Modelling the Dynamics of Public Attention towards Environmental Issues

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Abstract: Public attention, traced over time, often displays seemingly paradox behaviour: Contrary to what one might expect, public concern is seldom highest when the environmental conditions are the worst. Rather, concern most often rises when conditions have already become better. Furthermore, public attention dynamics frequently shows self-reinforcing behaviour resulting in distinct cycles, e.g. due to some trigger event. In this paper, public attention is viewed as a social macro-level phenomenon that is sought to be explained by the interaction of a multitude of single actors, namely individual citizens, the press, and politicians. First, a causal model based on rational choice theory is constructed in order to elucidate the mechanisms according to which public attention dynamics develop and to address the question of when and why public attention rises and falls. Key variables include the acuteness and visibility of the issue at stake as well as the ability to "solve" the underlying problem. Self-amplifying behaviour of agent interaction on different time scales adds to the complexity of the model. In a second step, an agent-based computer model is constructed from the conceptual rational choice model. It allows to reproduce the basic features of typical issue-attention cycles such as those analysed in empirical case studies. The model elucidates the causal mechanism and clearly displays the emergent structure, i.e. the typical, complex patterns of attention cycles. It thus serves to test and validate the conceptual model. In addition, it allows to incorporate additional conceptual refinements such as simultaneously tracking attention towards multiple issues. However, further research is needed to elucidate the mechanism(s) according to which public attention declines.

***Keywords**:* Agent-based modelling; rational choice, issue-attention, media coverage, public attention

1. INTRODUCTION

Different environmental problems receive different and varying degrees of public attention. Some issues are high on the public agenda when environmental conditions are most severe, while others start to be of high public concern only when the problem has already been halfway solved. Certain issues display both characteristics. Summer smog, for instance, is an issue that becomes "popular" each summer season when air concentrations of tropospherical ozone become high due to solar radiation. On a long-term track, however, quite a different picture could be observed (cf. figure 1): In the 1990s, when the issue of summer smog first entered the public arena and year by year became more important, ozone peak values had already begun to gradually decrease due to fewer emissions of ozone precursors by industry and transportation. What is more, public attention dynamics frequently shows self-reinforcing behaviour resulting in distinctive patterns. Thus, some issues might suddenly come up, often due to some trigger event, rise sharply – no longer in relation to the actual development of the environmental conditions –, and wane from the public agenda as quickly as they appeared.

Public attention being of chief relevance for political decision-making (cf. Mahon and Waddock 1992: 22), much research – albeit rather selective – has been conducted and many a theory has been put forward to describe and explain dynamics of public attention.

In this paper, a conceptual model based on previous research by the author will be presented, tested against empirical data and then implemented in the form of an agent-based computer model in order to verify the causal model and compare the model output with empirical data and thus test it on plau-

