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# MODELING OF INTERNET INFLUENCE ON GROUP EMOTION

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Long-range interactions are introduced to a two-dimensional model of agents with time-dependent internal variables $e_i = 0, \pm 1$ corresponding to valencies of agent emotions. Effects of spontaneous emotion emergence and emotional relaxation processes are taken into account. The valence of agent $i$ depends on valencies of its four nearest neighbors but it is also influenced by long-range interactions corresponding to social relations developed for example by Internet contacts to a randomly chosen community. Two types of such interactions are considered. In the first model the community emotional influence depends only on *the sign* of its temporary emotion. When the coupling parameter approaches a critical value a phase transition takes place and as result for larger coupling constants the mean group emotion of all agents is nonzero over long time periods. In the second model the community influence is proportional to magnitude of *community average emotion*. The ordered emotional phase was here observed for a narrow set of system parameters.

*Keywords*: Agent-based modeling; sociophysics; Internet; emotions.

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## 1. Introduction

The Internet revolution has changed the world to a global village. We are immersed in many Internet communities (Facebook, Twitter, etc.) that offer us an important social feedback. As result we can discuss problems and share our opinions not only with close friends or acquaintances, but also with all Internet users. In other words the Internet gives us an opportunity to communicate with many people from various communities what leads to qualitative as well as quantitative changes in the human behavior (Refs. 1–4). Flows of information among individuals contacting via the Internet (Refs. 1–7) are strongly connected with flows of emotions (Refs. 8–14). People affected by some external emotional factors (i.e. an emotional message from other people) can change their internal emotional states and can express their emotions posting messages to others.

There is no generally accepted definition of emotions and several concepts are used to quantify emotional states in social sciences (see e.g. Refs. 15–20). Emotions are usually considered as specific states of mind AND body (Ref. 19) lasting for a period of maximum of a few minutes (Ref. 20) although some researchers assume that emotional states can be preserved for several years (Ref. 21). There is also no agreement about a total number of possible distinct emotions or a number of variables needed to describe them. For many years psychologists assumed existence of sets of so-called discrete emotions (such as surprise, joy or anger) and considered them as disjoint phenomena corresponding to independent emotional dimensions (Ref. 22). In 1980 a new approach was introduced by Russell (Ref. 23) who proposed a circumplex emotion model where any emotion was described by two variables only: an emotional valence and an arousal. The number of emotional components can be increased by taking into account e.g. an affective dominance or unpredictability that were considered in Ref. 24 and an eight-dimensional emotion model was proposed in Ref. 25.

All these models are based on attempts to categorize the affective states by psycho-physiological observations. Complex systems researchers (Refs. 26–33 and 38) and computer scientists (Refs. 34–36) take advantage mostly of one or two dimensions. Most of them are focused on individual emotions (emotional behavior) and its influence on social interactions with other group members as well as reactions to others emotions. Researchers tried to model key features of emotions following the theory of emotion explored by social scientists. Gratch and Marcella in Refs. 34–36 focused on appraisal theory of emotions (Ref. 37) and based on that assumption they developed a computational model called EMA (for Emotion and Adaptation).

Recently physicists have entered the research of emotions and they treat emotional dynamics as a combined effect of internal stimuli of individuals and mutual affective interactions between different agents (Refs. 9, 27, 28 and 32). In Ref. 28 we proposed an agent based model of emotional dynamic with one emotional dimension: valence and we examined how the average group emotion was changing in time. A heterogenous population of agents was placed in sites of a square lattice, an individual agent valence was a time dependent variable that could take one of three values and the spontaneous emotional arousal, the emotional relaxation (Ref. 16) as well as a specific transfer of emotions were taken account. Extensive numerical simulations shown that in such a model collective emotional states possess an oscillatory character and the average group emotion was fluctuating around zero in the course of time. Schweitzer and Garcia (Ref. 27) considered another agent based model where Brownian agents possess valence and arousal components that are treated as continuous variables and are coupled to emotional fields generated by the whole social group. Using a mean field approximation for mutual agent interactions as well as assuming a nonlinear form of couplings between valency/arousal fields and agents internal states one could estimate conditions for emergence of collective emotions in such a system. Numerical simulations confirmed that *a collective emotional state appears, fades out and reappears again* (Ref. 27). Mitrovitz and Tadic (Ref. 31) applied the model of Ref. 27 to describe patterns of affective messages observed during discussions at Blogs and Diggs. An emotional content of Blogs data was used in Ref. 9 to study the emergence and evolution of internet communities. In Ref. 32 it was shown that emotional messages in Diggs, Blogs and BBC forums are clustered in groups of a similar emotional valency what can be quantitatively explained using a model of preferential cluster growth. The result means there are attractive interactions among community members expressing the same emotions. The evolution of affective patterns during Internet discussions was studied in Refs. 14 and 33. A common behavior is a decay in the course of discussion affective states that were dominant at beginning of a debate what can be understood as a growth of emotional entropy (Ref. 33). In the case of BBC Forum negative emotions are dominant (Ref. 14) and they boost user activity, i.e. an average emotion of longer threads is more negative and the number of negative comments decays in time in all threads.

In our paper we consider a new model describing group emotions in the sense of a mean community emotion. The study is an extension of our model of emotional agents at the square lattice developed in Ref. 28 by introducing special long-range interactions corresponding to Internet communication. We consider only the emotional valence that plays the pivotal role in the emotion research since it makes possible to distinguish between pleasure and displeasure. Moreover we shall assume a three-states model, i.e. emotional states of agents can be only positive, neutral or negative. This reduction of emotion complexity is in agreement with the current state of art of sentiment analysis approach and classification of emotions from texts (Refs. 29 and 30). In most cases, algorithms for automatic emotional classification can assign an emotional content to one of such three groups (Refs. 12−14).

