When Schelling met Michael Jackson

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Workshop on Networks 2013

Segregation Models: Schelling

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1971, Vol. 1, pp 143–186

DYNAMIC MODELS OF SEGREGATION†

THOMAS C. SCHELLING
Harvard University

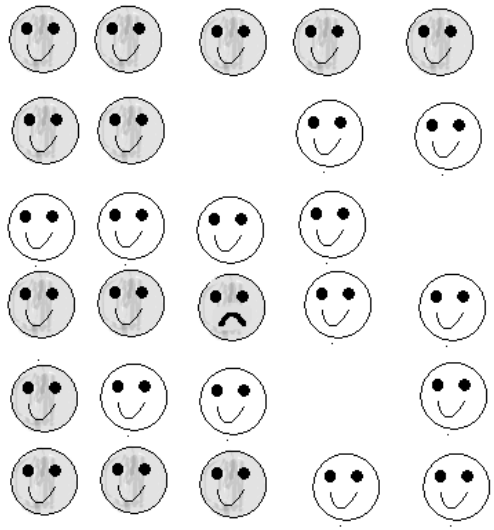
If blacks exclude whites from their church, or whites exclude blacks, the segregation is organized, and it may be reciprocal or one-sided. If blacks just happen to be Baptists and whites Methodists, the two colors will be segregated Sunday morning whether they intend to be or not. If blacks join a black church because they are more comfortable among their own color, and whites a white church for the same reason, undirected individual choice can lead to segregation. And if the church bulletin board is where people advertise rooms for rent, blacks will rent rooms from blacks and whites from whites because of a communication system that is correlated with churches that are correlated with color.

discriminatory behavior → awareness, conscious or unconscious, of sex or age or color that influences decisions: • where to live; • whom to sit by; • what occupation to join or to avoid; • whom to play with; • whom to talk to.
individual residential preferences → segregated neighborhood patterns.
modest levels of racial preferences → high levels of global segregation.

Segregation Models: Schelling

original model

- Agents are black or white, and they are located in a square lattice with a proportion of empty sites.
- An agent is *unhappy* when the proportion of agents of the other color among its neighbors is greater than his tolerance (T).
- Unhappy agents will move to an acceptable empty place if they can find one.



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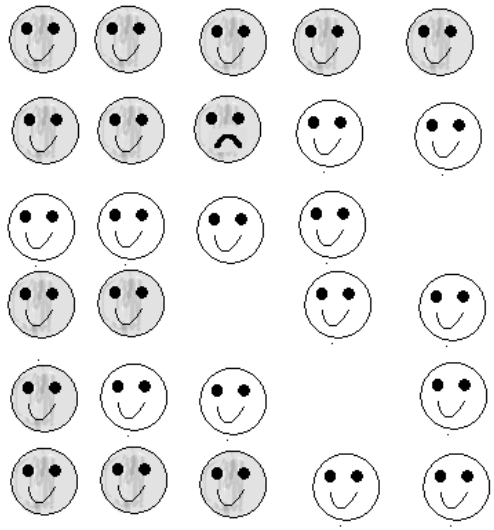

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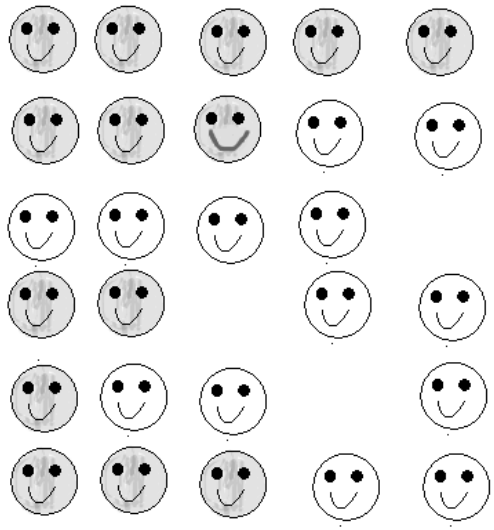

Opinion and Language Dynamics Models

Voter model

- Holley et al. (1975): two neighboring agents are selected at random, and one of them changes its opinion as a result of the interaction.
- interaction: agent follows the opinion of the majority.
- For regular lattices it is well known that one of the opinions prevails and the other disappears.
- extensively studied by researchers from complex systems and statistical mechanics.

Language model

- Nettle (Lingua, 1999) considered several agents interacting in a network, and changing their languages according to certain rules.
- Abrams and Strogatz (Nature, 2003): approach based on ordinary or partial differential equations.
- Pinasco and Romanelli (Phy.A 2006): possibility of coexistence of two languages by including resources for each population as in Lotka-Volterra models.

Mixing both models ... Schelling met Michael Jackson

Schelling-Voter model:

- An agent is *unhappy* when the ratio between the number of agents of the opposite language and the number of agents in his neighborhood is greater than T. An unhappy agent can play one of two different games:
- (Schelling) The agent tries to change his location (with probability p).
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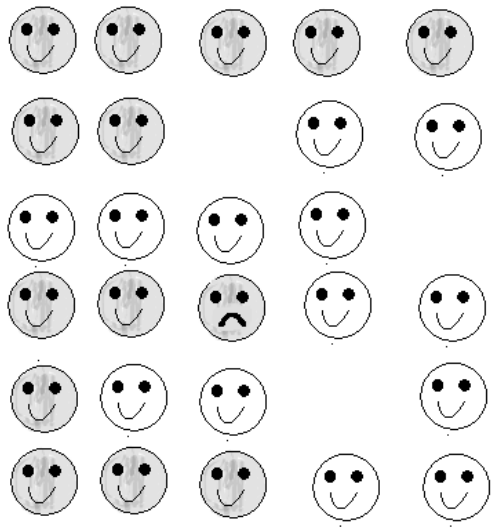

