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Modelling social behavior with a socio psychological simulation approach

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Abstract. The research work presented here seeks answers to the following question: What are the conditions that foster widespread, effective inner dynamics that change collective environmental overuse (in thinking and action) to collective, environmentally-responsible thinking and acting?
Our research approaches this question using computer simulation. The simulation is based upon a model that is a highly expanded extension of the rational choice model. The model goes beyond the "economic man" approach to include inner psychological factors, such as motives, values, and attitudes, and it considers social influences on a person's behavior.
To this purpose, we first design a basic model of an individual, which – as 10,000 identically structured copies (equipped, however, with individually different characteristics) – serves as the basis for the simulated influencing and resource-use processes. The model yields information about the inner psychological processes that take place when people use environmental resources. These processes change, in dependency on further internal and external conditions, the ways in which we feel, think, and argue about the environment and the way we act toward the environment. The simulated individuals have at their disposal variously structured social contact nets.
Using simulation, the following research questions are investigated:

– How must a minority of people behaving in an environmentally friendly way be distributed and networked within a population in order that the environmentally unfriendly majority comes to change its attitudes and behavior?
– What types of role models for behavior are required for the population to follow the example of such pioneers?
– How must the social surround be perceived for people to become willing to use an environmental resource sustainably?
– What is the effect of convincing attempts (persuasion) in populations, according to individuals' concern about the environment, knowledge of the environment, and biases?

A highly condensed summary of the results yields the following conclusion: For a collective reorientation in a population towards environmentally sustaining behavior to occur, there must be – with the forms of intervention we have proposed – a sufficient number of active, "convinced" persons who have "close" enough relations with other persons.
The present contribution attempts to show that the old triad of "traditional information campaigns", "legal measures", and "economic measures" can be complemented by additional, novel strategies. These potentially successful forms of intervention should be tested in practical application.

Keywords: Psychological factors, social simulation, social psychology, intervention strategies

1. Introduction

In economically highly developed countries, many of the conditions that would allow people to behave in environmentally responsible ways are already in place. We have a lot of knowledge; for years now, surveys have shown that people give top priority to the need to act on environmental issues. The necessary technical and economical resources are also available. But there is little sign of a real about-face except in limited areas. We believe that the much cited discrepancy between cognition and behavior, between lip service and a person's own contribution to conserving the environment, can be better understood if we also take people's

perceptions of the social surround into consideration.

To view human beings as *homo economicus* [7,15] falls short, because the economic man approach does not take into account explicitly inner psychological factors, such as motives, values, and attitudes, nor does it consider social influences on a person's behavior. The present research conceives a model of behavior that in addition to economic factors includes personal and social factors.

Environmental consciousness is determined to a significant degree by social systems, or that is to say, by people's corresponding social representations. An individual's personal contribution seems insignificant in the face of massive destruction of the environment caused by many. This perception – that there is nothing we can do personally, that each one of us is powerless – as well as a reluctance to be the 'sucker,' are important causal factors in behaviors that overuse environmental resources. It does not seem rational to exercise personal restraint (for example, by not driving), because not only will we suffer from the harm caused by the general public's overuse (the consequences of air pollution), but from a reduction in our own direct return as well (time saved, comfort). However, as this state of affairs applies equally to all individuals in a society overusing environmental resources, people mutually trap each other in patterns of actions that harm the environment. It is fo r this reason that we are particularly interested in examining the psychological conditions that would form the basis of a collective reorientation towards environmentally sustainable behavior. Starting out from new, environmentally friendly behaviors of some "pioneer" individuals, we wish to discover the social psychological conditions that would ensure that the number of persons joining ranks with such pioneers would continue to automatically increase and result in a true, large-scale "turn-around" of previous, environmentally harmful patterns of behavior. The focal question of our research can thus be framed as follows: What are the conditions that foster widespread, effective inner dynamics that change collective environmental overuse (in thinking and action) to collective, environmentally-responsible thinking and acting? Findings generated by this research will lend scientific support to the planning of environmental protection campaigns.

2. Method

2.1. Procedure

If we start from the assumption that environmental problems originate in the overusing behaviors of very many individuals, we need to consider how new solutions might be tested in a problem area of this magnitude. The instrument of the questionnaire, based upon imaginary situations or conditions, seems ill-suited ("How expensive would gasoline have to be for you to change to public transportation?"). Massive field experiments that translate the issue directly in real social systems can also be eliminated: Given our present state of scientific knowledge, such experiments would be both financially and ethically irresponsible. Laboratory experiments, which would not require intervention in existing social systems, can not be carried out with large groups of persons (1000 and more). Computer simulation provides a possible solution. Simulation aims to reconstruct the relevant cause-and-effect relationships in a problem area in the form of a model. With the aid of empirical data, the relati onships can then be validated. In this way, we can test 'experimentally' the most various and unconventional ideas of ways to spread environmentally responsible thinking without incurring the risk of intervention in real social systems.

Our procedure consisted of the following steps:

A. Following a preliminary selection of the most important, empirically well founded theoretical approaches within the field of social influence, the theories' most relevant and significant core statements were – according to content criteria – formulated.
B. In the ensuing modeling, the core statements of the theories were described with the existing variables and set into relation to one another according to certain systems-theoretical rules. For lack of space, we here dispense with a presentation of the systems theory models and their programming/technical implementations (but see Mosler [23] for details).
C. The design of the simulation model was validated through the aid of experts' evaluations and replication of findings from the fields of environmental and social psychology.
D. Experiments with various strategies for the spread of behaviors were then conducted. The following will report on the most important and meaningful experiments.
E. From the findings of the simulations, conclusions were drawn pertinent to both environmental practice and basic research. The most well known forms of intervention stemming from environmental research receive a new interpretation; well-founded recommendations for the field of intervention are derived.

2.2. The model

A great many simulations work from the very start at the level of collective variables (macroanalytic simulation, such as of, for example, the influence of prices on total consumption by the public). However, if we aim to tap into the dynamics of the spread, or dissemination (or non-spread, respectively), of environmentally responsible thinking and behaving, we must first of all begin at the level of individuals. We then allow them to interact with each other within the framework of the simulation (microanalytic aggregative simulation). The difficult task is to model the relevant processes of the individual in this area of conflict on the computer. We assume that humans are in principle beings that are free to make their own decisions, and we hold that a computer program cannot represent the richness of human individuality, as it is primitive in comparison. On the other hand, in many areas we do find empirically well founded uniformities in human behavior. Our way of proceeding springs from the will and hope to develop, from such empirically proven knowledge, a useful working model of the processes taking place within the individual. Usefulness is measured according to whether or not the model can be validated by the behavior of real collectives and in terms of whether the simulation based upon the model widens and furthers our understanding of the dynamics of these processes.

For this reason, we first design a basic model of an individual, which – as 10,000 identically structured copies (equipped, however, with individually different characteristics) – serves as the basis for the simulated influencing and resource-use processes (see Fig. 1).

These persons differ individually only in their values of the variables. They all function according to the same social psychological principles. These principles base on a few central and well-founded essences of theories, which are presented in detail in the presentation of results. The framework model first specifies the input and output variables of the theory-based processing by individuals. The model yields information about the inner psychological processes that take place when people use environmental resources (for example, use the resource of air when they drive or heat their homes) or influence each other mutually, whether deliberately or unintentionally. Inner psychological processes are triggered as people communicate with one another in daily life and observe themselves and others. These processes change, in dependency on further internal and external conditions, the ways in which we feel, think, and argue about the environment and the way we act toward the environment.

These simulated individuals have at their disposal differently structured social contact nets (number of friends, acquaintances, neighbors, and strangers they observe).

