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Comparing Two Models of Cultural Standardization Emergence in Hunter Gatherer and Sedentary Societies

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In this contribution we present some experimental results of two ABM models implemented to simulate how cultural identities and cultural standardization may have emerged in a prehistoric past as a consequence of the everyday-life interactions in hunter-gatherer or sedentary early complex societies. Our models are based on archaeological data from ancient Patagonia in South America and Late Bronze Age in Europe. Our purpose is to analyze how diversity and self-identification may have emerged in the small-scale societies of our prehistoric past. We have not built realistic models of cultural diversity and ethnogenesis but just explored some possible consequences of theoretical assumptions. We have not modeled the decision process from the point of view of individuals, but at the level of the population. Social dynamics has been formulated as a set of factors constraining action. The agent does not decide, but probabilities for action are re-calculated at each cycle as soon as local conditions change. This is not a mistake, nor a limitation. It is a way of analyzing the consequences of actions without regarding the cognitive causes of action.

We consider that as a consequence of different forms of social interaction and exchange between related individuals cultural consensus may emerge, and human groups can aggregate into greater groups culturally homogenous, what affect social reproduction, increasing similarity in the long run, and reducing the risk of being attacked by groups identified as “enemies” (out of the new cultural consensus).

In the case of hunting and gathering societies, technology and knowledge about how to interfere with natural productivity were limited. In such conditions, humans were conditioned by their environment and, because of their extreme dependence to local carrying capacity and diminishing returns from labor; they were obliged to constant geographical mobility, given that they could not restore what they extracted from nature. In such conditions, the more people interacted in looking for animals and participating in collective strategies, the better, because it contributed to increase labor efficiency. On the other hand, sedentary societies substituted territorial mobility by sedentariness, and agriculture. The relevance of technology (metal tools) was higher, and the nature of social interaction (both exchange and war) more complex. But also in those circumstances ethnicity appears as long-term cultural standardization that influence the updating of social identities and the possibilities of economic cooperation.

In our Hunter and Gatherer simulation, agents are modeled as a number of individuals acting as a decision unit, that is, what we usually name “family” in real live, and what anthropologists define as “domestic unit” or “household”. They are defined in terms of their LABOR (l_i) and CULTURAL IDENTITY. Each agent has its own TECHNOLOGY (β_i), an ENERGY-CONSERVATION factor (d_i) expressing the efficiency of storing and preservation methods, and a SURVIVAL THRESHOLD ($\bar{e}_i$), defined on the basis of an individual needs of 730 kilocalories per year (2000 calories per day). The sedentary society simulation is defined around AGENTS that represent regions, defined in terms of the statistical mode of all archaeological sites within a determined buffer zone. Such virtual “geographical regions” are defined in terms of their population, that is, the number of labor units, cultural identity and the number of tools people living in the region have at the current time. Additional attributes and parameters are the amount of produced food, the surplus of food the agent can accumulate and the survival threshold, which depends on the number of labor units within the agent. Each agent (Region) is connected to other through cost-weighted geographical distances, in such a way that there are no possibilities of Random connection between them. Distances based in cost-weighted models try to define the least costly path to reach each known point using the path with least accumulated travel cost.

Among the specificities of our models, there is the way we are dealing with the very idea of CULTURAL IDENTITY. We have adopted the classical Axelrod approach using a vector of X dimensions that represents an organized list of meanings, values, beliefs and symbols inherited at birth, learnt within the evolving group, modified all along the life of the agent and transmitted to the new generation.

In both cases, we have imagined a world without topographical barriers, where resources are irregularly distributed across geographical space, and with a founding population having a single homogenous identity, with a constant, but random internal change rate. At each patch, resources vary in their abundance and in their difficulty of acquisition. There are also seasonal variations. Resources at each patch have also a DIFFICULTY level (h_i). It is a uniformly distributed parameter counting the difficultness of resource acquisition (the more mobile the resource –animals- and the less abundant, the more labor or more technology is needed to obtain resources up to survival threshold.

One time step (cycle or "tick") in the simulations roughly represents what an agent is able to do and move in six months. Different sub-processes are responsible for all system dynamics: agents hunt-and-gather, produce food and exchange or make war to survive and they use existing interaction flows to decide whether *cooperate*, exchange or steal the other. Consequently, they need to *identify* other agents and build social networks, which evolve to configure *social aggregates*. Within such aggregates, identity evolves and updates, and it is transferred to new born agents when *reproducing.*

> SURVIVE: Agents use of their accumulated surplus to survive, and when it is not enough, they are obliged to hunter and gather or to produce food by agriculture
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> HUNT-and-GATHER. Energy is obtained by agent *i* by means of labor ($l_i(t)$) with the contribution of its own technology, whose efficiency is estimated as β_i(t).
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> PRODUCING FOOD (AGRICULTURE). Food is produced by labor, which has always the same efficiency. However, there is a variable parameter representing local conditions of soil quality, water availability, etc., whose effects should be compensated using technology, which vary from agent to agent, and between time-steps.
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> EXCHANGE: When produced food is not enough because of low supply of labor or technology, or the high local difficulty of producing food, agents ask other agents for part of their surplus or the part of their technology they do not need. It is important to take into account that technology loses its efficiency at each cycle, and it should be substituted from time to time. In some scenarios, the only way to renovate technology is through exchange or robbery. Asking for help in the form of produced food or produced tools is mediated by the actual identity similarity and weighted by cost-distance.

