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Gossip for social control in natural and artificial societies

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Abstract

In this work we propose a theory of gossip as a means for social control. Exercising social control roughly means to isolate and to punish cheaters. However, punishment is costly and it inevitably implies the problem of second-order cooperation. Moving from a cognitive model of gossip, we report data from ethnographic studies and agent-based simulations to support our claim that gossip reduces the costs of social control without lowering its efficacy.

Keywords

agent-based simulation, cognitive modeling, evolution of cooperation, gossip, punishment, reputation, social control

1. Introduction

If one were to enumerate the most influential and universal social behaviors in human societies, gossip would undoubtedly be one of them. Exchanging social information is fundamental for partner selection, social control, and coalition formation, just to name some of its main functions. In social groups, humans exchange information about other individuals, their actions, behaviors and attitudes, and social issues have been proven to be among the most recurring topics of human conversations.[1]

Gossip is an influential theme also in research, as witnessed by the huge amount of studies carried out on it by scholars coming from different disciplines. Since the appearance of Gluckman's[2] article in 1963, in which gossip was defined as a 'culturally controlled game with important social functions' (p. 312), several researchers endeavored to unveil these functions. Almost 50 years later, the list of functions served by gossip is far from being definitive and there is a lack of agreement on both its ultimate and its proximate causes (for example, see the contributions by Barkow,[3] Goodman and Ben-Ze'ev,[4] Dunbar,[5] Gintis et al.,[6] Baumeister et al.,[7] Wert and Salovey,[8] and Piazza and Bering[9]).

One of the proposed functions of gossip is the management of reputation.[10] Theories of indirect reciprocity explain large-scale human cooperation in terms of conditional helping by individuals who want to uphold a reputation and then to be included in future cooperation.[11] Reputational information can also help to solve the tragedy of commons,[12] a social dilemma referring to the fact that when everyone benefits from an intact resource, there is an individual advantage to cheat (e.g. overexploit or pollute), because cheating brings economic advantages to the executor, whereas costs are distributed among all group members.[13]

In economic experiments, the possibility of recording other players' reputations actually prevents the public resource from being overused.[14] Economic experiments from traditional societies all over the world have provided strong support to the idea that reputational concerns can promote cooperation and altruistic behaviors.[6,15] However, many influential economists believe that reputation, along with kin selection and reciprocal altruism, offers a rather incomplete picture of those evolutionary forces that shaped human cooperation,[16] and propose to explain cooperation among selfish unrelated individuals in terms of 'strong reciprocity', which

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'is characterized by the willingness to altruistically reward cooperative acts and to altruistically punish norm-violating, defecting behaviors' (Fehr and Schneider,[17] p. 1315; for the debate between supporters of the strong reciprocity theory and its critics see Fehr and Schneider[17] and Burnham and Hare[18]).

Although extremely interesting, there are still open questions, such as: how can cooperation evolve in mixed groups in which cooperators are exploited by cheaters? How can cooperators be protected against retaliation or how can they deal with second-order punishment?

A solution to this issue has been often found in social control, a rather complex phenomenon on which there is a great deal of scientific work, neither conclusive nor consistent. Unfortunately, for social control to work, and then to achieve high benefits costs must be high as well. How could this costly solution have evolved?

In this paper, we will present social control as a culturally evolved decision tree, with branches standing for different alternatives for decisions possibly evolved in different phases of the human cultural evolution. Starting from the analysis of costs and benefits of different types of social control, we will ask ourselves under which conditions it is possible to optimize it. Next, we will put forward a model of social evaluation, including reputation. From this model, we will derive some properties of gossip as a process that circulates reputation. Thanks to these properties, gossip will be shown to have a strong adaptive advantage over alternative modalities of social control, entailing lower costs without reducing its benefits.

The organization of the paper follows the reasoning along which the whole argument is unfolded. In Section 2, we model social control as a decision tree in which costs and benefits of identification and reaction are analyzed and discussed. In Section 3 we introduce our cognitively grounded theory of gossip, and we put forward our hypothesis about the role of gossip for social control. Section 4 is intended as a bridge between the theory (Sections 1–3) and the data (Sections 4–6). In Section 5 we check whether our model of gossip and the properties we analyze are backed up by etnographic evidence, whereas Section 6 is devoted to test through agent-based simulation whether our hypothesis on gossip for social control matches simulation data. Finally, in Section 7 some conclusions are drawn and ideas for future work are outlined.

2. Social control as a decision tree

Social control is generally viewed as a conceptual category subsuming several behavioral phenomena. In sociology, the concept of social control has been used to capture the ways in which individuals, communities, and societies respond to a variety of forms of deviant behavior.[19] At first, social control referred to a society's capacity to regulate itself. Then it was employed to indicate the more repressive and coercive forms of top-down control in capitalist regimes. From the 1950s onwards, social control has been conceived more narrowly in relationship to deviance and/or crime: social control refers to those mechanisms that are put into operation in response to crime, deviant behavior, or other deviations from socially prescribed norms.[20]

In this section, we will describe social control as a decision tree, where branches represent more or less efficient trajectories, possibly explored by our species during its evolution. Social control will also be described as a multi-action plan, specifying the conditions that must be verified to achieve the end of the plan, that is, reduce future costs caused to cooperators by non-cooperators. In the subsequent section, gossip will be argued to score high on efficiency, as it allows costs to be drastically reduced with respect to benefits.

Thinking of social control as a decision tree that specifies alternatives for action allows us to compare them in terms of efficiency, that is, their respective costs and benefits. As will be shown later on in this section, ordinary communication acts on the side of benefits but is unable to reduce costs. Instead, the special form of communication that is allowed by gossip, taking advantage of specific properties of the human mind, has the peculiar effect of optimizing social control by reducing its costs while keeping benefits constant.

