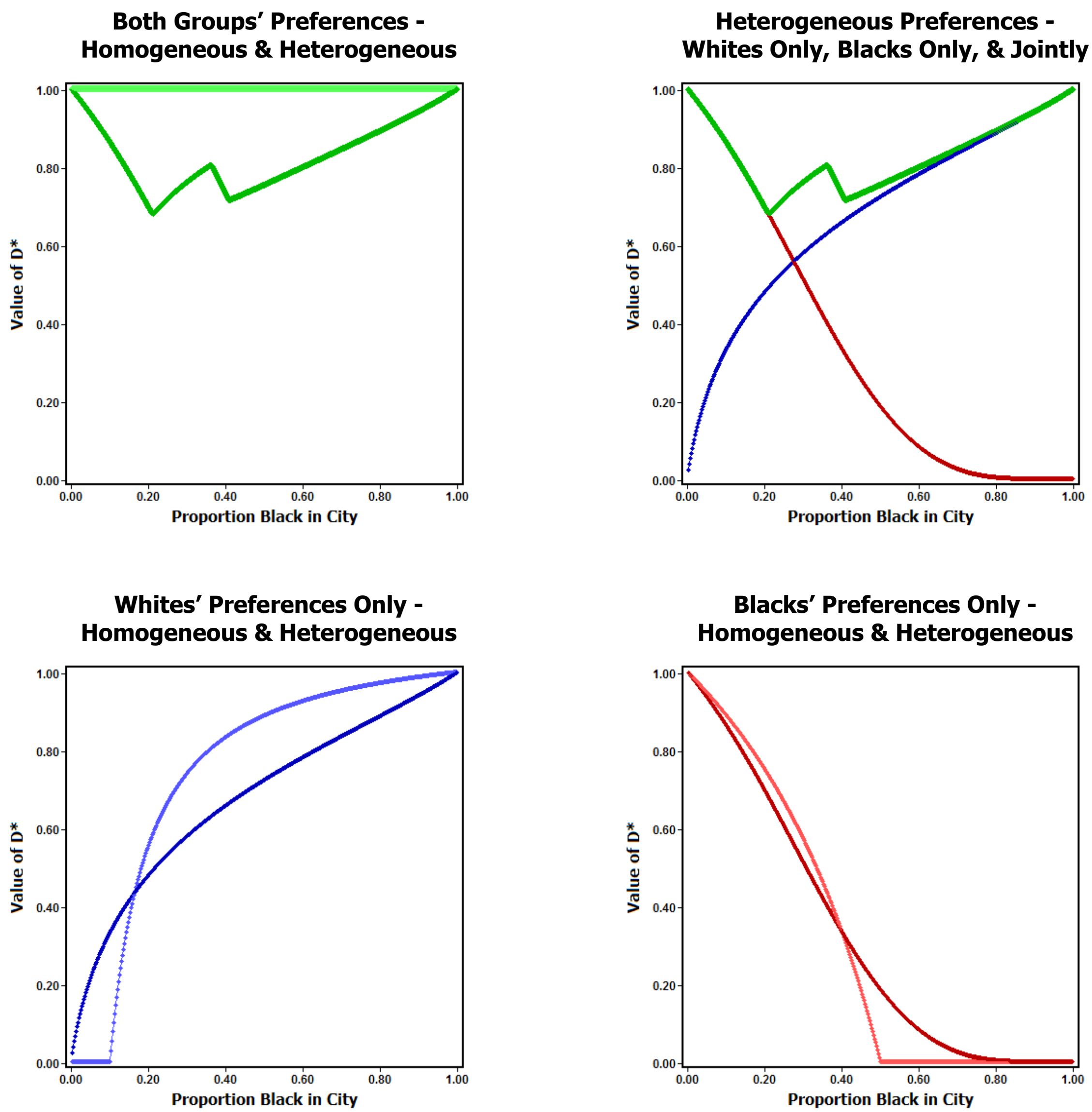
The MIG-B segregation charts reflecting the impact of blacks' preferences on possibilities for integration (found in the lower right-hand panel of the figures) reveal the same general pattern. The segregation chart in Figure 14 is a simple rectangle indicating that all partially-integrated neighborhoods have the same ethnic mix (i.e., $q_i = \lambda$). In contrast, the same segregation chart in Figure 13 shows a pattern indicating that integrated neighborhoods vary in proportion black from Q to 1.0. Again, the overall level of segregation is about the same in both cases and the reason for this is the same as before. The presence of blacks with in-group preferences (λ) below the median (50) permits the creation of neighborhoods with an ethnic mix closer to Q. But the presence of blacks with in-group preferences above the median forces the creation of neighborhoods with an ethnic mix exceeding the amount permitted by the median preference. In this example as before, the two impacts largely offset one another but in this case the first one is slight larger so D* is *lower* under heterogeneous preferences (the resulting D* values are 78 and 82, respectively).

The impact of heterogeneity in preferences on the possibility of achieving integration is greater when both groups' preferences are considered jointly. The MIG-J segregation chart in Figure 13 shows a nontrivial amount of integration is possible under strategic placement with heterogeneous preferences. In contrast, the segregation chart for the joint consideration of white and black preferences in Figure 14 shows that even under strategic assignment maximum segregation results because it is not possible to place whites and blacks together without violating someone's preferences for co-ethnic contact. Thus, the value of D* is 100 under joint consideration of homogeneous preferences and 78 under joint consideration of heterogeneous preferences. Interestingly, the result based on joint consideration of heterogeneous preferences is exactly the same as the result based on consideration of only blacks' preferences. As will be seen shortly, this is result occurs under some conditions but not others.

A More General Consideration of the Impact of Heterogeneity in Preferences

The example just considered focuses on a single city with an ethnic mix of 85% white and 15% black. However, since the impact of preferences on possibilities for integration under strategic assignment is strongly contingent on the demographic mix of the city, further analysis is needed assess the general impact of heterogeneity on possibilities for integration. To accomplish this, I used the D-Star

Figure 15
Values of D* by Percent Black (Q) in the City Based on Homogeneous and Heterogeneous Preferences for Minimum In-Group Contact for Whites Only, Blacks Only, and Jointly



Notes: D* signifies minimum feasible segregation under strategic assignment. The median preference for in-group contact for Whites is 90. For Blacks it is 50. The preference distributions are shown in Figure 12. Calculations are performed using Rule II as described in the text.

program to calculate the values of D* for values of Q ranging between 0.0 and 100.0. The results are displayed in graphical form in Figure 15.

This figure includes four panels that show how values of D* vary when computed under different assumptions regarding which group's preferences are considered and whether preferences are homogeneous or heterogeneous. The lower, left-hand panel of the figure displays values of D* computed based on consideration of only whites' preferences (α). One curve depicts scores resulting under the heterogeneous preferences for whites shown in Figure 12. The other curve depicts scores resulting under the assumption of homogeneous preferences (i.e., with all preferences set to the median preference in the heterogeneous distribution). This second curve was seen earlier (in Figure 9) and can be recognized by the fact that D* registers 0 until Q reaches 10 (i.e., when $Q \leq [1-\alpha]$) and then rises sharply as Q increases beyond 10. The curve for the values of D* based on consideration of Whites' preferences for in-group contact under heterogeneity is similar in some key respects to the curve seen for values of D* based on homogeneous preferences. In both cases, D* is a positive, non-linear but monotonic function of percent black in the city.

Interestingly, the curves for the two functions cross when percent black is at about 16. When compared to the curve for D* under homogeneous preferences, the curve for D* under heterogeneous preferences is higher *before* the curves cross (i.e., when percent black in the city is below 16) but is lower *after* the curves cross. Thus, in this case, heterogeneity apparently "dampens" the "speed" of the transition from extreme low to high values of D*.

A similar pattern is seen in the results for the values of D* based on consideration of Blacks' preferences for in-group contact (shown in the lower, right-hand panel of Figure 15). Under both homogeneous and heterogeneous preferences, D* is a negative, non-linear, but monotonic function of percent black in the city. Again, heterogeneity "dampens" the transition from extreme low and high values of D*. Thus, the curve for heterogeneous preferences changes more gradually crossing the curve for homogeneous preferences when Q is about 40. The curve for D* under heterogeneous preferences is lower before the two curves cross, but is higher after the curves cross. The difference is especially pronounced when Q is in the range of 45-60. Under homogeneous preferences the value of D* falls to 0 when Q reaches 50 (i.e., when $Q \geq \lambda$), but is about 20 under heterogeneous preferences.

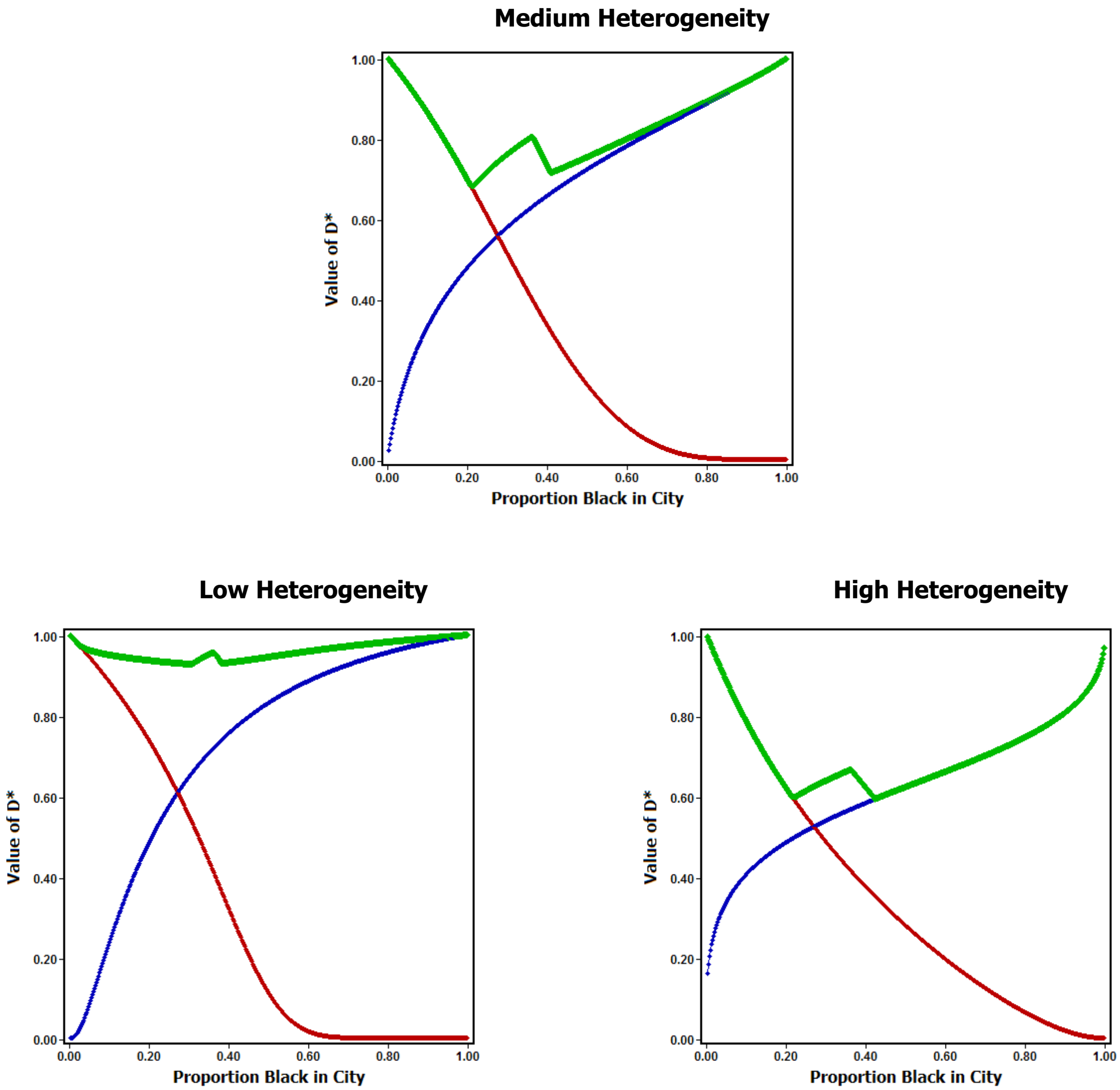
The situation is much more complicated when both groups' preferences are taken into account simultaneously. As shown in the upper, left-hand panel of the figure, D* under joint consideration of homogeneous preferences is always at its maximum value of 100 (1.0) because the groups' preferences are incompatible. In contrast, D* under joint consideration of heterogeneous preferences approaches this maximum value only in cases where the city is almost completely white or almost completely black. Otherwise, the value of D* under heterogeneous preferences is lower. Thus, in general, integration is more feasible under heterogeneous preferences than under homogeneous preferences. However, since D* never falls below 65 and is often well above 80, it is also clear that the level of feasible integration under strategic assignment is never great. Beyond this, it is hard to summarize the nature of the curve because the relationship between city ethnic mix and D* under joint, heterogeneous preferences is quite complex.

The graph in the upper-right quadrant of Figure 15 reveals how D* assessed based on the joint consideration of heterogeneous preferences for both groups tracks D* assessed based on each group's preferences considered separately. It shows that when D* is based on both group's preferences it closely tracks D* based on blacks' preferences when percent black in the city ranges between 0 and 20. It also closely tracks D* based on whites' preferences when percent black in the city ranges between 40 and 100. But, when percent black is between 20 and 40, D* based on both group's preferences breaks away from the falling curve associated with blacks' preferences and rises to a peak of about 80. Then it reverses directions again and descends back to join up with the rising curve based on whites' preferences. Thus, the slope of the curve is negative in two noncontiguous ranges of percent black in the city and is positive in two noncontiguous ranges of percent black in the city. This complicated nonlinearity results from the complex ways that the tails of heterogeneous preference distributions "interact" under the strategic placement algorithm.

Considering the Impact of Variation in the Degree of Heterogeneity

How does the pattern just reviewed hold up when the amount of heterogeneity in ethnic preferences varies? Figure 16 presents data that addresses this question. The upper graph in the figure reproduces the graph in the upper, right-hand panel of Figure 15 (just considered) for purposes of comparison. Below it are two graphs that are identical to the first one in all respects but one – the degree of heterogeneity (i.e., dispersion around the median) in white and black preferences for co-ethnic contact.

Figure 16
Values of D* by Percent Black (Q) in the City Based on Three Patterns of Heterogeneous Preferences for Minimum In-Group Contact for Whites Only, Blacks Only, and Jointly



Notes: D* signifies minimum feasible segregation under strategic assignment; the green curve is based on consideration of only Whites' preferences; then maroon curve is based on consideration of only Blacks' preferences; and the red curve is based on consideration of both groups' preferences jointly.

Compared to the analyses just discussed (and displayed again in top pane of this figure), the degree of heterogeneity in white and black preferences is reduced in the analyses shown in the bottom, left panel and it is increased in the analyses shown in the bottom, right panel. More specifically, the standard deviation used to disperse preferences around the median preference in the analyses depicted in the lower left panel of Figure 16 is *half* the value of the one used to disperse preferences in the analyses depicted in the top panel of the figure while the standard deviation used to disperse preferences in the analyses shown in the lower right panel is *double* this value.[1]

The green curves for D* based on the joint consideration of both whites' and blacks' preferences in the two bottom graphs is informative. When heterogeneity in preferences is low, the green curve is everywhere higher (compared to the top panel). When heterogeneity in preferences is high, the green curve is everywhere lower (compared to the top panel). Thus, holding constant the ethnic mix of the city, the greater the heterogeneity in ethnic preferences, the greater the possibilities for integration under strategic assignment.

This can be understood in fairly intuitive terms. Recall that the curve for D* under homogeneous preferences was at a maximum over the entire range for percent black in the city (review the top-left panel of Figure 15). The reason for this is that the median white preference for 90% co-ethnic contact and the median black preference for 50% co-ethnic contact are incompatible and thus integration is not feasible regardless of city ethnic mix. As dispersion around these central tendencies increases, combinations of compatible white and black preferences come into existence and D* drops away from its maximum value. How far D* drops depends on the degree of heterogeneity and the ethnic mix of the city. One pattern seems clear, as heterogeneity increases, the D* values based on a consideration of both whites' and blacks' preferences drop down toward limits set by the curves for ${}_{W}D_{B}$ and ${}_{B}D_{W}$.

The role of these "lower limits" is seen in the fact that D* never falls below the higher of the two values of ${}_{W}D_{B}$ and ${}_{B}D_{W}$. The nature of these "lower limits" is itself a bit of a "moving barrier". Close inspection reveals that the curves for ${}_{W}D_{B}$, while similar across the three panels, vary discernibly. The same is true for the curves for ${}_{B}D_{W}$. On the whole, however, this is a secondary aspect of the patterns revealed in Figure 16.

[1] Recall that the standard deviation is applied to the logit-transformed distribution of preferences which follows a normal.

As previously noted, the relationship between D* and percent black in the city is complex and difficult to summarize. The curves for D* in Figure 16 are nonlinear and non-monotonic and they are contingent on the degree of heterogeneity in the group preference distributions. Still, certain aspects of the behavior of D* are clear. One is that it never falls below the higher of the values of ${}_{W}D_{B}$ and ${}_{B}D_{W}$ for any particular city-wide racial mix. Thus, while there are circumstances where ${}_{W}D_{B}$ and ${}_{B}D_{W}$ sometimes assume very low values, D* does not. Another is that the impact of heterogeneity in preferences appears to be reasonably straightforward – D* is a negative, monotonic function of heterogeneity in preferences.[1] This effect is bounded at the high end by 1.0, the maximum score set by incompatible homogeneous preferences, and at the low end by the higher of the values of ${}_{W}D_{B}$ and ${}_{B}D_{W}$ at any particular city-wide racial mix.

I can offer an even broader set of substantive implications at this point. But, before doing so, I remind the reader that the interest in D* traces back to Massey and Gross' conjecture that ethnic preferences and city ethnic demography may combine to foster a *structural propensity* for segregation. They investigated this idea focusing on the impact of preferences held by whites and assuming that these were homogeneous. They concluded that the structural propensity for segregation was low in cities where percent black was small and increased as a positive, monotonic function of percent black.

My analyses extends their valuable insight in important ways; I assess the implications of the preferences held by all groups considering them separately and jointly, and I use a more refined approaches for computing minimum segregation measures.[2] The results I obtain based on analysis of the kinds of preferences documented in surveys lead me to substantive conclusions that are fundamentally different from the ones originally offered by Massey and Gross? I summarize these basic substantive conclusions as follows.

1. When the implications of all group's preferences are taken into account, the structural propensity for segregation is *never* low.

