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# Simulating the Formation and Change of the Strength of Political Attitudes

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## Summary

The first part of this PhD presents a novel computational model for simulating the formation and change of individual political attitude strength. The second part is an application of the model in the domain of optimizing the temporal allocation of a pre-defined campaign budget.

During the last two decades, the concept of attitude strength has become a focal issue in the fields of attitude psychology and theories of public opinion. Since there is no direct definition of attitude strength in the literature, the notion has to be defined indirectly. In terms of *measurable components* of attitude strength, strong attitudes of an individual can be defined as attitudes which are extreme, consistent (non-ambivalent), and important to the holder (held with a high level of involvement). In contrast, weak attitudes are tempered, ambivalent, and unimportant to the holder (held with a low level of involvement). In terms of the *consequences* of attitude strength, the most important characteristic of strong attitudes is that they are considerably more predictive of behavior than weak attitudes. The research on attitude strength was initiated in the late 1980s and invigorated in the 1990s after empirical studies had almost unanimously pointed out the difficulty of explaining and predicting behavior from the traditional concept of attitudes, just comprising the measurement of valence and extremity.

As a complement to empirical studies on attitude strength, this thesis is the first attempt to present a *computational simulation model* of the mental structures and processes underlying the formation and change of the components of attitude strength. The simulation model is called the Political Attitude Strength Simulation model (the *PASS* model, from here on). With respect to the components of attitude strength defined above, the *PASS* model simulates the individual time traces of the attitude extremity, the attitude ambivalence and the attitudinal involvement of 100 individual artificial citizens over one year before voting day. Integrating these components, the resulting level of the attitude strength is used to distinguish voters from non-voters at the simulated voting day. Furthermore, the combined level of the attitude extremity and the attitude ambivalence (ignoring the level of involvement) is used to distinguish between certain and uncertain citizens. Whereas certain citizens argue *either* pro *or* contra a certain political issue, uncertain citizens argue both pro *and* contra. The benefit of this

certainty-based differentiation is the differentiation between citizens that *increase* the certainty of their communication partner and citizens that *decrease* the certainty of their communication partners.

The citizens are embedded in a virtual social network. Previous to each model run, a newly constructed algorithm generates a natural data-based citizen network. The data required for the algorithm are the frequency distribution of ego-network sizes and the heterogeneity of the network in regard to the attribute of the citizen's party identification.

The target of the attitude formation and change process in the *PASS* model are two political parties. Starting from an individual initial attitude towards the parties, during the model run every simulated citizen changes her attitude in response to the coverage from the mass media, the activities of the parties, and the content of the interpersonal communication. The *PASS* model is applied to compare the effectiveness of six different strategies of allocating campaign activities towards voting day. The strategies were evaluated in terms of their relative competitiveness represented by the probability of winning the election if the party uses a particular degree of accumulation. The probability estimates (including the corresponding confidence intervals) were derived by running a series of Monte Carlo Experiments using the *PASS* model. The variation ranges of the input parameters used in the experiments were estimated based on data available from the German General Elections. The results from the Monte Carlo Experiments are partly coherent with the current practice of accumulating campaign activities towards voting day in Germany. Yet, the remaining deviation of the model results from the current practice suggests that parties may be generally inclined to mistrust the effectiveness of more continuous campaign strategies and often employ a "Final Burst" strategy. The structures and processes implemented in the *PASS* model might be used as a dynamic explanatory device for demonstrating the proclaimed effect of "permanent campaigning".

## Zusammenfassung

Im ersten Teil präsentiert diese Doktorarbeit ein Computermodell zur Simulation der Bildung und dem Wandel von individuellen politischen Einstellungen. Im zweiten Teil wird das Modell für die Optimierung der zeitlichen Allokation eines vorgegebenen Kampagnenbudgets angewendet.

