Modern Physics Letters B
Vol. 31, No. 6 (2017) 1750058 (8 pages)

DOI: 10.1142/S0217984917500580

Effects of convincing power and neutrality on minority opinion spreading

Yue Wu

Computer and Software Engineering, School of Xihua University,
Chengdu 610039, China
wuyue_xh@sina.com

Xi Xiong

School of Information Security Engineering,
Chengdu University of Information Technology,
Chengdu 610225, China
xiongxi@cuit.edu.cn

Yi Zhang

Mathematics School of Yibin University, Yibin 644000, China

Received 3 November 2016
Revised 9 January 2017
Accepted 11 January 2017
Published 28 February 2017

The dynamics evolution of the minority opinion in public debates is studied using a convincing power (CP) model with neutrality. In a given group, an agent with a definite standpoint (yes or no) can be persuaded to be a neutral agent, if its capacity of persuasion is lower than the average CP of its opponents. Besides that a neutral agent will change its state and follow a more persuasive opinion. Starting from two opposite opinions with different rates, repeated local discussions are found to drive the minority reversal. It reveals that in addition to the initial minority, the number of neutral agents is also an important factor to the eventual winners. During the process of consensus, there exists a threshold of initial fraction to guarantee one side win. The results have a guiding significance for designing strategies to win a public debate.

Keywords: Minority opinion; convincing power; neutrality.

1. Introduction

As a new branch of Sociophysics,[1] opinion dynamics has been a hotspot research in the last 20 years. This recent research concentrates on analyzing the complicated psycho-sociological mechanisms.[2] In particular, focusing on the mechanisms involved in the process of minority opinion spreading.[3–10]

Intuitively, the initial minority opinion will be drowned out under the democratic principle, such as majority rule.[3] However, this is not always the case. Galam[2,4] employed the "inertia principle" for the opinion propagation with no advantage to the minority, and found the total opinion refusal had been completed within few days. Huang[5,6] focused on the effect of a network's structure on the process of opinion formation. The simulation results show that, if the link probability ratio is less than the critical point, the global minority will be dominant in the local discussion. Shen[7] studied the effects of network structure and confidence scale on minority opinion, the results demonstrate that the heterogeneity of networks is advantageous to the minority, exchanging views between more agents can reduce the opportunity of minority's success. Galam[8] investigated the role of inflexible minorities in the breaking of democratic opinion dynamics and found that, if the percentage of inflexible minorities was above 17%, the minorities would win whatever the initial conditions were. Sznajd-Weron[9] proposed a model of opinion dynamics with conformity and independence, experiments suggest that, above a certain critical independence value, there is no majority in the society. Crokidakis[10] considered a limited-persuasion mechanism in the majority-rule model. He supposed that agents with a local majority opinion in a given group could be persuasive only if their average convincing power (CP) was larger than the minority's conviction. This rule makes it possible for minority to dominate the population in the long-time limit. This kind of mechanism is also considered in other models, a reputational mechanism is considered in the Sznajd sociophysics model,[11] the introduction of reputation avoids full consensus even for initial densities of up spins greater than 0.5. Moreover, the effect of agents' reputations is considered in the persuasion rules, in other words, high-reputation group with a common opinion may convince their neighbors with probability p. These rules make the full-consensus states more difficult to be reached.[12] Stauffer[13] modified the Sznajd model in the sense of Deffuant *et al.* and Hegselmann, that only neighbors of similar opinions can be convinced. The results suggest that consensus is easy for the competition of up to three opinions but difficult for four and more opinions.

In this work, we further study the role of CP based on Ref. 10. Aside from the proponents and opponents, we introduce another type of agents with no preferred opinion,[14] which is called neutral agents. Neutral agents can easily change their opinions, and affect the final opinion distribution dramatically,[15] they provide the communication channel between the opposite sides[16] and should be considered to explore the influence of persuasion.[17] Thus, we study the role of CP with neutrality in the proposed models.

This work is organized as follows. In Sec. 2, we present the CP model with neutrality, define its microscopic rules. We discuss the simulation results in Sec. 3. Our conclusions are presented in Sec. 4.