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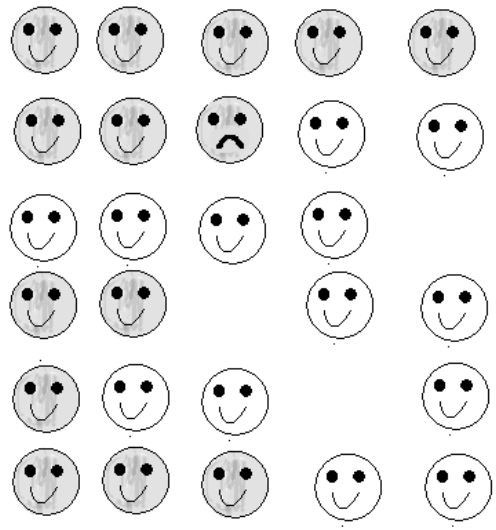

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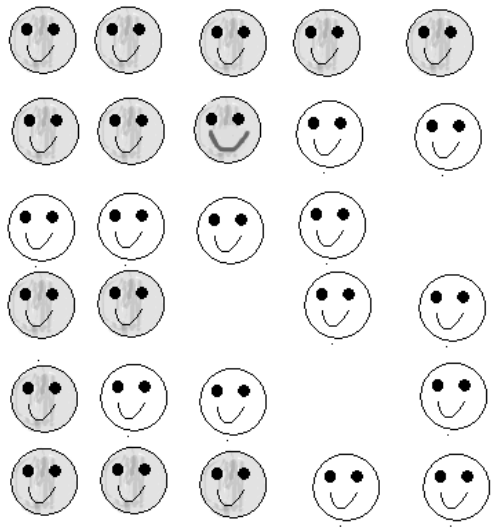

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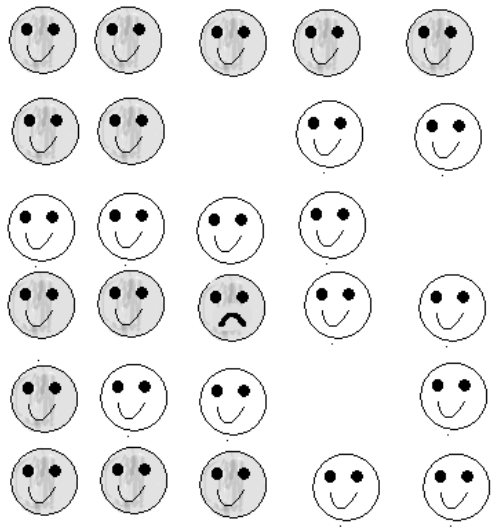

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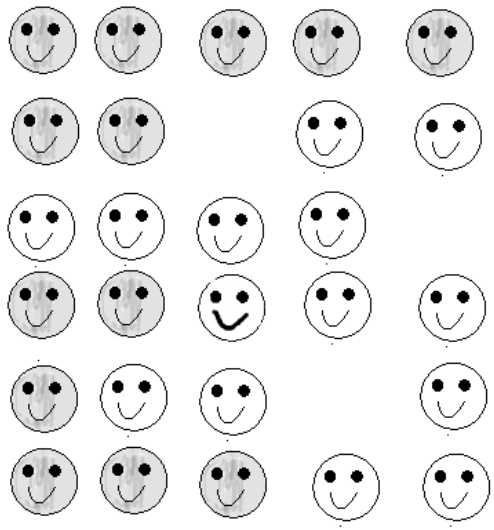

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Model parameters:

- $1-\rho \in (0,1)$ is the *density* of empty sites.
- $T \in [0,1]$ is the *tolerance*.
- $p \in [0,1]$ is the *possibility to migrate*
- $s \in (0,1)$ is the *prestige* of b, which defines $q_{b\to w} = s\frac{W}{(B+W)}$ and $q_{w\to b} = (1-s)\frac{B}{(B+W)}$

$W =$ total agents w

$B =$ total agents b

Schelling-Voter Model: results

Model parameters:

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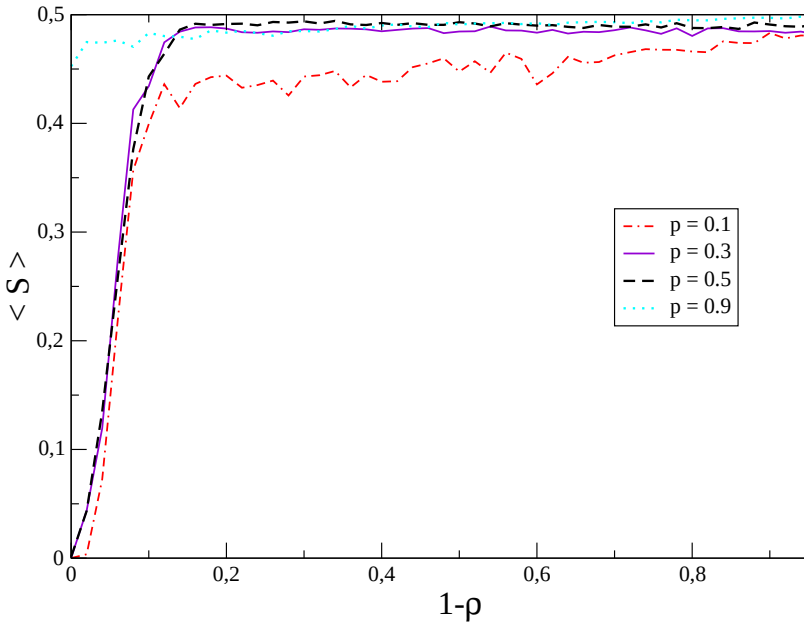
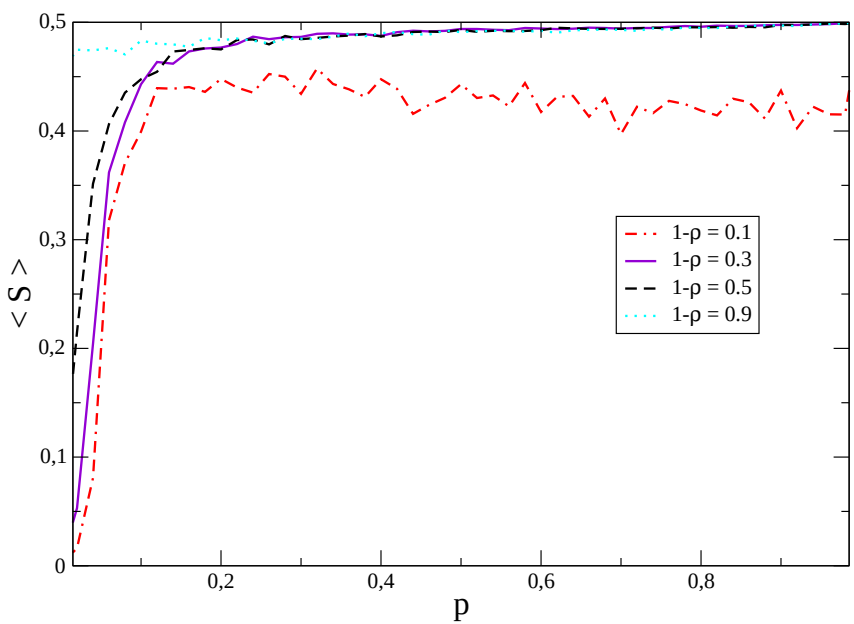
- $T \in [0, 1]$ is the *tolerance*.
- $s \in (0, 1)$ is the *prestige* of b.
- $p \in [0, 1]$ is the *possibility to migrate*.

Simulations:

- start with two similar populations in a square lattice of side $L = 50$.
- free boundary conditions.
- the same prestige $s = 0{,}5$ to both languages.

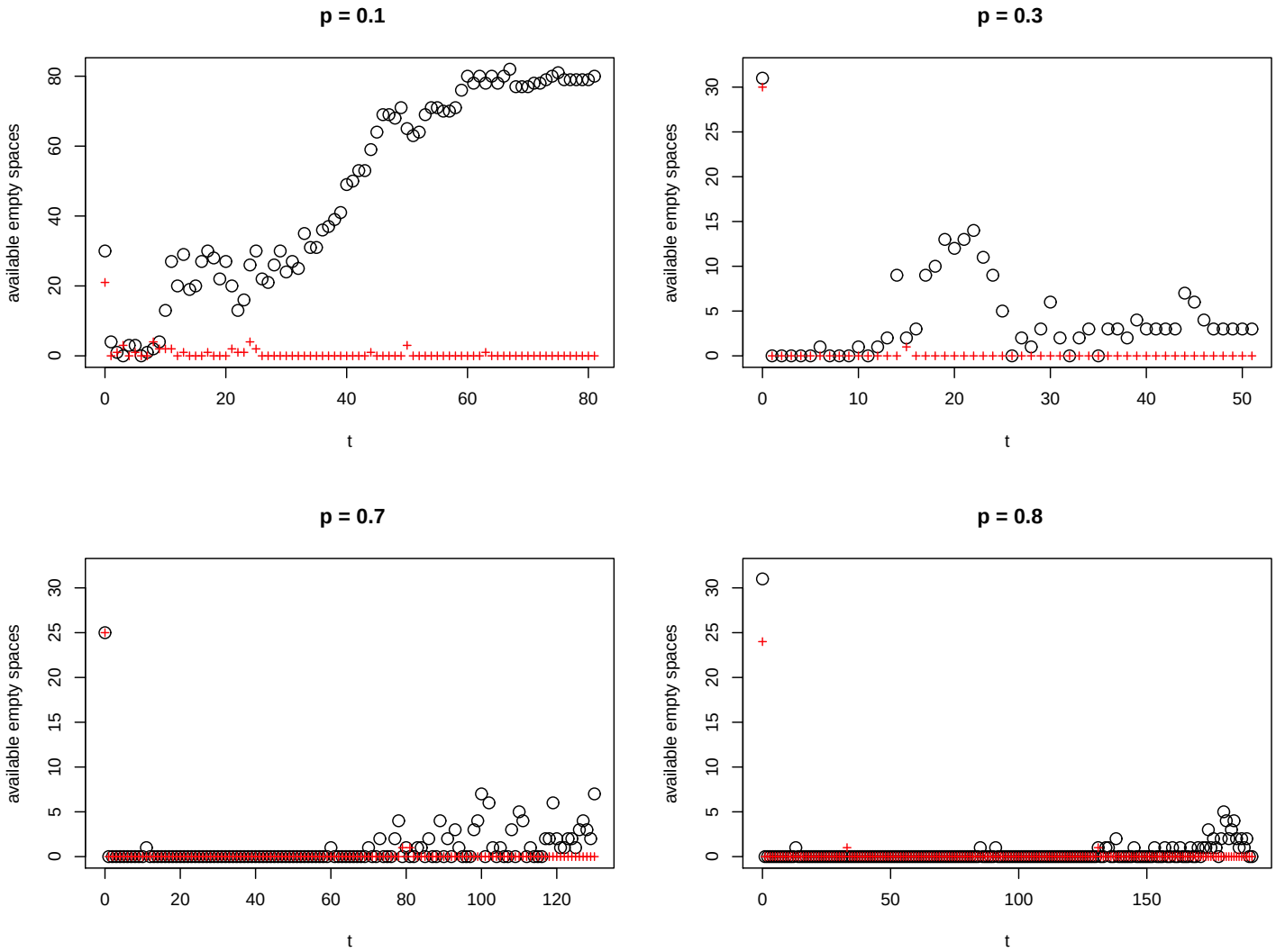
Size of the population speaking the minority language as a function of $1 - \rho$ and as a function of p and $T = 0{,}3$