We shall consider two separate cases of agents interactions. In the first one the long-range coupling is dependent only on a temporary sign of a mean value of emotion calculated for a randomly selected community. In the second case the influence depends also on the absolute value of community emotion. Extensive numerical simulations have been performed to demonstrate collective effects in both models.

## 2. Definition of Model Dynamics

As it has been already stated in the Introduction the present paper is an extension of our approach introduced in Ref. 28 by taking into account long-range interactions corresponding to Internet influence. Let us recap assumptions that were used in Ref. 28. Basing on psychological and sociological observations of emotional states we considered internal and external factors which influence agents emotional states (Refs. 15−22). In fact emotions can be caused by some intrinsic stimuli leading to spontaneous emotion emergence. Moreover, most of the time, individuals are affected by social influence of other group members what can also include emotional interactions. An important feature of all emotions is their short life times, one can say that an emotion emerges and disappears (mostly) as a spur of the moment. Usually, in the absence of internal or external stimuli, the emotion relaxes fast to a neutral state.

Let us consider $N$ agents that are placed at the square lattice (the lattice constant equals to one). Similarly as in Ref. 28 every agent $i$ possesses an internal, time dependent variable $e_i(t)$ that corresponds to his emotional valence and we shall call it *emotion*. For simplicity the variable can take only one of three values $e_i = 0$ (neutral state), $e_i = -1$ (negative emotion) and $e_i = +1$ (positive emotion). The emotion $e_i$ can change in time as result of the following processes:

(i) Spontaneous emotion emergence
Agent $i$ can randomly change his emotional state $e_i(t)$ to any possible state with a probability $p_s/3$. For calculation simplicity we allow also a change to the neutral state as well as preserving the initial one.

(ii) Emotional relaxation process
The positive or negative emotional state $e_i(t) = \pm 1$ can relax to the neutral state $e_i = 0$ if during $\tau$ time steps the agent and his closest neighbors $j$ located at the distance $r_{ij} = 1$ did not change their emotional states.

(iii) Local affective interactions
Agents at a distance $r_{ij} \leq \epsilon$ can influence each other with a probability $p$ as follows: a positive (negative) emotional emitter has a positive (negative) influence on an emotional receiver. An agent in the neutral state does not influence his neighbors. Details of these interactions are presented in Table 1.

(iv) Long-range affective interactions
These interactions arise from coupling of the agent to a community that is formed as a randomly chosen subgroup of other agents placed anywhere (see Fig. 1) what corresponds to the presence of Internet links. The influence of such a community resembles the *Majority Rule* used for modeling of opinion dynamics Refs. 39 and 40. Details of the coupling will be given below.

Similarly as in the models discussed in Ref. 28 for every agent $i$ first we consider the effect of relaxation process, then the spontaneous emotion emergence. After that we randomly select $N$ agents that act as emotion emitters and we consider the processes of local affective interactions in their neighborhoods. At the very end we consider interactions with a community emerging due to the presence of the long-range links. We randomly select $N_g = x_g \cdot N$ agents ($0 < x_g \leq 1$) forming this community and we calculate a corresponding mean *community emotion* that can influence in this moment all $N$ group members:

$$\langle e_g \rangle(t) = \frac{1}{N_g} \sum_{i=1}^{N_g} e_i(t). \tag{1}$$

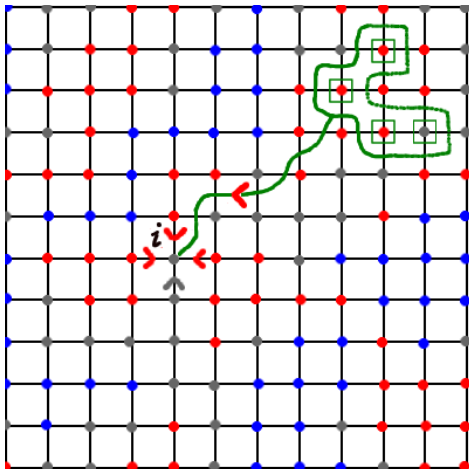



Fig. 1. (Color online) Scheme of affective interactions between agents. The agent $i$ is influenced by emotions of his four nearest neighbors and by an average emotion of a randomly chosen community. The members of the community are chosen randomly and can be far separated one from another.

The factor $x_g$ represents the relative *activity* of society members in the Internet space. The case $x_g$ close to 1 corresponds to the society where everyone has influence on the whole group as a result of his online activity and eventually the whole group can take the majority emotion. In contrast for $x_g \ll 1$ only a very limited number of agents express their emotions in the Internet community. Every agent can be influenced by the *community emotion* $\langle e_g \rangle(t)$ with a probability $p_g$. We consider two types of community interactions.

(i) The probability $p_g$ to be influenced by the community is constant in time and the community influence is sensitive only to the *sign* of $\langle e_g \rangle(t)$. Results of such interactions are similar to these presented in the Table 1 if one only changes $e_i$ to $\langle e_g \rangle(t)$. It means that positive (negative) *community emotion* has a positive (negative) influence on individuals but one does not take into account the magnitude of the average community emotions.

Table 1. Scheme of influence of emotional emitter $i$ on his neighbor $j$.

| $e_i(t)$ | $e_j(t)$ | $e_j(t+1)$ |
|---|---|---|
| $e_i(t) < 0$ | $-1$ | $-1$ |
| | 0 | $-1$ |
| | 1 | 0 |
| $e_i(t) > 0$ | $-1$ | 0 |
| | 0 | 1 |
| | 1 | 1 |

(ii) Community interactions are sensitive to the *magnitude* of average community emotion $\langle e_g \rangle(t)$. In such a case the probability to be influenced by the *community emotion* is time-dependent and is proportional to the absolute value of mean community emotion: $p_g(t) = A_g|\langle e_g \rangle(t)|$ where $A_g$ is a positive coupling constant.