In its basic form, the model is an expanded "rational choice" model [6,7]. It bases upon the theory of planned behavior [2] (see the section 'Processes Leading to Behavior' below), but it extends the theory to include

a) a factor called "cost-benefit analysis", to do justice to people's economic considerations
b) a "sustainability" factor [18], in order to include people's thinking on resources (see Fig. 1).

The following section explains the external and internal input variables as well as the inner processes.

2.2.1. External input variables

External input variables are the influences that exert upon a person from the outside and are perceived by the person in some form. Possible distorted perceptions of individuals on the basis of biases are not taken into consideration in this model. For each individual some output variables are calculated that function as external input variables for other persons with whom the individual has contact ('contacts') (see Fig. 1). Also, some non-social input variables, such as specific situational parameters and the momentary state of the resource being used, enter into the calculation of an individual's output value.

Use, contact: A summary of all environmentally-related behaviors shown by a contact. These behaviors towards the environment are conceived as resource-using behaviors. For resource utilization, a particular resource can be entered into the model with its characteristic parameters (resources: for example, water, air, wild game populations; parameters: for example, rate of regeneration).

Attitude, contact: A summary of a contact's opinions and evaluations of environmental issues, objects, and behavior towards the environment, as expressed in most various ways.

Status, contact: This variable represents the sum of a contact's relevant personal resources (for example, social competence, trust, prestige, knowledge, power, possessions, and so on.).

Persuasiveness, contact: The intensity and quality with which a contact makes a case for various attitudes related to the environment. While direction is

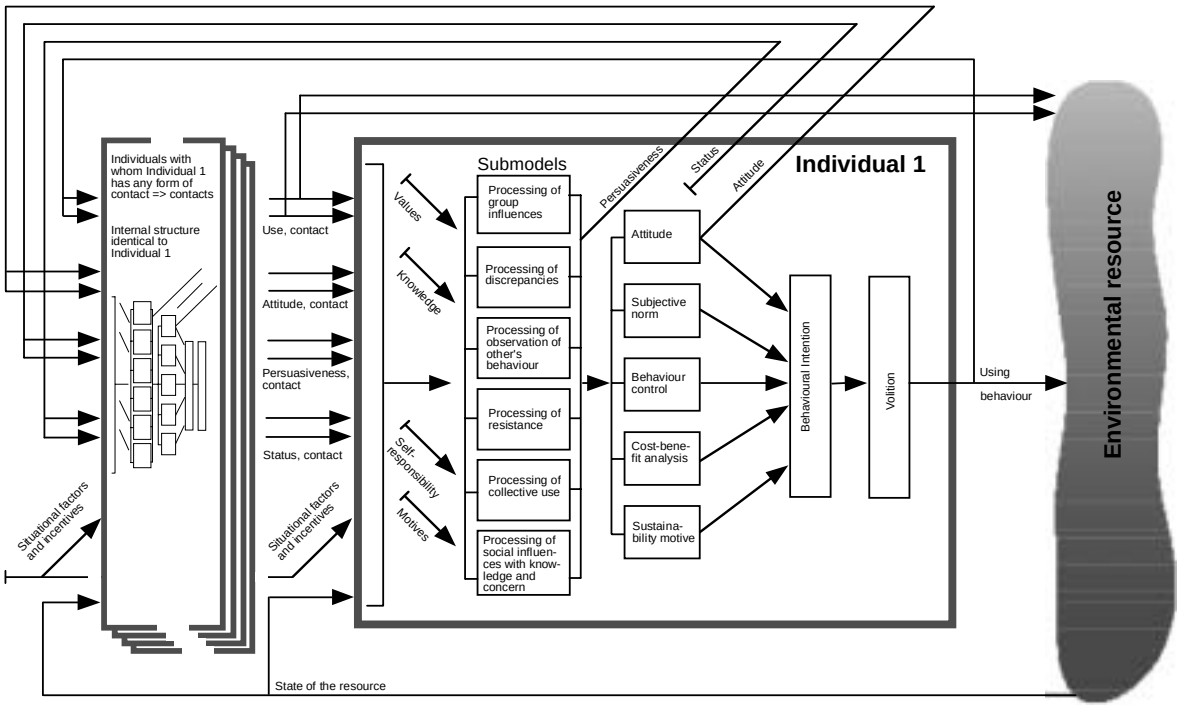

Fig. 1. Framework model of behavior.

given for an attitude (in other words, "for" or "against" environmental protection), persuasiveness indicates the intensity and quality with which these attitudes are presented.

Situational factors and incentives: These include all influences from the societal-institutional surround (rules and prohibitions, positive and negative incentives, and the like). From the entire spectrum of the possible scope of a behavior, situational factors "filter" a partial spectrum.

State of resource: State of the environment, or state of a particular environmental resource, as "noticed" and established by the person.

2.2.2. Internal input variables

Internal input variables have an effect on the simulated psychological processes "from the inside". The emergence of individual degrees of markedness of these variables due to the individual's learning history is not examined in this simulation.

Values: Stable orientation with regard to environmental facts, objects, and behaviors.

Knowledge: Extent and quality of information about the environment, such as knowledge of the regeneration parameters of a specific resource.

Self-responsibility: Describes the extent to which people attribute responsibility to themselves for the state of the environment (as opposed to holding other persons, organizations, or institutions responsible).

Motives: A summary of various motives, such as curiosity and laziness, that enter into a person's readiness to act in certain ways. Dependent upon these motives, an act – independently of its consequences – will be viewed as "easy" or "desirable".

2.2.3. Processing of input variables in the sub-models

External and internal input variables are processed in different sub-models (see Fig. 1) according to the theory being applied. The output values of the sub-models have either a direct outward effect on other persons with whom the individual has contact (attitude, persuasiveness), or they affect processes leading up to behavior and decisions on the use of resources and consequent actions. The following sub-models were designed and simulated (in parentheses is found the relevant section in the text; for lack of space, simulations of sub-models II and IV will not be presented.):

I. (2.1) Processing of group influences upon attitudes towards the environment: application of the theory of Social Comparison Processes.
II. Processing of discrepancy between environmental behavior and environmental attitude: application of Dissonance Theory.

III. (2.2) Processing of observation of others' behavior towards the environment: application of Bandura's Social Learning Theory.
IV. Processing of resistance to environmental protection measures: application of Reactance Theory
V. (2.3) Processing of information on the collective utilization of an environmental resource: application of Commons Dilemma research.
VI. (2.4) Processing of communicative influence in view of the individual's feeling of concerned consternation about the state of the environment, knowledge about the environment, and biases: application of the Elaboration Likelihood Model.

2.2.4. Processes leading to behavior

Processes leading to behavior are direct preliminary steps towards behavior. On the basis of the Theory of Resource Mobilization [18] and of the Theory of Planned Behavior [1,2,13], we start from the assumption that the following five components play an important role in behavioral intentions relating to the environment:

- Attitude towards the environment as the attitude towards environmental protection and individual behavior regarding the environment
- The subjective norm as "perception of pressure from the social surround". This expresses the expectations that confront the individual and the degree to which the individual is willing to fulfil these expectations.
- Behavioral control as the subjective conviction that one can in fact carry out the behavior
- Cost-benefit analysis as a motive for behaviors, which results from weighing the direct costs and direct benefits of actions
- Sustainability as a motive, leading to willingness to restrict personal use of a resource. This readiness depends upon both the absolute value that a person places on an environmental resource and on the current discrepancy between collective, sustainable use and the actual pattern of use shown by others. The higher the subjective value of the environment, or the smaller the discrepancy between actual and sustainable patterns of utilization, the greater the effect of the sustainability motive in the sense of a person's own restraint in use.

As a fundamental extension of the theory of planned behavior [2], we have added an additional factor, cost-benefit analysis. Although the theory of planned behavior does contain a kind of cost-benefit analysis, in that its components are broken down in "expectation x evaluation products", we conceptualize this factor as an independent component. With this we expect to achieve better explanation of the variance for intention, but more importantly, to gain added starting points for intervention measures. Cost-benefit analysis models people's "economic" considerations, as they determine whether it will pay for them to act in certain ways. The model is thus the first to integrate economic and social psychological components (see also [29]).