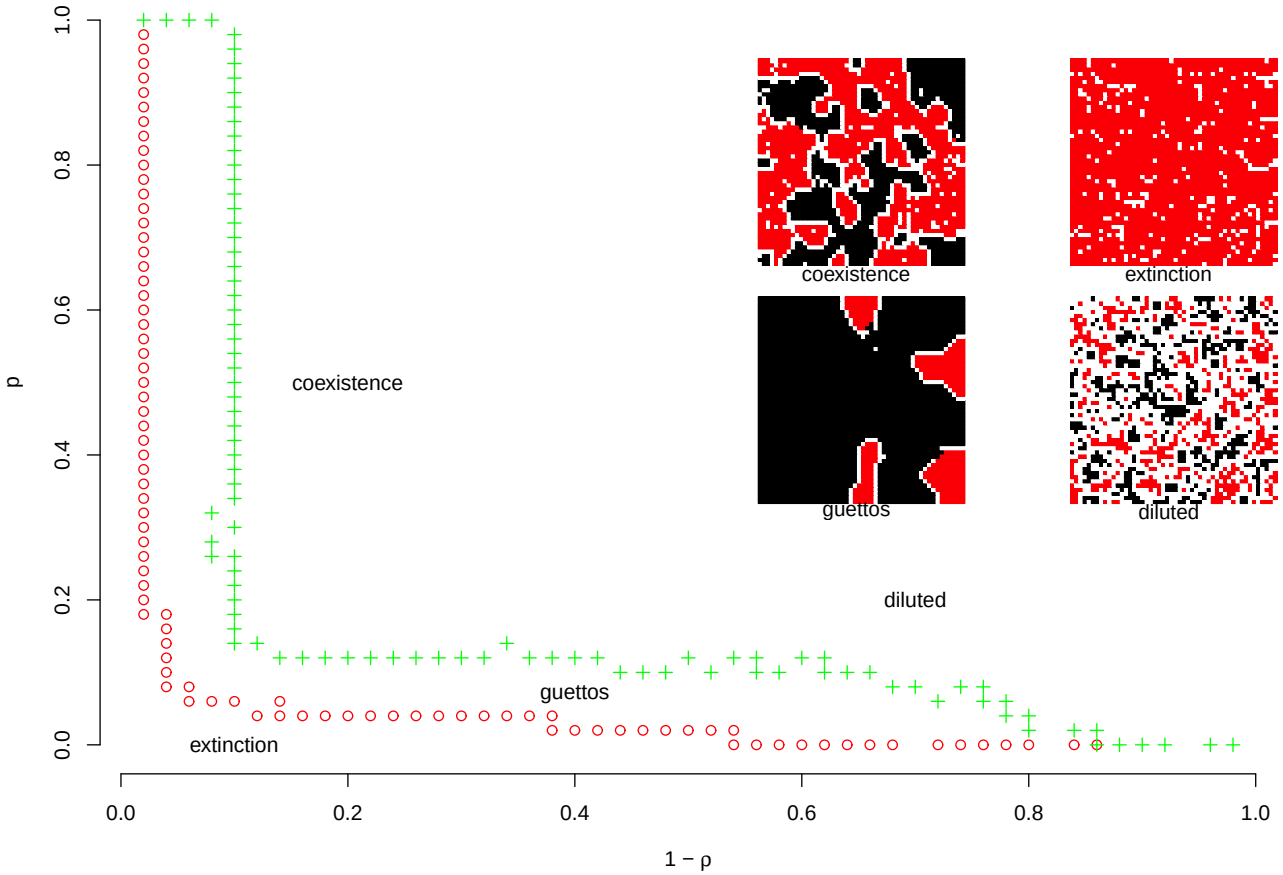
time interval: comprises several generations of individuals
each agent: small group of people (family)

Schelling-Voter Model: empty spaces



Available empty spaces for the populations.

Schelling-Voter Model: Phase space



UNESCO's Endangered Languages Programme found that there exist almost 3000 endangered languages in the world

