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Towards an Enhanced Understanding of Ethnic Group Geographies Using Measures of Clustering and Unevenness

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Introduction

The ethnic geographies of Britain have been the subject of considerable academic interest over the last decade, accompanied by political and policy debate about the extent to which ethnic groups are 'pulling apart' or integrating (this is now well-documented in the academic literature: Finney and Simpson, 2009; Phillips, 2006; Robinson, 2005). Debates about the extent of segregation between ethnic groups, how it is best measured, and indeed if this matters (Peach, 2009; Simpson and Finney, 2009) have been subject to fresh attention following data releases from the 2011 Census in late 2012 and early 2013, the data having revealed a more ethnically diverse population than ever before. Yet there remain gaps in our knowledge as to the extent to which people from different ethnic groups live together or apart, and how this has changed in recent years. Through an approach to considering unevenness and clustering concurrently, this paper builds on the early insights into the extent of segregation, mixing and diversity drawing on 2011 Census data offered by Johnston *et al*. (2013, 2015), Harris (2014) and Catney (2015a, b, c), to explore change in residential segregation between the most populous ethnic groups of England and Wales in a period of increasing ethnic diversity and new immigration streams. This is the major empirical contribution of the paper, but it also relates to the paper's methodological offering – to enhance current understandings of the interrelations between two different forms of segregation. The analysis combines spatial with non-spatial information, looking both at the spread of ethnic groups across England and Wales and how similar the prevalence of an ethnic group is between neighbouring small areas (Census Output Areas).

The central hypothesis is that these two measures taken together provide a better understanding of ethnic group residential patterning than when analysed separately, giving a more detailed picture of neighbourhood segregation, and of the experiences of members of different ethnic groups (for example, if group members reside in few 'distinct' locales, or are geographically spread across the country). The paper does not seek to systematically explore multiple dimensions of segregation, but instead focuses on two dimensions that are important

for understanding the distribution of ethnic groups. Explored in unison and over time, these measures offer the potential to provide enhanced insight into the spatial trajectories of ethnic groups. The paper thus adds to the British debate, but also makes some contribution to the broader international literature on segregation and its measurement.

The spatial distributions of ethnic group populations

The 'index approach' to measuring segregation is well-established and forms the backbone of a decades-old empirical, methodological and theoretical literature (see Massey and Denton, 1988) The 'index wars' are now a well-rehearsed debate, concerned with the relative merits of the properties of each index, the insights they offer into ethnic group population distributions, and the potential of alternative approaches, including spatially-weighted measures and typologies of segregation, diversity and change (see Peach (2009) and the volume edited by Lloyd *et al.* (2014), for overviews). The aim of this paper is not to enter these debates directly, but to explore the opportunity for profiling the spatial patterning of ethnic groups and changes in this patterning over time, in order to understand better the dynamics of ethnic group segregation and change. This is achieved through an analysis of the smallest areas possible (Output Areas, described later), and which compares measures of two dimensions of segregation: (un)evenness and clustering captured, in turn, by the Index of Dissimilarity and the Moran's *I* spatial autocorrelation coefficient.

Internationally, the most frequently utilised measure of segregation in the literature is the Index of Dissimilarity (*D*), which measures how (un)evenly distributed a given ethnic group is with respect to the rest of the population, or compared to another ethnic group. It is therefore useful as a measure of the spread of an ethnic group. Described in detail in Duncan and Duncan (1955) and Massey and Denton (1988), the sum of the differences between the spread of group *x* (e.g., the Chinese ethnic group) and group *y* (e.g., the population other than Chinese) across all areas (here in the $i = 1,\ldots, N$ Output Areas in England and Wales) is computed by:

$$D = 0.5 \times \sum_{i=1}^{N} \left| \frac{x_i}{X} - \frac{y_i}{Y} \right| \tag{1}$$

X and Y are the total number of people in that group in the study area.

The Index of Dissimilarity, hereafter *D*, is easy to compute and conceptually intuitive. Having been multiplied by 0.5 to range from zero to one, a *D* value of zero indicates a completely even spread of the group's population relative to the other ethnic groups, and one indicates complete separation.

The Moran's I statistic (Cliff and Ord, 1973; Moran, 1950) with weights, w_{ij}, between locations i and j row-standardised (the weights for each location i sum to one) is computed with:

$$I = \frac{\sum_{i=1}^{N} \sum_{j=1}^{N} w_{ij}(z_i - \bar{z})(z_j - \bar{z})}{\sum_{i=1}^{n} (z_i - \bar{z})^2} \tag{2}$$

where the values z_i (here, percentages of an ethnic group ($x_i/t_i \times 100$, where t_i is the total number of people in area i) have the mean $\bar{z}$. Positive values of I indicate positive spatial autocorrelation (clustering), while negative values indicate negative spatial autocorrelation. Moran's I is an appropriate measure of clustering – it measures the covariance between a variable measured in zone i and in the neighbouring zones standardised by the variance (i.e., it is a correlation measure) and is here used to measure the tendency for neighbouring ethnic group percentages to be similar. Weights were based on queen contiguity (whereby all adjacent zones are treated as neighbours with equal weight).

Harris (2015) has argued that effective segregation measurement should combine the non-spatial Index of Dissimilarity in parallel with a spatial measure of segregation. In his study, spatial versions of D are computed in addition to standard D and these spatial measures are shown to capture clustering and inter-group exposure, with some caveats. Given the potentially complex interpretations of these indices (one of the spatial measures employed confounds clustering and centrality), his work is added to here by suggesting that it is conceptually and computationally simpler simply to use Moran's I.

