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INDUCED MONOCULTURE IN AXELROD MODEL WITH CLEVER MASS MEDIA

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A new model is proposed, in the context of Axelrod's model for the study of cultural dissemination, to include an external vector field (VF) which describes the effects of mass media on social systems. The VF acts over the whole system and it is characterized by two parameters: a nonnull overlap with each agent in the society and a confidence value of its information. Beyond a threshold value of the confidence, there is induced monocultural globalization of the system lined up with the VF. Below this value, the multicultural states are unstable and certain homogenization of the system is obtained in opposite line up according to that we have called *negative publicity* effect. Three regimes of behavior for the spread process of the VF information as a function of time are reported.

1. Introduction

Agent-Based Models (ABMs)[1,2] are computer simulations of the local interactions of the members of a population which could be plants and animals in ecosystems,[3] vehicles in traffic, people in society,[4] etc. Locally interactions at lower level give rise to the spontaneously emergence of higher level organizations whose properties are not possessed by the individuals neither directly determined by them. Complex and nonlinear phenomena have attracted the attention of the scientific community to study the interplay between the lower and higher levels of organizations.[5] These models typically consist of an environment or framework in which the interactions occur among some number of individuals defined in terms of their behaviors

(procedural rules) allowing the tracking of the characteristics of each individual through time.

There are lots of applications to model different aspects of dynamics in society.[6–8] Specifically, the Axelrod model (AM)[4,9,10] is an ABM designed to investigate the dissemination of culture among interacting agents in a society. In this model, society is represented by a lattice composed by a two-dimensional array of vectors (agents) with a number of entries called "features." The definition of its culture is given by the set of traits an agent has in its features. The AM has been exhaustively implemented to study a great variety of problems: the nonequilibrium phase transition between monocultural and multicultural states,[11] the cultural drift driven by noise,[12,13] nominal and metric features,[14,15] propaganda,[16] time evolution dynamics,[17] the resistance of a society to the spread of foreign cultural traits,[18] finite size effects,[19] the impact of the evolution of the network structure with cultural interaction[20] among others.

Some works have been done including on the AM an extra agent acting as a vector field (VF) over the whole society with the purpose of simulating mass media effects.[21–24] In all of them, the interaction between the external VF and agents is similar to that between an agent and its neighbors: they interact only if they have at least one common trait in their corresponding features. In this formalism, the inclusion of an external field, which does not change its values on time, introduces an asymmetry on the lattice, which can now be described as composed by two groups of agents: group A where agents have trait(s) in common with the VF and group B whose agents do not. All the interactions can now be classified as follows: agents from group A with VF (A–VF), agents from group B with VF (B–VF),
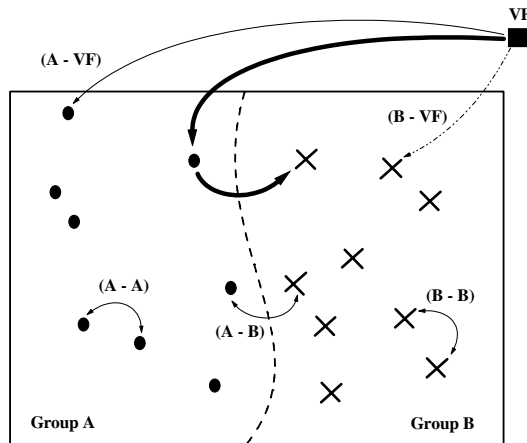

Fig. 1.   Former models representation of agents and dynamics interactions in the lattice when the VF is included (represented by a big square). Agents from group A are indicated with dots while agents in group B are indicated with crosses. Different interactions are represented with different lines. The diffusion mechanism from the VF to agents in group B is represented by thick lines. Null direct interaction between VF and agents from group B is represented by dash-dot-dot line.

between agents from group A (A–A), between agents from group B (B–B), and finally between agents from groups A and B (A–B). See Fig. 1 and lines therein. The (B–VF) interaction, showed as dash-dot-dot line in the figure, is a null interaction because agents from group B do not share traits with the VF. In this way, the only opportunity of agent B to acquire one VF trait is through a diffusion mechanism with the combined interactions (A–VF) plus (A–B), as pointed out in Fig. 1 with a thick line. In those models, it is also included the strength of the VF as a probability P of interactions A–VF and B–VF while the probability of interactions A–A, B–B, and A–B are given then by $1 - P$. Therefore, the diffusion mechanism, showed with a thick line in Fig. 1, has very low probability as P increases and agents from group B are set apart from the VF information. Furthermore, the mechanism B–VF can be very active (time consuming) but with null effects, and the internal relaxing mechanism B–B is not able to drive agents to the final state in an efficient way. Thus, the final absorbing states obtained in those previous models consisting in multicultural states when the VF strength is increased is then not surprising.