[1] The relationship is monotonic rather than strictly negative because increasing heterogeneity in preferences does not reduce D* until the relative frequency distributions of λ and 1-α (i.e., δ) begin to overlap, where λ represents blacks' preferences for co-ethnic contact and δ represents whites' maximum tolerance for contact with blacks (which is given by 1-α where α is whites' preferences for co-ethnic contact).

[2] Specifically, I corrected errors in the formula that Massey and Gross used to calculate D* under homogeneous preferences, I developed computer algorithms to assess the implications of heterogeneous preferences, and I introduced procedures for calculating a wider range of minimum segregation measures (e.g., G*, I*, R*, etc.).

2. While never low, the structural propensity for segregation varies in highly complex ways. It is a complex, non-monotonic function of city ethnic mix and is contingent on the degree of heterogeneity in preferences.

These substantive conclusions support theoretical arguments advanced by Schelling (1969; 1971; 1972) and Clark (1991; 1992) and provide a compelling basis for arguing that sociologists and other social scientists should take the role of preferences in shaping segregation more seriously.

Other Combinations of Preference Distributions

To this point, I have focused on combination of white and black preference distributions where the median co-ethnic preference for whites is 90 and the median co-ethnic preference for blacks is 50. This combination is hardly arbitrary. It approximates "typical" preferences reported in surveys and thus provides a reasonable starting point from which to consider the possible implications of preferences for segregation in American urban areas.

However, while this combination of preferences is an obvious choice for intensive exploration, it also is useful to consider other combinations of ethnic preferences. Accordingly, I used the D-Star program to explore combinations three different regimes of heterogeneous in-group preferences for whites and blacks. The three regimes of preferences are shown in Figure 17. Each consists of 401 preferences for in-group contact ranging from a low of 0% to a high of 100%. In the regime of "weak" in-group preferences, the median value of the in-group preference is 15% with half of the population holding an in-group preference of 15% or less and half holding one of 15% or more.[1] In this distribution, about 84% have an in-group preference under 50. In the regime of "moderate" in-group preferences, the median preference is for 50% in-group contact and about 90% of the population has an in-group preference in the range of 25-75%. The regime of "strong" in-group preferences is the "mirror image" of the regime of weak in-group preferences. The median in-group preference is 85% with half of the population holding an in-group preference of 85% or more and half below. In this distribution, about 84% of the population holds in-group preferences above 50%.

[1] As noted earlier, the D-Star program generates these model preference distributions based on a normal distribution for the logits (log-odds) of the in-group preference. The distribution is centered on the median preference. The program provides for five options for the degree of dispersion around the central tendency. The third or "medium" option is selected here.

Figure 17
Distributions of "Weak", "Moderate", and "Strong" Preferences for Co-Ethnic Contact

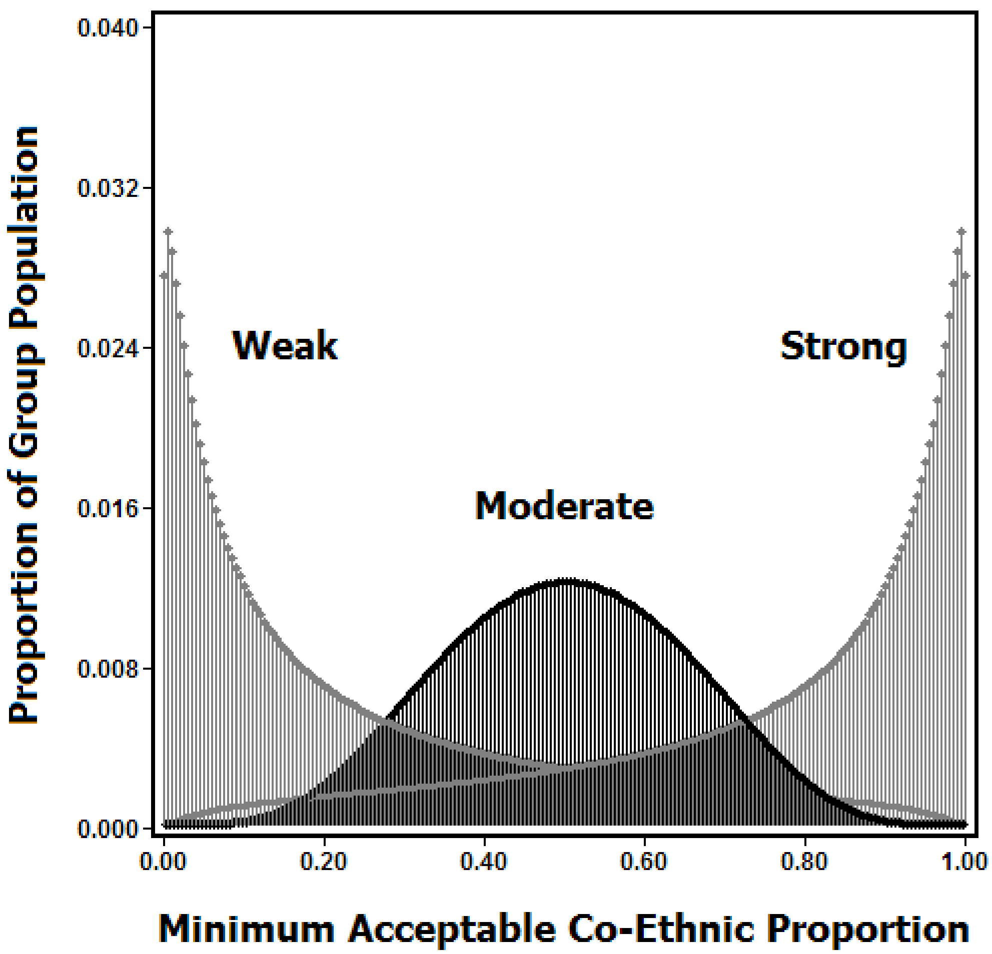
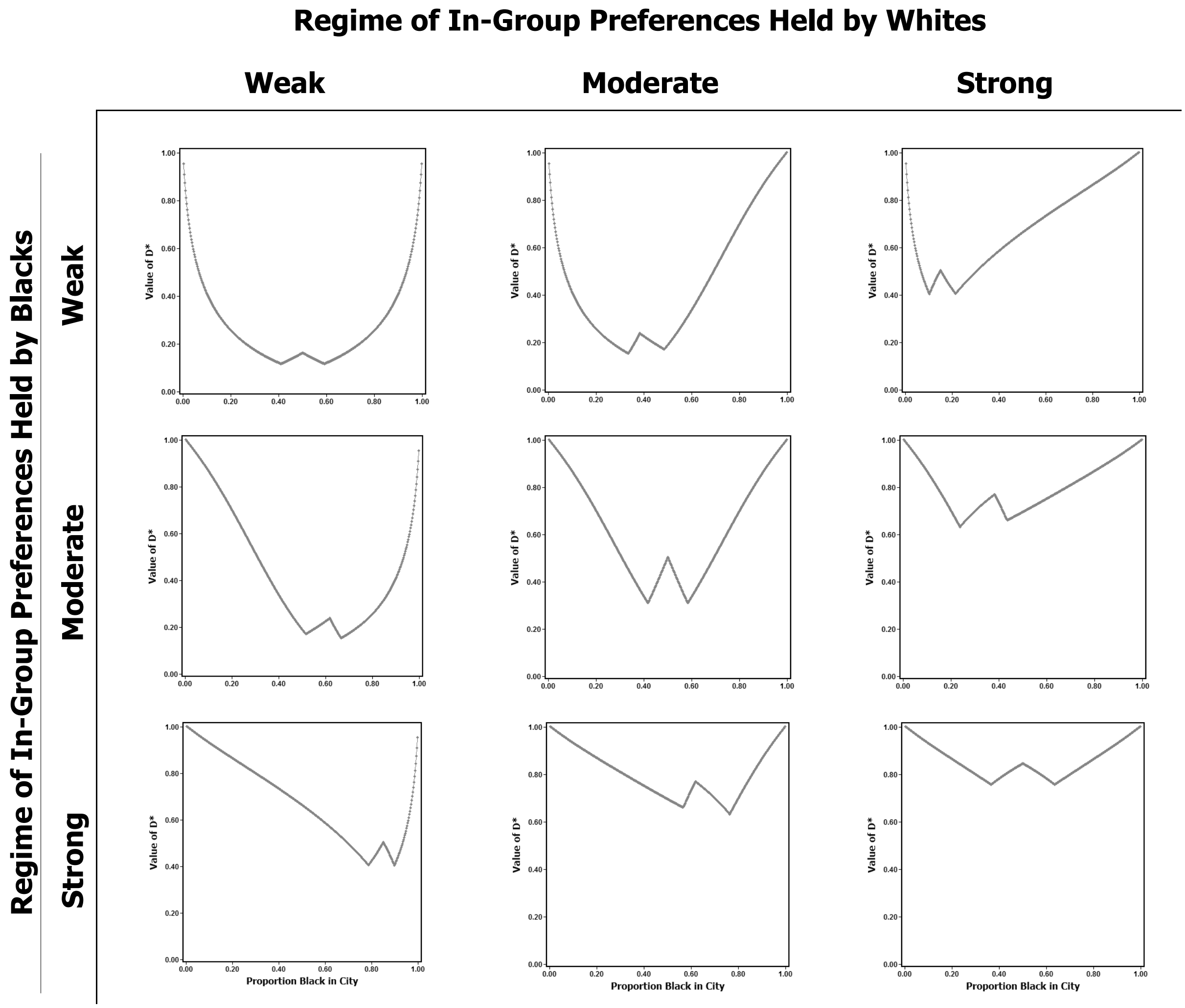


Figure 18 presents the nine separate graphs (one for each of the nine possible combinations of the three preferences regimes for whites and blacks). Each graph plots the value of D* assessed based on joint consideration of both whites' and blacks' preferences for co-ethnic contact as city racial mix varies from under 1% black to over 99% black. Figure 19 presents similar results for the gini index (G*). The results show that the values of D* and G* vary widely depending on the combination of the three factors: the white preference distribution, the black preference distribution, and the racial mix of the city. Not surprisingly, D* and G* tend to be lowest overall when whites and blacks both have relatively weak preferences for in-group contact (upper left cells) and tend to be highest overall when both groups have relatively strong preferences for in-group contact (lower right cells).

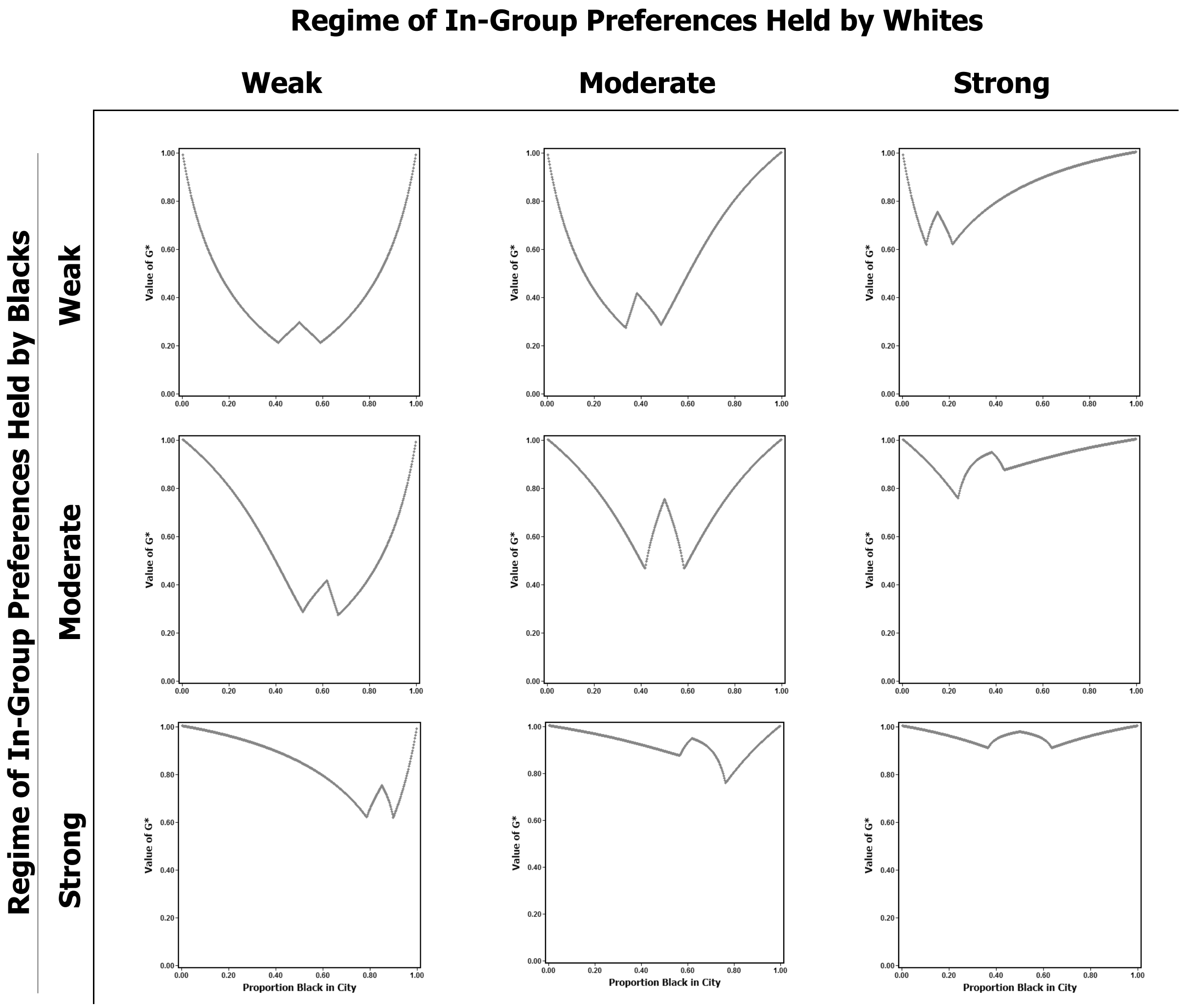
Figure 18
Minimum Value of D* Based on Joint Consideration of Both White and Black Preferences by Proportion Black in the City Under Nine Possible Combinations of Three Regimes of Heterogeneous In-Group Preferences for Whites and Blacks



Note: Values of D* were computed using the D-Star program.

Figure 19

Minimum Value of G* Based on Joint Consideration of Both White and Black Preferences by Proportion Black in the City Under Nine Possible Combinations of Three Regimes of Heterogeneous In-Group Preferences for Whites and Blacks



Note: Values of G* were computed using the D-Star program.

When whites and blacks have identical preference distributions for in-group contact (the diagonal cells running from the upper left to the lower right), the resulting graph is symmetrical. In this situation, the highest values of D* and G* occur when the racial mix of the city is highly unbalanced (e.g., one group or the other is less than 10% of the population). The lowest values occur when percent black is relatively balanced (i.e., in the range 33-67. Interestingly, there are distinct secondary peaks in these middle regions at the points where the black-white mix is 50/50. The lowest values of D* and G* are seen at off-center points where the black-white mix is approximately 41/59 or 59/41. Similar complex nonlinear patterns are seen in all the graphs. These curious nonlinearities trace to the fact that the minimum values of D* and G* are complex nonlinear functions of (a) the central tendency of the group preference distribution, (b) the degree of heterogeneity in preferences (i.e., the dispersion around the central tendency), and (c) the relative size of the two populations. The complex shapes of these curves again highlights the consistent finding that the role of preferences is very difficult to anticipate based on intuition or "common sense" reasoning.

The higher values of D* and G* observed when percent black is in the range 1-33 reflect the impact of in-group preferences held by blacks since it is relatively easy to satisfy whites' preferences when percent black is low. Similarly, the higher values of D* and G* observed when percent black is in the range 67-99 reflect the impact of in-group preferences held by whites since it is relatively easy to satisfy blacks' preferences when percent black is high.

When whites and blacks have different preference distributions for in-group contact, the highest values of D* and G* still tend to be observed when the racial mix is highly unbalanced (e.g., when one group is less than 10%). However, these graphs are asymmetric in shape and the lowest values do not occur when the racial mix is balanced. Instead, the regions of lowest values for D* and G* shift left (toward predominantly white racial mixes) when in-group preferences for blacks are weaker than those for whites. They shift right (toward predominantly black racial mixes when in-group preferences for blacks are stronger than those for whites.

Significantly, relatively high levels of D* and G* are observed when white and black preferences approximate distributions similar to those documented in public opinion surveys. Thus, when blacks have a "moderate" preference for in-group contact and whites have a "strong" preference for in-group contact, the values of D* are well above 0.60 (and the values of G* are well above 0.70) *under any racial mix*. These results are conservative in at least one sense – the preference distributions documented in studies by Clark (1991; 1992), Farley et al. (1994), and Zubrinsky and Bobo (1996) suggest that the preferences for co-ethnic contact held by whites and blacks are *stronger* (i.e., contain greater preferences for in-group contact) than the "strong" and "moderate" distributions used in this exercise.

Another interesting finding is that there are no graphs in the figure where low levels of D* and G* are observed consistently across all city racial mixes. Furthermore, this is especially true when attention is focused on the range where percent black varies between 5 and 25 (the range that includes most American metropolitan areas). This provides yet another reason for directing more energy to gaining a better understanding of the role of ethnic preferences in residential segregation.

Section VI
Willing to Mix Preferences

Some recent studies call attention to ethnic preferences of a different type from those considered so far. Specifically, they focus on what I term "willing to mix" preferences. These preferences are measured by asking respondents not what neighborhood ethnic mix they prefer *most*, but rather what neighborhood types they would be "*willing to enter*" (i.e., not rule out as unacceptable). Data on such preferences indicate that blacks are more "willing to mix" with whites than whites are "willing to mix" with blacks. For example, most blacks say they would be willing to enter neighborhoods that are 50% white whereas only a small fraction of whites say they would be willing to enter neighborhoods that are 50% black.

It is important to note that discussions of "willing to mix" preferences (e.g., Krysan and Farley 2002) introduce notions about the role of preferences that are different than those considered in the previous sections of this paper. Specifically, these discussions introduce a distinction between "preferred" ethnic composition and "acceptable" ethnic composition. For example, Krysan and Farley report that the overwhelming majority of blacks indicate that they *prefer* neighborhoods that are at least 50% black but at the same time the overwhelming majority of blacks also indicate that they would be willing to enter areas that are only 20% black.

The distinction between "preferred" and "acceptable" outcomes greatly complicates theoretical analysis of the impact of ethnic preferences. To highlight the difference, recall the analyses presented in earlier sections of this paper that assessed the segregation-promoting implications of homogeneous preferences for minimum in-group contact and maximum out-group tolerance. In that earlier analysis, in-group preference and out-group tolerance were conceived as "flip" sides of one another. For example, if all whites hold a preference for a minimum of 85% in-group contact, all whites will by definition tolerate up to 15% out-group contact. Under this conception, the implications of preferences for segregation are identical regardless of how the preference is described; D* values will be the same whether assessed using the formula based on preferences for in-group contact or the formula based on tolerance of out-group contact. The notion of out-group tolerance used in this earlier analysis is not the same as that used in discussions of "willingness to mix" preferences. It might be described as registering "maximum *tolerated* out-group contact based on minimum *desired* in-group contact". In contrast, willingness-to-mix preferences might be described as registering the "maximum acceptable out-group contact *regardless* of the individual's desired level of in-group and/or out-group contact".