While the Theil Information Theory Index (H) is an effective means of characterising the *diversity* of neighbourhoods (Reardon and Firebaugh, 2002), D and I have been selected as they allow for a straightforward comparison of two aspects of segregation for *each* group against *all* others. Evenness and clustering are favoured over alternative dimensions of segregation (see Massey and Denton, 1988) given their ability to offer, when explored in unison, insight into *overall* difference (evenness) and *neighbouring* difference (clustering), and thus capture a comprehensive segregation profile. This paper does not attempt to add to the statistically-based literature which has assessed the relative contributions of dimensions of segregation and ultimately (and insightfully) argued for their rationalisation from five (evenness, exposure, concentration, centralisation and clustering: Massey and Denton, 1988) to two 'superdimensions' (separation and location: Johnston *et al*., 2007; spatial exposure and spatial evenness: Reardon and O'Sullivan, 2004). Instead, the methodological development attempted in this paper is driven by its potential added value to empirical observations of ethnic group residential patterning and change over time. Given the differing histories and contemporary experiences of minority ethnic groups resident in England and Wales it would be reasonably expected that levels of ethnic group residential spread nationally and at the neighbourhood level will vary. By exploring these dimensions in unison we can improve our understanding of how ethnic geographies are evolving over time.

The combination of measures applied here is useful because the interpretation of one measure is dependent on the other and one measure alone provides only a partial picture of the distribution of an ethnic group. Figure 1 provides three synthetic scenarios to illustrate the value of measuring these two dimensions in combination. It is analogous to the checkerboard

diagram used to justify the spatial measurement of segregation (O'Sullivan and Wong, 2007), but here used for a different purpose. D and I were computed for each of the three scenarios, with: dark grey cells = 100 group x and 0 group y; light grey cells = 0 group x and 100 group y. For I these values are expressed as percentages of group x, whereas for D these are counts in each group. The values were then re-scaled so that dark grey cells = 75 group x and 25 group y and light grey cells = 25 group x and 75 group y. Figure 1 shows how D is equal for the same cell values, irrespective of spatial configuration. That is, D reflects the magnitude of differences between cells, regardless of 'neighbourhood' (cell) location. I is the same for the same neighbourhood configuration irrespective of different group sizes; this is because I is based on deviations from the mean rather than raw data values. Scenario a is an illustrative example of no clustering, yet the same unevenness levels as scenarios b and c. Differences in I values between grids a and b reflect differences in the spatial scale of clustering; this is largest for grid b (0.848; large scale clustering) and smaller for grid c (0.411; discrete, small scale clusters). Thus, I reflects the *magnitude* of differences between neighbouring cells. Taken together, D and I provide a composite measure of overall variation or spread (D) and the spatial configuration of values (I).

Figure 1 about here

To aid understanding of the possible scenarios which may lead to changes in evenness and clustering, Figure 1 additionally provides a brief description of examples of some of the potential processes which may give rise to increases or decreases in these two segregation dimensions (note that these are not exhaustive nor do all processes need to occur for these changes in segregation to be observed). These examples are related back to the experiences of change for each ethnic group in the analysis sections.

British ethnic residential segregation: a brief overview of what we know so far

A picture of ethnic demographic change and the geography of ethnic group distributions in the noughties has been provided by a number of Geographers and Demographers. Peach 1996(a) demonstrated how Britain was not home to US-style 'ghettos', supported by Simpson (2007), who showed that ghettos had not subsequently become a feature of the England and Wales landscape, in response to claims to the contrary (see Simpson's paper for a review of the key arguments at the time). Sabater (2010) revealed how declines in segregation between 1991 and 2001 varied according to life-course stage, but were consistent between ethnic groups of the same age cohort. Rees and Butt (2004) pointed to a growing trend towards deconcentration from urban centres by more affluent minority ethnic group populations, following common patterns of suburbanisation. This *process* of desegregation in Britain via minority ethnic group movement has received attention in studies of ethnic group-specific internal migration, such as by Stillwell and Phillips (2006), Simpson and Finney (2009), Catney and Simpson (2010), Stillwell (2010), and Gale (2013). Constraint in housing choice, discrimination and intolerance, and stubborn employment and educational inequalities have been cited as some of the drivers of persistent ethnic clustering in certain locales (Manley and van Ham, 2011; Phillips, 2006). However, work by Phillps *et al*. (2007) serves as a useful reminder that while housing aspirations towards suburban neighbourhoods may be common to all ethnic groups, preferences for residing in areas of higher co-ethnic concentration remain

for some. A strong sense of family values, religious practice, and low levels of alcohol consumption, are some of the positive associations with South Asian urban clusters, for example, rendering these 'enclaves' as attractive and dynamic, rather than threatening and divisive (Peach, 2009).