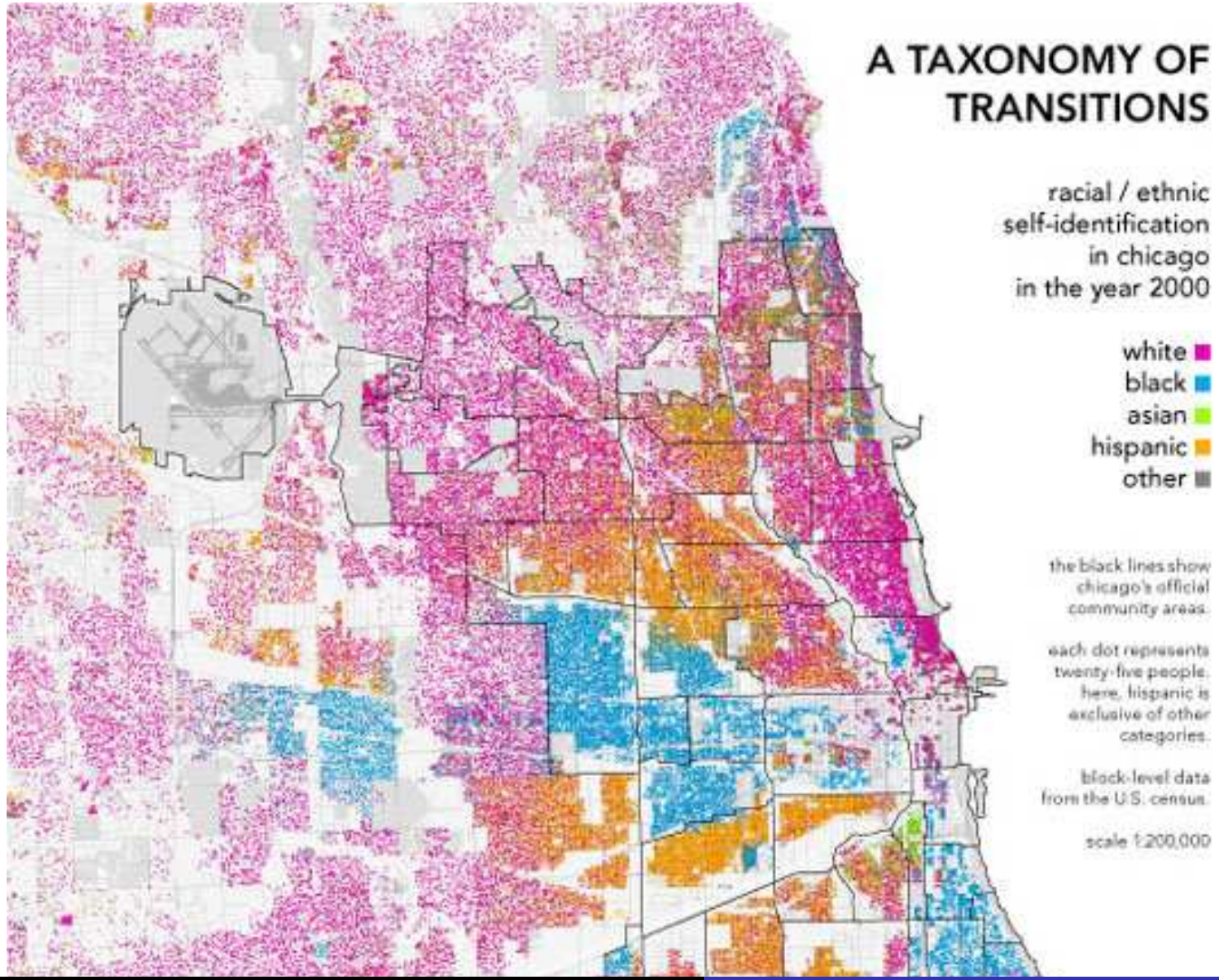
Below red symbols $\langle S \rangle < 0{,}1$; between red and green symbols: $0{,}1 < \langle S \rangle < 0{,}45$; beyond green symbols: $\langle S \rangle > 0{,}45$

p is high when the difficulty to learn the other language is high or when it is easy to move to other sites

http://www.unesco.org/new/en/culture/themes/endangered-languages.

Application: Language Competition

Chicago, data from Census 2010. Base map © OpenStreetMap, CC-BY-SA Eric Fischer, *Race and ethnicity (2010)* http://www.flickr.com/photos/walkingsf/sets/
Red is White, Blue is Black, Green is Asian, Orange is Hispanic, Yellow is Other, and each dot is 25 residents.

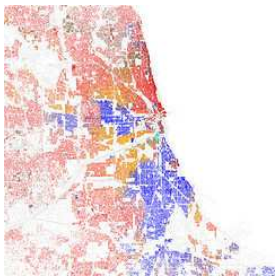


Application: Language Competition

US Census Data: US Census Bureau (2010).
http://www.census.gov/hhes/socdemo/language/data/acs/appendix.htm

...almost 30 percent of the population older than 5 years who speak Spanish, Chinese, or Korean languages at home, speak English *not well* or *not at all*..

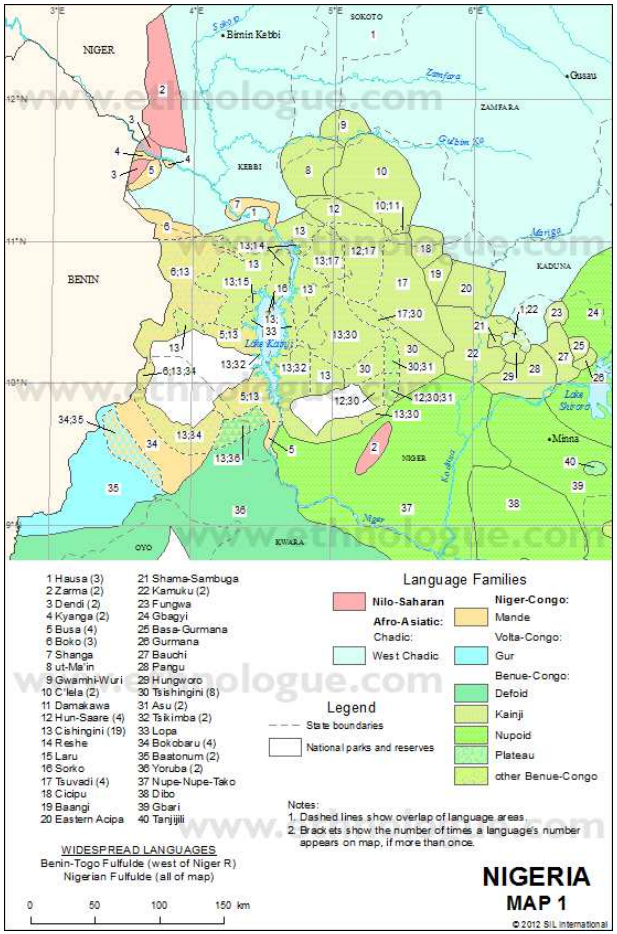
Segregation by ethnicity observed in the maps is also segregation by language.

