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Confirmation Bias and Convergence of Beliefs: an Agent-Based Model Approach

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Abstract: We simulated societal opinion dynamics when there is confirmation bias in information gathering and spread. If decision making is influenced by confirmation bias, an agent puts more weight on positive information to confirm hypothesis or reservation in the learning process, which renders selectivity in information gathering. If the utility discovered post-purchase is low, it is externalised rather than internalised (i.e. self-blame) for the selectivity of information. This causes the agent to outweigh the negative information. These two mechanisms are simulated to investigate societal opinion dynamics and explain behavioural patterns such as over-confidence and convergence of opinions.

Keywords: Confirmation bias, convergence, hypothesis testing, opinion percolation and selectivity in information search
JEL classification: C15, C63, D81, D83

1. Introduction

Opinion dynamics (OD) refers to the process of opinion adjustments and formations among interacting agents. We built on the communication regime by Hegselmann and Krause (2002) to describe opinion dynamics and convergence when agents exhibit confirmation bias in learning and spreading opinions. The bias results in average social characteristics such as over-confidence, convergence and divergence of beliefs and stickiness of response being exposed to positive feedback. The bias reflects social psychological behaviour in information selectivity and opinion dynamics.

It is common for humans to learn through observation and communication with other agents before making a purchase decision. This practice enables them to test the expectation or the hypothesis formed prior to the purchase. During the search process, hypothesis-consistent information is more easily adopted to confirm the hypothesis than hypothesis-inconsistent information to disconfirm the hypothesis. In psychology, this learning mechanism is referred to as confirmation bias. Confirmation bias can be defined as the seeking or interpreting of evidence or information that conforms to the existing beliefs, expectations or hypotheses (Nickerson 1998). In this article, we intend to describe this learning process and relate it to collective societal decisions.

Consumers begin to form hypotheses and beliefs on a particular product through observation and experience, which is then used as a benchmark for subsequent learning process. For example, through previous experience of a movie star or a director, consumers

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expect the same or better stunts and innovations from the newly released movie. If these prior expectations are successfully captured in the trailer or preview, the producer needs less compelling evidence to convince the consumers than when the movie is new. Similarly, if an advertisement successfully forms a reference product in the mind of the consumers, the search process will look for information that conforms to the benchmark.

In the learning process with confirmation bias, people typically seek information that supports their hypotheses or beliefs and interpret information in ways that support these hypotheses or beliefs. However, people tend not to seek and perhaps even avoid information which is against their hypotheses or beliefs (Koriat *et al.* 1980). Several mechanisms are at play in this process. First, people tend to restrict their attention to a favoured hypothesis. Second, they prefer information that increases their confidence in their favoured hypothesis. Third, people look only or primarily for positive cases as examples to support their hypothesis, which then leads them away from discovering that the hypothesis is incorrect (Nickerson 1998). Fourth, people tend to overweigh hypothesis-consistent evidence and underweigh hypothesis-inconsistent evidence. In other words, people tend to require less hypothesis-consistent evidence to accept a hypothesis than hypothesis-inconsistent information to reject a hypothesis (Pyszczynski and Greenberg 1987). Fifth, people see what they are looking for. If they are looking for evidence to support their existing hypothesis, they will see this supporting evidence.

Psychologists cite many sources of positive expectation, and among the common ones are preferential treatment for supportive evidence for one's opinions or beliefs (Baron 1995), over-confidence of one's beliefs or hypotheses (Pyszczynski and Greenberg 1987), effects of one's expectations (Snyder and Campbell 1980) and loss aversion (Tversky and Kahneman 1991). When people form hypotheses or beliefs, they tend to expect their beliefs to be confirmed rather than disconfirmed. However, this is not to suggest that agents deliberately ignore evidence, as once expectations are formed, the cognitive process of information search and evaluation takes over, giving the sense that the search process is impartial and unbiased. Unaware of the consequences of bias, people engage in the search and evaluation process without intending to treat evidence in a biased way (Nickerson 1998).

This paper intends to model confirmation bias at the micro level decision making process and relate it to macro level opinion formation. We find that confirmation bias reinforces confidence and encourages opinion convergence when the hypotheses are confirmed. This is because positive and favourable information reinforces confidence level more strongly than non favourable and negative information. However, opinion divergence can happen if the hypotheses are disconfirmed. This is because if confirmation bias is caused by loss aversion—when the utility loss if a hypothesis is disconfirmed is higher than the utility gain if a hypothesis is confirmed—agents would externalise the blame for the choices made and spread negative information (Tversky and Kahneman 1991). This causes the spread of favourable information to be slower than the spread of negative news.

