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The Peace Mediator Effect

A. Guazzini · G. Barnabei · T. Carletti · F. Bagnoli · D. Vilone

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Abstract Statistical mechanics has proven to be able to capture the fundamental rules underlying phenomena of social aggregation and opinion dynamics, well studied in disciplines like sociology and psychology. This approach is based on the underlying paradigm that the interesting dynamics of multi-agent systems emerge from the correct definition of few parameters governing the evolution of each individual. Into this context, we propose a new model of opinion dynamics based on the psychological construct named "cognitive dissonance". Our system is made of interacting individuals, the agents, each bearing only two dynamical variables (respectively "opinion" and "affinity") self-consistently adjusted during time evolution. We also define two special classes of interacting entities, both acting for a peace mediation process but via different course of action: "*diplomats*" and "*auctoritates*". The behavior of the system with and without peace mediators (PMs) is investigated and discussed with reference to corresponding psychological and social implications.

Keywords opinion dynamics · complex systems · peace mediation · cognitive dissonance

1 Introduction

In recent years we have seen the emergence of a new breed of professionals broadly called Peace Mediators, PMs for short, involved in the process of peace (re)construction. They

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are deployed in countries torn by conflict or post-conflict areas in order to create conditions for sustainable peace. PMs act with the goal of reduce the fragmentation among different parts of the society until a suitable threshold, below which a widespread consensus is achieved and peace can be maintained.

Our model is based on the assumption that it is possible to study the evolution of a social phenomenon by directly considering a few of attributes of the individuals coupled by specific interaction rules. For these reasons, we adopt an agent based model, in which local rules are inspired by the *cognitive dissonance* [1], a cognitive construct that rules the evolution of human social cognition [3]. According to Cognitive Dissonance Theory, when unknown individuals interact, they experiment an *internal conflicting state* because of their respective lack of information. In order to avoid the cognitive dissonance, individuals adopt heuristics strategies making use of *mental schemes*[1] [2]. The mutual affinity is the mental scheme employed to overcome this lack and to perform the optimal choice in terms of opinion production. Two heuristics strategies are generally employed:

A) if the affinity towards the interacting partner is below some threshold, then the individual will tend to crystallize its actual opinion, while for higher values of affinity he will change its opinion in the direction of the partner's one;
B) if the opinion difference between the two interacting agents is below a critical value, then each one will increase its affinity towards the partner, otherwise the affinity score will decrease.

These two way of acting are modulated by internal factors, such as the *openness of mind* and the *confidence*[2], and external ones, such as the possibility of interacting given by its own social system. Moreover, affinity acts as a long term memory in which individuals can store information useful to solve similar future situations.

By formalizing agents in such a way, we will obtain a dynamical population where interacting agents share their opinions by trying to maintain an acceptable level of dissonance. The asymptotic states of such system are either a global consensus (i.e. into an hypothetical opinion space, a mono-clustered state) or a social fragmentation (i.e. crystallization of no longer interacting clusters of opinion). Of course, in the goal of PM, latter state must be considered *dangerous*, since once obliged to interact, the low level of mutual affinity and the differences in opinion, may lead to strong social contrasts between these agents. For this reasons, the goal of PM can be translated into a reduction of the social fragmentation, namely into a reduction of opinion distances of agents into the opinion space.

The aim of this paper is to present two possible models of PM behavior. In the first case, we emphasize principally the skill of interacting and negotiating with people along large opinion distances. We label these PMs as "*diplomats*" and we tag their most prominent characteristic as openness of mind. Classical examples are actual diplomats, transactors, intermediaries, etc. On the other hand, we consider as fundamental attribute the PM reputation. The source of information is an essential ingredient to let the information to enter and spread into a population. We hence label this PM figure by "*auctoritas*", being characterized by an established opinion and the aptitude to influence the society by their prestige. For sure we can set in this category Mahatma Gandhi and Nelson Mandela.

Targets of this work are to obtain a mathematical representation of both PM's figures and to investigate how they can affect a formalized social system of *normal* agents in order to reach a widespread social consensus.

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[1] Symbolic and synthetic representations builded up through inferential, imaginative and emotional processes. Because of mental schemes can be upgraded in real time during interactions with other individuals, they are used as a guidance for quick decisions in stereotypical situations.

[2] The openness of mind is the limit of permissiveness that individual introduces interacting with other people. It allows to ignore the perception of incompatibilities existing between oneself and others and consequently to interact with individuals having very distant opinions. The confidence is the minimal reputation required to accept instance from others.

The paper is organized as follows. The next section is dedicated to describe the model. In forthcoming section we present numerical simulations. Fifth section is devoted to essential results and in the last section we will sum up and talk about future perspectives.