2.1. Related work

Social control is a spontaneous, decentralized social phenomenon, which allows the costs of prosocial behavior to be redistributed over a population in which altruists live side-by-side with non-altruists. Some specific phenomena are usually subsumed under the large heading of social control. This includes ostracism[21,22] and altruistic punishment. The latter is usually defined as a costly aggression inflicted to cheaters by members of the group who did not necessarily undergo attacks from the punished, nor get direct benefits out of the sanction applied.[23]

Some crucial questions concern the efficacy of central versus decentralized forms of social control, and its reproductive advantage over direct cooperative behavior. Sociologists[24–27] have been wondering about the inter-relationships among cooperation and social control. In their perspective, social control could be defined as second-order cooperation, that is, urging others to

cooperate, although cooperation at one level does not imply cooperation at the other level.

Social control represents a solution to a major problem of adaptation: how to cooperate in a mixed population[28] where non-altruists are known to out-compete altruists.[29]

This problem, known as the puzzle of cooperation,[30,31] was given many specific solutions:

(a) partner selection, based on (i) memory of previous experience,[32] (ii) observation of others' deals,[33] and (iii) exchange of information based on previous experience;[34]
(b) ostracism;[22]
(c) altruistic punishment.[23,35]

An operational variant of the last one, named strong reciprocity,[36,37] has received considerable attention in the last decade. Gintis[38] developed an analytical model in which, under a given condition, strong reciprocity can emerge through group selection. Bowles and Gintis[39] used computer simulations to test the validity of the model, designing an egalitarian society of hunter–gatherers divided into three subpopulations: Reciprocators (R), Cooperators (C), and Selfish (S). Only Reciprocators punish shirkers and they do so at a personal cost that is by definition lower than the costs of cooperation. Results clearly point to the evolutionary role of strong reciprocators. After the first few tournaments of the simulation, the rate of shirking and the fitness of Selfish agents lower dramatically, while the payoffs of Cooperators and Reciprocators increase after the initial collapse. Even more interestingly, Cooperators will never reach either the Selfish or the Reciprocator payoffs, but the population will not be invaded by cheaters.

The theory of strong reciprocity raises some questions. Firstly, how did strong reciprocity and more generally altruistic punishment evolve? Was it a sudden single mutation that proved adaptive or one step in a complex algorithm prompting different solutions to the problems of adaptation?

Secondly, why should one be willing to perform *altruistic* punishing? To define punishment as less costly than cooperation provides no conclusive answer to this question: why should a costly behavior explain the evolution of an even more costly one? To make sense, this hypothesis should imply that punishment is a *low*-cost behavior, but this is not so obvious, especially if we consider that it may lead to simultaneous or later counter-attacks.

Let us now examine alternatives to punishment, analyzing the respective efficiency in terms of costs-to-benefits, and compare their competitive advantages.

2.2. Plan for social control

Social control should not only be seen as a decision tree but also as a sequence of actions, a multi-action plan in which at least two action levels can be distinguished. At the top level we find the end of the plan, reducing future costs caused to cooperators by non-cooperators. The major end of social control can be achieved either by avoiding the bad guys or by punishing them. The former option, in turn, can be realized by mechanisms of partner selection or by a generalized form of ostracism. Bad guys may simply be avoided by the single cooperator when choosing partners for its own utility (partner selection), or may be shut out from the group as a whole (ostracism). As will be discussed next, the respective costs and benefits of these two options vary considerably.

At the lower level of the plan stands a necessary condition for applying any specific strategy of social control. To perform it, social controllers need first to discriminate between the good and the bad. How do they find this out? Both directly, through the memory of previous experience, and indirectly, building on others' experience. But how do we access the experience of others? There are two solutions: either by observing others interacting (the well-known *image score*),[33,40] or by exchanging information with them, that is, through communication.[41]

2.2.1. Comparing efficiency. One mechanism for deciding among different options for social control is to evaluate their respective efficiencies in terms of costs and benefits.

Starting from the bottom, let us look at the costs and benefits of identification when the group size makes re-encounters unlikely. Under such a condition, the benefits of *direct experience* are low as it is difficult to meet the same partner again; instead, its costs are high, because part of the information acquired has been paid at a fairly high price (being cheated).

As to indirect information acquisition, onlookers are usually unharmed witnesses of social encounters. However, as the observation window is generally limited, they get only moderate, but low-cost, benefits. With communication, instead, the basin of information can potentially extend to the whole group. Hence, although information can be false or mistaken, benefits are much larger. Still, costs are also high, for at least three reasons: (a) information may be transmitted to the wrong recipient, providing them with precious information that can be used to exploit other altruists; (b) information transmitted can be wrong, causing damage to the recipient and provoking their retaliation; (c) information conveying a bad evaluation and

including the source's identity may sooner or later get to the ears of the evaluation's target, leading them to take revenge against the initial informer.

If we compare alternatives in identification, the most efficient alternative seems to be the observation of others' experience, but this option does not allow one to collect much information, it requires a consistent amount of time, and it is particularly inadequate in large social groups.

Let us now turn to reactions. Once the non-altruists have been identified, one is faced with two alternative reactions: avoidance and punishment. Avoidance is consequent to either banning the bad guys from the whole group, or individual agents excluding them from their partnerships. Banning is highly beneficial, if efficacious, but is rather expensive, requiring a continuous deployment of resources in patrolling the group's boundaries. The benefits of individual partner selection in turn are compensated by the high probability of error and the missed deterrence.

What about active punishment? Benefits, as shown by Bowles and Gintis,[39] are high, potentially including also some deterrent effect. However, and unlike what was supposed by these authors, costs are also high, amounting to the costs of punishment, which can reasonably be assumed to be lower than the costs of cooperation, plus the costs of potential retaliations by the punished.