Let us underline that models (i) and (ii) correspond to opposite assumptions about possible emotional group influence on the individual agent. While the Model (i) is a highly nonlinear threshold model, the Model (ii) corresponds to a continuous emotional influence. We consider both these limits since no quantitative data exist about emotional group interactions in e-societies. We suppose that the Model (i) can apply for communities of people discussing some disputed threads belonging, e.g. to religion, or nationalistic subjects. In such a case even a small emotion can trigger a large effect. The case (ii) corresponds to communities where more objective−like behavior is common and the influence of emotions is negligible. In such a case the majority of people stay in an emotionally neutral state but the emotional impact increases continuously with the fraction of community that lost its nonemotional behavior.

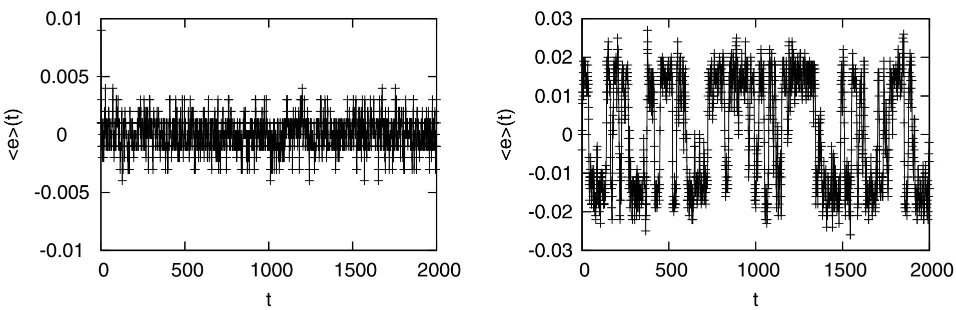
## 3. Results

### 3.1. *Sign sensitive community coupling*

Let us consider the case (i) of the sign sensitive community coupling. We study the time dependence of mean emotion in the whole society

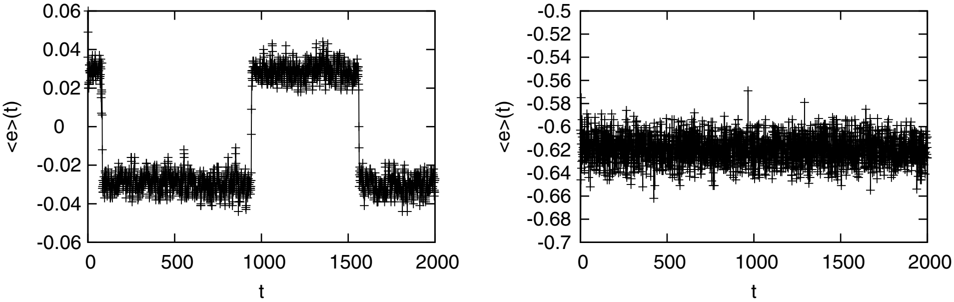
$$\langle e \rangle(t) = \frac{1}{N}\sum_{i=1}^{N} e_i(t) \tag{2}$$

for different values of community coupling parameter $p_g$ and different values of activity factor $x_g$. Representative results of computer simulations are presented at Figs. 2 and 3. All simulations were performed for the following system conditions: system size




(a) $p_g = 0, p = 0.001, p_s = 0.001$ (b) $p_g = 0.005, p = 0.001, p_s = 0.001$

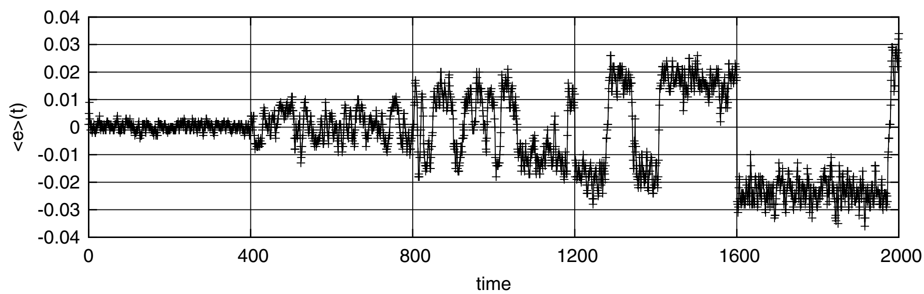
Fig. 2. Behavior of *group emotion* $\langle e \rangle(t)$ for Model (i) using algorithm $A$ with $p = 0.001$, $p_s = 0.001$, $x_g = 0.2$ and for different values of $p_g = 0, 0.005, 0.01, 0.5$ in (a)−(d), respectively.



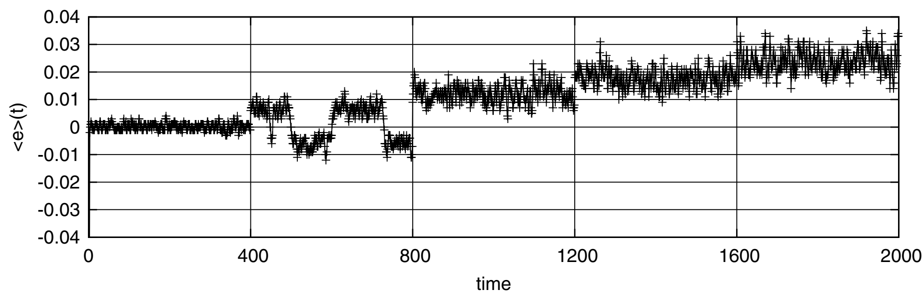

(c) $p_g = 0.01, p = 0.001, p_s = 0.001$ (d) $p_g = 0.5, p = 0.001, p_s = 0.001$

Fig. 2. (*Continued*)

$X = Y = 40$ $(N = 1600)$, relaxation time $\tau = 2$, total simulation time $T = 2000$ steps. We considered two ways in which a community influences a single agent. In the case $(A)$, the community is selected for one step of simulations and it influences emotions of all members of the society in the same way. In the case $(B)$, the community is chosen randomly for every agent.




