Physica A 414 (2014) 254–262

Contents lists available at ScienceDirect

Physica A

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

A dynamic evolution model of human opinion as affected by advertising

Gui-Xun Luo [a,b], Yun Liu [a,b,*], Qing-An Zeng [c], Su-Meng Diao [a,b], Fei Xiong [a,b]

[a] School of Communication and Information Engineering, Beijing Jiaotong University, Beijing 100044, China

[b] Key Laboratory of Communication and Information Systems, Beijing Municipal Commission of Education, Beijing Jiaotong University, Beijing 100044, China

[c] Department of Computer Systems Technology, North Carolina A&T State University, Greensboro, NC 27411, USA

HIGHLIGHTS

- We propose a model to study opinion dynamics as affected by advertising.
- The marginal influence of friends will decrease with an increasing number of friends.
- We use Hermann Ebbinghaus's forgetting curve to describe the decline of opinion.
- A proper assessment of advertising's influence and coverage is necessary.
- The intensity of exchanging opinion is a key factor in the success of advertising.

ARTICLE INFO

Article history:
Received 15 April 2014
Received in revised form 10 July 2014
Available online 23 July 2014

Keywords:
Advertising
CODA model
Forgetting curve
Opinion dynamics

ABSTRACT

We propose a new model to investigate the dynamics of human opinion as affected by advertising, based on the main idea of the CODA model and taking into account two practical factors: one is that the marginal influence of an additional friend will decrease with an increasing number of friends; the other is the decline of memory over time. Simulations show several significant conclusions for both advertising agencies and the general public. A small difference of advertising's influence on individuals or advertising coverage will result in significantly different advertising effectiveness within a certain interval of value. Compared to the value of advertising's influence on individuals, the advertising coverage plays a more important role due to the exponential decay of memory. Meanwhile, some of the obtained results are in accordance with people's daily cognition about advertising. The real key factor in determining the success of advertising is the intensity of exchanging opinions, and people's external actions always follow their internal opinions. Negative opinions also play an important role.

1. Introduction

Sociophysics [1–3] is "the use of concepts and techniques that are taken from statistical physics to investigate some social and political behavior" [4]. Its origin dates back to the late 1970s, discussed in a personal testimony [1]. Within the

* Corresponding author at: Key Laboratory of Communication and Information Systems, Beijing Municipal Commission of Education, Beijing Jiaotong University, Beijing 100044, China. Tel.: +86 1051684227.

E-mail addresses: luoguixun@gmail.com (G.-X. Luo), liuyun@bjtu.edu.cn (Y. Liu), qzeng@ncat.edu (Q.-A. Zeng), diao.simon@gmail.com (S.-M. Diao), xiongf@bjtu.edu.cn (F. Xiong).

http://dx.doi.org/10.1016/j.physa.2014.07.055
0378-4371/

field of sociophysics, models of opinion dynamics have attracted a great deal of attention in recent years [5–10]. Based on local updating rules, more and more models of opinion dynamics have been proposed. As an example, the Sznajd model proposed the principle "United we stand, divided we fall". In addition, many mathematical models are used to address the essential physics of complex systems. For example, the Ising model [11,12] was applied to describe a social system by Galam [2,13], with an outlook considering "Humans behaving like atoms".

These research works can be broadly divided into two categories: one focuses on the model itself and its features; the other applies the model in practical fields. The models can, again, roughly fall into two classes: discrete opinion and continuous opinion models. The Voter model [14,15] and Majority model [16] were proposed based on two-state discrete variables. In the real world, people are usually confronted with a limited number of choices under certain circumstances, frequently with as few as two (e.g., yes or no, support or opposition, iOS or Android). Therefore, it is reasonable to utilize discrete variables to represent opinion in certain circumstances.