The convergence of beliefs can be traced to different factors. Many studies have attributed it to rational choice, informational cascade and herd behaviour. The rational choice model assumes identical and homogenous agents who possess perfect rationality and expectations about the situation they face (Arthur 1995). Agents are also assumed to imitate the actions of peers when the information is incomplete and ignore their own private information (Banerjee 1992; Bikhchandani *et al.* 1992). This creates a cascade which is uninformative since agents are mainly imitative. In the herd behaviour model, agents are assumed to possess their own private signals and may have acted differently (Celen and Shachar 2004).

While the models successfully illustrate the learning process, the outcome may break down easily. Consider the rational choice model, if the computational capability is limited or if one agent arrives at a different conclusion, other agents may expect something different and deviate. This causes other agents who have not yet deviated to change their expectations too. The informational cascade is also prone to deviation and is very fragile. Many empirical tests and experimental evidence shows the lack of robustness of the model in the learning process (see Anderson and Holt 1997; Huck and Oechssler 2000; Goeree *et al*. 2003). Our analysis differs from those of these studies in that we assume agents learn from their peers by updating their own beliefs. Heterogeneity is created by assuming that agents possess their own personal hypotheses about a product. At the global level, we can think of the economy as consisting of a collection of beliefs and hypotheses which are constantly formulated and changed, acted upon and discarded. All these beliefs are constantly interacting, competing and evolving or co-evolving. These incremental updating rules, therefore, differ also from those in Celen and Shachar's study (2004). Our aim is to discover the emerging pattern at the macro level when agents possess personal psychological views of a product.

The paper is divided into 6 sections. Section 2 focuses on past studies on confirmation bias and reviews some of the applications of confirmation bias in different streams of literature. Section 3 shows how confirmation bias is formed and how it is applied in the learning process. Based on Section 3, simulations are conducted to test the opinion dynamics given the different levels of confirmation bias. This is done in Section 4. Section 5 discusses the results of the simulations, particularly the formation of opinion clusters. Section 6 concludes the paper.

2. Literature Review

In the models by Weisbuch *et al.* (2001) and Hegselmann and Krause (2002), opinion dynamics occur when opinions of the interacting agents are close and below a threshold value. Opinions which exceed the threshold level are ignored or opinions which are sufficiently different do not have influence on the agents concerned.

This selectivity is referred to as confirmation bias in psychological literature, (for a comprehensive review, see Nickerson (1998)). People tend to give greater weight to information that supports their view rather than information that run counter to it. This preferential treatment for the supportive information is tested based on the tendency of the research participants to recall or produce reasons supporting the view they have. In the experiment by Perkins *et al.* (1991), participants were able to generate more reasons supporting their views than reasons which run counter to it. Indeed, psychologists have perceived this tendency as the desire to believe.

The possible explanations for confirmation bias are as follows. First, people have the desire to believe. They find it easier to believe propositions that they would like to be true than propositions that they would prefer to be false. Second, people value consistency and rationality. They would like beliefs and evidence to be consistent, and consistency is an important requirement for rationality. Third, people have cognitive limitations. People tend to acquire information about only one hypothesis at a time, and this hypothesis is considered to be either true or false, but never both simultaneously. People may also fail to consider an alternative hypothesis because they simply do not think to do so. Fourth, people tend to have positivity bias. When there is no compelling evidence, people tend to assume a statement to be true than false (Nickerson 1998). Fifth, people are pragmatic and tend to avoid making errors. People are more likely to be concerned about desirable outcomes than about the truth or falsity of hypotheses (Schwartz 1982). Another reason for the presence of bias is deduced from the prior information -dependent behaviour. Studies by Snyder and Gangested (1981) and Snyder and Swann (1978), using personality tests, highlighted the degree to which people see or remember a particular occurrence corresponding to what they look for in a similar situation in future settings.

Bias is also present in many learning processes. In a study by Baron (1995), many people judged the quality of arguments to be higher for one-sided arguments than for two-sided arguments. This finding suggests that the bias for one-sided arguments may be partially due to common beliefs about what makes an argument strong. In another study (Kuhn 1989), children and young adults did not acknowledge evidence that was inconsistent with a favoured theory or saw the evidence selectively or distortedly. The same evidence was also interpreted differently in relation to a favoured theory versus an unfavoured theory. Matlin and Stang (1978) argued that people find it easier to believe propositions they would like to be true than propositions they would prefer to be false. This argument is furthered by Weinstein (1989) who proposed that people demand very little compelling information for a conclusion that they would like to accept.