Data from the 2011 Census revealed how the ten-year period from 2001 was one of an ethnic diversification of the population of England and Wales; the population affiliating with a 'non-White' ethnic group had reached 14 per cent of the total, at nearly 8 million people — an increase of over five percentage points. Minority ethnic groups other than White British had grown to make up just under 20 per cent of the England and Wales population in 2011. The England and Wales population born outside the UK increased from nine to 13 per cent, of which around half arrived during that decade[1]. Drawing on 2011 Census data, a number of publications have shed light on the geography of contemporary changes in ethnic group residential dynamics. A policy briefing series hosted by the *Centre on Dynamics of Diversity* (CoDE)[2] included two articles which were the first analyses following Census data releases to deal directly with issues of change in segregation in England and Wales at a national (Simpson, 2012) and sub-national (Catney, 2013) level. The predominant messages of these briefings were of decreasing segregation for all ethnic groups between 1991 and 2011, and increased neighbourhood mixing for all minority groups in the last decade. An extended version of these findings can be found in Catney (2015b). Johnston *et al*. (2013) published an early piece which applied an area typology to evidence the increased sharing of residential spaces in England and Wales between 2001 and 2011. For the same time period, Catney (2015a) demonstrated decreased minority ethnic segregation in small areas and in urban locales across England and Wales. Harris (2013) shared two 'motion chart' graphics to represent changing segregation in English local authorities, and provided methodological and empirical insight through his analysis of spatial discontinuity (Harris, 2014), finding that differences in the ethnic compositions of neighbouring small areas had reduced. Johnston *et al*. (2015) looked in more detail at the changing ethnic composition of London, showing evidence of greater inter-ethnic mixing between 2001 and 2011 in previously predominantly White neighbourhoods. The capital was also the focus of work by Kaufmann (2014), who found evidence of White British exit from London, but questioned the role of racist sentiment ('White flight') in driving this migration. This theme was also visited by Catney (2015c), who analysed data for England and Wales from 1991 to 2011, and showed common loss in shares from London and metropolitan places for every ethnic group — White British and minority — and a growth and spreading out of ethnic diversity from traditionally diverse locales.

This paper builds on these contributions to consider in more detail the ways in which ethnic group populations are mixing, and to explore the potential methodological value of combining a well-used segregation index with a measure of spatial clustering. The next section of the paper briefly discusses ethnic group data available from the England and Wales Census, before the measures of evenness and clustering introduced earlier are reported, for

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[1] Author's own calculations on 2011 Census Tables QS203EW, QS801EW, KS201EW, 2001 Census Table UV008, and complete population estimates based on the 2001 Census (all Crown Copyright).
[2] Available at www.ethnicity.ac.uk

small areas, in 2001 and 2011. A discussion of typologies of change for all ethnic groups ensues.

Data and geographical zones

The Census provides full population estimates for England and Wales, at a fine spatial scale, and thus is an unrivalled data source for studies of segregation and diversity. Given that an additional two ethnic groups were introduced in 2011 (White Gypsy/Irish Traveller and Arab), there are no comparable figures for these groups for 2001. Some ethnic groups (Other Asian, Other Black, Other Mixed and Other) are considered to be incomparable between Census periods given changes in ethnic group affiliations over time (as demonstrated in the longitudinal analysis by Simpson *et al*., 2015) Hence, the values for these groups can be explored for each time point individually and compared between groups, but not between years.

The 2001 Census suffered from a degree of population undercount, disproportionately affecting some minority ethnic groups, men and those in urban areas (Sabater and Simpson 2009). These biases can result in unreliable comparisons of the population over time, and Sabater and Simpson (2009) have revised the 2001 Census outputs to produce estimates of the population which are deemed to be more accurate for studies concerned with ethnic group dynamics; these data are used here[3]. In 2011, ethnic group populations are regarded as well-estimated (Office for National Statistics, 2012a), and the ONS statistics are used here.

Computation of *D* and *I* for the lowest level geography possible (Output Areas, OAs) gives the most insightful picture of ethnic group (un)evenness and clustering. In 2011, England and Wales consisted of 181,408 OAs, with a mean population of roughly 300 people and 130 households. The number of OAs increased since 2001 when there were 175,434 (and hence the boundaries of some existing OAs also changed; note that the mean number of people remained approximately the same since OAs were constructed such that the total population and household numbers were above a set threshold and close to a target size). Between 2001 and 2011, 97.4 per cent of OAs remained unchanged, the rest being split into two or more OAs, merged with one or more OAs, or redesigned (Office for National Statistics, 2012b). These changes will make minimal difference to the overall picture of volume and direction of change in segregation presented in the paper.

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[3] The data are available to users in UK higher and further education institutions via the UK Data Service http://ukdataservice.ac.uk/ The 2001 population counts and thus segregation values reported here are slightly different than when computed using the standard estimates.

Ethnic group spread in 2001 and 2011

Figure 2 shows, respectively, *D* and *I* values in 2001 and 2011. These values are for each ethnic group compared to the remainder of the population, for OAs within England and Wales. A pseudo-significance level can be derived for Moran's *I* using a randomisation procedure; using this approach all reported *I* values have a pseudo-significance level of $p = 0.001$.

Figure 2 about here

Considering each time point in turn, ethnic group segregation in 2001 could be characterised by three dominant features: relatively high levels of unevenness and clustering for South Asian (Indian, Pakistani and Bangladeshi) and Black (African and Caribbean) groups; low unevenness and relatively high clustering for White groups, and low levels of both forms of segregation for Mixed groups. By 2011, these patterns had somewhat altered; the South Asian and Black groups saw a decline in unevenness and a small increase in clustering, with the exception of the Caribbean group. White groups continued to have low unevenness and high clustering. The new 2011 groups of Gypsy/Irish Traveller and Arab each formed a very small proportion of the England and Wales population. The former had very high unevenness and very low clustering, while the Arab group had moderate clustering and relatively high unevenness. Figure 2 is revisited in the next analysis section.