To sum up, in both levels of the social control plan, benefits are high when costs are also high (see Table 1).

Under these conditions, it is difficult to account for a highly distributed system of social control: why should group members sustain such a burden? Why and how did social control evolve at all? Which solution could it provide to the puzzle of cooperation?

2.3. Optimize social control

How do we improve the efficiency of social control?

One way to do so is raising the *benefits* of strategies. With reactions, the benefits of avoidance heavily depend on the mechanisms of identification, which will be examined below. Those of punishment depend on the efficacy of deterrence, and ultimately on the credibility and authority of the punisher, which are essentially subjective features. In identification, the benefits depend on the dimension of the network of agents exchanging information: any other mechanism is clearly less beneficial. Benefits increase with the number of agents participating in the network. The question is how incentive agents participate, if costs remain high.

Let us now turn to costs. Assuming that to reduce the costs of punishment is beyond control, the only means left is to reduce the costs of identification. As previously argued, the efficiency of avoidance ultimately depends on the mechanism of *communication*.

Hence, we can formulate some preliminary conclusions.

> 1st conclusion: to optimize social control implies reducing the costs of cheaters' identification.

As one's own experience and others' observations will never be able to equal communication in the amount of information acquired, we can draw another conclusion.

> 2nd conclusion: to optimize social control implies reducing the costs of communication.

The efficiency of social control, that is, its advantage in solving the puzzle of cooperation, depends on the mechanism of communication. The less detrimental the communication, the higher the incentive for group members to participate in it, the greater the quantity of information circulating in the system, and finally the more efficient the system of control.

The consequent question then is: how did our species solve the problem of communication, reducing its costs so as to provide an incentive for group members to participate? In the next section, we will argue that gossip provides a solution to this problem. Indeed, we can formulate our main conjecture.

Table 1. In this table the costs and benefits of identifying and punishing selfish agents are summarized. Experience implies Low (L) benefits and High (H) costs; observation provides only Mild (M) benefits without any costs, whereas communication has High benefits but also High costs. In the right-hand part the costs and benefits of two different forms of reaction, Avoidance and Punishment, are also indicated

	Identification			Reaction	
	Experience	*Observation*	*Communication*	*Avoidance*	*Punishment*
Benefits	L	M	H	M	H
Costs	H	–	H	–	H

Hypothesis: gossip evolved because it enabled our species to solve a major problem of adaptation, that is, it reduces the costs of communication in social control.

Dunbar[5] suggests that gossip evolved as an adaptive response to a selective pressure towards enlarging hominids' settlements. In his work, gossip is argued to have evolved taking advantage of a human cognitive mechanism by providing incentive to participate in social control, because it lowers its costs while keeping its benefits constant (as will be shown below, spreading meta-evaluation inhibits retaliation).

Moreover, the importance of cultural evolution for the spreading and maintenance of social behaviors has attracted broad attention in recent decades (for a review, see Henrich and Henrich[42]).

In this work, we build on the idea that the combination of genetic and cultural evolutionary traits have favored the appearance of gossip and that, thanks to this specific mechanism, gossip enabled humans to reduce the costs of communication in social control. Let us now turn to a cognitively grounded theory of social evaluation, from which we derive the main properties of gossip.

3. A cognitive theory of gossip

Since the appearing of Gluckman's article on gossip among Makwa Indians,[2] gossiping has received much attention by scholars coming from different disciplines (for example, see the contributions by Dunbar,[1] Barkow,[3] Goodman and Ben-Ze'ev,[4] Gintis et al.,[6] Baumeister et al.,[7] Wert and Salovey,[8] Ellickson,[43] and Noon and Delbridge[44]). It is worth noticing that most of these accounts provide interesting theories about the functional aspects of gossip, but they fail to describe the internal motivations to gossip.

Gossiping requires choosing an addressee, selecting the topic, and deciding in which way an information has to be transmitted. These decisions all follow from the epistemic and motivational representations individuals hold or, in other terms, from their beliefs and goals. For instance, gossip can be used for strategic purposes, that is, to influence other individuals by generating new beliefs and goals, thus modifying their behavior.

In order to describe gossip from a cognitive viewpoint, we first need to characterize it as a process through which social evaluations are transmitted. An evaluation is social when an agent is considered as a means to achieve the evaluator's goals in terms of some standards or norms.[45] Consider the example: 'John is a good teacher'. There is an agent (John) who is evaluated with regard to the goal of the evaluator of receiving/providing high-standard education. Humans can represent and transmit social evaluations in two different ways: either as *image* or as *reputation*.[46]

In the former case, the source of the evaluation is explicitly stated and this implies an assumption about the truth value of that information. Therefore, image is defined as a social evaluation – regarding another agent's competence, behavior, attitudes, etc. – that the agent assumes to be true. When an agent reports it to others, they transmit it as one's own evaluation of a given target. An agent may also report the image that someone else formed about a given target. In this case, they may not assume it to be true, but there is another defined agent who does.

On the other hand, in reputation the evaluation is not necessarily assumed to be true, nor it is traced to a definite source. Reputation designates a meta-evaluation, that is, a belief about an evaluation. In a sense, reputation is a collectively held meta-evaluation because there are agents believing that some others, preferably in their group, believe that a given agent is told to have some features.

This difference is not inconsequential and leads us to point out that gossip for social control has evolved thanks to the following properties of reputation transmission:

1. there is no commitment of the speaker on the evaluation's truth value;
2. there is no responsibility about the evaluation's credibility and consequences ('I am told that...').