2. CP Model with Neutrality

As the CP model described in Ref. 10, we suppose a population of N agents hold three kinds of opinions, called A, B and O, which represent positive, negative and neutral opinions, respectively. The number of agents who hold the opinion A is represented as n_A, similarly, n_B is the number of B-supporters, n_o is the number of neutral agents, $N = n_A + n_B + n_o$. $D = n_A/N$ at time $= 0$, which can be viewed as the initial fraction of A-supporters. Each agent i has its own CP p_i, which is sorted uniformly inside a given interval $[-C, C]$ initially, $C = 5$.

In the evolution process of discussion, a group is selected randomly every time, a group is composed by three random individuals (i, j, k). Notice the individual can hardly change its opinion to accept the opposite view suddenly, we assume that both agents with opinions A or B will flip their opinions to the neutral opinion firstly if they were persuaded, the neutral agents have no power to persuade the others. We set the opinion update rules of CP model with neutral agents in (2-1)–(2-5) and give some examples in Fig. 1.

(2-1) If there is no neutral agent in the group and $p = (p_i + p_j)/2$ is larger than p_k, agent k will hold the opinion as others, at the same time, $p_i \to p_i + 1$, $p_j \to p_j + 1$.

(2-2) If there is an agent k with neutral opinion in the group and the other two agents i and j have the same opinion. Agent k will change its opinion as the others and $p_i \to p_i + 1$, $p_j \to p_j + 1$.

(2-3) If the agent k hold the neutral opinion, agents i, j hold the opposite opinion in the group, and $p_i > p_j$. Then agent k and j will change their opinion the same as the point of view of agent i, and $p_i \to p_i + 1$.

(2-4) If there are two neutrals in the group, say agents j and k. Agents j and k will change their opinions to suit agent i and $p_i \to p_i + 1$.

(2-5) Otherwise, nothing occurs.

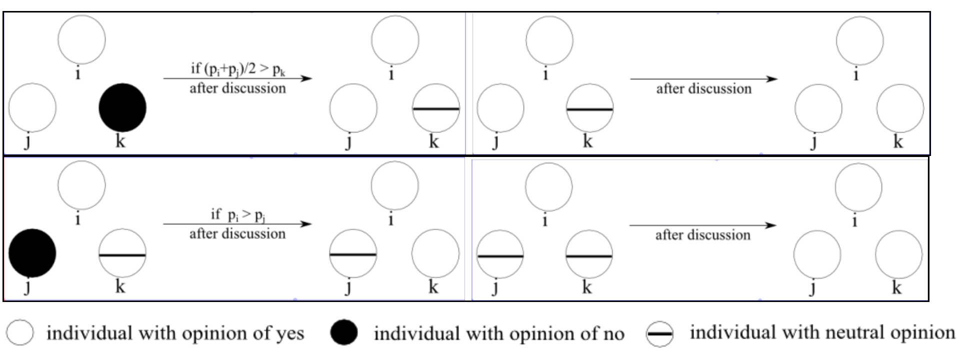

Fig. 1. Examples of local discussion processes.

3. Results and Discussion

For ease of calculation, we suppose the number of the neutral agents is zero at first, that is, $n_o = 0$ when time $= 0$. Since the system is symmetric around $D = 0.5$, we present results for $D < 0.5$ and $N = 10^3$. D is adjusted from 0.01 to 0.5 with growth rates of 0.01. One time step consists of the opinion update rules N times, and the time evolution will be over no matter any one of the fraction of either opinion A or$B$ fells to zero.

We observe the time evolution of the fraction of A-supporters n_A for varied D, with each simulation for D repeated 100 times. Interestingly, the time evolution is varied even with the same D, which is different from what occurs in the CP model.[10] We calculate the winning probability for A-supporters ($n_A = N$), as illustrated in Fig. 2. When $0.01 \leq D \leq 0.08$, the winning probability for A-supporters increases as D increases. When $0.08 < D \leq 0.2$, the probability decreases with rising D roughly. When $0.2 < D < 0.5$, it keeps around 0.53. Accordingly, there exists an optimum D, at which A-supporters achieve the maximum chance to win. In this experiment, the optimal value of D is 0.07, the maximum probability of winning is 0.82.

