Repression of Satisfaction as the Basis of the Emergence of Old World Complex Societies

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History has seen many empires across all lands. Empires are various communities and groups with different cultures and ethnicities, expanded over large areas of land and ruled by the same polity. The main objective of this paper is to increase our understanding of the formation of Old World complex societies from primitive societies, using agent-based modeling. Sigmund Freud considers that civilization could not exist without the restraint of human desires. The repression of satisfaction is the prerequisite for progress and the formation of civilization. For individuals to cooperate in a large group, it is necessary to repress some desires and respect norms to keep harmony in the group. This will lead to the increase of group progress and the formation of huge and complex societies.

In this paper, we describe a theoretical agent-based model that explains the rise of Old World complex societies through Freud's model. The main assumption of our model is based on the following causal chain: intensification of warfare → more repression of satisfaction (social norms and institutions) → more progress → increasing group productivity → rise of Old World complex societies.

Keywords: agent-based modeling; repression of satisfaction; cooperation; competition; Old World complex society

1. Introduction

Civilizations first appeared in river valleys, because of fertile land and excess of water that favored intensive agriculture. Governments, states and empires arose when a minority took over the majority of resources and made themselves rulers of great territories. They often used social institutions and norms—that were usually based on religious beliefs and behaviors—to maintain social cohesion and keep their power over larger areas.

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History has seen many empires across all lands. Empires are various communities and groups with different cultures and ethnicities, expanded over large areas of land, and ruled by the same polity [1]. Since the Bronze Age, many large societies have appeared and disappeared in a continuous sequence. The first appearance of large societies was due to the competition between nomads and agrarians. Pastoral nomads attacked settled agriculturalists to take agricultural products by force. Agrarian communities needed to cooperate to defend their products and territories. And then, nomadic pools had to collaborate together to get the odds in their favor again, and so on. They realized that external competition reinforces the cooperation within groups and extends the ultra-social norms and institutions [2].

Ultra-sociality is used to describe the capacity of large groups of individuals to live and cooperate with each other, without any genetic relation between them. It is the reason for the coherence and the power of the society [3]. Turchin's theory was largely inspired by Ibn Khaldun's theory of collective solidarity (*asabiyyah*). According to him, those ultra-social norms and institutions can evolve and be maintained because of competition and warfare between societies [3]. The main assumption of his model is based on the following causal chain: *spread of military technologies → intensification of warfare → evolution of ultra-social traits → rise of large-scale societies*. Turchin et al. [3] built an agent-based model to explain when and where large-scale societies emerged in the Old World. They represent ultra-social traits and military technology, respectively, by two binary vectors (presence and absence of a trait). U contains n_{ultra} ultra-sociality traits and M contains n_{mil} of military technology traits. The power of a polity i depends on the number of ultra-sociality traits that are equal to 1, as well as the size of the polity [3]:

$$\text{Power}_i = 1 + \beta S_i \overline{U}_i, \tag{1}$$

where

$$\overline{U}_i = \frac{\sum_k \sum_j u_{jk}}{S_i}.$$

S_i is the size of the polity and β is a parameter of the model.

Power is responsible for winning an attack, and military technology is responsible for ethnocide (the defeated cell will copy the ultra-sociality traits of the winning polity) [3].

Another agent-based model suggested by Guzmán et al. [4] proposes that the evolution of intensive agriculture could explain the appearance of complex societies. The grid cells of the model are considered as an isolated zone, occupied at the start only by simple societies [4]. The isolated zone is divided into two areas: the core land (where intensive agriculture is feasible) and the marginal land (a harsh area). They differ in production methods, type of land, living habits and strategies of war. The model introduced three successive eras consistent with historical data. In the first, simple societies occupied all the land using extensive agriculture, and small complex societies appeared using intensive agriculture, but they collapsed shortly after. In the second era, complex societies coexisted with simple ones. However, complex societies disappeared fast, for reasons of war, collapse and annihilation. Sometimes, they even collapsed all together at once. Finally, the third era arrived, which is characterized by the dominance of large, complex societies that are expanded on the core land. The simple societies, on the other hand, are limited to marginal land (steppes, mountains, deserts, forests, jungles, etc.) [4].