As an illustrative example to better explain the discussion of 'clustering' given in the introduction, Figure 3 is a map of the (a) White British and (b) Bangladeshi groups, as a percentage of the total population in 2011, for OAs in England and Wales (with London as an insert; note that because of the considerable differences in group size, the range of categories differs between maps). The White British group had in 2011 an unsurprising dominance in much of England and Wales, and was fairly evenly spread across all small areas. An exception was London, where by far the largest concentrations of groups other than White British could be found. The Bangladeshi group was much more spatially defined than the White British group, its largest populations being found in inner London. High Bangladeshi Muslim segregation in London in 2001, in particular in the borough of Tower Hamlets, was identified by Peach (2006). Johnston *et al.*'s (2015) study of London showed that by 2011 the proportion of those in the Bangladeshi group who lived in the highest concentrations of Bangladeshis had declined.

Figure 3 about here

Figure 3 is helpful in illustrating how while the White British and Bangladeshi groups have very different spatial characteristics, both groups have similar levels of 'clustering'. Most OAs in England and Wales in 2011 had relatively large proportions of the White British

group and thus *I* was large and *D* was small. While most OAs had small proportions of the Bangladeshi group, *I* was also large, because neighbouring areas were spatially similar (in that they few of the Bangladeshi group). However, while the OAs which had (relatively) large proportions of the Bangladeshi group tended to be in close proximity (and thus neighbouring areas are alike), these zones were small in number and so *D* is large. This provides a strong justification for the analysis of *D* and *I* in conjunction.

Change in segregation over the decade

Table 1 shows *change* in evenness and clustering between 2001 and 2011. For comparative purposes, in 2011 the new ethnic group White Gypsy/Irish Traveller is merged here with Other White and Arab is merged with Other; hence, the values being compared for these groups differ slightly from those presented in Figure 2. For context, Table 1 also provides the percentage of each ethnic group of the England and Wales total population, for 2001 and 2011.

Table 1 about here

All minority ethnic groups experienced a decrease in unevenness across OAs between 2001 and 2011. In other words, each minority group became more evenly geographically spread over the decade. The smallest decrease in unevenness was -0.02 (Other White), although for most groups this decrease was considerably greater; the mean change in unevenness for all groups was -0.067. On the other hand, clustering increased for all ethnic groups except White Irish and Caribbean, with both groups seeing a small decrease in *I* values. Recall that higher levels of clustering are indicative of neighbouring areas which are similar in terms of their proportion of that ethnic group. Thus, while the language of 'clusters' implies high segregation, this runs contrary to the interpretation of Moran's *I*. To add clarity to the discussion of the results, unevenness is referred to in terms of *spread*, and clustering in terms of *spatial similarity*.

Four dominant trends in segregation change can be identified from Figure 2 and Table 1; additionally, the four hypothetical examples provided in Table 1 (of which example iii is not observed in practice) are referred to, for ease of interpretation:

1. and 2. *Increased ethnic group spread across neighbourhoods and increased spatial similarity between neighbouring small areas.* This is signified by decreasing *D* values and increasing *I* values (scenario ii in Table 1), and can be observed for all ethnic groups except White Irish, Caribbean and White British. This pattern, whereby *localised* (measured by *I*) and *across* England and Wales (measured by *D*) differences were decreasing on average, can be approximately separated into two further categories of change: (1) large (>0.05) decreases of unevenness and large increases in spatial similarity (all four Mixed groups, Other Asian, Other, Chinese); (2) moderate but decreasing values over time of both

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unevenness and spatial dissimilarity (African, Indian, Other Black, Pakistani, Bangladeshi, Other White). Note, however, that the Other Black group experienced moderate decreases in unevenness but relatively large increases in spatial similarity, and the African group's decrease in unevenness was large, while change in clustering was negligible.

3. *Decreased unevenness across neighbourhoods and decreased spatial similarity between neighbouring areas* (decreasing *D* and *I* values; scenario iv in Table 1). This is observed for the White Irish and Caribbean ethnic groups.

4. *Increased unevenness and increased spatial similarity* (increasing *D* and *I* values; scenario i in Table 1); this pattern was experienced solely by the White British group, albeit with only very small changes in clustering and evenness (change of under 0.02).

Of the 'non-White' minority ethnic groups other than Mixed or Other Asian, the Chinese group consistently had the lowest levels of unevenness (Figure 2). The Mixed groups had low levels of segregation in 2001, with unevenness decreasing in the decade to follow. The Mixed White and Asian group saw the largest decline in unevenness in the period (-0.148). For Mixed and Chinese groups, this decline in unevenness was also accompanied by increased spatial similarity between neighbouring areas (trend 1). Each of the Mixed groups, in addition to Chinese, had low levels of clustering in 2001 and 2011. The low levels of clustering and unevenness observed indicate a residential spread across England and Wales, but not towards distinct geographical concentrations. Simpson and Finney (2009) used location quotients to determine that the Chinese and Mixed groups were the most evenly spread of minority ethnic groups in Britain in 2001. Specialised forms of employment which are not necessarily geographically-specific, such as the catering industry, might have favoured a more dispersed geography of settlement for the Chinese group throughout the 1960s and 1970s (Simpson and Finney, 2009). This may continue to influence residential patterns, along with Chinese student immigration to university residences[4]. The population in a Mixed or multiple ethnic group constituted over two per cent of the England and Wales population by 2011 (Table 1). The most significant contribution to the growth of the Mixed groups since 2001 was through the births of children in these groups (Simpson and Jivraj, 2015), mainly to parents with a different ethnic group to each other, suggestive of improved ethnic inter-relations and tolerance of mixed partnerships. Growth in the Mixed groups might be expected to be more common in neighbourhoods with lower levels of segregation; Feng *et al.*'s (2010) British-wide longitudinal study of 'out-partnering' showed how mixed ethnicity partnerships between a White and minority individual were more common in areas with lower concentrations of that minority group.