3. Information Search and Adjustment of Opinions

We started with a population of N agents with continuous beliefs or hypotheses (R) which are randomly distributed among agents on a lattice. We adopted the communication regime by Hegselmann and Krause (2002) and assumed that all agents can perceive all local agents' opinions. We limited local interaction to eight agents. In each time step, an agent can interact with one agent locally, and that agent interacts with his neighbouring agents locally. This gives a total of 50 x 50 agents on the lattice.

Each individual is represented by a vector on a site which consists of four elements. The first element is the opinion, which is represented by $X \in \{-\infty,1\}$; $R \in \{0,1\}$ is the reservation value; $U \in \{0,1\}$ is the utility and $I \in \{R,1\}$ is the information spread in the lattice. If the opinion X is less than one, it means that the agent has not bought the product. The agent will adjust his opinion until X = 1 when he adopts the product (the adjustment process is explained below). The values of hypothesis or reservation or expectation (R) of the product is exogenously determined and assumed to be constant. A high value of R reflects that the agent has a high expectation of a product whereas a low value of R means a low expectation. We limited the information relayed after the adoption ranged from 0 to 1. If U exceeds R, the agent will relay positive information ranging from R to 1, and if R exceeds U, the information ranges from 0 to R.

During interaction, the value of R is the benchmark value against information spread in the lattice. The value was compared to information relayed in the lattice to evaluate whether the information was positive or negative. Information which exceeded this value was considered positive, otherwise negative.

At each time step, any two agents will meet and seek information about a particular product from the agent they interact with. Adjustment of opinion takes place between these two agents. Suppose two agents x_i and x_j meet and the adjustment of opinions takes place:

$$X_i = x_i + \mu(\{I_j\}, R_i), \tag{1}$$

where i ≠ j and μ: $[P(I_j), R_i] \rightarrow \Re$, where $\Re$ is a positive real number. Equation (1) adjusts the opinion of agent *i* based on a prior opinion (x_i) after comparing the information relayed by agent *j* (I_j) with his own hypothesis or reservation R_i. The μ is a convergence parameter which is determined by information (I) and reservation or hypothesis (R). In Equation (1), if $I_j > R_i$, the adjustment of μ is + 0.3, and -0.1 otherwise. Therefore upward adjustment of opinion is faster when the information is positive than when the information is negative. After adoption of the product, X=1, the information relayed will follow the equation:

$$I_i = \beta(U_i, R_i) \tag{2}$$

The information spread by agent i depends on the difference in utility attained and the reservation value of agent *i*. If $U_i > R_i$, the value of β will be in the range of (R, 1). This means that if the utility is higher than the reservation or hypothesis, the agent will spread information (I) at the level which is higher than the reservation point (R), and if it is lower than the reservation value, the agent will spread information (I) lower than his reservation value.

The agent practices confirmation bias in three different ways. First, we assume that the agent will increase his preference for a product by 0.3, i.e., $x + 0.3$ in each interaction if he receives positive information from either one of his eight neighbouring agents. That is, the information received from one of the agents is $I_j > R_i$, provided that the neighbouring agent has adopted the product, $X_j = 1$, and the agent himself has not adopted the product, $X_i = 0$. However, it takes *three* agents to persuade that the product is not good and the agent decreases his opinion by 0.1. We denote *á* as a subset of the agent's eight neighbours, ***Á*** = {N, NE, E, SE, S, SW, W, NW} where *á* =3 can be any three agents from set ***Á*** who have had a bad experience with a particular product. If *á* displays negative feedback, i.e., $U_{á} < R_{á}$, the agents relay $I_{á} < R_c$, where agent *c* is not from set *á*. An example for adjustment of opinion in 2 time steps is as follows: If in the first interaction, agent *c* interacts with *á* ={E, N, W} and in the second interaction, *á* = {S, NW, SW }, the adjustment of opinion with confirmation bias can be illustrated as

$$X_i(t) = x_i$$

$$X_i(t+1) = X_i(t) + \tilde{\mu}(I_E(t), I_N(t), I_W(t), R_{E,N,W}(t))$$

$$X_i(t+2) = X_i(t+1) + \tilde{\mu}(I_S(t+1), I_{NW}(t+1), I_{SW}(t+1), R_{S,NW,SW})$$

we set $\tilde{\mu}(\bullet) = -0.1$ for both cases. Thus, the opinion dynamics is biased for reservation or hypothesis-consistent information.

Second, in the learning process, the agent will decrease 0.1 of his preference if he finds there are three agents in the neighborhood who have not adopted the product. Let $(x_i)_{i=1}^{\infty}$ denote the hypotheses formed in a lattice, and the local interaction of x_i is $(x_i)_{i=1}^{A}$. If $\sum x_{i=1}^{3} = 0$, then $\mu_i \rightarrow -0.1$.

