Community rituals promote the self-organization of cooperation: The case of the Otomí, Mexico

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1 Introduction

Rituality and religion are among the hallmarks of human culture. They have been object of intense research from a variety of disciplines such as Sociology, Anthropology, Psychology, Philosophy and Economics. Since the work of Emile Durhkeim on religion [1], it has been suggested that religion and rituality have played an important role in promoting social solidarity and cooperation. Ethnographic records and experimental data continue to support these ideas, at least in general. Two competing hypothesis based on the idea of cultural evolution can be identified.

Some approaches suggest that religion is either an adaptation *per se* why? examples!!![2]. But for the majority of researchers, its origins may be found in the convergence of a set of by-product of some other cognitive adaptations. For those who endorse the view that religion is a by-product, cognitive adaptations relate to the detection of other minds as proposed by the *Theory of the Mind* approach and may include the capacity to detect and *inferring the content of other minds and sensitivity to one's prosocial reputation* (look at [3, 4, 2] for a list of prosocial cognitive adaptations). Regardless of whether religion arose as an adaptation or a by-product, both perspectives are in agreement that religion plays an important role in promoting cooperative behaviors, even to strangers and to nonkin group members. They also coincide in situating their explanations exclusively at the timescales of individual psychology, cultural evolution, and biological evolution, while social dynamics taking place at the level of the community as a whole are rarely taken into account.

Rituality is particularly interesting from an evolutionary perspective because it implies a behavior that may have a cost to the individual without having any immediate benefits. The question regarding rituality is that non-related individuals get engaged in an activity in which personal material interests are sacrificed. According to Nowak (2006), in a world of selfish agents kin selection, direct reciprocity, indirect reciprocity, group selection and network reciprocity are the five rules for the evolution of cooperation. But when it comes to rituality it is hard to understand how such an altruistic behavior is displayed towards an immaterial and imagined authority. For these reasons some believe that for the case of rituals there must have been evolutionary pressures to favor religious commitments in which costly behaviors are difficult to fake (Norenzayan & Shariff 2008).

It has been suggested that these five rules may fall short due to population size. It is argued that human populations are too big for kin and group selection to be effective ways of maintaining cooperation among agents as genetic distances increase between individuals. Reciprocity may be equally ineffective to keep an eye on trustworthiness reciprocation (Norenzayan & Shariff 2008; Atran & Henrich 2010). Indirect reciprocity may be a candidate answer but during rituality is common to find that there are sacrifices that represent a loss that seems counterintuitive in terms of any immediate utility gain and sometimes sacrifices are extreme, as abundantly documented by anthropologists (Atran & Norenzayan 2004, Raymond Firth 1963, Evans-Pritchard 1940; Rappaport 1968) (need to explain better— Do we know of any examples of ritual self-sacrifice? That would be the ultimate argument against indirect reciprocity since you are not going to be alive to see any benefits! ;-)).

In this context, rituals have been seen as promoters of prosociality in the community, working as honest vehicles for expressing social commitment. Rituals play the role of being hard-to-fake behaviors that would prevent freeloaders to take advantage of the community. Devotional behavior and sacrifices makes possible to send a message of commitment and self-sacrifice towards ingroup members (Sosis & Bressler 2003; Atran & Norenzayan 2004). [1]

[1] It is important to notice that linkage of religion and cooperation has been proposed for large societies. For the case of small groups cooperation based on kinship and reciprocity seems to work fine. Nevertheless, leaving open the question about rituality and religion for such small societies or when a group is a small group. It is also worth noticing that no evidence or formal proof of the size argument was cited. Another issue is that non of

Costly behavior in rituals may have different cultural expressions but it is very common, and perhaps invariable (Atran & Norenzayan 2004), that rituals include hierarchical display and submission to the supernatural to which even the high ranked individuals are submitted. During rituals, individuals are subject of humiliation, temporal social exclusion, loss of social status and ambiguity (among others), all these being part of what Turner called anti-structure during rituals [5]. As costly behavior, they may be a signal of commitment and complience towards the community and to social norms, but this psychological account leaves out potential effects on the level of the community as a whole. As anti-structural behavior, a systemic (systems) perspective would conceptualize them as organizationally meaningful in that they have the power to move the system away from basins of local optima and facilitate the exploration of attractors for global optima. This is the perspective we will investigate.

