Multiple attitude dynamics in large populations

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Wander Jager[1], Frédéric Amblard[2]

1:Faculty of Management and Organisation, University of Groningen, The Netherlands. w.jager@bdk.rug.nl
2: IRIT-UT1 - University of Social Sciences Toulouse 1, France. frederic.amblard@univ-tlse1.fr

1: Introduction

The recent rejection of the European Constitution by the voters in France and the Netherlands (2005) instigated a debate on how this could happen in countries having a basically pro-European-Union attitude amongst the population. We hypothesise that the complexity of the constitution, along with the limited information on its potential effects, caused many people not to process the arguments in defining their vote, but rather used the position of other people, and in particular that of major politicians, to determine their position. Especially the fact that the unpopular leaders of the government strongly campaigned in favour of the constitution may have resulted in a contrasting effect on this topic, despite the population's initial pro-European attitude.

Experimenting with the dynamics of attitude or opinion dynamics is not possible using laboratory studies. Field data on the contrary are too complex to identify the causalities of observed dynamical processes. Multi agent simulation provides a tool allowing experimenting with these dynamics, because large series of experiments can be performed systematically varying assumptions on how people change of opinion, and conditions of the initial opinions of the population. This has resulted in an increasing body of research on opinion dynamics using multi-agent simulation. Several researchers have worked on simulating how opinions, attitudes or voting behavior in groups emerges from locally interacting people, some working on binary opinions (e.g., Latane and Nowak 1997, Galam 1999) and some using continuous opinions, where influence is dependant on distance (using a threshold, e.g., Deffuant et al. 2001, Weisbuch et al. 2002, Deffuant et al. 2002, Hegselmann and Krause 2002).

These studies mainly used attraction of opinions as a mechanism to generate opinion dynamics, and hence did not use existing behavioural theory on attitude change to formalise agent rules. More recently, researchers have started to use behavioural theory in formalising these rules, e.g. Social Judgement Theory as a formalisation of both assimilation and rejection effects (Jager & Amblard, 2005) and Self Categorisation theory in studying meta contrast effects (Salzarulo, 2004).

To study the dynamics involved in attitude change, we formalise relevant social psychological theories in the architecture of agents. The field of persuasion, social influence and attitude change provided us with a rich theoretical perspective on how people change their attitudes, and the factors determining the degree and stability of these changes. In particular the Social Judgment Theory (SJT: Sherif and Hovland 1961) is

relevant in understanding how people assimilate or contrast their opinion after being confronted with another position. The basic idea of this theory is that a change of a person's attitude depends on the position of the persuasive message that is being received. If the advocated position is close to the initial position of the receiver, it is assumed that this position falls within the *latitude of acceptance* of the receiver. As a result, the receiver is likely to shift in the direction of the advocated position (*assimilation*). If the advocated position is distant to the initial position of the receiver, it is assumed that this position falls within the *latitude of rejectance* of the receiver. As a result, the receiver is likely to shift away from the advocated position (*contrast*). If the advocated position falls outside the border of the latitude of acceptance, but is not that distant that it crosses the border of the latitude of rejectance, it will fall within the *latitude of non-commitment*, and the receiver will not shift its initial position.
Formalising this Social Judgement Theory in an agent-based model allowed us to study the conditions under which the attitudes in populations tend to polarize, converge, or display pluriformity (Jager & Amblard, 2005). One main result was that when the latitude of non-commitment gets small, which has been found to happen in crisis situations (O'Keefe 1990), our model produces polarization effects.

However, both the experimental based laboratory studies as well as the social simulations addressed processes where only a single attitude is taken into consideration. Yet the example of the vote on the constitution indicates that often more than one attitude is taken into consideration. Many people reported to have voted against this constitution, not because of their negative attitude against this constitution, but because of their negative attitude towards the political leaders advocating a positive vote[1]. In this paper we will study to what extend processes such as congruity affect attitude dynamics in large populations.). In the work that we plan to present in this paper, we will focus on (1) two attitude dimensions rather than one, (2) cognitive effort in the processing of information, and (3) possible effects of mass-media performances of popular versus unpopular leaders.

People may spend more or less cognitive effort in elaborating on the attitude position of another person. This is captured in the *Elaboration Likelihood Model (ELM*; Petty and Cacioppo, 1986), which discerns a *central* and a *peripheral route* to attitude change. The central route pertains to the elaboration of pure arguments in a persuasive message and/or new information. Here people are motivated and capable of processing the arguments of the message, whereas peripheral processing is more likely when people's motivation to elaborate is low, and or their cognitive processing ability is limited (i.e., complex issues). The peripheral route is concerned with the elaboration of form aspects or cues of a message such as the number of arguments, the credibility and the attractiveness of the source. The attractiveness of the source is related to similarity of attitudes. Generally, people like to have similar opinions as people they interact with (Festinger, 1954). This implies that when engaging in peripheral processing, people may compare on one attitude dimension how similar they are, and depending on that observed (dis)similarity either accept or reject the information of the other attitude dimension.

In the following we will outline the formalisation of this theory in rules that apply to the agents we use.

[1] Actually, also a lot of people reported to have voted in favour of the constitution because they disliked the political position of politicians advocating to vote against the constitution.

2: The model

For the formalisation of the Social Judgement Theory, which refers to central processing, we follow the model as used by Jager and Amblard (2005). This formalisation implies that we have a population with N individuals. Each individual i has got an opinion (an attitude) x_i, a threshold determining the latitude of acceptance u_i and a threshold determining the latitude of rejection t_i with $t_i > u_i$. Varying the values of t_i and u_i allows for modeling agents having different attitude structures. For example, an agent having a high ego-involvement can be formalized as an agent where t_i is slightly larger or equal to u_i. The agents are scheduled to communicate on a random basis by scheduling random pairs for each time-step of the simulation. During the interaction between individual i and individual j, the following rules are applied:

If $|x_i - x_j| < u_i \qquad dx_i = \mu.(x_j - x_i)$

If $|x_i - x_j| > t_i \qquad dx_i = \mu.(x_i - x_j)$

where the parameter μ controls for the strength of influence.

The same rules are applied for the update of the opinion of the individual j.

For the formalisation of peripheral processing we formalise two attitude dimensions on which agents discuss. After encountering another agent, the attitudinal shift on one dimension will affect the shift in the other dimension, thus indicating peripheral source effects. A assimilation or contrast effect on the first attitude dimension will also translate in a similar assimilation or contrast effect in the second dimension. Here agents select attitude A for the interaction process, and depending on the outcome (assimilation, non commitment or contrast) they will also apply this outcome to the dimension B. The rule describing peripheral processing is:

If $|xA_i - xA_j| < u_i \qquad dAx_i = \mu.(xA_j - xA_i)$ and $dBx_i = \mu.(xB_j - xB_i)$

If $|xA_i - xA_j| > u_i \qquad dAx_i = \mu.(xA_j - xA_i)$ and $dBx_i = \mu.(xB_i - xB_j)$

3: Results

In experimenting with the model we use a research design using three basic experimental conditions. In experiment 1 we will replicate the experiments of Jager and Amblard (2005), only here we will formalise two attitude dimensions instead of one. Three conditions will be tested, which lead in the original single dimension experiment to polarization, convergence and pluriformity. In experiment 2 we will introduce peripheral processing on attitude dimension B. The same three conditions will be run. Finally, in experiment 3 we will explore how a meta-actor that is capable of addressing all agents simultaneously will affect the attitude dynamics. Also here we will explore these effects for the three conditions, and we will explore the effects of extreme versus average positions of the meta-actor on the two attitude dimensions.