In real world the mass media, when acting over the agents of the society, designs its actions in a clever way to always have something in common with the people chosen as target of publicity or propaganda. Mass media follows the maxim "to produce a change it is necessary to be *different* but, at the same time, it is necessary to be *close enough* to be taken into account."[25] Mass media uses language and symbols shared by all the individuals in society to introduce its information with the purpose to homogenize people dressing, way of thinking, etc.

In this paper, we will focus on those agents in society which are under the direct and effective influence of mass media. As an approximation, we neglect the actions from agents of group B because we consider either they are not numerous or its influence over agents from group A through the diffusion mechanism is not so important. In any case, we are trying to answer the question of how the whole society evolves when an omnipresent mass media is acting with effective influence over the corresponding agents. For that purpose, we include an additional nonzero probability of all agents to copy a trait from the VF, even if they do not share any trait of their features. As mentioned in Ref. 21, the media information is socially processed through personal networks. Then, the interaction between agents in society will have the same "strength" as the interaction with the VF. We consider this model more realistic.

The structure of the paper is as follows. Section 2 is devoted to the description of the model. In Sec. 3, some numerical calculations are exposed and, finally, some conclusions are outlined in Sec. 4.

2. The Model

2.1. *Nominal features*

The system consists of L^2 agents as the sites of a square lattice. The state of an agent i is defined as a vector of F *nominal* components called features given by $\sigma_i =$

$(\sigma_{i_1}, \ldots, \sigma_{i_f}, \ldots, \sigma_{i_F})$ which characterize the nominal F-dimensional culture of the corresponding agent. This way, each agent has four nearest neighbors but as the fifth it is introduced the VF $\mathcal{M}$ with nominal features $\sigma_{\mathcal{M}} = (\sigma_{\mathcal{M}_1}, \ldots, \sigma_{\mathcal{M}_f}, \ldots, \sigma_{\mathcal{M}_F})$. The VF intends to simulate an external mass media or publicity which acts over the whole society. Then, each agent can interact with five agents: its four nearest neighbors and the VF $\mathcal{M}$, all with equal probability 1/5. Additionally, each feature σ_{i_f} and $\sigma_{\mathcal{M}_f}$ can take any of the values in the set $\{0, 1, \ldots, q-1\}$ which are the corresponding cultural traits of an agent i or the VF $\mathcal{M}$. Initially, the values of the vectors σ_i and $\sigma_{\mathcal{M}}$ are randomly and independently set with one of the q^F state vectors with uniform probability.

The interaction between different agents is possible only when the two vectors have an overlap $0 < l < 1$ where the overlap between two agents i and j is the number of shared traits and it is given by $l(i,j) = \sum_{f=1}^{F} \delta_{\sigma_{i_f}, \sigma_{j_f}}$. Here δ is the Kronecker symbol. The probability, which we call here *nominal* probability, of the interaction between two agents is given by $p(i,j) = l(i,j)/F$.

2.2. *Effective features*

In general, the situation $p(i,j) = 0$ is possible when the overlap between two agents is zero but, as mentioned before, the case where the probability between an agent and the VF is zero is not an acceptable situation for a clever publicity (or mass media). In this case the connection is always active. In order to include this important effect in our model, we included some *effective* features ϵ, besides nominal features F, that the VF always shares with each agent. The specific nature in real society of the effective features is not of importance here. It could be the use of the same language, symbols with common interpretation of people in everyday life, etc. In general, it is different for different agents, but the intention is to take into account the clever design of the publicity that mass media does to influence everyone. Each individual "understand" the publicity, even if they accept it or not.

Then, in our model an agent has F nominal features and ϵ effective features which always shares with the VF. Therefore, the probability of interaction between the external vector and agents, which we call here *extended* probability, is written as

$$p(i, \mathcal{M}) = \frac{l(i, \mathcal{M}) + \epsilon}{F + \epsilon} = \frac{l(i, \mathcal{M})/F + \epsilon/F}{1 + \epsilon/F}, \tag{1}$$