These components all influence behavioral intention, which leads to behavior towards the environment. Additionally, we introduce volition into the model, which is closer to actual behavior than behavioral intention. Psychological research [12] has shown that the act of making a decision commits a person to the when and where of attempting to realize an intention.

3. Simulation experiments and results

In the following, after a brief introduction of the various sub-models, the conditions for the simulation experiments are described, and the results are presented.

In describing the sub-models, we focus on experiments with populations of 10,000 persons and omit the experiments that we conducted with 1 to 10 persons in order to reach a basic understanding of the processes and to validate the model with the aid of existing empirical findings.

All variables range within a dimension from 0 to 100. For variables related to environmental orientation, 100 signifies maximum environmental friendliness, and 0 indicates maximum lack of environmental friendliness; 50 represents a point of "neither/nor". In the graphics presenting the findings, average behavior towards the environment, or the average attitude towards the environment by the population, is always put on the ordinate. If a curve rises, this means that the population is changing in the direction of environmental responsibility. On the abscissa, we find the simulation steps. A step means that in a complete calculation cycle, all individuals exert influence on their contacts, or are themselves influenced, and – together with the others – utilize a resource. The linear progression of the steps should be interpreted as the progression of time; more exact temporal pinpointing is not possible.

For the experiments, we usually started out from populations that were rather eco-unfriendly (mean of 40),

whereby the values of this variable in the individuals strew around this mean.

In order to avoid the reproach that we may have built the results of the simulation right into the program, all experiments were conducted according to a baseline/control group design. The results of a number of steps with and without manipulations (control group) form the basis for comparison; populations were always identical (which is only possible in computer simulation). In the following, we will examine important issues in social intervention and campaign planning with the aid of the simulation model.

The following sections on the sub-models are each organized according to a research issue and a reference to the theories being applied.

3.1. How must a minority of people behaving in an environmentally friendly way be distributed and networked within a population in order that the environmentally unfriendly majority comes to change its attitudes and behavior?

The processing of group influences upon attitudes towards the environment: Application of the Theory of Social Comparison Processes [10].

3.1.1. Description of the sub-model

Frey, Dauenheimer, Parge & Haisch (1993, p. 114ff.) developed an integrative concept of social comparison processes that encompassed Festinger's theory [10], Tajfel's theory of social identity [12,37,38], and Thibaut and Kelley's theoretical concept of the comparison level for alternatives [12,40]. According to the integrative conception of social comparison processes [12], 111ff. persons in groups change their own attitudes in dependency upon the existing pressure to conform, the attractiveness of the group, and the perception of threat to their self-concepts should they change their own positions (be untrue to the self under social pressures). Attitude change results from the pressure to conform, weighted by the attractiveness of the group. If the self-concept is threatened, however, people will not change their attitudes. Threats to a person's self-concept arise when his or her values differ to a certain de gree from the average attitudes of other members of the group. Individuals experience too great a discrepancy between their own values and the group's attitude as threatening: in order to adapt to the group, the individual would have to deviate too far from personal values. Under social pressure, they would become untrue to themselves.

People are more likely to change an attitude the more attractive the group is and the greater the group pressure to conform. Attitudes will change in the direction of the average attitude of the group. Attitude change occurs, however, only if the change does not pose a threat to self-concept. The attractiveness of the group results from two components: (1) the difference between a person's own attitude and the average attitude of the group – a group is all the more attractive the more that person and group are on the same "wavelength" – and (b) the average status of the group: its prestige, power, social resources.

The conformity pressure of a group can be calculated according to Tanford & Penrod's [39] well-documented formula. Pressure to conform, in reference to the total number of group members, is calculated in an exponential function separately for a minority and a majority member.

3.1.2. Simulation experiments

The population is structured in groups of 10 persons, whereby each group is in contact with two other groups. For the intervention, we assume that an environmental campaign can bring 10% of the population to clearly embrace more friendly attitudes towards the environment than previously (an increase in 25 points), for a limited period of time (for example, for one week = one step in the simulation). These persons we call (attitude) "pioneers". Pioneers are, moreover, more strongly sensitized to deviations from their own positions. Through this, they acquire a particularly low susceptibility to social influencing attempts: even minor deviations of other individuals in the group from their own, pioneer positions imply a potential endangering of their sense of self-esteem. This leads to the less susceptible attitudes of the 'pioneers' in the group.

As a further form of intervention, pioneers are variously organized. Following the short environmental campaign,

- they remain in their groups (isolated) with no wider contacts to the outside,
- they remain in their groups, but are in contact with other pioneers (networks), or
- they form their own groups (core groups), which may have few or many contacts with other groups.

Figure 2 documents the experiments conducted as well as their results. The intervention applies only to the fifth step; the dynamics described below result from this short-term intervention.

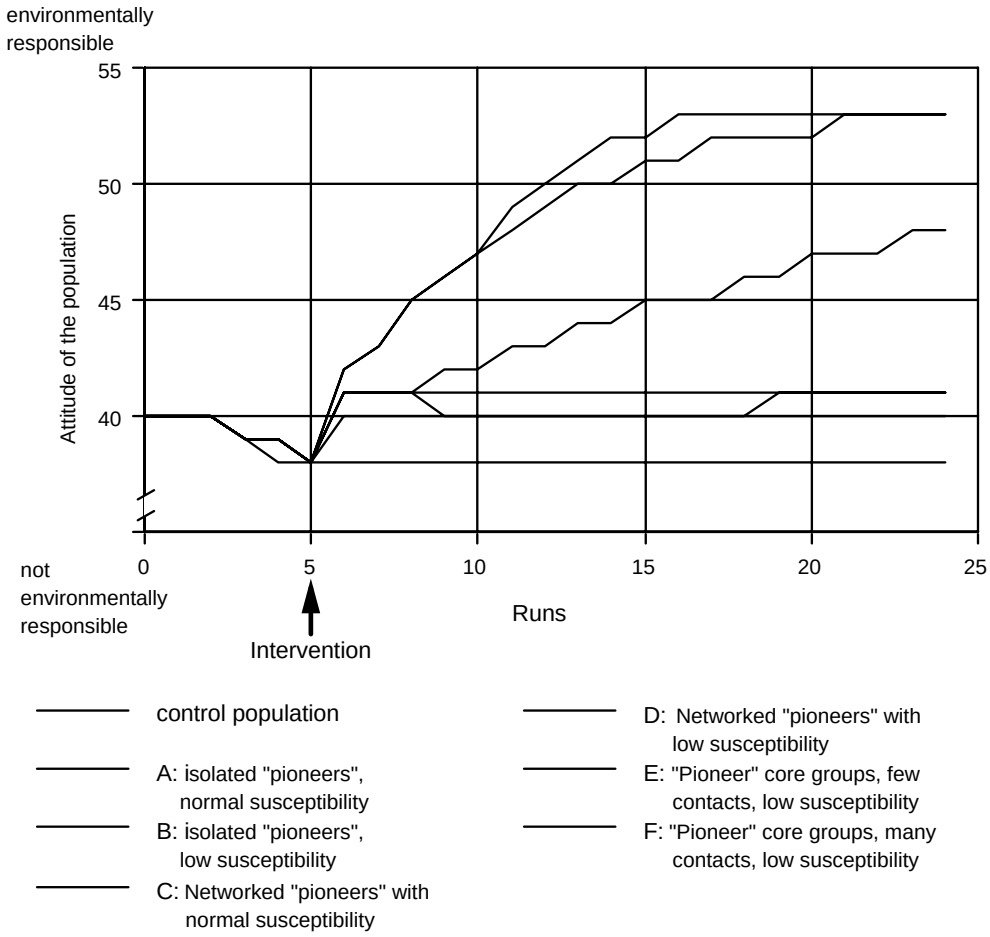

Fig. 2. Change in average attitude of the population according to various group-oriented forms of intervention, as described in the text.