The distinction between "preferred" and "acceptable" may sound like a minor one, but it introduces great complexity to theoretical analysis of the segregation-promoting implications of ethnic preferences. Specifically, the distinction explicitly introduces the notion that the preferences individuals hold involve a range of graduated responses to varying neighborhood ethnic mixtures. For example, a hypothetical white individual might "prefer" a neighborhood that is at least 85-90% white, be just as "comfortable" with neighborhoods that are 91-95% white but not be specifically motivated to seek this level of white representation, look askance at a neighborhood that is "lilly-white" (i.e., 96-100% white), be willing to consider neighborhoods that are as low as 70% white, be uncomfortable with neighborhoods that are less than 50% white, and never voluntarily enter neighborhoods that are less than 25% white.

One way to work quantitatively with conceptual distinctions of this nature is to think of ethnic preferences as reflecting "attraction to" (or, alternatively, aversion to) neighborhoods based on their ethnic composition with the magnitude of the attraction (aversion) varying on a continuum as neighborhood ethnic mix varies. Viewed from this perspective the relationship between "attraction" and neighborhood ethnic mix is not likely to be simple. For the hypothetical white individual described in the previous paragraph, the relationship is clearly complex and nonlinear. A "plateau" of maximum attractiveness is reached when neighborhoods are between 85 and 95% white. Attractiveness begins to decline monotonically when percent white rises *above* 95% (e.g., imagine a parent who desires a certain minimum level of ethnic diversity in the neighborhood schools their children attend). Finally, attractiveness also declines monotonically when percent white falls *below* 85% and crosses substantively important attractiveness "thresholds" at approximately 70%, 50%, and 25% white.

This complex conceptualization of ethnic preferences is more realistic than the notion of discrete, "either-or" preferences used in the previous sections. It implicitly carries with it the notion that attraction (aversion) to neighborhood ethnic composition is a matter of degree that is weighed against competing concerns that influence residential location decisions (e.g., housing quality, proximity to shopping and employment, neighborhood amenities, etc.). The problem with this notion is that its complexity poses major challenges for theoretical analysis of the implications of preferences. What exactly are the implications for segregation if whites are *maximally attracted to* areas that are 85-95% white *but would not absolutely rule out* areas unless they are less than 25% white?

One possibility is to treat the absolute lower boundary of "voluntary" consideration as the value that governs the decision rules used in the strategic placement algorithms introduced above in earlier sections. This, in fact, is the approach I adopt in analyses reported below.[1] There is a clear practical advantage of this approach – it is easy to implement. The chief disadvantage of the approach is that it yields assessments of the "structural propensity" for segregation that are lower-bound in the extreme and, thus, are of questionable relevance for informing our understanding of segregation patterns in "real" cities. Simply put, it is difficult to argue that "willing-to-mix" preferences of this nature would "drive" residential choices in any important way. It is much more likely that residential choices will be driven by top-ranking preferences for neighborhood ethnic mix, not by "minimally acceptable" outcomes that are undesired relative to other alternatives.

Willing-to-mix preferences might conceivably be relevant in situations where higher-ranking preferences are hard to meet (i.e., if neighborhoods with more attractive ethnic mixes did not exist), but this is not generally the case. Krysan and Farley (2002) report that about half of whites report that they would be willing to enter a neighborhood that is 35% black. At the same time, however, whites identify predominantly white neighborhoods as their top-ranked preference. Such neighborhoods are common in most cities so it is not easy to imagine that whites would locate in 35% black areas even though most whites are "willing" to do so. Similarly, Krysan and Farley report that most blacks report being willing to enter predominantly white neighborhoods. However, this is clearly far from a top-ranking choice. Blacks' top-ranked preference is for areas with a 50/50 black-white mix. Areas with this mix are not common and cannot be easily chosen. However, most blacks place neighborhoods with higher levels of black representation (e.g., 70-100% black) among their top choices and *the vast majority of blacks prefer neighborhoods with this ethnic mix over neighborhoods that are predominantly white*. Areas that are 70-100% black are common in most cities and thus blacks could in principle (i.e., if not blocked by discrimination) choose between neighborhoods that are predominantly white and areas that

[1] Another option is to use continuous (not binary) measures of attraction (aversion) to neighborhood ethnic composition. The complexity this introduces makes analysis using the kinds of strategic placement algorithms implemented here extremely difficult (if not impossible). Elsewhere (Fossett 2003) I use simulation methods to assess the implications of ethnic preferences conceived in this way.

are predominantly black.[1] Thus, the same surveys that indicate that most blacks are *willing* to enter predominantly white areas also indicate that there is little basis for expecting blacks' to choose this option since higher-ranking alternatives are readily available.

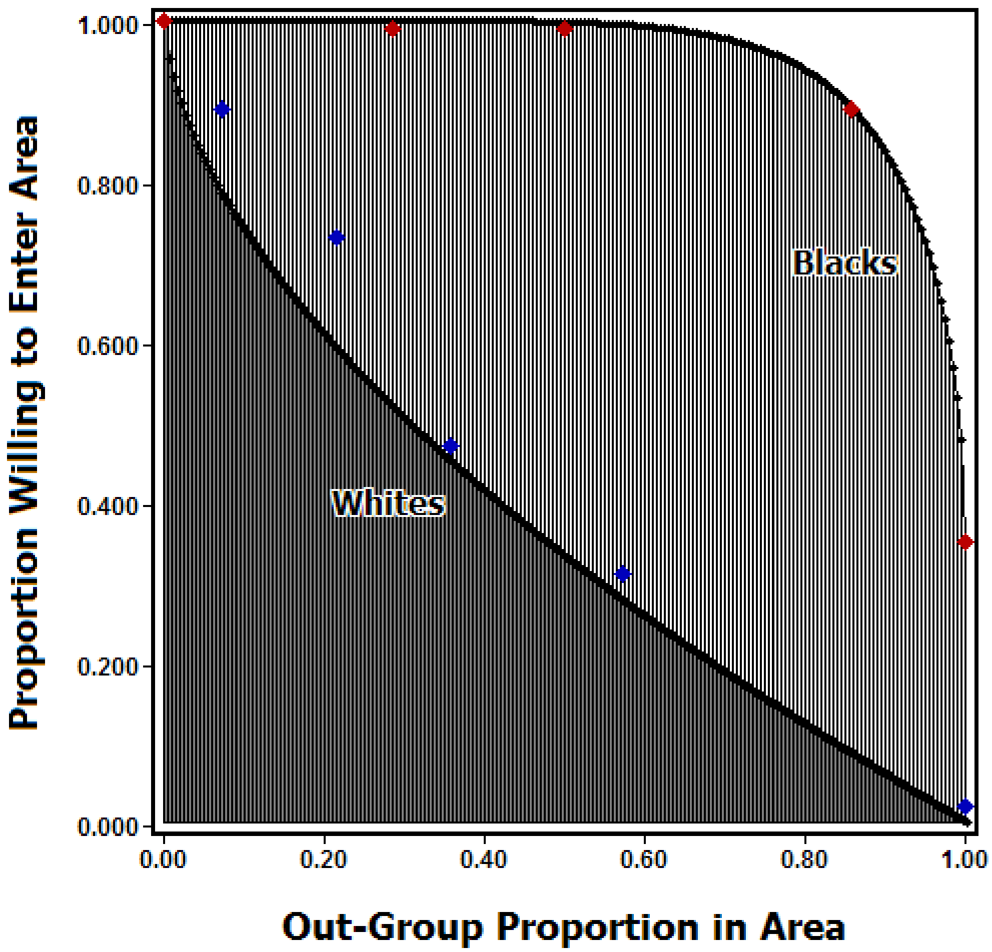
Now that the question of whether willing-to-mix preferences are likely to play an important role in shaping segregation patterns has been introduced, I set it aside to consider a separate question – To what extent do willing-to-mix preferences (i.e., maximum acceptable, but not necessarily preferred, levels of out-group contact) create possibilities for integration? To answer this question, I use the D-Star program to (a) generate model-based, "willing-to-mix" preference distributions and then (b) implement strategic placement algorithms that calculate the minimum possible level of segregation (maximum possible level of integration) that can be achieved in cities with populations holding these preferences.

In this case, I draw on the two-parameter beta distribution (rather than the normal distribution I used in earlier exercises) to generate the model preference distributions. I use the beta distribution here because its shape is more flexible than the normal distribution (which is a special case of the beta distribution) and can generate model preference distributions that correspond closely to empirical distributions of willing-to-mix preferences for whites and blacks reported in the literature. Figure 19 presents the first two model-based distributions I use to explore the implications of willing-to-mix preferences. It is obvious from the distributions presented in this figure that blacks are much more willing to "mix" with whites than whites are willing to "mix" with blacks. More than 90% of blacks are willing to enter areas that are 80% white. In contrast, less than 10% of whites are willing to enter areas that are 80% black. Similarly, 30% of blacks report being willing to enter an all-white area whereas less than 1% of whites report being willing to enter an all-black area.

Figure 19 also shows data points from willing-to-mix preference distributions reported in Krysan and Farley (2002). Generally speaking, the points from the empirical distributions fall close to the points on the curve for the model-based distributions. To the extent that there are differences, the model-based preference distribution for whites shows them to be slightly *less* willing-to-mix than is

[1] The role of discrimination is, of course, ignored in all of the theoretical exercises assessing the implications of preferences for segregation.

Figure 19
Distribution of "Willing-to-Mix"
Preferences for Whites and Blacks



suggested by the data reported in Krysan and Farley (2002) and the model-based preference distribution for blacks shows them to be slightly *more* willing-to-mix than is indicated by the data reported by Krysan and Farley.[1]

I specified the model-based distributions in this way to assure that any discrepancies between the empirical distributions and the model-based distributions would be favorable to the conclusions that Krysan and Farley advanced concerning the impact of group preferences on the possibilities for inte-

[1] All of the data points for whites are on or *above* the model distribution curve. All of the data points for blacks are on or *below* the model distribution curve.

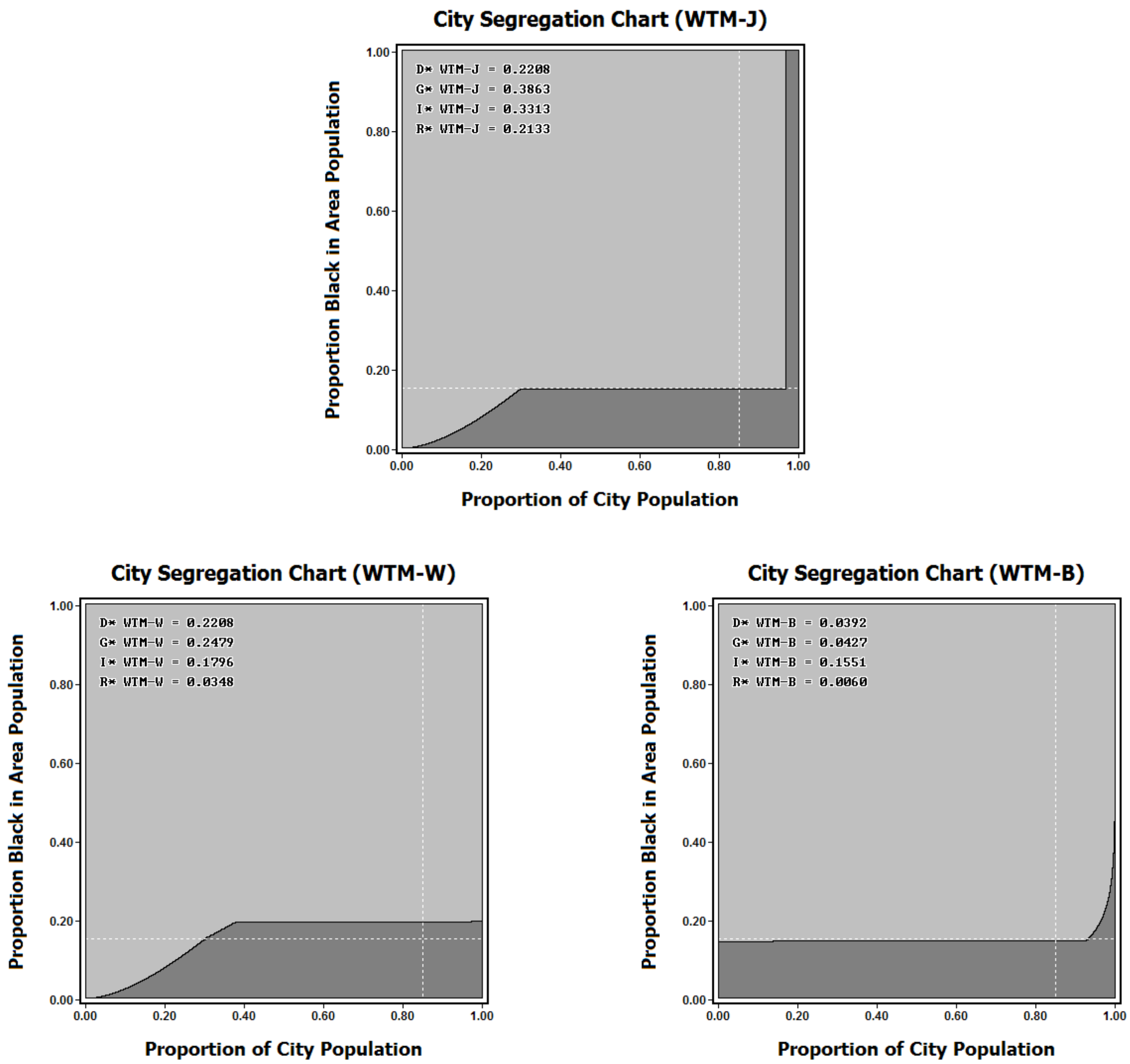
gration. Specifically, Krysan and Farley conclude that blacks' willing-to-mix preferences are compatible with extensive integration and that whites' willing-to-mix preferences are a significant impediment to integration.

Are these conclusions defensible? To explore this question, I developed an algorithm similar to the ones I introduced earlier for computing D* measures under heterogeneous preference distributions. In this case, the algorithm yields the minimum value of D that can be obtained under a model in which white and black households are strategically placed in neighborhoods with ethnic mixes that are acceptable to them based on their "willing-to-enter" preferences. The steps in the algorithm can be summarized as follows:

1. Begin with a perfectly segregated city in which all whites live in all-white areas and all blacks live in all-black areas.
2. Attempt to move individuals into integrated neighborhoods of different ethnic mixes beginning with an area that is 0.25% black and progressing by increments of 0.25% up to an area with an ethnic mix that is 99.75% black.
3. For each neighborhood ethnic mix, determine how many whites and blacks are "willing" to move from the area they presently reside in to the area being considered.
4. Place as many whites and blacks in the area being considered as is feasible (the area may not be able to accommodate everyone who is willing to enter it) subject to the following condition – individuals can be moved from their current area of residence to the area under consideration *only if* the move will reduce segregation (increase integration) by producing a more even distribution of whites and blacks across areas. More specifically, an individual residing in area i can be moved to area j only if $|Q - q_i| > |Q - q_j|$.

I applied this algorithm three different ways to a city that is 85% white and 15% black (the same demographic mix I used in some earlier examples). First I applied it considering whites' willing-to-mix preferences (WTM-W), assuming all blacks would enter any area. Next I applied it considering blacks' willing-to-mix preferences (WTM-B), assuming all whites would enter any area. And finally I applied it considering both whites' and blacks' willing-to-mix preferences jointly (WTM-J). The results from this exercise are displayed in Figure 20 using the graphical device of the "segregation chart" introduced earlier.

Figure 20
Segregation Charts for D* Calculations
Based on Heterogeneous "Willing-to-Mix" Preferences for Whites Only, Blacks Only, and Jointly



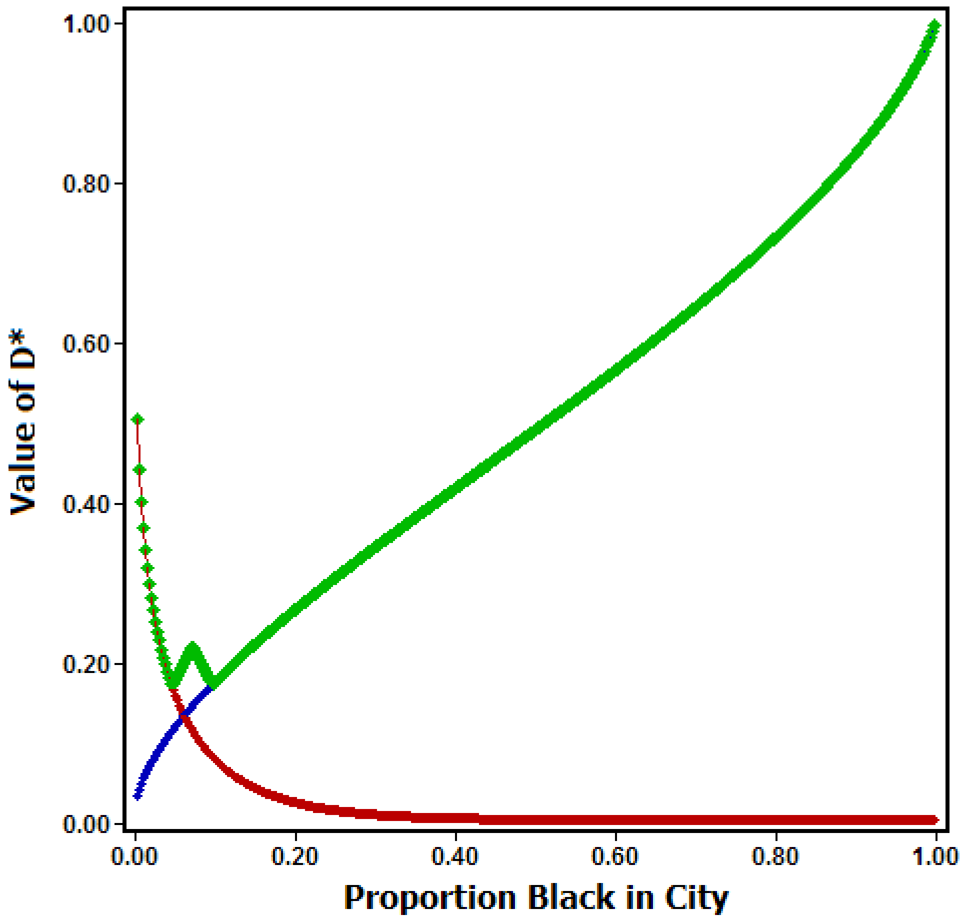
Notes: D* signifies minimum feasible segregation under strategic assignment algorithm; WTM-W indicates only Whites' preferences were considered, WTM-B indicates only Blacks' preferences were considered, and WTM-J indicates both groups' preferences were considered jointly.