3.1: Experiment 1: central processing on two dimensions

In the first experiment agents engage exclusively in central processing on both dimensions according to the principles of the Social Judgement Theory. Sixteenhundred (1600) agents are positioned on regular lattice, and randomly contact one of their four neighbours, either south, east, north or west (Von Neumann neighbourhood). The contact implies a comparison and resulting shift first on attitude dimension A, and subsequently on dimension B.

$$If\ |xA_i\text{-}xA_j|<u_i \quad dxA_i=\mu.(xA_j\text{-}xA_i)$$

$$If\ |xA_i\text{-}xA_j|>t_i \quad dxA_i=\mu.(xA_i\text{-}xA_j)$$

$$If\ |xB_i\text{-}xB_j|<u_i \quad dxB_i=\mu.(xB_j\text{-}xB_i)$$

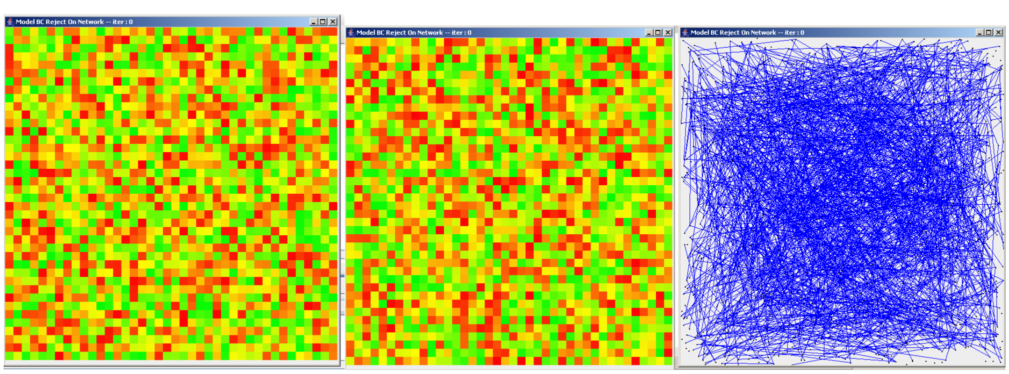
$$If\ |xB_i\text{-}xB_j|>t_i \quad dxB_i=\mu.(xB_i\text{-}xB_j)$$

Condition experiment 1

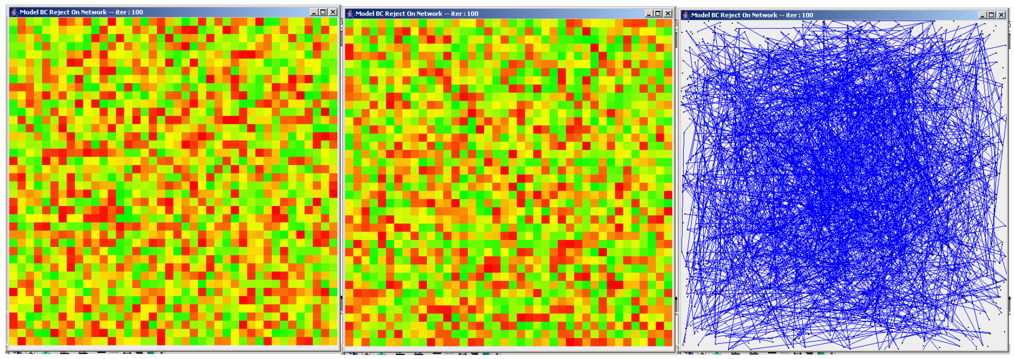
In this experiment we create a condition where the latitude of acceptance is high and the non-commitment is high, by setting U at 1.0 and T at 1.5. In the single attitude condition (Jager & Amblard, 2005) this condition stimulated convergence to a single attitude position.

Results experiment 1

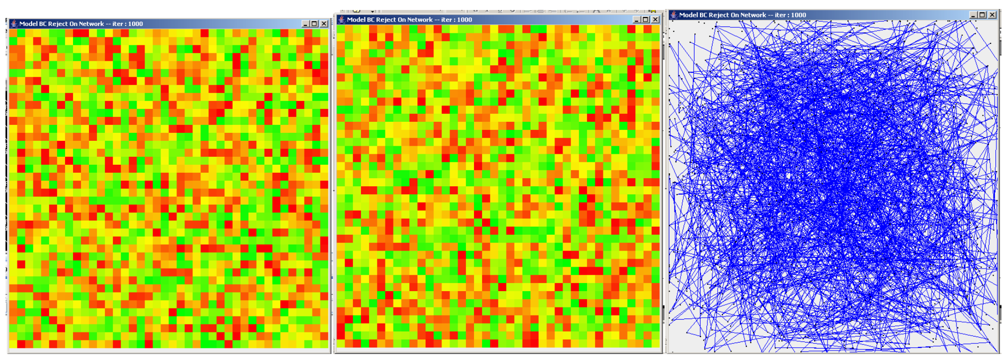
In the following figures we present the developments on both attitudes for different time steps of the simulation. In every time-step a single agent is randomly selected. This agent randomly interacts with one of its four neighbours. Hence, in 1600 time steps each agent on average had two interaction contacts, one because it was selected to engage in an interaction, and one because it was selected by another agent. On each grid, the color figures the opinion of the agent between -1 (red) and +1 (green) yellow coding for opinions near 0. The right hand figure positions agents on the basis of their attitude position on A (horizontal axis) and on B (vertical axis, thus indicating the relation between positions on A and B. The blue lines here indicate the social network, i.e. the links between the agents.



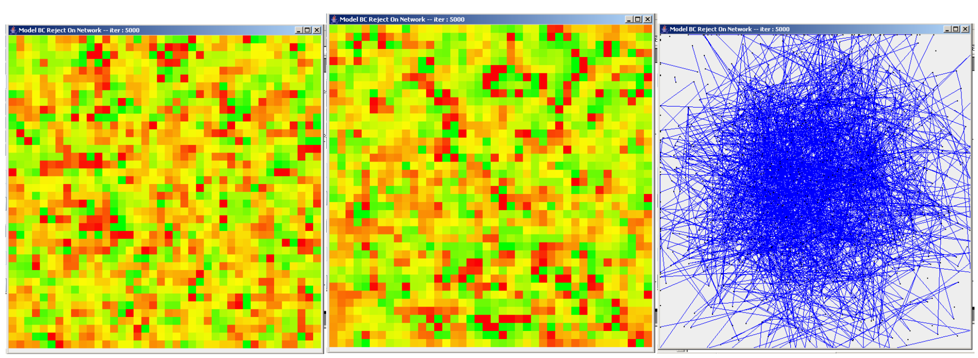
Time step 0 Attitude A Attitude B relation A and B