A. In each group there is an isolated pioneer whose susceptibility to influence is the same in degree as that of the members of the group majority.
B. In each group there is an isolated pioneer whose susceptibility is lower than that of the members of the group majority.
C. In each group there is a pioneer whose susceptibility is the same in degree to that of group members; in addition, the pioneer is in contact with 10 other "pioneers" in other groups. They thus no longer experience themselves to be a minority.
D. As in C. above, but here pioneers have a lower degree of susceptibility.
E. All pioneers are concentrated within their own core groups and show low susceptibility to influence. Each pioneer is in contact with another person outside of the core group.
F. As in E. above, whereby here pioneer group members are in contact with 10 other persons outside of the core group.

3.1.3. Results

a) It is extraordinarily important for pioneers' susceptibility to be low, in order that they do not too soon once again adapt to the surrounding majority.
b) If susceptibility is not low, there will be no positive effects from being networked with other pioneers and experiencing themselves no longer as a minority.
c) Core groups (also with low susceptibility) only then have an effect on the surrounding majorities in the group if they have numerous outer contacts (curve F in Fig. 2 continues to climb in further steps, but not as high as curves B and D).

In sum:

– Pioneers have to hold to a stronger environmentally responsible attitude, and their susceptibility

to influence must be low. In effect, they feel quickly threatened in their self-concept.
– Pioneers should be activated or active in as many groups as possible and should not be concentrated in just a few groups. Further measures are not required.

3.2. *What kind of models of behavior are necessary for the population to follow pioneers' examples?*

Processing of observed behavior towards the environment: application of Bandura's Theory of Social Learning

3.2.1. *Description of the sub-model*

According to Bandura [5] people learn not only through direct personal experience, but also through observing others. In this way they gain an idea of how an action is performed. The probability that a learned behavior will be carried out depends on motivation, and motivation is dependent upon expectations of efficacy (self-efficacy [4], p. 390ff) and determined by anticipated self-regulation ([4,36] p. 390ff). Bandura does not, however, give any indication of the effect on a person's behavioral repertory when there are several, contradictory behavioral models. For example, someone might observe environmentally responsible behavior in some people, while others demonstrate behavior that is damaging to the environment. In order to model contradictory influences on self-efficacy, we turned to Latané's theory of social impact ([19,20]; further specified in [30,31]. In this theory, social influence bases upon the following factors, which stand in a multiplicative relationship:

– Strength: power, importance, intensity, unusual quality or features of the source person for the target person.
– Immediacy: directness, immediacy in space and time, absence of barriers or filters.
– Number of sources: number of group members, number of persons present.

The multiplicative relation of the three variables expresses the fact that the effect of one of the variables is greater, the greater the value of the other variables. There is no effect at all if one of the variables equals zero. According to the theory, moreover, the effect of the variable N (number) is not linear, but rather is an exponential function: $I = sN^t$, where I is impact, s is a constant, and the exponent t is a value less than 1. The parameters s and t are different for each situation and have to be determined empirically. The factor "number" thus has the effect that the first person has the greatest impact and each person thereafter ever less of an impact. With an increasing number of influencing source persons, the social impact on a person rapidly decreases.

3.2.2. *Simulation experiments*

Within the framework of an intervention, incentives can move persons having above-average status, for example, to change their behaviors during the intervention phase in the direction of environmental acceptability. On the other hand, it is possible to raise the status of persons displaying above-average environmentally friendly patterns of behavior through various measures (for example, by means of public commendation awards, coverage in the media, and so on). The experiments were conducted with 300 or 500 persons and included varying degrees of "visibility", in that selected persons displayed their environmental behaviors to many (15) or a few (5) contacts (Fig. 3). Visibility of resource use has already been demonstrated to be an effective factor [16,24].

A. In this experiment, 500 persons of high status are selected and caused to adopt a behavior that is more eco-friendly for the duration of the intervention. They are to demonstrate this behavior to many others (15 contacts).
B. As in A. above, but here only 300 persons are selected.
C. As in A., but here the behavior is demonstrated to only 5 contacts.
D. Here we selected 500 persons showing very environmentally sustaining behavior patterns, which they demonstrate to 15 contacts. In this case, their status is raised for the duration of the intervention.

3.2.3. *Results*

a) It appears to be more effective to select persons having high status as role models and to induce them to behave in a more environmentally friendly way for the duration of the intervention than to temporarily raise the status of persons already showing such behaviors.
b) An increase in the number of contacts, that is, an increase in the visibility of the environmentally sound behavior, achieves relevant effects.
c) An increased number of role models also has a strong effect.

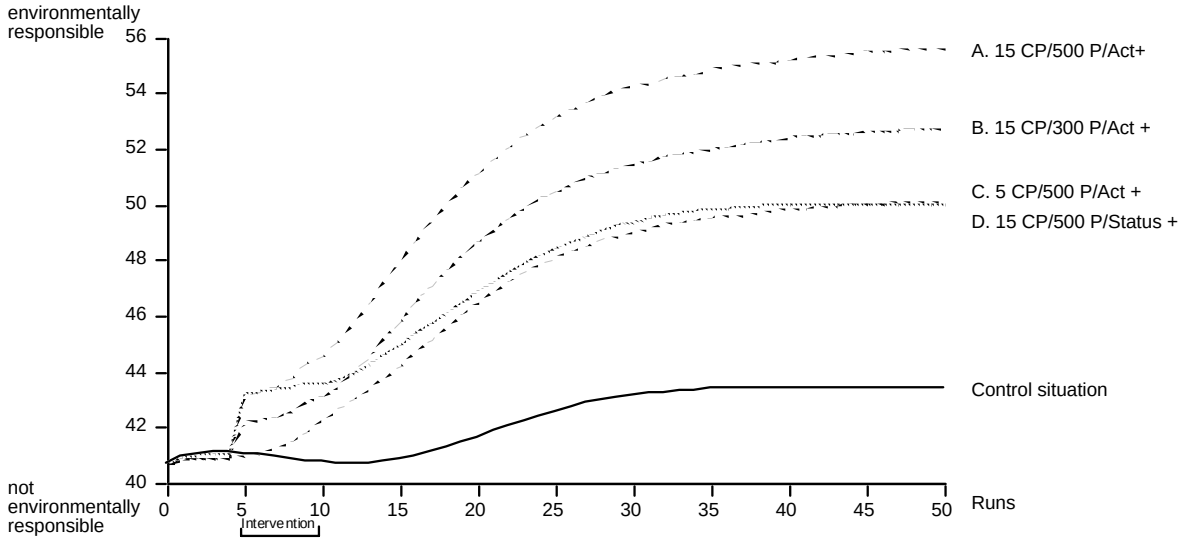

Fig. 3. Course of average population behavior with differing interventions based on observational learning (CP: contacts per person; P: number of persons addressed (role models); Act+, Status+: more responsible acts towards environment, increased status of role models during intervention).

d) The dissemination process continues to progress automatically for some time after the intervention, as the entire social system must again adapt to the changes.

In developing concepts for environmental campaigns, simulation can contribute support with regards to the implementation of efficient means. It can answer questions as to the number of role models required, how these should be selected, and what changes they should show, the degree of visibility necessary, and so on. In particular, simulation allows us to estimate the effects that can be achieved by means of compensation in other values, which makes a direct contribution to an increase in efficiency (for example, an increase in visibility at the expense of the number of role models).

