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Impacts of suppressing guide on information spreading

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HIGHLIGHTS

- The impacts of suppressing guides on information spreading are analyzed quantitatively.
- The spreading threshold was depending on the attractiveness of the information and the topology of the social networks without guide.
- The inclusion of suppressing guiding nodes leads to effective stimulation of the rumor spreading on considering the reversal mind.

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ABSTRACT

It is quite common that guides are introduced to suppress the information spreading in modern society for different purposes. In this paper, an agent-based model is established to quantitatively analyze the impacts of suppressing guides on information spreading. We find that the spreading threshold depends on the attractiveness of the information and the topology of the social network with no suppressing guides at all. Usually, one would expect that the existence of suppressing guides in the spreading procedure may result in less diffusion of information within the overall network. However, we find that sometimes the opposite is true: the manipulating nodes of suppressing guides may lead to more extensive information spreading when there are audiences with the reversal mind. These results can provide valuable theoretical references to public opinion guidance on various information, e.g., rumor or news spreading.

1. Introduction

Exploring the dynamics of information spreading and disease propagation is an important topic, which has attracted increasing attention in recent years [1–4]. The spreading of information may be influenced by social reinforcement and public opinion guidance [4–10]. Social reinforcement is defined as the situation in which an individual, before adopting an opinion, requires multiple prompts from his or her neighbors [11]. Introducing guide into the spreading system is a common phenomenon in our daily life [12], especially during the period of emergencies [13,14]. Guides are very common and active in viral marketing while viral messages are playing an important role in influencing and shifting public opinions about corporate reputations, brands, and products as well as political parties and public figures, etc. [15]. However, the results of opinion-guiding may not always be the same as desired. Contrary to prompting the spreading of the information for certain, the suppressing effect of the guide may sometimes lead to the reversal of the audience attitude [16,17], and eventually decreases the probability of extensive information spreading. While there are abundant qualitative analysis of the

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effects of opinion-guiding, mainly based on the principles of mass media, psychology and other social sciences [10,11,17,18], quantitatively analyzing the suppressing effect and the reversal effect still remains a crucial and urgent topic in the field of information spreading.

In this paper, we focus on two factors, *the suppressing guides* whose effect is to decrease the probability of their network neighbors adopting the information as well as *the reversal mind of audiences* whose effect is to provoke information spreading when there are suppressing guiding nodes. We found that if there is no guide, the breaking point of information depends mainly on the network topology and the attractiveness of the information. As different rates of the suppressing guides appear, stimulating, ineffective or inhibitory impacts may occur under different conditions. Finally, the effect of "reverse psychology" and stimulation of information spreading caused by suppressing guide are investigated and revealed quantitatively. This paper is organized into four parts. The first part is the Introduction. The second part presents our model and the third part quantitatively analyzes the information spreading procedure. The fourth part includes conclusions and discussions.

2. Model

Model studies usually aim to reproduce some empirical observations to uncover the main mechanisms of the underlying processes. Dynamic process of complex systems can be considered as one taking place on a network formed by pairwise interactions between the constituents of the system [19,20], and the information spreading that takes place within the network.

Our model consists of a random network of N nodes, representing N participants in the information spreading system. At each discrete time step t, each node k may be in one of the two states $S_k(t) = 0$ or $S_k(t) = 1$, representing unknown/non-acceptance or adoption of certain information, respectively. When a node k is in the adoption state $S_k(t) = 1$, node m receives an input of strength A_{km} from k. Each node k is either an ordinary person or a suppressing guide, corresponding to $A_{km} > 0$ or $A_{km} < 0$ for all m. Negative strength means the prevention of the information spreading by suppressing guides. If there is no connection between node k and node m, then $A_{km} = 0$. At time $t + 1$, the state of node n switches as a Markovian process with the following transition rule:

$$S_n(t+1) = 1, \quad \text{with probability } \sigma\left(\sum_{m=1}^{N} A_{mn} S_m(t)\right),$$

and $S_n(t+1) = 0$, otherwise, where the transfer function is piecewise linear defined as

$$\sigma(x) = \begin{cases} 0, & x \le 0, \\ x, & 0 < x < 1, \\ 1, & x \ge 1. \end{cases}$$

Intuitively, in our model, the "adoption" of an agent is the comprehensive effect of all its neighbors. Analogously, an "adoption" agent changing the state to "unknown or unconvinced" also depends on the effect of all their neighbors. In fact, no matter what states (0 or 1) the agents are in, the probability of choosing state 1 depends on the states of all their neighbors, and so is the probability of choosing state 0. For example, in the social media such as micro-blog or WeChat, one's adopting and forwarding a certain message is merely the effect of his/her "neighbors" list in the circle of friends. According to our model, when there is no adoption node, or when there are suppressing guiding nodes in the network, a node would never adopt the rumor. Moreover, larger ratio of the suppressing guiding nodes around would lead to lower probability of a node's adopting the information since the A_{km} is negative if node k is a suppressing guide. On the other hand, if there is no suppressing guiding node in the network, more adoption nodes around will lead to larger probability of a node's switching from unknown/non-acceptance to adoption [21].

We consider the dynamics described above on a directed random network. The connecting probability of each pair of nodes is p. Each nonzero connection strength A_{km} is independently drawn from a uniform distribution on $[0, 2r]$, with mean strength r. The larger the value of r is, the more popular or attractive the information is. Next, a fraction of the nodes α is designated as suppressing guides and each row of the matrix A that corresponds to the outgoing connections of a suppressing guiding node is multiplied by -1.

In this work, we focus on the average adoption nodes of the network, defined as

$$S(t) = \frac{1}{N} \sum_{n=1}^{N} S_n(t), \tag{1}$$

which is the fraction of nodes that is of the adoption state at time t. According to Eq. (1), if the entire network does not know the information, $S = 0$, it will remain unknown indefinitely. In the following, we will investigate the effect of parameters r and α, namely, the effect of the attractiveness of information and the ratio of suppressing guides.