In this paper we advance a model in which selfish agents (but belonging to the same group) self-organize to cooperate or optimize the group global gain. Our particular approach doesn't start from the cultural evolution and psychological functions of rituality. Instead, focus on its contribution to the spontaneous organization of behaviors, resulting in emergent cooperation and prosociality. The empirical ground for our computational model is the Carnival and social organization of the Otomí, a Mexican indigenous group which we introduce in the next section. Carnival as, other festivities practiced by the Otomí, seem to reinforce social ties, specially long range links between different neighborhoods and villages. The Carnival is also relevant because it represents a period of apparent chaos in which the world goes "upside-down". In our model such period is implemented by a moment in which agents get a different state randomly, and from the perspective of anthropological theory it is conceptualized as anti-structure and liminality [5].

2 The Otomí Carnival

The Otomí or *ñ'yühü* people is an indigenous group from Mexico of prehispanic origins. They currently live in the area known as Mesoamerica,

the work on religion, rituals and prosociality makes reference to the network reciprocity –Nowak's (2006) fifth rule– for the evolution of cooperation, in which cooperation emerges if benefit-cost ration is greater than the average degree: $b/c > k$.

specifically in the mexican states of Guanajuato, Querétaro, Tlaxcala, Hidalgo and Puebla. The first references to the Otomí goes back to the 8^{th} century [6].

As most indigenous societies in Mesoamerica today, there are two forms of social organization. One that is the civilian organization and another one that is religious and revolves around rituals and festivities. The Otomí religious beliefs are a syncretic mixture of prehispanic traditions and catholicism as expressed in their mythology and rituality [7]. This is important because the religious social organzation does not depend solely on the Catholic Church. It is likely that Catholic festivities were incorporated to the traditional form of organization of religous social life from prehispanic times or that it is the resulting combination of 500 hundred years of history.

Our model takes as reference the Carnival of the Otomí of San Pablito, from the Mountains of Puebla (where one of us did ethnographic field work) and is not an exception regarding the relgious social organization. San Pablito has around 4000 inhabitants, it's divided into three neighborhoods and households that have between 5 members in average. San Pablito's Carnival is primarily an agricultural festivity, and its celebration has the purpose of bringing fertility to Earth [9]. During the Carnival, each neighborhood creates one or more "cuadrilla" groups. Such groups are formed by the captain who needs to be a well respected, married man, other men that are dressed as oldmen and are called *hmnde*, and other men dressed like women, these are called *hošisu* (pronounced hoshisu). Besides the captain, *cuadrillas* are composed four or five *hmnde*, but there is no limit in the number of *hošisu*. Actually, the more the better.

The *hmnde* and *hošisu* are demons from the underworld and the sons and daughters respectively of *Tsitú*, the devil and lord of the Carnival. *Tsitú* is impersonated during the Carnival as a baby –doll- that is born in the morning of Ash Wednesday and killed at night, as a pig that is eaten in the last supper closing the Carnival, and as an metaphysical entity that is an aknwoledged during the festivity.

Beginning on Sunday before Ash Wednesday, and finishing the Sunday after, "cuadrilla" groups, all with their faces covered and keeping their anonimity, go visiting houses at different neighborhoods, playing music, dancing and telling jokes, while they get in return food and drinks. Traditionally neighborhoods are considered rivals but anonimity of "cuadrillas", imply

that they get equally treated when visiting households of a different neighborhood from their own.

As a first approach, in our model we assume that the social organization of the Otomí, based on rituality, has an important part in building a small-world topology. Small-world topology is defined by high local clustering and short a average path length [10]. There is small ethnographic evidence that traditional communities are structured as small-worlds, nevertheless there is evidence that suggests that it might be the case. Furhtermore, ethnographic data from the Otomí seem to imply that religious rituality plays a central role in establishing long range links at different scales, that is, connecting neighborhoods to a higher village level, and at the level of several villages [11].