Nevertheless, in some instances, people's opinions vary continuously from one side to the other instead of there being just two extremes. For example, individuals' evaluation of a new product might gradually change over time as they learn more about it, and it should not be restricted to mere approval or disapproval. Therefore, the bounded confidence model [17–19] by adopting continuous opinions was proposed, where an uncertainty or tolerance value, ε, was introduced, and the distinction of opinion between a person and his neighbors that is less than ε can give influence to each other. Notably, once the opinions are initially set up, the range of opinions is limited to a certain extent.

In addition, Martins [20,21] designed another type of model known as the Continuous Opinions and Discrete Actions (CODA) model, which combined the main ideas from the above two types of models. In the CODA model, the continuous opinion is an inner opinion, which expresses the degree for an agent to make a certain choice. The discrete action is an outcome when the inner opinion is greater than a particular value. Based on these discrete actions of the agent's neighbors, the agent updates his/her inner opinion and external action. Naturally, the CODA model is more suitable for application to understand certain phenomena in daily life [22].

Meanwhile, another group of scholars has begun to apply the model in the real world. Sznajd-Weron uses a two-dimensional Ising spin model to describe the mechanism of advertising in a duopoly market [23] and presents the financial application of the Sznajd model [24]. Bernardes and Stauffer give election results by applying the Sznajd rule [25,26]. Kun and Kocsis introduce an agent-based model for the spreading of technological developments in socio-economic systems [27]. Bouzdine-Chameeva and Galam apply the Galam sequential probabilistic model of opinion dynamics (GSPMOD) into word-of-mouth application to a wine market [28]. A lattice model is proposed by Lin to investigate the dynamics of human innovative behaviors combined with the evolutionary game [29].

In this paper, we focus on the opinion dynamics in a specific practical field: advertising. With the rapid development of the commodity economy and the diversification of mass media, advertisements have become more ubiquitous than ever [30]. No matter whether people like it or not, nobody can avoid its influences. Therefore, we want to figure out how individual opinion is affected by advertising. The goal of merchants is to create successful advertising. Thus, further research is needed to determine what impact advertising will have on opinion dynamics. When a new product is first launched, people have no opinion about it. Then, as a result of the advertising propaganda and the actions of their friends, people start to form an opinion on it. As the opinion accumulates to a certain extent, people will appear to favor it and buy it.

Considering the above reasoning, we propose a new model within the field of sociophysics to study the evolution of an opinion and action as they are affected by advertising based on the CODA model. Meanwhile, another influential factor that should be considered in our model is forgetting. It is reasonable to assume that people's opinion about a product will decline when they are not affected by advertising or friends. We use the forgetting curve proposed by the famous psychologist Hermann Ebbinghaus [31] to describe the decline of opinion.

The remainder of the paper is organized as follows. In the next section, the model is presented, and we consider the changing influence of friends and the decline of memory. In the third section, various results from numerical simulations are acquired in which we adopt the unstructured network. Finally, we draw various conclusions and note the directions for further studies.

2. Model

To explore the basic rules of how human opinion is affected by advertising, we focus specifically on three main aspects: advertising's influence on individuals (A_i) [32], friends' influence on individuals (F_i) [33], and memory decline [31]. According to Nielsen's latest report, *Global Trust in Advertising and Brand Messages* [34], and practical experience, word-of-mouth recommendations from friends, which are often referred to as "earned advertising", are the most influential factor. Therefore, the friend's influence (F_i) should be greater than advertising's influence on individuals (A_i). To investigate the relation between the influence from friends and the number of friends, we borrowed the effect of diminishing marginal returns [35] from economics and applied it to our model. Hence, it is reasonable to assume that the influence of having one additional friend will be diminished as the number of friends increases.

The continuous variable p_i is used to represent the inner opinion of agent i in regards to a product or service. We use a discrete field, σ_i, to describe the actions of agent i. If agent i adopts the product or service, then $\sigma_i = +1$. In this case, agent i will have a positive effect on his/her neighbors. If agent i does not adopt the product or service, then $\sigma_i = 0$, and agent