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Simulating Prehistoric Ethnicity. The Case of Patagonian Hunter-gatherers

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The basis of this research project is the computer simulation of the emergence of ethnicity and cultural differentiation in Prehistory. We propose a predictive simulation of a historical case where the knowledge about the simulated social system is available at the necessary level of detail, using data from archaeological, ethnological, and historical research. The aim of this research is to test existing social theories of social evolution through history by creating a computer model of a theoretically possible society in which we may identify yet unknown social relationships and interactions.

Keywords: Simulation, Hunter-gatherer, Patagonia, Ethnicity.

1. Introduction.

The identification of "ethnic groups" in the usage of social scientists has often reflected inaccurate labels more than social realities. That is to say, the identification of an ethnic group by outsiders, e.g. anthropologists, may not coincide with the self-identification of the members of that group.

An ethnic group is a group of people whose members explicitly regard themselves and are regarded by others as truly distinctive, through a common heritage that is real or assumed- sharing "cultural" characteristics. Members of an ethnic group are conscious of belonging to a differentiated group; moreover ethnic identity is further marked by the recognition from others of a group's distinctiveness (BARTH, 1969; VINCENT, 1974; JONES, 1997; COHEN, 2000).

Additionally, it can be argued that the components of ethnicity mostly arise in situations of contact and contrast, being *interaction* the motor of generation of categories of ascription and ethnic differentiation. Such an interaction should be considered both positive (exchange) and negative (conflict), in such a way that different ways of social fusion, fission and friction develops a set of representations and values that set the terms from which social clustering and self-ascriptions are constructed.

Processes that result in the emergence of such inclusiveness are called ethnogenesis (WEBER, 1922; BANTON, 2007). Given that those processes should be analyzed in behavioral terms, we should accentuate dynamic and negotiable social identities, involving both social permeability of borders and rejecting the monolithic categories of common cultural forms such as language or particular genetic or cultural traits.

The key of our perspective is that any shared traits among agents, their behavior, their beliefs, and their language, the products of their work and/or the material or immaterial results of their actions should be contingent to the social interaction process that generated those traits. In so saying, we follow a constructive approach to "ethnicity".

This conception of ethnicity is hardly applicable to prehistory, given the limitation of data. The only knowledge about the most remote past is composed by the material consequences of actions having been performed then. As a consequence, archaeologists usually emphasize "observable similarities" as a surrogate of "ethnicity".

Certainly, ethnic groups are usually expressed as a set of shared norms, transmitted through beliefs, religion, language. The similarity in language and material culture or the constriction of groups to a restricted geographical area can be regarded as the consequence of people that worked together and had common goals, and people that segregate those who neither work nor cooperate with them. The similarity in biological phenotype, for instance, is the result of the way agents that reproduce among them chose their reproductive mates within an already defined group. The more cultural transmission among individuals connected by the same social network, the more similar are the agents, their actions and the material and immaterial consequences of their actions.

Nevertheless, relying only on observable similarities is misleading because the mere commonality is not a sufficient condition to understand the formation of an aggregate of people. Materially expressed, cultural boundaries are not always clearly defined, nor necessarily correspond with ethnic boundaries. Then, is the archaeological study of prehistoric ethnicities impossible ?

We cannot travel to the past in an effective way but we can do it in a virtual way. History only runs once, but inside a computer a virtual model of the historical past may run infinitely many times. In the computer, we can explore (by altering the variables) the entire *possible* range of outcomes for different past behaviors. The basis of this research project is then simulating inside a computer what we know about actions that took place in the past and experimenting with the effects they may produce in such a virtual world.

Our aim is to simulate human beings "living" in a virtual environment that is an abstraction defined by us on the basis of social theory and/or historical data (BARCELÓ, 2008). In the framework of agent-based modeling, the artificial societies we aim at building are based on a set of simulated social agents represented as members of an evolving (virtual) population of social procedures (mechanisms), which determine important aspects of the population structure and development and therefore of the individual's behavior. Inside the computer simulation, and similarly to what prehistoric people did in their real world, computer agents act as influenced by other agents reinforcing some actions, interfering with others, and even sometimes preventing the action of other people.

Running a computer model of a prehistoric society simply amounts to instantiate the simulated populations of people, letting the agents interact, and monitoring what emerges. Although embodied agents tend to be computationally simple and they "virtually" live in computationally simplified environments, if one places many agents together in the same environment interesting collective behaviors tend to emerge from their interactions. What *emerges* from the collective execution of rules packaged in form of agents is a gradual updating of agent's beliefs and the concomitant modification of their plans, arriving at some form of *social order*. This should be conceived as any form of systemic structuring which is sufficiently stable, to be considered the consequence of social self-organization and self-reproduction through the actions of the agents, or consciously orchestrated by (some of) them.