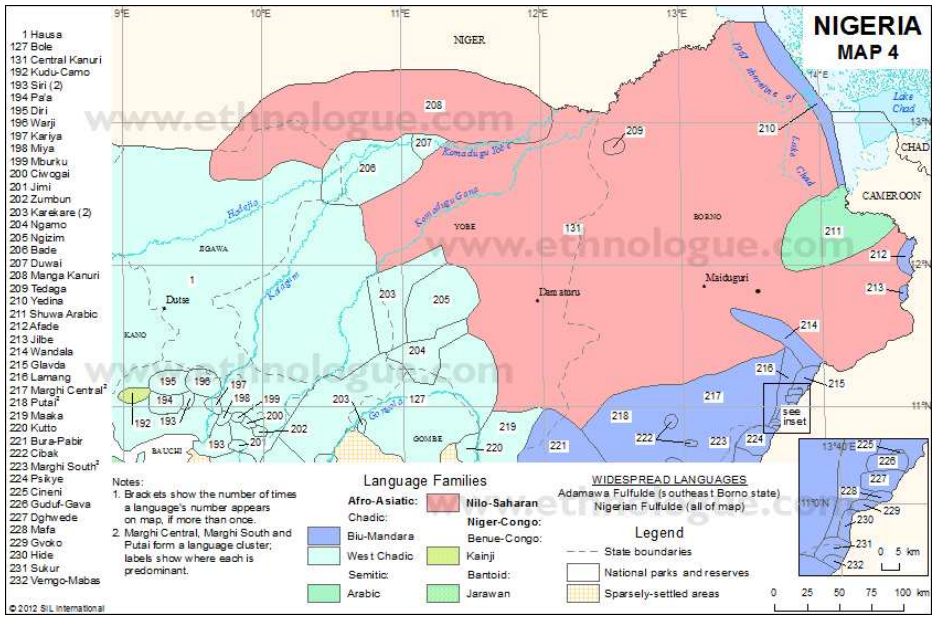


Application: Language Competition

Lewis, M. Paul, *Ethnologue: Languages of the world, sixteenth edition*, Dallas, TX, USA: SiL International. Online version: http://www. ethnologue. com (2009).

Nigeria has more than 500 languages belonging to at least three main families (Nilo-Saharan, Afro-Asiatic, and Niger-Congo), with around 169 million people, and 950.000 km^2; its density of inhabitants is higher than the one of the European Union.





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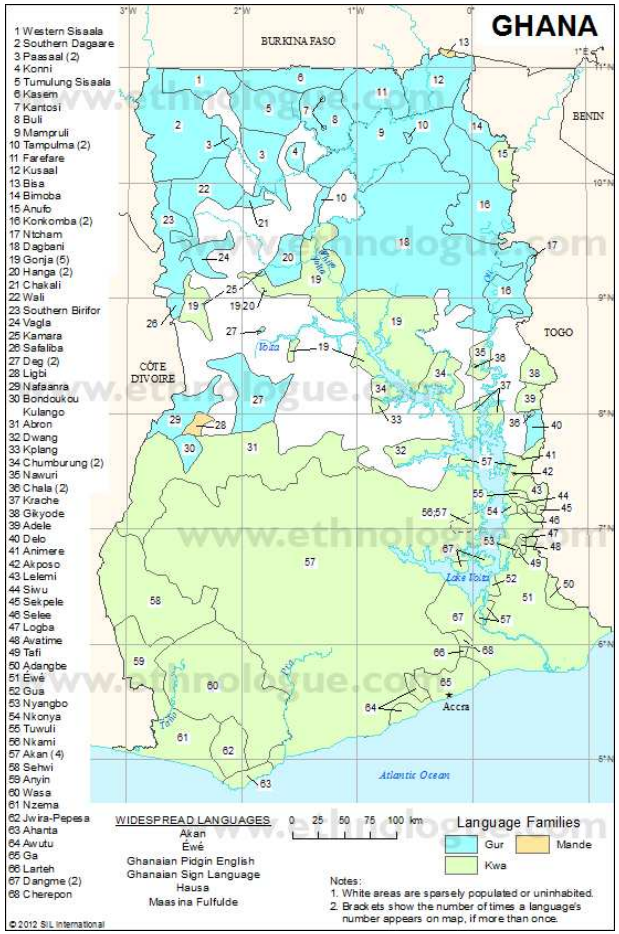
Ghana has several languages, two main families (Gur, Kwa). 30 different languages coexist in each zone around the bifurcation of the Black and White Volta Rivers.