The Other ethnic groups experienced a similar pattern of segregation change to the Mixed and Chinese groups. These groups are presented for completeness but, as noted, these groups are not strictly comparable over time. The Other Black and Other Asian groups might be characterised as having moderate-high unevenness and clustering values at both time points. The heterogeneity of these groups makes it difficult to assess *why* these residential patterns may be observed. In addition to natural increase, immigration, and shifts between Census

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[4] Note that in Catney (2015b) Chinese segregation (measured solely through the Index of Dissimilarity) was shown to increase slightly over the same period when measured at the larger spatial scale of wards; this reflects the scale dependency of segregation analyses.

categories over time (Simpson *et al*., 2015), a diversification of immigration streams from new countries will also constitute part of the growth of Other groups.

Trend 2 is associated with relatively modest declines in segregation. As measured by ethnic group spread (*D*), segregation of the Other White group was amongst the lowest of all groups, and has decreased on this low base. Growth of the Other White group was considerable in the period, and an important source of this group's population increase was immigration from Poland and other EU Accession countries since 2004. The low levels of unevenness and spatial dissimilarity (high clustering; *I*) shown in Figure 2, despite the recent arrival of much of this group, are likely explained by their (mainly labour-driven) spatially dispersed settlement patterns (Robinson, 2010). The Indian group (the largest 'non-White' ethnic group; Table 1) had low and declining levels of segregation compared to other South Asian and Black groups; this group's relative socio-economic advantages, longer residence in Britain, and sizeable proportion of the population in older age groups (Simpson and Finney 2009; Simpson and Jivraj, 2015) will, for some, have led to dispersal from urban concentrations, associated with life-course migration along the urban-suburban-rural hierarchy. Residential segregation which is observable for this group will likely be associated with more recent arrivals; while much of the Indian group is long-settled or UK-born, immigration contributed to the growth of this group in the period (Simpson and Jivraj, 2015).

Simpson (2007: 412) showed that, in 2001, "the groups with the most recent history of immigration to England and Wales, the Pakistani, Bangladeshi and African populations, are most clustered". These patterns are again observable in 2011; Bangladeshi segregation remained the highest, however, as would be expected, a decade on each of these groups has experienced a decrease in segregation. Decreased *D* and increased *I* implies that small areas have, on average, become more similar to one another.

Of all groups other than the Mixed or Other groups, the African group experienced the largest decline in unevenness (-0.101). Some 990,000 individuals identified with the African ethnic group in 2011, this group having grown rapidly through immigration and births (Simpson and Jivraj, 2015). Segregation may have decreased for this group through dispersal from concentrations in, for example, London to other areas, and/or through new immigration streams to areas outside London. This fairly dramatic decrease in segregation for the African group is interesting when we consider what was observed for this group just one decade earlier: "the African population is of relatively recent residence in Britain, and unlike the Chinese population has concentrated in a few districts, mainly in London." (Simpson and Finney, 2009: 45). This group is highly heterogeneous, with origins in several countries, and within-group differences in demographic and cultural characteristics. For those born outside England and Wales, reasons for immigration will of course vary and thus be associated with distinct settlement patterns; labour migration is likely, at least initially, to be associated with particular urban centres, while asylum migration may be more dispersed, reflecting policy developments (Robinson, 2010).

The third identifiable pattern of change in segregation shows the White Irish and Caribbean groups to be less clustered and more evenly spread over time, although change was fairly modest as measured by either segregation dimension. This may be suggestive of a modest spreading out of these groups, but not into new 'discrete' neighbourhoods. The extent of clustering for the groups in 2001 and 2011 (Figure 2) was relatively high for both groups, while unevenness was moderate for the Caribbean group and very low for the White Irish group. Indeed, the White Irish group had the lowest levels of unevenness at both time points. This group's long-establishment in England and Wales and on average older age profile would be expected to equate to lower levels of segregation. The Caribbean ethnic group similarly is long-established in the UK, with the group's main period of immigration some 60 years ago; nearly 15 per cent of this group was aged 65 or older in 2011, and the minimal growth in the period is a result more of births than immigration (Simpson and Jivraj, 2015).

The fourth trend identified applied only to the White British population, by far the largest ethnic group in England and Wales, at over 48 million individuals in 2011. Increased unevenness and clustering was found for this group between 2001 and 2011. While this implies a story of increased polarisation of the White British population, the picture is more complex. Elsewhere, increased ethnic diversity in traditionally homogenous White British areas is demonstrated (Catney, 2015c; Johnston *et al*., 2015), as is the increased sharing of residential space between the White British group and minority ethnic groups (in relation to unevenness across OAs within the 348 districts of England and Wales) (Catney, 2015a). In essence, there has been a decline in the considerable proportion of neighbourhoods which were entirely or predominantly White British in 2001. The increase in Moran's *I* demonstrates how neighbouring small areas have become less different over time, again a result of a 'bridging' between almost exclusively White British areas and those with a larger share of minority ethnic populations. Increased *I* and increased *D* indicates that not only have predominantly White British neighbourhoods become less dominated by that group between 2001 and 2011, but that the difference between exclusively (or nearly exclusively) White British small areas and their neighbouring zones has decreased. If minority ethnic groups are changing in broadly similar ways (for example, moving out of inner city concentrations, as discussed earlier and evidenced by Finney and Simpson (2009), amongst others), then *D* for the White British group relative to the rest of the population can increase, while *D* for any minority ethnic group relative to the rest (including the White British) can decrease. This reflects the greater geographical similarity between minority ethnic groups than between the White British and each minority ethnic group at each time point, and their common patterns of change.

