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Patagonian Ethnogenesis: towards a computational simulation approach

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Abstract. The basis of this research project is the computer simulation of the emergence of ethnicity and cultural differentiation in prehistoric hunter-gatherer groups. Instead of working directly on a universal theoretical model, we have preferred a predictive simulation of a historical case (ancient Patagonia) 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 simple computer model of a society in a theoretically possible historical context, in such a way that we may identify yet unknown social relationships and interactions.

1 Motivation

This paper presents a simulation experiment of the historical trajectories of a known society. 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. Obviously, virtual agents are not real people, and they behave differently. The purpose is not to reproduce what we know from ethnographic and archaeological data, but using a computer methodology to test explanatory hypotheses about the emergence of cultural and "ethnic" differentiation in the past. We have here defined

the very concept of "ethnogenesis" as the historical emergence of groups of people whose members explicitly regarded themselves and are regarded by others as truly distinctive, through a common heritage that is real or assumed- sharing "cultural" characteristics (Barth 1969, Jones 1997, Cohen 2000). We should take into account that 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.

2 Simulating the Emergence of Ethnicity in Prehistoric Patagonia

For the most part of their history Patagonian human groups built hunter-gatherer production systems with enough flexibility to be able to exploit different resources at different places with different intensities. Hunter-gatherer production does not mean simple societies, however. Human groups were not determined by what nature offered to them, but just constrained by the spatial availability of some resources and the absence of others, and by the temporal unpredictability of natural productivity. Human groups (families) moved from place to place for social and political needs, in such a way that extremely long and complex interaction networks developed. Such physical mobility was an economic strategy, socially implemented, that allowed the exploitation of wider economic territories and simultaneously contributed to the creation of social exchange networks.

As a consequence, goods and information would have travelled more than people would. In such context, the dynamic and relational nature of ethnicity would have involved both social permeability of borders, allowing us to reject 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 behaviour, 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. 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 follow a constructive approach to "ethnicity". The emergence of groups or clusters of social agents ("ethnic" groups) is the consequence of the way different social agents have 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 interaction. 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.

The question is "why groups of people are the way they are" in terms of how agents acted when they became integrated into a single group. We suggest that in Patagonia an isolation-by-distance model was in action, which suggests that human groups will reflect geographic separation in the pattern of their between-group distances (Barceló et al. 2009). The eventual result is a greater similarity between geographically proximal populations and increasing differences between groups that are further and further apart. Consequently, the less the intensity and frequency of inter-group relationships, the greater the differences in ways of speaking and other cultural features manifested by groups. However, in the case of inter-group conflict, the intensity and frequency of violent contact may have generated high degrees of differentiation, and probably also of domination.

3 A Simple Model of Ethnic Differentiation

As we have previously seen, ethnicity phenomena are quite complex, and consequently any attempt to formalize them as computer models is a difficult trade-off between simplicity (understanding) and descriptiveness. We propose a first approach to hunter-gatherer ethnogenesis based on an economic perspective, i.e. the success of cooperative activities within a group supports and promotes its existence. Under this assumption, people split into groups in which individuals work together, and this collaboration facilitates cultural diffusion that reinforces the particular identity of each group, but geographical distance weakens these social ties and can promote further differentiation.

We are not interested in building a computer program which "imitates" actual bands of Patagonian hunter-gatherers. Our simulation bears little direct similarity with real humans having existed in the past, because we intend to analyze hypothetical mechanisms of social organization which could have generated the way actual human groups joined and separated among themselves.

We have considered 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 probabilities of subsistence. That means that households are our unit of study, not because in the ethnographic present societies were organized at the scale of independent families, but because the social mechanisms involved in organization acted at such a scale producing as a result higher level groups (residence camps, settlements).