where $l(i, \mathcal{M})$ is the overlap of the nominal features between agent i and the VF $\mathcal{M}$. This way, the overlap l counts the number of nominal features shared between agent i and agent j or an agent i and the VF $\mathcal{M}$. This single parameter is related fundamentally with the dynamics between agents because it is the only mechanism for them to interact, while the single parameter ϵ counts the effective features an agent i and the VF $\mathcal{M}$ share. It constitutes the measure of its dynamics. For $\epsilon/F < 1$, the VF and agents share more nominal than effective features and the VF constitutes a "perturbation" to the internal interaction between different agents in the society.
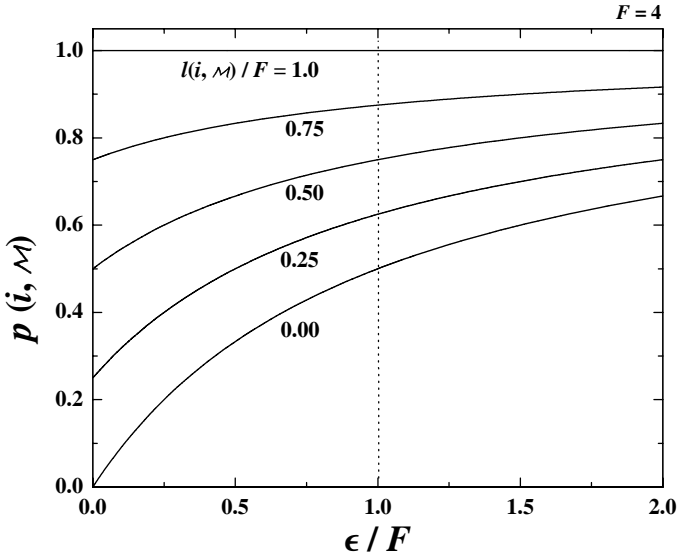
Fig. 2. Probability of interaction between the agent i and the vector field $\mathcal{M}$ as a function of ϵ/F for fourth nominal traits ($F = 4$) and different values of the overlap $l(i, \mathcal{M})$.

The case $\epsilon/F > 1$ means that there are more effective features that certainly share each agent with the VF than the number of nominal features each agent has. Then it is now the society which can be considered as a "perturbation" with respect to the more robust influence of the VF over the agents. As a generalization, and in order to fully study the dependence of the system with respect to the parameter ϵ, it can take not only natural values, but also fractional values.

In Fig. 2 the values of the probability $p(i, \mathcal{M})$ as a function of ϵ/F for fourth nominal features ($F = 4$) and different values of $l(i, \mathcal{M})$ are shown. The values of $l/F = 0.00$, 0.25, 0.50, 0.75, and 1.00 are obtained when the agent shares with the VF 0, 1, 2, 3, and 4 nominal features. As seen, the probability is zero only when there are no effective features ($\epsilon = 0$) and the overlap between the agent i and the VF is zero. In contrast, in all the other cases the probability $p(i, \mathcal{M})$ is always different from zero. For $\epsilon = 0$, the values for the case with no effective features are recovered. As expected, the probability is larger for larger values of the effective features ϵ at a given value of $l(i, \mathcal{M})$ and also increases for larger values of the overlap $l(i, \mathcal{M})$ at a given number of ϵ. Finally, when the agent i and the VF share all the nominal features ($l(i, \mathcal{M}) = 1$) the probability is always one for any value of ϵ.

In Ref. 26, the authors have used an expression similar to Eq. (1), but only with $\epsilon = 1$. As in Ref. 22, they have modeled the strength of the VF as a probability of the interaction between agents and the VF. Increasing values of this probability implies a decreasing value of the probability for agents interacting between each other. Then the corresponding socialization process is decreased. This is not a

realistic or desirable effect. They have found that only monocultural states are obtained and only by introducing a noise rate it is possible to drive the system to a multicultural final state.

2.3. *Confidence value for the mass media traits*

In our case, we are not interested to include the effects of random noise perturbation effects. We are instead interested in considering the influence that could have the value of the credibility the information of the mass media has. This value is clearly tested in massive inquiry done by different social organizations in society, for example, when elections are closer in order to know the acceptance of a candidate. It is expected that a high value of this credibility increases the influence of the mass media over the whole society and, on the contrary, a lower value could make the propaganda perhaps almost invisible. To study these effects we introduce a parameter called here the "confidence." It is included as an extra probability $p' = \mathcal{C}$ for agent i to copy an entry directly from the VF or an entry from another agent j with a trait value equal to that of the VF. It is also included as an extra probability $p' = 1 - \mathcal{C}$ when agent i, when copping a trait from agent j, will delete an information agent i possesses which is equal to that of the VF in the same feature.

To clarify this important concept, we show in Fig. 3 four situations of interaction which resume all the possible cases. In Case A, it is described an interaction between agent i and the VF which has been set to $(0, 0, 0)$ without loss of generality. None of the nominal features are shared and the extended probability of interaction $p(i, \mathcal{M})$ depends only from the value of the effective features ϵ according to the expression in the figure. In the practical case when agent i copies, for example, the first entry, the
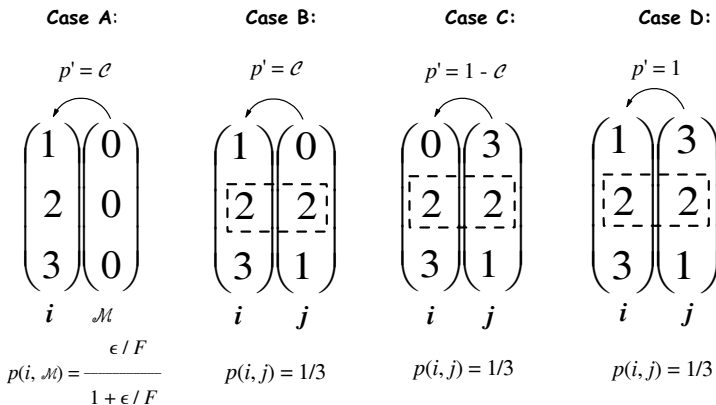