These properties of reputation transmission result in several interesting effects at the group level. In particular, transmitting an inaccurate reputation leads to less severe consequences than spreading an inaccurate image, as the agent who spreads it is not responsible for it. Reputation is anonymous in itself: it circulates in the social network but its origin is unknown. Therefore, reputation spreading is easier than image transmission and, once circulated, reputation is also more difficult to modify. This is mainly due to the fact that it is practically impossible to trace a belief about others' beliefs back to its origins and to those who hold it.

Regarding the agents involved, gossip has a triadic structure in which we can distinguish the following.

A **gossiper**: an agent who has the goal to spread information.

A **topic**: an agent whose behaviors, attitudes, choices, and emotions are the topic of the communication. The target belongs to the same group as the gossiper and receiver and they are judged according to the group's rules and habits.

A **receiver** (or more than one): one or more agents chosen from the gossiper to be told about the target.

Receivers belong to the same social network, sharing the same knowledge and values of the gossiper and gossiped. Choosing the receiver is pivotal to achieve the gossiper's goals: the receiver can be the actual target of communication or they can serve as a vehicle to reach the intended target.

Reputation and gossip are based on a specific form of social intelligence evolved by humans for more general reasons, that is, the ability to form and manipulate mental representations on the mental states of one's peers (known as *mindreading*[47]). Moreover, several studies[18,48,49] point out the existence of cognitive mechanisms or neural substrates evolved especially for taking into account the presence of others and the possibility of being evaluated by them. Reputation can work as a useful guidance when making decisions about possible interactions, evaluating candidate partners, understanding and predicting their behaviors, and showing one's acceptance of the group's values. The importance of such a capacity for our species' adaptation is hardly questionable; making assumptions on others' internal states allows us to anticipate and possibly prevent their future behaviors, choosing the most appropriate conduct. The capacity to form and transmit meta-beliefs has also been pivotal to the evolution of reputation and gossip. By transmitting meta-evaluations, to the point that the source of evaluation gets lost, our ancestors could exploit the benefits of communication, while sustaining its costs, thus generating a distributed and cheap form of social control. According to Ingram et al.,[50] in systems of indirect reciprocity, reputation is a powerful signal of the quality of the potential partner, and communication about others' reputations greatly enlarges the possibilities for cooperation. This has created a selective pressure on humans to evolve specific cognitive mechanisms to represent and manipulate their own reputation in the eyes of other group members.

In traditional societies, in which social relationships, alliances, and feuds heavily rely on the accuracy of social evaluations and their transmission, gossip represents a powerful means to apply social control without bearing the costs of retaliation.[51] Through reputation spreading, individuals can circulate evaluations to either condemn or praise their peers' behaviors, in order not only to share their views with the rest of their group, but also to influence them indirectly.

The cognitive model of gossip leads us to our third conclusion:

> 3rd conclusion: by transmitting meta-evaluations, gossipers (a) do not commit to the truth values of nested evaluations (b) nor take responsibility over their consequences.

4. From model to data

Our analysis of costs and benefits of social control, along with the cognitive account of gossip, set the stage for the discussion of ethnographic data and the presentation of simulation results. Before going on, we want to briefly recap our conclusions, whose relevance and appropriateness will be supported by observations from traditional societies. On the other hand, our hypothesis will gain support from data on artificial agents exchanging different kinds of information.

Moving from a definition of gossip as a 'social cognitive process based on meta-evaluations', we claim that it allow agents to avoid (i) commitment to the truth value of the evaluations transmitted and (ii) responsibility over the consequences of such transmission. Given the aforementioned properties, gossip prevents retaliation and could therefore evolve as a means for reducing the costs of distributed social control. This claim will be supported by two different kinds of natural evidences and artificial data. On one hand, reports from traditional societies lend support to the proposed model, whereas data from agent-based social simulations (ABSSs) will show more precisely the costs and benefits of different kinds of information, in different settings.

We claim that gossip evolved as a solution to the problem of adaptation posed by social control, because gossip permits one to reduce the costs of cheaters' identification, but it is also effective in reducing the costs of communication by transmitting meta-evaluations. Agents endowed with the capability of holding meta-beliefs and acting upon them do not commit to the truth values of nested evaluations nor take responsibility over their consequences.

Meta-beliefs reduce the potentially damaging effects of communication, thus providing group members with high incentives to participate in it. This, at the group level, will result in an increasing of the quantity of information circulating in the system, and will finally end up with a more efficient control.

5. Gossip in human societies: Ethnographic evidence

To what extent does the ethnography of gossip match with our description? In this section we will report on evidence collected by ethnographers in different traditional societies all around the world, and compare it with the model described above to check whether gossip's features, functions, and rituals as described by scholars working in the field may lend support to our model. We will restrict our analysis to five main

examples: the *Nakulalelae*'s *fatufatu*; the *Talanoa* in the *Fiji* islands; the use of gossip among the *Hopi*; the case of *Kwanga*; and that of *Makah*.

5.1. Fatufatu

Among the Nukulaelae, who live in a Polynesian atoll of the Central Pacific, Besnier[52] found fatufatu, a vacuous, 'women's' language, strongly disparaged by the high-status part of the society to which only men are entitled to belong. Nonetheless, that of fatufatu is a real art, requiring considerable expertise and a dramatic competence. Fatufatu is an interactive activity. Initialized by a single member of the group, it is transmitted to the audience through a manipulative strategy in which the recipients become co-producers of the gossip. The speaker often pauses dramatically at strategic moments, waiting for interlocutors' interjections or comments on the scandalous content of the narrative. This behavior has been interpreted as a way of *sharing the responsibility* for what is told, while at the same time allowing the speaker to maintain control upon the floor.

