Physica A 458 (2016) 399–411

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

Modeling of agent-based complex network under cyber-violence

Chuanchao Huang [a], Bin Hu [a], Guoyin Jiang [b,*], Ruixian Yang [c]

[a] School of Management, Huazhong University of Science and Technology, Wuhan 430074, China
[b] School of Information Management, Hubei University of Economics, Wuhan 430205, China
[c] College of Information Management, Zhengzhou University, Zhengzhou, 450001, China

ARTICLE INFO

Article history:
Received 7 October 2015
Received in revised form 23 February 2016
Available online 19 April 2016

Keywords:
Public opinion reversal
Individual opinion
Choice behavior
Agent-based model
Complex networks

ABSTRACT

Public opinion reversal arises frequently in modern society, due to the continual interactions between individuals and their surroundings. To explore the underlying mechanism of the interesting social phenomenon, we introduce here a new model which takes the relationship between the individual cognitive bias and their corresponding choice behavior into account. Experimental results show that the proposed model can provide an accurate description of the entire process of public opinion reversal under the internet environment and the distribution of cognitive bias plays the role of a measure for the reversal probability. In particular, the application to cyber violence, a typical example of public opinion reversal, suggests that public opinion is prone to be seriously affected by the spread of misleading and harmful information. Furthermore, our model is very robust and thus can be employed to other empirical studies that concern the sudden change of public and personal opinion on internet.

1. Introduction

The rapid advance in modern information technology has given rise to the wide presence of Bulletin Board Systems, online discussion forums and social networking sites. Unlike newspapers, broadcasts and televisions, this kind of mass media endows common people with new platforms to air their opinions punctually and conveniently. Along with the advent of these advanced techniques, the study of public opinion under the internet environment has received increasing considerations in recent literature [1–4]. It has been observed that establishing a suitable model for the evolution of online public opinion can improve our understanding of this complicated social phenomenon, thus supporting the elucidation of its underlying mechanisms.

As intelligent animals, human beings always change their ideas and make adaptive decisions according to the information acquired from the whole society and their surrounding environment. The cognition process absolutely plays a central role in individual decision-making [5,6]. For example, people are prone to irrational behaviors as long as they are confronted with intricate situations [7,8]. Traditional methods, e.g. Refs. [9,10], which usually ignore the influence of individual cognition on her/his final decision, are obviously inapplicable to the analysis of the dynamics of online public opinion discussed here. Therefore, it is necessary to develop an appropriate model that can incorporate the relationships between people's cognition processes and their attitudes toward somebody or something.

* Corresponding author.
E-mail address: jiangguoyin@hbue.edu.cn (G. Jiang).

http://dx.doi.org/10.1016/j.physa.2016.03.066
0378-4371/

It is well-known that a butterfly flapping its wings in South America can affect the weather in Central Park. Similarly, a public opinion is most likely to reverse suddenly due to the slight change of certain individuals' thoughts. This emergent social phenomenon, called public opinion reversal, is also referred to as cyber violence in some cases [11–13], which attracts our special interest and will be discussed systematically later in this paper. To the best of our knowledge, the continuous opinions and discrete actions (CODA) model seems the most suitable description tool for representing sudden change in public and individual opinions at present. In this model, individuals can share their opinions with others even if their ideas are extreme and violate and can have a slight influence on public opinions [14–16]. Furthermore, individual opinion is seldom polar. Instead, they probably lie somewhere between the two extremes. The CODA model cannot only describes the continuous transitions in public opinion, but also can capture the discreteness of individual decision-making behavior. Therefore, the model has been successfully utilized to deal with the nonlinear phenomena which occur in the change process of public opinion [15,16], providing us a deeper understanding of individual choice behavior through online interactions.

In this study, we put particular emphasis on the role of individual cognitive bias in the reversal process of public opinion and the influence of cyber violence on the trend in the evolution of public opinion. The rest of this paper is organized as follows. We begin with a brief review of previous works about opinion dynamics, such as the bounded confidence model and the minority reversal theory in Section 2. Section 3 proposes our new model for public opinion reversal. In Section 4, we report the numerical results about the evolution of public opinion, and discuss the differences between the proposed model and several existing models. In Section 5, we further check the effects of unbounded communication and the robustness of our model. We conclude this paper and give some potential research directions in Section 6.

2. Related works

Social physicists have applied the models and methods in information science and complex network to the investigation of public opinion reversal and have achieved some promising results in the last decade [17,18]. Agent-based modeling originated in the study of social dynamics has been substantially utilized to conduct researches involving online networks. Some scientists advocated the importance of leadership and external impact in opinion formation [19], while others introduced models concentrated on the discrete nonlinear and non-autonomous properties in consensus realization [19]. However, these models fixed the opinions to be binary and thus fail to reveal the cognitive degrees of different individuals. Furthermore, the existing models can capture the evolution of the majority opinion or the minority opinion only.

The bounded confidence models incorporated the nonlinear interactions into the agent-based model and assumed that a pair of agents begin to affect each other when the difference between their opinions is below a given threshold. For instance, Deffuant et al. built a multi-agent system to check the interdependence between the similarity of agents' opinions and the frequency of their contacts [20]. Besides, Krause and Hegselmann proposed a relative-agreement model quite similar to the former one [21]. It is more reasonable that the opinions in this type of model can take continuous values, say, a number between 0 and 1, as the individuals' attitudes toward an event usually lie in somewhere between the two extremes.

Another major line of previous works focus on the relationship between the propagation of personal ideas and the evolution of collective opinions. It has been found that individuals prefer to communicate with the peers who agree with themselves [22,23]. In some situations, the public opinion is seriously swayed by the viewpoint held by a small proportion of people at the initial time [24,25]. In addition, the opinions of the individuals fluctuate dramatically in certain organizations [2,26]. Researchers have also explored other related subjects, including the individual inflexibility in opinion dynamics [27], minority tipping thresholds [2], consensus and attitude changes in groups [28], etc. Despite the surge of tremendous studies concentrated on public opinion assimilation, integration, and separation, there still remains no work that systematically considers the relationship between the individual cognitive levels and their corresponding choice behavior in these studies, let alone in the investigation of public opinion reversal.

Although several methods mentioned above have achieved promising results in modeling of public opinion, they still exist many intrinsic shortcomings. The bounded confidence model can provide an accurate description of the gradual transition of individual opinions during the interaction process, but failed to precisely depict the sudden shifts in opinion [3]. It is worthwhile to note that there exist three different layers of the interactions between individuals, which constitute a hierarchical tree and are listed as follows. At the personal level, decision-making behavior and opinion formation are closely associated with the cognition of events [29] and cognitive bias is probably an influence on individual opinions. By forming a group, individuals remove their trust boundaries of thresholds in online communities. Finally, individual cognition is simultaneously affected by the public opinion and the ideas from their neighboring individuals at the organization level. As a result, we need to take all the information into consideration when we construct a complicated model for the formation and evolution of online public opinion.

As we all know, the communications between individuals are, in general, very helpful to achieve consensus in public opinion formation, owing to the social homoplasy. The public opinion, however, is likely to be reversed, if an individual throws an idea opposite to those of the majority and shares it with the other people in the whole social network freely, as often observed in the real life. In this paper, we postulate that there is no bounded threshold for the interactions between individuals, since people are able to contact others without limitation through the internet. The evolution of public opinion relies on the topology of the social network, which has been concisely represented as a complex network in previous works [26,30,31] as well as in our model.