Fig. 3.   Four possible cases of interaction for a system with $F = 3$ features. Shared features are indicated inside a dashed rectangle. The probability of interaction $p(i, j)$ (or $p(i, \mathcal{M})$ in Case A) is indicating below. In each case the trait in σ_{i_1} will be deleted by coping trait σ_{j_1} (or by trait $\sigma_{\mathcal{M}_1}$ in Case A). The probability of coping/deleting trait 1 is given by (a) $p' = \mathcal{C}$, (b) $p' = \mathcal{C}$, (c) $p' = 1 - \mathcal{C}$, and (d) $p' = 1$.

VF trait is copied with probability $p' = \mathcal{C}$ which characterize the confidence of the information it possesses. In the next cases, the interaction occurs between agents i and j which only share one trait of three possibles. The probability of interaction is then given by the nominal probability $p(i, j) = 1/3$ in all these cases. In Case B, the nominal feature that agent i selects to copy from agent j coincides with the value the VF has in the same feature. Then, as in Case A, the corresponding trait is copied with probability $p' = \mathcal{C}$. In Case C, when coping, agent i will delete its trait which is equal to that possessed by the VF. Then, it is deleted with probability $p' = 1 - \mathcal{C}$. Finally, in Case D, the traits copied and deleted are not related with the VF and then they are copied with probability $p' = 1$. Note that according with these rules of interaction, when the confidence of traits possessed by the VF is the highest possible ($\mathcal{C} = 1$), these traits are always copied with probability $p' = 1$ and never deleted. Otherwise, if the confidence of the traits possessed by the VF is the lowest possible ($\mathcal{C} = 0$), these traits are never copied ($p' = 0$) and are always deleted with probability $p' = 1$. Then, starting from the initial condition described above, the system evolves by iterating the following steps:

(1) Select at random an agent i on the lattice, which is the active element.
(2) Select at random, with equal probability, an agent of interaction. It could be one of the four nearest neighbors or the VF.
(3) Calculate the overlap $l(i, s)$ where $s = j$ for the neighbor or $s = \mathcal{M}$ for the VF. If $s = \mathcal{M}$, the agent i and the VF interact with the extended probability $p(i, \mathcal{M})$. If $s = j$ and $0 < l(i, j) < F$, agents i and j interact with the nominal probability $p(i, j)$.
(4) In case of interaction between agent i and agent s, choose a position trait h at random such that $\sigma_{i_h} \neq \sigma_{j_h}$ (or $\sigma_{i_h} \neq \sigma_{\mathcal{M}_h}$) and then set $\sigma_{i_h} = \sigma_{j_h}$ (or $\sigma_{i_h} = \sigma_{\mathcal{M}_h}$) according to:

    (4.1) if $s = \mathcal{M}$ then set $\sigma_{i_h} = \sigma_{\mathcal{M}_h}$ with probability $p' = \mathcal{C}$,
    (4.2) if $s = j$ and $\sigma_{j_h} = \sigma_{\mathcal{M}_h}$ then set $\sigma_{i_h} = \sigma_{j_h}$ with probability $p' = \mathcal{C}$,
    (4.3) if $s = j$ and $\sigma_{i_h} = \sigma_{\mathcal{M}_h}$ then set $\sigma_{i_h} = \sigma_{j_h}$ with probability $p' = 1 - \mathcal{C}$,
    (4.4) if $s = j$ and both $\sigma_{j_h} \neq \sigma_{\mathcal{M}_h}$ and $\sigma_{i_h} \neq \sigma_{\mathcal{M}_h}$, then set $\sigma_{i_h} = \sigma_{j_h}$ with probability $p' = 1$.

Finally, the full probability of agent i copies a trait from agent $s = \{j, \mathcal{M}\}$ is given by

$$\mathcal{P}(i, s) = \begin{cases} \dfrac{1}{5}p(i, j)p' \, ; & s = j \, , \\[2mm] \dfrac{1}{5}p(i, \mathcal{M})p' \, ; & s = \mathcal{M} \, . \end{cases} \tag{2}$$

2.4. *Original Axelrod model*

Before studying the effects of the VF in our model let us review the original AM. The computational dynamics of this model ends when the system reaches an absorbing

state characterized by either $l(i, j) = 0$ or $l(i, j) = F$ for all pairs of closed neighbors (i, j). A class of absorbing state, given by q^F different possible configurations is called the "monocultural" state which corresponds to the case where $l(i, j) = F$ for all pairs of closed neighbors. In this case, all agents in the network share the same trait at each feature ($\sigma_{i_h} = \sigma_{j_h}$ for all (i, j)) and the dynamics ends. Another class of absorbing state is called "multicultural" state and consist of at least two (or more) homogeneous domains which agents have cultural traits completely different. This way, two agents belonging to two different domains have zero overlap. The multicultural state is reached when each agent in the lattice has full of null overlap with all its neighbors. In these cases, a domain is given by a set of contiguous sites with identical state vector.