Different evolution processes have different relaxation times to reach stable states without considering the eventual winners, as exhibited in Fig. 3. In terms of distribution characteristics, the relaxation time first increases then decreases as D increases. Combining Figs. 2 and 3, one can see that when $D = 0.2$, both fractions win the discussion with a probability of 50%, meanwhile, the relaxation time attains its maximum value. This illustrates that it will take a long time to reach a balance state if 20% of population share one opinion, and the rest of them keep the opposite point of view in the beginning.

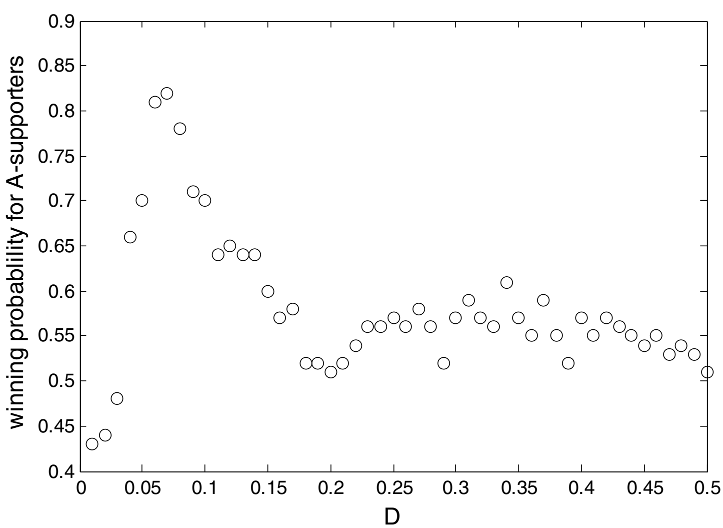

Fig. 2. Average winning probability for A-supporters with varied D. For each D, there are 100 samples.

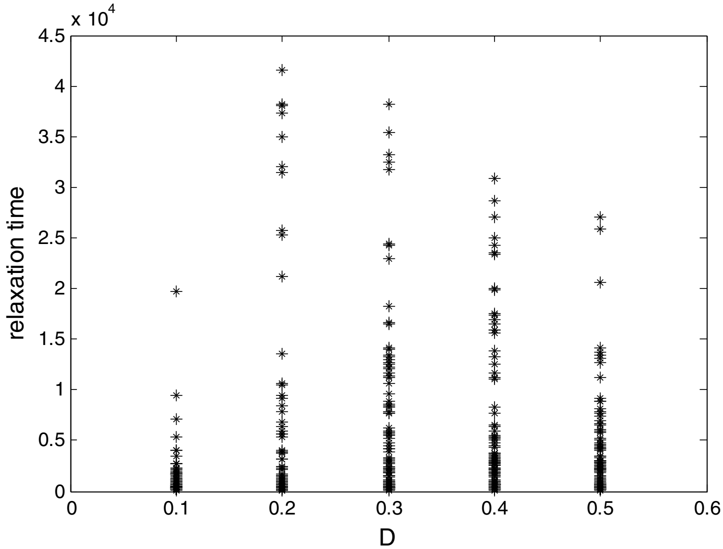

Fig. 3. Distribution of relaxation time with varied D. Each point represents a single simulated result.

Due to the introduction of neutrality, the time evolution of each fraction is varied with the same D. For the case $D = 0.1$, A-supporters have 70% probability to win and 30% probability to lose. Figure 4 shows simulated samples with two entirely different endings. In the case B-supporters win, see Fig. 4(a), about 10% of the individuals starts with opinion A, 90% starts with opinion B and there is no neutral agent at the start. Afterwards, the number of individuals with opinion A first increases then declines, and later raises to a state near the consensus with $n_A = N$ for a long time, but after that the number of individuals with opinion B starts to increase and suddenly grows until the consensus state with $n_B = N$.