2. Cooperation as Basis of Societies

Evolution is any genetic change in organisms from one generation to the following generations [5]. Biological evolution was explained by Darwin's theory of natural selection. The theory of natural selection states that creatures with characteristics that are more suited to their environment are more likely to survive and reproduce, passing their genes to following generations [6].

Later, a new type of natural selection was proposed, kin selection, also known as "inclusive fitness." This theory suggested that natural selection can favor cooperation between relatives. Organisms that help their offspring and sacrifice for their relatives will have a greater chance to prevent the extinction of their genes [7].

In nature, scientists observed altruistic behaviors between different species with no genetic relation. This was the basis for the theory of group selection, also known as multilevel selection theory. The principle of this theory is that natural selection can act on multiple levels of organisms (e.g., in groups) and not only on individuals [8]. Cooperation may be disadvantageous for the individual—if it is done at the expense of one's own interests—but it benefits the group by giving it an advantage over other groups.

Other scientists tried to explain more fully how cooperation evolves in nature. They defined rules and models for the evolution of cooperation. Nowak defined five mechanisms for the evolution of cooperation: (a) *kin selection*: cooperation with relatives; (b) *direct reciprocity*: if you cooperate, I cooperate; (c) *indirect reciprocity*: cooperate to have a good reputation—an individual that helps others is more likely to be helped; (d) *network reciprocity*: the group of cooperators surpasses defectors; (e) *group selection*: a group of cooperators has more chances to be successful than a group of defectors (competition is also between groups) [9]. In [10] Sachs et al. offered three models to understand how cooperation can evolve and be maintained: (a) *direct reciprocation*: if you cooperate, I cooperate; (b) *shared genes*: kin selection, cooperation with relatives; (c) *byproduct benefits*: cooperation is just an unplanned result of a selfish act [10].

Another interesting framework for understanding cooperation in biological and social organisms is the theory of games. Game theory is a framework for studying the possible strategies to use in a game between competing players, first developed by von Neumann and Nash, as well as economist Oskar Morgenstern [11]. For example, the prisoner's dilemma is a good game for studying cooperation and defection between individuals [12]. Axelrod and Hamilton, after testing different types of strategies against each other, such as TIT FOR TAT (if you cooperate, I cooperate; if you defect, I will defect), ALL D (always defect no matter what the other does), ALL C (always cooperate) and other more complex strategies, found that for a single-tour game of prisoner's dilemma, it is absolutely better to defect, but in a repeated game, it is better for the players to cooperate with each other than to defect [12].

Besides cooperation, repression of competition is also considered as a principal process of the evolution of complex societies. Complex societies and the evolution of larger group sizes are due to the suppression of reproductive competition for humans [13, 14]. Alexander argued that the repression of competition within the group and the growth of competition between groups (group against group) helped the spread of human social structures [13–15]. In all cases, reducing competition inside the group facilitates the promotion of group fitness and increases the average of successful members in the group. Despite that, repression of competition within groups is not always privileged in natural selection. In nature, individuals are usually forced to compete with their neighbors to get the maximum of resources, causing low fitness for the whole group and low average success of the group members. The dilemma here is how, even if natural selection favors selfish behaviors and competition, the traits of internal repression keep evolving in nature [16, 17]. Frank proposed a model for repression of competition that studies the progress of two traits. The first is the competition intensity of individuals in the group, represented by the variable z. The second is represented by the variable a, and is called mutual policing, which is the individual's contribution to repressing competition and selfishness in the group. It is called "policing" or "punishment" according to the context [16].