(a) $x_g = 20\%$

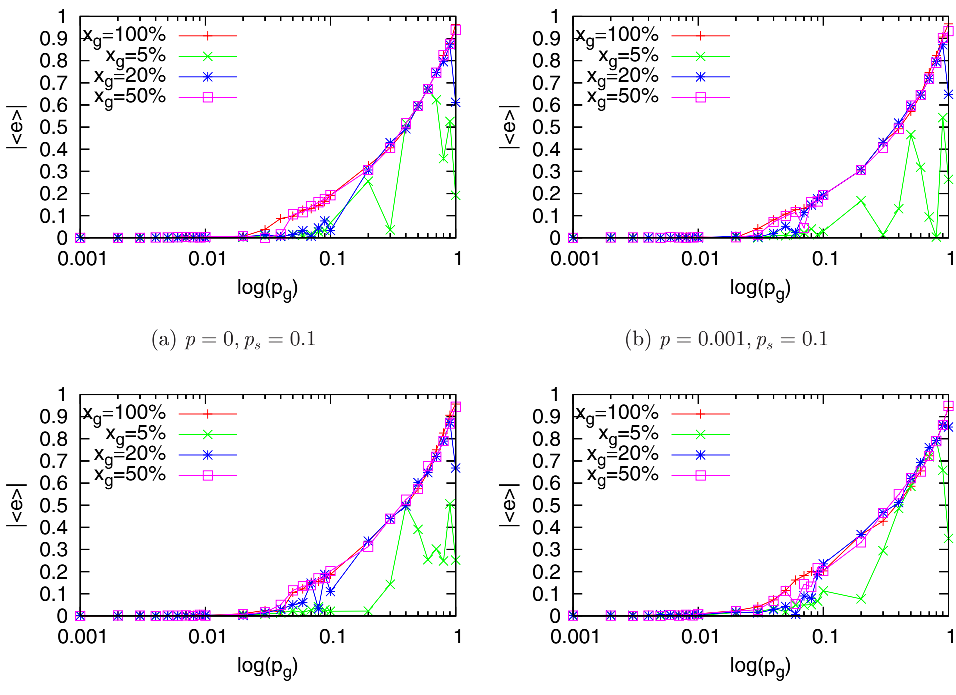



(b) $x_g = 100\%$

Fig. 3. Behavior of *group emotion* $\langle e\rangle(t)$ for Model (i) using algorithm $A$ with $p = 0.001$ and $p_s = 0.005$. For every time window $t = 400$ we increase $p_g$ from 0 to 0.008 with step 0.002.

The choice of these two various approaches reflects a broad spectrum of existing e-communities. The case $(A)$ corresponds to a community formed by (temporary) authorities, e.g. politicians, celebrities that can influence the whole society using the e-media. On the other hand the case $(B)$ corresponds to popular Fora, e.g. BBC Forum or CNN Forum, where participants are influenced by some active Forum writers and various participants take part in various discussions threads.

One can see in Figs. 4 and 5 differences in system behavior for algorithms $(A)$ and $(B)$. Noticeable differences can be observed for low values of activity factor $x_g$, it is when the chosen community that influence the whole society are very small. In such a case, the model $(B)$ reaches ordered state (i.e. absolute value of *group emotion* averaged over time $T$ is nonzero) for a lower value of coupling parameter $p_g$. However, qualitative behavior of the system for large groups does not differ since the averaging effect in such a case is dominating, i.e. a similar mean emotion can be expected in any subgroup forming 40% of the society. For this reason and for the numerical simplicity we focused on the algorithm $(A)$. One can observe that for low