Third, after adoption, the agent will relay two types of information: (1) bias up and (2) bias down. Bias up occurs when the agent outweighs the positive information. If the agent is neutral, and no bias is applied, the positive information relayed ranges from R to 1 when $U > R$. However, if it is outweighed, the information relayed becomes $I_{\text{bias up}} = (R + □, 1)$, where □is a positive number. Further, if $U<R$, the agent will apply bias on the negative information relayed, $I_{\text{bias down}} = (0, R - □)$. In a situation when the agent outweighs negative information over positive information, then $I_{\text{bias down}} \succ I_{\text{bias up}}$ where "$\succ$" is denoted as preference over. However, if the agent is biased for positive information, then $I_{\text{bias down}} \prec I_{\text{bias up}}$. This third assumption is based on the behaviour of consumers who like to externalise the hypothesis-inconsistent information. Instead of blaming himself for his selectivity of information as in the two learning processes explained above, the agent blames the low quality of the product and the producer.[1]

4. Simulation

We simulated the opinion dynamics when agents practice confirmation bias in information gathering and spreading. We hypothesised that:

- The convergence of opinions occurs if information spread conforms to reservation or hypothesis.
- If the information is confirming, the adoption rate is higher than when the information is disconfirming; this renders different speeds of adoption in the two situations.
- Disconfirming information is over-weighted more than confirming information after purchase which causes opinion divergence.

Confirmation bias results in higher sensitivity of consumers to positive news than negative news. Figure 1 illustrates the opinion dynamics of different levels of information spread and reservation value. If we imagine R to be different levels of hypothesis of a consumer, any level of information (information spread depends on the level of utility spread in the lattice by other agents), which is disconfirming (low I as a result of low U from other agents), will not be adopted. However, when the information conforms to the hypothesis, as when the level of U is high, the adoption of the information is smooth. This different response renders various slopes of adoption curves in the figure for different values of U. As shown in the figure, the adoption rate is higher when there is hypothesis-consistent information than when there is hypothesis-inconsistent information.

4.1. The Basic Case: Small Threshold

We start with the simulation when the threshold value between reservation and *ex post* utility is at the minimum, i.e., $U - R \geq 0$. For a small threshold, opinion dynamics are thwarted by a high reservation value although the *ex post* utility is high.

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[1] The programme of confirmation bias in mathematica is available upon request from the corresponding author at *cks@usm.my*