An intense competition between individuals of a group reduces the group's overall efficiency and destroys the shared resources. Frank defined the fitness of an individual by (first model based on competition) [16]:

$$w_{ij} = \left(\frac{z_{ij}}{\overline{z}_i}\right)\left(1 - \overline{z}_i\right), \tag{2}$$

where w_{ij} and z_{ij} are the fitness and the intensity of competition, respectively, for the j^{th} individual in the i^{th} group, and $\overline{z}_i$ is the average competitive intensity for members of the i^{th} group. $z_{ij} / \overline{z}_i$ is the benefit to an individual of the group resources, $1 - \overline{z}_i$ is the average productivity of the group—if the group is very competitive, $\overline{z}_i$ is high, and the average group fitness $\overline{W}_i = 1 - \overline{z}_i$ will be reduced [16]. If there is a genetic relation between the group's members (kin selection), it is more likely that the members may cooperate and compete less, which will increase the group success. But the problem is that the genetic relation between group members of different generations is often low, because of mixing within the group and mutation. Therefore Frank explains the evolution of cooperation by the repression of competition and defines mutual policing a as a mechanism that reduces competition among all members. The new fitness function will be [16]:

$$w_{ij} = \left[\overline{a}_i - c a_{ij} + \frac{\left(1 - \overline{a}_i\right) z_{ij}}{\overline{z}_i}\right]\left[1 - \left(1 - \overline{a}_i\right)\overline{z}_i\right], \tag{3}$$

where a_{ij} is an individual's participation in mutual policing, $c a_{ij}$ is its cost, and $\overline{a}_i$ is the average amount of policing in the group. The opportunity for gain by the victor and the harm to local resources are both decreased in every interaction that is potentially competitive. They are represented by $\left(1 - \overline{a}_i\right) z_{ij} / \overline{z}_i$ and $\left(1 - \overline{a}_i\right)\overline{z}_i$, respectively [16].

Sigmund Freud considers that civilization could not exist without the restraint of human desires. The repression of satisfaction is the prerequisite for progress and the formation of civilization [18]. In this paper we propose a theoretical agent-based model to explain the rise of Old World complex societies through Freud's model. The main assumption of our model is based on the following causal chain: intensification of warfare → more repression of satisfaction → more progress → increasing group productivity → rise of Old World complex societies.

3. Social Simulation

Social simulation is a new approach that uses computer-based methods and technologies to simulate human social behaviors in different social situations. It is described as the third way of doing science,

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besides deductive and inductive methods [19]. The purpose of social simulation is to better understand a social phenomenon or to predict its evolution [20]. Social simulation is used every time the social phenomenon is complex and nonlinear, so that it cannot be studied with classical mathematical equation-based models. The importance of social simulation is mostly due to its ability to offer simple explanations for complex phenomena that resist theoretical understanding.

The most-used methods in social simulations are based on two approaches, according to the abstraction level. The first one, called "top-down," is a holistic approach. The methods based on this approach are included in the superclass of *variable-oriented* social simulation, also called *equation-based* social simulation [21]. The second one, called "bottom-up," proposes to explicitly model the behaviors of entities by considering that the global dynamics of a system at the macroscopic level results directly from the interaction of behaviors at the microscopic level [20]. The bottom-up approach is an alternative approach that models the social system as interactions between adaptive agents that influence each other in response to the influence they receive. Certainly, one of the key points of this approach is the emergence of macro-level phenomena from actions and interactions at the micro level [22, 23]. This approach argues that simple and predictable local interactions can generate global behaviors such as the spread of information, the emergence of norms or participation in collective actions.

Agent-based modeling (ABM) is a bottom-up approach to social simulation, also called *social multi-agent systems in computer science*. ABM is composed of three basic ingredients: agents, environment and rules. *Agents* are generally human actors (can be individuals or communities) represented as agent objects that have attributes and methods. *Environment* is the place where the agents are placed, and they can exploit it and interact with it. Lastly, *rules* are the guidelines for agent and environment behaviors. There are three types of rules: (a) *inter-agent rules*: govern the interactions between agents; (b) *agent-environment rules*: control the impact of environmental conditions on agents and vice versa; (c) *intra-environment rules*: control the change of biophysical elements of the environment [21, 24].