5.2. Talanoa

Talanoa is the name of an idle talk of Hindu inhabitants from the village of Bhatgaon in Fiji, as described by Brenneis.[53] Here, reputation is the kernel of social hierarchy and reputation management is one of the core activities of social life. Gossip is created jointly by all participants and this relationship between the gossiper and the audience leads to two main consequences: it does not cause sanctions or retaliation and makes recipients form opinions 'of their own'. A requirement of Talanoa emerging from transcriptions is the continuous and repeated use of the word 'bole' (literally the third singular person of the present tense of the verb 'to speak'), used to mean 'I have heard saying' or 'they say' that refers to an indefinite speaker or source. In both cases, the use of 'bole' allows the speaker to keep at a distance from what s/he says: s/he is not reporting on his/her own opinion but on voice or rumors. Moreover, Talanoa transcriptions cannot be understood without previous knowledge, due to a heavy use of metaphors, irony, and ambiguous references that suggest that what is hidden is more than what is said. Gossip among Bhatgaon people has three main features:

(a) indefinite characters;
(b) targets are never clearly identified;
(c) the authorship of a particular gossip is blurred.

5.3. The Hopi

Cox[54] studied gossip between two political factions in 11 villages within the Hopi reservation in Arizona. Moving from the view of gossip put forward by Brison,[55] Cox tried to figure out to what extent gossip promotes or discards group unity. Gossip starts when political authority is monopolized by one group and the powerless party uses gossip to keep authority under control and form alliances. This form of control is especially powerful because victims cannot escape the effect of accusation, since the source is not revealed, and evidence is neither brought about nor disconfirmed.

5.4. The Kwanga

More recently, Brison[55] studied the Kwanga, a tribe of hunter–gatherers in Papua New Guinea that live in numerous villages characterized by complex social networks. Initiated men form a community of equals in which attempts to command lead to loss of support. The *Kwanga* used to hold long community meetings to discuss matters of common concern, during which gossip was spread about men as a means for social control and for gaining prestige. If asked to produce evidence, the accused resorted to a conventional solution: they claimed their words were *just talk*, rumors, thus lowering the importance of what they said without denying it.

5.5. The Makah Indians

In a pioneering work on gossip, Colson[56] described this activity among Makah Indians, a small group of Native Americans from USA. In this population, gossip is used to criticize others and to question their social status. Far from being disruptive, this activity helps the group to build up a sense of cohesion; this is especially important in that context in which their cultural identity was in danger of extinction due to attempts to turn them into American citizens. The Makah gossip has a twofold function: it enforces the group's identity while, at the same time, it works as a tool to maintain equality between all group members. Being a Makah means to be able to gossip in the appropriate way, respecting the ritual and being able to manage the topic, and strangers cannot join the gossip circle.

To sum up, we find interesting features in all four examples. Gossip leaves indefinite the target (see the *Kwanga*) and the source (see the use of *bole*), is spread in absence of a target (*Talanoa*), cannot be falsified and is unaccountable (*Hopi*), and maintains group values and identity (*Makah*), but also creates alliance[57,58] of the underprivileged against the luckier,

prevents retaliation (many), is fun (*Talanoa*), and deplorable (*Fatufatu*). Gossip spreading means to transmit impersonal narratives, without any commitment on truth value, with indefinite authorship, and indefinite targets, all traits that are common in small acephalous communities (see also Boehm[51]) in which members are interdependent and act covertly instead of taking direct action that might offend others.

Ethnographic evidence seems to provide support to our cognitive analysis, showing that universal features of gossip converge on the transmission of a reported-on evaluation (reputation). This prevents retaliation, sparing participants both the costs of acquiring information, and the costs of transmitting it, thus providing incentives for group members to participate in social control.

So far, we have analyzed social control in its atomic actions, and found out that under the need, or selective pressure, to optimize efficiency, the human species might have evolved a special mechanism for transmitting evaluations to one another. Ordinary communication, in which agents commit to the truth value of messages and take responsibility over its consequences, reduces the costs of obtaining information, but in the case of social evaluations, this exposes the source to the risk of retaliation. Here is where human cognition went to the rescue of the species members, by providing them with the capacity to discriminate between image and reputation and to spread reputation, without taking responsibility for its truth value and for its consequences.

Gossip in traditional societies seems perfectly suited to allow members of the group to exercise social control on one another, while at the same time preventing the escalation of violence and retaliation. This in turn might have allowed for enlarging the group, affording partner selection and informational exchange among non-familiar agents.

So far we have tested our model of gossip. What about our hypothesis about the role of gossip in optimizing social control? In the last section of this paper, we will turn to artificial societies as a virtual experimental setting in which to test our theory.

6. Gossip in artificial societies

Several attempts have been made to model and use reputation in artificial societies, especially in two sub-fields of information technologies, that is, computerized interaction (with a special reference to electronic marketplaces) and agent-mediated interaction (for a review, see Mui et al.[59]).

Models of reputation for multi agent systems applications[60–62] clearly present interesting new ideas and advances over conventional online reputation systems, and more generally over the notion of global reputation, or centrally controlled image. Indeed, models of trust and reputation abound in this field (for a couple of exhaustive reviews, see Ramchurn et al.[63] and Sabater and Sierra[64]).

Here, we want to test the effectiveness of gossip in promoting social control at the aggregate level, using agent-based simulations (ABSs) in order to validate the hypothesis drawn from the cognitive model. A similar attempt to apply a sophisticated model of human cognition to explain the evolution of social phenomena has been made by Chavalarias,[65] who included metacognitive representations in his model of the evolution of imitation rules.

In the previous sections we suggested that gossip may have evolved because it enabled our species to reduce the costs of communication in social control. More specifically, we try to disentangle the effects of reputation transmission from those produced by image in two different systems. Artificial experiments not only allow us to isolate the effects of identifying cheaters and reacting to their actions, but also to evaluate to which extent the transmission of reputation can positively affect partner selection while preserving agents from being retaliated.