The results are easy to describe; extensive integration is possible under every method of calculation and this is reflected by the low values for D* obtained in each case. The lowest D* value of 0.04 is obtained based on consideration of blacks' preferences only. A higher D* value of 0.22 was obtained based on consideration of whites' preferences only and also based on consideration of both groups' preferences. This value is obviously higher than 0.04, but it also very low compared to scores computed from empirical residential distributions. Thus, while it might be technically correct to say that in this example whites' preferences do limit the amount of feasible integration more than blacks' preferences, the major finding is that the difference is not very important since the "structural brake" that whites' willing-to-mix preferences put on integration is not great.

In sum, Krysan and Farley's suggestion that white-black differences in willingness to mix may play an important role in limiting possibilities for integration is not supported in this analysis. Instead, the preference data they report in their study are compatible with extensive integration. Why do the results here differ from their prediction? I suspect the major reason is that their analysis does not use any kind of formal theoretical model to assess the implications of preferences for segregation patterns. Their hypotheses and conclusions are instead based on the "common sense" intuition that since whites are significantly less open to "mixing" than blacks, whites' preferences are likely to place a significant limit on the possibilities for integration. While this expectation is plausible, the analyses reported in this paper make it very clear that common sense intuitions or speculations are sometimes contradicted when systematic models are used to assess the implications of preferences for segregation.

Another limitation of Krysan and Farley's analysis is that they do not consider the fact that the demographic mix of the city (i.e., 85% white and 15% black) powerfully conditions the consequences of preferences for segregation and integration. Whites are much less willing to mix with blacks than blacks are willing to mix with whites. But in this example (as in most US cities) the city is predominantly white. As a result, whites' preferences turn out to be compatible with extensive integration (i.e., even distribution of whites and blacks in most neighborhoods) even though whites are not especially open to mixing. By now the reader should recognize this as the "flip" side of the "paradox of weak minority preferences" discussed earlier. This might be termed the "paradox of weak majority tolerance" wherein limited openness to mixing on the part of the majority nevertheless creates substantial possibilities for integration under the demographic conditions where the majority group is a numerical as well as a power majority.

Figure 21
Distribution of D* Values Based on
"Willing-to-Mix" Preferences for Whites and Blacks
Considered Separately and Jointly



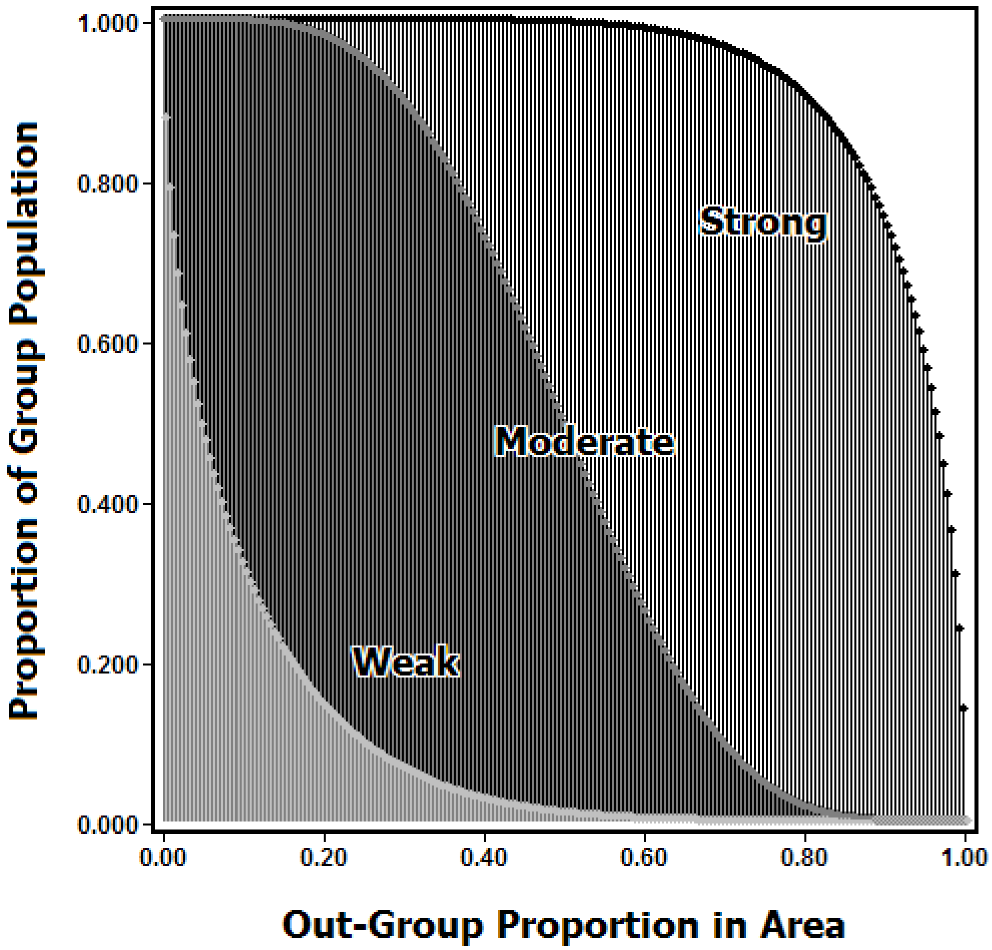
It is clear that the consequences of whites' and blacks' preferences for the structural possibilities for integration depend on city demographic mix and cannot be assessed based simply on knowledge of each group's openness to out-group contact. This point is further illustrated in Figure 21 which shows how the three D* values just computed for the above example vary across cities with different ethnic demographic mixes. The blue curve traces the value of D* based on whites' preferences only, the red curve traces the value of D* based on blacks' preferences only, and the green curve traces the value of D* based on joint consideration of both groups' preferences.

All three versions of D* vary dramatically depending on the city's ethnic mix. When only whites' preferences are considered, D* is a positive, nonlinear function of percent black in the city. Extensive integration (as indicated by low D* values) is feasible when percent black in the city is under 30, which it is in most US metropolitan areas. However, as percent black in the city begins to climb above 30, whites' preferences increasingly limit the possibilities of integration (i.e., D* values climb). When only blacks' preferences are considered, D* is a negative, nonlinear function of percent black in the city. Extensive integration is feasible when percent black in the city is above 5, but blacks' preferences limit the possibilities for integration when percent black falls below this level. When both groups' preferences are considered, D* is a complex, nonlinear function of the city's ethnic mix. The joint consideration of both groups' preferences limits the possibilities of extensive integration when percent black is below 5 (due to the impact of black's preferences) or above 30 (due to the impact of whites' preferences). Otherwise, considerable integration is feasible.

In sum, while the importance of the consequences of willing-to-mix preferences for segregation is open to question – I suspect higher-ranking preferences for neighborhood ethnic mix are much more important than willing-to-mix preferences – it is clear that their potential importance of willing-to-mix preferences is no simple matter to assess. Model-based analysis is needed and the examples just examined show that the consequences are complicated and in some cases counter-intuitive.

I provide a first step toward a systematic exploration of the implications of willing-to-mix preferences by using the D-Star program to consider a wide variety of scenarios based on combinations of city-wide ethnic mix (ranging from below 1% to above 99% black), three regimes of heterogeneous willing-to-mix preferences for whites, and three regimes of heterogeneous willing-to-mix preferences for blacks. The three regimes of preferences are shown in Figure 22 which plots the proportion in the group that is willing-to-enter an area based on the proportionate representation of the out-group in the area's population. The three preference distributions are labeled "weak", "moderate", and "strong" based on the group's willingness to enter areas with high out-group representation. The figure depicts "reverse" cumulative distributions that begin at 1.0 and fall off toward 0.0 as the out-group proportion in the area increases. These distributions are based on relative frequency distributions for 401 possible willing-to-enter "maximums" ranging from a low of 0.0 (not willing to enter an area if it has any out-group presence) to a high of 1.0 (willing to enter an all out-group area). As noted earlier, the D-Star program draws on a two-parameter beta distribution to generate these relative frequency distributions.

Figure 22
Three Distributions of "Weak", "Moderate", and "Strong" Willing-to-Mix" Preferences



In the regime of "weak" willing-to-mix preferences, less than 20% of the group will enter an area that has 20% out-group representation and less than 2% will enter an area with 50% out-group representation. In the regime of "moderate" willing-to-mix preferences, about 98% will enter an area with 20% out-group representation and 50% will enter an area with 50% out-group representation. In the regime of "strong" willing-to-mix preferences, more than 98% will enter an area with 50% out-group representation, 90% will enter an area with 80% out-group representation, and 75% will enter an area with 90% out-group representation.

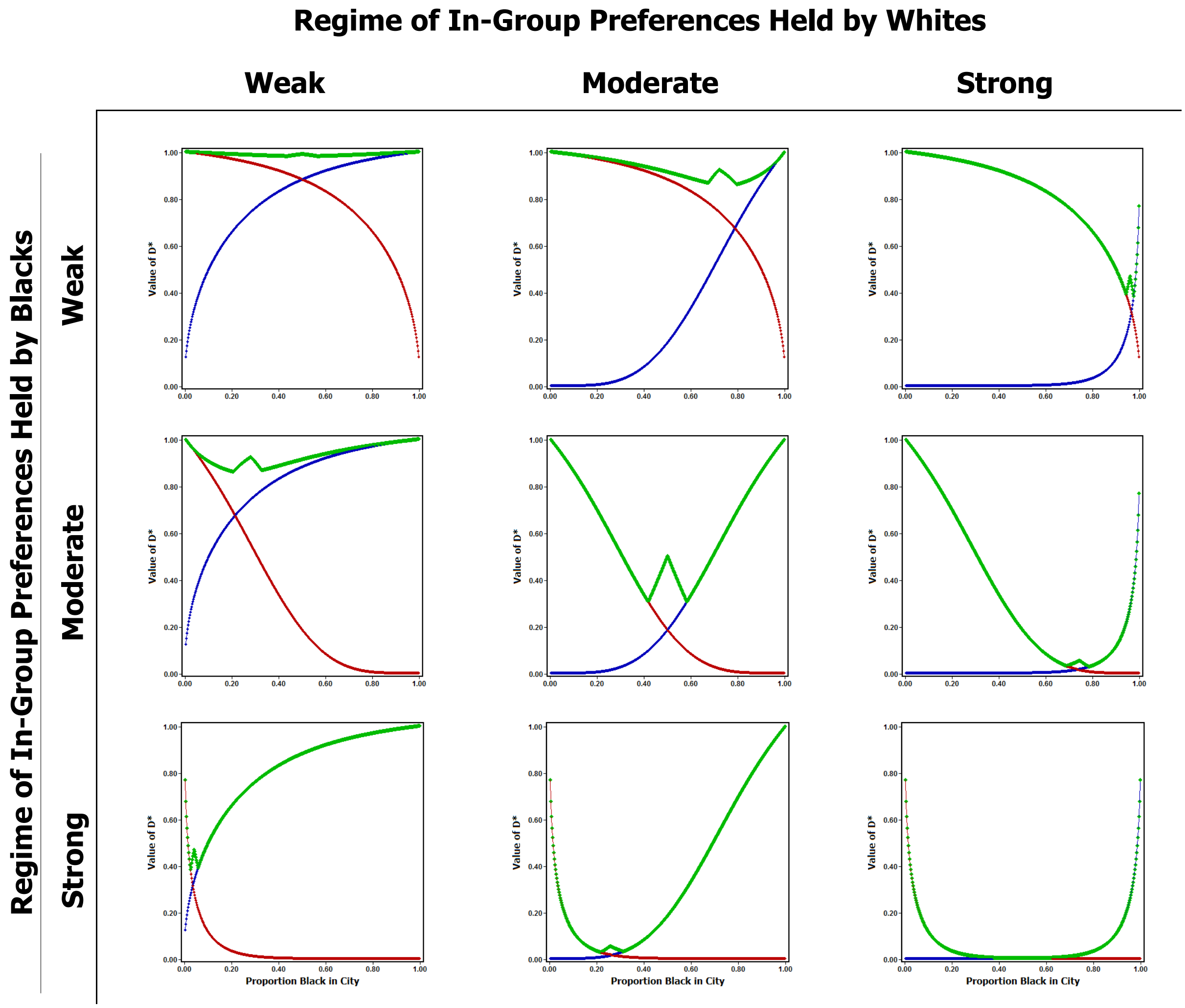
Figure 23 presents the values of D* computed under the range of scenarios outlined above. The green curve in each graph reflects the value of D* when the preferences of both groups are taken into account. The blue curve reflects the value of D* when the preferences of only whites are taken into account and blacks are assumed to be willing to enter any area. The red curve reflects the value of D* when the preferences of only blacks are taken into account and whites are assumed to be willing to enter any area.

The results can be summarized as follows. When whites and blacks have the same preference distributions, the green curves representing the impact of both groups preferences considered together are symmetrical and the red and blue curves representing the impact of only one group's preferences are asymmetrical mirror images of each other. Regarding the value of D* when both groups' preferences are considered, the possibilities of integration (low segregation) increase greatly as willing-to-mix preferences move from weak to moderate to strong. Under the weak-weak combination, segregation is high under *all* racial mixtures. Under the moderate-moderate combination, a substantial portion of the curve for D* is below 60 (i.e., when percent black is in the range 25-75%) and it dips below 40 in some limited ranges. Under the strong-strong combination, the curve for D* is below 10 under most racial mixes (i.e., when percent black is in the range 15-85%).

As observed previously in the analyses of the consequences of heterogeneous in-group preferences, the relationship between D* and city racial mix is complex. In the cases of the weak-weak and moderate-moderate combinations, the green curve starts and ends at very high levels controlled initially by the segregation-promoting impact of blacks' preferences and controlled at the end by the segregation-promoting impact of whites' preferences. In between, the curve falls generally toward lower levels when the demographic mix is not extreme. But the complex interaction of group-specific heterogeneity in the preference distribution and the city demographic mix creates a secondary peak when the black-white racial mix is 50/50 with the lowest values occurring on either side of this center peak.

When one group is less willing-to-mix than the other (i.e., in the off-diagonal graphs), the green curve depicting the value of D* considering both groups' preferences is asymmetric with the asymmetry reflecting the impact of the group that is less tolerant of mixing. For example, the three graphs in the top row of the figure matrix all involve weak willing-to-mix preferences for blacks. When whites are more open to mixing (i.e., in the columns where whites' willing-to-mix preferences are moderate

Figure 23
Minimum Value of D* Based on Joint Consideration of Both White and Black Preferences by Proportion Black in the City Under Nine Possible Combinations of Three Regimes of Heterogeneous Willing-to-Mix Preferences for Whites and Blacks



Note: Values of D* were computed using the D-Star program.

and strong), the blue curve that registers the impact of whites' preferences considered alone drops to lower levels but the green curve "follows" it down only a short ways before it meets the red curve that registers the impact of blacks' preferences considered alone. The exact opposite pattern can be seen in the three graphs in the first column of the figure matrix which all involve weak willing-to-mix preferences for whites. In this case, when blacks are more open to mixing (i.e., in the rows where blacks' willing-to-mix preferences are moderate and strong), the red curve that registers the impact of blacks' preferences considered alone drops to lower levels but the green curve "follows" it down only a short ways before it meets the blue curve that registers the impact of whites' preferences considered alone. This combination of patterns provides another powerful illustration of the basic finding that the theoretical implications of preferences for segregation can be highly complex. They cannot be easily assessed based on common sense or intuitive reasoning but must instead be explored within a more rigorous analytic framework such as the one used here.

Before leaving this section, it is worth reiterating that, while the results just reviewed show that the theoretical possibilities for the impact of willing-to-mix preferences defy simple summary, it would appear that the willing-to-mix preferences documented in surveys of white and black residential preferences permit substantial opportunities for integration. Whether residential choices of whites and blacks follow these possibilities or not is an unanswered question that needs to be addressed in future research.

Section VII
Consideration of Broader Implications and Questions

The findings set forth in the analyses presented in the previous sections of this paper draw on the most rigorous theoretical models available for assessing the implications of ethnic preferences for residential segregation. They support a simple and important conclusion – there is a compelling, theoretically grounded basis for hypothesizing that the ethnic preferences held by whites and blacks have the potential to generate and/or sustain residential segregation under conditions of voluntary choice in residential location. The question that now arises is "How should these findings from theoretical analysis inform our understanding of "real" racial residential segregation in the past, present, and future?". I address this broad question in the present section by exploring three narrower questions: "What is the theoretical standing of preference models of segregation?", "What are the behavioral implications of preferences?", and "Are preference theories incompatible with theories of segregation that emphasize the role of discrimination and/or other social dynamics?".

The Theoretical Standing of Preference Models of Segregation

Proponents of preference models (e.g., Clark 1991; 1992; Schelling 1969; 1971; 1972) and those who take the implications of these models seriously(e.g., Glazer 1999; Thernstrom and Thernstrom 1997; Patterson 1997) see ethnic preferences as capable of playing an important role in shaping both micro-level residential decisions and macro-level residential patterns. They see ethnic preferences as encompassing both the positive, affirming aspects of ethnic affiliation and community and its less congenial dimensions including negative stereotyping, prejudice, intolerance, and aversion to out-groups. Significantly, both aspects of preferences can promote segregation. The "warm and fuzzy" aspects of ethnic affiliation and community can produce segregation when group members seek to maximize co-ethnic contact in neighborhoods in order to experience, affirm, and reproduce social and cultural communities. For example, immigrant groups may seek out communities where their language, religion, and customs are maintained; whites may seek out neighborhoods where "mainstream", middle-class conventions are observed; and blacks may seek out neighborhoods where "black" cultural traditions are respected, valued, and affirmed.

Alternatively, preferences can produce segregation when prejudice, ethnic stereotyping, and "rational discrimination" lead individuals to choose residential locations that limit out-group contact to minimally acceptable levels. For example, whites may avoid areas where blacks are present in significant proportions based on negative affect rooted in early socialization, based on a desire to avoid contact with different (and unappreciated) cultural traditions, based on fears of crime, or based on concerns about property values and neighborhood stability.[1] Similarly, blacks may avoid predominantly white areas based on ethnocentric aversion to whites and "white" culture, based on anxieties that their culture (e.g., tastes, traditions, language usage, etc.) will not be respected and valued, or based on concerns about being isolated from familiar social and cultural surroundings.