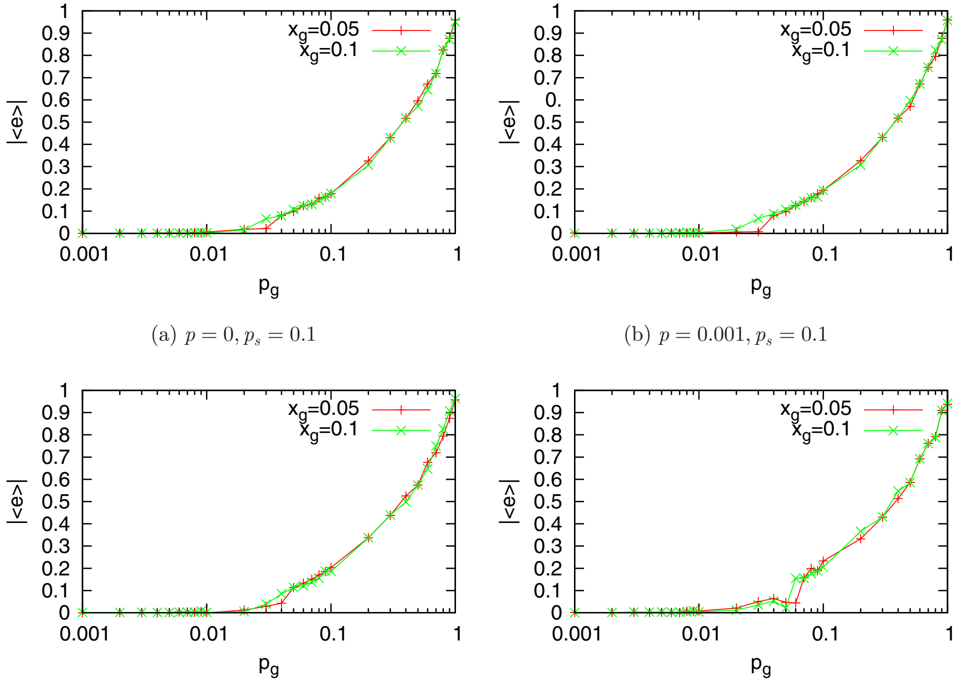

(a) $p = 0, p_s = 0.1$

(b) $p = 0.001, p_s = 0.1$

(c) $p = 0.010, p_s = 0.1$

(d) $p = 0.050, p_s = 0.1$

Fig. 4. (Color online) Behavior of absolute value of *group emotion* $|\langle e\rangle|$ averaged over time $T$ for Model (i) using algorithm $A$ as a function of $p_g$ with $p_s = 0.1$ and for different values of $p = 0, 0.001, 0.01, 0.05$ in (a)–(d), respectively.




(a) $p = 0, p_s = 0.1$

(b) $p = 0.001, p_s = 0.1$

(c) $p = 0.01, p_s = 0.1$

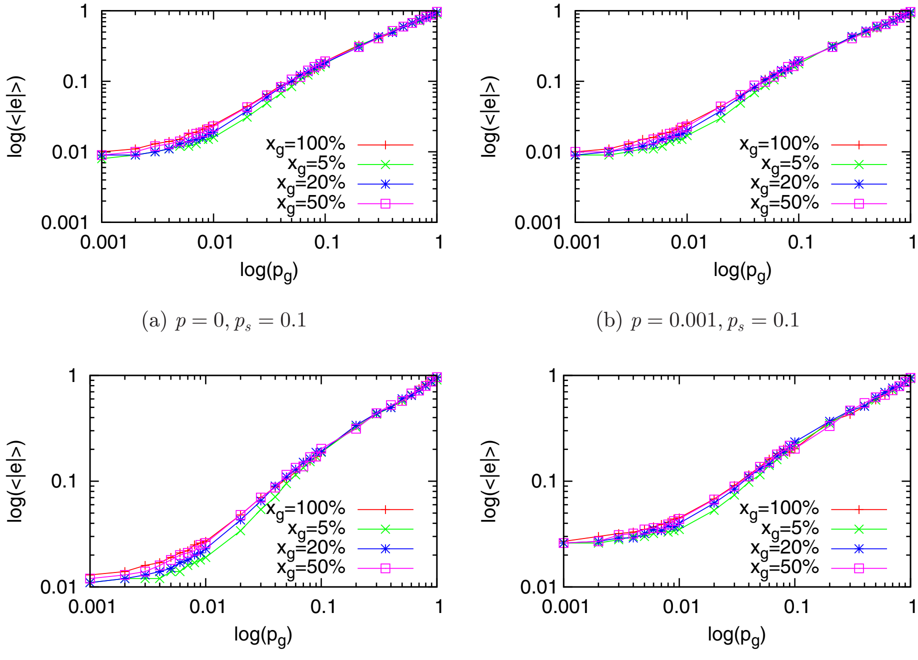
(d) $p = 0.05, p_s = 0.1$

Fig. 5. (Color online) Behavior of absolute value of *group emotion* $|\langle e\rangle|$ averaged over time $T$ for Model (i) using algorithm $B$ as a function of $p_g$ with $p_s = 0.1$ and for different values of $p = 0, 0.001, 0.01, 0.05$ in (a)–(d), respectively.

values of $p_g$ the *group emotion* $\langle e\rangle(t)$ oscillates around zero. There is some critical value of $p_{gc}$ and above this value the *group emotion* oscillates around one of two nonzero values $e^*$ or $-e^*$ that correspond to new ground states of this system. It follows there is a quantitative change in system behavior that can be understood as a phase transition at point $p_{gc}$. Just about the critical point of $p_{gc}$ there are additional irregular transitions between $e^*$ or $-e^*$ levels [see Fig. 2(b)]. These transitions are less frequent for larger values of $p_g$ [see Fig. 2(c)].

Figure 3 presents the behavior of *group emotion* when the coupling parameter increases every 400 time steps. Figures 4 and 5 show absolute value of *group emotion* $|\langle e\rangle|$ averaged over the time period $T = 2000$ for different system parameters.

The value of $e^*$ corresponding to the spontaneous system order parameter is displayed at Figs. 6 and 7 as a function of $p_g$. One can see that $e^* \propto (p_g - p_{gc})^\beta$ where the critical exponent $\beta$ can be measured as $\beta \approx 0.75$ provided that the probability of local interactions is small, $p < 0.05$. Since the probability of long-range interactions $p_g$ corresponds to the Internet influence on individuals emotions, we can point out that for some characteristic value of this parameter $p_{gc}$ the system can reach an ordered behavior that can be preserved over longer time. It means that the Internet is