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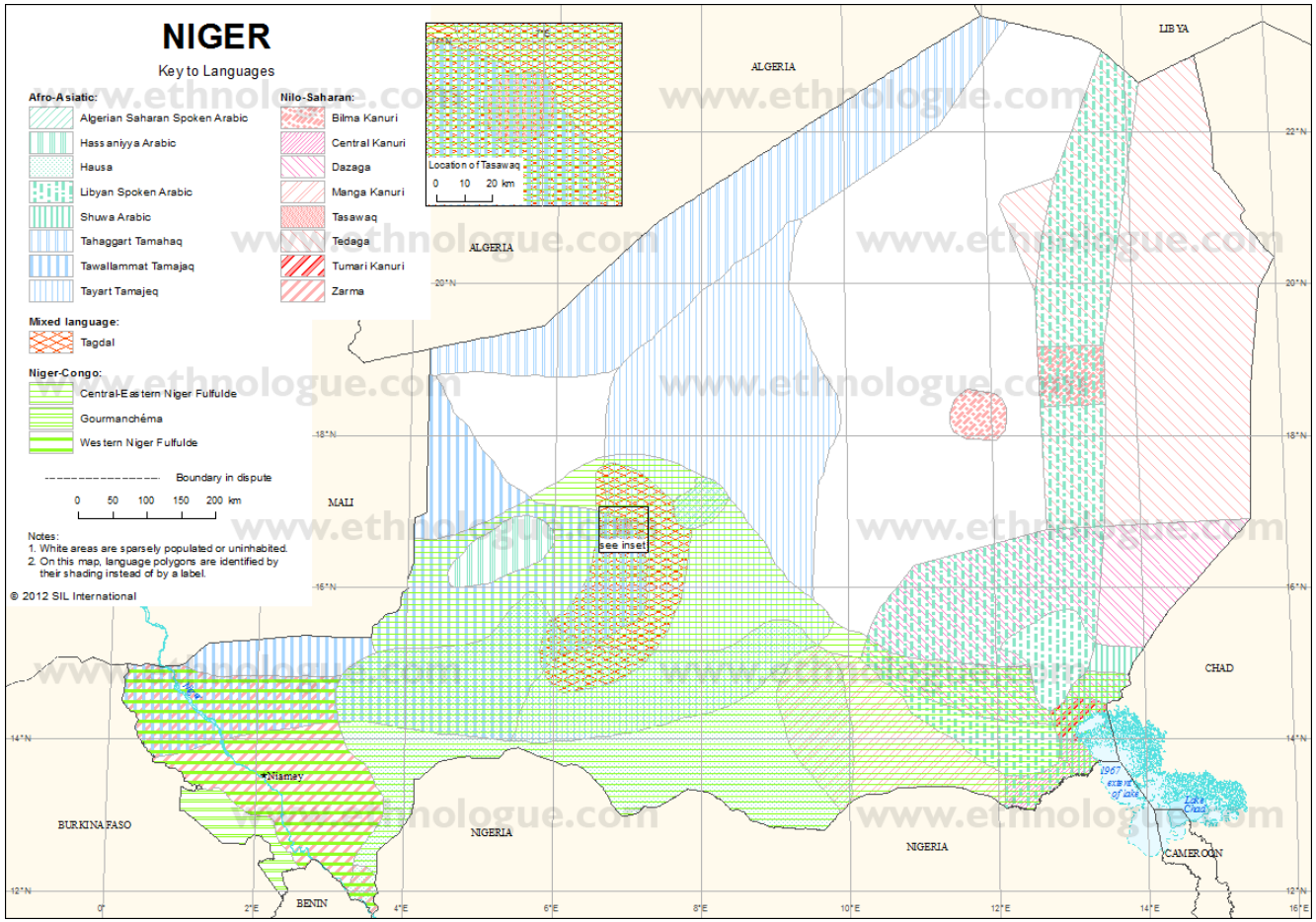
Niger has a very low population density (around 12 persons per km^2), several different languages coexist



A

Related work

- (2006) D. Zanette and S. Gil, *Opinion spreading and agent segregation on evolving networks* (Physica D) stochastic model where the distribution of opinions in a population of agents coevolves with their interaction network. The system evolves towards a state where the network's structure and the opinion distribution is frozen, and the population is divided into disconnected communities.

Related work

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- (2008) F. Vazquez, V. M. Eguíluz, M. San Miguel, *Generic Absorbing Transition in Coevolution Dynamics* (PRL): coevolution voter model on a complex network. A mean-field approximation.

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- (2012) Durrett, Gleeson, Lloyd, Mucha, Shi, Sivakoff, Socolar, Varghese, *Graph fission in an evolving voter model* (PNAS): model of a social network in which opinions of the individuals and the network connections coevolve.

Conclusiones

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- *Future work:* variations in the tolerance parameter (heterogeneos), more than two languages, and the dependence with the topology of the underlying network.