The concept of learning from a model is also well suited to illustrate the phenomenon of mutual trapping in behaviors that overuse environmental resources. In the control group, each person behaves in accordance with others' behavior, and the others do the same. In consequence, nothing changes. Only well conceived intervention is capable of bringing motion into such a paralyzed system.

3.3. *How must the social surround be perceived for people to become willing to use an environmental resource sustainably?*

The processing of information on the collective use of an environmental resource: application of research on the Commons Dilemma

3.3.1. *Description of the sub-model*

When people act upon the environment, they usually utilize an environmental resource. Utilization of a resource available to all (common property) involves an interpersonal conflict Liebrand, Messick and Wilke, 1992 [22]. It is in each individual's interest to keep the personal benefit as large as possible, while the harm incurred by or the depletion of the resource must be borne by all [26,34]. Sustainability as a motive to become willing to protect common property, the environment, depends upon both the absolute value a person places on environmental goods and the current discrepancy between collective, sustainable use and actual patterns of use shown by others (expectation of sustainable utilization). The more highly the individual values the common property of the environment, or the smaller the discrepancy between actual and sustainable patterns of use seems, the greater the effect a sustainability motive will have. Under these con ditions, the individual is motivated to make a personal contribution to sustainable patterns of use.

3.3.2. *Simulation experiments*

If no particular interventions take place, there is a danger that dynamics such as those shown in Fig. (4a) will develop. With an optimistic starting value with regard to average use within a population (over 50 = environmentally friendly use), the state of the resource briefly improves. Due to its improved state, its value declines (only goods in short supply are valuable), and the individuals in our simulated population

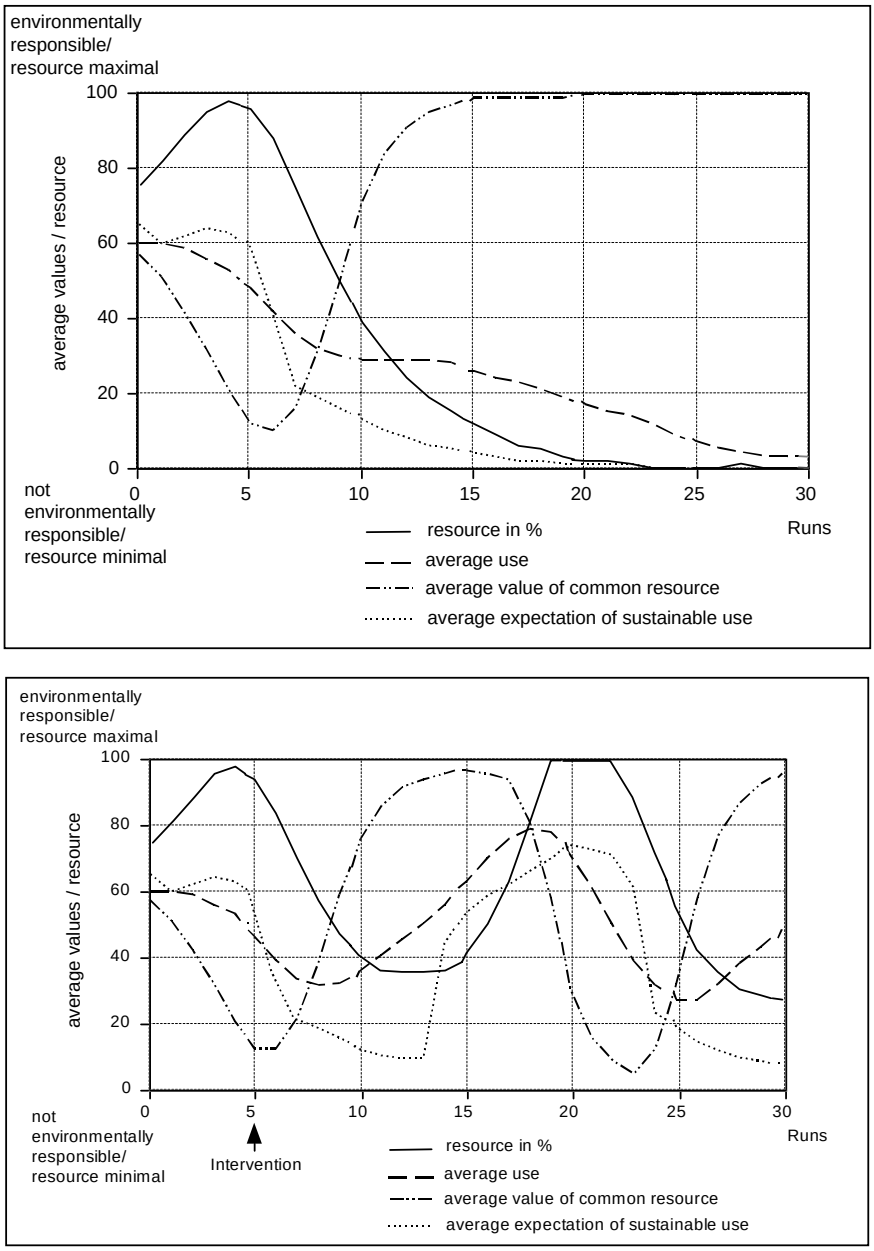

Fig. 4. Use of an environmental resource by a population. The figure also illustrates the course of significant inner variables. 4a (top): Control situation, 4b (bottom): With intervention. The variables are explained in the text.

resume stronger exploitation of the resource. As soon as from the fifth step onwards, this tendency results in clear over-utilization (average use under 50). This increases the discrepancy between actual and sustainable use patterns, and expectations of sustainable use correspondingly decrease. The individual is less motivated to make a personal contribution to sustainable patterns of utilization ("... personal restraint on my own part would not make any difference; no one else is showing restraint, so it is better for me to help myself to the resource so long as it i s still up for grabs ..."). And so the state of the resource deteriorates. Its value rises, which does not, however, lead to a marked reduction in utilization. There is no stopping the course of these "downhill" dynamics, and the resource is destroyed.

To counteract the negative dynamics illustrated

above, we ran a campaign in the fifth step that aimed to (a) lead persons, in their own use behavior, to orient themselves less to other persons' patterns of use and (b) lend heavier weighting to the importance of the resource. Through this, the common property becomes more highly esteemed.

3.3.3. Result

We found that the utilization behavior of the population becomes more environmentally sustaining (see Fig. (4b)). If individuals use a resource in an environmentally sustainable fashion on the average, the state of the resource improves. This line of development continues until the resource has regenerated. At this time, the resource is available in over-abundance so to speak, whereby its value again declines, and intensity of use increases. Downhill dynamics develop until that crucial point where they are again brought under control. A dynamic-stable balance has emerged, in which utilization continually adapts to the state of the resource by means of inner personal factors. The resource will never be completely destroyed.

Through the interaction of the social system and the resource, the resulting system behavior shows large fluctuations. Following Forrester ([11] p. 48ff), fluctuating system behavior results when in a system of interlocking feedback loops two or more temporal delays occur. In the present simulation model, there are delays both within the social system and between the social system and the resource system. The average expectation that one can make an effective contribution to sustainable use of a resource reacts with a delay to the average resource use behavior of the social surround. The rise and fall of the average value of the common good reacts with a delay to the development of the resource.

Our simulation approach is not directly comparable to Forrester's approach. Forrester observes only one macrosystem, while the simulation builds upon numerous microsystems – individual persons –, who join to form the macrosystem – the social system.

3.4. What is the effect of convincing attempts (persuasion) in populations, according to individuals' concern about the environment, knowledge of the environment, and biases?

Processing communicative influencing: Application of the Elaboration Likelihood Model [32,33].