4. Methods

In this paper, we propose a theoretical agent-based model that explains how Old World complex societies emerged in human history. The simulation space is a grid of cells. At the start of the simulation, each cell will be occupied by a polity (independent community).

Each polity i in each time step t is characterized by a binary vector of satisfaction traits $\pi^i(t)$, contains n_{sat} traits,

$\pi^i(t) = \left(\pi^i_{n_{\text{sat}}}(t), \ldots, \pi^i_2(t), \pi^i_1(t)\right)$ where $\pi^i_k(t) \in \{0, 1\}$ $\forall\, k \in \{1, \ldots, n_{\text{sat}}\}$, where n_{sat} is a parameter of the model. We note $\pi^{ij}(t) = \left(\pi^{ij}_{n_{\text{sat}}}(t), \ldots, \pi^{ij}_2(t), \pi^{ij}_1(t)\right)$ is the binary vector of satisfaction traits in the i^{th} polity of the j^{th} group (multicell polities). At the beginning of the simulation, satisfaction traits in all primitive societies (simple societies—uncivilized societies—absence of social norms and institutions) are set to 1.

Freud said: *"It is impossible to overlook the extent to which civilization is built up upon a renunciation of instinct, how much it presupposes precisely the non-satisfaction (by suppression, repression or some other means?) of powerful instincts."* [18]. In this model, we suppose that the transition from primitive society to Old World complex society requires the repression of satisfaction. Losing satisfaction traits allows groups of communities to work and function together without separating. Communities are grouped within multicell polities. In this model the agents are autonomous polities. An agent can represent a simple society (polity) or a complex society (multicell polities).

The *satisfaction intensity* $\pi^{ij}(t)$ for the j^{th} individual (polity) in the i^{th} group (multicell polities) is the average value of satisfaction traits of the j^{th} individual:

$$\pi^{ij}(t) = \frac{1}{n_{\text{sat}}} \sum_{k=1}^{n_{\text{sat}}} \pi^{ij}_k(t), \tag{4}$$

where $\pi^{ij}_k(t)$ is the value of satisfaction trait in the k^{th} locus of the polity j of the group i.

The *fitness function* w_{ij} of a polity (individual) j of multicell polities (group) i is inspired by Frank's model in order to model the Freudian repression of satisfaction [16]:

$$w_{ij}(t) = \left[\overline{\sigma}_i(t) - c\sigma_{ij}(t) + \frac{\left(1 - \overline{\sigma}_i(t)\right)\pi^{ij}(t)}{\overline{\pi}_i(t)}\right]\left[1 - \left(1 - \overline{\sigma}_i(t)\right)\overline{\pi}_i(t)\right], \tag{5}$$

where $\sigma_{ij}(t)$ is an individual's participation in the mutual repression of satisfaction, which has a cost $c\sigma_{ij}(t)$ to the individual (cost to live in a group). c is a parameter of the model. $\overline{\sigma}_i(t)$ is the average level of the suffered repression by the polity i from its neighborhood [25–27]. And $\overline{\pi}_i(t)$ is the average satisfaction in the group i:

$$\overline{\pi}_i(t) = \frac{1}{S_i} \sum_j \pi^{ij}(t),$$

where S_i is the polity size (the number of communities).

In the case of simple polity i (one independent community), $w_i(t) = 1 - \pi_i(t)$, where $w_i(t)$ and

$$\pi_i(t) = \frac{1}{n_{\text{sat}}} \sum_{k=1}^{n_{\text{sat}}} \pi_k^i(t)$$

are the fitness function and the satisfaction intensity of the polity i, respectively.