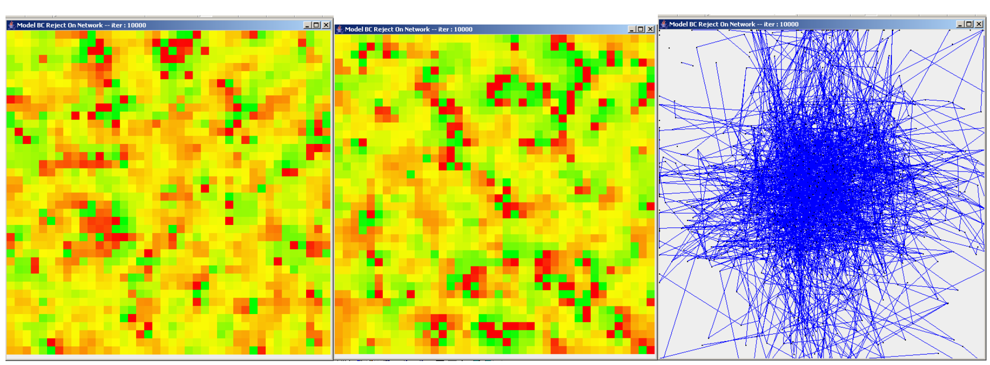
Time step 100 Attitude A Attitude B relation A and B



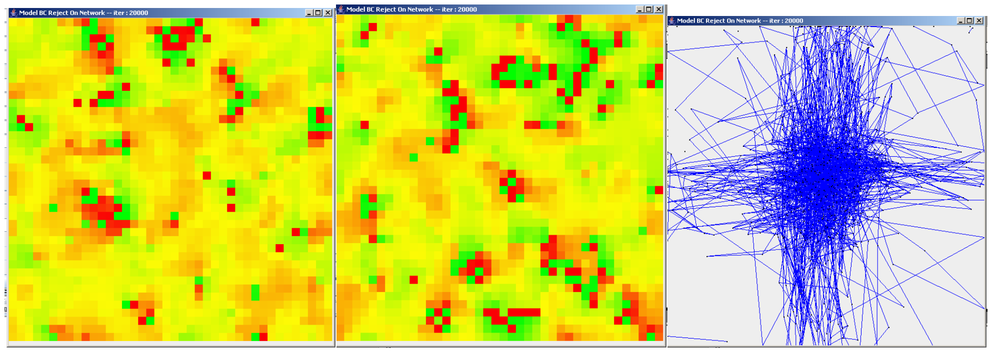
Time step 1000 Attitude A Attitude B relation A and B



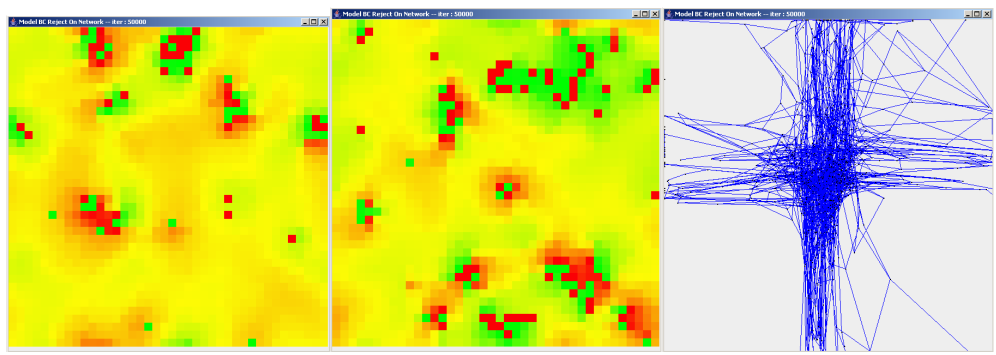
Time step 5000 Attitude A Attitude B relation A and B



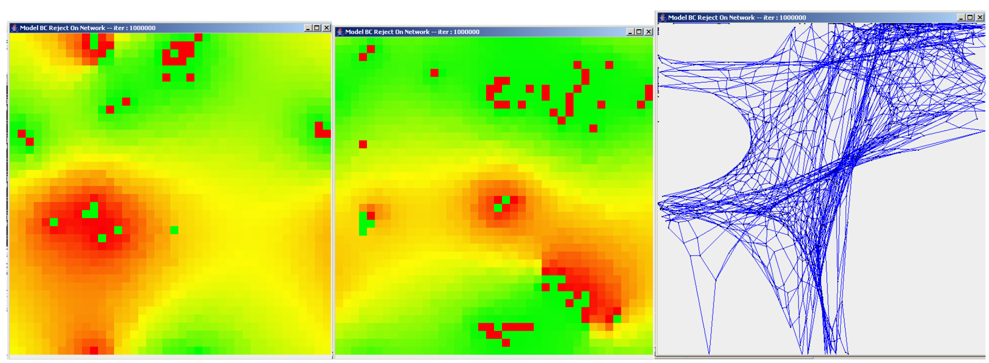
Time step 10000 Attitude A Attitude B relation A and B



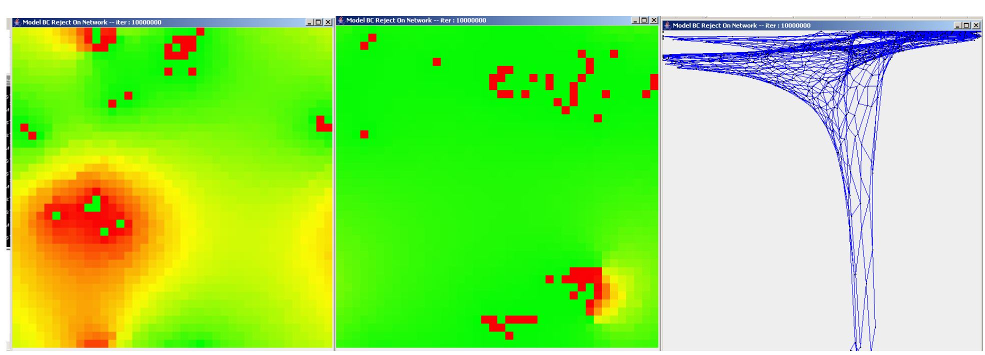
Time step 20000 Attitude A Attitude B relation A and B



Time step 50000 Attitude A Attitude B relation A and B



Time step 1.000.000 Attitude A Attitude B relation A and B



Time step 10.000.000 Attitude A Attitude B relation A and B

Figure 1: Attitude position on A and B over time

What can be observed in this experiment is that after a large number of time steps attitudes appear to converge on both attitude dimensions. There is still a minority of agents having an extreme position. However, an agent having an extreme position on one dimension is most likely to have a mid position on the other dimension, resulting in the emergence of the cross-like figure in the relational graph. One has to be aware that this cross-like figure is not a systematic outcome of this condition. Sometimes, the population converges quickly towards an extreme on the first attitude A, and then the second dimension B stays quite uniformly distributed between –1 and +1. Instead of a cross-like figure, convergence to an extreme on attitude A results in a vertical line either on the left (A = -1) or the right (A = +1) of the figure. Looking at Figure 1, we observe that whereas at t = 50000 it appears that the attitude dimensions tends to grow towards a convergence, the number of extremists is still large enough to generate large attitude shifts, as the results of t = 1.000.000 and 10.000.000 indicate. Here we observe that despite the initial tendency toward convergence, a polarization on dimension B emerges, with a large majority adhering to the green position. Also it can be observed that in the most extreme attitude areas (red or green) small numbers of dissidents show up. Here a sharp polarization effect emerges on the very local level.