People process information in varying degrees of thoroughness: the "depth" of processing is a function of processing motivation and processing ability; areas of great personal relevance (concerned consternation about the environment) and self-responsibility (here responsibility for the state of the environment) increase motivation to process [35]. Where deep, complete processing of information occurs, the results of campaigns to convince are primarily dependent upon the quality of the arguments presented; in the case of superficial processing, superficial cues, such as status, credibility and attractiveness of the communicator, gain more weight. Furthermore, individuals holding extreme attitudes or values tend to process information in a biased way: when a person's own position is too removed from the attitude advocated by the influencing campaign, there can be a "boomerang" effect, whereby the person changes his attitudes in a direction opposing the persuasive arg uments. If the advocated position is close to one's own, there will be convergence between them. The principle mechanisms involved may be illustrated by a simplified, information-campaign experiment.

3.4.1. Simulation experiments with information campaigns

We assume to this purpose (as an exception) that the individuals do not influence each other mutually, but that in 5 steps they are presented with information campaigns (the individuals do not discuss the subject of the environment among themselves, but they all stand under the influence of the campaigns). The campaigns promote strong environmentally friendly attitudes by means of good arguments (leading to high persuasiveness) and/or by means of strong peripheral cues (communicators having high status, as for example esteemed public figures). In addition, we assume that in the campaigns, an appeal can cause persons' self-responsibility to increase. Average attitudes and values are low on environmental friendliness, the extent of the sense of self-responsibility is low, and the state of the environment is poor. Persons having environmentally friendly values experience high concern under the condition of poor state of the environment. The following interventions were "tested" [25].

A. An information campaign presenting upon good arguments (Fig. 5, persuasiveness+).
B. An information campaign which works with well-known and esteemed personalities (Fig. 5, status+).
C. An information campaign based on good arguments and well-known, esteemed personalities (Fig. 5, persuasiveness+/status+).

D. An information campaign with well-known, esteemed personalities that moreover appeals to people's sense of environmentally oriented self-responsibility (Fig. 5, self-responsibility+/status+).

3.4.2. Results

Let us first examine results with individual persons selected from the population. Person A – who is biased due to an environmentally non-friendly attitude - places a negative value even on good arguments (Curve Persuasiveness+). In contrast, good arguments effect even more environmental consciousness in Person B, who has environmentally responsible attitudes from the start, as information processing is hardly biased here.

A campaign using esteemed public figures is effective with both Persons A and B, if they tend to process information relatively superficially (Curve Status+). But if Person A's depth of processing is increased by means of self-responsibility (Curve Self-responsibility+/Status+), he or she then shows biased processing, and his/her attitude changes in the direction away from that advocated by the campaign. In the total population, the average attitude becomes most changed by means of good arguments and presentation by esteemed personalities. But as shown in Fig. 5, we must always take into consideration that these average values within the population hide very contrasting effects upon differing individuals.

3.4.3. Simulation experiments with multiplicators

For various experiments with multiplicators (persons who advocate their environmental attitudes to others) a communication net was constructed. Each simulated person "talks" about environmental issues with 5 friends and one stranger during each step, whereby the friendships are assumed to be lasting and reciprocal. The relationships to strangers are different each step. Initial values in the population are the same as those described above for the information campaign experiment. Within the framework of an environmental action campaign, 500 persons (multiplicators) having very environmentally friendly attitudes receive training in argumentation (increasing persuasiveness, see here Gonzales et al. [14]). In a variant of this experiment, the status of these persons is raised (as for example through public commendation awards). The following interventions were carried out:

A. Multiplicators with good arguments (Fig. 6, Persuasiveness+)
B. Multiplicators with raised status (Fig. 6, Status+)
C. Multiplicators with good arguments and raised status (Fig. 6, Persuasiveness+/Status+)
D. Control situation

3.4.4. Results

In Fig. 6 we again see two selected individuals A and B, who both stand under the influence of the action campaign. A glance shows that these graphs are not as smooth as the information campaign graphs. The curves would be smoother if, after a short leveling-off phase, there were only the influence of a constant group of friends. But the ever-changing influence of strangers, upon Persons A and B and also upon their friends, causes fluctuations in attitudes. We can still recognize certain tendencies in the development of attitudes, however. Person A's attitude becomes less environmentally friendly relatively quickly. Later changes to a more responsible attitude are only brief and are repeatedly destroyed by the not environmentally friendly social surround. Person B shows initial swings in attitude, but then develops a tendency towards an attitude less environmentally friendly. Both Persons A and B react to the introduction of multiplicators having high status (Curve Status+) with an increasingly environmentally friendly attitude. This effect is even stronger if multiplicators in addition show high persuasiveness (Curve Persuasiveness+/Status+). But if multiplicators demonstrate only persuasiveness (Curve Persuasiveness+), they have no effect upon Person A. There is an initial effect in this case upon Person B, but the influence of the rather environmentally unfriendly social surround can not be cancelled out. The same effects find expression at the level of the population: multiplicators with raised status are just as convincing as those who also show increased persuasiveness. Multiplicators who have only high persuasiveness at their disposal have a counterproductive effect.

4. Summary and conclusions

The concept of the model, which bases on an elaborated rational choice theory, has proved to be – in connection with the simulation method – a valuable tool for the drafting, designing, and testing of environmental psychological interventions.

A common denominator of the results can be formulated as follows, in analogy to Latané's [20] theory of social impact: For a collective reorientation in a population towards environmentally sustaining be-

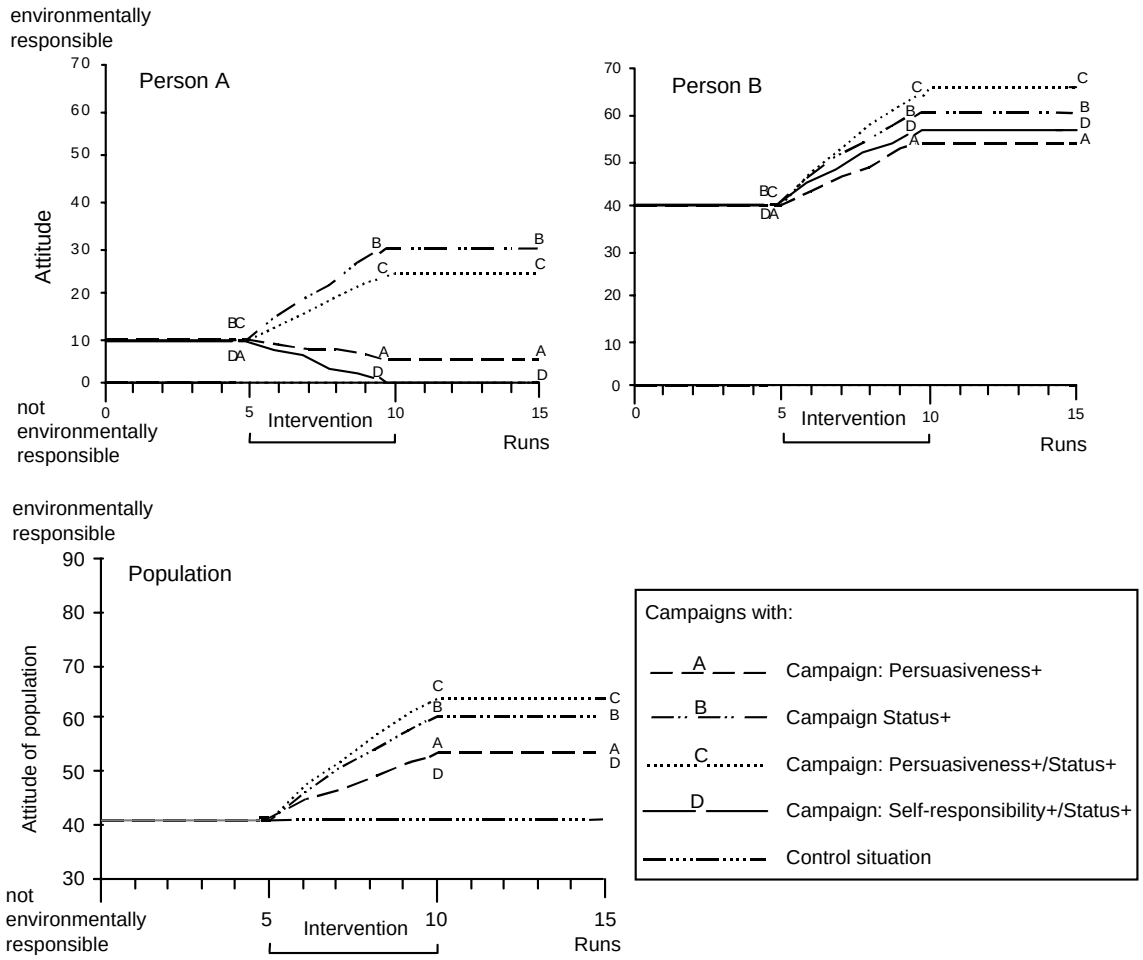

Fig. 5. Information campaign experiments, with no environmentally relevant communication among persons. Above: Individuals in the population. Below: Population values. The three graphs present courses of attitude change in four different experiments and the control situation.