Identity similarity should be calculated at each time on the basis of the binary vectors containing all we know about material culture. It should be taken into account that such identity is in constant renegotiation and updating. When identifying other agents in the area, each agent calculates the normalized Euclidean or Hamming distance between each pair of identity vectors. The Hamming distance between two strings of equal length is the number of positions at which the corresponding symbols are different. How big should be this similarity value to allow cooperation between agents or increase the probabilities of being attacked? Agents calculate at each time a Similarity Threshold on the basis of the percentage of consensus needed, depending on how much they need food or tools from others to survive. The more at risk they found themselves, the less tolerant to the others difference.

But Cultural similarity is not enough. Even in the case of a similarity above the similarity threshold, the agent with food or technology in excess should decide whether the proposed exchange has long term benefits: the more the actual cultural consensus, the less risks of being attacked later. We have modeled this decision in terms of a variation of the classical Prisoner's Dilemma.

In case there are no agents with a cultural similarity above the actual value of similarity threshold to exchange food and/or technology, the agent may steal what culturally different agents have produced. The agent selects the nearer agent (in terms of cost-weighted distances) with the maximum cultural difference, and attacks if it expects it will win because it has more warriors and weapons.

Cultural identity is in a state of constant updating and modification. We have implemented two mechanisms, a random parameter simulating local change, invention or variation within a community, and a collective mechanism of cultural consensus formation, in such a way that cooperating agents update their culture towards the coincidence with the more successful agent in producing food and/or technology

Preliminary Results. We have calibrated our models to historical data in the sense proposed by Epstein (2008). In general, our simulations show that social aggregates emerge constantly as a consequence of the benefits of cooperation at work (communal hunting or food/technology exchange). As a result of economic interaction, agents aggregate in space, configuring what we can consider social networks of cooperation. Such networks constitute an initial form of ethnogenesis. Network embeddedness means that everybody did not interacted equally with everybody else, but was constrained by needs (expected benefits), geographical neighborhood and prior cultural consensus (common history). Agents within the network interacted among themselves more often than with others out of the network, which means that a subset of the population may be excluded from positive interaction and hence the process of similar identity negotiation and innovation diffusion.

The degree of ethnicity and cultural standardization has been measured in our simulations in three steps: fractionalization, generalized resemblance and demographic polarity. Fractionalization measures the probability that two randomly drawn agents belong to two different groups (*ethnia*). It gives us a measure of the *depth* of the divisions that separate members of one group from another, which is a necessary factor for inferring *social tension.* Those results should be interpreted as the expected dissimilarity (in Euclidean distance terms) between two randomly drawn individuals.

In the cases we have explored, the poorer the world, the higher the expected dissimilarity. When the world seems rich enough and fractionalization is less conspicuous, expected similarity is far greater. These results seem to be concordant with the process of cultural hybridization. What appears to be fractionalized when resources were scarce and concentrated became homogenized when technology increased suddenly its efficiency (imported colonial items, horse domestication) and resources increased by foreign factors.

Generalized resemblance does not solve our problem about the emergence of segregation and territoriality when group fractionalization increases. “Polarization” is needed to transform difference into competition. It is here calculated in terms of the “distance” between two groups corrected by the sizes of each group in proportion to the total population. Results capture how far the distribution of social aggregates may be from a bipolar case. In any case, although never very high, demographic polarization attains higher values when the world has the more abundant resources, and when fractionalization has low values. These results contrast with the expected increased territoriality as a consequence of resource scarcity and spatial concentration.

CONCLUSIONS

Our model is in the lineage of Axelrod essays to understand the Diffusion of Culture and its effects. Axelrod modeled a population of actors holding a number of cultural attributes which interacted with culturally similar neighbors as interaction partners to suggest an idea of homophily. Our model differs in important aspects: mobility and transmission of cultural features are allowed; Culture is not fixed, but evolves as soon as cooperation appears to be advantageous; Random cultural drift simulates internal process in addition to external interaction ; Survival depends on cooperation ; Cultural transmission depends also on survival and hence on cooperation; Cooperation and reciprocity depends on the probabilities of survival

We propose an analytical view of *ethnicity*, based on the idea that the emergence of identity is a consequence of the very fact that some individuals interact more often with a restricted group of people than with people out of that group. That means that people embedded in social networks interact with a subset of population and define themselves in terms of the similarity with the people they interact. So both “ethnogenesis” -as a collective process- and “identity formation” -as an individual process- could be understood as emerging results of stress between a set of contradictory forces: (a) *social inertia*, as knowledge acquired by direct inheritance, (b) *cultural consensus*, as knowledge socially built during cooperation and labor exchange, and (c) *cultural innovation*, as knowledge adaptively acquired and built during isolated problem-solving situations.

Cultural differentiation existed in prehistory, but cultural groups adopted the form of networks of cooperation and exchange instead of “nations” in the modern style with clear-cut and well defined borders and frontiers.