Während der letzten zwei Jahrzehnte hat sich das Konzept der Einstellungsstärke zu einem zentralen Gegenstand innerhalb der Einstellungspsychologie entwickelt. Vom Blickwinkel der messbaren konstitutiven Elemente her gesehen können starke Einstellung als extrem, konsistent und für den Träger als wichtig (mit einem hohen Involvement verbunden) definiert werden. Im Gegensatz dazu sind schwache Einstellungen eher gemässigt, ambivalent und für den Träger unwichtig (mit einem tiefen Involvement verbunden). Vom Blickwinkel der Folgeerscheinungen her gesehen ist das wichtigste Merkmal starker Einstellungen, dass sie sich deutlich besser zur Erklärung und zur Vorhersage von Verhalten eignen. Die Forschung rund um das Konzept der Einstellungsstärke begann in den späten 1980er Jahren und verstärkte sich in den 1990er Jahren, nachdem empirische Studien fast einhellig zur Schlussfolgerung gelangt waren, dass traditionelle Einstellungsmasse (beschränkt auf die Messung von Valenz und die Extremität) nur in einem sehr beschränkten Mass dazu geeignet seien, Verhalten zu erklären und vorauszusagen.

Der spezifische Beitrag dieser Arbeit ist das Computersimulationsmodell *PASS* (Political Attitude Strength Simulation), das diejenigen mentalen Strukturen und Prozesse simuliert, welche der Bildung und dem zeitlichen Wandel von Einstellungsstärke zugrunde liegen. Das *PASS* Modell berechnet die individuelle zeitliche Entwicklung der Einstellungsextremität, der Einstellungsambivalenz und des Einstellungsinvolements der politischen Einstellungen von 100 künstlichen Bürgerinnen und Bürger (nachfolgend wird nicht mehr zwischen dem Geschlecht unterschieden, da stets von geschlechtsneutralen Computerakteuren die Rede ist) während eines Jahres vor Wahltag. Die Integration dieser Komponenten ergibt schliesslich die Stärke der Einstellung. Diese Grösse wird dazu genutzt, am Wahltag Wähler von Nichtwählern zu unterscheiden. Darüber hinaus ist eine weitere kombinierte Grösse aus Einstellungsextremität und Einstellungsambivalenz dazu geeignet, um

zwischen Bürgern mit sicherem und unsicherem Argumentationsverhalten zu unterscheiden. Während sichere Bürger entweder für *oder* gegen ein politisches Thema argumentieren, sprechen unsichere Bürger für *und* gegen den Gegenstand. Durch diese Unterscheidung können Bürger auseinandergehalten werden, welche die Ambivalenz ihrer Gesprächspartner erhöhen, und Bürger, welche die Ambivalenz ihrer Gesprächspartner senken.

Die Bürger sind in einem virtuellen sozialen Netzwerk eingebettet. Ein spezieller Algorithmus generiert vor jedem Modellauf eine „natürliche“, datenbasierte Vernetzung der Bürger. Die hierzu verwendeten Daten aus empirischen Studien zu politischen Diskussionsnetzwerken sind die Häufigkeitsverteilung der Egonetzwerkgrößen und die Heterogenität des Netzwerks im Hinblick auf das Merkmal der Parteiidentifikation.

Der Gegenstand der Prozesse der Einstellungsbildung und –veränderung im *PASS* Modell sind zwei politische Parteien, die im Wettbewerb um die Wähler stehen. Ausgehend von einer individuellen Starteinstellung ändert während des Modelllaufs jeder simulierte Bürger seine Einstellung gegenüber diesen beiden Parteien aufgrund der Aktivitäten der Parteien, der Massenmedien und der interpersonalen Kommunikation.

Im zweiten Teil der Dissertation wird das *PASS* Modell dazu eingesetzt, um die Effektivität von sechs verschiedenen Akkumulationsgraden von Kampagnenaktivitäten („Schlussspurts“) vor dem Wahltag zu vergleichen. Die Akkumulationsgrade werden bezüglich ihrer relativen Konkurrenzfähigkeit bewertet, welche sich durch die Gewinnwahrscheinlichkeit für die Wahlen ergibt. Die Schätzer der Wahrscheinlichkeiten (inklusive der entsprechenden Konfidenzintervalle) stammen aus einer Reihe von Monte Carlo Experimenten. Als empirische Quelle für die Schätzung der Variationsbreiten der in der Simulation verwendeten Inputparameter dienten Daten aus Deutschen Bundestagswahlkämpfen. Die Resultate aus den Monte Carlo Experimenten decken sich teilweise mit der gängigen Praxis der Parteistrategen. Die restliche Inkohärenz zwischen den Resultaten und der gängigen Praxis weist auf die Tendenz der Parteien hin, der Wirkung einer eher kontinuierlichen Werbestrategie zu unterschätzen und den Schlussspurt zu übertreiben. Die im *PASS* Modell implementierten mentalen und interpersonalen Strukturen und Prozesse können dazu dienen, die proklamierte Wirkung der permanenten Kampagnenführung (permanent campaigning) mit einem theoretisch und empirisch plausiblen Mechanismus zu unterlegen.