havior to occur, there must be – with the forms of intervention we have proposed – a sufficient number of active, "convinced" persons who have "close" enough relations with other persons [28]. In a word: gain followers who will themselves gain followers! Success in getting 3, 5, or even 10 percent of a community to become active does, however, seem an impossible task. According to the Swiss Environmental Survey [8], 16 percent of people in Switzerland are members of environmental groups. This existing potential, distributed dispersely, needs to be seen as a resource that can be activated and brought together within the framework of concerted environmental efforts. If efforts are not sufficiently coordinated, they fall flat.

Other results suggest the implementation of other strategies for change: in the entire population, external (environmental behavior) and internal factors (self-responsibility, values) must be changed by means of interventions such as incentives, commitment, "consciousness raising", or appeals. Other well-known forms of intervention would also enter in here, such as the "foot in the door technique" [3] or the "minimal justification technique" [17]. Unfortunately, these and other in part very successful techniques have not been implemented and put to the test on a large scale.

The conception of our experiments, with various forms of intervention as well as the application of terms suited to translation into action, might create the impression that we underestimate the problems of implementing in reality the forms of intervention studied. We are conscious of the fact that there are great gaps (theoretical as well as empirical) and incalculabilities between "population simulations" based upon simulated individual behavior and possible processes in real populations. Many sub-components are missing in our model or are as yet not adequately designed

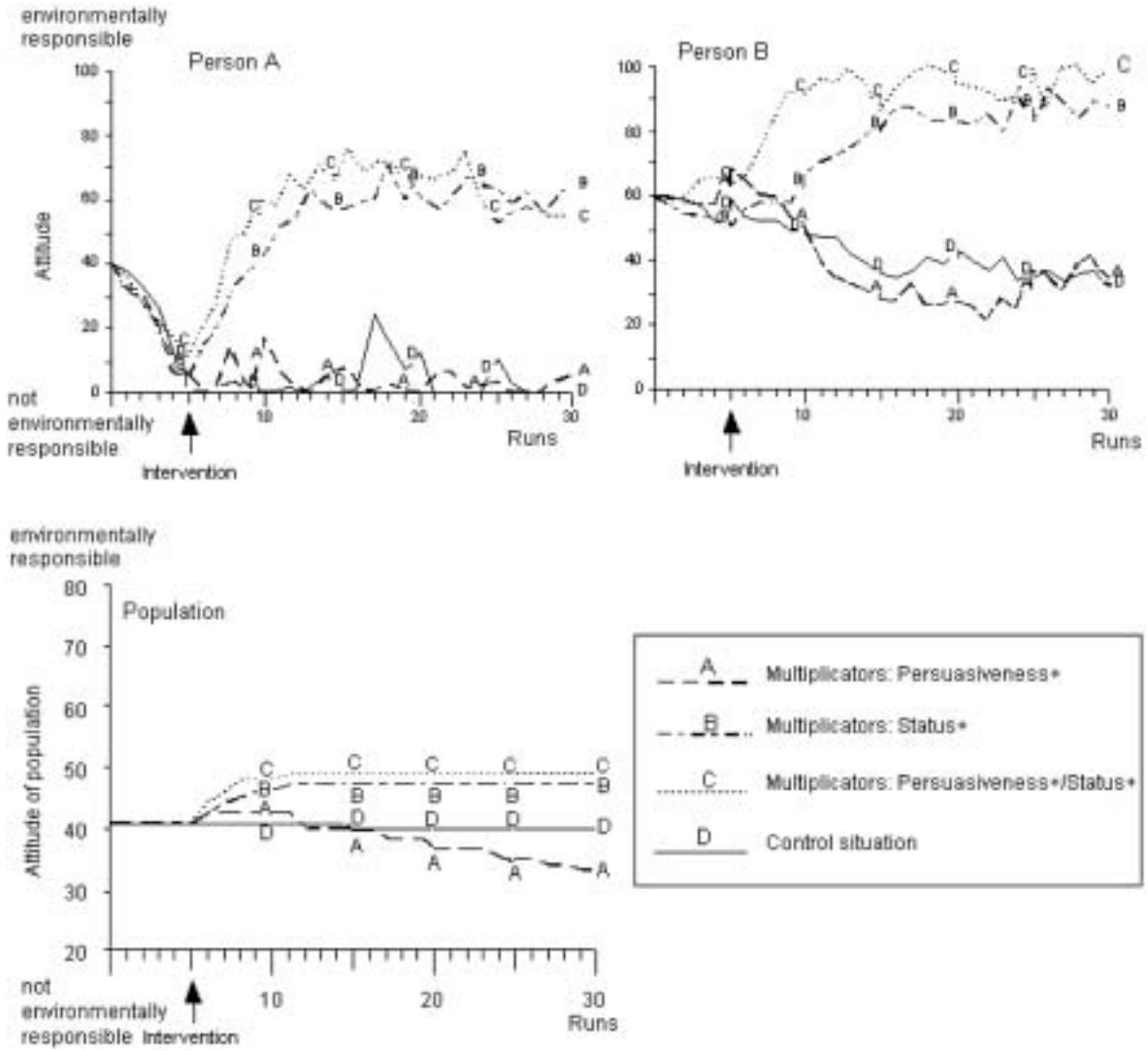

Fig. 6. Experiments with multiplicators. Individual graphs show the course of attitude change in three different experiments and the control situation.

or validated. In spite of all this, from our perspective there is no other alternative: we should indeed take on the challenge of examining the complexity of such dynamic processes by means of appropriate instruments. Simulation is an instrument well suited to enlarging our understanding of basic, underlying social processes and developing further those explanatory approaches that are almost exclusively static and based on one-person models. Against the possible view that our approach is far from reality, it must be objected that the forms of intervention we propose are founded upon empirical knowledge gained in small-scale field experiments [9,27]. In the next phase of research, we plan stage-by-stage testing of the simulation model as a logical step in its proof in practice. Here, in the sense of a practice-oriented "acid test", we will strive towards process-oriented validation. To gain well-founded understanding of the dynamics of existing social systems, data must be collected in real social systems that is relevant to indications resulting from the simulation and that can then be entered into the simulation itself. The focus of the investigation would be the topic of dissemination of new behavior patterns throughout existing social networks. The optimal method would consist in large-scale field experiments.

It is not our intention to propagate as "tested" or "problem-free" the application of those forms of intervention judged effective on the basis of our simulations.

Our purpose, rather, is to show environmentally conscious people, responsible persons, and politicians how worthwhile it can be to expand the old triad of "traditional information campaigns", "legal measures", and "economic measures" by means of additional, novel strategies and to test these potentially successful forms of intervention in practice.