2 The Model

The adopted model has already been studied in [3–5]. Hereby we briefly recall its main features. The model is characterized by a continuous opinion and a random binary encounter dynamics. We consider a system composed by N autonomous agents, the individuals, each one characterized by the two constant parameters ΔO_c and α_c, respectively the openness of mind and the confidence. Agents are also described by the two variables α and O, respectively affinity and opinion, $\in [0,1]$ and self-consistently adjusted during time evolution according to the following update laws:

$$O_i^{t+1} = O_i^t - \mu \; \Delta O_{ij}^t \; \Gamma_1(\alpha_{ij}^t) \tag{1}$$

$$\alpha_{ij}^{t+1} = \alpha_{ij}^t + \alpha_{ij}^t \; [1-\alpha_{ij}^t] \; \Gamma_2(\Delta O_{ij}) \tag{2}$$

where the functions Γ_1 and Γ_2 respectively read:

$$\Gamma_1(\alpha_{ij}^t) = \frac{1}{2} \left[\tanh \left(\beta_1 \; (\alpha_{ij}^t - \alpha_c)\right) + 1\right] \tag{3}$$

$$\Gamma_2(\Delta O_{ij}) = -\tanh \left(\beta_2 \; (|\Delta O_{ij}^t| - \Delta O_c)\right) \tag{4}$$

being ΔO_{ij}^t the difference at time t between the two opinion values of the interacting partners, μ a convergence parameter and β_1 and β_2 set large enough to consider the activating functions as step functions.

At each step t two interacting agents are selected as follows: the i-th agent is drawn with uniformly distributed probability from the population, while the j-th one is the one who minimize the social metric:

$$D_{ij}^t = d_{ij}^t + \eta(0,\sigma) \tag{5}$$

composed by the two terms, respectively the *social distance*:

$$d_{ij}^t = \Delta O_{ij}^t (1-\alpha_{ij}^t) \qquad j = 1,...,N \qquad j \neq i \tag{6}$$

and the gaussian noise (η) with mean value zero and variance σ, called *social temperature* [2], modulating the mixing degree in the population.

Being the ultimate goal of PMs the reduction of social fragmentation, both *diplomats* and *auctoritates* will act in this direction, but via different courses of action. *Diplomats* are assumed to have a larger ΔO_c then *normal* agents and consequently they can interact in the opinion space with far away agents. According to Eq. 1, this way of acting will lead to an increase of the individuals affinity towards *diplomats*. On the other hand, *auctoritates* are assumed to employ their notoriety; this is translated in our model by imposing that all agents have a larger affinity value towards them, directly promoting the convergence into opinion space.

3 Numerical simulations

Simulations are performed with following parameters. N is fixed once for all to 100, including PMs. The social temperature $\eta(0,\sigma)$, the affinity threshold α_c and the convergence parameter μ are fixed once for all, respectively at 0.003, 0.5 and 0.5. *Normal* agents have a $\Delta O_c = 0.2$, while for *diplomats* $\Delta O_c = 0.5$. Entries in the affinity matrix α are initialized between *normal* agents with uniformly distributed probability in $[0, 0.5]$, while entries corresponding to *normal* agents towards *auctoritates* are set at 0.75.

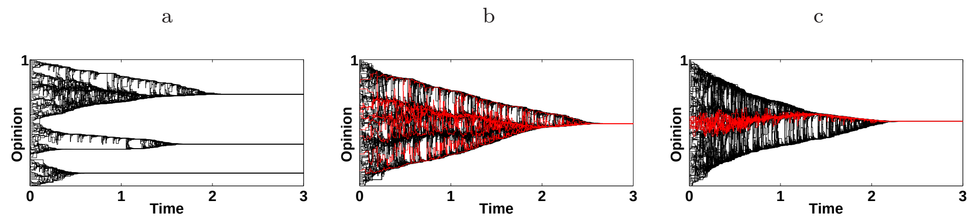

Fig. 1 Typical opinion trajectories. Each time step are 10^4 interactions. a) *Normal* agents; b) *Normal* agents (black) and *diplomats* (red); c) *Normal* agents (black) and *auctoritates* (red).

We have considered both the fraction of PMs over the entire population and their distribution in the opinion space as the relevant control parameters, hereby measuring the mean number of survived clusters at the equilibrium over 100 runs. The range of employed PMs is from 5% to 50% in steps of 5%[3].

Runs are stopped when the system converge to an equilibrium asymptotic state. We define a such state is reached when the affinity matrix will no longer change. We know that for communities larger than 20 agents, the system converge with respect to the opinion before than respect to the affinity [5]. Hence, when affinity reaches a state where it no longer evolves, the whole system, i.e. also the opinion, will freeze. Such asymptotic state will be characterized by the number of clusters in the opinion dimension.