We will review two different studies in which the spread of social evaluations is intended to facilitate partner selections. In the first work, developed using the REPAGE platform (for a more detailed account, see Sabater et al.,[66] Conte et al.,[67] and Giardini et al.[68]), the role of information reliability has been addressed, with the aim of understanding how false information can affect agents' decision-making processes. In the second study, an artificial industrial district was modeled and the effects of image and reputation on the selection of reliable suppliers and consequent product quality were tested.

Regarding the first study,[69] agents are situated in a market-like scenario designed with the aim of reproducing the simplest possible setting in which information is a valuable but scarce commodity. Agents are endowed with a specific cognitive architecture, called REPAGE, which provides evaluations on potential partners and is fed with information from others plus outcomes from direct experience. To select good partners, agents need to form and update own social evaluations; hence, they must exchange evaluations with one another.

The REPAGE cognitive architecture can be used by artificial autonomous agents in different scenarios, be they multi-agent system (MAS) applications, artificial markets, or teamwork. It has been especially developed as a module for social reasoning and decision making that, as an output, supplies advices about a given target and how to interact with it. Furthermore, this module

has been designed to provide information to be plugged into the planner of an agent, information about a set of possible solutions to improve the reliability of the provided information.

In brief, the REPAGE architecture, as shown in Figure 1, is composed of three main elements: a memory, a set of components called detectors, and the analyzer.

REPAGE is not only a passive module the agent can query to obtain information about image and the reputation of another agent, but it also permits agents to manage the information they get in order to decide among alternative courses of action that can be followed to improve the reliability of the available information. After the information received has been filtered and manipulated, new predicates are added to the main memory. The planner uses the information in the main memory to produce plans. By means of the analyzer, REPAGE always suggests new actions to the planner in order to improve the accuracy of existing images and reputations. The planner can decide whether to look for new information by asking informers or directly interacting with other agents, in order to gain useful insights to improve the system's response accuracy.

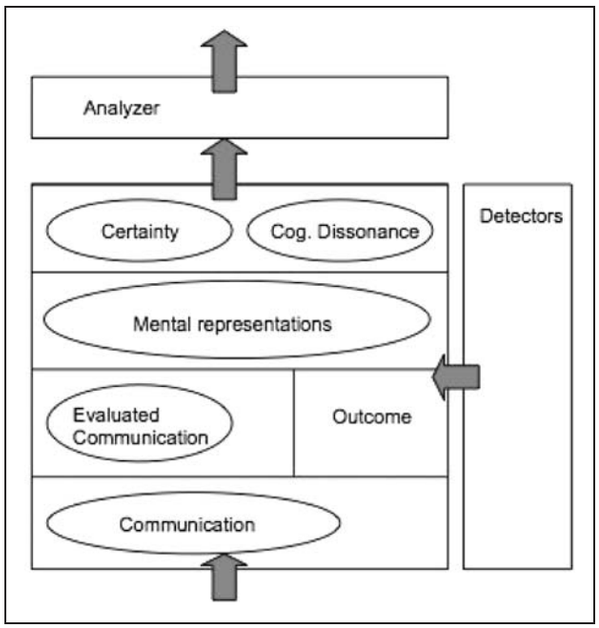

Figure 1. A graphic representation of the REPAGE architecture. In the MEMORY module the different predicates coming from the DETECTORS are stored according to their typology (reputation, image, etc.). The main task of the ANALYZER is to propose actions that (i) can improve the accuracy of the predicates in the REPAGE memory and (ii) can solve cognitive dissonances in order to reduce uncertainty (adapted from Sabater et al.[66]).

The simulation environment is market-like and consists of given percentages of Buyers (Bs) and Sellers (Ss). Bs need to find good Ss endowed with a given stock of products, but Ss' products are subject to depletion. Once an agent's stock is exhausted, that S disappears and the B needs to find a new one. There are differences in quality of products, therefore Bs look for agents selling high-quality goods. In this setting, information plays a crucial role in favoring the discovery of good sellers, but, at the same time, agents have an incentive to cheat. Limited resources make informational cheating a strategic choice that prevents one's own good sellers from being exploited by other agents, but informational cheaters are punished with false information.

Under these experimental conditions, does reputation transmission make any difference with respect to image transmission? Results reported by Quattrociocchi et al.[69] and collected in 28 market scenarios with varying percentages of cheaters and different distributions of good and bad products show that the performance of the system changes not only with respect to the average of cheaters in the population, but it is also affected by the specific kind of circulating evaluation.

Two conditions were tested: L1 in which only image was transmitted and L2 in which agents circulated and received both image and reputation. In Figure 2 the quality of products for different cheating rates is displayed. Image is less sensitive to informational cheating and it guarantees low but stable results. On the other hand, reputation is more sensitive for given parameter values; it favors identification of liars and can cope with a large amount of cheaters (60%) before collapsing.

This seems to support our hypothesis about the role of information in lowering and distributing the costs of social control, but it is also interesting because it supports our claim about the importance of choosing between two different mental objects. Although encouraging, these results pose the problem that REPAGE is a highly complex architecture whose high computational complexity prevents it from being applied in rich environments and limits its applicability to more complex settings.