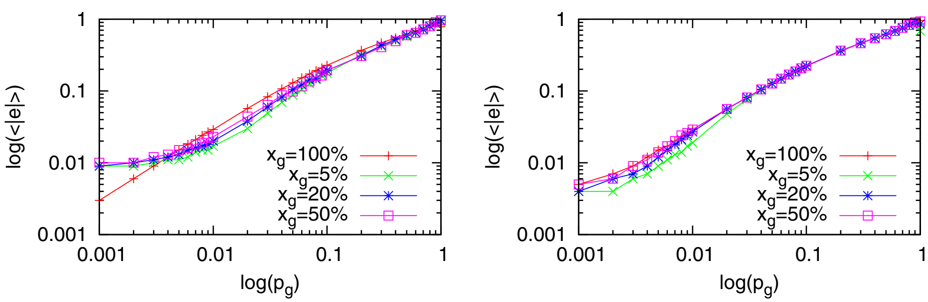



(a) $p = 0, p_s = 0.1$ (b) $p = 0.001, p_s = 0.1$

(c) $p = 0.010, p_s = 0.1$ (d) $p = 0.050, p_s = 0.1$

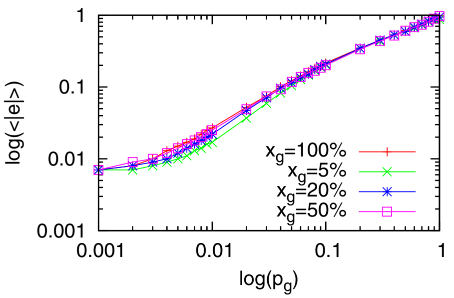
Fig. 6. (Color online) Behavior of absolute value of *group emotion* $\langle |e| \rangle$ averaged over time $T$ for Model (i) using algorithm $A$ as a function of $p_g$ with $p_s = 0.1$ and for different values of $p = 0, 0.001, 0.01, 0.05$ in (a)−(d), respectively.

a medium that links people in long distances and can cause *long-lasting group emotions*. Participation in Blogs, Fora and in other forms of on−line discussion brings a very strong external feedback and leads to ordering of group emotion around some nonzero values.

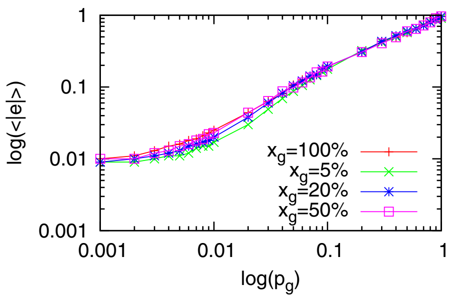



(a) $p = 0.001, p_s = 0.001$ (b) $p = 0.001, p_s = 0.010$

Fig. 7. (Color online) Behavior of absolute value of *group emotion* $\langle |e| \rangle$ averaged over time $T$ for Model (i) using algorithm $A$ as a function of $p_g$ with $p = 0.001$ and for different values of $p_s = 0.001, 0.01, 0.05, 0.1$ in (a)−(d), respectively.




(c) $p = 0.001, p_s = 0.05$




(d) $p = 0.001, p_s = 0.1$

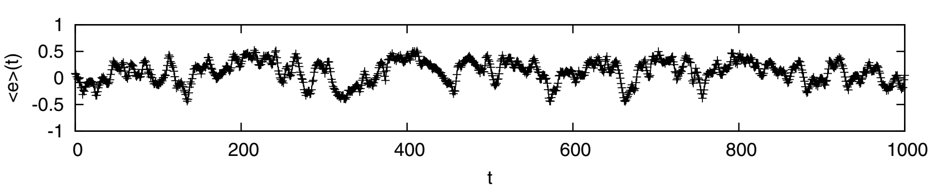
Fig. 7. (*Continued*)

### 3.2. *Coupling parameter as a function of magnitude of community emotion*

Now let us consider the case (ii) when the influence of a community on individuals depends on the magnitude of mean community emotion. The community influence can be positive or negative, depending on a temporal sign of $\langle e_g \rangle(t)$ similarly as in the previous model. As we mentioned before, because of absence of significant qualitative and quantitative differences in the way community is selected we focus on the case when it is randomly chosen once in time step and it influences all agents in the same way (case $(A)$).

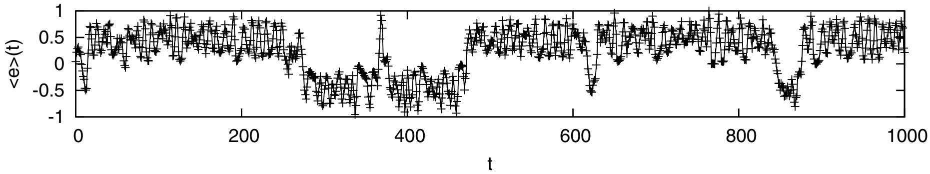
We examined behavior of the mean *group emotion* for the different values of coupling constant $A_g$, for different values of activity factor $x_g$, probability $p_s$ of spontaneous emotion emergence and the probability $p$ of local interactions between neighboring agents. Similarly to the model (i) there is a phase transition to the ordered state.

Time dynamics of *group emotion* is shown at Figs. 8 and 9 and various states of collective behavior are observed. For some sets of parameters the *group emotion* fluctuates around a nonzero value during long time periods (see Figs. 9(a) and 9(b)). Such an ordered state is here more difficult to observe as compared to the model (i)

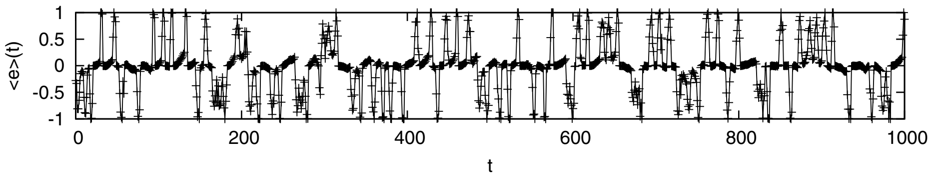



(a) $A_g = 0.05, x_g = 0.001, p = 0.1, p_s = 0.001$

Fig. 8. Behavior of *group emotion* $\langle e \rangle(t)$ in time for Model (ii) using algorithm $A$ with $p = 0.1$, $p_s = 0.001$, $\tau = 2$, $x_g = 0.001$, and for different values of $A_g = 0.05, 0.2, 0.5$ in (a)–(c), respectively