Scenarios. The behavior of the two PMs figures are separately studied in a starting system which entries of opinion vector O are initialized uniformly spaced in $[0, 1]$. *Diplomats* are distributed along the opinion space by substituting them to the already initialized *normal* agents and according with the following modalities. In the "*uniform*" distribution *diplomats* are spread along the opinion space with uniformly distributed probability; in the "*gaussian*" one with a gaussian distribution (mean 0.5, standard deviation 0.2); in the "*bimodal*" distribution they are inserted with a bimodal distribution.

The same opinion vector initialization and distribution strategies are used for *auctoritates*, with the addition of a "*delta*" strategy in which all *auctoritates* are grouped around the center of the opinion space, namely around 0.5.

The "*two opposing factions*" case. Hereby we propose an application of the model. We consider a starting opinion space in which agents are divided into two large clusters, such that their respective opinion distances are larger than the opinion threshold of any single agent. In such a way, there is no possibility of interaction between agents belonging to the two different groups. Nevertheless, *diplomats* are able to interact with both factions because of their large openness of mind, while *auctoritates* can attract individuals because of their high reputation. We thus compare the two different courses of action.

4 Results

Figure 1 shows typical trajectories into the opinion space of a system of *normal* agents (1a), a system influenced by *diplomats* (1b) and a system influenced by *auctoritates* (1c), respectively. While the system of *normal* agents quickly converge to a fragmented asymptotic state, the insertion of PMs increases the convergence time needed as so as the chances of obtaining a mono-clustered state. We remark the different courses of action of the two PMs. Because of the great ΔO_c value, *diplomat* increases affinity towards neighbourhood, approaches partner and inclines it towards its own opinion. Agents inside the opinion bounds of *diplomat* have a larger probability of collapse in the same final position, and

[3] We remark that, so as formalized, the increase of fraction of PMs can corresponds respectively either to a fixed number of PMs having to do with smaller group, or to a population having a higher mean ΔO_c (*diplomats*).

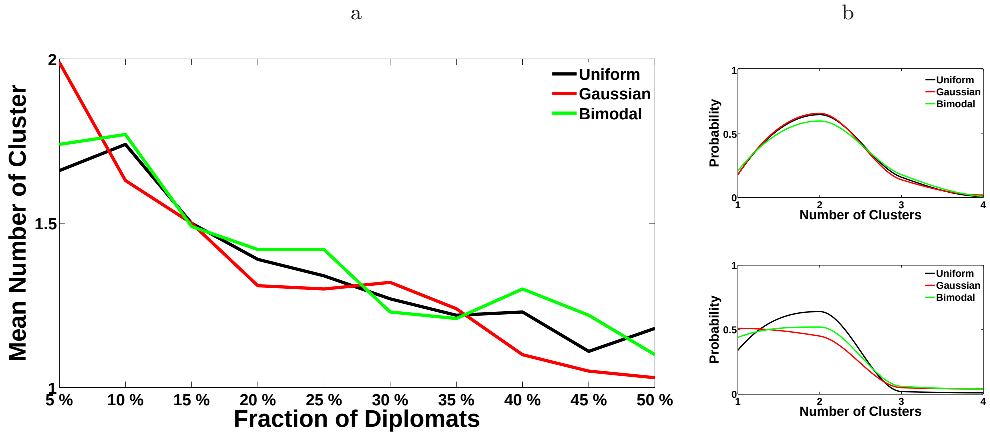

Fig. 2 Behavior of a system modulated by *diplomats*, spread as in legend. a) Mean number of survived clusters at the equilibrium as a function of the fraction of *diplomats*. b) Probability of having N clusters at the equilibrium in a single run, 5% of *diplomats* (upper figure), 50% of *diplomats* (lower). For sake of clearness, the histograms are interpolated by ninth degree polynomials.