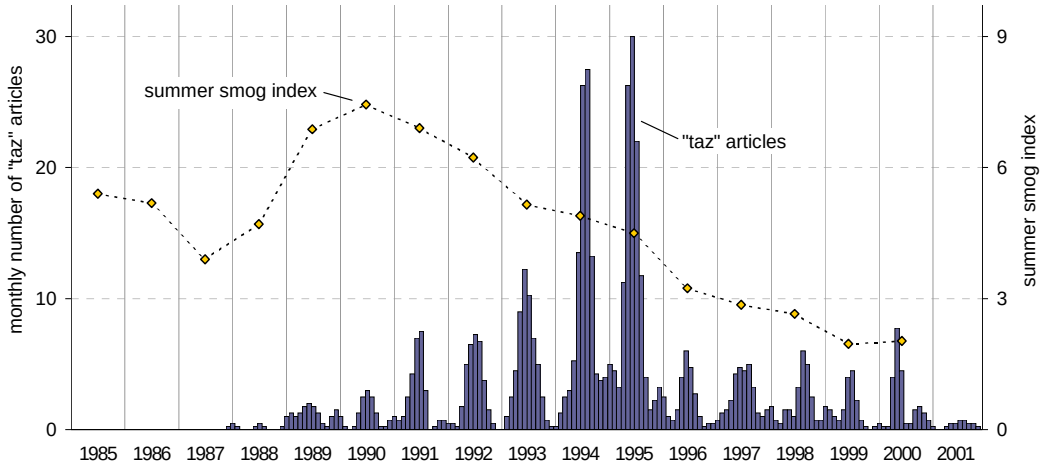

Figure 1: Public attention towards the "summer smog" issue, measured by monthly numbers of press articles[1], and an annual summer smog index. For both time series, 3-period centred moving averages have been used to even out random fluctuations.

sibility and to gain further insights into the proposed mechanisms. Central research questions to be tackled are: (1) When and why does public attention towards environmental issues rise and fall? (2) By what causal mechanism(s) can the dynamics of public attention be modelled?

2. CONCEPTS AND TERMINOLOGY

In order to avoid confusion with differing results in the literature, the fundamental concepts of "attention", "public", and "issue" shall be briefly discussed.

Attention denotes the resources (time and other) that people dedicate towards an issue and often signifies considerable political pressure. Regarded over time, attention can be conceived as an intensity (resource employment per time unit). Attention is also a scarce resource many issues are competing for (cf. Hilgartner and Bosk 1988; Zhu 1992). In contrast, "attitude" is commonly defined as "a learned predisposition to respond in a consistently favorable or unfavorable manner with respect to a given subject" (Fishbein and Ajzen 1975: 5), "opinion" denoting a verbalized attitude (cf. Zimbardo, Ebbesen and Maslach 1977: 20). Both do not necessarily involve resources.

In our model, we distinguish *public* from political, where the first refers to citizens (as potential voters), special-interest groups and the mass media, whereas the latter refers chiefly refers to politicians, parties and governmental officers. Furthermore, public attention as a sociological construct certainly involves an element of communication. If a multitude of private individuals devoted their attention towards an issue but there was no communication about it, this would not be public attention.

In today's democracies, public attention, as we conjecture, tends to form around *issues.* They focus on relatively small-scale problems like summer smog, BSE, ozone depletion, waste incineration and so forth that are sufficiently distinct to still be publicly perceived as units (cf. Dunlap and Jones 2002: 485–486). This is no longer the case with extensive problem areas such as air pollution or waste management, which merely serve as *categories* comprising and thereby classifying the multitude of different issues.

3. CONCEPTUAL MODEL

3.1 Theoretical assumptions

Some authors have sought to model public attention dynamics in a purely statistical manner by correlating aggregate measures of public attention with external variables or by regression analysis of attention time series (Henry and Gordon 2001; Soroka 2002). The disadvantage is that explanations remain on the aggregate level. Here, we opt for a different approach. Starting from individual actors, we seek to model the emergent phenomenon of public attention by the interaction of multiple individual actions. More abstractly speaking, our aim is to explain the social macro-level phenomenon by social micro-level processes (cf. Coleman 1990: 13–18). We base our theoretical model on the following general assumptions:

- Methodological individualism, i.e. actors (individual or collective) are the basic elements of analysis (not social systems).

[1] The German left-wing newspaper "taz" has been selected for good and early availability of electronic data. Although not representative in terms of its political content and audience, the "taz" follows basically the same attention cycles as all German newspapers (cf. Newig 2003).

- utility/interest-maximization under conditions of limited resources and cognitive capacity ("bounded rationality", cf. Simon 1972).

In order to keep our theory as simple as possible (and thus attain a high degree of generality, applicability and relevance), we distinguish only two different types of relevant actors whose interests and preferences, resources and restrictions will be portrayed in the following. In an earlier version of the conceptual model, we included four different types, adding politicians and interest groups to the ones presented here (cf. Newig forthcoming). For the sake of simplicity, we left out all interactions with political action in this first version of the computer model.