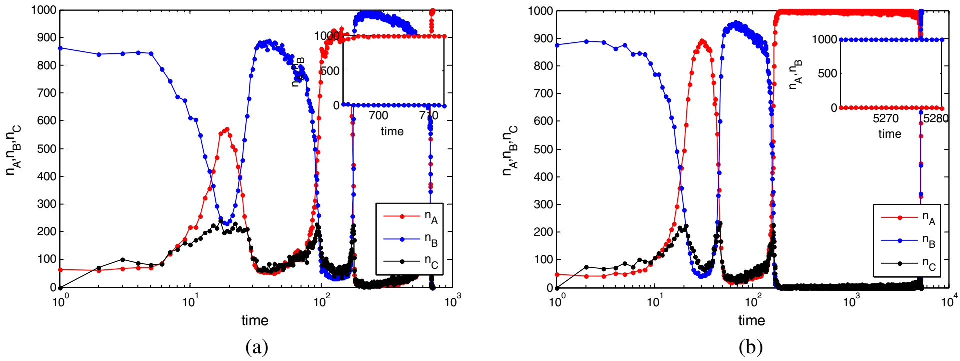

Fig. 4. (Color online) Time evolution of the fraction n_A, n_B and n_C for $D = 0.1$. (a) B-supporters win the discussion. (b) A-supporters win the discussion.

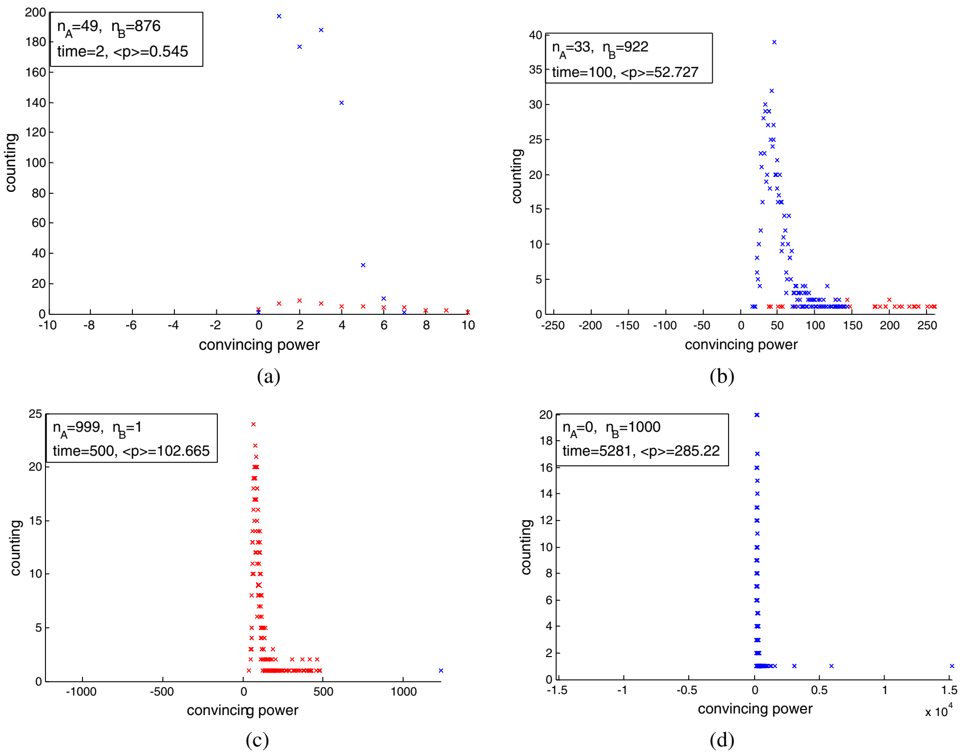

Fig. 5. (Color online) Time evolution of A- and B-distributions of the CPs for the sample of B-supporters win, $D = 0.1$, distinct time steps, $\langle p\rangle = \sum p_i/N$. Blue points are CPs of B-supporters and red points are CPs of A-supporters.