Otomí rituals, the Carnival included, involves local neighborhood participation, acknowledging existing strong social ties. It also involves a mechanism that creates or reinforces long distance social links between neighborhoods and even between villages. In the particular case of the Carnival, one of such mechanisms is the participation of "cuadrillas" visiting houses from different neighborhoods, promoting intense interaction between neighborhoods for the short period of the festivity.

2.1 One week of chaos in the world

The Otomi believe that the world is divided in two complementary halves, one on top, the other at the bottom. Each half comprises a set of entities that live in there. The upper part of the world is inhabited by the "antiguas", the owners of the world, those that at the beginning of time created what is on Earth. The bottom, the underworld or *the place of the death*, is inhabited by the *Tsitú*, *los viejos* or the oldmen, and the *malos aires* or bad spirits that make people sick [8]. Such vision of the world also implies values and behaviors. The part above represents the good, the ordered, masculinity, cold and the Law. Its counterpart represents death, hot and humidity, femininity, sex, and chaos. For the Otomí, most of the year takes place according to the part above, but during the Carnival there is an inversion of the world [9].

For the Otomí, the Carnival represents the sexual intercourse of the main characters and the union of masculinity and femininity to bring fertility to Earth. The symbolic intercourse takes place three times during the Carnival but what it stands out and what represents chaos most clearly is the

fact that is an incestuous relation because the characters involved are siblings, father and daughters, mother and son. The father reproduces with his daughters, from which he is born again. He is also killed several times, one when he is represented as a baby born from his daughters but killed by his sons the *hmnde*. And on the last day of Carnival he is embodied in a pig that is killed and cooked for the last meal that only the *hošisu* –again, his daughters- will eat.

All the activities taking place during the Carnival imply a cost without an evident benefit. Costumes for the members of *cuadrillas* may be expensive. *Cuadrillas* need to hire musicians that will be part of the company when visiting houses. Moreover, they will not go to work in the field or to any other activity that represents an income for their families. This means that being part of it can be severly costly since this is a poor commuity. It is also an economic sacrifice for the rest of the population because they need to give good food and alcoholic drinks to *cuadrillas* and to those who go with them as *hošisu*, as many times they get visited.

3 Methods

From our model perspective we explore the mechanisms through which cooperation can emerge regardless of ritual behavior being an adaptation or not. Moreover, it doesn't relay on any cognitive traits as the capacity to read minds and so have a perception of being perceived by some supranatural entities.

We implemented a model inspired by Victor Turner's notion of antistructure an explicit period in which agents display random behavior is incorporated. Such periods facilitate coordination among agents helping to find optimal states of utility for the system, even if there is a cost for individuals. Specifically, our model is based on a coordination model developed by Watson et al. [12] and Davies et al. [13].

3.1 Structure

Our model involves $N = 120$ agents that represent each of the households of the Otomí community. Since the model is a coordination game, each agent

can assume any of two states, either $1, -1$.

The connections between the nodes have the following restrictions:

- $w_{ii} = 0 \forall i$ (No node is connected to itself).
- $w_{ij} = w_{ji}, \forall i, j$ (Connections are symmetric).

The model requires two networks, one that we call the *original* network. Each node is randomly assigned with a state and its connections are also assigned randomly with a weight of $1, 0, -1$. This network represents the dependencies ω_{ij}^{O} between nodes and they cannot be altered by them. The second network is a copy of the original but it is the *learning* network. In this networks is where learning takes place due to the modification of weights of edges or dependencies ω_{ij}^{L}, according to the perceived utility of nodes. The states of the nodes are the same as in the original network but initially, the all the weights of the edges are set to 0.

The topology of the networks is exactly the same for both, and we defined it as a random network, with a probability $p = 0.7$ in order to avoid as possible unconnected nodes that could not become active agents during the simulation.