It has been shown[10] that the system reaches monocultural or multicultural states in dependence of lower ($q < q_c$) or higher values ($q > q_c$) of the cultural diversity q. To characterize the transition it has been considered two different order parameters: the average fraction of different cultural domains or the average number of agents in the biggest domain $\langle S_{\max} \rangle$ normalized to the number of lattice elements.

In our case, it will be shown how our model produces a complex pattern of social behavior with affinities and repulsions to the influence of the VF in dependence of the effective features ϵ and the confidence $\mathcal{C}$ of the information.

3. Numerical Results

3.1. *Absorbing states*

We have computed numerical simulations in lattices with $L^2 = 30 \times 30$ agents and $F = 4$ features each. Different absorbing states have been found and we report the average realization number of agent in the largest domain over 50 different initial conditions.

Figure 4 shows the calculations of $\langle S_{\max} \rangle$ as a function of q at the absorbing state. Each panel shows the result for a certain value of the ratio ϵ/F and different values of the confidence $\mathcal{C}$. The result using the AM without VF is included for comparison with full square dots. In this case, the system reaches a monocultural state at $q < q_c \approx 18$ and a multicultural state at $q > q_c$. In panel (a) we set $\epsilon = 1.0$. It can be seen that when the value of the confidence $\mathcal{C}$ is small ($\mathcal{C} = 0.05$), the results are very close to those of AM. The monocultural states remain unchanged at $q < q_c$, but the multicultural state is less "robust" and higher values of $\langle S_{\max} \rangle$ are obtained. For increasing values of $\mathcal{C}$ higher values of $\langle S_{\max} \rangle$ for $q > q_c$ are obtained, as seen with $\mathcal{C} = 0.10$, and finally, at $\mathcal{C} = 0.15$, the multicultural states vanish and the system remains in monocultural states for all values of q. Then, it can be concluded that the increasing value of the confidence induces an homogenization of the cultural information the system has, even at those values of q where the system reaches multicultural states when there is no VF. Multicultural states are unstable for increasing values of the confidence $\mathcal{C}$ at this value of the effective trait ϵ.
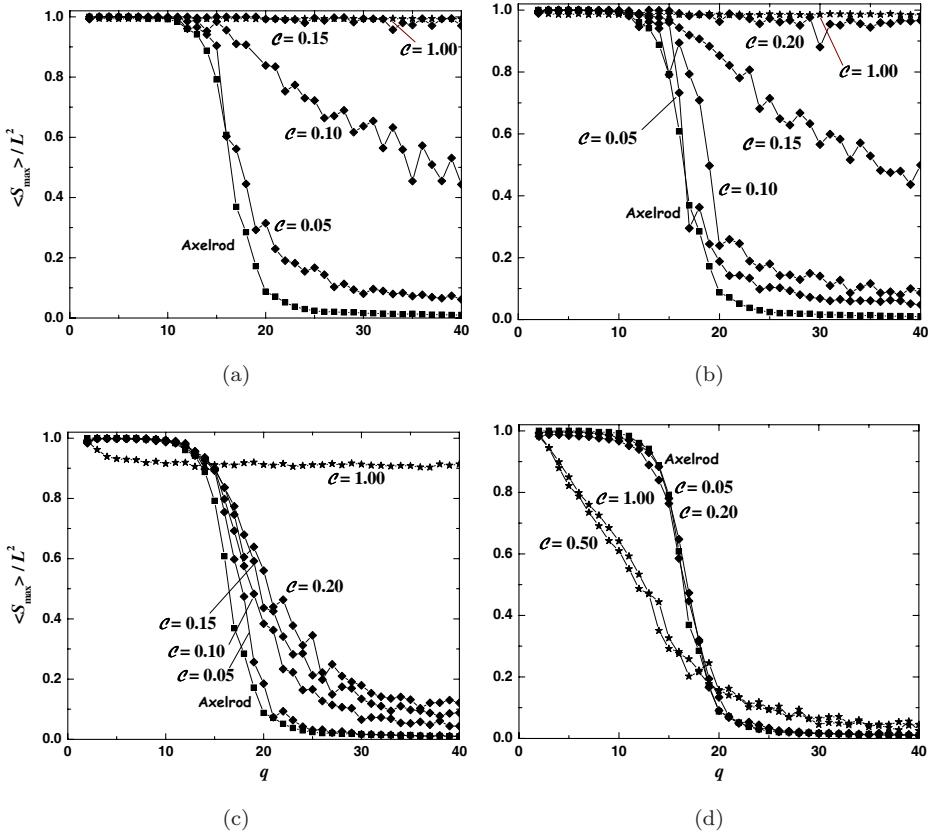
Fig. 4. Calculation of the normalized average number of agent in the greatest domain at an absorbing state as a function of q averaged over 50 realizations. The values of the ratio ϵ/F are (a) 0.25, (b) 0.125, (c) 0.025, and (d) 0.0025. At each panel, different value of the confidence $\mathcal{C}$ is taken into account in increasing order. The case of the AM without VF is included in each panel with full square dots. Full rhombus indicate that the corresponding absorbing states do not share the information possessed by the external field, while full stars indicate full coincidence of the absorbing state with the VF.