These views contribute to a simple, but important position; ethnic preferences lead whites and blacks alike to evaluate residential choices in significant degree on the basis of neighborhood ethnic mix. Over thirty years ago, Schelling (1969;1971; 1972) built on this simple assumption and advanced theoretical analyses that showed that preferences regarding neighborhood ethnic composition have the capacity to generate and/or sustain ethnic segregation. The results of the theoretical analyses reported here are consistent with Schelling's position and evidence from surveys of residential preferences (e.g., Clark 1991; 1992) also lends support to his views. At present, however, the implications of preference models of segregation are not widely accepted by social scientists.[2]

Some critics have claimed to advance theoretical arguments that undermine preference models. For example, Massey and Denton (1993:96-97) and Yinger (1995) offer the critique that preference dynamics are incapable of generating and/or sustaining segregation on their own and must be "jump started" or "assisted" by discrimination that constrains the residential choices of minority households. I have examined these critiques at length elsewhere (Fossett 2003). They are deficient. They take the form of discursive arguments that do not directly engage, much less undermine, Schelling's formal

[1] It matters not that any empirical connection between minority entry and property values might be explained in terms of a self-fulfilling prophecy.

[2] A recent paper by Krysan and Farley (2002) may represent a significant "break" in this general position. They appear to acknowledge that the "top-ranking" preferences of whites and blacks are not compatible with integration. However, they argue that black preferences should not be seen as playing a central role for two reasons. The first is that blacks' "willing-to-mix" preferences serve to promote integration while whites' do not. I show this view is incorrect in Section VI of this paper. The second is that blacks "top-ranking" preferences are not "authentic" expressions of ethnic solidarity but instead reflect blacks' well-founded concerns about ill-treatment by whites. I examine this argument elsewhere (Fossett 2003) and note that Krysan and Farley's own data analysis suggests that blacks' top-ranking preferences are in substantial degree not grounded in concerns about white hostility.

theoretical work. And, on careful examination, the discursive arguments that have been offered are flawed and do not identify significant weaknesses in Schelling's models.

A common *informal* objection to Schelling's theoretical work, an objection that also would apply to the analyses presented here, is that the models are too simplistic and are not relevant for understanding "real world" segregation patterns. The inevitable progression toward and subsequent long-term stability of segregation in analytic models appears to strike many as "contrived" or "artificial". In the "real world" neighborhood dynamics are messy and complicated. Integrated areas can be found in many cities, cities vary their levels of segregation, segregation varies over time, and segregation is manifest in different ways for different groups. Thus, many observers have an intuitive sense that real world segregation is too complex to be explained by a theoretical model with so few "moving parts". This kind of "gut-level" objection to the implications of preference theory is difficult to counter; it is amorphous and is not articulated in a way that facilitates testing or theoretical critique. Elsewhere (Fossett 2003), I have used simulation methods to test Schelling's hypotheses in the context of a "virtual" urban system that is much more complicated than the idealized system found in Schelling's work. The results of those analyses support Schelling's theories and contradict the counter arguments his critics have offered.

In my opinion, the time is at hand when the debate regarding whether ethnic preferences are *capable in principle* of generating segregation can be viewed as settled; *they are*. The literature should incorporate this fact and move forward toward assessing the *empirical* importance of these effects under different conditions and in comparison with other potential determinants of segregation. Those who doubt that preference models are relevant for understanding "real-world" segregation patterns must concede that these models have yet to be challenged on the basis of rigorous theoretical critique. The basis for objection must be found elsewhere.

Behavioral Implications of Racial Preferences

One important question that deserves attention is that of how important ethnic preferences are empirically when compared to other preferences that also shape residential location decisions. Households hold many preferences and consider many different factors when choosing a residential location. Housing quality, crime, amenities, schools, public services, neighborhood status, and proximity to centers of shopping and employment are just a few examples of the factors individuals may take into account when choosing between housing alternatives. The question then arises, how important can a single factor – ethnic preferences and neighborhood ethnic composition – be in shaping residential patterns?

Intuitively, one might hypothesize that the impact of ethnic preferences on segregation will be significantly "blunted" when neighborhood ethnic composition is just one among many factors that individuals "weigh" when making residential choices. We have seen, however, that intuitive reasoning about the impact of preferences can lead to mistaken conclusions. So it is in this case. Simulation analyses I have presented elsewhere (Fossett 2003) show that, when ethnic preferences are segregation-promoting, they can generate ethnic segregation even when households give considerable weight to other factors (e.g., housing quality and neighborhood status) when choosing among housing alternatives. The chief reason for this is that the satisfaction of other preferences *does not necessarily require* compromise on ethnic preferences. When high status whites and blacks have the means to locate where they wish and hold incompatible ethnic preferences, what prevents them from simultaneously realizing goals for high-quality housing, low crime, and high status neighbors, good services, desirable amenities, *and* ethnic preferences by locating in segregated suburban areas? Similarly, while lower status whites and blacks are constrained by means to live in working class areas, what prevents them from choosing among these neighborhoods based on their ethnic composition. Thus, it is an empirical question, not an analytic question, as to whether racial preferences are sufficiently strong to create segregation in the face of other preferences.

The role of ethnic preferences should not be underestimated in this regard. Neighborhood ethnic composition is something that many households attach considerable importance to and it has yet to be demonstrated empirically that households will compromise on this preference in order to satisfy others, at least not to the point that it would significantly attenuate the impact of ethnic preferences on residential segregation. Aside from the occasional gentrification area (statistically a minor phenomenon), whites rarely enter minority neighborhoods regardless of whether the area is attractive on other dimensions or not. For some whites, the decision to avoid areas with significant minority presence reflects a "pure" ethnic preference (i.e., in-group preference and/or out-group rejection). Other whites may rely on neighborhood ethnic composition as an easily observed index of neighborhood attractiveness based on the strong historical correlation between neighborhood ethnic composition and present and future states of racial and non-racial characteristics of neighborhoods. Recent studies document that whites seek to avoid locating in neighborhoods with significant minority representation (Emerson et al. 2001) and there is also evidence that whites will pay more for housing to secure this "amenity" (Cutler, Glaeser, and Vigdor 1999). The fact that whites' expectations and choices may promote a self-fulfilling prophecy is beside the point. There is little basis for imagining that individual whites would ignore this dynamic; that in itself is one of the more insidious and intractable aspects of the dynamic implications of preference theory.

Will middle-class minorities "chase" whites who are seeking to avoid areas with significant minority presence? Will they pay extra for the "privilege"? At one time, an affirmative answer was plausible since white neighborhoods provided the only realistic opportunities for gaining access to high quality housing stock, middle-class amenities, and desired services. However, the explosive growth of minority suburbs has changed this equation dramatically. High-quality housing, middle-class amenities, and ethnic composition compatible with top-ranking minority preferences are now readily available in most metropolitan areas. In view of this, one need not invoke discrimination to explain the fact that minority households move into predominantly white neighborhoods at lower rates than would be expected based on their "willingness" to do so as expressed in surveys.

Finally, it is important to stress that the implications of ethnic preferences for segregation are not negated by the fact that preferences for co-ethnic contact may reflect different motivations on the part of whites and blacks. Suppose, for example, that white preferences for co-ethnic contact reflect racism, prejudice, and stereotyping and that black preferences for co-ethnic contact reflect a desire to avoid being socially and culturally isolated in majority-white areas.[1] Such differences would be important to understanding the dynamics underlying residential choice. However, the different "meanings" underlying the ethnic preferences members of the two groups hold does not change the implications they have for segregation. Preferences for co-ethnic contact can generate high levels of segregation regardless of the rationale underlying such preferences.

In sum, there are compelling arguments supporting the hypothesis that most households can satisfy preferences about housing, neighborhood status, crime, schools, and other amenities without com-

[1] Lake's (1981) study of the attitudes of black families settling in suburban areas did reveal concerns about avoiding racial hostility. Similarly, Krysan and Farley (2002) also report evidence that racial hostility is an important concern. Equally importantly, however, Lake's study also revealed concerns to avoid social isolation (especially with regard to its potential impact on their children) and to maintain ethnic identity and access to ethnic culture (1981:130-135). Likewise, Krysan and Farley's data also showed that blacks preferences for disproportionate ethnic representation were grounded in other concerns approximately half the time, despite the fact that their coding scheme gave priority to concerns about racial hostility.

promising on ethnic preferences. This hypothesis is consistent with the explosive growth of minority suburbs in recent decades and it is supported by results from simulation analysis of the impact of ethnic preferences on segregation in the context of competing preferences (Fossett 2003). In view of this, the hypothesis must be taken seriously and warrants careful consideration in future empirical and theoretical research.

Preference Dynamics or Discrimination – A False Choice

One question that arises is do the results of theoretical and model-based analyses of the implications of ethnic preferences lead to the conclusion that segregation in American cities is the product of ethnic preferences *rather than* discrimination or other possible contributing factors? *They do not*. It is difficult to stress this point too strongly. There are several reasons for this. One is that the fact that preferences *can* produce segregation under theoretically interesting circumstances (e.g., free exercise of choice in a housing market where groups have incompatible preferences for neighborhood ethnic composition) does not necessarily mean that equivalent circumstances in fact hold in American urban areas. At a minimum, however, these theoretical results do indicate that the hypothesis that preference dynamics play an important role in residential segregation is plausible and must be explored more carefully; they simply cannot be casually discounted or dismissed as has often been the case in the past.

Another point to emphasize is that, even if future research shows that the preferences *do* have an important contributing impact on segregation, this would not necessarily lead to the conclusion that discrimination or other factors do not also play important roles. *Preferences, discrimination, and other factors are not mutually exclusive causes of segregation*. It is logically possible that two or more factors may be capable of generating and maintaining substantial levels of segregation on their own. When they operate together, segregation may be strongly *overdetermined.* That is, segregation may be created and/or sustained by two or more independent forces each one having the capacity to be a sufficient cause of segregation on its own. Furthermore, it is plausible to speculate that multiple factors are involved and that the effects of each separate factor are amplified and reinforced by the effects of other factors (i.e., the effects of each separate factor may interact with the effects of other factors).

The role of discrimination in the past is especially clear. Research is unequivocal in showing that historically the exercise of residential choice was highly constrained for minorities seeking to move into predominantly majority areas. It is a well documented fact that in earlier historical eras formal and informal discrimination restricting black residential choices in American cities was widespread, vigorous, and extremely effective (Lieberson 1980; Massey and Denton 1993). Consequently, there is no dispute about the conclusion that discrimination played a major role in creating and maintaining patterns of white-black segregation in American cities.

It is only with respect to the present and the future that the role of discrimination is being reconsidered. There is ample evidence that discrimination also exists in the contemporary era, but even leading discrimination theorists do not argue that its nature, uniformity, and effectiveness are similar to what they were in earlier eras. One obvious reason for this is that many forms of informal and formal discrimination have clearly been curtailed. For example, restrictive covenants are no longer enforced. Similarly, informal acts of intimidation, threat, and violence against minorities entering white neighborhoods occur less frequently nowadays and in many areas are exceedingly rare. And, in contrast to earlier eras, such acts are no longer broadly tolerated by whites and civil authorities.

These and other changes are noted in Cutler, Glaeser, and Vigdor (1999), who examine the rise and decline of the African American ghetto over the course of the twentieth century. They establish a theoretical basis for inferring the nature of segregation dynamics based on relative housing costs paid by whites and blacks. Briefly put, segregation maintained by discrimination in the form of white exclusion of blacks is predicted to lead to higher relative housing costs for blacks as their housing demand is concentrated in a restricted portion of the city. In contrast, segregation maintained by white avoidance of areas with significant minority presence under conditions of unconstrained black movement is predicted to lead to higher relative housing costs for whites as whites bid up housing prices in predominantly white areas leaving blacks attractive choices in integrated areas and areas undergoing later stages of succession. Cutler and colleagues report that analysis of housing cost data for decades spanning the 20th century suggests that exclusionary discrimination was a major factor in segregation up until 1970; they found evidence of a "segregation premium" in the form of higher relative housing costs for blacks in highly segregated cities.[1] However, they also report that the pattern begins to reverse sharply around 1970 and by 1990 with higher relative housing costs are seen for whites rather than blacks in segregated cities.

[1] Kain and Quigley (1975) reported similar findings for this era and interpreted the finding in a similar way.

Their interpretation of this evidence fits well with the hypothesis that, following the demise of effective mechanisms of exclusionary discrimination, white aversion to residential integration expressed itself in what Culter and colleagues term "decentralized racism" – accelerated movement (i.e., "flight") to predominantly white outer-ring suburban areas. This movement reduced demand for high-quality housing in mid-town and inner-ring suburbs giving minorities favorable housing options not previously open to them. It also reduced the practical necessity middle-class minorities previously faced in having to locate in predominantly white areas to gain access to high-quality housing in middle-class settings and possibly helped pave the way for rapid black suburbanization observed after 1970. The ingredients of this plausible scenario suggest that segregation could persist at high levels based increasingly on voluntary location decisions. If whites are willing to pay higher housing costs to avoid extensive residential contact with minorities as suggested by Cutler et al. (1999), it would further strengthen the argument that segregation is likely to persist at high levels even under conditions where effective exclusion of minorities is declining. The minority preferences reported in surveys indicate that it is not difficult for whites who are so inclined to avoid minorities and maintain residential separation. To reduce segregation under these circumstances, blacks would have to specifically adopt the goal of achieving proportionate residential contact with whites and be willing to "pursue" whites into new, more expensive areas to achieve this goal. Furthermore, in doing this, blacks would have to "leap frog" over attractive housing opportunities in inner suburban areas.

Despite evidence of major changes in the nature of housing discrimination in American urban areas, there is still abundant evidence that many forms of racial discrimination still continue in urban housing markets. Apartment managers discriminate to maintain ethnic composition of apartment complexes, landlords and property managers discriminate based on racial stereotypes, realtors engage in racial steering and provide differential levels of service to whites and blacks, and mortgage companies differentially deny loans to minority households and to properties located in minority residential areas. These practices have been documented in dozens, even hundreds, of studies using a wide variety of methods including in-depth interviews, direct observation, multivariate statistical analysis, and quasi-experimental audit studies.

These data are compelling. Even so, the hypothesis that discrimination is less pervasive, vigorous, and effective today compared to earlier eras is cannot be dismissed or discounted. For example, the same audit studies which provide evidence that blacks receive differential treatment in housing markets also provide evidence that the differential treatment is by far from universal. Compared to whites, blacks are shown fewer houses and houses in different areas, but even so there is substantial overlap in the housing shown to whites and blacks and in the services provided to whites and blacks by realtors (Wienk et al 1979; Fix and Struyk 1993; Yinger 1995). Thus, Galster (1990), in an article reporting racial steering by realtors documented in audit studies, stated that

> "... steering did not limit the number of alternative areas shown to black auditors, nor their geographic concentration. Rarely were black auditors not shown dwellings in predominately white areas, especially if they requested such." (1990:39)

This suggests that discrimination is not necessarily sufficiently pervasive and effective that it would prevent minority households from identifying and locating housing in predominantly white areas if that was a major concern driving their choice of a residential location.

Similarly, Lake (1981) in a study of black movement to suburban areas, presented data indicating that the percentage of blacks who reported some kind of discrimination in purchasing a home in a suburban area (where discrimination is presumably highest) was less than 25%. This is not nearly as high a figure as would seem to be implied by explanations of segregation that hold that discrimination is the primary if not sole factor preventing integration in suburban areas. Significantly, the percentage of blacks located in predominantly white suburban neighborhoods who reported perceiving discrimination was not much different from the similar percentage of blacks locating in other suburban neighborhoods (differing by less than 5 percentage points). This suggests that black families living in predominantly white suburban areas did not represent a small minority of such families who had somehow slipped through a discrimination net that had generally kept most black families out. To the contrary, in Lake's survey of black families moving to suburban areas, *all families expressing a preference to live in a mainly white neighborhood located in such a neighborhood* (1981:132). Similarly, less than 10% of black families expressing a preference to live in an integrated neighborhood instead lived in a neighborhood where black representation equaled or exceeded 80%.

In sum, the evidence that minority households encounter discrimination is compelling, but few if any contemporary studies would suggest that discrimination is so pervasive and effective that minority families with both means and motivation would be unable to identify and locate in a predominantly white areas if that was a major preference guiding their choice of a residential location.

The credibility of this speculation is further strengthened by results of studies of residential succession, long a staple of the literature on racial residential segregation. These studies provide evidence that even in earlier historical eras discrimination was not wholly effective in preventing black entry into predominantly white areas. To the contrary, it has long been documented that neighborhoods often undergo gradual transitions from one ethnic mix to another. The process has been documented to proceed in stages. First, an ethnically homogenous neighborhood experiences "invasion" by minority "pioneer" households (usually from the higher socioeconomic strata within the minority group). Then the neighborhood undergoes early and late succession as more minority households follow and whites decline to enter. Often this proceeds to the final stage of "consolidation" in which the area comes to be resegregated with a new and homogeneous ethnic mix. Classic studies in this tradition (Cressey 1938; Duncan and Duncan 1957; Taeuber and Taeuber 1965; Massey and Mullen 1984) show that under some conditions predominantly white areas occasionally are "invaded" by black "pioneers." Obviously this cannot happen if discrimination in housing is 100 percent effective.

Historically, the entry of black households into predominantly white areas has often been followed by relative rapid racial succession and resegregation. However, this does not diminish the significance of the fact that blacks gained access to the neighborhood at some point in time. The transition from early to late succession is more rapid and the continuation to resegregation more likely in the case of black-white succession compared to other succession patterns (e.g., European immigrants and native whites, Anglos and Hispanics). This is consistent with "tipping" models of neighborhood change which emphasize the instability of integration under conditions of strong racial preferences. It does not *require* that discrimination be invoked to account for the result. However, it also does not preclude the possibility that discrimination may be implicated.

Processes of invasion and succession have been documented for earlier eras when informal and institutional discrimination constraining black entry into majority white areas was greater. It is by no means implausible then to argue that the possibility for blacks to gain access to predominantly white residential areas today is not zero and may be increasing over time. Farley et al. (1993) presents evidence which suggests that this is at least partly consistent with this view. They report that a clear majority of black respondents report that discrimination by white owners, real estate agents, and banks causes blacks to "miss out on good housing" either "almost never," "rarely," or only "sometimes" (1993:Figure 6). This is significant because an explanation of segregation in terms of discrimination *alone* requires that discrimination be *very* effective. If this is not the case, additional factors are needed to explain the continuing persistence of high levels of racial segregation.

This suggests that the potential role of preferences and voluntary choice should not be ignored or casually discounted by sociologists. It is reasonable to hypothesize that preferences play a more important role in segregation patterns today than in the past and that this role is steadily increasing in importance. Since housing discrimination in American urban areas is not universal, both preferences and discrimination can logically contribute to segregation patterns. They are not incompatible; they are not mutually exclusive. They can and in fact are likely to operate simultaneously and thus it is a false choice to pit one against the other as the exclusive explanation of segregation.

