Developing a Multi-Agent System to simulate shifts from indifferent and ambivalent to polarized opinions for the case of nuclear waste in Switzerland

Roman Seidl

1 Public response to contested issue

It is difficult to anticipate the public’s opinion and voting behavior especially regarding a contested and value-laden issue. However, from a policy planning perspective it may be highly relevant to know more about likely opinion shifts during public discourses. Available general theoretical considerations on how people form and exchange their opinions do not help much in specific cases since it is largely unknown how people form opinions exactly about these specific issues and how from these micro opinions a macro (= public) opinion emerges and how this in turn influences the individual one. That is, how do people develop their opinion – especially in response to media communications and influence from their social networks – to finally decide if and how to decide in a public vote. Additionally, which dimensions, that is especially: which positive and negative aspects, are relevant to constitute an opinion and where are likely attractors for this opinion (Eiser, 1994)? We are interested in specific cases of contested discourses of siting infrastructure, where polarized opinions exist, and some people are extremely involved. Therefore, particularly within this field the design of the participatory process and communication are crucial for acceptance. Individuals with rather pronounced opinions could become ambivalent about the issue at hand for instance because of discussions in heterogeneous groups (Huckfeldt, Johnson & Sprague, 2004). Ambivalent or indifferent individuals in contrast could converge to a certain polarized opinion.

In the proposed project we investigate the formation and development of opinions about a planned repository for radioactive waste in Switzerland that is highly contested. Yet, an intense and long-term participatory process for selecting the respective sites is ongoing, planned by the Swiss department of Energy (SFOE, 2008). One of our aims, therefore, is to explore which potential effects the planned steps but also other external events such as catastrophes and respective media coverage might have on the opinions.

2 Research goals and methods

We investigate the emergence from individual to public opinion which is beyond the scope of opinion surveys (Page & Shapiro, 1992; Price, 1992). We aim at gaining knowledge about how opinions about a radioactive waste repository are formed and updated and we want to understand the development of opinions over time. This will also be addressed by empirical investigations using specifically designed interviews and questionnaires. One possible way is to use two dimensions, thus splitting opinion into a positive and a negative aspect (for an overview see Thompson, Zanna & Griffin, 1995).

1 Roman Seidl (email: roman.seidl@env.ethz.ch), ETH Zürich, Institute for Environmental Decisions (IED) Universitätsstrasse 22; CH-8092 Zürich, Switzerland
We explicitly address a list of positive and negative aspects and let participants weight the importance of each item. This approach permits addressing opinion strength and differentiating potential kinds of ambivalence and indifference (see Table 1). The mean values for benefit and risk ratings respectively per participant can serve as initial values for the agent profile (Table 2).

Table 1: Example of addressing positive and negative aspects of a DGR to investigate ambivalent opinions about a topic in a questionnaire.

We explicitly address a list of positive and negative aspects and let participants weight the importance of each item. This approach permits addressing opinion strength and differentiating potential kinds of ambivalence and indifference (see Table 1). The mean values for benefit and risk ratings respectively per participant can serve as initial values for the agent profile (Table 2).

Table 2: The parameters and variables of the agents’ profile in the model. This list will be changed and/or updated by new survey data.

The changing and updating of an opinion during an interaction with other actors is a crucial question which is not easy to illuminate empirically. We aim at addressing the process of dynamic opinion formation and the occurrence of tipping points by conducting semi-standardized interviews. The interview script includes questions to address the exchange habits and important factors regarding opinion formation about the nuclear waste repository, for instance, the expert status of significant others. Additionally, it would be interesting to get information about the recalled development of the individual perception of risk and benefit aspects. We plan to assess this by using an adapted analog scale (see Figure 1). Participants should indicate their current perception of the risk and benefit dimensions as well as remembered past and prospective possible future developments. If changes have occurred, we will ask for the reasons, as it is important to know about the influence of exogenous sources.