Throughout the entire process, the number of neutral agents goes up and down, and drops to 0 in the end. In the case of A-supporters win, Fig. 4(b), the early evolution of the fraction $n_A$is similar to which in Fig. 4(a), but in later stages, n_A drops to a very small value and win the final consensus.

For better understanding the behavior presented in Fig. 4, we follow the time evolution of individuals' CPs A- and B-distributions. In Fig. 5, we exhibit the distributions of CPs of the case B-supporters win, Fig. 6 shows the CPs of the case A-supporters win, at certain time step. Through the contrast, one can see that, at time $= 2$, $\langle p\rangle$ is almost equal to 0 and the distribution of CPs of Fig. 5(a) is similar to that of Fig. 6(a). After 100 time steps, the difference between the two samples gets bigger and bigger. In Fig. 5(b), one can see that agents who have high CPs are mainly A-supporters, which is similar to the state in Fig. 6(c). But the CPs of A-supporters in Fig. 6(c) are much higher than which illustrated in Fig. 5(b), thus resulting in two entirely different endings: A-supporters eventually win the discussion in Fig. 6(d), and they nearly dominate the whole population except one in Fig. 5(c). It is the special agent who has CP high enough, cannot be persuaded to change to the majority opinion, and finally turn the public opinion

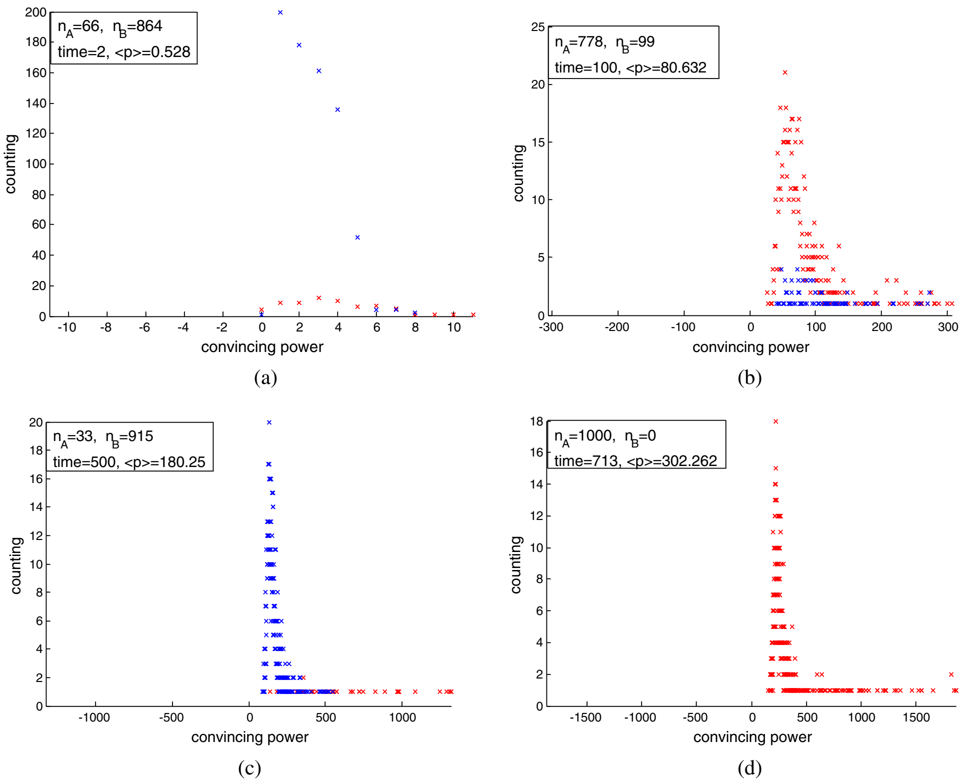

Fig. 6. (Color online) Time evolution of A- and B-distributions of the CPs for the sample of A-supporters win, $D = 0.1$, distinct time steps, $\langle p \rangle = \sum p_i/N$. Blue points are CPs of B-supporters and red points are CPs of A-supporters.

around. This special agent acts as an "inflexible" or "intransigent" individual, that cannot be persuaded to change opinion. These inflexible zealots often dictate the final distribution pattern of public opinion.[8,18,19] This characteristic leads to the mentioned behavior (inversion of the current majority).