Yinger (1995) has argued that prejudice is determined by segregation and discrimination and thus preferences are not a cause of segregation. This argument puts the cart before the horse (how did housing discrimination and segregation arise before preferences existed?) and denies the obvious logical possibility that segregation, discrimination, and preferences can be mutually reinforcing. Preferences underlie and sustain discrimination and segregation; segregation and discrimination shape preferences.

The logical possibility of this reciprocal influence is not merely an academic point. Consider the hypothesis that minority preferences for in-group contact derive solely as an adaptation to discrimination and differential treatment.[1] Once established these sentiments of ethnic solidarity are real. They take on a life of their own and may continue to have causal force even after discrimination weakens. This logic of this argument parallels Massey and Denton's (1993) argument that segregation and discrimination in the past can produce an autonomous and enduring minority subculture in the present.[2] The direct negative consequences of this present-day subculture for socioeconomic attainment (e.g., educational attainment) can be recognized at the same time that it is understood as being situated in a particular history.

The question of which is more important – preferences or discrimination – in accounting for currently observed patterns of segregation is not as easy to answer as some would wish or the current lit-

[1] I consider this hypothesis implausible because it is contradicted by standard accounts of immigrant populations and generally denies any pre-existing autonomy of minority ethnic solidarity and culture.

[2] Massey and Denton hold that discrimination and segregation are the root cause of "oppositional" subcultures in central city ghettos. At the same time they also that these cultures gain autonomy and exert independent effects that must be acknowledged.

erature would suggest. Evidence that discrimination has been and is currently a factor contributing to segregation patterns is overwhelming. However, this does not in and of itself justify the conclusion that present day discrimination *directly* generates high levels of segregation and that presently observed segregation would quickly decline to very low levels if housing discrimination were to end.[1]

Theoretical and analytic arguments that preferences can be important in residential segregation are available cannot be easily dismissed. However, empirical work dealing with racial preferences is spotty. Most empirical work on racial preferences has tended to be descriptive in nature. Little work has been geared to establishing the consequences that these preferences have implications for individual behavior and ultimately for macro-level segregation outcomes. Nevertheless, the role ethnic preferences, including minority preferences for co-ethnic contact, has been acknowledged and even taken for granted in some portions of the literature on ethnic residential segregation. It is commonly asserted, for example, to contribute to the emergence of immigrant enclaves as areas which provide a haven from prejudice and discrimination and as areas which are attractive to ethnics because they reproduce a valued elements of a culture of origin.

In contrast, the relevance of ethnic preferences to black-white segregation has been strongly discounted and even dismissed by many sociologists. This dismissal has not been based on strong evidence that ethnic preferences do not exist. Similarly, it has not been based on any compelling theory demonstrating that they would not matter if they did exist. Rather it has been based on two different arguments. One is that formal and informal discrimination have been seen as so widespread and effective that other factors which might also contribute to segregation need not be seriously considered. This position may or may not have been appropriate for earlier historical eras. However, is not inappropriate today to consider the possibilities that (a) preferences may emerge as a more important factor in the future as discrimination wanes, or (b) the role of preferences in contemporary patterns of residential segregation may already be greater than is now generally recognized.

The second argument for discounting preferences in the role of black-white segregation is that the "traditional" ecological model of segregation and spatial assimilation that incorporates preferences has not applied to black-white segregation (Massey 1985). The traditional ecological model is one in

[1] I emphasize the word "directly" here because discrimination is likely have an indirect effect on segregation through its impact on black preferences. This effect is much more complicated to assess, in part because the lag between significant reductions in discrimination and changes in black preferences may be significant.

which majority preferences to avoid contact with lower status immigrants initially combine with the immigrants' desires to reproduce the cultural institutions of their homeland to create an immigrant community or enclave.[1] With acculturation and socioeconomic assimilation, however, the majority's motivation to avoid contact with the immigrant group diminishes and the minority group's strong desire to seek out ethnic cultural institutions and co-ethnic contact also weakens. Segregation then gradually declines especially after higher status members of the minority group with strong desires for assimilation begin to seek out and gain access to higher status neighborhoods which are predominantly majority in terms of ethnic composition.

The fact that historically this process has not been observed for black-white segregation does not imply in and of itself that preferences are irrelevant to segregation in the present. One important factor that should be considered is the minority's goals regarding assimilation. The traditional ecological model of spatial assimilation is one in which the immigrant group's entry into the urban system is voluntary and is governed by selection factors (operating both in the initial immigration stream and in the return migration stream) which skew the composition of the group toward individuals who are likely to emphasize aspirations of socioeconomic assimilation over goals of maintaining ethnic identify and participating in ethnic communities. Such a presumption of a strong and universal endorsement of assimilationist sentiments by members of a minority population should not be invoked uncritically. Indeed, traditional theories of spatial assimilation in ecology have been criticized, and rightly so, for naively assuming that minorities are willing, much less eager, to abandon minority ethnic culture and social structures in order to rapidly assimilate socioeconomically.

It is appropriate then to consider how goals that blacks have for spatial assimilation are balanced against goals for cultural and structural pluralism (i.e., the maintenance of minority ethnic culture and social structures). Blacks' attitudes toward these goals are heterogeneous and, while blacks almost universally endorse fair housing principles and related legislation, many blacks do not endorse spatial assimilation (in the sense of even distribution) as either a personal or group goal. One reason for this is that certain consequences flowing from integration may moderate minority preferences for full spatial assimilation. For example, black representation among elected and appointed officials often is tied to

[1] I use the term enclave in the sense that Abrahamson (1995) uses it – an area with a distinct, homogeneous population that also has institutional structures and to which the population has a sense of attachment.

black population concentration in wards, precincts, school districts, and other local political divisions. Thus, blacks considering a move to predominantly white areas may have rational concerns that teachers, police officers, school board representatives, and other local officials will rarely be black and may be insensitive to minority concerns.

Massey and Denton (1993) argue that blacks' history of extreme segregation has had consequences that can be reasonably seen as weakening blacks' preferences for assimilation. They argue that social isolation resulting from extreme segregation contributes to the emergence of various minority subcultures which are distinct from, in some cases "oppositional" to, the broader culture. Thus, political and moral views as well as patterns of speech, dress, and behavior which are common and accepted in inner-city predominantly black neighborhoods may be distinct from those that prevail in predominantly white residential areas (and vice versa). The scenario Massey and Denton develop is one in which black motivation to move into predominantly white areas might well be undercut by the fact some aspects of a minority world view and culture are likely to be devalued and rejected in those areas. Such cultural differences can be understood as arising out of a prior history of discrimination and segregation. However, that does not negate the fact that, once they exist, they have the potential to exert independent and autonomous effects.

McKee has criticized the tendency of sociologists to ignore the role of the minority group in race relations, especially the role of minority ethnic solidarity and emergent nationalism. This leads to the danger of seeing minority groups as irrelevant players in race relations. In the extreme, it may misguidedly imply that cultural institutions, social solidarity, and social organization of the minority group are mere epiphenomena. This occurs when group relations are seen as completely determined by the majority group with differences between the minority and the majority with respect to goals, preferences, culture, and social organization being seen as more apparent than real. The differences between minority culture and social organization are seen as transitory based on the implicit assumption that in the absence of majority discrimination and exclusion the minority will abandon its culture, institutions, and social organization and adopt the majority's culture and integrate into the institutions and social organizational structures of majority society.

This rests on an the assumption that the minority group is in the final analysis strongly assimilationist and that manifestations of minority ethnic solidarity and cultural nationalism are not intrinsic or enduring, but instead are ephemeral adaptive responses to discrimination by the majority and will be quickly dissipate when discrimination eases.

I make one final point in this section. It focuses on the relative capacity of discrimination and preference models to account for racial segregation in multi-ethnic, multi-minority settings. Ethnic minorities are not merely segregated from the majority population; they also are often segregated from each other. In the United States, for example, segregation between Asians, Latinos, Blacks, and other power minorities is substantial (Massey 2002). Indeed, the level of inter-minority segregation sometimes approaches the level of segregation between minority and majority.

Discrimination models overwhelmingly emphasize the role of the majority group in structuring discrimination and exclusion experienced by minorities. This is understandable since majority groups not only have segregation-promoting preferences, they also have the capacity to influence residential outcomes. However, standard theoretical models emphasizing white prejudice and discrimination cannot easily account for multi-group segregation patterns. Preference models can. Zubrinsky and Bobo (1996) present data indicating that black, Latino, and Asian minorities all have moderate to strong preferences for in-group contact *and* prefer whites to other minorities when expressing preferences regarding contact with out-groups. These preference structures will easily produce minority-minority separation. Traditional discrimination models emphasize whites' ability to effectively exclude minorities from white areas. These theories do not emphasize either a rationale or a mechanism whereby whites orchestrate separation among minorities in predominantly nonwhite areas.

Summary of Key Findings and Conclusions

The key finding advanced in this paper is that analytic models of segregation that emphasize ethnic affinity, solidarity, prejudice, intolerance, and aversion cannot be dismissed. Segregation is a distinct logical possibility when groups have incompatible preferences for co-ethnic contact which render fully integrated neighborhoods (in the sense of even distribution) an unattractive choice for all groups. To the extent that ethnic preferences have behavioral consequences (i.e., if they affect residential location decisions), they are likely to be a contributing cause of segregation. These effects will be attenuated only to the extent that ethnic preferences are weak relative to other preferences that that guide housing choices or to the extent that households are constrained from realizing their choices.

Discrimination models and preference models should not be cast as incompatible, competing models. Discrimination and preferences may both operate simultaneously in ways that reinforce and complement one another. The fact that discrimination is present in housing markets cannot be denied. It is important to recognize and stress this both for the sake of understanding segregation patterns and for emphasizing the clear policy implications for anti-discrimination enforcement. However, it also is important to acknowledge that the existence of discrimination in housing markets does not in itself justify the conclusion that preferences are irrelevant to segregation outcomes. Logically, the impact of preferences can be a contributing cause of segregation and, if segregation is overdetermined by a combination of discrimination and preference dynamics, segregation may not necessarily decline even if housing discrimination were reduced or eliminated completely.

Appendix A
Listing of Terms Used in Formulas and Derivations

Terms Relating to Citywide Ethnic Composition

T = the total population of the city.

W = the number of whites in the city.

B = the number of blacks in the city.

Q = the proportion black in the city (i.e., B/T).

P = the proportion white in the city (i.e., W/T or 1-Q).

T* = the total population residing in integrated and semi-integrated neighborhoods.

W* = the number of blacks residing in integrated and semi-integrated neighborhoods.

B* = the number of blacks residing in integrated and semi-integrated neighborhoods.

Terms Relating to Neighborhood-Specific Ethnic Composition

i = a neighborhood index running from 1 to N (the number of neighborhoods in the city).

t_i = the total population in neighborhood i.

w_i = the number of whites in neighborhood i.

b_i = the number of blacks in neighborhood i.

p_i = the proportion white in neighborhood i (i.e., w_i/t_i).

q_i = the proportion black in neighborhood i (i.e., b_i/t_i).

Terms Relating to Homogeneous Ethnic Preferences

α = the minimum proportion white that whites seek in their neighborhoods.

δ = the maximum proportion black that whites will accept in their neighborhoods.

λ = the minimum proportion black that blacks seek in their neighborhoods.

π = the maximum proportion white that blacks will accept in their neighborhoods.

Terms Relating to Heterogeneous Ethnic Preferences

α_i = the minimum proportion white that the i'th group of whites (grouped on the basis of α) will seek in their neighborhoods.

δ_i = the maximum proportion black that the i'th group of whites (grouped on the basis of δ) will accept in their neighborhoods.

λ_i= the minimum proportion black that the i'th group of blacks (grouped on the basis of λ) will seek in their neighborhoods.

π_i= the maximum proportion white that the i'th group of blacks (grouped on the basis of π) will accept in their neighborhoods.

Terms Relating to Neighborhood Ethnic Mix and City-Wide Segregation

all-white area – a neighborhood where all residents are white (i.e., $q_i = 0$).

all-black area – a neighborhood where all residents are black (i.e., $q_i = 1$).

exactly integrated area – a neighborhood where the racial mix (proportionate representation of whites and blacks) exactly matches that for the city as a whole (i.e., $q_i = Q$).

partially or semi-integrated area – a neighborhood that is not all-white or all-black but where the racial mix (proportionate representation of whites and blacks) does not exactly match that for the city as a whole (i.e., $q_i \neq Q$ and $0 < q_i < 1$).

complete or maximum segregation – the residential pattern where all areas in the city are either all-white or all-black.

full integration (minimum segregation) – the residential pattern where all areas in the city are exactly integrated.

partially segregated or partially integrated – any residential pattern where at least one area in the city is a partially integrated area.

Appendix B

Review of Massey and Gross' Derivation of the $_{W}D_{B}$ Construct

Massey and Gross (1991) offer the following formula for $_{W}D_{B}$.[1]

$$_{W}D_{B} = (Q-\delta)/(Q-Q^2). \quad [B.1]$$

They derived this expression by starting with the premise that $_{W}D_{B}$ is determined by the following expression:

$$_{W}D_{B} = SM / IM. \quad [B.2]$$

The denominator in this expression, "IM" (for "Integrating Moves"), represents the number of black moves required under complete segregation to achieve complete integration.[2] The numerator in the expression, "SM" (for "Segregating Moves"), is the number of black moves needed under complete integration to satisfy white preferences.

Massey and Gross present separate derivations for SM and IM and then combine the results to obtain Equation B.1. However, while the basic logic of Equation B.2 is correct, Massey and Gross' expressions for IM and SM are incorrect and consequently their formula for $_{W}D_{B}$ (i.e., Equation B.1 above) is incorrect.

In the sections that follow, I first review and critique Massey and Gross' derivations. Then I present revised (and corrected) expressions for IM and SM and show that they lead to the formula for $_{W}D_{B}$ that I offer in this paper.

Massey and Gross' Derivation of Integrating Moves (IM)

Massey and Gross argue that the denominator of Equation B.2 – IM or "Integrating Moves" (the number of black moves needed under complete segregation to achieve complete integration) – is given by (1-Q)B. Their reasoning for this conclusion is restated here as follows.

1. Under complete segregation all blacks live in all-black neighborhoods.
2. Under complete integration all blacks live in integrated neighborhoods where the black representation is equal to the citywide proportion Q.

[1] Massey and Gross used the term D*. I have modified their notation and terminology to maintain consistency with the present paper and to facilitate exposition.

[2] Integration here refers to evenness of distribution. Thus, complete integration occurs when the proportionate representation of whites and blacks is the same in every neighborhood.

3. Q blacks can remain where they are initially, but (1-Q) blacks must move to new neighborhoods to achieve integration. The required number of black moves to achieve complete integration (IM) is thus (1-Q)B.

Below I show this logic is erroneous. The number of Integrating Moves (IM) is not given by (1-Q)B as Massey and Gross state. Instead, IM is simply B.

Massey and Gross' Derivation of Segregating Moves (SM)

Massey and Gross argue that the numerator of their measure – SM or "Segregating Moves" (the number of black moves needed under complete integration to bring neighborhood racial compositions into conformity with white preferences for contact with blacks) – is given by $(Q - \delta)T$. Their logic for this conclusion is restated here as follows.

1. Under even distribution, white contact with blacks is Q.
2. When Q exceeds δ, the difference $(Q - \delta)$ gives the amount by which Q must be reduced in each neighborhood to yield integrated neighborhoods compatible with white preferences. Otherwise, SM is 0.
3. The difference $(Q-\delta)$ can be multiplied by T to determine the minimum number of black moves needed to bring neighborhoods into conformity with whites' ethnic preferences. Thus, the necessary number of segregating moves (SM) is $(Q-\delta)T$.

Below I show this logic is flawed. The number of Segregating Moves (SM) is not given by $(Q-\delta)T$. It is instead given by $B - (W\cdot\delta) / (1-\delta)$.

Massey and Gross' Derivation of $_{W}D_{B}$

Using the expressions they developed for IM and SM, Massey and Gross then expressed $_{W}D_{B}$ as

$$_{W}D_{B} = SM / IM$$

$$_{W}D_{B} = (Q-\delta)T / (1-Q)B. \qquad [B.3]$$

They then manipulated Equation B.3 to obtain a more generic formulation as follows. First they rearranged the expression to obtain

$$_{W}D_{B} = (Q-\delta)/(1-Q) \cdot T/B$$

Capitalizing on the fact that T/B is equal to 1/Q, they substituted terms to obtain

$$_{W}D_{B} = (Q-\delta)/(1-Q) \cdot 1/Q.$$

They then multiplied this out to obtain

$_WD_B = (Q-\delta)/(Q-Q^2)$

which is the final version of their computing formula presented earlier in Equation B.1.

Discarding the Stated Formula for $_WD_B$

The formula for $_WD_B$ that Massey and Gross report in the text of their article is incorrect. It is not necessary to review the derivation of the formula in any detail to see this. Cursory examination reveals that it can generate invalid values. Specifically, $_WD_B$ calculated from Equation B.1 will exceed 1.0 whenever Q^2 exceeds δ, which it can easily do. For example, if δ is 0.2 and Q is 0.7, then $(Q-\delta)/(Q-Q^2) = (0.7-0.2)/(0.7-0.49) = 2.38$. Since values of the index of dissimilarity (D) must fall in the range $0 \leq D \leq 1$, the formula is clearly flawed and must be set aside.

An Alternative Formula That is Improved, But Still Flawed

On close examination, the values of $_WD_B$ reported in the Massey and Gross article appear to be computed from a different formula than the one they report in the text of their paper. The values of $_WD_B$ Massey and Gross report cannot be reproduced using Equation B.1. Instead, they appear to be obtained from the formula $_WD_B = (Q-\delta)/Q$. This differs from Equation B.1 in the fact that the denominator is Q rather than $Q-Q^2$. This formula for $_WD_B$ also is not correct. But it is closer to the correct formula for $_WD_B$ derived in this paper.

The alternative formula $_WD_B = (Q-\delta)/Q$ can be obtained by making two changes to the original derivation of $_WD_B$ outlined by Massey and Gross. One change is correct. The other is flawed. The first change involves correcting the expression they give for the denominator of their measure, IM – the number of integrating moves. The number of integrating moves is "the number of blacks that would have to move to achieve evenness under conditions of maximum segregation" (1991:17). As noted above, Massey and Gross give IM as (1-Q)B. This is incorrect. The correct number is simply B; that is, all blacks. This can be established as follows. Under maximum segregation, all blacks live in all-black neighborhoods. Under integration, all blacks must instead live in integrated neighborhoods with whites. Thus, to bring about even distribution of whites and blacks across neighborhoods, it is obvious that all blacks in the city must move from the all-black areas where they initially reside to other neighborhoods where whites reside.[1] The required number of black moves is B.