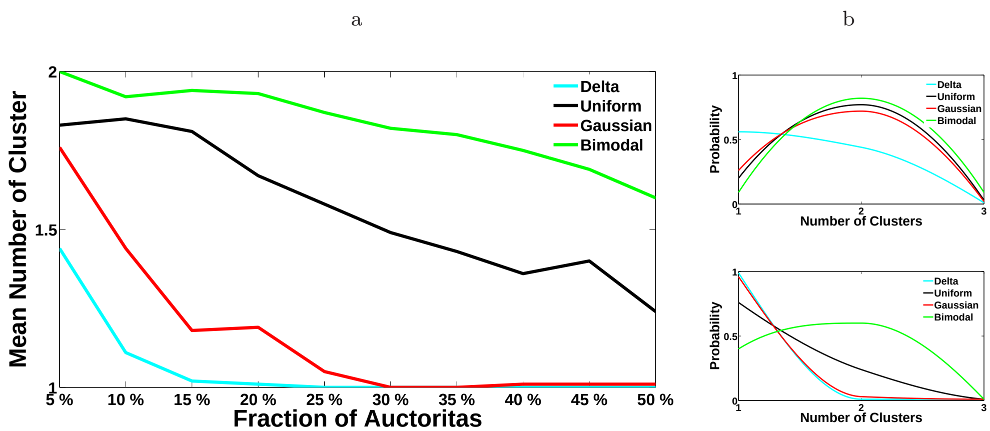

Fig. 3 Behavior of a system modulated by *auctoritates*, spread as in legend. a) Mean number of survived clusters at the equilibrium as a function of the fraction of *auctoritates*. b) Probability of having N clusters at the equilibrium in a single run, 5% of *auctoritates* (upper figure), 50% of *auctoritates* (lower). For sake of clearness, the histograms are interpolated by ninth degree polynomials.

the *diplomat* has the possibility to explore the entire opinion space. On the other hand, *auctoritas* tends to reach the equilibrium with the same opinion value with respect to the initial condition. In this latter case, the affinities of *normal* agents towards *auctoritates* trigger the convergence dynamics to monocluster.

Figure 2 resumes results relative to *diplomats*. The insertion of *diplomats* reduces the mean degree of fragmentation at equilibrium. Moreover, this reduction is linear and positively correlate with the fraction of employed *diplomats*. Although the three distribution strategies have similar trends (Fig. 2a), by augmenting the fraction of *diplomats*, the *gaussian* one tends to reach the greater number of mono-clusters at equilibrium (Fig. 2b, lower).

Figure 3 resumes results relative to *auctoritates*. Once more the insertion of PMs reduces the mean degree of fragmentation at equilibrium, but hereby the adopted distribution strategies significatively influence results of simulations (Fig. 3a). By varying the

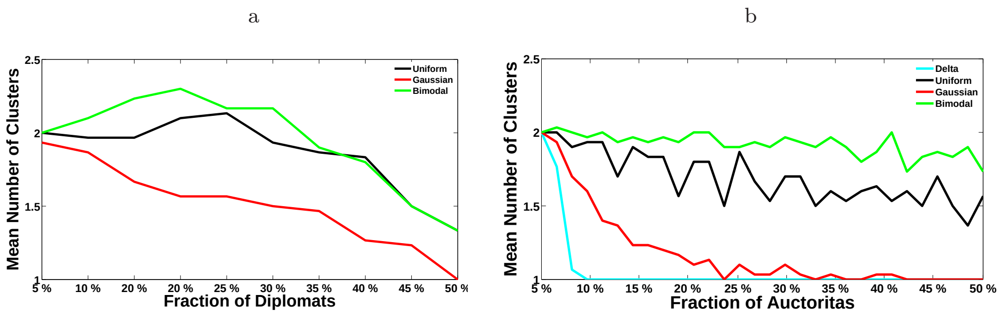

Fig. 4 Behavior of a bi-clustered starting system, spread as in legend. Mean number of survived clusters at the equilibrium as a function of the fraction of PMs, spread as in legend. a) Acting *diplomats*; b) acting *auctoritates*.

employed fractions of *auctoritates*, *gaussian* and, mainly, *delta* distributions show best trends in terms of convergence to a mono-cluster state. The *bimodal* distribution tends to converge to a bi-clustered state (Fig. 3b, lower).

Figure 4 shows results of insertion of PMs into a bi-clustered starting population; previous results are confirmed. *Diplomats* become efficacious only for higher fractions of employment and mainly with a *gaussian* distribution. *Auctoritates*, spread with either a *gaussian* or, above all, a *delta* strategy, assure the convergence to a mono-clustered asymptotic state since lower fractions of employment.

5 Conclusions and future perspectives

In this paper we propose an application of the model of continuous opinion dynamics already introduced in [3–5], by inserting two figures of PMs, one by one either *diplomats* or *auctoritates* respectively, into a population of *normal* agents. We describe the behavior of the system in terms of opinion convergence and mean degree of fragmentation for different fraction of employed PMs, also in reference to a more likely situation, namely the case "*two opposing factions*".

The typical *modus operandi* of *diplomats* becomes more effective by inserting many of them. By referring to Note 3, both the insertion of few *diplomats* into groups of small size and the increase of the mean ΔO_c value of the population would lead to the same result. On the other hand, the promotion of few *auctoritates* can assure the convergence to a widespread consensus into populations of any sort.

The combined efforts of both the two PMs figures remain to test, as so as the effects of the population size and the time needed by such figure in order to reach the global consensus.

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