## General Introduction

The main goal of this PhD thesis is the development of an empirically grounded computational simulation model in the discipline of political psychology. The focus of the model is on the strength of political attitudes. The attitude strength construct is currently one of the “hot spots” of attitude research in general (Krosnick & Petty, 1995; Franc, 1999; Bizer & Krosnick, 2001) and of attitude research in political psychology in particular (Krosnick, 1988; Liu & Latane, 1998; Huckfeldt & Sprague, 2000; Lavine, Borgida, & Sullivan, 2000; Meffert, Guge, & Lodge, 2000; Lavine, 2001).

To the best of my knowledge, *computational* models of the formation and change of strength-related attitudinal substructures are missing in attitude research. Although there are several computational models of attitude change (Nowak, Szamrej, & Latane, 1990; Latane, Nowak, & Liu, 1994; Hegselmann, Müller, & Troitzsch, 1996; Regenwetter, Falmagne, & Grofman, 1999; Nowak, Vallacher, Tesser, & Borkowski, 2000; Mosler, Schwarz, Ammann, & Gutscher, 2001), this is the first computational model of the formation and change of the *strength* of attitudes and the dynamic interrelationship between several components of attitude strength.

The method of computer simulation has been chosen due to three main reasons:

1. Deriving theoretical implications from combined assumptions related to attitude strength formation like memory decay, attitude bolstering, ambivalence formation etc. is very difficult (if not impossible) because the combination of assumptions is prone to produce non-linear functional relationships (e.g. positive feedbacks) between model variables. Using traditional box-arrow diagrams and describing all the assumptions of the model in verbal form runs the risk to ignore a lot of valuable implications that are inherent in the combination of assumptions (Harris, 1976). In contrast, computational simulation maintains the possibility of deriving implications from complex combination of assumptions in a more formal and systematic way. The simulation method can be seen as a method of “disciplined speculation” (Schnell, 1990) about possible model implications. Merely pondering about possible implications on the basis of complex box-arrow diagrams does often overstrain the researcher’s cognitive abilities and is likely to yield non-systematic and biased speculation.



2. The formalization of verbal assumptions required for the translation into computer program code enhances their precision and clearness. Formally stated assumptions (in the language of mathematical equations, pseudo-code or true program code) are no longer hidden in long text passages and open to criticism. Theoretical flaws are likely to be detected during the model building process and sophisticated hypotheses for subsequent experimental studies can be derived from these flaws. To be sure, computer simulation is not proposed to replace the verbal representation of theories. Rather, the following sketch of the advancement of theory is considered as a fruitful combination of the strengths of verbal theories on the one hand and formal theories like computer simulation on the other hand. In a first step, the theory is stated verbally in its full richness and concreteness. In a second step, the theory is formalized within a computational simulation model. In the last step, the lessons learned from the implementation process and the insights into the implications of the theoretical assumptions are used to restate the original verbal theory more precisely, consistently and completely (Lindenberg, 1971).
3. Running computational models yields another advantage in contrast to the representation of complex models using box-arrow diagrams and descriptive text. The model runs tell complete “step-by-step stories” between the initial model state and the end state of the simulation. Time traces of particular model variables provide an important basis for deriving additional implications from the model assumptions in terms of *emergent processes* that would have been undetected on the basis of static box-arrow diagrams. For example, if two assumptions are combined at the micro-level of the model, their interaction can produce an exponential growth of some model variable(s) on the macro level due to unexpected reinforcement mechanisms. The correction of undesired model behaviors on the macro level can help to improve the exact statement of the model assumptions on the micro level.  
In the following, the model developed in this thesis is referred to as the *Political Attitude Strength Simulation (PASS) Model*. It is supposed to contribute to three fields of research: development of attitude theory, the methodology of simulating cognitive agents interacting in interpersonal communication networks on a computer, and the optimization of advertising strategies in political campaigns. However, the main contribution of this PhD thesis is clearly the advancement of attitude theory. In this field, the PASS model is aimed at