The second change involves a revision (but not a correction) in Massey and Gross' stated derivation of the numerator of their measure, SM – the number of segregating moves. This is "the number of black moves required to yield a neighborhood composition that whites would find acceptable, compared to integration" (1991:17). Stated another way, SM is the number of blacks who would have to move out of an exactly integrated neighborhood in order to lower the proportion black in the area from Q – the value under even distribution – to δ – the maximum value acceptable to whites.

When the citywide proportion black (Q) does not exceed δ, no black movement is required and white preferences have no implications for segregation. However, when Q exceeds δ, some blacks must move to insure that white contact with blacks is lowered to a level acceptable to whites. It appears that Massey and Gross may have assessed the required number of segregating moves (SM) as $B(Q-\delta)/Q$ based on the following flawed reasoning. (This is my guess. I based this on the fact that this expression for SM generates the [flawed] formula that Massey and Gross apparently used to compute the values of ${}_{W}D_{B}$ reported in their paper.)

1. Under even distribution, white contact with blacks is Q. (This step is unchanged from the original derivation reported in their paper.)
2. When Q exceeds δ, the difference $Q-\delta$ gives the amount by which Q must be reduced in each neighborhood to satisfy white preferences. Otherwise SM is 0. (This step also is unchanged.)
3. The required number of segregating black moves (SM) is $B(Q-\delta)/Q$ where B is the total number of blacks and $(Q-\delta)/Q$ is an (incorrect) expression intended to register the proportion of blacks in the city that must move. (This departs from their original derivation which gave SM as $(Q-\delta)T$.)

Putting the corrected denominator (IM = B) together with the alternative (but still incorrect) numerator ($SM = B(Q-\delta)/Q$) yields the expression

$$ {}_{W}D_{B} = B(Q-\delta)/Q \,/\, B \qquad [B.4] $$

[1] Consistent with the standard interpretation of D, this presumes that only one group (in this case blacks and not whites) moves to bring about even distribution. While it would be possible to let both groups move and then determine the minimum number of moves for whites and blacks, Massey and Gross do not take this path.

which simplifies to

$${}_{W}D_{B} = (Q\text{-}\delta)/Q. \qquad [B.5]$$

This formula for ${}_{W}D_{B}$ is not explicitly stated in their paper. But, as best I can surmise, this Equation B.4 appears to be the basis for the values of ${}_{W}D_{B}$ reported in Massey and Gross' (1991) paper.

Obtaining a Correct Expression for SM

The number of segregating moves (SM) required to bring black representation in white areas down from Q to δ is not given by B(Q-δ)/Q as step 3 of the previous section would suggest. The expression B(Q-δ)/Q represents something quite different; it registers the number of blacks that would have to *leave the city* to reduce black representation *in the total population of the city* from Q to δ.

A different expression is needed to register the number of blacks that must move to new neighborhoods to bring the proportion black *in areas where whites reside* down to δ. I derive a correct expression as follows. First, I establish the number of segregating moves as

$$SM = B - B^* \qquad [B.6]$$

where B is the total number of blacks in the city and B* is the number of blacks that reside in the semi-integrated neighborhoods where whites reside. The difference B-B* is the number of blacks that must move and thus determines the number of segregating moves needed to reduce proportion black in the integrated area from Q to δ.

Let the terms W*, B*, and T* stand for the number of whites, blacks, and total (whites and blacks combined) residing in the integrated area where proportion black is δ. Given this, B* can be expressed as

$$B^* = T^* \cdot \delta. \qquad [B.7]$$

and

$$W^* = T^* \cdot (1\text{-}\delta).$$

Since all whites (W) live in the semi-integrated neighborhoods, "W" can be substituted in the above expression yielding

$$W = T^* \cdot (1\text{-}\delta).$$

Multiplying both side of this expression by 1/(1-δ) isolates T* as follows

$$T^* = W / (1\text{-}\delta).$$

Substituting the right-hand side of this expression for the term T* in Equation B.7 yields

$$B^* = (W / (1-\delta))\cdot\delta$$

Which can be restated as

$$B^* = (W\cdot\delta) / (1-\delta). \quad [B.8]$$

This term can be substituted in Equation B.6 to give the number of segregating moves (SM) needed to bring the proportion black in semi-integrated areas down from Q to δ as

$$SM = B - B^*$$

$$SM = B - (W\cdot\delta) / (1-\delta).$$

Obtaining a Correct Formulation of $_WD_B$

With correct expressions for both segregating moves (SM) and integrating moves (IM) in hand, a corrected version of Massey and Gross' formula for $_WD_B$ can be developed. Start with the compact expression for B*

$$_WD_B = SM / IM$$

$$_WD_B = (B-B^*) / B$$

Then restate this as follows

$$_WD_B = B/B - B^*/B$$

$$_WD_B = 1 - B^*/B . \quad [B.10]$$

Next substitute the right-hand side of B.8 [i.e., $(W\cdot\delta) / (1-\delta)$] for B* to get

$$_WD_B = 1 - [(W\cdot\delta) / (1-\delta)] / B .$$

Restate this as

$$_WD_B = 1 - W/B\cdot\delta / (1-\delta) .$$

Finally, draw on the fact that the ratio P/Q is the same as the ratio W/B, and restate this as[1]

$$_WD_B = 1 - P/Q\cdot \delta / (1-\delta) . \quad [B.11]$$

This is the formula for $_WD_B$ reported in the text of this paper and derived in Appendix C.

Implications

A question that arises is whether the empirical results in Massey and Gross's paper are affected by the fact that they used a flawed formula to calculate values of $_WD_B$. This is certainly true if the for-

[1] Alternatively, multiply W/B by 1 in the form of (1/T)/(1/T) and restate the result (W/T)/(B/T) as P/Q.

mula offered in the text of their paper – $(Q-\delta)/(Q-Q^2)$ – is used. But, as I noted above, I speculate that their values of ${}_WD_B$ were actually computed based on $(Q-\delta)/Q$. (While I do not know this for certain, I can reproduce the values of ${}_WD_B$ reported in their paper using this formula.) Values of ${}_WD_B$ computed using this formula will be lower than those computed using the correct formula derived here and given in Equation B.10. Thus, the values Massey and Gross report *underestimate* the structural propensity of segregation resulting from white preferences and demographic structure.

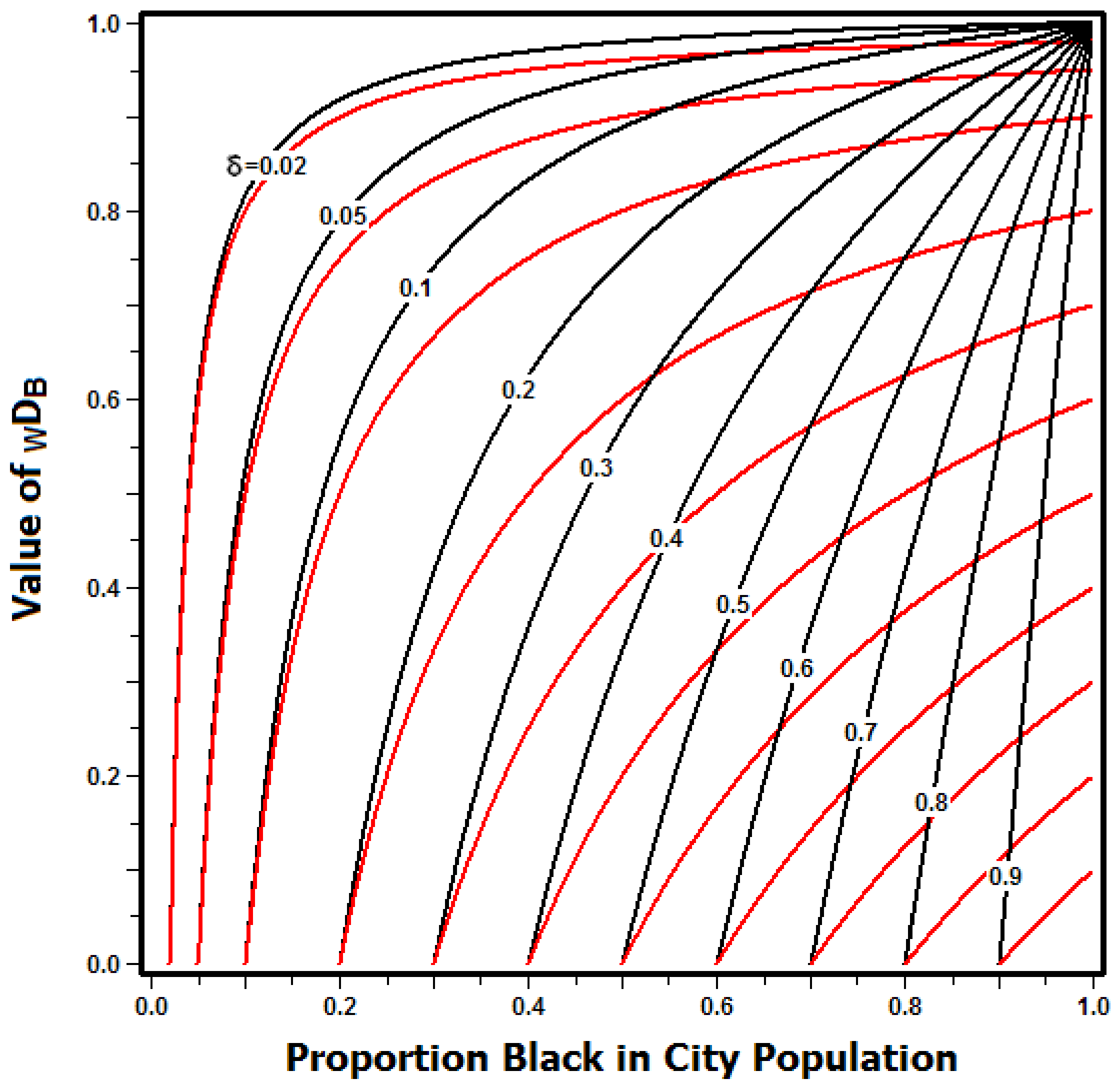
To illustrate the potential magnitude by which ${}_WD_B$ can be underestimated, consider a city where the proportion black (Q) is 0.25 and where the white tolerance for black representation in areas where whites reside (δ) is only 0.05. ${}_WD_B$ for this city computed using the correct formula is 0.842 whereas the value computed using $(Q-\delta)/Q$ is 0.800. Whether or not this difference is substantively important would depend on the specific question being addressed. Clearly both values indicate that a substantial level of segregation is required to insure that no whites' preference is violated. On the other hand, the incorrect formula yields an estimate that is about 5 percent lower than the correct estimate and that may be a concern. All else equal, the extent to which ${}_WD_B$ is underestimated by the Massey and Gross formula increases as Q increases and as δ increases.

This pattern is illustrated in Figure B.1 which plots values of ${}_WD_B$ under the selected values of whites' tolerance for contact with blacks (i.e., δ = 0.02, 0.05, 0.10, 0.20, 0.30 ... 0.90) using the correct formula for ${}_WD_B$ and the formula that I speculate was used in Massey and Gross' paper. The figure shows clearly that when δ is low and Q does not exceed δ by a large margin, the two values are close. However, at higher values of either δ or Q, the two values diverge, often by a considerable margin.

It may be comforting to note that the formula Massey and Gross used (or so I speculate) tends to be consistent in proportionately underestimating ${}_WD_B$. Consequently, the correlation between the values of ${}_WD_B$ computed using the correct formula derived here and the values obtained using $(Q-\delta)/Q$ is likely to be high. This is because they vary from low to high together even though one is consistently lower than the other. With this in mind, and recognizing that the value for δ used by Massey and Gross is low (i.e., 0.05), the substantive implications of the regression analyses using ${}_WD_B$ reported in Massey and Gross probably are not affected by their error in any dramatic way. Some unstandardized coefficients might change when the correct values for ${}_WD_B$ are used in the analysis. But the correlation between the values they use and the correct values are likely to be so high that the direction of the effects and the statistical significance of effects will not change.

Appendix Figure B.1

Alternative Formulations of $_{W}D_{B}$ by Proportion Black in the City for Selected Values of δ for Whites



Appendix C
A General Formula for $_{W}D_{B}$ Under Homogeneous White Preferences

This section manipulates the standard computing formula for the index of dissimilarity (D) to derive a general formula for $_{W}D_{B}$ under homogeneous white preferences (δ). Begin by stating the standard computing formula for D which is

$$D = \tfrac{1}{2} \sum |w_i/W - b_i/B| . \qquad [C.1]$$

Homogeneous White Preferences, δ ≥ Q

In the case where whites' preferences are homogeneous and whites' tolerance for blacks (δ) is greater than or equal to the proportion black (Q) in the city, whites' preferences permit full integration. That is, all whites and blacks can be placed in a single area where the proportion black in the area is exactly the same as the proportion black in the city (i.e., $q_i = Q$). To help illustrate the point, this situation is depicted in the segregation chart shown in the top-left panel of Figure C.1. This figure was previously presented in the main text and is presented again here for convenience. In this particular figure, Q is set to 0.25. But that is arbitrary and is not crucial to the discussion of the general result (i.e., the formulas developed below are all expressed in generic form).

In this case, there is only one area with $w_1 = W$ and $b_1 = B$ and thus

$$_{W}D_{B} = \tfrac{1}{2} \sum |w_i/W - b_i/B| .$$

$$_{W}D_{B} = \tfrac{1}{2} |w_1/W - b_1/B| .$$

$$_{W}D_{B} = \tfrac{1}{2} |W/W - B/B| .$$

$$_{W}D_{B} = \tfrac{1}{2} |1 - 1| .$$

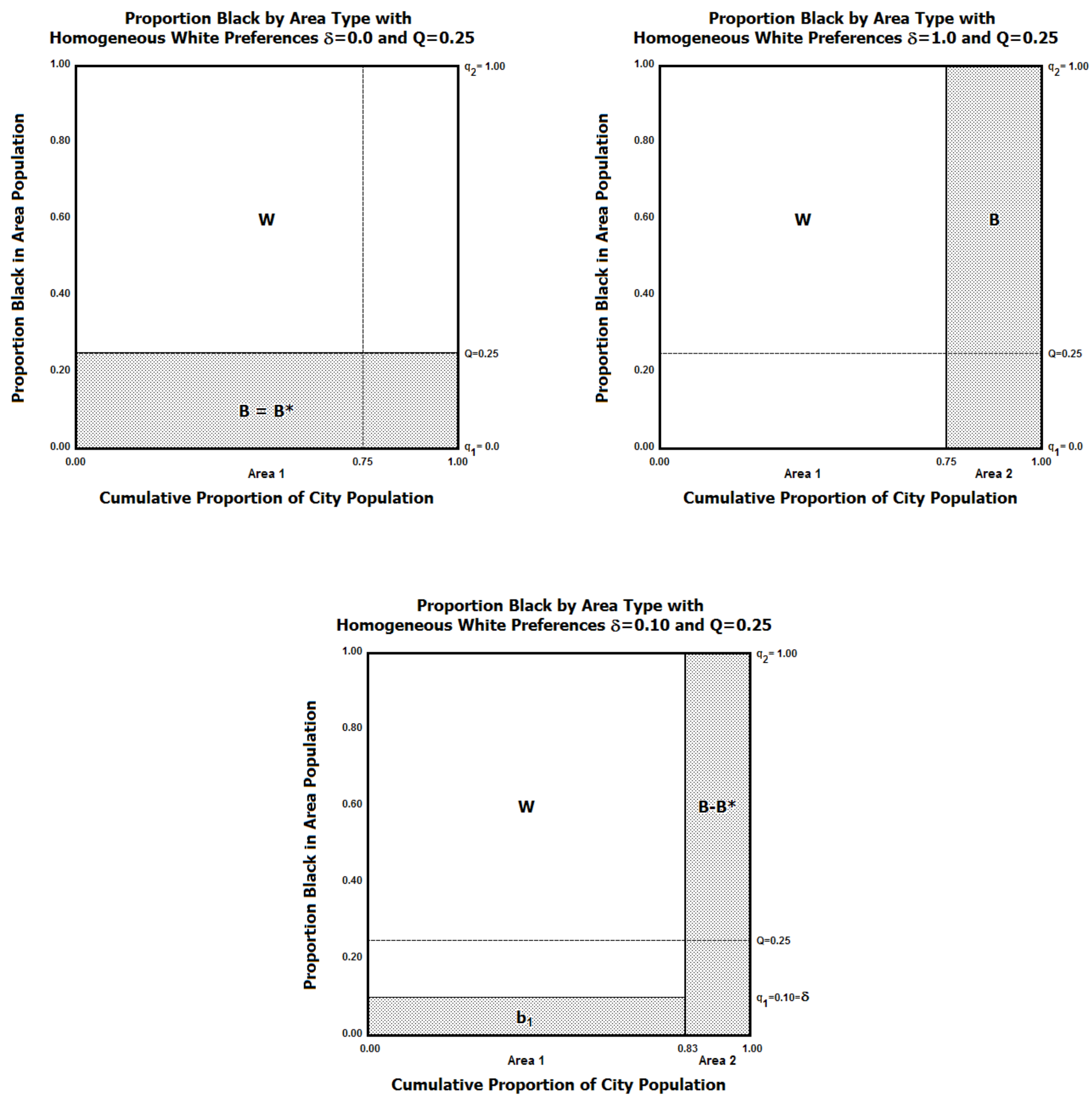
$$_{W}D_{B} = 0.$$

Homogeneous White Preferences, δ = 0

In the case where whites' preferences are homogeneous and where whites' tolerance for blacks (δ) is zero, whites' preferences permit no integration. All whites must be placed in an all-white area (Area 1) and all blacks must be placed in an all-black area (Area 2). This type of situation is depicted in the segregation chart shown in the top-right panel of Figure C.1 (previously presented in the main text and presented again here for convenience).

Figure C.1

Segregation Charts Illustrating Residential Distributions Resulting Under Homogeneous White Preferences for Selected Values of δ and Q



In this case, $w_1 = W$ and $b_1 = 0$ and $w_2 = 0$ and $b_2 = B$ and thus

$$_W D_B = ½ \sum |w_i /W - b_i /B| .$$

$$_W D_B = ½ (|w_1 /W - b_1/B| + |w_2 /W - b_2/B|).$$

$$_W D_B = ½ (|W/W - 0/B| + |0/W - B/B|).$$

$$_W D_B = ½ (|1 - 0| + |0 - 1|).$$

$$_W D_B = ½ (2).$$

$$_W D_B = 1.$$

Homogeneous White Preferences, 0 < δ < Q

The more interesting case is when whites' preferences are homogeneous and whites' tolerance for blacks (δ) is greater than 0 but less than the proportion black (Q) in the city (i.e., $0 < \delta < Q$). In this case, partial integration is possible. All whites and some blacks can be placed in a semi-integrated area (Area 1) where $0 < q_i < Q$ and some blacks will be placed in an all-black area (Area 2). This type of situation is depicted in the segregation chart shown in the bottom panel of Figure C.1 (previously presented in the main text and presented again here for convenience).