Summary and conclusions

The first decade of the 2000s was one of significant change in ethnic group population dynamics in England and Wales. All ethnic groups grew numerically, some considerably, and the minority ethnic population in England and Wales reached the one fifth mark. This was also a period of increased diversity in new places (Catney, 2015c). This paper had two aims; to understand better changes to ethnic residential segregation in England and Wales via an approach to considering unevenness and clustering concurrently, and thus, secondly, to add to

current empirical and methodological understandings of the geographies of ethnicity and their evolution over time.

This paper used 2011 Census data to consider if the growth of ethnic diversity which had taken place in the decade previous had gone hand-in-hand with growth in ethnic clusters or decreasing segregation, the latter being the dominant pattern ten years before (Finney and Simpson, 2009). To gain better insight into ethnic geographies at one point in time and their change over time, a 'joined up' approach to measuring segregation is adopted. By analysing evenness and clustering in unison, new characteristics of the ethnic geographies of England and Wales are revealed, providing a firmer methodological base for more nuanced understandings of the processes behind these changes. The results demonstrate how the spreading out of ethnic diversity shown in Catney (2015c) has been matched by increased residential mixing. Decreased segregation has been dramatic for some ethnic groups, while more modest for others. To summarise, change in ethnic group segregation between 2001 and 2011 has been characterised by three major trends: increased ethnic group spread across neighbourhoods and increased spatial similarity between neighbouring small areas (all minority ethnic groups except White Irish and Caribbean); decreased unevenness across neighbourhoods and decreased spatial similarity between neighbouring areas (White Irish and Caribbean); and increased unevenness and increased spatial similarity (White British).

Groups with older age profiles and little growth through immigration (for example, White Irish and Caribbean) will have different residential patterns from those ethnic groups for whom immigration still plays a role in their growth. While the balance of births over mortality was the largest contributor to the increase in Pakistani and Bangladeshi populations in the period (Simpson and Jivraj, 2015), national origins with high levels of 'family-route' migration and associated granted settlements include Pakistan and Bangladesh (Achato et al., 2011). For these groups, segregation decreased but remained relatively high; the influence of chain immigration in historically significant settlement areas and the attractiveness of these diverse areas for housing and labour opportunities and communal support (Peach, 1996b) might be expected to retain these residential patterns. Likewise, the relatively high (but decreasing) levels of segregation for the South Asian and African groups may be influenced by unequal opportunities for socio-spatial mobility, as a result of structural socio-economic inequalities (see the volume edited by Jivraj and Simpson, 2015), or racism and neighbourhood stereotyping which renders some areas 'out of bounds' (Phillips et al., 2007). The Mixed groups are composed mainly of young UK-born individuals; these groups' residences are dispersed and becoming more so, likely given the dynamics of ethnic group mixing and inter-group relations which are largely responsible for their growth (Simpson and Jivraj, 2015). In contrast to these experiences, the immigration streams of much of the most recently arrived Other White group (dominated by those with Eastern European origins) is associated with non-traditional geographies of settlement, following labour market opportunities (Robinson, 2010). The reasons for immigration will of course also impact upon settlement patterns; for example, student immigration will have a different spatial bias to family reasons for migration, both forms potentially resulting in concentrations of existing members of that group. The Chinese and Indian groups, for example, each have a well-established history in England and Wales, yet are also comprised of high proportions of (for the most part temporary) student immigrants. Given the importance of generation and the

timing of immigration in explaining residential patterns, the introduction of a question on period of arrival in the 2011 Census could prove a fruitful resource for future research.

This paper sought to explore the potential benefit of measuring information on the overall spread of each group nationally (evenness; measured using the Index of Dissimilarity) *and* the similarity of the ethnic group composition of neighbouring areas (clustering; measured using Moran's *I*). The added value of the approach explored here is that it offers a lens into the evolution of ethnic group residential geographies over time. By combining spatial and aspatial information, this approach provides a profile of segregation and change over time, which takes account of two significant ways in which ethnic groups could be similarly or distinctly distributed across residential space, and the nature of ethnic groups' spatial trajectories. When considered in conjunction with migration histories and socio-economic and demographic experiences, this more detailed profile of segregation offers the potential to consider important policy-relevant indicators such as the persistence of spatial inequalities.

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Ethnic group	2001 Population size (% of total pop. 52,359,978)	2011 Population size (% of total pop. 56,075,912)	Change in D, 2001-2011	Change in I, 2001-2011
White British	87.3	80.5	0.012	0.018
White Irish	1.2	0.9	-0.032	-0.016
Other White	2.6	4.5	-0.020	0.017
Indian	2.0	2.5	-0.050	0.022
Pakistani	1.4	2.0	-0.026	0.042
Bangladeshi	0.5	0.8	-0.022	0.024
Chinese	0.4	0.7	-0.059	0.191
Other Asian	0.5	1.5	-0.141	0.125
Black African	0.9	1.8	-0.101	0.001
Black Caribbean	1.1	1.1	-0.045	-0.018
Other Black	0.2	0.5	-0.048	0.185
Mixed White-Caribbean	0.5	0.8	-0.134	0.136
Mixed White-African	0.2	0.3	-0.054	0.13
Mixed White-Asian	0.4	0.6	-0.148	0.147
Other Mixed	0.3	0.5	-0.130	0.209
Other	0.4	1.0	-0.070	0.217

Table 1. Ethnic group percentages and changes in unevenness (Index of Dissimilarity (D)) and clustering (Moran's I (I)), 2001-2011, Output Areas in England and Wales.