Additionally, the results do not indicate a string correlation between the attitude position on A and B. To get a better view of the relation between A and B, we calculated the correlation between A and B over time for ten simulation experiments:

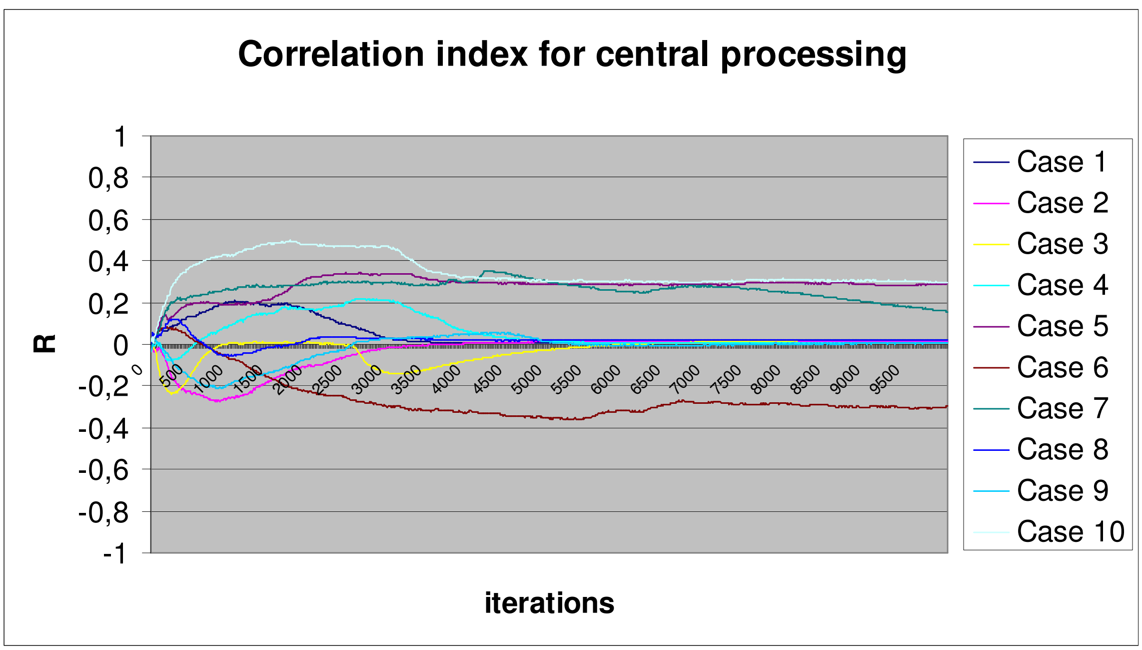


Figure 2: correlation between A and B over time for 10 simulation runs.

Figure 2 shows that most correlations remain close to 0 (no relation), whereas four cases show a moderate correlation emerged coincidentally.

3.2: Experiment 2: central and peripheral processing

In the second experiment we implement central processing on dimension A according to the Social Judgement Theory, and peripheral processing on dimension B. Here we select at random existing relationships on the social network, and let the agents interact on dimension A and B. They apply the central processing rule for attitude A. For attitude B they apply the peripheral rule as follows:

$$If\ |xA_i\text{-}xA_j|<u_i \qquad dAx_i=\mu.(xA_j\text{-}xA_i) \text{ and } dBx_i=\mu.(xB_j\text{-}xB_i)$$

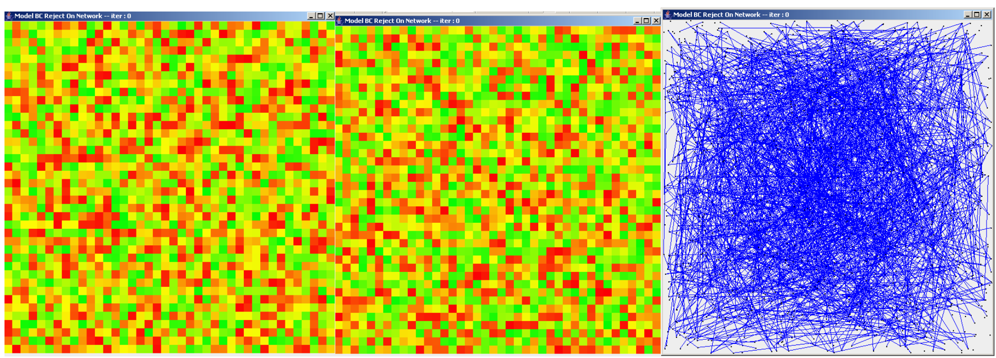
$$If\ |xA_i\text{-}xA_j|>t_i \qquad dAx_i=\mu.(xA_i\text{-}xA_j) \text{ and } dBx_i=\mu.(xB_i\text{-}xB_j)$$

Condition experiment 2

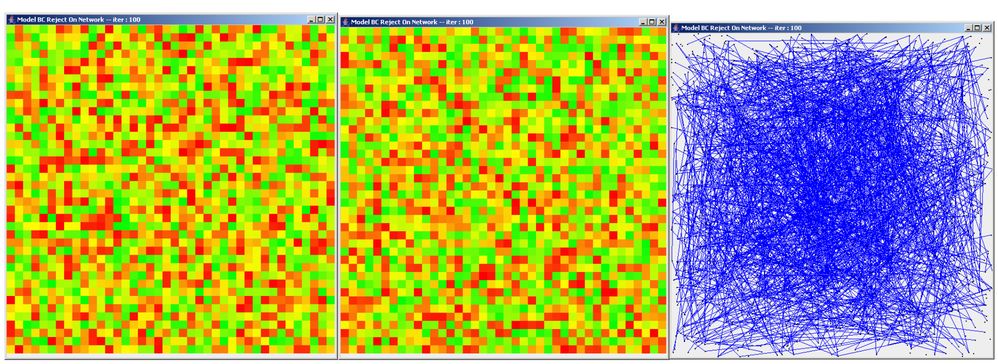
Experiment 2 replicates experiment 1 by setting the latitude of acceptance and the non-commitment high (U at 1.0 and T at 1.5).