In Figs. 4(b)–4(d), it is calculated the $\langle S_{\max} \rangle$ for smaller values of ϵ. It can be seen that multicultural states at $q > q_c$ are again obtained for low values of $\mathcal{C}$, but now higher values are needed for the confidence to produce a cultural homogenization ($\langle S_{\max} \approx 1 \rangle$). This can be seen when comparing the results for $\mathcal{C} = 0.15$ in Fig. 4(a) with $\epsilon = 1$ and in Fig. 4(b) with $\epsilon = 0.5$. In Fig. 4(c) it can be seen that at a very small value of ϵ ($\epsilon = 0.1$) the system has a multicultural state for $q > q_c$ with small increases of $\langle S_{\max} \rangle$ for increasing $\mathcal{C}$, and even at $\epsilon = 0.01$ [Fig. 4(d)] the transition from a monoculture to a multiculture at $q \approx 18$ is independent of the confidence for values between 0.0 and 0.2.

Nevertheless, care has to be taken when analyzing the information of the induced monoculture at $q > q_c$ when the VF is present [as the case $\mathcal{C} = 0.15$ in Fig. 4(a)

and $\mathcal{C} = 0.20$ in Fig. 4(b)]. It is interesting to know whether the greatest domain in the absorbing state characterized by $\langle S_{\max} \rangle$ has, or not, the information possesses by the VF in the corresponding nominal features. This information is indicated in Fig. 4, where all the full rhombus show absorbing states where the corresponding greatest domain does not possess the information of the VF in any of its features. That is, the overlap between VF and the cultural state of the largest domain is zero. Only at those absorbing states indicated by full stars [$\mathcal{C} = 1.00$ in all panels and $\mathcal{C} = 0.50$ on Fig. 4(d)] the corresponding biggest domain fully shares the information at nominal features of the VF. Then, it is obtained the interesting result that, at low confidence values $\mathcal{C}$, the culture homogenization induced by the VF results in a negation or cancelation by the agents of the lattice of the information possesses by an external media. Here we call this phenomenon *negative publicity* effect. It represents the process occurring in society when a group or different groups of people gather together, physically or intellectually, against an external action they consider misconceived.

3.2. *Time dependent evolution*

In order to study in more detail how the information of the VF spreads (or not) into the society, we have defined the parameter ρ which gives the percent of the total amount of the information that agents share in their nominal features with the VF as a function of time. It is given by

$$\rho(\%) = 100 \times \frac{1}{L^2 F} \sum_{i=1}^{L^2} \sum_{f=1}^{F} \delta_{\sigma_{i_f}, \sigma_{\mathcal{M}_f}}, \tag{3}$$