- integrating existing procedural models of serial information integration in the political science with models of attitude strength in social psychology
- integrating the individual process of political attitude formation with models of interpersonal communication in ego-centric political discussion networks

The main assumptions of the resulting integrative theory are presented in the in the third chapter.

In the field of the *methodology* of computational social simulation, the PASS model proposes an algorithm that allows simulating interpersonal communication within “naturally” homogeneous discussion networks that are based on empirical data (see chapter 7 in this thesis). This algorithm might be of some interest for other modelers working on simulation projects addressing the subject of attitude formation or the diffusion of attitudes within social networks. Additionally, this thesis hopefully motivates other researchers working with stochastic models to test some statistical properties of their simulation runs by performing Monte Carlo experiments. Unfortunately, in the field of social simulation, it is still current practice to simply present some isolated model runs as the only results of the study. However, single runs of stochastic models leave the question of representativeness and robustness of the results widely unanswered (Van der Sluijs, 1997).

In the field of *political advertising strategies*, the PASS model explores the implications of the implemented combination of theories (for the specific theories, see chapter 4 in this thesis) in a series of Monte Carlo experiments. The focus of the interest is on detecting the optimal degree of accumulating political advertising resources in political campaigns towards voting day. Tackling this question requires (and therefore justifies) the entire richness of the model (e.g. memory decay, cognitive biases, attitude strength, and interpersonal communication) and its implementation as a computer model. Because of the complexity of the interacting model components, the question would overstrain the expert’s cognitive resources. The German General Elections as the domain of application has been selected because relatively rich data sets encompassing both the cognitive level of citizens and the social level of interpersonal communication are available in this domain (e.g. from the *Zentrum für Umfragen, Methoden und Analysen* at Mannheim or the *Zentralarchiv für Empirische Sozialforschung* at the University of Cologne).

The PASS model is not a general model of attitude formation and change that works in arbitrary contexts. It comprises a minimal set of assumptions that are appropriate for the purpose of simulating the formation and change of political attitude strength during the one year time period before voting day. At the moment, it can handle political systems that can be reduced to two party systems. Importantly, it is too general to replicate the progression of one single election campaign in the past or (even less likely) to forecast the outcome of an ongoing campaign. In other words, as a model of the general persuasive effectiveness of *qualitatively* different advertising strategies, it does not address the effect of unanticipated political scandals around parties or candidates, the superiority of one party against the other regarding the design of the TV spots, or the citizen's expectation of the economic development of the country. As will be shown in the general discussion of this work, the current model structures and processes might be extended in the direction of simulating consumers forming impressions of low-involvement consumer products like different brands of toothpaste, soap powder, or breakfast cereals.

The model is implemented in the JAVA-based simulation environment called *Quicksilver* (Burse, 2000). Quicksilver consists of a set of Application Programmers Interfaces (APIs), a set of tools for the creation and execution of models, and a set of tutorial examples and examples of completed projects. The source code of the PASS model is available at <http://www.eawag.ch/~mmoptmod/PASS/>.

This work is divided into eight chapters. In the first chapter, the theoretical and historical roots of capturing the link between beliefs and attitudes are presented. The second chapter focuses on models of serial information integration in the political sciences. Three existing models are shortly sketched as the main sources of inspiration for the current work. The third chapter provides a survey of the theoretical core assumptions of the PASS model. In the central chapter 4, the technical description of the model on the level of mathematical equations is given. Furthermore, the model is applied to the primacy-recency dilemma of optimally accumulating campaign resources towards voting day. Chapter five goes into the general methodological questions behind the process of validating computer models and presents an assessment of the degree of validation that has been performed with the PASS model. As a possible field of applying the PASS model for better theoretical understandings, in chapter six the discipline of environmental psychology has been selected. Chapter seven turns to the

detailed presentation of the algorithm that allows generating data-based social networks with “natural” degrees of homogeneity. In chapter eight, the general discussion of the strengths and limitations of the model, its generalizability and further developments concludes this PhD thesis.