In order to test our theory in a more realistic market-like environment, a different scenario, in which firms are modeled as agents organized into three different layers, has been implemented.[70,71]

This model, called SOCRATE, has been developed in order to provide empirical support to the claim that in industrial districts actors are embedded in networks of informal relationships that may heavily affect innovation and economic performance.[72] In industrial districts, agents' access to information and goods are partly dependent on their personal relationships, and

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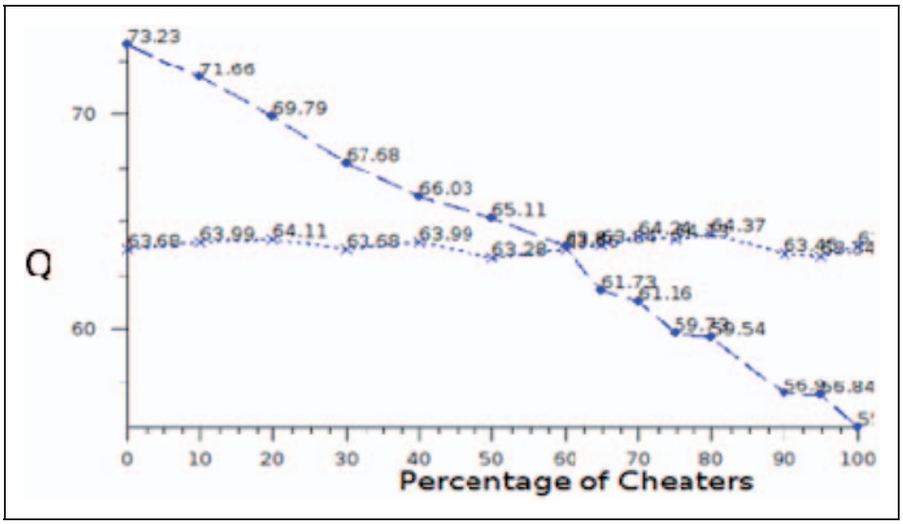

Figure 2. A summary of main results obtained with the REPAGE architecture. Image is less sensitive to informational cheating and leads to low quality but results are stable. On the other hand, reputation is more sensitive and for given parameter values favors the identification of cheaters. However, quality of information collapses when the cheating rate exceeds 60% (adapted from Quattrociocchi et al.[69]).

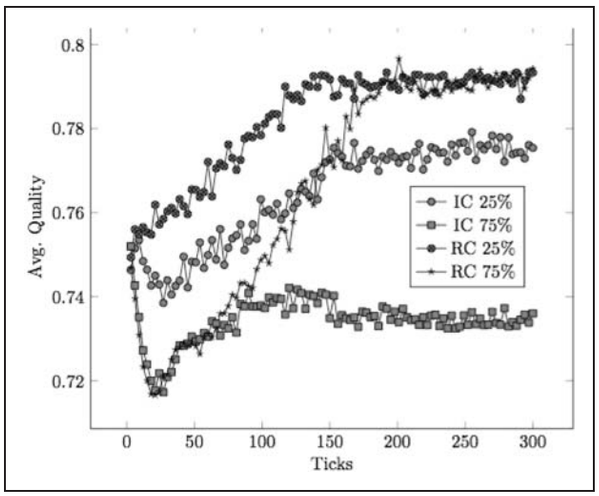

Figure 3. Results obtained with the SOCRATE model. This figure shows the average quality of production for different cheating rates both in the Image condition (IC) and the Reputation condition (RC). Reputation spreading sustains quality of production even in those cases in which the percentage of cheaters is very high (75% of the total number of agents) (adapted from Giardini et al.[70]).

reputation plays a relevant role in relationships among firms.[73]

For this reason, an ideal-typical cluster has been designed, and agents took part in two kinds of exchanges: informational exchange and material exchange. In the latter case, they had to choose the best available supplier in order to deliver high-quality products. When their usual suppliers were not available, they relied on informers, that is, other agents transmitting evaluations, in order to avoid the costs of direct interaction and to acquire useful information. Two different settings were tested: an image setting, in which agents could transmit only their personal evaluations, thus exposing themselves to the risk of retaliation, and a reputation setting. In this latter condition, evaluations were communicated without reporting the source, so that reactions against bad informers were de facto impossible.

We tested the model for two different percentages of informational cheaters in the population. For each tick of the simulation, results of past interactions with suppliers are recorded, while informers' suggestions are stored in a different table. When agents receive a false image, they retaliate by providing cheaters with false information (basically, they suggest the worst supplier from their list of actual interactions). On the contrary, when they receive a false reputation, they cannot retaliate because they do not know the source of it.

The results obtained from 10 simulations per each experimental condition (300 agents on three layers interacting for 300 simulation ticks) showed that the quality of products was higher in the cluster with reputational information, compared to the cluster with image, for the same percentages of cheating (see Figure 3). We also replicated the results by varying the distribution of firms on the three layers, thus designing a market with harsh competition for good partners, and we found that the exchange of reputational information also allows the whole cluster to obtain higher profits.

In other words, social information gave rise to different configurations: image-based clusters performed better when cheaters were few but quality of production dramatically decreased for higher levels of cheating. Conversely, clusters in which agents exchanged reputation were more flexible and robust when the number of cheaters was high, and the cluster's quality of products was only partially affected. In addition, agents in these networks explored the environment by both spreading and using untested evaluations, so that innovation was promoted through the inclusion of new partners and informers.

How should we interpret the main results of both studies? Essentially, they show that gossip allows agents to solve the dilemma arising from the fact that resources are scarce, so lying about sellers and suppliers with high-quality products is a way to protect them from exploitation by others, but false information is punished. Reputation is a means to punish untruthful informers without bearing the costs of further retaliation and this, in a quite counterintuitive way, protects the system from collapsing. In addition, for certain percentages of cheating rates, in both studies, agents exchanging reputation perform better than agents transmitting image, showing how relevant the role of reputation is in enhancing the quality of products. This result is found both in markets characterized by scarce good sellers and in industrial clusters with a limited number of good producers, even with considerable informational cheating. Why is this?