The individual's contribution to the mutual repression of satisfaction $\sigma_{ij}(t)$ is defined as:

$$\sigma_{ij}(t) = \frac{\overline{\sigma}_i(t)\pi^{ij}(t)}{\overline{\pi}_i(t)}. \quad (6)$$

The *polity's power* is defined by:

$$\text{Power}_i(t) = \beta S_i \overline{w}_i(t) + 1 \quad (7)$$

$$\overline{w}_i(t) = \frac{1}{S_i} \sum_{j=1}^{S_i} w_{ij}(t), \quad (8)$$

where $\overline{w}_i(t)$, S_i and β are, respectively, the average fitness of the group i, the polity size and the coefficient that interprets the repression of satisfaction into the polity's power.

The *suffered repression* is defined by:

$$\overline{\sigma}_i(t) = \frac{\sum_{j \in V_i} \text{Power}_j(t-1)}{|V_i|}, \quad (9)$$

where V_i and $|V_i|$ are the set of neighboring societies of the polity i and the cardinality of V_i, respectively (see Figure 1).

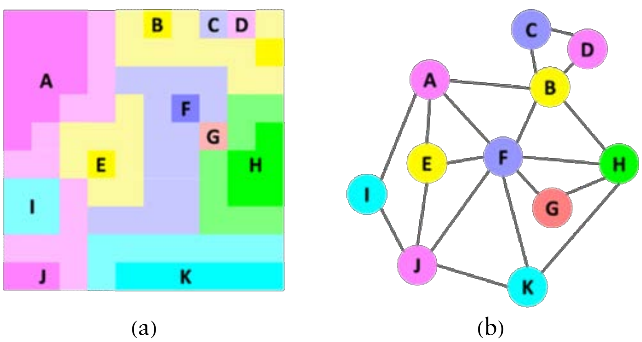


Figure 1. The network in (b) represents the neighbors of each society in (a). Source: [4].

4.1 Interpolity Wars: Multicell Polities' Rise and Expansion Process

In this version, battles take place in a random sequence. An iteration starts by randomly choosing a polity/agent from the ensemble of all polities to be the attacker polity. The same polity can be chosen again in the next iteration, because it will still be in the ensemble of polities. However, this ensemble can change from one iteration to another because the polities change after conquering cells (see Figure 2). To be specific, V_i can denote the set of neighboring polities of the attacker agent i.

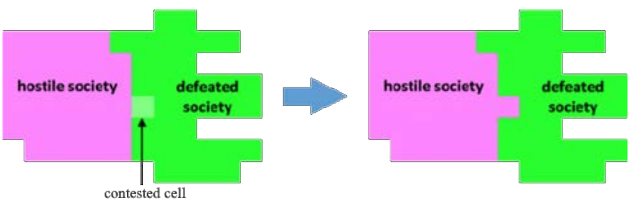
The decision that an agent/polity i (randomly selected) attacks another agent/polity j in its neighborhood is made after considering the probability of winning calculated as follows for each j polity in V_i (inspired from gravity model [28]):

$$p_{ij}(t) = \frac{\left(\text{Power}_i(t) \,/\, \text{Power}_j(t)\right) \cdot \alpha}{\sum_{k \in V_i} \text{Power}_i(t) \,/\, \text{Power}_k(t)}, \tag{10}$$

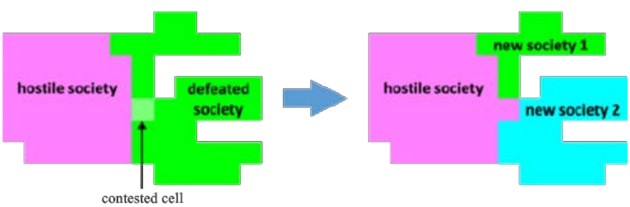
where α is a random variable in $[0, 1]$.