# 1 General Models of Information Integration

Since the early beginnings of the psychological discipline, hypothetical constructs and process metaphors have been introduced and used as vehicles for theorizing about covert processes of the human mind (Draaisma, 2000). The skeptical position of behaviorism proposed to completely avoid the use of any concepts of covert mental representations. However, this position, which has been prevailing from the 1920s until the 1950s, has not proved to be as fruitful as the subsequent cognitive research paradigm. The resurrection of the focus on covert cognitive structures and processes became obvious after the “cognitive revolution” in the 1960s (Gardner, 1985). Since then, the cognitive paradigm has clearly sustained its dominance.

A focal concern regarding covert processes in the human mind is the link between beliefs and attitudes as reflected in theories of information integration. In the following two sections, the broad categories of instantaneous vs. sequential integration models are distinguished. Next, three characteristic models of sequential information integration developed in political psychology are portrayed: The Community Referendum Model by Abelson & Bernstein (1963), the Receive-Accept-Sample Model by Zaller (1992) and the Impression-driven Model by Lodge, McGraw & Stroh (1989).

## **Instantaneous information integration**

The expectancy-value model (Fishbein, 1963; Fishbein & Ajzen, 1975) was the first theory that introduced explicit sub-units of attitudes in the form of beliefs about specific attributes of the attitude object (some person, object, place, or issue). A belief about a specific attribute  $i$  is characterized by the subjective probability  $p_i$  that the attribute characterizes the attitude target (expectancy-component) and the subjective desirability  $e_i$  of the attribute (value component). Multiplying the probabilities and desirabilities of the  $n$  most important (salient) attributes of the attitude target and adding these probability-desirability pairs yields a measure of the expected general desirability  $A$  of the attitude object (see equation 1.1).

$$A \propto \sum_{i=1}^n p_i e_i \quad [\text{eq. 1.1}]$$

The expectancy-value type of information integration is part of the Theory of Reasoned Action (Fishbein et al., 1975) and its successor, the Theory of Planned Behavior (Ajzen, 1985, 1991). A prominent example in the field of political psychology is the spatial theory of voting (Enelow & Hinich, 1984).

In the more general averaging model of attitudes (Anderson, 1971), the *subjective weight*  $w_i$  of a given stimulus subsumes the expectancy component of the expectancy-value models as a special case. For example, the weights might encompass an expectancy component (in the form of a subjective probability  $p_i$  that the attribute characterizes the attitude target) and an independent judgmental weight  $w'_i$  of attribute  $i$ . The *subjective value*  $s_i$  of the stimulus is equivalent to the desirability component of the expectancy-value model. The total response  $R$  towards the attitude object is proportional to the sum of all weight-value pairs divided by the sum of the weights (see equation 1.2).

$$R \propto \frac{\sum_{i=1}^n w_i s_i}{\sum_{i=1}^n w_i} = \frac{\sum_{i=1}^n w'_i p_i s_i}{\sum_{i=1}^n w'_i p_i} \quad [\text{eq. 1.2}]$$

The weights represent any positive and negative number or any function comprising a set of auxiliary parameters. If applied to a specific field of research, it is left to the researcher to develop and test a domain-specific theory underlying the weights. In the domain of political psychology, an example of the averaging model is the “The Simple Act of Voting” theory (Kelley & Mirer, 1974).

Importantly, both the expectancy-value and the averaging model of attitudes in its general form are mute with regard to the temporal sequence in which the stimuli have been perceived.