References

[1] I. Ajzen, The theory of planned behavior. Some unresolved issues, *Organizational Behavior and Human Decision Processes* **50** (1991), 179–211.

[2] I. Ajzen and T.J. Madden, Prediction of goal directed behavior: attitudes, intentions, and perceived behavioral control, *Journal of Experimental Social Psychology* **22** (1986), 453–474.

[3] J. Arbuthnot, R. Tedeschi, M. Wayner, J. Turner, S. Kressel and R. Rusch, The induction of sustained recycling behavior through the foot-in the-door technique, *Journal of environmental systems* **6** (1976), 355–368.

[4] A. Bandura, *Social foundations of thought and action*, New York: Prentice-Hall, 1986.

[5] A. Bandura, *Sozial-kognitive Lerntheorie*, Stuttgart: Klett-Cotta, 1979.

[6] G.S. Becker, *The economic approach to human behavior*, Chicago: The University of Chicago Press, 1976.

[7] A. Diekmann, Homo ÖKOnomicus, Anwendungen und Probleme der Theorie rationalen Handelns im Umweltbereich, in: *Umweltsoziologie Sonderband 36 der Kölner Zeitschrift für Soziologie und Sozialpsychologie*, A. Diekmann and C. Jaeger, eds, 1996, pp. 89–118.

[8] A. Diekmann and A. Franzen, *Der Schweizer Umweltsurvey 1994*, Codebuch, Bern: Institut für Soziologie, 1995.

[9] W.O. Dwyer, F.C. Leeming, M.K. Cobern, R.E. Porter and J.M. Jackson, Critical review of behavioral interventions to preserve the environment. Research since 1980, *Environment and Behavior* **25**(3) (1993), 275–321.

[10] L. Festinger, A theory of social comparison processes, *Human Relations* **7** (1954), 117–140.

[11] J.W. Forrester, *Grundzüge einer Systemtheorie*, Wiesbaden: Gabler, 1972.

[12] D. Frey, D. Dauenheimer, O. Parge and J. Haisch, Die Theorie sozialer Vergleichsprozesse, in: *Kognitive Theorien* (*2*), D. Frey and M. Irle, eds, Bern: Hans Huber, 1993, pp. 81–122.

[13] D. Frey, D. Stahlberg and P.M. Gollwitzer, Einstellung und Verhalten : Die Theorie des überlegten Handelns und die Theorie des geplanten Handelns, in: *Kognitive Theorien 2*, D. Frey and M. Irle, eds, Bern: Verlag Hans Huber, 1993, pp. 361–398.

[14] M.H. Gonzales, E. Aronson and M.A. Costanzo, Using Social Cognition and Persuasion to Promote Energy Conservation: A Quasi- Experiment, *Journal of Applied Social Psychology* **18** (1988), 1049–1066.

[15] J.C. Harsanyi, *Rational behavior and bargaining equilibrium in games and social situations*, Cambridge: Cambridge University Press, 1977.

[16] D.O. Jorgenson and A.S. Papciak, The effects of communication, resource feedback, and identifiability on behavior in a simulated commons, *Journal of Experimental Social Psychology* **17** (1981). 373–385.

[17] R.D. Katzev and T.R. Johnson, A social-psychological analysis of residential electricity consumption: The impact of minimal justification techniques, *Journal of Economic Psychology* **3** (1983), 267–284.

[18] B. Klandermans, Mobilization and Participation: Social-Psychological Expansions of Resource Mobilization Theory, *American Sociological Review* **49** (1984), 583–600.

[19] B. Latané and S. Wolf, The social impact of majorities and minorities, *Psychological Review* **88** (1981), 438–453.

[20] B. Latané, The Psychology of Social Impact, *American Psychologist* **86** (1981), 343–356.

[21] W. Liebrand, D. Messick and H. Wilke, *Social dilemmas*, Oxford: Pergamon Press, 1992.

[22] H.-J. Mosler, Umweltprobleme: Eine sozialwissenschaftliche Perspektive mit naturwissenschaftlichem Bezug, in: *Oekologisches Handeln als sozialer Prozess*, U. Fuhrer, eds, Basel: Birkhaeuser, 1995, pp. 77–86.

[23] M.-J. Mosler, *Computersimulation sozialpsychologischer Theorien*, Studien zur Veränderung von Umwelteinstellung und Umweltverhalten Weinheim: Psychologie Verlags Union, 2000.

[24] H.-J. Mosler, Self-Dissemination of environmentally-responsible behavior: The Influence of trust in a commons dilemma game, *Journal of Environmental Psychology* **13** (1993), 111–123.

[25] H.-J. Mosler, F. Ammann and H. Gutscher, Simulation des Elaboration Likelihood Model (ELM) als Mittel zur Entwicklung und Analyse von Umweltinterventionen, *Zeitschrift für Sozialpsychologie* **29** (1998), 20–37.

[26] H.-J. Mosler and H. Gutscher, Kooperation durch Selbstverpflichtung im Allmende-Dilemma, Kölner Zeitschrift für Soziologie und Sozialpsychologie, *Sonderheft Umweltsoziologie* **36** (1996), 308–323.

[27] H.-J. Mosler and H. Gutscher, Umweltpsychologische Interventionsformen für die Praxis, *Umweltpsychologie* **2** (1998), 64–79.

[28] H.-J. Mosler and H. Gutscher, Wege zur Deblockierung kollektiven Umweltverhaltens, in: *Umweltgerechtes Handeln*, V. Linneweber and E. Kals, eds, Barrieren und Brücken. Berlin: Springer, 1999, pp. 141–164.

[29] H.-J. Mosler and R. Tobias, Die Organisation kollektiver Aktionen durch Beeinflussung der individuellen Teilnahmeentscheidung, Eine Simulationsstudie, *Kölner Zeitschrift für Soziologie und Sozialpsychologie* **52**(2) (2000), 264–290.

[30] A. Nowak and B. Latané, Simulating the emergence of social order from individual behavior, in: *Simulating societies*, N. Gilbert and J. Doran, eds, London: UCL Press, 1994, pp. 63–84.

[31] A. Nowak, J. Szamrej and B. Latané, From private attitude to public opinion: A dynamic theory of social impact, *Psychological Review* **97**(3) (1990), 362–376.

[32] R.E. Petty and J.T. Cacioppo, The elaboration likelihood model of persuasion, in: *Advances in Experimental Social Psychology*, L. Berkowitz, ed., New York: Academic Press, 1986, pp. 123–205.

[33] R.E. Petty and J.T. Cacioppo, *Communication and persuasion: Central and peripheral routes to attitude change*, New York: Academic Press, 1986.

[34] H. Spada and A.M. Ernst, *Wissen, Ziele und Verhalten in einem ökologisch-sozialen Dilemma*, Forschungsbericht. Psychologisches Institut der Universität Freiburg, 1990.

[35] D. Stahlberg and D. Frey, Das Elaboration-Likelihood-Modell von Petty und Cacioppo, in: *Kognitive Theorien 2*, D. Frey, and M. Irle, eds, Bern: Verlag Hans Huber, 1993, pp. 327–360.

[36] J. Stalder, Die soziale Lerntheorie von Bandura, in: *Gruppen– und Lerntheorien*, D. Frey and M. Irle, eds, Bern: Verlag Hans Huber, 1985, pp. 241–272.
[37] H. Tajfel, *Differentiation between social groups*, London: Academic Press, 1978.
[38] H. Tajfel, Individual and groups in social psychology, *British Journal of Social and Clinical Psychology* **18** (1979), 183–190.
[39] S. Tanford and S. Penrod, (1984). Social influence model: A formal integration of research on majority and minority influence process, *Psychological Bulletin* **95** (2), 189–225.
[40] J.W. Thibaut and H.H. Kelley, *The social psychology of groups*, New York: John Wiley, 1959.