The key for the success of gossip is tolerance. Gossip allows for social evaluation to circulate in larger informational networks as compared to what happens in image-based networks, because it is a forgiving strategy. In reputation networks, *informational* cheating is less punished than in image networks. Hence, gossip allows for partner selection at the material level, giving it up at the informational level. Social information circulates in a wider group, providing members with an incentive to participate in the exchange of information. The incentive takes the form of a preventive defense: gossipers protect the identity of the evaluation source, thus reducing the chances for retaliation. As more information circulates in the gossip network and more agents participate in it, the average chances for agents to perform partner selection and find good partners for exchange (market) or cooperation (industrial district) increase, keeping low the costs of communication, which is exactly what we expected to find.

In sum, gossip allows one to select against material cheaters, by putting up with informational cheaters. Trust networks, that is, image-based networks in which members trust each other as informers, are progressively bound to shrink, allowing only an always smaller number of agents to find good partners and build on an increasingly lower capital of experience and information. On the contrary, the dimension of gossip networks may even exceed the dimension of material partnership, allowing a larger number of agents to access the good sellers and therefore accumulating and circulating into the network a growing social knowledge.

However, there is also the bad side of the coin. In gossip networks, the information circulating is less accurate and more easily corrupted. Hiding themselves behind the shutter of an indefinite source, people may spread all sorts of lies and calumnies. If it is an incentive to participate in the informational network, gossip is bound to incentive deception as well. What is the good of exchanging information, if this generates informational lemons?

Our findings provide only a partial answer to this specific question. They show that, for given values assigned to parameters, the gossip network is robust until the number of informational cheaters exceeds the majority of the population, which indeed is a rather unlikely event. Of course, nothing can put up with a thoroughly corrupt social environment. A more satisfactory, if not complete, answer requires further simulation studies, exploring the parameters' space to extensively check the quantitative and qualitative conditions under which the theory is verified.

7. Conclusions

The academic interest for reputation is constantly increasing, and the importance of social evaluations is now widely acknowledged across a wide range of different disciplines. In this work we have crossed disciplinary boundaries to merge cognitive science, ethnography, and computer science with the aim of investigating the role that reputation and gossip play in social control. Exercising social control roughly means to isolate and punish cheaters. However, punishment is costly and it inevitably implies the problem of second-order cooperation. Moving from a theoretical analysis of social control we showed that it requires two activities: identifying the violators and avoiding or punishing them. Punishment is highly efficacious but expensive for both the victims and the executors, whereas exclusion is a less explicit mechanism, and therefore is less persuasive, but is inherently self-protecting.

In any case, whether punishment or exclusion, what secures high benefits in social control is finding out the cheaters. Communication is by far more beneficial than any other identification system, but is not for free. Indeed, ordinary communication, in which the source of evaluation concerning unreliable partners is known, entails serious risks of undergoing retaliation.

The question is how to reduce these risks and capitalize not only on information acquisition, but also on information transmission. We claimed that gossiping, that is, the spreading of information about third parties, can provide a solution when *reputation* is transmitted. Contrasting the transmission of information in which the source is hidden, what Conte and Paolucci[46] call *reputation*, and *image*, that is information with an undisclosed source, we put forward the hypothesis that gossip reduces the costs of social control while leaving its benefits intact.

We found support for our model of gossip in ethnographic data that show that in traditional societies all around the world gossip presents some common features so that gossipers circulate each other's evaluations without committing to the truth value of the information, thus preventing retaliations and the escalation of counter-punishment. We also tested our hypothesis about the effects of image and reputation for social control using data coming from ABSs in which evaluations were used as a means for partner selection. In the first study the emphasis was on results coming from REPAGE, a computational system for partner selection based on a model of reputation (beliefs about shared voice on a given target), image (own evaluations), and their interplay. In the second study simpler agent architecture was tested in an ideal-typical industrial district in which agents had to maximize the quality of their production. In both cases, reputation was the most efficient modality of transmission regarding partner selection and social control. Even more interestingly, our results showed also that the system's response to different percentages of cheaters varied depending on the kind of information circulating in the system itself.

Although the relevance of reputation for cooperation and partner selection has been widely acknowledged,[6,33,48,74] it is often considered as an alternative to other and more plausible hypotheses, such as 'strong reciprocity'.[17] Moreover, few attempts have been made so far to link the evolution of reputation and punishment. One of the most recent ones[75] simply introduces a 'punishment score' as a measure of an individual's reputation of being a punisher. This score is analogous to the 'image score'[33,40] and it allows punishers to receive more collaboration in the future, contributing to the evolutionary stability of cooperative behavior.

A completely underrated issue in studies of reputation is its specificity as opposed to general communication. An interesting exception is the work of Ingram et al.,[50] in which they claim that reputation played a role in the evolution of the uniquely human cognitive structures needed to deal with the complexity of creating and manipulating social evaluations. Analogously, we claim that relying on third parties' evaluations when deciding whether to interact with strangers is a specific human feature. Relying on this kind of information is crucial in order to avoid costly interactions and it permits one to save time and to be protected against cheaters.

Giving incentive to participants for sharing socially relevant information, gossip allows group members to accumulate a large social knowledge capital through which a large number of agents can find the good partners. Cruel with regard to suspected material cheaters, often unable to defend themselves from accusations, gossip is a forgiving strategy with regard to liars, and this might be one of the reasons why it is blamed both in traditional and in modern societies. However, this did not prevent gossip from proving adaptive in the evolution of our species, contributing to the emergence of cooperation in large social groups that include altruists and non-altruists.

These evolutionary aspects will be addressed by future studies, aimed at designing a simulation model to test the effects of gossip on different kinds of societies, modeled after the traditional societies described by ethnographers. We are interested in understanding to what extent gossip affects groups with different social organizations, both in terms of group cohesion and social control. Another future strand of research will consist of merging this theory with social network analysis, in order to test how gossip spreads in networks, whether the network topology affects the gossip transmission, and how socio-technical systems should be designed to support gossip.

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Conflict of interest statement

None declared.

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