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Peer-to-peer and mass communication effect on opinion shifts

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ABSTRACT

Opinion dynamics is studied through a minimal Ising model with three main influences (fields): personal conservatism (power-law distributed), inter-personal and group pressure, and a global field incorporating peer-to-peer and mass communications, which is generated bottom-up from the faction supporting the new opinion. A rich phase diagram appears separating possible terminal stages of the opinion diffusion, characterizing failure phases by the features of the individuals who had changed their opinion. An exhaustive solution of the model is produced, allowing predictions to be made on the opinion's assimilation in the society.

1. Introduction

It was always the nature of revolutions, in the wide sense, that they started from rather localized events, but developed due to systemic conditions.

Examples are throughout human history from the time of the discovery of fire and agriculture, through the transformation of the Goths from a band of refugees into the dominant force in Europe, and to the current social and economic crises.

The scientific quantitative study of opinion shifts and revolutionary progress has been envisaged in the last decades but it is significant that some of the trials were formulated at the fringe of the scientific community (e.g. the fictional science Psychohistory, introduced by Isaac Asimov in his Foundation universe or the reflexivity idea formulated by Soros in the 1960s but published only recently [1]).

The recent capabilities, afforded by the internet in peer-to-peer and in enhanced mass communication, have further enhanced the possibility of individuals to influence not only their limited number of acquaintances, but also a significantly larger amount of individuals. This has been shown to completely change not only the conditions but also the character of the transition that the system, i.e. network of people, undergoes [2].

In the present paper, we consider the minimal dynamical model that describes the opinion-shift dynamics in the presence of peer-to-peer and mass communication. In doing so, we include both the new elements introduced by the internet communication (communication unlimited by physical distance) as well as elements that characterize human society since pre-history (mutual influence between close individuals, the reactionary influence of the establishment).

We include three effects which influence opinion diffusion in our model: (1) personal affiliation towards the introduced opinion, (2) group pressure of closest acquaintances, and (3) global influence, such as media, peer-to-peer and mass communication (especially the internet and cellular oriented peer-to-peer devices, such as: phone calls, SMS, emails, twitter, Internet sites and blogs, etc.). The global influence (Eq. (1)) is created bottom-up from the fraction of change adopters, and then acts top-down on the entire population.

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The ideas above define the core of our model, and understanding their interdependence in relation to the outcome of the opinion assimilation is our primary goal. Previous works in the field (for example Refs. [3,4]) include only some of the effects described above, but not a full combination of them.

Our results imply that the degree of the opinion shift may be predicted. In other words, the influence of societal characteristics in respect to revolutionary/innovative parameters is clarified.

2. Method

It has been previously [5] postulated that social mass-behavior might be modeled through the Ising model, where the value of each spin *i* represents the state adopted by that individual in respect to his view. Given that, we examine when a complete opinion shift takes place, as inspired by percolation theory [6,7].

In the present paper, we have initially used an athermal 2D square lattice of $L \times L$ spins. In a more general case of network structure, L may take different meanings, and could even lose its relevance altogether. The total number of individuals is defined as N_{tot}, and in our specific implementation $N_{\text{tot}} = L^2$.

A square lattice compels high probabilities that the closest acquaintances of any individual may have another common closest acquaintance between them. This signifies a certain structure of the society.

We have also used a random graph model with similar characteristics to the square lattice, where each individual (node) has exactly four neighbors, but their geographical representation is random, so that the probability that the closest acquaintances of any individual may have a common closest acquaintance between them is very small. In addition, the graph is connected (no unlinked components), to focus on the major part of the society engaged in the opinion dynamics. At any rate, following the small-world experiments [8–10] the graph should not allow unlinked components, and thus should be connected. The graph generation process is similar to that proposed in Ref. [11].

Let us express the elements of the model quantitatively.

1. We express the overt position of each individual *i* by a variable S_i that is $+1$ in the case that it conforms to the "old" opinion and -1 if it adopts the new "revolutionary", or innovative stand.
2. We take into account that the conservatism of each individual *i* is a heterogeneous variable, which we label $h_i > 0$.
   a. For somebody who is completely immune to the influence of the predisposed and accepted opinion $h_i = 0$, while for somebody who is very attached/aligned with the old stand, h_i is large.
   b. In agreement with many empirical facts from similar systems [2,12,13], we assume that the distribution of values h_i is given by a power law: the fraction of individuals *i* whose initial attachment to the old order is less than *h* is given by the cumulative probability distribution $P(h_i < h) \propto h^c$ for $h \in [0, d]$. $P(h_i < h) = 1$ if $h > d$, while d and c are parameters. The normalization explicitly demands $P(h_i < h) = (h/d)^c$. Although Gaussian distributions have a long history in science, they may lead to negative fields. Log-normal distributions are Gaussian in the logarithm of the field and would be more suitable. However, recent decades concentrated a lot of effort on Pareto-like power-law distributions, like for (self-organized) critical phenomena, strong fluctuations in financial markets and many other social phenomena. Therefore, we distributed the individual h_i according to a power law.
3. We assume that only several ($N_s > 0$) individuals across the network are initially predisposed with the newly introduced opinion, and thus for them $S = -1$. These individuals are randomly distributed (uniformly) and thus are not necessarily spatially related. All other individuals are initially aligned with the old opinion, and thus for them $S = +1$.
4. All other individuals may change their stand if the global and local pressures as detailed below upset their initial stand.
5. The global influence depends on the total current number N of change adopters [14]. We will employ now and further in the research the notation of $R = N/N_{\text{tot}}$ and $R_{\text{init}} = N_s/N_{\text{tot}}$ for convenience:

$$H(R) = aR^b \quad \text{where } a \text{ and } b \text{ are parameters.} \tag{1}$$

6. The local influence is assumed to be proportional to the sum of the positions of the "acquaintances" of *i* (defined by the links (i, j) of the social network of *i*): $H_{\text{local}}(i) = J \cdot \sum_j S_j$, where J is a parameter and the acquaintances *j* of *i* are defined through assuming a particular social network between the individuals in the system. For example, in the case of a 2D square lattice, each individual has four acquaintances: North, East, West and South.
7. Rules 4, 5, and 6 have the potential of insuring the propagation of the opinion shift across the network's links. More precisely, if the condition

$$h_i + H_{\text{local}}(i) < H \tag{2a}$$

   is fulfilled, then *i* adopts the new opinion. Our "minimal" model does not allow individuals to change back their tendencies once they have adopted change. This requirement maintains the initial N_s revolutionaries, and does not allow them to be swallowed-up by the conformists.

In order to avoid scaling problems, we have $J \le 1$, $0 < b < 1$, $c \ge 1$ and without loss of generality we set $d = 1$. Besides that, we will work with relatively low values of $R_{\text{init}} = N_s/N_{\text{tot}}$ (up to 0.1) since if they are large, the meaning of an opinion shift becomes fickle.