2. The Case of Prehistoric Patagonia.

Instead of working directly on a universal theoretical model, we have preferred a predictive simulation of a historical case where the knowledge about the simulated social system is available at a necessary level of detail, using data from archaeological, ethnological, and historical research. The aim of this research is to test existing social theories of social evolution through history by creating different computer models of theoretically possible societies in which we may identify yet unknown social relationships and interactions.

Why Patagonia? The historical process of those societies is well known not only through archaeology but also from the ethnographical record (BARCELÓ *et al*., 2009). Some years ago, hunter gatherer practices coexisted with a capitalist economy.

As in any hunter-gatherer historical situation, Patagonians moved from place to place for social and political needs, in such a way that extremely long and complex interaction net-works developed. Goods and information traveled more than people would. Therefore, physical mobility was an economic strategy, socially implemented, that allowed the exploitation of wider economic territories and simultaneously contributed to the creation of social ex-change networks. As a consequence of these mobility patterns, linguistic, cultural, economic and even territorial frontiers were extremely permeable, suggesting a considerable degree of population mixture.

In Patagonia, biological and linguistic differentiation among human groups has been found to be strongly associated with spatial separation. According to this view, we propose an "isolation by distance" hypothesis predicting that human groups will reflect geographic separation in the pattern of their between-group distances. The eventual result is a greater similarity between geographically proximal populations and increasing differences between groups that are further and further apart.

The key of our explanatory model is that any shared traits among prehistoric Patagonian inhabitants, their behavior, their beliefs, and their language, the products of their work and/or the material or immaterial results of their actions should be contingent to the social interaction processes that generated those traits. After all, what has traditionally been called "ethnic" differentiation is nothing more than a consequence of the diverse degrees of social interaction between human communities. In so saying, we suggest that the

emergence of groups or clusters of social agents ("ethnic" groups) in Patagonia was the consequence of the way different social agents interacted along a period of time. And they may have interacted for many reasons and in many ways: cooperating to acquire subsistence, cooperating to produce tools and instruments, cooperating to exchange subsistence and/or tools, cooperating for reproducing themselves, refusing such cooperation, or compelling other agents to work in their own benefit, etc. War and conflict are also another kind of interac-tion. In all those cases, interactions vary in intensity and frequency defining a complex network of positive or negative intergroup relationships. As a result, agents adopt similar activities, and their actions tend to generate similar results.

3. A preliminary computer model of Ethnicity Formation

Obviously we cannot implement the complexities of ethnogenesis formation in a computer model. We prefer to implement some parts of a future computer model to understand the social mechanisms involved in the emergence of social order. Some enhancements to this model are foreseen, as it will be explained later.

The preliminary model is very simple but it makes emphasis on the main components to understand the emergence of ethnicity (Figure 1). Let us imagine a population of virtual agents, moving randomly in search for resources, and organized in households as ancient Patagonians did. There are two kinds of economic activities: gathering, which is an individual task, and hunting, which is only possible when the members of different, culturally similar households cooperate. There are increasing returns to cooperation, i.e. families get more resources working together than individually, modulated by the global parameter *returns-to-cooperation*. Nevertheless, hunting is also affected by *diminishing* marginal returns relative to the number of cooperating households (another model parameter). To find cooperators, households should interact with others within a single local neighborhood –its geographical radius is a model parameter–, within the limits allowed by their perceived cultural similarity. Households have a distinctive cultural identity, modeled as a F dimensional space of cultural features, each with q different cultural traits. This is a surrogate for language and cultural values differences. In this simple model we are not interested in the precise representation of what differentiate "cultures", but only in the intensity of such a difference. Cultural similarity is measured as the relative number of shared cultural dimensions. Consequently, two households consider themselves as belonging to the same "ethnic" group if they are appropriately culturally similar, that is, if their cultural similarity is above a critical threshold, also a model parameter.

"Culture" diffuses within population through a local imitation process. With a fixed probability level a household copies some trait of the mode of her group, in such a way that consensus increases and "culturally" homogeneous groups tend to emerge. Moreover, "culture" evolves through local mutation, that is, the attained levels of "cultural" identity are also subject to random cultural drift. With a fixed probability level, a household mutates one of her cultural traits which is simultaneously copied by her group (we assume that geographical proximity ensures that the culture of all group members evolves in the same direction).