Notes: For comparability over time, in 2011 White Gypsy/Irish Traveller is merged with Other White and Arab is merged with Other.

Sources: 2011 Census, Table KS201EW (Crown Copyright), and complete population estimates based on the 2001 Census (Crown Copyright). Author's own calculations.

a
Checkerboard pattern

b
Clustering (but not discrete clusters)

c
Discrete clusters
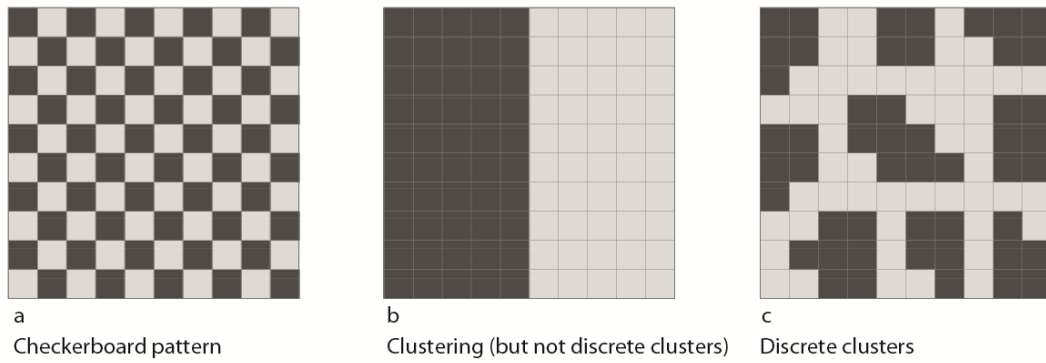
Grid	Group size	D	I
a	0/100	1.000	0.848
b	0/100	1.000	0.411
c	0/100	1.000	-0.077

Grid	Group size	D	I
a	25/75	0.500	0.848
b	25/75	0.500	0.411
c	25/75	0.500	-0.077

	Increase in D	Decrease in D
Increase in I	**(i) Increased unevenness and increased spatial similarity** Group migration into, or *in situ* growth in, own-group concentrations, and other group growth in all/most locales	**(ii) Increased ethnic group spread across neighbourhoods and increased spatial similarity between neighbouring small areas** Within-country migration out of existing clusters; direct immigration to new areas
Decrease in I	**(iii) Existing concentrations increasing their co-ethnic share** *In situ* growth; sustained chain immigration flows	**(iv) Decreased unevenness across neighbourhoods and decreased spatial similarity between neighbouring areas** Spreading out from co-ethnic clusters; decrease in existing concentrations through natural change (mortality of older groups)

Figure 1. Synthetic scenarios to illustrate the measurement of unevenness and clustering in combination, and the possible processes which lead to their change over time.

Notes: Unevenness is referred to in terms of spread, and clustering in terms of spatial similarity (for further clarity see the discussion in the analysis section 'Change in segregation over the decade').
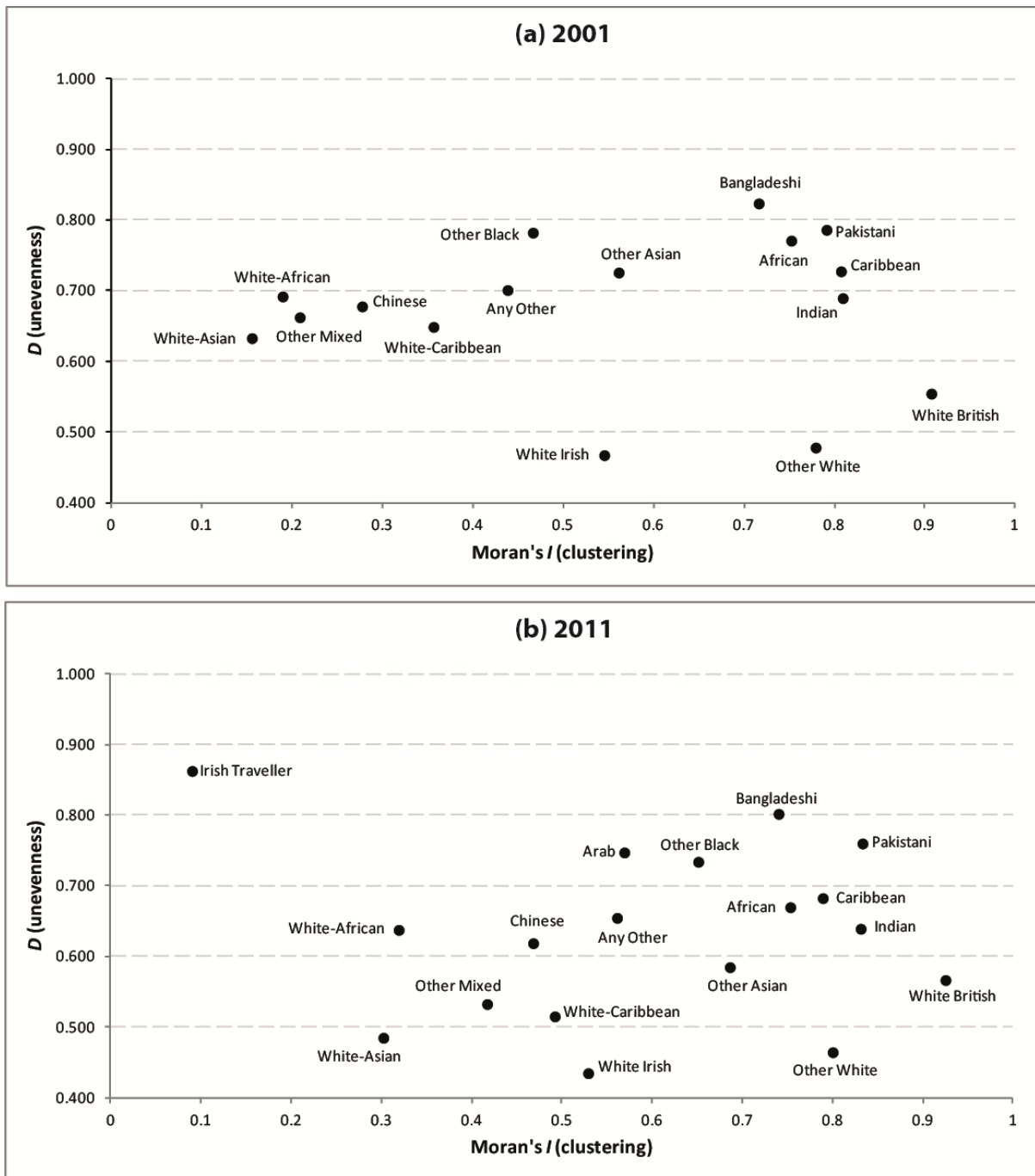
Figure 2. Evenness (Index of Dissimilarity; *D*) and clustering (Moran's *I*) in Output Areas in England and Wales, for each ethnic group in (a) 2001 and (b) 2011