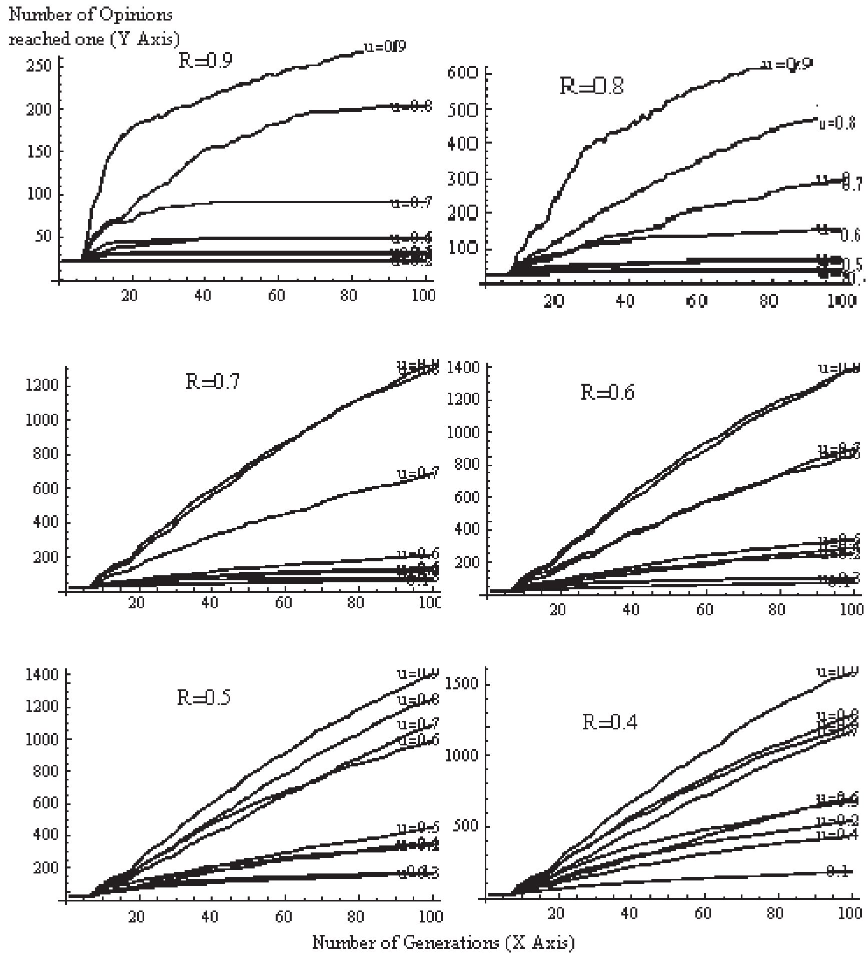

Figure 1: *The opinion dynamics for different levels of information spread (I) and different levels of utility (U) . Axis y denotes the number of opinions reaching 1, and axis x denotes number of interactions when R varies.*

- For a small threshold value between reservation and *ex post* utility, many clusters of opinion will be formed.
- The non consensus of opinions causes heterogeneous information to be relayed. Convergence occurs only at the local level; global convergence is difficult to achieve.

4.2. High Threshold When U > R

When the *ex post* utility is higher than the reservation value of an agent, he will relay $I_{\text{bias up}} = (R + □, 1)$. We observed a convergence of opinions into a single cluster on the lattice. This is due to the over confidence and favourable treatment of positive information. Over-confidence occurs when agents spread bias up information, and the contacted agents increase their opinions faster when the information is confirming rather than disconfirming.

4.3. High Threshold When U < R

When the utility is lower than the reservation, disconfirming information will be outweighed, causing global non consensus. Agents start to blame the low quality of a product rather than the selectivity of information during the search process. The bias down information, i.e., $I_{\text{bias down}} = (0, R - \square)$, will be further enhanced by lower reserved agents. If two contacting agents are related through a chain of interactions, the bias down information will spread and convince other agents from different reservation clusters.

5. Results and Discussion

When comparing the opinion dynamics for different thresholds, decreasing difference in reservation and utility results in a larger variety of final opinions (opinion clusters). Observing the initial and final opinions in Figure 2, one sees the dynamics converge to many opinion clusters. Initial opinions gathered are later segregated due to low difference between utility and reservation values. Many outliers are apparent in the plot. A similar pattern is observed in Figure 3 with a higher value of reservation and utility level.

5.1 Large Differences Between Reservation and Utility

Large differences of reservation and utility, particularly when *U*>*R*, render fast adoption due to selectivity of information to confirm hypothesis during the learning process. An explanation offered is that adopting a confirming information is faster than accepting a disconfirming information. When agents become overconfident, clusters of opinions break down. Figure 4 shows the opinion convergence.

However, in the case when *R* > *U*, initial opinions are segregated further by agents over-weighting the negative quality information. When the *ex post* utility is low, an agent will tell a very bad story about the product to other interacting agents. This bias in information spread

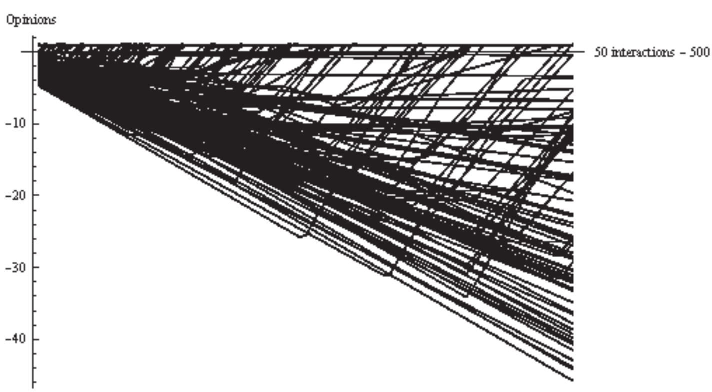

Figure 2: *Slow opinion convergence when R={0.3,1} and U={0.3,1}, for 200 individuals and 50 to 500 interactions. Each line represents individual opinion.*

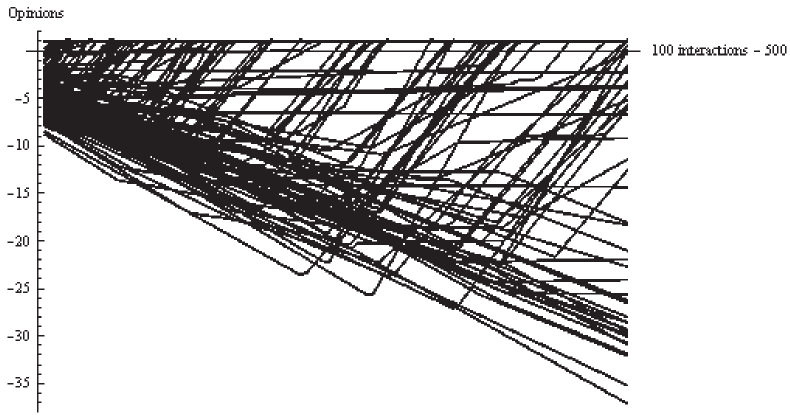

Figure 3: *Opinions clusters when R={0.8, 1} and U={0.8,1}, 200 individuals for 100 to 500 interactions.*