The geographical space is modelled as a finite toroidal grid of regular patches. Local interactions in this space facilitate cultural diffusion and ethnic differentiation. The model parameters and components can be summarized as follows[1]:

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[1] The model has been implemented in Netlogo and can be downloaded from http:// ingor.ubu.es/models/patagonia/asmed/

- There is a constant population of agents $N=\{1,2,\ldots,n\}$ that differ in (1) their capacities to exploit environmental resources, a variable $c_{j\in N}$ defined on $[0,1]$; and in (2) their cultural identity [Axelrod 1997], an integer vector of k features (cultural dimensions) which can take any value (cultural trait) within the set $\{1,2,\ldots,r\}$.
- Each agent moves randomly through the territory and interacts within her local environment (neighbourhood) with those others regarded as similar (local group). The size of the neighbourhood is modulated by the global parameter η. In addition, two agents regard themselves as similar if both belong to the same group.
- There are increasing returns to cooperation, i.e. agents get more resources working together than individually. We define an output function for each agent j as a weighted average of the sum of the capacities of her local group $G_j(t)$ raised to the power of $\theta>1$, which modulates increasing returns to cooperation:

$$O_j(t) = \frac{c_j}{\sum_{k\in Gj(t)} c_k} \left(\sum_{k\in Gj(t)} c_k\right)^{\theta} = c_j \left(\sum_{k\in Gj(t)} c_k\right)^{\theta-1} \quad \text{with} \quad \theta \geq 1 \tag{1}$$

- The agent j has a surplus S_j that depends on her output function O_j, a depreciation parameter $\rho\in[0,1]$ and a minimum subsistence S_o according to the equation:

$$S_j(t+1) = \left[O_j(t) + S_j(t)(1-\rho) - S_o\right]^{+} \tag{2}$$

- "Culture" (a vector representing shared traits among households or families, their behaviour, their beliefs, and their language, the products of their work and/or the material or immaterial results of their actions) diffuses into population through a local imitation process. With probability p_{diff} a household copies some trait of the mode of her local group.
- Moreover, "culture" evolves through local mutation. With probability p_{mut} a household mutates one of her cultural traits which is simultaneously copied by her local group (we assume that geographical proximity and repeated interactions ensures that the culture of all group members evolves in the same direction).
- Agent's maximum age follows a Poisson distribution with mean a particular life expectancy. Whenever an agent dies, either by old age or starving ($S_j=0$), she is replaced. The newcomer inherits the characteristics of a household in the population chosen through a roulette wheel, i.e. agents have a probability of being replicated directly proportional to their surplus.

Individual households do not have complete information about all other agents or groups of agents in the population; they can only differentiate other households in their neighbourhood and interact with them in consequence. So, we do not presuppose ethnic groups, only a measure of cultural proximity which makes two households regard themselves as more or less similar. Then, ethnic groups are the result of local interactions, and we identify them using a particular abstraction of the cultural network in which two households have a link if they are culturally close, i.e. the relative number of cultural dimensions they share is greater than the global parameter $\delta\subset[0,1]$. Ethnic groups are defined as the components of this network.

The model evolves over time as follows: at a time period t each agent moves randomly to one of her neighbour patches and updates her local group. In this way, we define a residence camp as all households in the neighbourhood with the same cultural tag. The agent updates the surplus according to Eq. 1 and Eq. 2; with probability p_{diff} she copies some trait of the mode of her actual residence group, and with probability p_{mut} she mutates one of her cultural traits and spreads it to her local group; any household that either reaches the maximum age or does not have surplus is replaced; finally, ethnic groups in the whole population are computed again.

4 Simulations

Under the hypotheses of the model, the system does not have absorbing states. Because we are interested in the study of the limiting behaviour, we have oriented simulations to compute the occupancy distribution (i.e. the long-run fraction of the time the system spends in each state) starting from an initial state of a culturally homogeneous population. For this reason we have explored any particular parameterisation running just one simulation for a long enough time, that we have set to 1 million time periods in all experiments shown in this paper, although we cannot guarantee that this occupancy distribution coincides with the limiting one, provided it exists (a property that is true for ergodic systems (Izquierdo 2009)).