Citizens are generally interested in maintaining or improving the environmental conditions which affect them. As rational individuals, they dedicate their time and attention preferably towards those issues which they have an interest in. At the same time, however, citizens try to minimize the costs – monetary as well as cognitive – involved in finding out about how different political actors will deal with a specific environmental issue, which often requires understanding the environmental problem and the effect of proposed measures. Avoiding these (mental) costs, most citizens remain "rationally ignorant" (Downs 1957) towards most issues.

The *mass media*, considered as media enterprises free of any outward political influence, seek to maximize print runs or viewer levels. Therefore, they tend to cover the issues they believe the audience is interested in or concerned with. The publisher will discover whether or not a newspaper, for example, meets the expectations of its readers by monitoring print runs ("voting at the kiosk") and letters to the editor. Following this economic rationale, the mass media in our theory do not pursue any genuine *political* interests in the issue at stake.

3.2 Central causal mechanisms[2]

Possibly the most simple approach to issue-attention regarding environmental problems is the *problem-reaction model* employed in political science (cf. v. Prittwitz 1990: 103). According to this, public attention directly depends on the severity of the environmental condition (cf. figure 2): The higher the costs caused by the environmental problem (in terms of shortcomings in health or quality of life, or of the costs required to rectify these), the greater the stakeholders' discontent with the situation (cf. Opp 1996: 361–363, 368) and their interest in embarking on measures to improve the deficient situation and thus the greater the attention of all stakeholders towards the issue. This approach may be particularly applicable for threatening catastrophic events that are directly perceptible by the broad public and consequently lead to an immediate response in public attention. It particularly applies to environmental problems that have a direct effect on human health.

By contrast, the *capacity model* derived from social psychology tries to ascribe public attention to existing capacities for action, i.e. to resources for solving the problem at stake. The basic proposition is that deteriorations in environmental conditions remain unperceived unless they are or become technically solvable at economically viable costs. This is explained by the theory of cognitive dissonance (Festinger 1957). Accordingly, people generally strive to even out discrepancies between different perceptions – i.e. cognitive dissonances – or do not permit them to enter conscious reasoning in the first place (v. Prittwitz 1990). Environmental conditions that are significantly worse than the level of aspiration may constitute such discrepancies. Depending on the available resources, they can be resolved in different manners: When adequate resources to deal effectively with the problem are lacking, the aspirational level may be adjusted, or information regarding the actual state of the problem may be ignored or believed to be untrue in order to avoid cognitive dissonance and psychological stress. If, on the other hand, sufficient options for action are perceived, then actors will seek to implement measures to improve environmental quality, thus contributing to a rising public attention (cf. Opp 1996: 363).

In addition to these static mechanisms (both models hold independently of the temporal, historical development), public attention dynamics generally involves processes of self-organization as well (cf. Downs 1972: 38).

A completely new issue will at the beginning have difficulty to rise in public attention – even when the environmental conditions are quite severe and problem-solving resources are at hand –, because the mental costs of understanding the issue are often quite high, and the time needed to pay attention to an issue is scarce (cf. Zhu 1992; Neumann 1990). Every individual (or collective) actor can only receive a limited amount of information per time unit. In order to receive public attention, an environmental problem issue must be publicly perceptible and/or sufficiently simple to comprehend (visibility of the problem). Those already aware of the problem must both be willing and able to spread their knowledge and insight about the subject. In modelling issue-attention, this "stage" is the most sensitive. It is difficult to predict if and when the "critical mass" of theme-promoters is reached; "random" factors may be essential in determining whether or not and when an issue-

[2] For a detailed empirical test of basic model propositions cf. Newig forthcoming.