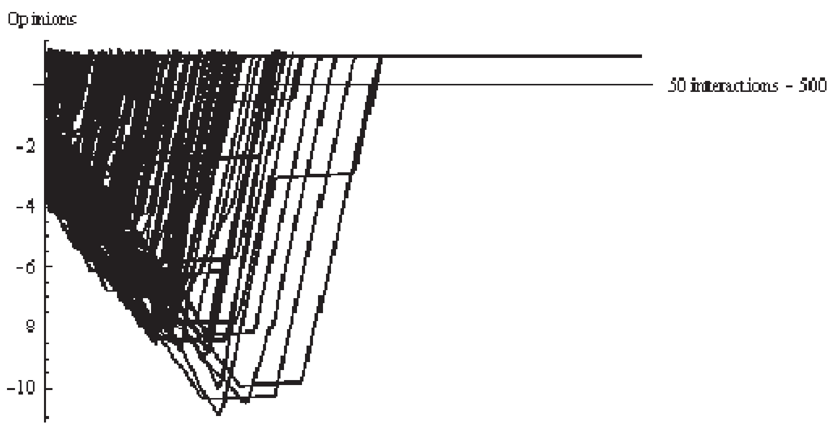

Figure 4: *Opinion convergence when R={0.3,1} and U={0.8,1}, 200 individuals for 50 to 500 interactions and the convergence occurs around 260 interactions*

will kill the product. Figure 5 shows the divergence of opinions when agents overweigh negative information.

5.2 Opinion Clusters for Different Values of R and U

For a large threshold value, when $U - R > 0.2$, opinion convergence or fewer clusters are observed. Many opinion clusters are formed if $U - R < -0.1$. The opinion dynamics become

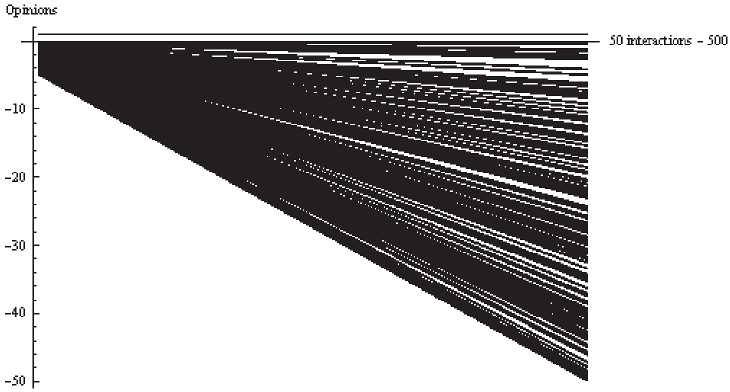

Figure 5: *Opinion divergence when R={0.8,1} and U={0.3,1}, 200 individuals for 50 to 500 interactions.*

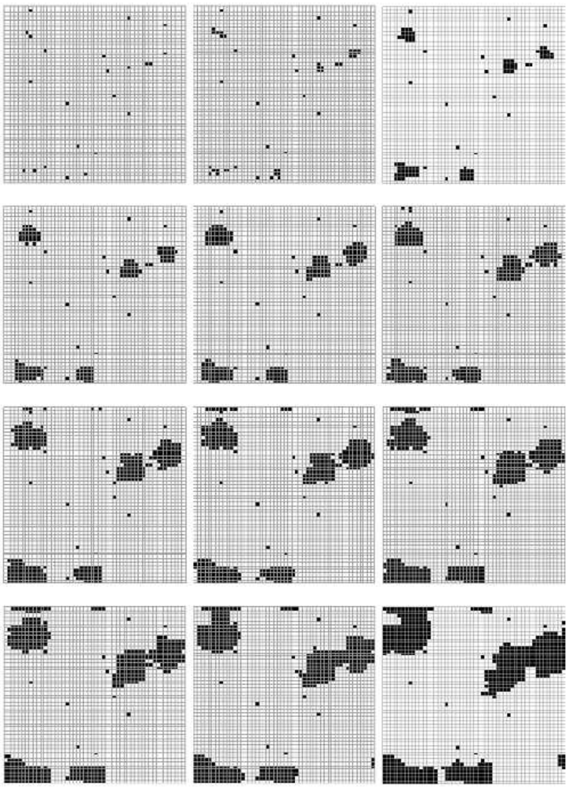

Figure 6: *The percolation of opinions when U=(0.8,1), R=(0.8,1), I=0.5 for 1(23), 10(48), 20(97), 30(147), 40(197), 50(246), 60(286), 70(327), 80(370), 90(404), 100(434) and 150(567) interactions (number of opinions reached one).*

