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Statistical physics of media processes: Mediaphysics

Dmitri V. Kuznetsov[a,*,1], Igor Mandel[b]

[a]Media Planning Group, Boston, MA, USA
[b]Media Planning Group, New York, NY, USA

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Abstract

The processes of mass communications in complicated social or sociobiological systems such as marketing, economics, politics, animal populations, etc. as a subject for the special scientific subbranch—"mediaphysics"—are considered in its relation with sociophysics. A new statistical physics approach to analyze these phenomena is proposed. A keystone of the approach is an analysis of population distribution between two or many alternatives: brands, political affiliations, or opinions. Relative distances between a state of a "person's mind" and the alternatives are measures of propensity to buy (to affiliate, or to have a certain opinion). The distribution of population by those relative distances is time dependent and affected by external (economic, social, marketing, natural) and internal (influential propagation of opinions, "word of mouth", etc.) factors, considered as fields. Specifically, the interaction and opinion-influence field can be generalized to incorporate important elements of Ising-spin-based sociophysical models and kinetic-equation ones. The distributions were described by a Schrödinger-type equation in terms of Green's functions. The developed approach has been applied to a real mass-media efficiency problem for a large company and generally demonstrated very good results despite low initial correlations of factors and the target variable.

Keywords: Sociophysics; Communications; Word of mouth; Opinion propagation; Influence; Mass media

1. Introduction

Processes of mass communications take place practically in all social and sociobiological systems [1,2]. In "real life" the mass communications are driving forces for many phenomena in marketing, economics, and politics. Traditionally, these phenomena are described by statistical approaches without a deep understanding and involving of the driving forces. The object of the present paper is a methodology of application of *statistical physics* to the complicated processes of mass communications. We called this kind of applications "mediaphysics", which is a part of sociophysics, studying processes of mass communications in social and sociobiological systems.

*Corresponding author.
E-mail addresses: dmitrikuznetsov@yahoo.com (D.V. Kuznetsov), igor.mandel@yahoo.com (I. Mandel).
[1]Affiliated member of Institute of Biochemical Physics, Russian Academy of Sciences.

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To make it clear, let us consider two data sets that are typical for statistics: (a) 20 weekly observations of J. Smith's Coca Cola purchases, and (b) 20 weekly observations of Coca Cola sales in the USA. Traditional statistics will treat those sets identically. However, they are qualitatively different. In case (a) the level of purchase is explained by individual behavior of J. Smith, his habits, income, etc. In case (b) the same explanation is applied too (all individuals, buying soda in the USA, have motivations, similar to J. Smith's one); but on the top of that, there is a structure of these individuals by their distribution in readiness and willingness to buy soda in general and Coca Cola specifically. Effects of advertising activities, economic factors and opinion exchange (word of mouth) depend on this distribution. The distribution is changing over time and that is something very important which does not exist in case (a). The observed sales value for the USA is in fact a result of millions of individual actions, which appear mostly in an unobserved form. The observations (sales, etc.) are just the tip of the iceberg.

Therefore, apart from its own subject, the mediaphysics can be characterized by the fact that it has to operate with *real-life data of certain types* that are untypical for traditional statistics and usual for statistical physics. Traditionally, social and biological sciences used statistics (not statistical physics) to describe the above-mentioned phenomena (a) and (b), ignoring the deep differences between two data types, while using just the observed ones. We propose to analyze systems like (b) using developed techniques of statistical physics. It is an appropriate tool due to the deep similarities between behaviors of particles or molecules en masse (typical unobserved units), and processes described above. Indeed, using traditional-statistical physics we can analyze the observed values of gas pressure and temperature without a detailed information about each particle, but knowing their distribution, responses to different fields and interaction with each other.

The placement of mediaphysics into sociophysical realm [3–5] needs some comments. Since it is related with disputable questions on history and terminology of the crossroads of sociology, economy, statistics, mathematics and theoretical physics, but does not directly touch the subject matter of this paper, we put our historical and terminological views and comments into Appendix. Here let us just say that the introduced mediaphysics overlaps with sociophysics and statistics, but focuses on communications and thus belongs to the sociophysics field inside its universal and broad definitions (see Appendix). The mediaphysics orients to real-life data, which currently is not typical for sociophysics simulations. It deals with both observed and unobserved data unlike traditional-statistical approaches. Plus, mediaphysics is associated with two meanings of the term "media", both of which are relevant to the approach: media as an environment in which mass processes of communications are taking place; and in a form of "mass-media", as an advertising (or other messages) spreading through mass-communication channels, which itself is a very important topic.

The article is organized as follows. Section 2 contains a discussion of the problem and defines new terms (it introduces important concepts used thereafter, especially one of mindset's space and motion in there); in Section 3 we describe the main formalism, based on Green's functions and Schrödinger-type equation; Section 4 demonstrates how this approach is related with two important modern statistical techniques; then in Section 5 we discuss model implementation to the real data; and Section 6 presents conclusion remarks.

2. Distributions in a space of persons' mindsets

In the modern world people are subjected to hundreds of activities intended to attract customers, voters, or followers. It creates a strong competitive environment and can be, roughly but quite reasonably, demonstrated in terms of a competitive fishing [6].

To formalize this environment, we introduced personal mindsets and their distributions for a human population in a space between two (Fig. 1) or many choices/brands (Fig. 2). In this space a specific mindset has the corresponding coordinates of its location in such a way that distances between the mindset position and the available choices/brands are relative measures of "willingness to buy" each brand (or "propensity to join or believe"). Changes in a personal mindset (stimulated by many factors including advertising activities and word of mouth) are reflected in the mindset motion between choices. Thus, in Figs. 1 and 2 the motion is presented by mindset positions for time $t = 0, 1, \ldots, 8$.

This motion is the Markovian process, which for an isolated person without motivations (no advertising, no opinion exchange, etc.) is a random walk that can be characterized by the next-step root-mean-square displacement a. We called the value a as a measure of personal "*flexagility*". This coined term reflects causes of