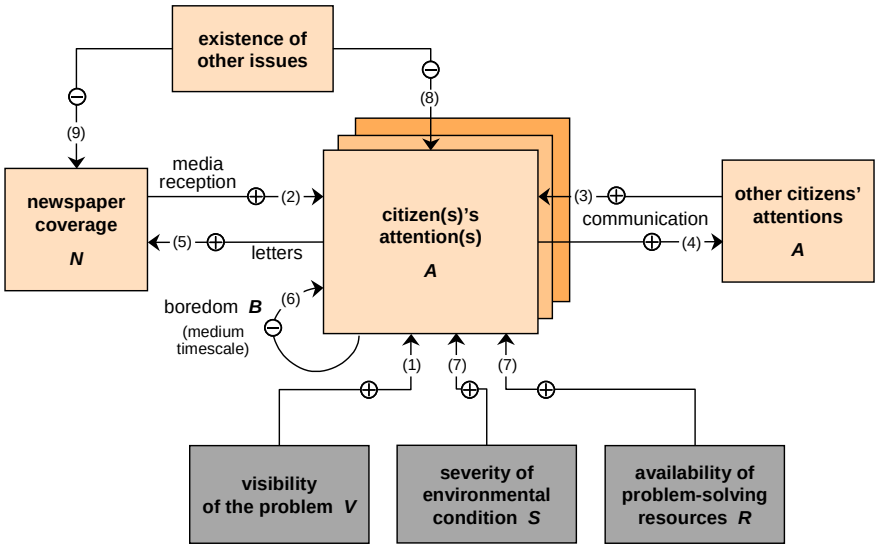

Figure 2: Elements of the causal model. Plus signs indicate positive, minus signs indicate negative feed-back. Numbers in brackets refer to the equations governing the computer model.

attention cycle is triggered. In such a non-linear dynamic system, small changes in initial conditions may lead to great changes in the resulting trend.

Once a critical mass is reached, the issue becomes a "fast-selling item" and attention towards it grows in an exponential manner, involving both interpersonal and mass media communication: The more individuals dedicate their attention to the issue and discuss it with others, the more individuals will be informed and possibly feel concerned about it. Thus, information costs decrease as more and more information becomes readily available, so it becomes rational for individuals to devote their attention to this issue rather than to others. An important factor in amplifying public attention are the mass media who – as rational agents – take up those issues they anticipate people to be interested in and in turn facilitate communication and information about the issue. The media thus act as *catalysts:* they increase the speed of news dissemination, but do not lead the discussion down a particular road[3]. Mathematically, this mechanism of self-amplification could be modelled in terms of diffusion theory (cf. Krampe 1989; Rogers 1995; Dearing and Rogers 1996).

Regarding the further "fate" of the issue-attention cycle, two different mechanisms exist: One is the "zero-sum game" of public attention (cf. Zhu 1992). Hence, when other issues gain in public attention, one issue may decrease simply due to increasing competition. The other, more important, mechanism acknowledges the fact that citizens get "fed up" and "bored" with an issue after having spent much attention on it for a long period of time (cf. Neumann 1990): Marginal benefits decrease, spending further attention on the issue provides less and less new information. This mechanism clearly introduces a negative feedback effect (cf. figure 2) on a medium time scale. The model thus becomes path-dependent, for it depends on the amount of time an issue has already received high public attention, whether it will continue to rise or start to decline. A third possible mechanism may consist in political action being taken (cf. Newig forthcoming) – this task will be left for further improvements of the model.

4. AGENT-BASED COMPUTER MODEL

4.1 Model structure

On the basis of the above considerations a computer model has been implemented in Java, using the social simulation environment Quicksilver[4]. The model represents a community of 20 citizens *c* and a newspaper company interacting with one another on a daily timescale. A number of *n* different issues *i* are modelled simultaneously. Every citizen has a fixed number of friends that are chosen randomly at the beginning of each model run.

For each issue, every citizen has a level of basic interest I_0 that depends on the issue's visibility *V*: Values of I_0 are randomly assigned between 0 and 1 according to a Gaussian distribution with mean *V*

[3] As much research as has been done to clarify whether the media influence the citizens or vice versa, it seems now that both are too closely intertwined to be able to decide on this: "In sum, there is considerable evidence that the direction of causality in the media-public relationship cannot be assumed" (Soroka 2002: 10). This may differ of course, from case to case.