## **Serial information integration**

If the order of the stimuli presentation is addressed explicitly, integration models get more complex because they have to describe the relationship between memory and judgment. Hastie and Park have proposed the “memory-based” and the “on-line” judgement reflecting two different types of this relationship (Hastie & Park, 1986). In a later clarification and extension of the original distinction, Hastie and Pennington (Hastie & Pennington, 1989) have introduced an additional intermediate model, the

“inference-memory-based” judgement. In table 1.1, the general characteristics of the three types of judgements are briefly summarized. Subjects are expected to form memory-based judgements if they have no foreknowledge of the judgmental task. If subjects are surprisingly prompted to render a judgment (e.g. in a political poll), they have to retrieve either the “raw” material itself (still accessible memory traces of the original stimulus events) or inferences derived from the “raw” material some time after the presentation of the stimulus events. These judgements are called “inference-memory-based”. If there are no previously formed inferences from the raw material, the judgement is purely “memory-based”.

In contrast, if subjects are carefully prepared for a judgmental task, they are likely to build inferences “on the fly”, i.e. during the presence of the stimulus events. After the presentation of the stimulus material they retrieve these “on-line” inferences from memory (mostly from working memory) and integrate them to form the judgment.

Table 1.1: Three types of the relationship between memory and judgement

critierion	on-line judgment	inference-memory-based judgement	memory-based judgement
Is the judgmental task expected or unexpected?	expected	unexpected	
What is the retrieved content for rendering the judgment?	inferences that were immediately formed during perception when the original stimuli were present	inferences that were immediately formed during perception when the original stimuli were present <u>and</u> inferences that were formed “in the mean-time” from “raw” memory traces	“raw” memory traces, no previously formed inferences available
Is the judgmental target present while forming the judgement?	yes	no	no
model most corresponding	“Community Referendum Model” (Abelson et al., 1963) Impression-driven Model (Lodge et al., 1989)	Receive-Accept-Sample model (Zaller, 1992)	--

Obviously, in the case of voting, citizens are carefully prepared by the mass media coverage and the political campaign to form a judgment until voting day. Therefore, the above categorization would clearly predict that citizens form on-line judgements of candidates and parties.



## 2 Serial Information Integration Models in Political Psychology

In the following sections, three models of serial information integration are briefly portrayed: The Community Referendum Model by Abelson et al. (1963), the Receive-Accept-Sample Model by Zaller (1992) and the Impression-driven Model by Lodge et al. (1989) These models are the approaches most closely related to the PASS model. During the development process, they have provided rich sources of inspiring material. Most importantly, as in the case of the RAS model (Zaller, 1992) and the candidate-impression formation model (Lodge et al., 1989), they provide much of the empirical support underlying many of the assumptions adopted in the PASS model.

### **The „Community Referendum Model“**

This model has been the first attempt to grapple with the full complexities of the political persuasion process with the help of a computer. The model was implemented on an IBM 7090, one of the first computers available at the American universities at all. Any contemporary political psychologist who goes through the model description published in the Public Opinion Quarterly journal in 1963 will be overwhelmed by the extreme richness of the model structure and the fine-grained processes involved. The “miniature dynamic model” encompasses the political process in a community during a campaign on a local issue on fluoridation. The change of the issue positions of 500 individuals during 10 weeks was simulated running a step-by-step model with a temporal resolution of one week.

The social level comprises the public channels of mass media and the network of interpersonal communication. At the set-up of the model, the modeler can assign the channels a variety of different assertions about the fluoridation issue. During the model run, if an artificial citizen is confronted with a particular assertion, a set of acceptance rules is activated which determine the acceptance or the refusal of the assertion. For example, according to one rule, the probability of an assertion to be accepted is lowered if i) the source is disliked, ii) the evaluative content is inconsistent with the citizen’s issue position, iii) the citizen is unfamiliar with the assertion, and iv) the assertion is uncongenial with the citizen’s value system.

The citizens differ in their initial positions toward the issue and are differently interested in the issue. Additionally, they have individual predispositions toward every campaign assertion that is presented in the public channels. Their issue positions change according to the actual balance of positive and negative assertions they have already accepted from the campaign channels. A remarkable detail of the model is that citizen learning is not limited to the change in the issue position: citizens judge how much they agree with the assertions they have already encountered from the different sources and establish different levels of attraction towards the sources. This is also true for the attraction towards other citizens. The probability of an interpersonal exchange of assertions grows if two citizens feel some mutual ideological compatibility.