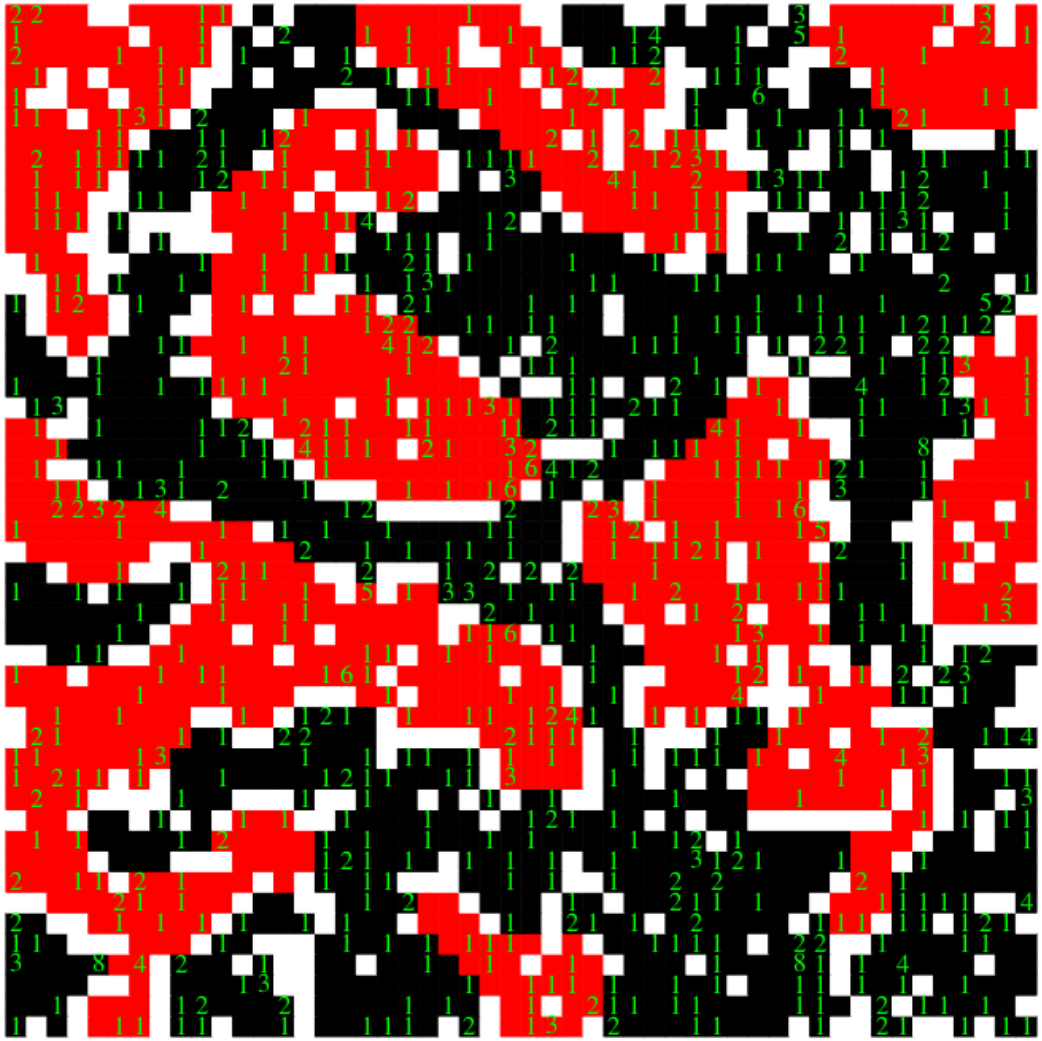
Thank you for your attention

...I Said If
You're Thinkin' Of
Being My Brother
It Don't Matter If You're
Black Or White...

Michael Jackson

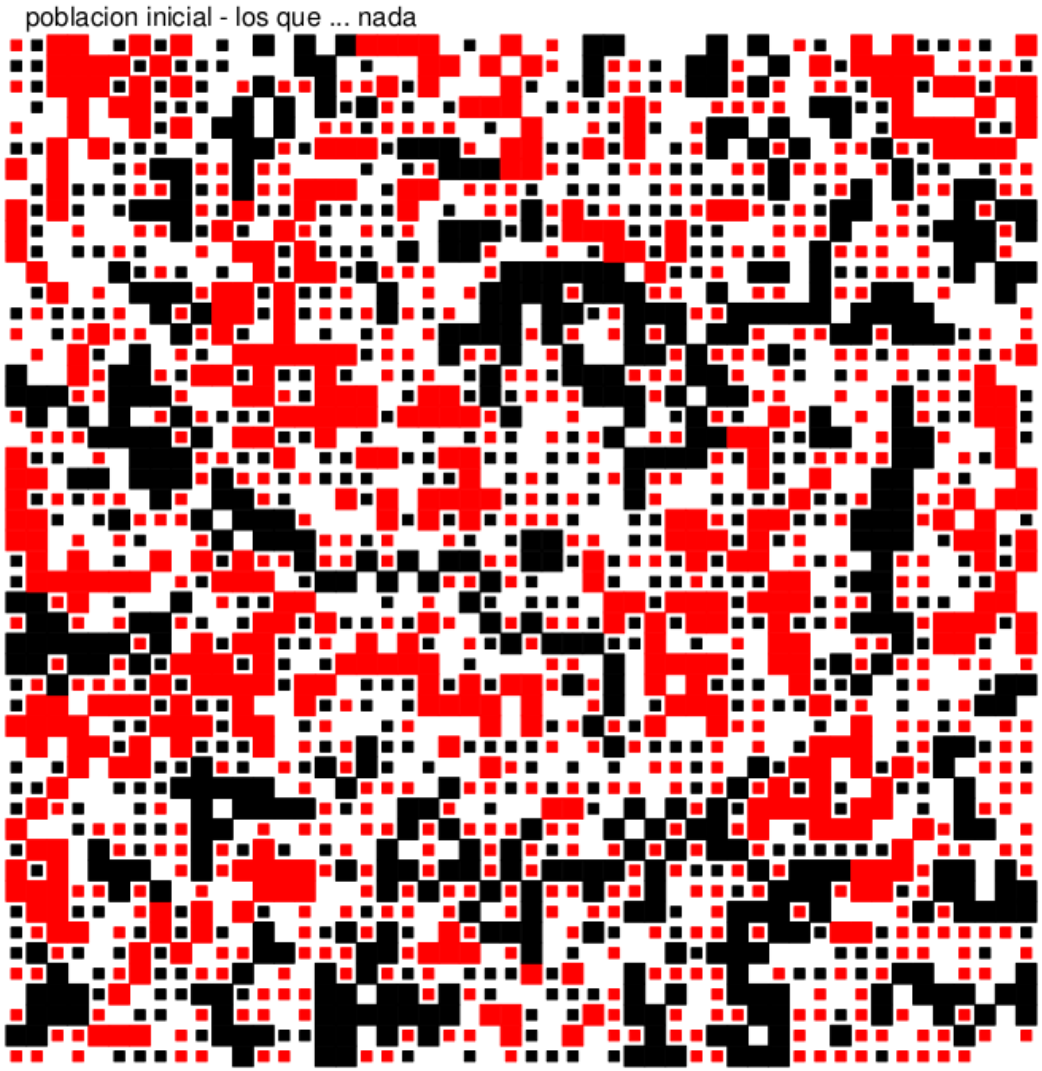
bilingual agents

poblacion final - cambios de idioma



nomads

agents who never change



Schelling-Voter Model: agents playing ...

▸ Start movie