A further goal is to clarify how tipping points in the simulation can be identified and defined for ambivalent/indifferent individuals to switch to polarized opinions (and vice versa). Additionally we are interested in showing the mutual influence of individual opinion development and emerging patterns at the macro level. Modeling these dynamics with agent-based approaches such as multi-agent systems (MAS) appears natural and encouraging applications in that field have emerged, for example regarding public political opinions and voting decisions (DEFFUANT, 2006; EARNEST & CORK, 2005; KOTTONAU & PAHL-WOSTL, 2004; NOWAK, SZAMREJ & LATANE, 1990). In the case of opinion dynamics, a basic result is the convergence of opinions among a population of agents to a consensus; however, heterogeneous patterns are possible (e.g. by polarization effects, HUCKFELDT et al., 2004). Among the existing models, JAGER and AMBLARD’s (2005) and HUET, DEFFUANT and JAGER’s (2008) approaches seem particularly fitting to our purpose and they are based on a sound social-psychological theory: Social Judgment Theory (SJT) (SHERIF & HOVLAND, 1961).
3 Preliminary model and outlook

Starting from the mentioned approach, we develop an MAS with agents representing interacting individuals who carry idiosyncratic profiles (see Table 2 and conceptual model in Figure 2). In a first version of the model we concentrate on two opinion dimensions research has identified as key variables (risk and benefit)\(^2\) (SEIDL, MOSER, KRÜTLI & STAUFFACHER, 2011; SIEGRIST, 2000). Empirical results of a representative Swiss questionnaire study (STAUFFACHER, KRÜTLI & SCHOLZ, 2008) serve as initialization values for these two variables (random normal distribution according to the mean and standard deviation; standardized to values between 0 and 1). The respective values for risks and benefits constitute the overall opinion \((\text{opinion} = \text{benefit} – \text{risk})\). Additionally, the agents have values for expertise (representing the involvement of agents) and social reputation (represented by the number of edges) to be able to check if other agents are suitable for interaction. We briefly illustrate the concept referring to the flow-chart in Figure 3 (a more detailed description using formalized language is available).

We use dyadic interactions, that is, an agent in each time step interacts with one other agent from its social network (no rewiring). First, the agent assesses if the agent to interact with is suitable at all for any exchange about the topic. Therefore, the other agent’s \(o\) values for social reputation \(SR_o\) and involvement \(I_o\) are compared to the own \(i\) ones \((SR_i\) and \(I_i\). Is the other agent more reputable and/or more involved (has a higher expert status)? Then: influence is possible. Otherwise: no influence is possible. In the next time step another agent from the network is chosen. In case the agent is suitable, the second step checks for the benefit and risk values: are the values for risk and benefit comparably high/low? We refer to HUET et al. (2008) who also use two dimensions (in their case two opinions). According to this approach similarity/dissimilarity of the opinion dimensions is measured with a threshold value \(U\), in HUET et al.’s model (2008) called “uncertainty”, which also serves as latitude of acceptance sensu SJT. Moreover, \(U\) defines the level of ego involvement \(I\). According to SJT theory, the smaller the latitude of acceptance, the more ego-involved a person is. In context of our approach: an agent with higher ego involvement is less uncertain about its opinion. A proxy to involvement is the empirical measure of importance by the survey (see Table 1). We have to consider three cases: (1) the values for both dimensions are below the acceptance threshold (then the own values are adapted); (2)

---

\(^2\) Here and in the remainder of the article we understand risk as denoting the negative and benefit as the positive aspects of a risk situation.
both dimensions range above acceptance threshold (too different – no adaptation happens); (3) different values on only one dimension above threshold (then it depends on how different the values actually are).

The final conceptual model depends on the empirical results of the planned interview study. Some issues we simply do not know yet, and their underlying structure and functions can only be assumed.

Figure 2: Conceptual model for one agent (left), illustrating additionally the connection to its social network (right). The continuous thick arrows indicate influence by another agent from the social network (comparing each value benefits and risks). The dashed lines denote the emergence of and feedback from collective influence (Media Coverage and Collective Mood). External Events are exogenous to the model’s dynamics but are captured by a scenario and fed into the simulation exogenously. The variables owned by each agent are listed in the table including respective value range and short description.

We currently work with a prototype of the model using NetLogo 5.0 (access by the link http://www.uns.ethz.ch/people/staff/seidiro/RADW_model.nlogo). The model reproduces opinion uniformity and pluriformity (considering the two dimensions risk and benefit) depending on the chosen tolerance level. We further plan to consider the social environment of each agent in an explicit way as emerging from individual opinions and being perceived by an individual as a collective opinion. This includes not only a belief about what other individuals in one’s personal network think but also comprises information received through media coverage. We therefore conceptualize the collective mood with a combination of the aggregate opinion of all individuals in a personal network and media influence (see Figure 2).
4 References