In a preliminary and oversimplified implementation, we consider only a constant population of agents (households), moving randomly in search for resources and interacting with others located in the same geographical area and belonging to the same ethnic group, in order to enhance their chances of subsisting. Local interactions facilitate cultural diffusion and ethnic differentiation.

At a time period t the household j gets resources according to the following production function (Eq.1):

$$O_j(t) = \frac{c_j}{\sum_{k \in G_j(t)} c_k} \left(\sum_{k \in G_j} c_k \right)^{\theta} = c_j \left(\sum_{k \in G_j(t)} c_k \right)^{\theta - 1}$$

$$with \ \theta \geqslant 1$$

where ck are the families capacities and θ modulates increasing returns to cooperation. The surplus of the household j depends on a depreciation parameter k and a minimum subsistence. Therefore, according to the Eq.2:

$$S_j(t+1) = \left[O_j(t) + S_j(t)(1-\rho) - S_o \right]$$

Families' maximum age follows a Poisson distribution whose mean is the parameter *life-expectancy*. Whenever a household dies, either by old age or starving, she is replaced. The newcomer inherits the characteristics of a household in the population chosen through a roulette wheel, i.e. families have a probability of being replicated directly proportional to their capacities.

4. A Netlogo implementation

An implementation of the previous model can be downloaded from:

http://ingor.ubu.es/models/patagonia/simple1.0

Figure 2 shows the Netlogo initial window with the different parameters that can be selected and updated by the user. Figure 3 depicts Netlogo world view of three system states: at the beginning, after the first time steps, when households spread through the virtual landscape, and at the time when emergence of different ethnic groups is observed.

5. Preliminary results

Our model has the same assumptions as the classical Axelrod's Dissemination of Culture model (1997):

1. people are more likely to interact with others who share many of their cultural attributes, and

2. these interactions tend to increase the number of cultural attributes they share (thus making them more likely to interact again).

We also confirm that the degree of cultural differentiation, and hence the emergence of more or less "ethnic" groups seems to depend on:

1. the number F of cultural features that characterize each agent,

2. the number q of traits that each feature can take on,

3. the size A of the territory or, equivalently, the number of interacting agents.

But the main result of our simplified model is the emergence of ethnicity and the partitioning of social networks even in the case of a constant population. In other words, cultural diversity not only depends on the size of population or on the extension of territory, but it is socially mediated by many other social feed-back processes that affect the way homogeneous groups are born, reproduce and die. Ethnic partitioning follows culture differentiation which also follows the intensity and reproduction of labor cooperation. This is a complex social mechanism characterized by the dialectical relationship between the higher payoffs of cooperation, the local carrying capacity, the level of technological development, and the risk of increasing social stress when surplus accumulates and wealth becomes unequally distributed.

The simulated model shows how "cultural proximity" – the threshold required for two households to regard themselves as belonging to the same group– influences the intensity of "ethnic" ties. When such a threshold is low (e.g. δ=0.2) the population evolves as one simple ethnic group because cultural mutation and local diffusion processes are not strong enough to break its ethnic identity. However, when it is higher, local differentiation forces (mutation and diffusion) can split the population into different ethnic groups.

On the other hand, the ethnic fragmentation in our model depends mainly on the importance of the increasing returns of cooperation. In the case of poor economic revenues from collaborative labour, there is no significant benefit in social interaction (see Eq. 1) and a household will have the same opportunities living alone or within a group. In such a scenario, we observe the repeated formation of differentiated groups (higher *ethnogenesis*). When the economic returns of cooperation are higher, those households which collaborate within a group get more surplus and therefore more replications in the future generations. In doing so, the population fragments into a smaller number of groups, hence there is less ethnic differentiation. This effect saturates for high enough values of cooperation returns, where we observe a minimum in the number of ethnic groups that depends on the natural noise of the system (due to mutation and replacement processes).

Those results are congruent with what we know of Patagonian prehistory, where social fusion tends to be less frequent than the fission of former groups, basically by the cost due to *diminishing* marginal returns relative to the number of households cooperating. Only if some individuals within the group increase their own productivity and the absolute volume of their production above a critical threshold, they can invest such a surplus to increase coercion, and hence maintain ever increasing levels of social inequality. Without a dramatic change in technology (i.e. agriculture, pastoralism) we think that this social change is rare.