The probability of agent i attacking agent j increases with the increase of p_{ij}. In the case of a successful attack, one contested cell of the defeated polity (chosen randomly from the frontier cells between the two polities) will be added to (annexed by) the attacker polity.

When the annexed cell is added to the winning polity, the losing one may maintain the unity of its remaining territory, or disappear if it was a one-cell polity, or be divided into two or three new polities separated by the annexed cell that is now a part of the winning polity. Figure 2 represents examples of this polity division [4].



(a) The attacking (*hostile*) society seizes the contested cell but it does not divide the defeated society.



(b) The attacking (*hostile*) society seizes the contested cell and divides the defeated society in two.

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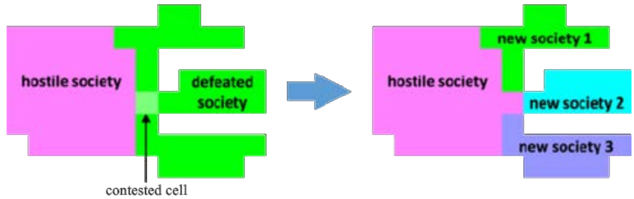

(c) The attacking (*hostile*) society seizes the contested cell and divides the defeated society in three.

Figure 2. A defeated society can split up when one of its cells is captured. Source: [4].

4.2 Sociocultural Dynamics

The dynamics of satisfaction traits are controlled by two mechanisms: mutation and forced cultural assimilation [3]. Mutation's process is: at every time step, the satisfaction traits that equal 0 may change to 1 with the probability μ_{01}, and traits equal to 1 may change to 0 with the probability μ_{10}. We assume that losing a satisfaction trait is very costly compared to gaining one $\mu_{10} \ll \mu_{01}$, because we consider losing a satisfaction trait as obeying the norms and rules of society [3]. Cultural assimilation can happen if a defeated cell is added to the winning polity. The new satisfaction $\pi^{ij}(t) = \left(\pi^{ij}_{n_{\text{sat}}}(t), \ldots, \pi^{ij}_2(t), \pi^{ij}_1(t)\right)$ of the annexed cell will be updated as:

for each $k \in \{n_{\text{sat}}, \ldots, 1\}$,

$$\pi^{ij}_k(t) = \begin{cases} 0 & \text{if } \frac{1}{S_i} \sum_{k=1}^{S_i} \pi^{ij}_k(t) < 0.5 \\ 1 & \text{otherwise.} \end{cases} \tag{11}$$

4.3 Internal Conflicts in Complex Polity: Civil Wars and Collapse

Civil war is a risk for large, complex polities. If the average satisfaction in the complex polity i is superior to a critical threshold γ (a parameter of the model), the polities of the complex polity start a civil war, and the complex society divides into two polities [4]. This division is random.

Each polity i with size superior to two may collapse into separated polities with territories of one cell each, with probability p_i at every time step [4]. The probability of this disintegration rises with the polity size S_i and falls with the average fitness w_i [3, 4]:

$$p_i(t) = \delta_0 + \delta_1 S_i - \delta_2 \overline{w}_i(t), \tag{12}$$

where δ_0, δ_1, δ_2 are parameters of the model. The probability of disintegration is limited to between 0 and 1.

5. Conclusion and Perspectives

In this first version, we try to understand how societies evolved from mini-groups of individuals to huge groups. For this purpose we consider repression and competition as key factors contributing to the evolution of cooperation within a group. One of the main reasons for maintaining the cooperation inside groups is the competition between different groups. Individuals of one group have to cooperate with each other in order to reinforce the group's power and be able to compete with the other groups. However, to reinforce this cooperation, the group needs to repress satisfaction. For individuals, to cooperate in a large group, it is necessary to repress some desires and respect norms to keep harmony in the group. This will lead to the progress of the group and the formation of huge and complex societies.

The next step will be to implement the model in a realistic geographical environment and validate it with historical data.

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