[4] For more information, see http://java4u.sourceforge.net/ and http://www.usf.uos.de/projects/quicksilver/.

and standard deviation 0.1. They influence both the citizens' actual interests in the course of the model run $I_{i,c}$ and a level of tolerance towards the environmental condition regarding the same issue

$$T_{i,c} = 1 - I_{0,i,c} . \quad (1)$$

The citizens' attention, defined on the interval [0,1], is determined in each time step t according to

$$A_{i,c,t+1} = A_{i,c,t} + A_{i,c,t}(\kappa C_{i,c} + \nu N_i - \beta B_{i,c}) I_{i,c} \quad (2)$$

with Greek letters indicating – throughout the paper – model parameters that weight the influencing factors according to their (relative) importance.

$C_{i,c}$ denotes a citizen's intensity of communication about an issue, given by

$$C_{i,c,t} = (\sum_{\tau=1}^{7} \frac{1}{\tau})^{-1} \sum_{\tau=1}^{7} \frac{1}{\tau} F_{i,c,t+1-\tau} \quad (3)$$

with $F_{i,c,t}$ being the number of friends an actor talks to on day t, that depends on the actual $A_{i,c}$:

$$F_{i,c,t} = 0.6\, A_{i,c,t} + 0.4\, random[0..1] . \quad (4)$$

Thus, the attention a citizen devotes to an issue depends on the intensity of communication not only of the present day but also – to a lessening extent – on the communication within the last week.

The intensity of newspaper coverage

$$N_{i,t+1} = N_{i,t} + \lambda N_{i,t} (\sum_{\tau=1}^{7} \frac{1}{\tau})^{-1} \sum_{\tau=1}^{7} \frac{1}{\tau} L_{i,c,t+1-\tau} . \quad (5)$$

depends on the number of letters to the editor $L_{i,c,t}$ within the previous seven days. Whether or not a citizen writes to the editor is depends on whether his/her $A_{i,c,t}$ is greater than a randomly generated number between 0 and 1.

Boredom of an issue

$$B_{i,c,t} = (\sum_{\tau=1}^{365} \frac{1}{\tau})^{-1} \sum_{\tau=1}^{365} \frac{1}{\tau} A_{i,c,t+1-\tau} \quad (6)$$

grows the more attention a citizen has already devoted to it, the "memory" lasting for one year with decreasing intensity.

The interest in an issue, which is initially given by the basic interest I_0, is altered according to the severity of the environmental problem S_i, the availability of problem-solving resources R_i and the individual level of tolerance versus a particular environmental problem T_i:

$$I_{i,c,t+1} = I_{i,c,t} + \sigma(S_{i,t} - T_{i,c}) + \rho\, S_{i,t}\, R_{i,t} . \quad (7)$$

Both A and N are conceived as a "zero-sum" game. I.e., in each time step, after all other actions have been taken, both variables are normalized to the effect that the sums of all $A_{i,c}$ and all N_i, respectively, become equal to 1:

$$A_{i,c} = A_{i,c} (\sum_{j=1}^{n} A_{j,c})^{-1} ; \quad (8)$$

$$N_i = N_i (\sum_{j=1}^{n} N_j)^{-1} . \quad (9)$$

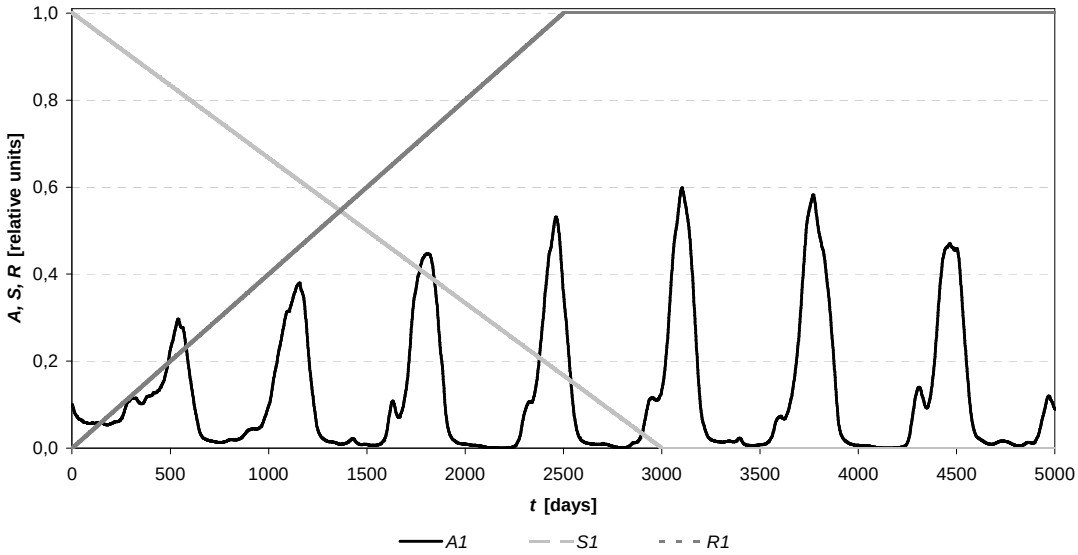

Figure 3: Example of model output for one of five issues, showing mean citizens' attention $\bar{A}_1$, severity S_1 and resources R_1 for this issue. κ = .35; ν = .2; β = .75; λ = .2; σ = .1; ρ = .1. Start values for all citizens' A_i: .1, .15, .15, .35 and .25, and N_i: .05, .1, .2, .4 and .25. V_i are .3 for issues 2 to 5, V_1 = .8. S_i and R_i are constant at .5 for issues 2 to 5.

4.2 Model results and discussion

The computer model being still in the test and validation phase, some preliminary results may already be shown. Figure 3 provides an example of a typical model output where $n = 5$ issues were tracked. It represents a scenario of rising problem-solving resources and a decreasing severity of the environmental situation, as often encountered in reality. The cyclical, yet not completely ordered time series of aggregated public attention[5] reflects well the non-linear, partly self-organising system of actors that is due to the positive feed-back mechanisms among citizens and the press, and the negative feed-back mechanisms of boredom and issue competition. However, public attention seems also susceptible to external variables: Both factors that positively influence attention – i.e., S_1 and R_1, – develop in an antagonistic way, with maximum positive influence expected at the intersection of both curves (cf. equation 7). Interestingly, the model output shows a time lag in the dynamics of the attention peaks, showing the largest attention cycle two to three periods after highest external influence. Only after some time, the lessening external stimulus becomes apparent in the attention dynamics.

5. CONCLUSIONS AND OUTLOOK FOR FURTHER RESEARCH

The proposed agent-based model, although still in its infancy, already reproduces basic features of empirical issue-attention time series, including (1) complex dynamics due to self-organisation of agents and agent communities, (2) the influence of external stimuli, i.e. the severity of the environmental condition and the availability of problem-solving resources, and (3) competition among issues. It thus supports the theoretical basis of the conceptual model.

It should be stressed, however, that the model in its present state of development does not yet allow to reproduce empirical time series of public (media or citizen) attention towards particular issues. Nor may the model parameters be attributed a specific meaning. Rather, it is expected that a further, systematic analysis of the model behaviour will yield relevant information regarding the (relative) importance of the model parameters and thus of the various influencing factors. Only then may the model be validated for specific historical issues. Moreover, an analysis of the actor network may result in deeper insights of the self-amplifying mechanism.

Possible improvements of the model structure will be to enlarge the number of issues in order to dampen the competition effect of each single issue, to allow new issues to appear in the course of a model run, and to refine the "boredom" mechanism which is still poorly understood on a conceptual level.

Thus, further research is needed to empirically test (and perhaps change) specific model assumptions, such as the boredom mechanism, the zero-sum game effect or the way in which external variables effect both media and citizens' attention.

[5] The model output for aggregated citizens' attention and for media coverage is typically very similar.

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