In particular, we want to see the influence of the increasing returns to cooperation parameter θ and the cultural proximity parameter δ. Fig.1 depicts the limiting mean of the number of ethnic groups in a population of $n=50$ households when we vary the parameters θ and δ[2]. The effect of δ is not surprising. Considering that δ is the cultural proximity required for two households to regard themselves as belonging to the same cultural network, when δ is low (e.g. $\delta=0.2$) 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 δ 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 to cooperation. For low values of θ (e.g. $\theta \approx 1$) there is no significant benefit in cooperative activities (see Eq. 1) and a household has the same opportunities living alone or within a group. Then, the replication process facilitates the reproduction of any emerged cultural differentiation and consequently we observe a higher number of ethnic groups. For larger θ, those households which collaborate within a group get more surplus and therefore more replications in the future generations, so the population fragments into a smaller number of ethnic groups. This effect saturates for high enough values of θ, where we observe a minimum number of ethnic groups that depends on the natural noise of the system (due to mutation and replacement processes).

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[2] The rest of the model parameterization for all experiments is: $n=50$, $\eta=2$, $k=8$, $r=8$, $p_{diff}=0.8$, $p_{mut}=0.05$, $S_0=0.4$ and $\rho=0.5$.
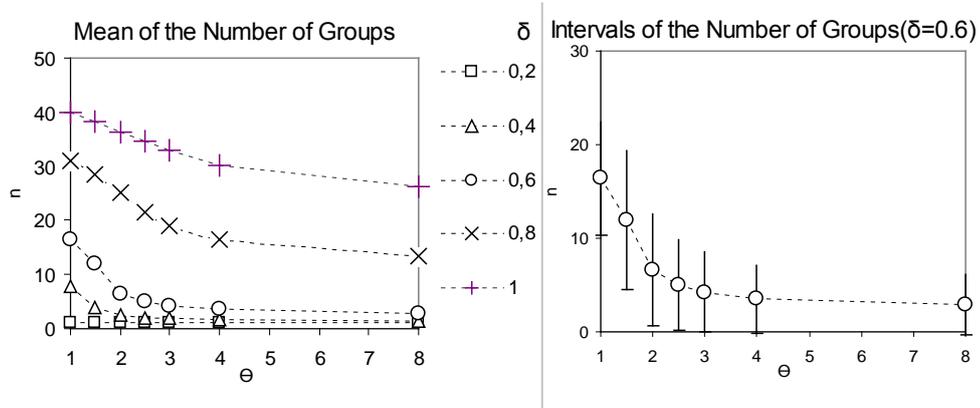
Fig. 1. The graph on the left depicts the estimation of the limiting mean of the number of ethnic groups $\hat{\mu}_g$ in a population of $n=50$ households when we vary the parameters θ and δ. The graph on the right shows the intervals $\hat{\mu}_g \pm 2\hat{\sigma}_g$ of the number of ethnic groups for a particular value of the cultural proximity parameter δ.

Besides the number of ethnic groups, we have studied the size of these groups. In general, the group size distribution seems to follow a sort of power law with one significant large ethnic group and several small ones. Fig. 2 shows the limiting size of the largest ethnic group for the same values of θ and δ. The results are coherent with the conclusions commented before. Modulated by the cultural proximity parameter δ, the effect of increasing returns to cooperation is to facilitate the emergence of a large ethnic group. Once again, the replication process imposed on the model accentuates the returns of large groups giving them more reproductive success.
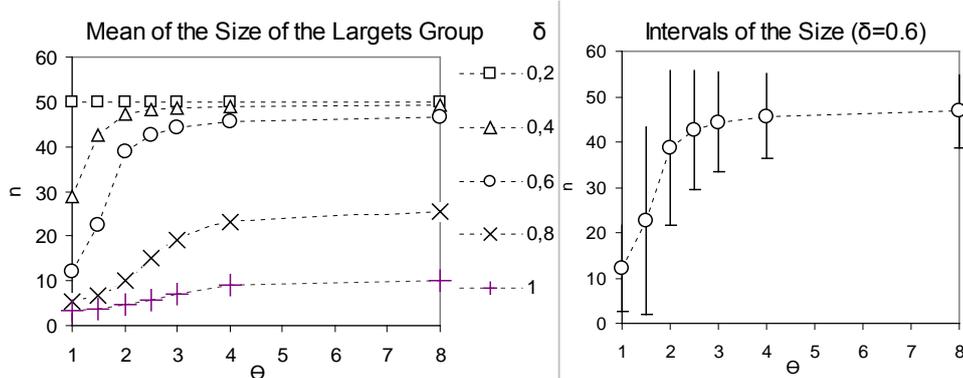