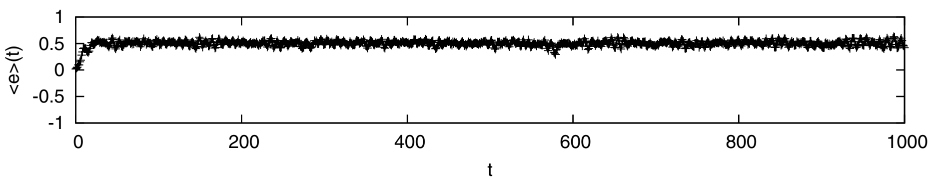



(b) $A_g = 0.2, x_g = 0.001, p = 0.1, p_s = 0.001$

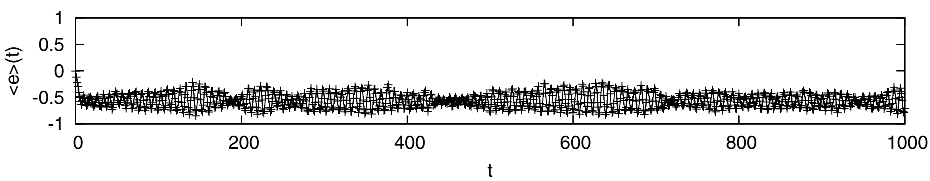



(c) $A_g = 0.5, x_g = 0.001, p = 0.1, p_s = 0.001$

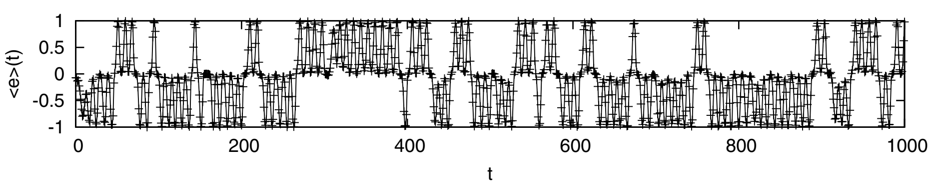
Fig. 8. (*Continued*)




(a) $A_g = 0.25, x_g = 0.05, p = 0.1, p_s = 0.001$



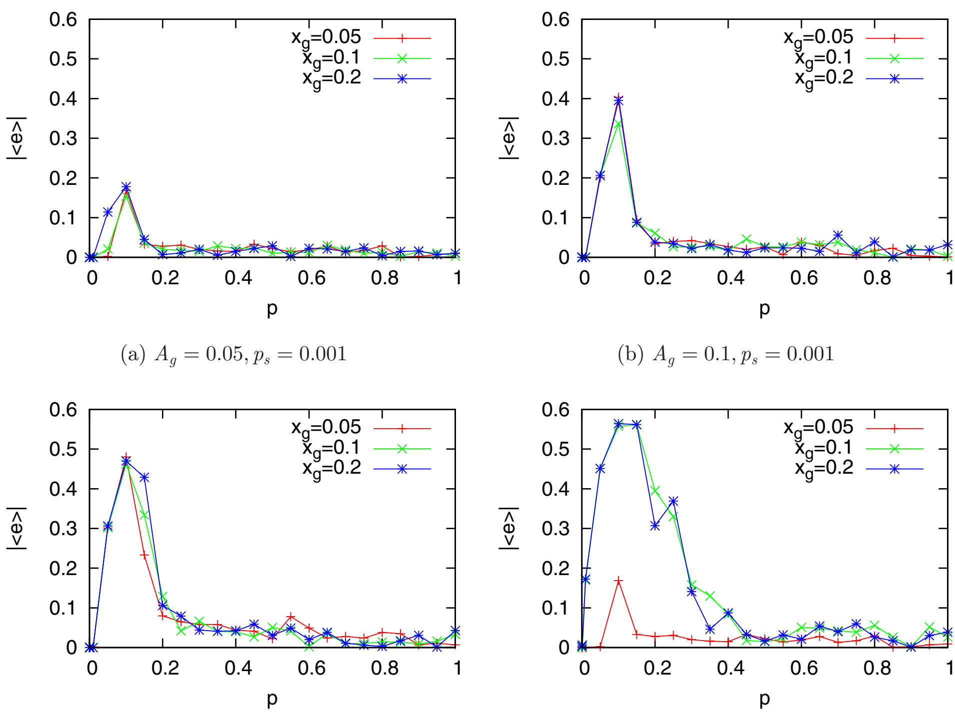

(b) $A_g = 0.5, x_g = 0.05, p = 0.1, p_s = 0.001$




(c) $A_g = 0.9, x_g = 0.05, p = 0.1, p_s = 0.001$

Fig. 9. Behavior of *group emotion* $\langle e \rangle(t)$ in time for Model (ii) using algorithm $A$ with $p = 0.1$, $p_s = 0.001$, $\tau = 2$, $x_g = 0.05$, and for different values of $A_g = 0.25, 0.5, 0.9$ in (a)–(c), respectively

and in majority of cases it does not exist. One can expect that the system orders when the noise level corresponding to the value of probability of spontaneous emotional emergence $p_s$ is low. The increase of $p_s$ causes oscillations of $\langle e \rangle(t)$ around zero. Moreover, the system can reach the ordered state only if the probability $p$ of local interactions between agents fulfils the relation $0 < p \ll 1$ (see Fig. 10). What is also interesting, we observed that in the case when the coupling constant $A_g$ is very high in comparison to the activity factor $x_g$ [see Fig. 10(d)], the ordered state is reached for higher value of $p$ and vanishes faster than in the case of higher $x_g$. Also the absolute value of ordered state is lower. One can see that the behavior of *group emotion* is independent of activity factor $x_g$ if its value is above the characteristic value $x_g > x_{g_c}$ where $x_{g_c} \approx 10^{-2}$ (see Fig. 11). It also shows that for low values of system noise $p_s$ and for intermediate values $p$ of local interactions probability the range of $A_g$ when the system orders is wide. Above $A_g \approx 0.7$ the group changes its collective behavior and the *group emotion* starts to oscillate around zero (see Figs. 11(b)–11(d)).



