An Agent-Based model of interaction between immigrants and a host population: self-organized and regulated adaptation

Carlos M. Lemos[1], Ross J. Gore[2], Laurence Lessard-Phillips[3], F. LeRon Shults[1]

1 - Department of Religion, Philosophy and History, Faculty of Humanities and Education, University of Agder, Kristiansand, Norway
2 - Virginia Modeling, Analysis and Simulation Center, Old Dominion University, Norfolk, VA, United States of America
3 - Institute for Research into Superdiversity (IRiS), School of Social Policy, University of Birmingham, Birmingham, United Kingdom

Immigration has both short- and long-term impacts on individuals, groups, and societies. The cultural interaction between immigrant minorities and a majority host population can lead to significant economic, social, and political changes – both positive and negative. The mechanisms involved in these changes, and the conditions under which they emerge, are currently widely debated in academic and policy circles. Intercultural contact creates a complex system across multiple domains (socio-political, socio-economic, cultural and spatial) with different structural factors (e.g. political and economic conditions of the host country), group perspectives (the host society and the immigrants) and individual traits (ethnic, cultural and psychological) all playing a role. This issue has been examined in the social science literature (see, e.g. Gordon [1]; Alba and Nee [2]; Berry [3]; Portes and Rumbaut [4]; Spencer and Charsley [5]), but rarely in a manner that encompasses all actors involved.

According to Berry [3], who generated a theoretical framework to understand the impact of intercultural contact on acculturation strategies on individuals, groups, and societies alike, this type of all-encompassing approach is an important requirement for understanding the societal impact of immigration and settlement patterns. This can be studied, to a certain extent, using traditional methods in social sciences (e.g. qualitative interviews or statistical analyses of surveys or indicators) and centered on the micro (individual) or macro (large-scale pattern) levels. More recently, simulation using agent-based models (ABM) has provided a path to understanding the emergence of large-scale social patterns in terms of the mechanisms of micro-interactions (e.g. Railsback and Grimm [6], Wilensky and Rand [7], Gilbert and Troitzsch [8], and Epstein [9]).

Several ABMs exist for describing the mechanisms and outcomes of the interaction between populations of individuals with different characteristics. Schelling's model successfully describes spatial segregation by means of a single threshold rule [10], [11]. However, cultural change involves dimensions other than spatial. Axelrod proposed a model of culture dissemination for explaining local homogeneity and global polarization of cultures in a spatial domain [12]. Axelrod assumes that the probability of interaction depends on "cultural distance", and the latter decreases after interactions. This model has the drawback of reducing the interactions to a spatial domain, and fails to explain persistent diversities within cultures [13]. Hammond and Axelrod proposed an ABM for explaining the evolutionary prevalence of ethnocentrism, in which agents play two-dimensional spatial prisoner's dilemma games and decide to

cooperate or defect based on only one attribute (e.g. "color") [14], and agents with a successful strategy are able to reproduce. One drawback of this model is that the spatial rule of reproduction leads to kinship selection instead of ethnocentrism [15]. The three classical models mentioned above (Schelling, Axelrod and Hammond/Axelrod) are based on spatial interactions in a lattice grid, which restricts the type of emergent patterns and does not reflect the network-based and multi-dimensional character of the interactions. Recently, Schelling's model was generalized to the emergence of segregation in social networks (e.g. [16], [17]).

In the proposed model, we present an ABM of an 'abstract' type [18] for describing the interactions between a host population and a minority of immigrants, which is inspired by the ABM models above, as well as the framework elaborated by Berry [3], which emphasizes the role played by culture, contact, and participation on processes of acculturation. The model entities are agents of a single type, a network between agents, and a "government" modeled as a "proto-agent". Agents´ attributes are the "generation" and a vector of features, which includes components, related to "welfare" (job status and education level), "culture", "identity" and "openness-closeness" to cooperation with other agents with the same or different identity. They also have variables related to "security" and "communality" needs. The network is undirected, and links have weights that depend on the number and type of past interactions between the end nodes. The "government" is a procedure or method, included in the model´s cycle, in which the user can implement "policies" that affect agents. The model does not require a spatial domain, but spatial interactions can be modelled using a lattice network.

In the model, agents interact with their network neighbors with a probability that depends on their education, cultural and identity "distance," as in Axelrod´s model of culture dissemination. If they have insufficient "communality" they try to interact with agents that are not in their ego network. The interactions are single iteration prisoner's dilemma games that depend on the strategies of the two players, as in the Hammond/Axelrod model [14]. After interaction, the intervening agents gain or lose "security" and the link between them will strengthen or weaken, leading to increased or increased communality. Agents with their "security" and "communality" needs above a given threshold will be able to reproduce. The agents also die, to keep the population(s) stable. The "government" can act in several ways, such as selectively increase the probability of immigrants to acquire "security" (e.g. jobs) or lower certain traits of the cultural barrier (e.g. language courses).