Results experiment 2

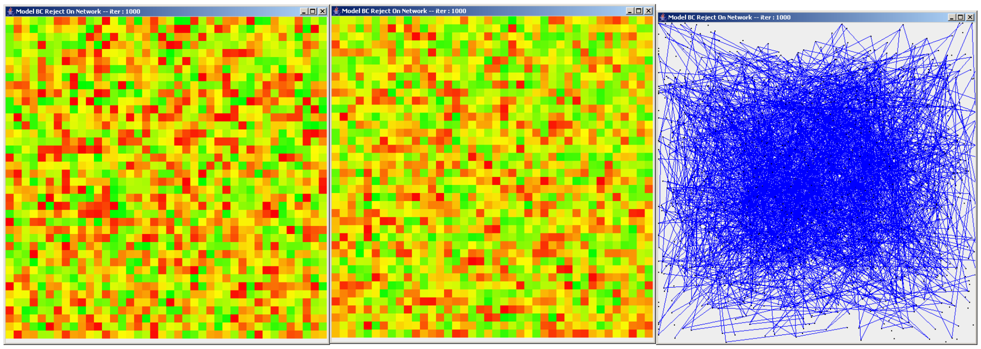
In the following figures we present the developments on both attitudes for different time steps of the simulation. The figures again represent the position on attitude dimension A, attitude dimension B and the relation between positions on A and B respectively.



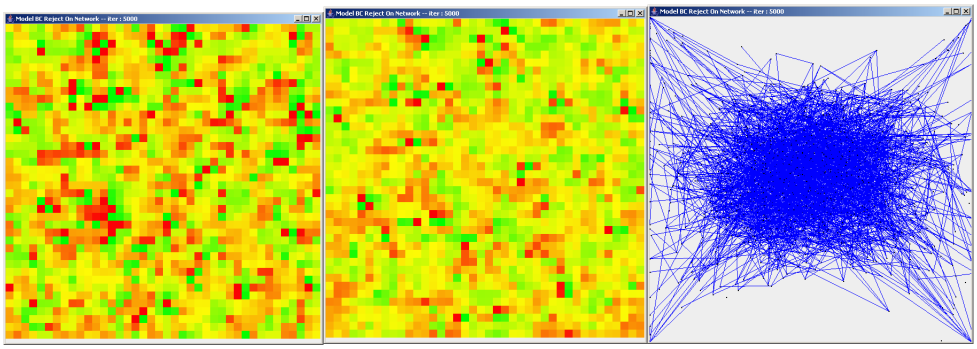
Time step 0 Attitude A Attitude B relation A and B



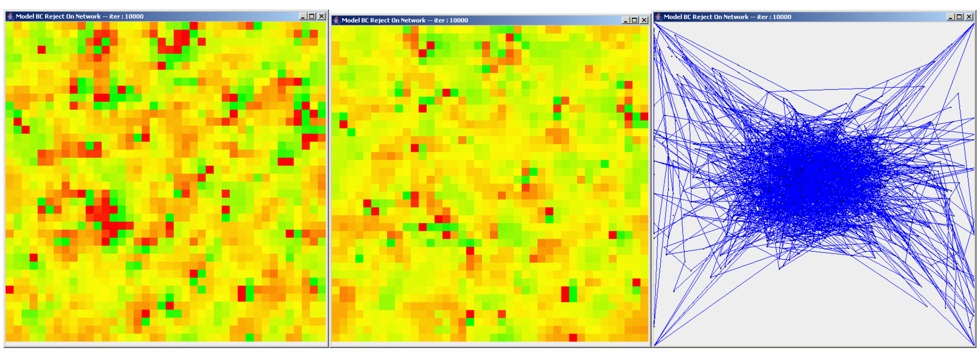
Time step 100 Attitude A Attitude B relation A and B



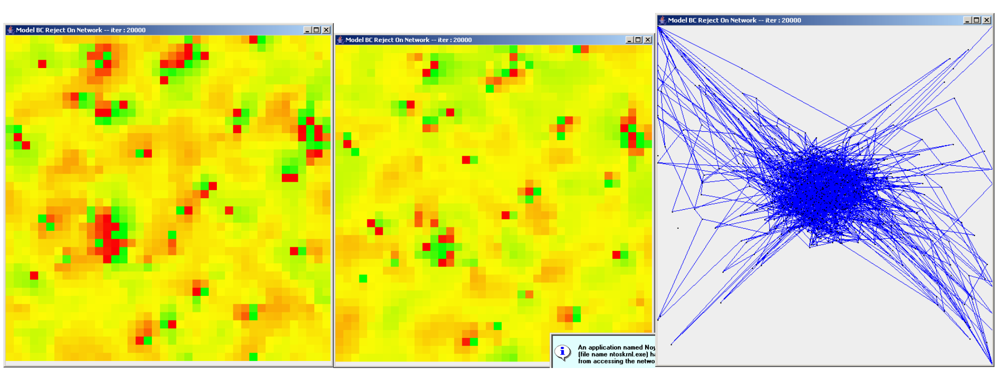
Time step 1000 Attitude A Attitude B relation A and B



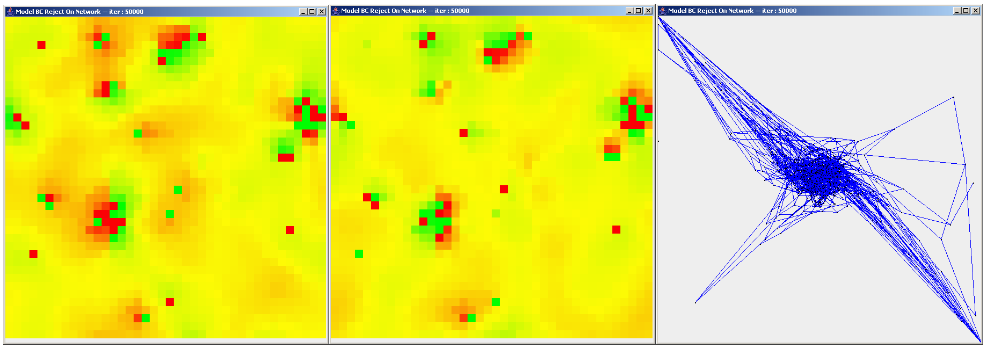
Time step 5000 Attitude A Attitude B relation A and B



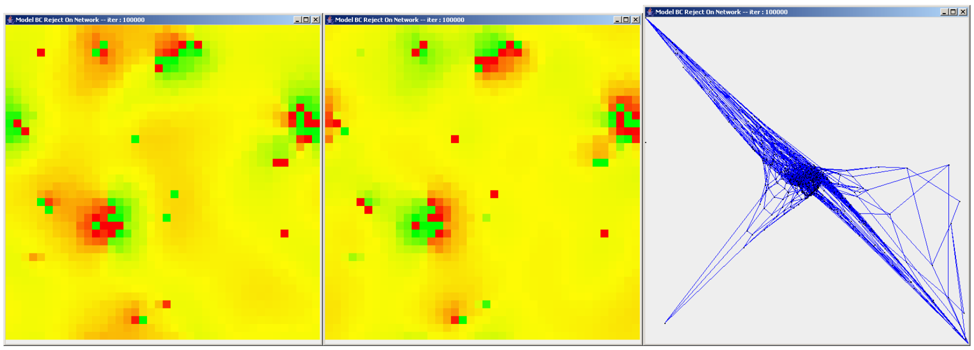
Time step 10000 Attitude A Attitude B relation A and B