and it is shown in Fig. 5. The calculation has been done for different values of the ratio ϵ/F and different values of the confidence $\mathcal{C}$ taking in consideration only one initial state. In straight lines we considered $q = 34$ while in dotted lines $q = 8$. When the dynamics starts from random initial conditions, the information possessed by the VF is already present in the lattice and shared by some agents. This anisotropy gives rise to the strong increase of its percent at the beginning, but if the confidence value is low, the information is avoided by agents when traits are copied and its percent decreases with time after some maximum is achieved. This can be seen for $\mathcal{C}$ equal or below 0.39, 0.40, and 0.41 in Figs. 5(a)–5(c), respectively. It is necessary for a higher value of $\mathcal{C}$ to drive the system to a monocultural state with all agents aligned with the VF information. On the other hand, if the confidence value is high enough, the percentage of the VF information increases continuously until the absorbing state is reached. This can be seen for $\mathcal{C} = 0.40$, 0.41, and 0.42 in Figs. 5(a)–5(c), respectively. At the same time, there is a sharp discontinuity between the regions of confidence values where the system remains monoculture and multiculture, as can be seen between $\mathcal{C} = 0.39$ and 0.40 in Fig. 5(a), between $\mathcal{C} = 0.40$ and 0.41 in Fig. 5(b), and between $\mathcal{C} = 0.41$ and 0.42 in Fig. 5(c). For high values of $\mathcal{C}$ the system reaches the monocultural state in only a few timesteps, while
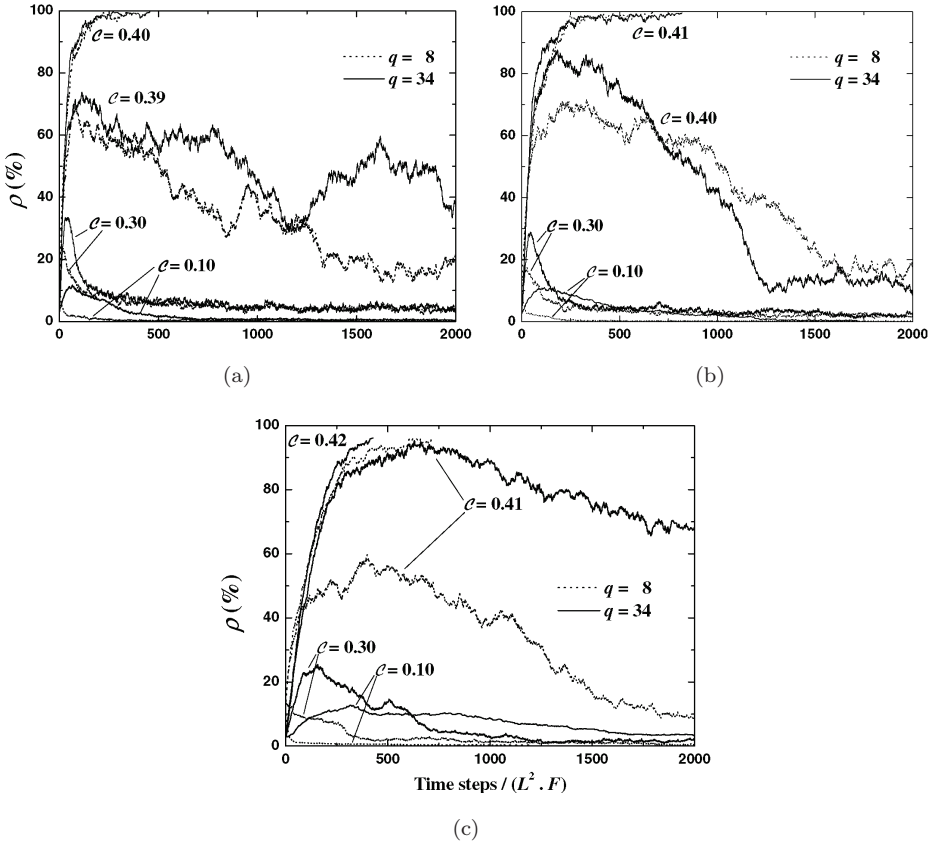
(a)

(b)

(c)

Fig. 5.   Percent of the VF information in the lattice as a function of time for different values of the ratio ϵ/F and the confidence $\mathcal{C}$. In straight lines is used $q = 34$ while in dotted lines it is used $q = 8$. The values of the ratio ϵ/F are (a) 0.25, (b) 0.125 and (c) 0.025.

for intermediate values of $\mathcal{C}$ the value of ρ changes slowly, at least until 2000 $L^2 F$ timesteps where the simulation was artificially aborted. At those values of $\mathcal{C}$, the system seems to be in a quasi-stationary state and no absorbing state was found in these regions. For enough low values of $\mathcal{C}$, as those shown in Fig. 4, the system reaches the multicultural state and there is almost no VF information on the lattice, as seen for $\mathcal{C} = 0.10$ in Fig. 5 in the three panels.

Finally, it is obtained that there are no fundamental differences between the behavior of the system with $q = 8$ and $q = 34$ for higher values of ϵ, as seen in Figs. 5(a) and 5(b). Otherwise, in Fig. 5(c) it is reported an important difference in the dynamics for $q = 8$ and $q = 34$ in the region of confidence values where the system remains multicultural. This behavior is connected with the strong decrease of $\langle S_{\max} \rangle$ in Figs. 4(c) and 4(d) for $\mathcal{C} = 1.00$ and for $\mathcal{C} = 0.50$ in Fig. 4(d). In these cases, the high value of the confidence quickly drives the system toward the absorbing state because of the strong assimilation of the VF information by those

agents that already share with it, at the beginning, the nominal traits. Then, the system quickly breaks down into domains with null overlap.

4. Conclusions

We have developed here a new model for the inclusion of an external VF in the AM at zero temperature to describe the effects of the mass media on a social system. The clever design of publicity which allows the mass media to have influence over all agents of the society was included as a nonzero *extended* probability of traits being copied. This important effect is related with a parameter ϵ which can be interpreted as extra effective features the mass media could share with each agent in society, beyond the nominal features. These effective features are used by the VF to reinforce the frequency of certain information already present on the society or to introduce a new one.