Conclusions

This preliminary and simplified model of ethnicity formation is based on 11 parameters:

- n-households: number of households (it remains constant during the simulation)
- neighborhood-radius**:** radius of the household's neighborhood
- %cultural-proximity**:** minimum relative number of cultural dimensions that two households should share in order to regard themselves as belonging to the same ethnic group
- cultural-dimensions**:** number of cultural dimensions
- cultural-traits: number of possible cultural traits for each dimension
- p-cult-diffusion**:** probability that a household copies some cultural trait of the mode of her group
- p-cult-mutation: probability that a household mutates one of her cultural traits, which is simultaneously copied by all members of her group
- returns-to-cooperation**:** parameter that modulates the increasing returns to cooperation of the household's production function (see Eq.1)
- subsistence**:** minimum surplus necessary to survive in a time period
- surplus-depreciation**:** rate of surplus decay, or depreciation
- life-expectancy**:** mean of the Poisson distribution that describes families' maximum ages

The most relevant aspect of this initial model is that ethnic groups have not been implemented as fixed entities, but they emerge as a consequence of cultural proximity relative to geographical neighborhood and the possibilities of joint collaboration. Individual households do not have information about all ethnic groups in the population, they only can differentiate other households in their neighborhood and they are allowed to build positive or negative connections with

them in consequence. Ethnicity appears then as an emerging partition and as an evolving social network, whose formative and "deformative" dynamics is what we want to study. Modulated by the cultural proximity parameter, the effect of increasing returns to cooperation is to facilitate the emergence of larger ethnic groups. *Ethnicity* appears to be a consequence of territorial and social mobility, mediated by the history of previous interactions and the degree of cultural similarity, the payoffs derived from cooperation (collective hunting, material exchange, social reproduction) and the costs generated by internal social conflict (social friction and fission). The model is based on the assumption that social behavior in groups is regulated by norms in such a way that interactions between individuals who share beliefs about how people should behave yield higher payoffs than interactions among people with discordant beliefs. Nevertheless, the sharing of social norms constitutes a historical result of the previous number of interactions, and this number is also a consequence of the different possibilities groups and individuals have of deciding for strategies of collective labor or individual subsistence acquisition. In its turn, the number of individuals also depends on the number of couples the internal structure of the group allows. Consequently, even the demographic rhythm of the group is socially mediated: cooperative groups should be more productive and also have more offspring than non-cooperative groups.

Nevertheless, if it is not the belief that creates the group, but the group that creates the belief in a shared community of features we need to find an external factor giving feedback to the dynamics of aggregation and segregation. Social Influence can be a good candidate for such a factor.