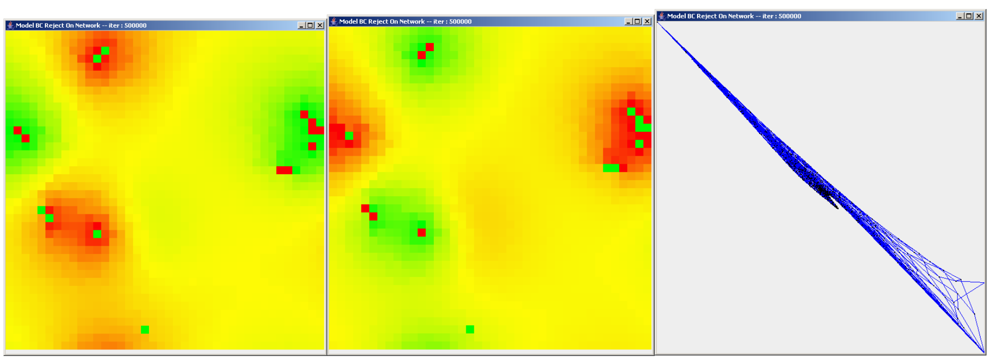
Time step 20000 Attitude A Attitude B relation A and B



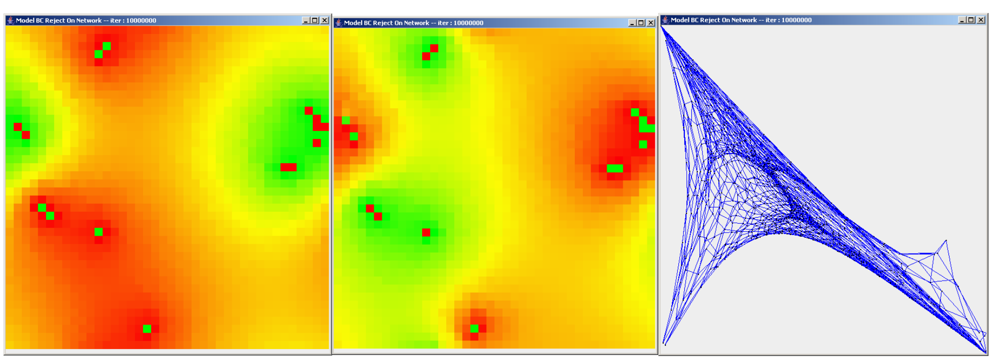
Time step 50000 Attitude A Attitude B relation A and B



Time step 100.000 Attitude A Attitude B relation A and B



Time step 500.000 Attitude A Attitude B relation A and B



Time step 10.000.000 Attitude A Attitude B relation A and B

Figure 3: Attitude position on A and B over time

This experiment shows that when agents engage in peripheral processing on dimension B, the attitude positions on A and B are becoming related. Whereas most agents tend to converge towards a mid position, we observe especially during time steps 5000 to 20.000 that a proportion of agents having an extreme position on attitude dimension A also develop an extreme position on dimension B. This is the result of the peripheral processing on B, where contrast and assimilation effects on A translate in the same effects on B. Initially there appears to be no strong correlation, as having an extreme positive position on A may coincide with a extreme positive or negative position on B, as indicated by the X-shaped relation graph. However, developments in later time steps show that a virtually perfect (in this case negative) correlation between the attitude positions emerges. This can bee seen in the colour distribution on dimension A and B, where the B figure is almost a perfect negative of the A figure (red is green and vice versa). Whereas here we observe that a positive position on A is coupled with a negative position on B, for other simulation runs we may find an equally strong positive correlation. Therefore we conducted 10 experiments and recorded the correlation over time (Figure 4).

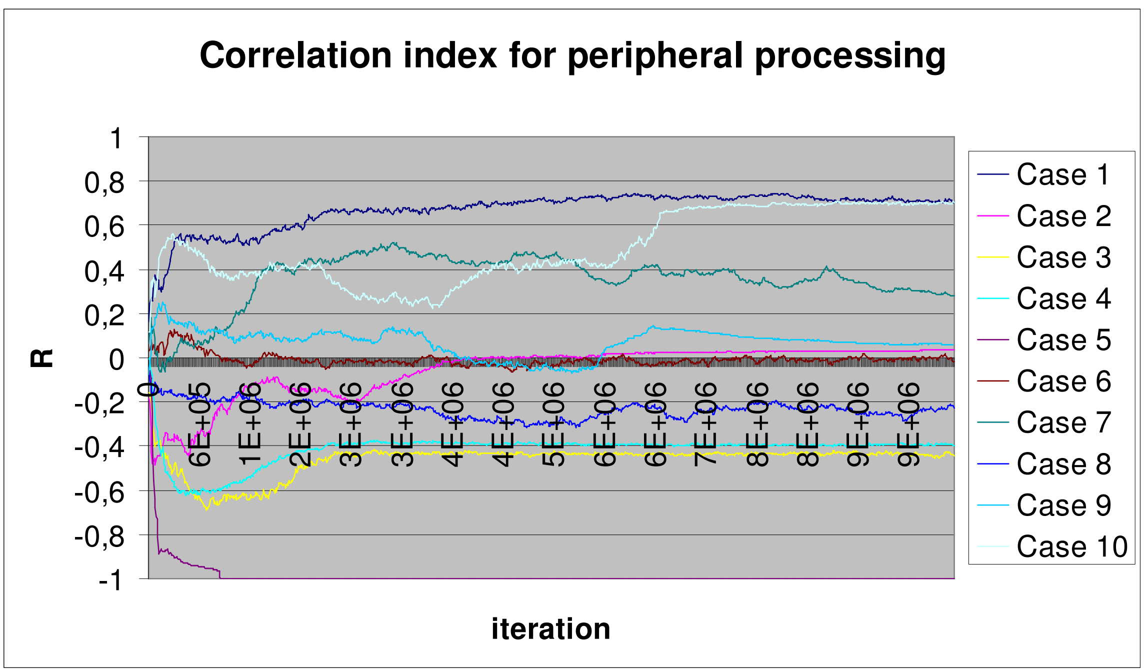


Figure 4: correlation between A and B over time for 10 simulation runs.

Figure 4 indeed shows that the correlations between A and B are much more prominent than in the condition of only central processing. Moreover, it can also be observed that this correlation may be positive or negative. It can also be observed that the correlations are not stable over time, indicating that attitude dynamics are continuous. In Figure 3 this can bee seen at t = 10.000.000, where a number of agents having an extreme negative position on both A and B (left bottom corner of the relation graph), thus indicating a positive correlation between the both dimensions for these agents, which originally was negative. This is being explained by the contrast effect as elicited by green position on dimension A of the single (green) agent located at the centre bottom. It can be observed that agents in the neighbourhood of this agent respond with reactance, in this case turning to red. Because this reactance effect translated to dimension B according to the peripheral processing, we also observe this reactance effect on dimension B, where the neighbouring agents also turn to red. These results indicate that the dynamics on the second attitude are quite unstable as singularities (like the green dot) tend to get amplified depending on the dynamics on the first attitude. With other words, the dynamics on the first attitude control the dynamics on the second one but in a different context. This may lead to situations where in one region the correlation between A and B is positive, whereas in another region this correlation is negative. Agents that are located in a transitional zone between these two contrasting situations are thus experiencing instability concerning the direction of the peripheral processing on attitude B, and thus may move hence and forth on this dimension.

