Dynamics of social and spatial segregation using mobile phone data

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In this paper we study segregation between several ethnic groups in a European city using anonymized mobile phone metadata collected from the major mobile phone operator. In particular we look at social segregation (patterns of communication), spatial segregation (patterns of movement) and how these relate to each other.
Over the last decades there has been an increased focus on the lack of social integration of immigrants in western societies. A policy tool often considered to mitigate this problem is resettlement programs enforcing spatial integration. This policy relies on implicit assumptions regarding the relationship and causality between social and spatial segregation. Even though this paper is not able to answer questions about the causal links between social and spatial segregation, we present evidence on the empirical relationship between these variables for different ethnic groups. We believe that a better understanding of the relationship between these variables, and the mechanisms involved, is crucial to developing more effective integration policies.

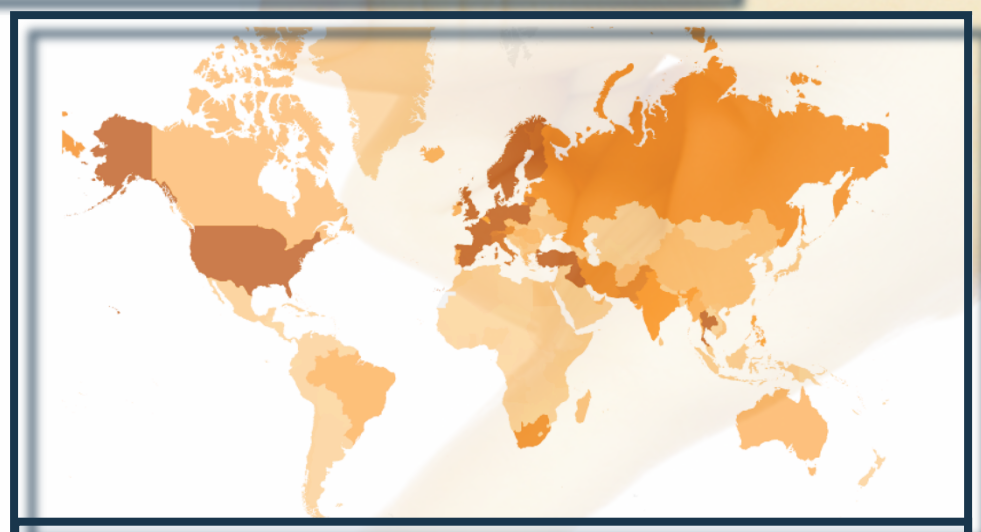

Figure 1 Defining a proxy for ethnicity We estimate a proxy for individual ethnicity by observing which countries people call the most on a regular basis.

When studying the relationship between spatial and social integration we make use of a "benchmark integration level" inspired by Blumenstock and Fratamico (2013). The benchmark is defined by what the structure of the social network would be assuming random pairing of nodes within a geographical area. We then compare this benchmark with the structure of the actual social networks. Based on this analysis we develop the "spatial-social-integration-matrix" which provides an overall picture of the extent to which the different groups are more/less integrated than what random pairing suggests.

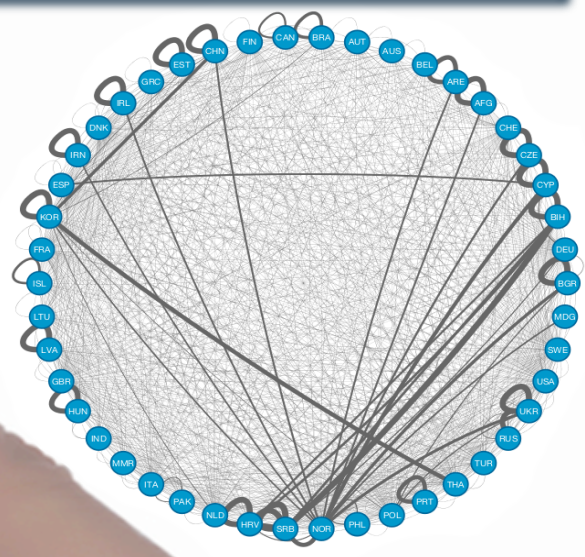

Figure 2 The social Matrix of Ethnicities The thickness of the links represent the fraction of actual contacts compared to a random-pairing model. Only the most overrepresented ethnicities are shown.