In this case, $w_1 = W$ and $w_2 = 0$ (for the moment b_1 and b_2 are treated as unknown) and the standard computing formula can be applied as follows.

$$_W D_B D = ½ \sum |w_i /W - b_i /B| .$$

$$_W D_B D = ½ (|w_1 /W - b_1/B| + |w_2 /W - b_2/B|).$$

$$_W D_B D = ½ (|W/W - b_1/B| + |0/W - b_2/B|).$$

$$_W D_B D = ½ (|1 - b_1/B| + |0 - b_2/B|).$$

$$_W D_B = ½ (|1 - b_1/B| + | - b_2/B|).$$

At this point it is useful to restate b_2 as $(B - b_1)$ which gives

$$_W D_B = ½ (|1 - b_1/B| + | - (B - b_1)/B|).$$

Next restate $(B - b_1)/B$ as $(1 - b_1/B)$ to obtain

$$_W D_B = ½ (|1 - b_1/B| + | - (1 - b_1/B)|).$$

Since b_1/B cannot exceed 1, the expression $(1 - b_1/B)$ will always be positive and it is obvious that the computation will proceed as follows

$$_W D_B = ½ ((1 - b_1/B) + (1 - b_1/B)).$$

$$_W D_B = ½ \cdot 2 (1 - b_1/B)$$

$_{W}D_{B} = 1 - b_1/B.$ [C.2]

This can also be given as

$_{W}D_{B} = 1 - B^*/B.$ [C.3]

where B* represents all blacks residing in integrated neighborhoods which in this case is simply b_1. This expression is useful when preferences are heterogeneous rather than homogeneous. (Note that this same expression appears as Equation B.10 in Appendix B.)

Next, it is useful to establish several additional terms and relations that will be used in later steps. First, define t_1 as the total number of persons (white *and* black) residing in the semi-integrated neighborhood (Area 1). Thus,

$t_1 = w_1 + b_1.$

Next, establish that the number of blacks (b_1) residing in the semi-integrated area (Area 1) can be obtained from the product of the total population in the area (t_1) and the proportion black in the area (q_1), which is equal to the white tolerance for black representation (δ). Thus,

$b_1 = t_1 \cdot \delta.$

Similarly, establish that the number of whites (w_1) residing in the semi-integrated area (Area 1) can be obtained from the product of the total population in the area (t_1) and the proportion white in the area (p_1), which will be equal to $(1 - \delta)$. Thus,

$w_1 = t_1(1 - \delta).$

Since all whites reside in Area 1, $w_1 = W$, this expression can be restated as

$W = t_1(1 - \delta).$

Rearranging the above expression establishes that the total population in the semi-integrated area (t_1) can be obtained by dividing the total number of whites (W) by the proportion white in the semi-integrated area $(1 - \delta)$. Thus,

$t_1 = W/(1 - \delta).$

With these terms and relations introduced, it is now possible to develop a general computing formula for $_{W}D_{B}$ using the following steps. Take the formulation of $_{W}D_{B}$ listed above in Equation C.2

$_{W}D_{B} = 1 - b_1/B$

and substitute $t_1 \cdot \delta$ for b_1 to obtain

$_{W}D_{B} = 1 - (t_1 \cdot \delta / B).$

Then substitute $W/(1 - \delta)$ for t_1 to obtain

$$_WD_B = 1 - \{ W/(1 - \delta) \cdot \delta / B \}.$$

Next rearrange terms to obtain

$$_WD_B = 1 - \{ (W/B) \cdot \delta/(1-\delta) \}.$$

Then multiply W/B by 1 in the form of (1/T)/(1/T) and restate the result (W/T)/(B/T) as P/Q to obtain

$$_WD_B = 1 - P/Q \cdot \delta/(1-\delta) . \qquad [C.4]$$

This last expression is Equation 1 given in the body of the paper. It is a generic formula that permits calculation of $_WD_B$ based on knowledge of only two terms – Q and δ. One point to remember is that this formula applies only in the relatively simple case where preferences are homogeneous. When preferences are heterogeneous, a more complicated expression is needed to give the value of $_WD_B$.

Other Measures of Segregation

Computing formulas for other measures of residential segregation can also be given based on the simple residential distributions that result under the situations reviewed here (i.e., homogeneous white preferences). Here I briefly review formulations for the gini index (G), the index of isolation (I), and the correlation ratio (R). The expressions I develop below draw on the fact that the residential distribution for the city is determined by whites' preferences (δ) and the racial mix of the city (Q) as indicated by the segregation charts shown in Figure C.1. The bottom panel of the figure, which depicts a segregation chart for a partially integrated city, is of particular interest. This chart depicts the "minimum segregation distribution".

The residential distribution of groups by area is dictated by the geometry of the segregation chart according to the following expressions (all of which were introduced above)

$w_1 = W,$

$w_2 = 0.0,$

$b_1 = W/(1-\delta)$, and

$b_2 = B - b_1 .$

These expressions can be generalized further by setting W to P and B to Q in which case

$w_1 = P,$

$w_2 = 0.0,$

$b_1 = P/(1-\delta)$, and

$b_2 = Q - b_1 = Q - P/(1\text{-}\delta)$.

It should be obvious that, since the residential distributions for both groups are given by the parameters δ and Q, *all segregation measures can be expressed in terms of these parameters in some way*. The task at hand, then, is simply to identify useful formulations of these expressions. I now review formulations that I have discovered for several alternative measures.

The gini index is a popular measure of segregation. Like the index of dissimilarity (D) it measures evenness of distribution (Massey and Denton 1988) and can be interpreted in relation to the geometry of the Lorenz curve for black population concentration (Duncan and Duncan 1955). One useful computing formula for the gini index is given by

$$G = \sum [\, (b_{i+1} / B)(\sum w_i) / W) - (w_{i+1} / W)(\sum b_i / B)\,] . \qquad [C.5]$$

In the simple residential distributions considered here, ${}_W G_B$ can be expressed as

$${}_W G_B = (b_2 / B)(w_1 / W) - (w_2 / W)(b_1 / B) .$$

As the segregation chart in the bottom panel of Figure C.1 shows, all whites reside in Area 1 and no whites reside in Area 2. Consequently, $w_1 / W = 1$ and the term $(b_2 / B)(w_1 / W)$ is simply (b_2 / B). Similarly, $w_2 / W = 0$ and thus the term $(w_2 / W)(b_1 / B)$ goes to zero and the expression reduces to

$${}_W G_B = b_2 / B .$$

Since b_2 is given by $B - b_1$,

$${}_W G_B = (B\text{-}b_1) / B$$

which can be restated as

$${}_W G_B = B/B - b_1/B$$

$${}_W G_B = 1 - b_1/B. \qquad [C.6]$$

This expression for G is equivalent to Equation C.2. Which obviously means that G can be given as

$${}_W G_B = 1 - P/Q\cdot \delta / (1\text{-}\delta) . \qquad [C.7]$$

which is equivalent to Equation C.4.

In sum, in this special situation, the values of ${}_W D_B$ and ${}_W G_B$ are identical and can be obtained from the same computing formulas. This is not generally the case when preferences are heterogeneous. Thus, the computing formulas for ${}_W D_B$ and ${}_W G_B$ are equivalent *only* in the simple situation where only one group's preferences are considered and where that group's preferences are homogeneous.

The index of black isolation (I) is a popular measure that registers the extent to which blacks residential "exposure" is with other blacks rather than whites. It is a special case (i.e., ${}_B E_B$) of the general family of asymmetric "exposure" measures ($_XE_X$) introduced by Bell (1954). One useful computing formula for the isolation index is given by

$$I = \sum (b_i / B)(b_i / t_i) . \qquad [C.8]$$

In the simple two-group case, the black isolation index (I) is equal to one minus blacks' average exposure to whites as given by

$$_BE_W = \sum (b_i / B)(w_i / t_i) .$$

and thus

$$I = 1 - \sum (b_i / B)(w_i / t_i) . \qquad [C.9]$$

In the simple residential distributions considered here, the black isolation index (I) can be expressed as

$$I = 1 - (b_1 / B)(w_1 / t_1) - (b_2 / B)(w_2 / t_2) .$$

As noted above, $w_1 = W$ and $w_2 = 0$. So this can be restated as

$$I = 1 - (b_1 / B)\ (W / t_1) .$$

$$I = 1 - (W / B)\ (b_1 / t_1) .$$

As noted above, $b_1 = t_1 \cdot \delta$. So this can be restated as

$$I = 1 - (W / B)\ (t_1 \cdot \delta / t_1) .$$

$$I = 1 - \delta \cdot W / B .$$

Multiply W/B by 1 in the form of (1/T)/(1/T) and restate the result (W/T)/(B/T) as P/Q to obtain

$$I = 1 - \delta \cdot P / Q . \qquad [C.10]$$

The correlation ratio (R) is a popular measure first introduced by Bell (1954) as the "revised index of isolation." Duncan and Duncan (1955) termed it "eta squared". It is sometimes seen as a type of "exposure" measure (Massey and Denton 1988), but also is sometimes seen as a measure of uneven distribution (James and Taeuber 1985; Stearns and Logan 1986). James and Taeuber (1985) note that it has several desirable qualities, but does not meet their principle of "composition invariance" which stipulates that values of a measure should not change as the relative proportion in a group changes.[1] A useful computing formula for the correlation ratio is given by

$$R = (I - Q) / (1 - Q) . \qquad [C.11]$$

[1] In contrast, the index of dissimilarity (D) and the gini index (G) both satisfy this principle. Both are given by the geometry of the Lorenz curve – also know as the "segregation curve (Duncan and Duncan 1955) when used in this literature – which does not change when proportion black in the city varies.

Appendix Figure C.2

Summary of Expressions for Selected Minimum Segregation Measures

	Value when $\delta \geq Q$	Value when $\delta < Q$
Index of Dissimilarity (D)	0	$1 - P/Q \cdot \delta / (1-\delta)$
Gini Index (G)	0	$1 - P/Q \cdot \delta / (1-\delta)$
Exposure to Whites (${}_BE_W$)	P	$\delta \cdot P / Q$
Isolation Index (I or ${}_BE_B$)	Q	$1 - \delta \cdot P / Q$
Correlation Ratio (R)	0	$1 - \delta / Q$

Note: These expressions apply under the following conditions: the population consists of only two groups (whites and blacks); whites hold homogeneous preferences (δ) for maximum tolerance of residential exposure to blacks; and the population has been strategically distributed so as to minimize the level of segregation without violating whites' ethnic preferences.

This formula highlights the fact that R can be interpreted as the difference between the observed level of isolation (I) and its minimum possible value (Q) expressed as a proportion of the maximum possible difference (1 - Q).

Substituting Equation C.10 for I in this expression yields

$$R = (1 - \delta \cdot P / Q - Q) / (1 - Q) .$$

Substituting (1 – P) for the second occurrence of P and substituting P for (1 – Q) yields

$$R = (1 - \delta \cdot P / Q - [1 - P]) / P .$$

This expression can be restated in the following ways

$$R = (P - \delta \cdot P / Q) / P .$$

$$R = P(1 - \delta / Q) / P .$$

$$R = 1 - \delta / Q . \qquad [C.12]$$

Figure C.2 summarizes the expressions for minimum segregation measures presented in this appendix. In each case, the value of the measure is given based on knowledge of two parameters – δ and Q (recognizing that P is given by 1-Q). In each case the level of segregation is the minimum that can be achieved given based on strategic placement aimed at minimizing segregation without violating whites' ethnic preferences. In each case the minimum level of segregation is given as a nonlinear function of whites' tolerance of blacks (δ) and the racial mix in the community. Finally, it is important to stress that these expressions apply to a very specific situation, one in which: the population consists of only two groups (whites and blacks) and all whites hold an identical ethnic preference (δ).

Appendix D
Comparison of Segregation Charts and Segregation Curves Obtained Using Rules I and II for Computing Minimum Segregation Measures

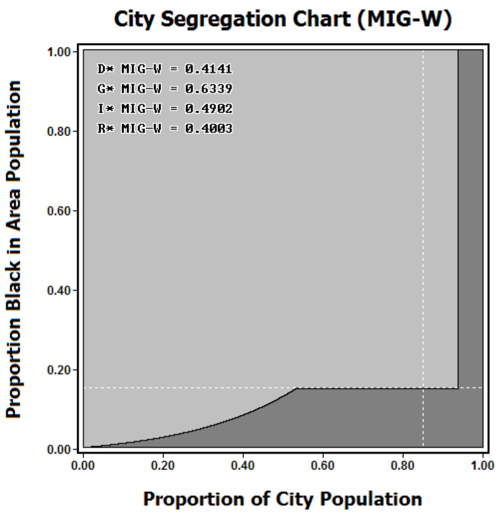
Rules I and II for computing minimum segregation measures yield identical results for D* but not for G*, I*, and R*. The basis for the difference can be illustrated by showing the segregation charts and segregation curves resulting from the application of these two computing rules. I apply the rules under the following conditions. I am assessing the implications of whites' preferences for minimum in-group contact for a city where the proportion black in the population (Q) is 0.15, and where the in-group preferences held by whites are heterogeneous and measured using "fine-grained" distinctions. The median in-group preference for whites is 90. Half of whites hold stronger in-group preferences and half hold weaker in-group preferences. The resulting distribution is unimodal, but strongly left-skewed with an interdecile range of approximately 55.

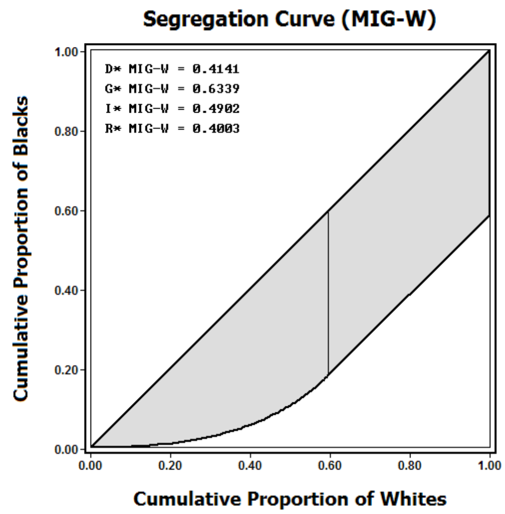
Figure D.1 shows the segregation charts that result when Rules I and II are applied to cities that are initially completely segregated. Rule I moves blacks into white neighborhoods whenever this is can be accomplished without violating whites' ethnic preferences *and* whenever the resulting moves will reduce the index of dissimilarity. Rule II builds on Rule I and goes further by implementing additional moves that are compatible with whites' ethnic preferences and will reduce blacks' residential isolation (i.e., increase blacks' residential contact with whites).

Figure D.1 also shows the segregation curves for the resulting residential distributions. This is the graphical tool for depicting segregation patterns was highlighted in Duncan and Duncan's (1955) authoritative review of methods of measuring residential segregation. It is obtained by ordering areas from low to high based on the proportion black in each area and then plotting the proportions of the white and black populations against each other as they are cumulated across neighborhoods. As is well known, the index of dissimilarity and the gini index are both given by the geometry of the curve. The index of dissimilarity is given by the maximum vertical distance between the diagonal line of "even distribution". The gini index is given by the ratio of the area between the diagonal and the curve to the total area under the diagonal.

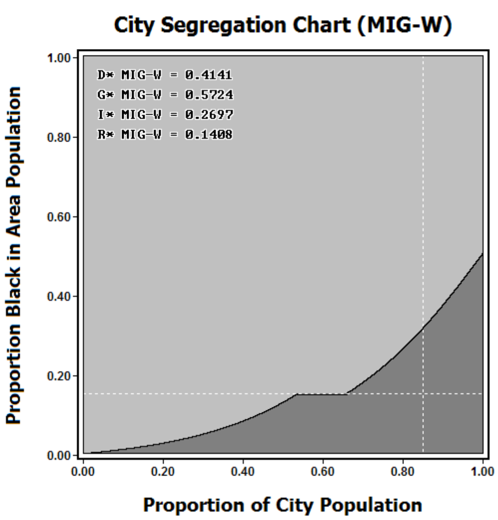
Appendix Figure E.1
Segregation Charts and Segregation Curves Obtained Using Rules I and II and Considering Heterogeneous Preferences for Minimum In-Group Contact for Whites Only (MIG-W)

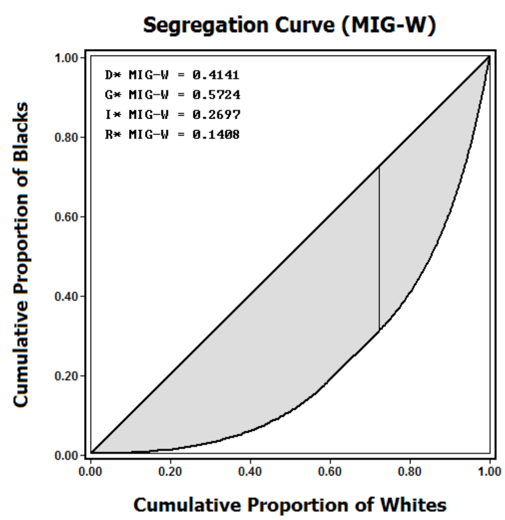
Using Rule I – Minimum D*, Minimum Movement





Using Rule II – Minimum D*, Minimum I*





Note: The in-group preference distribution for whites is left-skewed with a median of 90 and an interdecile range of 55. The proportion black (Q) for the city is 0.15.

Comparison of the segregation charts and segregation curves obtained using Rules I and II provide a clear illustration of the logical deficiency of the index of dissimilarity as a measure of segregation. The segregation curve resulting under Rule II depicts an obviously less segregated city. This is reflected in the segregation chart resulting under Rule II which depicts a city where black isolation in predominantly black areas is much lower than that resulting under Rule I.

The comparison confirms something that is well established in the methodological literature; namely, that the index of dissimilarity is a logically flawed measure of segregation (James and Taeuber 1985). The logical flaw that is clear here is that D is insensitive to how blacks are distributed among areas where the proportion black in the area exceeds the proportion black in the city (Q). Rule I places all such blacks in an all black area. Rule II places such blacks in areas with the lowest proportion black that can be achieved without violating preferences. The two rules thus highlight the degree to which black residential distributions can differ for cities with identical scores on D.

It is important to note that this alarming logical flaw in D is not usually of great practical import in empirical research. D and G are highly discrepant in this example. But in empirical studies they tend to be close correlates (Massey and Denton 1988).

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