To further study the reason of the inversion, extensive simulation experiments have been done for varied initial value of CPs, as seen in Table 1. From which we get the same conclusion, only below a certain threshold, the minority become small enough with sufficiently high CPs, can they guarantee a definitive inversion.

Table 1. Average winning probability for A-supporters with varied initial CPs and D.

Initial CPs \ D	0.05	0.1	0.15	0.2	0.25	0.3	0.35
Uniform distribution in $[-1, 1]$	0.8	0.72	0.5	0.58	0.54	0.52	0.55
Uniform distribution in $[-10, 10]$	0.77	0.7	0.49	0.54	0.55	0.56	0.5
Gaussian distribution $N(0, 1)$	0.84	0.78	0.58	0.58	0.56	0.53	0.51

4. Conclusion

To conclude, we propose a CP model with neutrality. Compared with the CP model, we suppose that people will not change their opinions to the opposite side suddenly, but there is an intermediate phase, called neutrality in this paper. By including neutrality, simulation results of CP model are changed. The eventual winners are not only decided by the initial minority, but also impacted by some accidental elements, such as the neutral agents. Moreover, in the evolving process of consensus, there exists a threshold of initial fraction to guarantee one side win with the maximum probability 0.82. The model may shed new light on minority opinion spreading and public opinion reversion.

Acknowledgments

Project supported by the National Natural Science Foundation of China (Grant Nos. 61472329 and 61602389), the Scientific Research Fund of Sichuan Education Department (Grant Nos. 15ZB0133 and 15ZB0295), the Open Research Subject of Key Laboratory of Xihua University (Grant No. szjj2015-058), the Key Scientific Research Fund Project of Xihua University (Grant No. z1422617) and the Key Lab of Internet Natural Language Processing of Sichuan Provincial Education Department (Grant No. INLP201501).

References

1. S. Galam, Springer Science & Business Media (2012).
2. S. Galam, *Eur. Phys. J. B: Condens. Matter and Complex Syst.* **25** (2002) 403.
3. P. L. Krapivsky and S. Redner, *Phys. Rev. Lett.* **90** (2003) 238701.
4. S. Galam, *Physica A* **320** (2003) 571.
5. G. Huang *et al.*, *Physica A* **387** (2008) 4665.
6. G. Huang, J. Cao and Y. Qu, *Physica A* **388** (2009) 3911.
7. B. Shen and Y. Liu, *Int. J. Mod. Phys. C* **21** (2010) 1001.
8. S. Galam and F. Jacobs, *Physica A* **381** (2007) 366.
9. K. Sznajd-Weron, M. Tabiszewski and A. M. Timpanaro, *Europhys. Lett.* **96** (2011) 48002.
10. N. Crokidakis and P. M. C. de Oliveira, *Physica A* **409** (2014) 48.
11. N. Crokidakis and P. M. C. de Oliveira, *J. Stat. Mech. Theory Exp.* **11** (2011) P11004.
12. N. Crokidakis and F. L. Forgerini, *Braz. J. Phys.* **42** (2012) 125.
13. D. Stauffer, *Int. J. Mod. Phys. C* **13** (2002) 315.
14. P. Sobkowicz, M. Kaschesky and G. Bouchard, *Government Information Quarterly* **29** (2012) 470.
15. M. He, Q. Sun and H. Wang, *Int. J. Mod. Phys. C* **15** (2004) 767.
16. L. A. Adamic and N. Glance, *Proc. 3rd Int. Workshop on Link Discovery ACM* (2005).
17. C. E. La Rocca, L. A. Braunstein and F. Vazquez, *Europhys. Lett.* **106** (2014) 40004.
18. N. Crokidakis and P. M. C. de Oliveira, *Phys. Rev. E* **92** (2015) 062122.
19. M. Mobilia, *Phys. Rev. E* **92** (2015) 012803.