Human societies, with their social interactions between individuals and organising structures, are examples of dynamic complex systems for the properties of which the network approach and mathematical modeling have turned out to be crucial in understanding their behaviour and how they change with time.

One of the interesting phenomena in a society – describable as a social network – is the process of opinion formation among people. Previously we have developed a model for opinion formation based on co-evolving social networks: the degree of agreeing with a single issue changes the structure of the network and vice versa. However, these two mechanisms evolve with different time scales. Opinion changes on a fast time scale (transactions) while the network exchange links with a slow time scale (generations). The dynamics of transactions are based on two main processes: one-to-one interactions, and an attitude parameter describing the personal reaction to the overall opinion (1). The rewiring mechanisms to obtain new acquaintances are taken from network sociology studies, and are basically of two types: focal closure, if one prefers to link to agents with the same attributes, or more commonly, a triadic closure, which means that one is more likely to make new friends from the friends of your friend.

We have extended this model to study the spread of scientific information among people under the influence of public science communication, such that during the process people may adopt it as truth, or reject it. The key ingredient is to consider the information available to all individuals as an external field, an external action that can influence individual decision-making processes (2). A good example of this situation is how much scientific and technological knowledge determines the public engagement with polemic issues that affect society.

Public Science Communication

Scientific literacy is not the only parameter involved in forming opinions. The attitudes of individuals depend on their cultural, educational, and environmental differences. In order to understand the public perception of science and technology many science communication models have been built (3), but there is still controversy between the so-called “scientific literacy model”, which assumes that knowledge increases the public acceptance of scientific research, and the “contextualist” approach, where social values and attitudes are also relevant.
A remark should also be made on cognitive models (4). Many of these are based on the cognitive miser model, where citizens are supposed to collect only as much information about the topic as they think is necessary to reach an opinion (4). Often the news, reported in different media, is the main component for the opinion formation process. There is also a deeper cognitive process that requires that the individual can overcome epistemological obstacles (5).

The goal of this contribution is to present a mathematical model where each citizen has a personal opinion that is related not only to his or her scientific knowledge but also to the cultural background and that is likely to change through one-to-one interactions. There is also an attitude parameter where the influence of friends, relatives and colleagues are included. Finally, there is also an external influence mostly due to the media.

Modeling social networks

All the details of our model can be found in reference 2. Here we are only presenting the main results that we think could be useful for the science communication community. In the model each agent has a continuous bounded state variable that quantifies the conviction of a fact. When it becomes +1 we consider it as expert knowledge while -1 means a fundamentalist opinion against a scientific fact, as it could be for instance against Darwin’s theory of evolution. When the parameter has a value around zero, we are dealing with ignorance. When an agent reaches +1 or –1 it stops changing links within the network. We find that agents stubbornly opposing scientific facts form tightly connected communities, which are not completely isolated because there are ignorant agents who bridge different groups of society. This suggests that scientifically sound concepts are more difficult to acquire because opposing individuals are very well organised. We have also observed that there is a critical value beyond which the dynamics slows down and a complete agreement in the social network is not reached.

We have compared the results of our model study to actual data on scientific perception surveys carried out in two different populations, from Europe (Eu) and from Mexico (Mx) (7) in order to analyse their peculiarities. Although the Mexican survey follows the methodology of the Eu survey, the multiple-choice answers are different. In the Mx survey the answers are: totally agree, tend to agree, tend to disagree, totally disagree and do not know, while in the Eu survey there is an extra possibility: neither agree nor disagree. We excluded the do not know and neither agree nor disagree and normalised the agreement and disagreement percentages, n+ and n-.

Then we selected 15 equivalent statements and use our judgement to order them from fallacies to obvious facts. They do not follow the same pattern of percentage of agreement because, as expected, there are cultural differences in specific questions. However, in questions only related to scientific knowledge the results are quite similar due to similar human cognitive processes and the globalised information we all have access to. For each survey we have used their resulting agreement fractions in science-related questions to adjust them to our external parameter. We could infer that a more sceptical society has a symmetrical response in the limits of strong positive and negative influences and favours divided positions under weak external influence.

A comparison between model results and a real opinion formation is beyond the possibilities of this model but it is an interesting task for the future. We have also shown that current
surveys are not enough for probing the intertwined relationship between social communities and opinion, but only measure the averaged results emanating from the social dynamics. We suggest that these surveys could be greatly improved by integrating data over time and keeping track of the details of the network topology.

References


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