It is also included on the model a *confidence* value of the information possessed by the VF. It is modeled as a probability of copying/deleting VF information which represents the criteria a person (or a group of persons) has (have) about what the mass media is proposing to the society. The confidence parameter $\mathcal{C}$ can be experimentally measured in the society through official inquiries of different organizations and, therefore, it could be advanced the results expected on a society when designing the publicity.

Three different regimes were found. First, for very low values of this confidence, the dynamics recovers the AM with no external field, but an increasing value produces a homogenization on the society which would be multicultural without the external influence. This cultural homogenization is lined up against the acting influence of the VF with a zero overlap with the VF information. We have called here *negative publicity* to this effect. It simulates the behavior of people in society who gathers together against the external information they estimate wrong, incorrect, nonethic, etc. Second, for large values of the confidence, the system reaches a quasistationary state with only slow changes of the amount of VF information in the society and no absorbing state was found for the amount of timesteps tested. Finally, in the third case, higher enough values of the confidence produce a completed homogenized lattice lined up with the VF information, a situation that could be the purpose of mass media, political party, etc. These results are qualitatively in agreement with the intuitive and realistic idea that with enough bombardment of the mass media information, that is accepted as valid and trusted by people, there will be a strong induced culture homogenization in the society. In other words, when people assume this information as personal the cultural differences tend to disappear.

We also studied the dependence with respect to the effective features and it was found that at small enough values, the system is independent of the confidence value reproducing the results obtained in the AM. For increasing value of the effective features, lower values of the confidence are needed to achieve monocultural systems lined up with the VF information.

Acknowledgments

References

1. E. Bonabeau, *PNAS* **99**, 7280 (2002).
2. R. L. Goldstone and M. A. Janssen, *Trends Cogn. Sci.* **9**, 424 (2005).
3. V. Grimm and S. F. Railsback, *Individual-Based Modeling and Ecology* (University Press, Princeton, NJ, 2005).
4. R. Axelrod, *J. Conflict Resolut.* **41**, 203 (1997).
5. R. Laughlin, *A Different Universe: Reinventing Physics from the Bottom Down* (Basic Books, New York, 2006).
6. W. Weidlich, *Sociodynamics* (Dover Publications, New York, 2000).
7. D. Helbing, *Quantitative Sociodynamics* (Kluwer Academic Publishers, Dordrecht, Boston, London, 1995).
8. C. Castellano, S. Fortunato and V. Loreto, *Rev. Mod. Phys.* **81**, 591 (2009).
9. R. Axelrod, *The Complexity of Cooperation* (Princeton University Press, New Jersey, 1997).
10. C. Castellano, M. Marsili and A. Vespignani, *Phys. Rev. Lett.* **85**, 3536 (2000).
11. K. Klemm, V. M. Eguíluz, R. Toral and M. S. Miguel, *Phys. Rev. E* **67**, 026120 (2003).
12. K. Klemm, V. M. Eguíluz, R. Toral and M. S. Miguel, *Phys. Rev. E* **67**, 045101(R) (2003).
13. L. D. Sanctis and T. Galla, arXiv:0707.3428v1 (2007).
14. A. Flache and M. W. Macy, arXiv:physics/0604201v1 (2006).
15. D. Jacobmeier, *Int. J. Mod. Phys. C* **4**, 633 (2005).
16. T. Carletti, D. Fanelli, S. Grolli and A. Guarino, *Europh. Lett.* **74**, 222 (2006).
17. F. Vázquez and S. Redner, *EPL* **78**, 18002 (2007).
18. N. Boccara, arXiv:nlin/0611035v1 (2006).
19. R. Toral and C. J. Tessone, *Commun. Comput. Phys.* **2**, 177 (2007).
20. D. Centola, J. C. González-Avella, V. M. Eguíluz and M. S. Miguel, *J. Conflict Resolut.* **51**, 2007 (2007).
21. Y. Shibanai, S. Yasuno and I. Ishiguro, *J. Conflict Resolut.* **45**, 80 (2001).
22. J. C. González-Avella, M. G. Cosenza and K. Tucci, *Phys. Rev. E* **72**, 065102(R) (2005).
23. J. C. González-Avella *et al.*, *Phys. Rev. E* **73**, 046119 (2006).
24. J. C. González-Avella *et al.*, *J. Artif. Soc. Soc. Simul.* **10**, 9 (2007).
25. G. Bateson, *Mind and Nature: A Necessary Unity* (Bantam Books, Toronto, 2002).
26. K. I. Mazzitello, J. Candia and V. Dossetti, *Int. J. Mod. Phys. C* **18**, 1475 (2007).