Notes: Mixed groups are White-Caribbean, White-African, White-Asian and Other Mixed.

Sources: 2011 Census, Table KS201EW (Crown Copyright), and complete population estimates based on the 2001 Census (Crown Copyright). Author's own calculations.
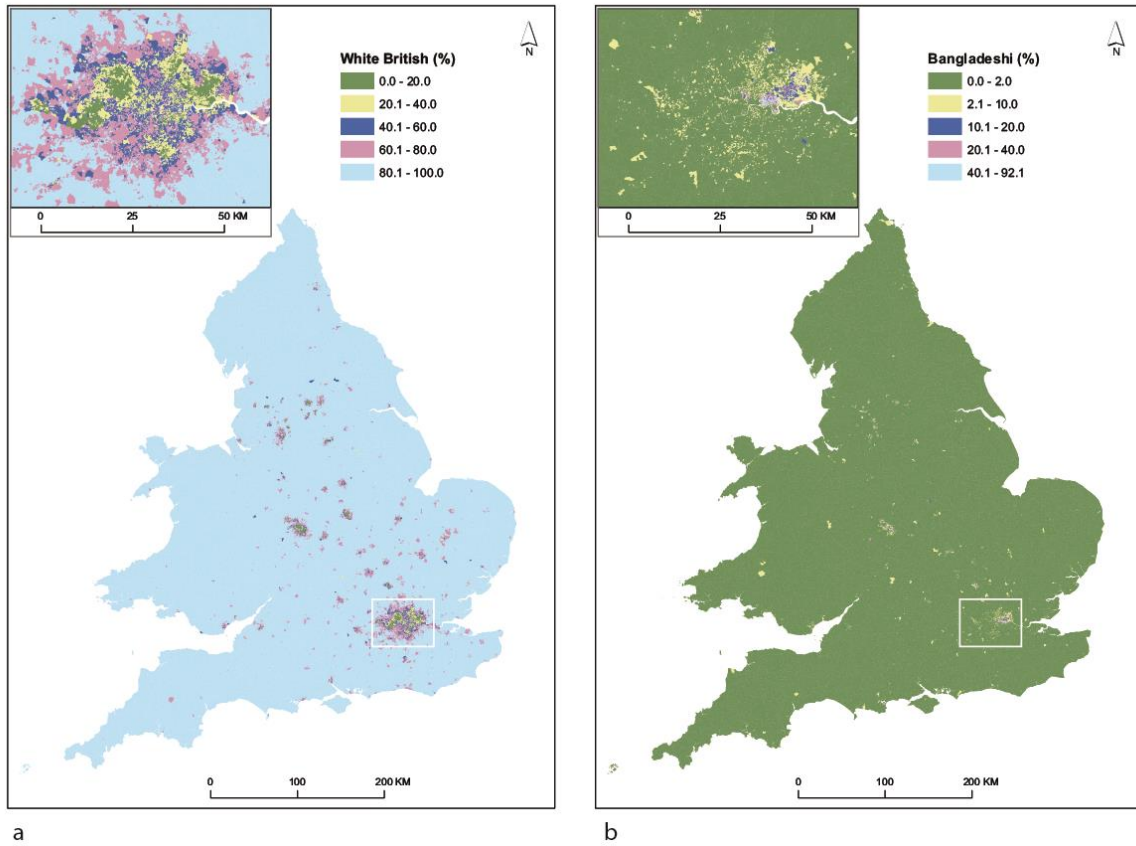
Figure 3. The 2011 spatial distributions of the ethnic groups (a) White British and (b) Bangladeshi (% of total population), Output Areas in England and Wales (with a London insert)

Source: 2011 Census, Table KS201EW (Crown Copyright). Author's own calculations.