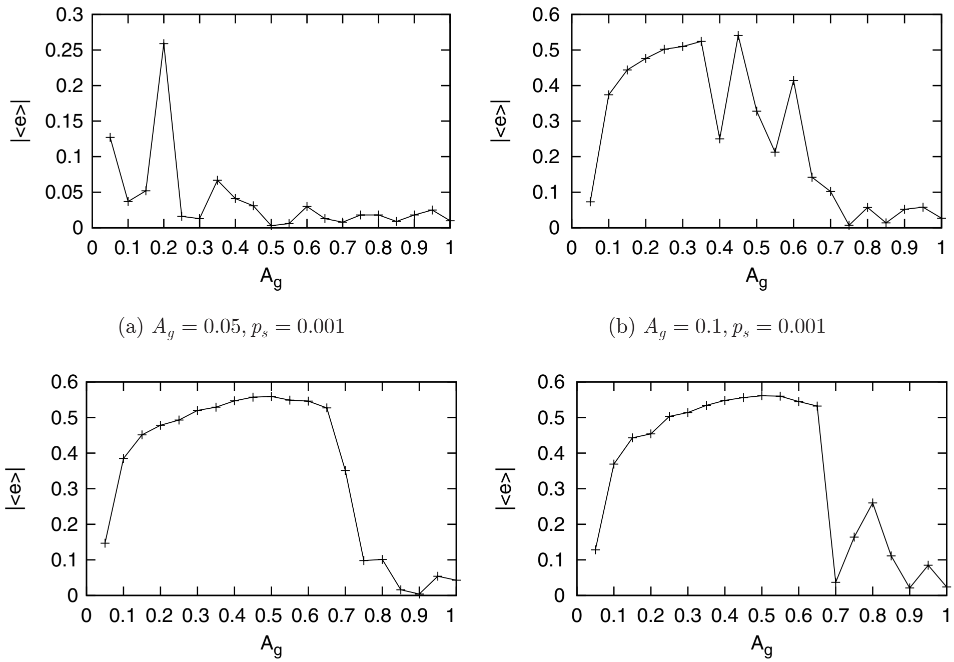

(a) $A_g = 0.05, p_s = 0.001$

(b) $A_g = 0.1, p_s = 0.001$

(c) $A_g = 0.2, p_s = 0.001$

(d) $A_g = 0.5, p_s = 0.001$

Fig. 10. (Color online) Behavior of absolute value of *group emotion* $|\langle e \rangle|$ averaged over $T = 2000$ time steps for Model (ii) using algorithm $A$ as a function of $p$ for $\tau = 2$, $p_s = 0.001$, for different values of $x_g = 0.05, 0.1, 0.2$ and for different values of $A_g = 0.05, 0.1, 0.2, 0.5$ in (a)–(d), respectively.




(a) $A_g = 0.05, p_s = 0.001$

(b) $A_g = 0.1, p_s = 0.001$

(c) $A_g = 0.2, p_s = 0.001$

(d) $A_g = 0.5, p_s = 0.001$

Fig. 11. Behavior of absolute value of *group emotion* $|\langle e\rangle|$ averaged over $T = 2000$ time steps for Model (ii) using algorithm $A$ as a function of $A_g$ for $\tau = 2$, $p = 0.1$, $p_s = 0.001$, for different values of $x_g = 0.001, 0.01, 0.05, 0.5$ in (a)–(d), respectively.

## 4. Conclusions

We have considered a two-dimensional lattice of emotional agents with an additional coupling between all agents and a randomly chosen community. We have taken into account two types of long-range interactions between agents. In the model (i), the emotion of an agent has been sensitive only to a sign of temporary community emotion. In the case of model (ii), we have considered also the influence of magnitude of temporary community emotion. For models (i) and (ii) we have taken into consideration two ways of community selection. In the scenario $(A)$ a community is chosen once in time step for all agents. In the scenario $(B)$ a different community is chosen for each agent in every time step during the simulation. For both models (i) and (ii), we have observed the emergence of nonzero *group emotion*, i.e. the mean emotion of agents in the system fluctuates around some nonzero value. Such a result means that the presence of the Internet or other medium linking a far away separated group of humans can induce collective affective states with majority of participants possessing the same nonzero emotional state for long time periods. What is important, the ordered-like behavior is observed for both ways of community selection $(A)$ and $(B)$ when the activity factor $x_g > 0.1$. It means that the qualitative behavior of the Internet society should be insensitive to a special topology of e-communities if sizes of their active parts are large enough. In the first model, the number of agents that follow such collective dynamics increases with the probability $p$ of local interactions. One can say that for specific values of system parameters there is a critical value of $p_g$ above which the system is ordered in a nonzero emotional value. It resembles the phase transitions from the paramagnetic to the ferromagnetic phase in the two-dimensional Ising-model when one increases the strength of local spin interactions. To induce such a transition in the considered system of affective agents the local interactions have to be supported by the random long-range coupling to a certain agents community. The size of the community bringing long-range interactions does not play a significant role for this phenomenon if it is larger than the number of agents taking part in local affective interactions. Especially in the case of the second model one can observe characteristic value of activity factor $x_{g_c}$ above which there is no influence on community size on the behavior of the *group emotion*. The collective states are also observed in the second model where the probability of community influence is proportional to the mean value of its emotion. However, the set of system parameters for which we have observed the ordered behavior is narrow. When the coupling constant $A_g$ increases, the range of these parameters also increases. It can be observed clearly only for the case when $A_g$ is very high and $x_g$ is very low. This situation corresponds to a small group of people whose influence on the whole society is very strong. They can convince a group, but that kind of order is unstable.

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