3.2 Default agents

Once the original network is set, each agent is allowed to update its states after observing the states of its neighbors, nevertheless, it can only adopt one behavior that is the one that maximizes it own utility, where individual utility is:

$u_i(t) = \sum_j (\omega_{ij}^{O} + \omega_{ij}^{L})(s_i)(s_j)$

And the system utility or global utility G is calcultated, which is simply the sum of all individual utilities:

$G(t) = \sum_i \sum_j \omega_{ij}^{O} s_i s_j$

In order for agents to update their states, they must compare the utility of staying in the same state or changing. This is done by calculating the utility outcome of both scenarios:

$$u_i = \sum_j (\omega_{ij}^O + \omega_{ij}^L)(-1)(s_j)$$

$$u_i' = \sum_j (\omega_{ij}^O + \omega_{ij}^L)(1)(s_j)$$

$$s_i \begin{cases} -1, if & u_i > u_i', \\ 1 & otherwise. \end{cases}$$

3.3 Update and simulation phases

The execution of the model is devided in three phases. In the first phase, the system resembles a Hopfield network [14]. During this period agents update their states for 1000 iterations so the system is allowed to converge to an attractor, then all agents change their state randomly and once again, agents update their states. With such combination of strategies –*i.e.* converge to an attractor and randomize states- the system can explore different attractors, and it is able to scape from local minima. Because during this period ω_{ij}^L are set to zero, agent's utilities are calculated only taking into account the values of ω_{ij}^O. This first phase does not contribute to self-optimizing the network; its purpose is to display most of all possible attractors of the system, which are, in general low quality. Finally, it is important to say that every 1000 steps counts as one *Time* step, with capital T, – *i.e.* T = *1000 steps*-. To this period we call it the *pre-learning phase* and is repeated for a certain amount of T steps.

The second moment in the simulation is called the *learning phase*. This is the period in which the mechanism for self-optimization takes place. Agents keep updating their states as in the *pre-learning phase* but in this case agents can modify the ω_{ij} of their interactions as the result of a perceived utility p_i. Such modification take place in the *learning* network and generating the perceived utility requires it.

In order to modify ω_{ij}^L, for every agent two utilities are calculated and compared. Different from the default agents utility calculation, the the sum of both networks weights, a learning constant r is added up. The agent compares both utilities and change the weigth of its interactions accordingly, by adding or sustracting r to ω_{ij}^L, which for the *learning* network were all weights equal to zero. The process goes as follows:

$$p_i = \sum_j (\omega_{ij}^O + \omega_{ij}^L + r)(s_i)(s_j)$$

$$p_i' = \sum_j (\omega_{ij}^O + \omega_{ij}^L - r)(s_i)(s_j)$$

$$\omega_{ij}^L = \begin{cases} \omega_{ij}^L + r, if & p_i > p_i' \\ \omega_{ij}^L - r & otherwise. \end{cases}$$

The learning process as presented, has two purposes. On one side interactions are either reinforced or weakened according the coordination or antico-ordination of the states of an agent and its neighbors. On the other side real utilities in the *original* network, will be calculated considering the distorted utility reflected in ω_{ij}^L, leading to a possible scenario in which an agent may choose a state that reinforces its interactions but detrimental in its own utility. During the *learning phase*, the system is allowed to converge to an attractor for one T, then all agents adjust the weight of their interactions, and then their states get randomized. This sequence is also repeated for a certain amount if T*'s*.

The final period of the simulation is a *post-learning phase*. In this period, agents stop modifying the weights of their interactions and change their states taking their resulting values from the previous phase into account. The purpose of this last phase is just to have time to see the behavior of the system. As in the former phases, the state of agents are randomized, then they choose their states, looking for their highest utility for one T and the system converges to an attractor and finally once the T is done, the states of the agents are randomized again. The sequence of this part of the simulation runs for certain number of T*'s*.

4 Discussion

According to ethnographic records, rituality among the Otomí strucutres social interaction [11], producing what resembles a small-world, social topology. One example of this process is the articulation of oratories and *cargo –needs to be explained* system celebrations that take place together as referenced by Dow [11]. We believe that another example is the Carnival itself.

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