3.3: Experiment 3: the influence of a meta-actor

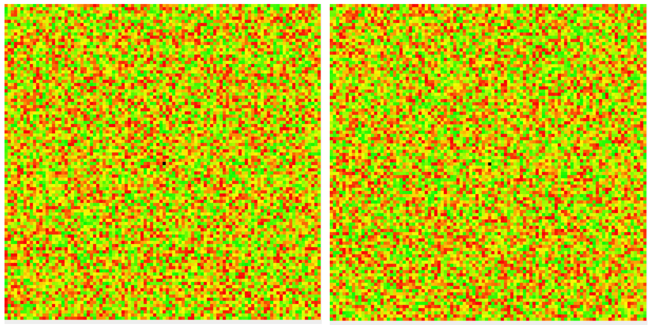
In the previous experiments the agents only interacted with their direct neighbours. However, often politicians or other spokesmen have a large audience they address on a frequent basis. Hence, before elections or votes, people not only discuss with their local peers, but are also influenced by what we call ‘meta-actors’. In the model, we formalise a meta-actor as an agent having a fixed position, hence it is not susceptible to influences of the opinion of others. In selecting an interaction partner, each agent randomly contacts either one of the four neighbours or the meta-actor. Hence the meta-actor has a chance of 20% of being contacted every time-step. In the experiments, the agents process centrally on attitude A, and peripherally on attitude B, thus replicating the conditions of experiment 2.

Conditions experiment 3

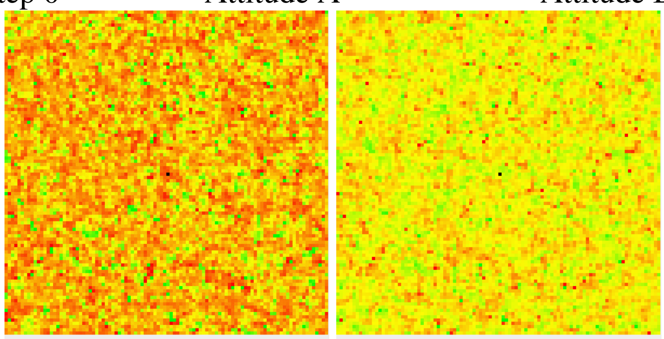
For the meta-actor we formalise an extreme position (-1, or red) on dimension A (central processing), and a neutral position (0 or yellow) on dimension B (peripheral processing). We use different settings for the agents. In experiment 3A the population is rather accepting by setting U at 1.5 and T at 1.7. In experiment 3B the population is less accepting by setting U at 1.0 and T at 1.2. Furthermore, the population is set at 10.000 agents. Concerning the interaction structure, we connect the meta-actor to all agents in the population. Each individual agent is now connected with 5 agents: North, South, East, West and Meta-Actor.

Results experiment 3a – an accepting population

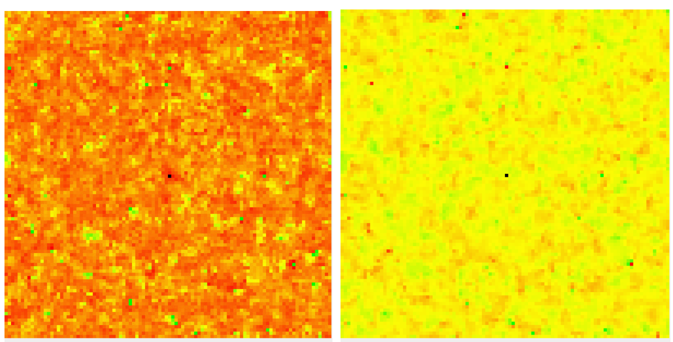
In the following figures we present the developments on both attitudes for different time steps of the simulation. The figures represent the position on attitude dimension A (left) and attitude dimension B (right). The black dot in the middle represents the meta-actor.



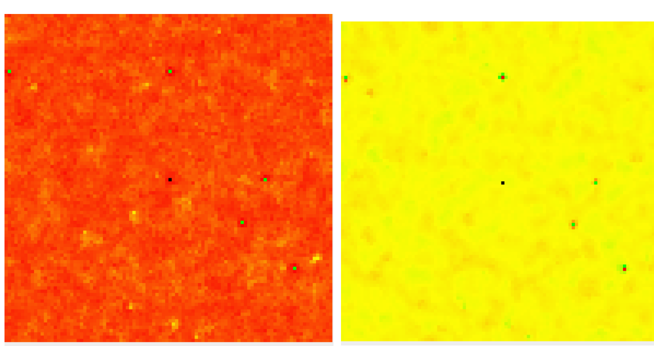
Time step 0 Attitude A Attitude B



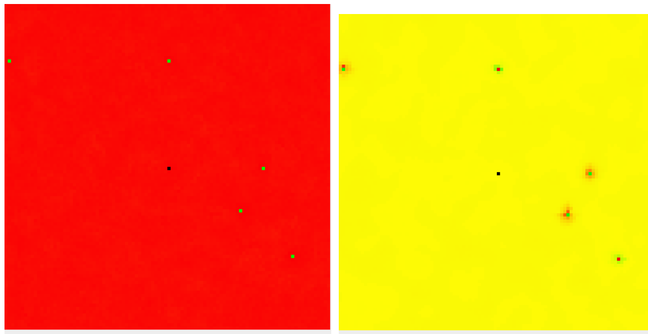
Time step 50.000 Attitude A Attitude B



Time step 100.000 Attitude A Attitude B



Time step 200.000 Attitude A Attitude B

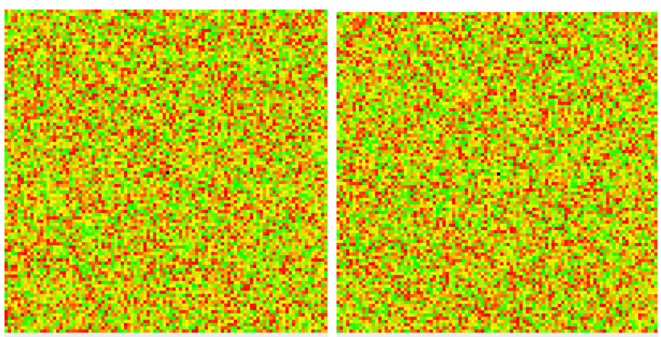


Time step 500.000 Attitude A Attitude B

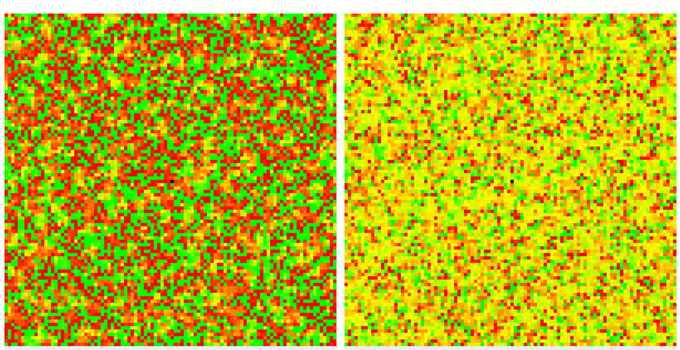
These results show that under conditions of an acceptable population, the vast majority of the population accepts the attitude position of the meta-actor. Only a few agents contrast with the meta-actor on attitude A (the green dots), and because their neighbours contrast themselves with these particular agents on dimension A, they also contrast on dimension B, resulting in the more red position of the neighbours on dimension B.