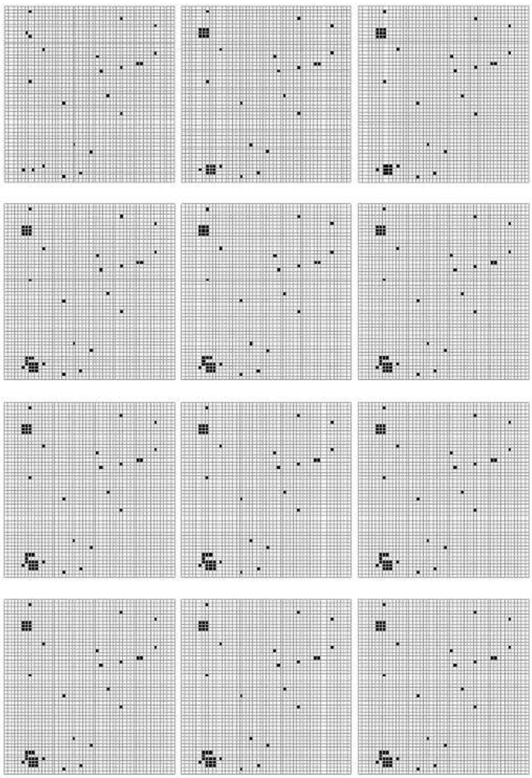

Figure 7: *The percolation of opinions when U=(0.3,1), R=(0.8,1), I=0.5 for 1(23), 10(38), 20(38), 30(43), 40(43), 50(43), 60(43), 70(43), 80(43), 90(43), 100(43) and 150(43) interactions (number of opinions reached one).*

static or stagnant when U - R is in the range of {0, 0.2 }. Figure 5 shows the opinion clusters for different values of utility and reservation.

Figures 6 and 7 show the opinion percolation when the reservation value is high. From the figures, the percolation (which is denoted by black dots on the lattice) is localised, that is, islands of opinion do not connect to each other. Consensus is reached when the threshold value, i.e., $U – R$ is larger than 0.2. Figure 8 shows the global percolation of opinion when the threshold value is high, R = 0.3 and U = 0.8.

6. Conclusion

In this paper, we simulated decision making when agents engage in confirmation bias. When there is confirmation bias, it takes less hypothesis-consistent information to confirm a reservation than hypothesis-inconsistent information to disconfirm a reservation. This causes faster upward opinion adjustment when agents receive positive information than negative information. We simulated three different sources of confirmation bias and related them to societal decisions.

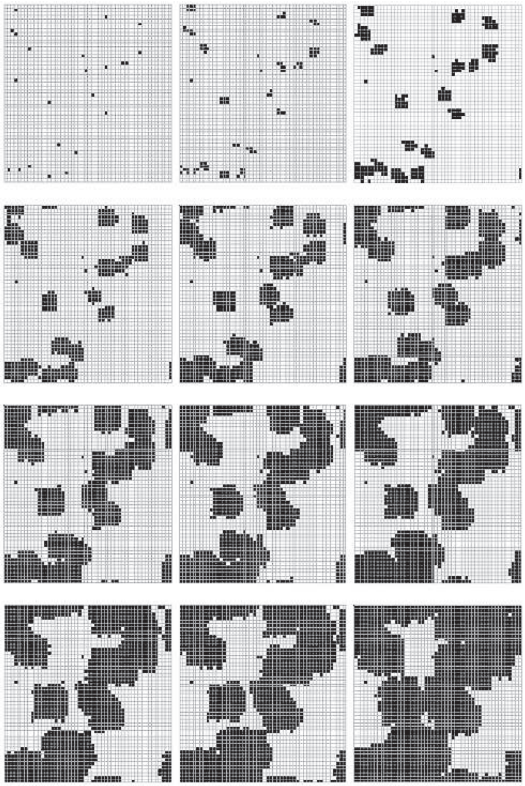

Figure 8: *The percolation of opinions when U=(0.8,1), R=(0.3,1), I=(0,R-0.5) for 1(23),10(93),20(250),30(424),40(612),50(774),60(911),70(1045),80(1155),90(1265), 100(1354) and 150(1720) interactions (number of opinions reached one).*

They are preferential treatment on supportive information by agents, overconfidence of one's belief, and externalisation of dissatisfaction when the quality after purchase is low. The first two learning processes lead agents to adopt positive information more easily than negative information, which leads to convergence of opinions. This convergence of beliefs can explain some of the societal behaviours such as overconfidence, path-dependent opinions (current opinions formed as a result of the influence of past opinions) and concentration of demand for a particular product.