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FIGURES

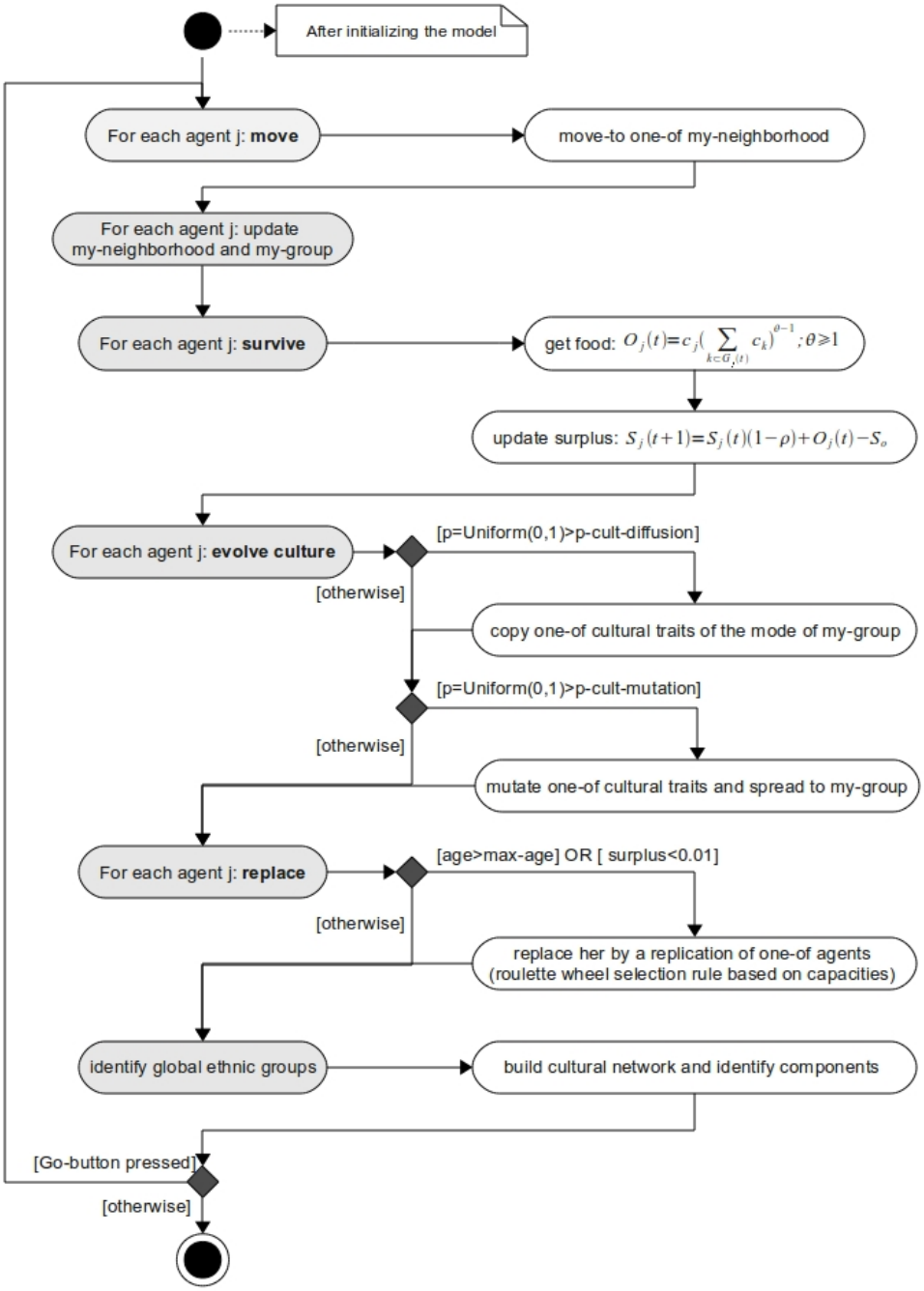

Figure 1: *Flow chart.*

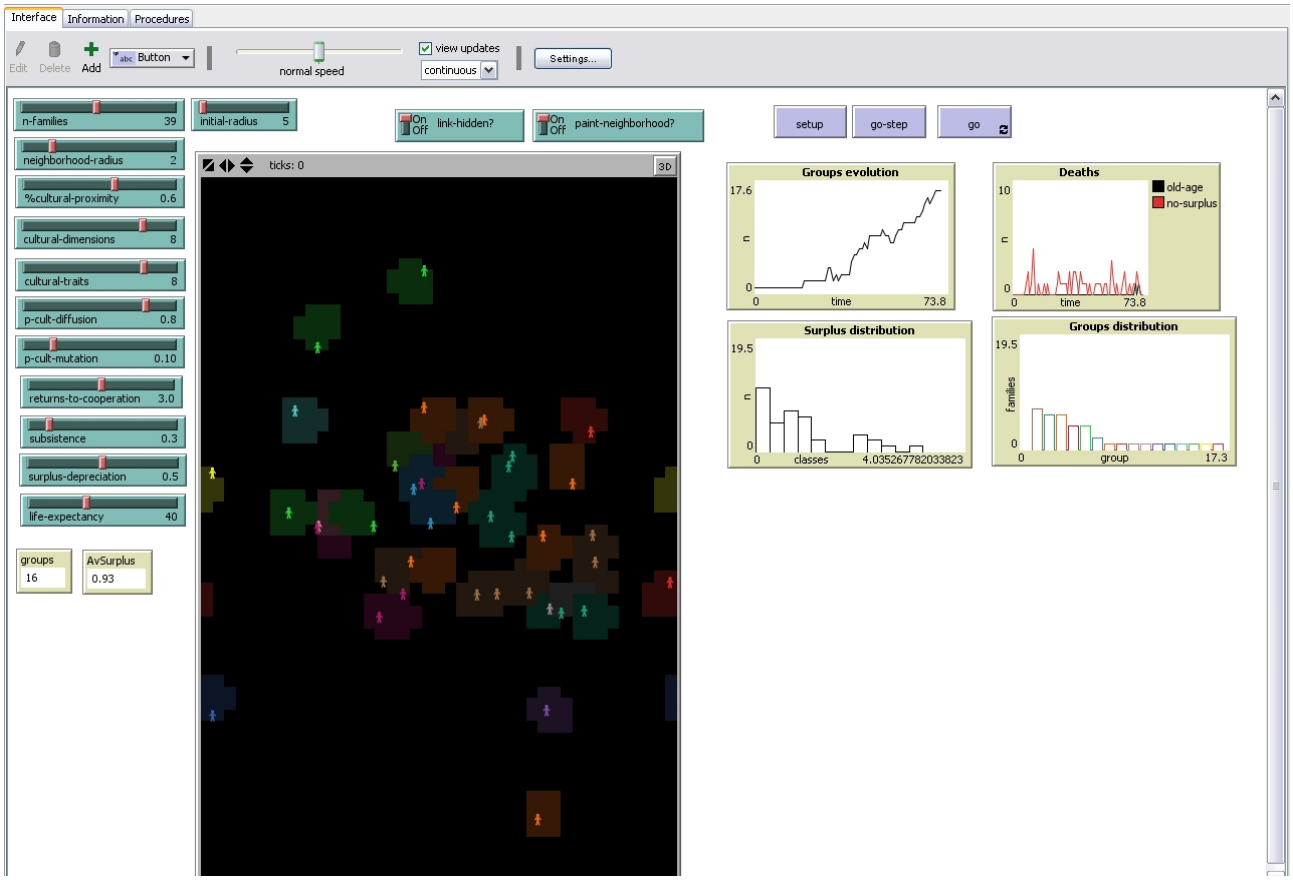

Figure 2: *A netlogo implementation.*