The host and immigrant population is initialized by generating the agents and setting their attributes according to user-specified distributions. The initial network is created using one of three network models: lattice (spatial), random Euclidean based on "cultural" instead of spatial distance, or via an algorithm for generating ego networks (e.g. [19]). During the simulation the model produces a dynamic network of links between the agents. The evolving network is analyzed using network segregation indices (e.g. Freeman [20] and spectral [21]), as well as algorithms for detection of social circles in ego networks [22], for each "identity" (host or immigrant), "closeness-openness" strategy, or cultural traits. These network patterns can be discussed in light of sociological theories [3], for different parameterizations and for both "self-organized" and "regulated" interactions. The model can be extended to include age and gender in both traits and reproduction, and different types of interactions (family, friends, and workmates) modeled via layered networks [23].

References

[1] M. M. Gordon, Assimilation in American Life: The Role of Race, Religion and National Origins, New York: Oxford University Press, 1964.

[2] R. Alba and V. Nee, "Rethinking assimilation theory for a new era of immigration," *International Migration Review,* vol. 31, no. 4, pp. 826-874, 1997.

[3] J. W. Berry, "Immigration, Acculturaltion, and Adaptation," *Applied Psychology: An International Review,* vol. 46, no. 1, pp. 5-68, 1997.

[4] A. Portes and R. G. Rumbaut, Legacies: The Story of the Immigrant Second Generation, University of California Press, 2001.

[5] S. Spencer and K. Charsley, "Conceptualising Integration: a Framework for Empirical Research, taking Marriage Migration as a Case Study," *Comparative Migration Studies,* pp. 4-18, 2016.

[6] S. F. Railsback and V. Grimm, Agent-Based and Individual-Based ModModel. A Practical Introduction, Princeton University Press, 2012.

[7] U. Wilensky and W. Rand, An Introduction to Agent-Based Modeling: Modeling Natural, Social, and Engineered Complex Systems with NetLogo, The MIT Press, 2015.

[8] N. Gilbert and K. G.Troitzsch, Simulation for the Social Scientist, Second ed., Open University Press, 2005.

[9] J. M. Epstein, Generative Social Science: Studies in Agent-Based Computational Modeling, Princeton University Press, 2007.

[10] T. C. Schelling, "Dynamic Models of Segregation," *Journal of Mathematical Sociology,* vol. 1, pp. 143-186, 1971.

[11] T. C. Schelling, Micromotives and Macrobehavior, Revised ed., W. W. Norton & Company, 2006.

[12] R. Axelrod, "The Dissemination of Culture: A Model with Local Convergence abnd Global Polarization," *Journal of Conflict Resolution,* vol. 41, pp. 203-226, #apr# 1997.

[13] J. Bednar, A. Bramson, A. Jones-Rooy and S. Page, "Emergent cultural signatures and persistent diversity: A model of conformity and consistency," *Rationality and Society,* vol. 22, no. 4, pp. 407-444, 2010.

[14] R. A. Hammond and R. Axelrod, "The Evolution of Ethnocentrism," *Journal of Conflict Resolution,* vol. 50, no. 6, pp. 926-936, #dec# 2006.

[15] F. Jansson, "Pitfalls in Spatial Modelling of Ethnocentrism: A Simulation Analysis of the Model of Hammond and Axelrod," *Journal of Artificial Societies and Social Simulation,* vol. 16, no. 3, p. 2, 2013.

[16] A. D. Henry, P. Prałatb and C.-Q. Zhangb, "Emergence of segregation in evolving social networks," *Proceedings of the National Academy of Sciences of the United States of America,* vol. 108, no. 21, pp. 8605-8610, 2011.

[17] F. Aguiar and A. Parravano, "Tolerating the Intolerant: Homophily, Intolerance, and Segregation in Social Balanced Networks," *Journal of Conflict Resolution,* vol. 59, no. 1, pp. 29-50, 2015.

[18] N. Gilbert, Agent-Based Models, SAGE Publications, Inc., 2007.

[19] X. Fang and J. Zhan, "Task-Oriented Social Ego Network Generation via Dynamic Collaborator Selection," in *2012 ASE/IEEE International Conference on Social Computing and 2012 ASE/IEEE International Conference on Privacy, Security, Risk and Trust*, 2012.

[20] L. C. Freeman, "Segregation in Social Networks," *Sociological Methods & Research,* vol. 6, no. 4, pp. 411-429, 1978.

[21] F. Echenique and J. Roland G. Fryer, *On the Measurement of Segregation,* 2005.

[22] Y. Wang and L. Gao, "An Edge-based Clustering Algorithm to Detect Social Circles in Ego Networks," *Journal of Computers,* vol. 8, no. 10, pp. 2575-2582, October 2013.

[23] J. T. Hamill, Analysis of Layered Social Networks, BiblioScholar, 2012.