However, if agents are more averse to utility loss when a hypothesis is disconfirmed than when it is confirmed during the learning process (Tversky and Kahneman 1991), externalisation would occur. This causes agents to blame the product rather than the selectivity of information during the learning process. Therefore, the spread of negative information is faster when a product is bad than the spread of positive information when the product is good.

References

Anderson, L.R. and C. Holt. 1997. Information cascades in the laboratory. *American Economic Review* **87:** 847-862.

Arthur, B. 1995. Complexity in economics and financial markets. *Complexity* **1(1)**: 20-25.

Banerjee, A. V. 1992. A simple model of herd behavior. *Quarterly Journal of Economics* **107(3)**: 797-817.

Barron, J . 1995. My side bias in thinking about abortion. *Thinking and Reasoning* **7**: 221-235.

Bikhchandani, S., D. Hirshleifer and I. Welch. 1992. A theory of fads, fashion, custom and cultural changes as informational cascade. *Journal of Political Economy* **100(5):** 992-1026.

Celen, B. and K. Shachar. 2004. Distinguishing informational cascade from herd behavior in the laboratory. *The American Economic Review* **94(3):** 484-496.

Goeree, J. K., T.R. Palfrey, B.W. Rogers and R.D. McKelvey. 2003. Self Correcting Information Cascades. Discussion Paper, Caltech.

Hegselmann, R. and U. Krause. 2002. Opinion dynamics and bounded confidence models: analysis and simulation. *Journal of Artificial Societies and Social Simulation* **5(3)**: 1-33.

Huck, S. and J. Oechssler. 2000. Information cascades in the laboratory: do they occur for the right reasons? *Journal of Economic Psychology* **21**: 661-671.

Koriat, A., S. Lichtenstein and B. Fischhoff. 1980. Reasons for confidence. *Journal of Experimental Psychology: Human Learning and Memory* **6**: 107-118.

Kuhn, D. 1989. Children and adults as intuitive scientists. *Psychological Review* **96**: 674-689.

Matlin, M. W. and D.J. Stang. 1978. *The Pollyanna Principle: Selectivity in Languages, Memory and Thought.* Cambridge, MA: Shenkman.

Nickerson, R. S. 1998. Confirmation bias: an ubiquitous phenomenon in many guises. *Review of General Psychology* **2(2)**: 175-220.

Perkins, D. N., M. Farady and B. Bushley. 1991. *Everyday Reasoning and the Roots of Intelligence.* Hillsdale, NJ: Erlbaum.

Pyszczynski, T. and J. Greenberg. 1987. Toward an integration of cognitive and motivational perspectives on social inference: a biased hypothesis testing model. In *Advances in Experimental Social Psychology,* ed. L. Berkowitz, pp. 297-331. New York: Academic Press.

Schwartz, B. 1982. Reinforcement-induced behavioral stereotypy: how not to teach people to discover rules. *Journal of Experimental Psychology: General* **3**: 23-59.

Snyder, M. and B. Campbell. 1980. Testing hypothesis about other people: the role of the hypothesis. *Personality and Social Psychology Bulletin* **6**: 421-426.

Snyder, M. and S. Gangestad. 1981. Hypothesis testing process. In *New Directions in Attribution Research,* vol. 3. Hillsdale, NJ: Erlbaum.

Snyder, M. and W.B.Swann. 1978. Behavioral confirmation in social interaction: from social perception to social reality. *Journal of Experimental Social Psychology* **14**: 148-162.

Tversky, A. and D. Kahneman. 1991. Loss aversion in riskless choice: a reference dependent model. *Quarterly Journal of Economics* **107(4):** 1039–1061.

Weinstein, N. D. 1989. Optimistic bias about personal risks. *Science* **246**: 1232–1233.

Weisbuch, G. D., F. Amblard and J.P. Nadal. 2001. Interacting agents and continuous opinions dynamics. Technical Report, Laboratoire associe au CNRS (URA 1306) , a I'ENS et aux Universities Paris 6 et Paris 7