Results experiment 3b – A less accepting population

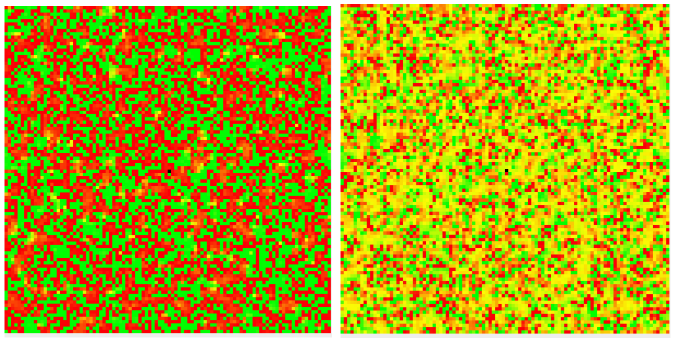
In the following figures we present the developments on both attitudes for different time steps of the simulation. The population is less accepting by setting U at 1.0 and T at 1.2. The figures represent the position on attitude dimension A (left) and attitude dimension B (right). The black dot in the middle represents the meta-actor.



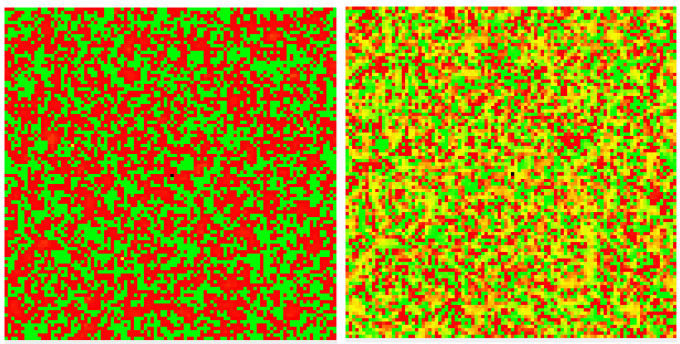
Time step 0 Attitude A Attitude B



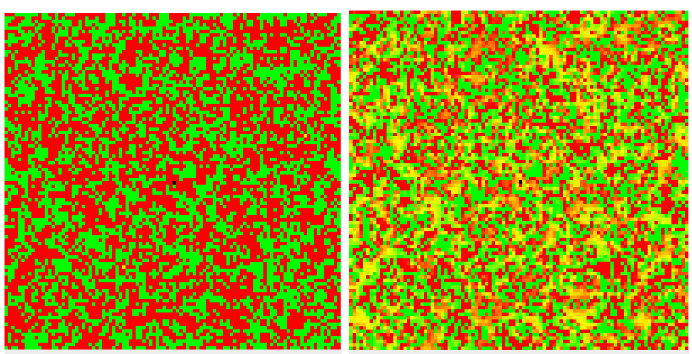
Time step 50.000 Attitude A Attitude B



Time step 100.000 Attitude A Attitude B



Time step 200.000 Attitude A Attitude B



Time step 500.000 Attitude A Attitude B

It can be observed that the attitudes on dimension A polarize, agents either become red or green. Apparently, the reds are having a slight majority due to the systematic influence of the meta-actor. Concerning dimension B we see heterogeneity. This is due to the fact that when agents contact the meta-actor, and assimilate his position, they will also assimilate the meta-actors position on B. Close observation indeed reveals that the agents contrasting with the meta actor on A (the green ones), also have an extreme position on attitude B, whereas for many actors being red on A holds that they are yellow on B, showing the systematic effect of the meta-actor. A particular case concerns those agents having a red position on both A and B. Interacting on dimension A with a green agent results in a contrast effect on both A and B, thus also stimulating a red position on B. However, interacting with the Meta actor results in an assimilation effect, which draws them to the yellow position on attitude B. The dynamics are then stable on both attitudes for the opponents on A (the greens), but rather unstable for the followers of the meta-actor on A (the reds) that result in alternating positions between red and yellow on the attitude B. Hence the meta-actor succeeds only in drawing people to his position on B for the agents that agree with him on A.

4: General discussion

Whereas an increasing number of scientists study attitude or opinion dynamics using multi-agent models, up till now there has hardly been any attention for the dynamics of multiple attitude dynamics. Both in experimental laboratory settings as in simulation studies researchers have focussed on single attitudes/opinions. Yet, observations from the field indicate that many people use a position on one attitude as a determinant for selecting a position on a –often unrelated – other dimension. These effects may pertain to simple consumer preferences, where people may have a tendency to have the same preference for a variety of unrelated consumer goods, thus generating subcultures where people have about the same preferences on basically unrelated issues. Especially when people have to select a position on an issue which is complex and/or less personally important, they may engage in simple processing, taking the behaviour of their peers to select a position. In the experiments as presented in this paper it can be observed that such decision strategies – here formalised as peripheral processing - has major impacts on the attitude dynamics. Basically, we observe that peripheral processing is often responsible for the emergence of a correlation between originally unrelated issues. Hence the assimilation or rejectance of other people's attitudes on the basis of a perceived (dis)agreement on another – more important - issue causes attitudes on different issues to become correlated. Because people are interacting with other people on a multitude of issues, it is expected that this relatedness of attitude dynamics may be important in understanding why certain clusters of people having the same opinion on various issues emerge, and how these clusters change over time (as formalised in the culture dynamics model of Axelrod with discrete tags on each dimension).

Additionally, the first experiments with the meta-actor demonstrated that under conditions of high acceptability of the population for deviant opinions, the meta-actor was capable of attracting virtually all agents in the populations to its own position on both attitude dimensions. The situation changed however when the population was less accepting, here we observed that a polarization emerged on the dimension on which agents processed centrally, whereas heterogeneity emerged on the dimension where agents processed peripherally. These results differ from situations where no meta-actor was available, showing that such an actor may have a considerable impact on the attitude/opinion dynamics that emerge.

These first experiments reveal just the importance of including several attitude/opinions simultaneously in understanding these dynamics, and the effect a meta-actor has on these dynamics. Many experiments have to be conducted to get a better understanding of these multi attitude dynamics, and the critical factors that determine clustering effects. Some issues that remain to be studied are (1) the differences and heterogeneity between agents concerning their tendency to assimilate, contrast and firmness of opinions, (2) the effects of the connectivity between agents (social network effects) and (3) strategies that can be employed by meta-actors in affecting these dynamics.

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