Fig. 2. The graph on the left depicts the estimation of the limiting mean of the size of the largest ethnic group in a population of n=50 households when we vary the parameters θ and δ; the graph on the right shows the corresponding intervals of the size of the largest ethnic group for a particular value of the cultural proximity parameter δ.

5 Conclusions

Hunter-gatherer societies have been traditionally defined in opposition to others and not internally, in terms of social and economical factors which affected the way they actually lived. The very concept of "ethnicity" has been misunderstood, considering that it is simply a marker trait imposed by neighbors, which hardly captures the notion of what organizes internally the group. On the opposite, we think that "ethnicity" is a dynamic social mechanism that forms and deforms the actual organization of the social group, and never finishes of conforming new ways of social organization.

Our simulated model represents a first step in a more ambitious research project that intends to simulate social, economic and political decisions in prehistoric hunter-gatherer groups in Patagonia. In any case, preliminary results allow us to consider an alternative explanation of cultural diversity in prehistory.

The model is based on a simplification of the way Patagonian hunter-gatherer acted in the ethnographic present and through their historical past. We assume that households moved around randomly, interacting with similar households on the grounds of a "cultural" trait list transmitted by imitation with mutation. It is obvious that none of this has any counterpart in actual hunter-gatherer societies. In the ethnographic-historical reality, families were typically divided into camps or residence groups composed of a number of households with cultural criteria for membership. When programming individual households as virtual agents moving around randomly and establishing social and economic ties with other agents, we intend to build an artificial society from the bottom up, considering the actual mechanisms that allowed the complex integration of different production/reproduction units unto a single "residential" group, with an apparently defined "cultural" core, but in fact very unstable, integrating new families and rejecting old groups when social and economical conditions al the local scale changed. And this is a fact well proved in ethnographic information: local groups emerged and disappeared as long as individual families decided to collaborate with other families or abandoned the group when new opportunities were available (Coan 1833, Musters 1873).

The historical dialectics of fusion and fission of social groups constituted an important characteristic of the social process in Patagonia, and probably among hunter-gatherers all over the world. In this way, we can understand the prehistoric formation of cultural and linguistic frontiers, especially in the case of relative economical homogeneity. More than geographical isolation and local adaptation, we suggest the irregularity in interaction flows as a consequence of variations in the productivity of economic cooperation and collaborative labour would have affected social reproduction. Population dynamics in an extremely extensive territory, the flexible degree of residence mobility, and occasional changes in natural productivity explain the prevalence of intra-group social interaction, although long-range social exchange networks were also extant.

As a result, ethnic, linguistic, cultural, economic, and even territorial frontiers were extremely permeable among hunter-gatherers, suggesting a considerable degree of population mixture and Patagonians were not an exception. Local groups adjusted

their interaction mechanisms (conflict, war, marriage, exchange, alliance, slavery) according to their concrete historical conditions and the changing nature of their social relations of production.

There is no doubt that ethnicity evolution is a complex phenomenon, and therefore it is necessary to consider more social and historical details in our particular story of ethnogenesis in hunter-gatherer groups. But, in order to reach that sort of knowledge, simple models like the one proposed in this paper are useful to understand how diverse hypotheses operate in more complex formalizations.

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