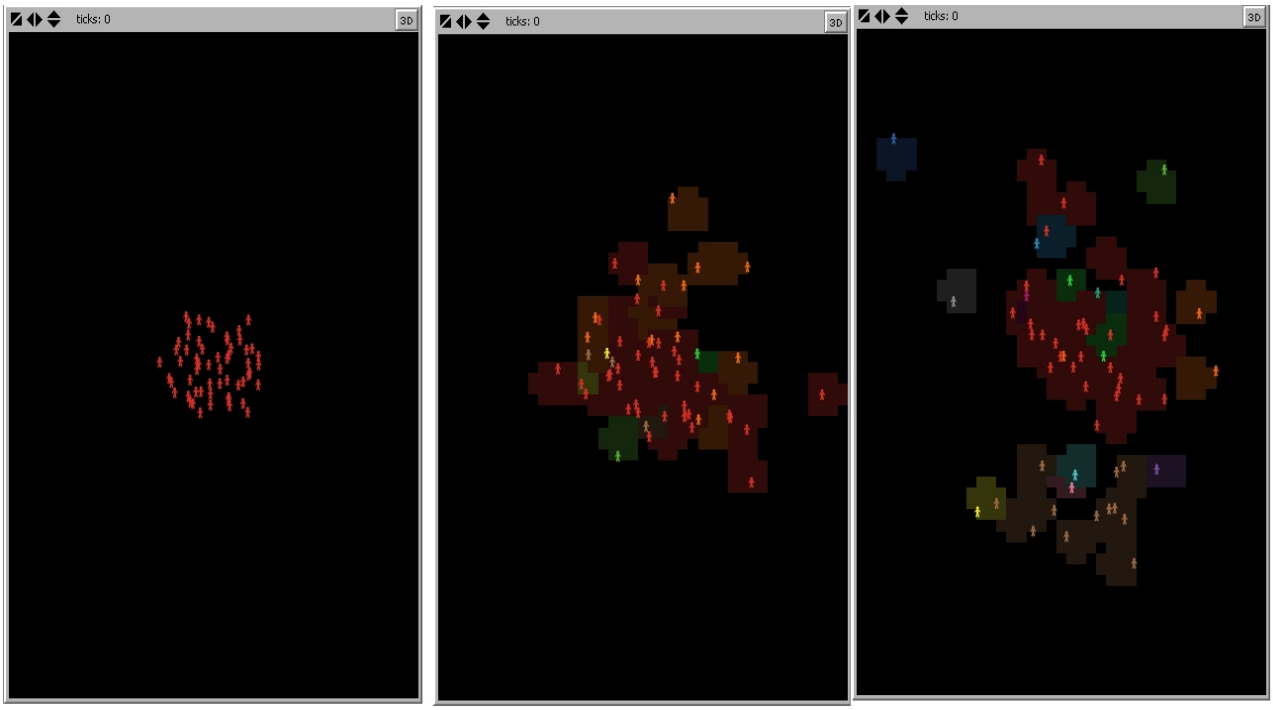

Figure 3: *Running the Netlogo applet: at the beginning, after the first time steps, when families spread throughout the grid, and at an emergence of different ethnic groups.*