Increasing the social integration between ethnic groups is often an important objective for policy makers. From the call data we obtain a proxy for ethnicity. This allows us to shed new light on social integration by providing an in-depth analysis of the communication patterns of different ethnic groups in the city. In particular we derive the extent of across-group and within-group communication for the different ethnic groups in the city. Using Hofstede's cultural dimension theory we derive a measure of cultural distance between the different ethnicities in the sample and find how much of the social integrations and across-group communication can be explained by this measure.

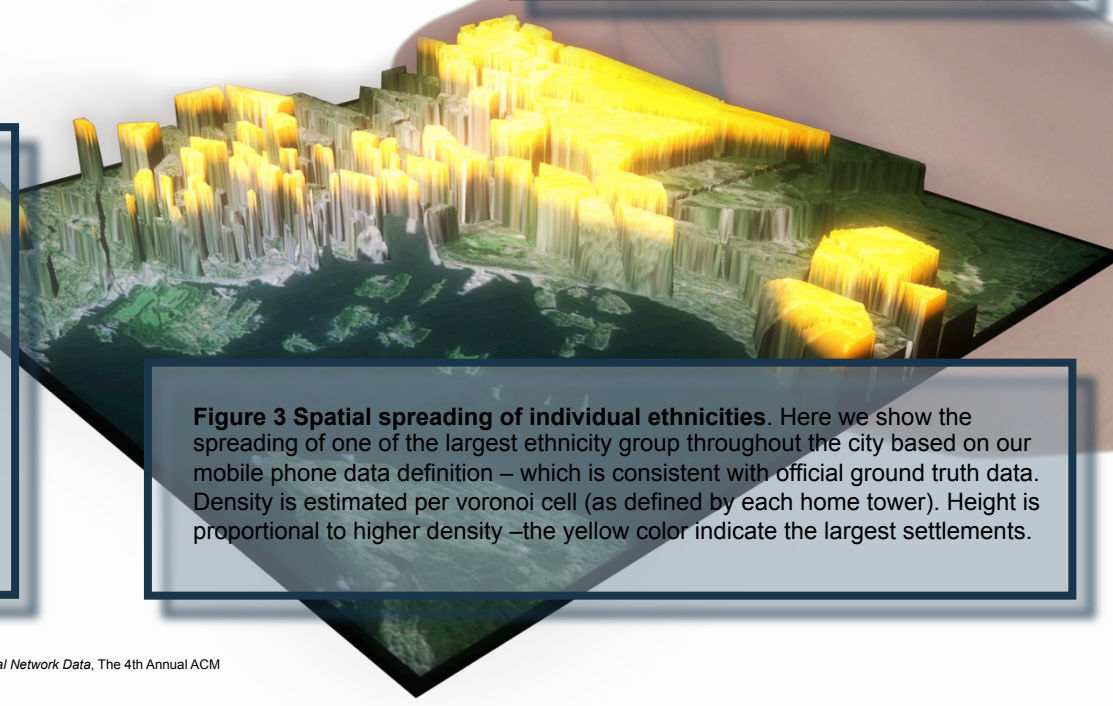

Figure 3 Spatial spreading of individual ethnicities. Here we show the spreading of one of the largest ethnicity group throughout the city based on our mobile phone data definition – which is consistent with official ground truth data. Density is estimated per voronoi cell (as defined by each home tower). Height is proportional to higher density –the yellow color indicate the largest settlements.

References
Blumenstock, JE and Fratamico L (2013). *Social and Spatial Ethnic Segregation: A Framework for Analyzing Segregation With Large-Scale Spatial Network Data*, The 4th Annual ACM Symposium on Computing for Development (DEV '13).