The model anticipates much of the current efforts in political psychology to introduce motivational components into models of citizens. The model is based on numerous psychological assumptions of motivational information processing and, despite of its pioneering character, addresses questions of both citizen conversion *and* of citizen activation. For example, the level of interest in the referendum raises in proportion to the number of encountered assertions.

Even the citizen participation or abstention at voting day is part of the model. It is simulated as contingent on the current interest in the referendum at voting day. Unfortunately, the model has not been tested against empirical data. The authors document some runs with artificial data, but the over-all impression is that the complexity of the model has dramatically exceeded the possibility for estimating all the great variety of parameters. Nevertheless, its stunning complexity is an admirable example of two political psychologists seeking for new frontiers in their discipline.

### **The Receive-Accept-Sample (RAS) Model**

In a series of studies, John Zaller has developed a parsimonious model of the stability and change of public opinion (Zaller, 1987; Zaller, 1992; Zaller, 1996). His main goal was to refine some general postulates originally proposed by Philip E. Converse (Converse, 1962). These postulates were relatively vague and not explicitly grounded in theorems from social psychology. Owing much to the stage model of attitude change (McGuire, 1969), Zaller has refined the ideas from Converse and has tested them against empirical evidence in a great deal of studies. In summary, his Receive-Accept-Sample (RAS) model proposes an elegant explanation of the unstable responding

behavior of a considerable percentage of citizens if they are prompted to report their political attitudes. Zaller proposes four basic axioms underlying the Receive-Accept-Sample model (RAS)(Zaller, 1992, p. 40-51):

A1: The Reception Axiom:

The greater a person's level of cognitive engagement with an issue, the more likely he or she is to be exposed to and comprehend – in a word, to receive – political messages concerning that issue.

A2: The Resistance Axiom:

People tend to resist arguments that are inconsistent with their political predispositions, but they do so only to the extent that they possess the contextual information necessary to perceive a relationship between the message and their predispositions.

A3: The Accessibility Axiom:

The more recently a consideration has been called to mind or thought about, the less time it takes to retrieve that consideration or related considerations from memory and bring them to top of the head for use.

A4 The Response Axiom:

Individuals answer survey questions by averaging across the considerations that are immediately salient or accessible to them.

In contrast, Converse's own interpretation of the instability of political attitudes claimed that "true" political attitudes do not exist. The argument supposed people to construct an arbitrary and therefore unstable pseudo-attitude without "true" considerations in mind (Converse, 1970). Five years later, another similarly extreme interpretation was published (Achen, 1975). Achen started from the proposition that "true" attitudes exist but that they are difficult to measure. In accordance with this perspective, the main proportion of the instability of public opinion has to be attributed to measurement errors.

Developing the Receive-Accept-Sample model, Zaller takes an intermediate position between these two extreme accounts (Zaller, 1992). In his view, the instability of political attitudes origins in the altering accessibilities of the political considerations available in the citizen memory. He associates the mind of the citizen with a sort of "bin" filled with a great deal of considerations about political parties, candidates, or political issues. The "consideration" concept is very broad encompassing "any reason that might induce an individual to decide a political issue one way or other" (Zaller,

1992, p. 40). If a person is unexpectedly asked for her/his opinion in a political poll, a subset of these considerations is sampled in the sense of the “raw material” of the subsequent memory-based judgment (Hastie et al., 1989). Importantly, more accessible considerations are more likely to be sampled in the consideration set (Bruner, 1957; Higgins & King, 1981; Wyer & Srull, 1989). That is, people construct their attitudes on the spot from the most accessible considerations.

The political predisposition and the level of political awareness are the only characteristics of the individual citizen determining the acceptance or refusal of newly encountered considerations from the mass media, party advertising and interpersonal communication. Interestingly, according to the Resistance Axiom, politically interested citizens are more resistant towards persuasive messages than politically uninterested citizens. The implications of this axiom will be tested in one of the sensitivity analyses conducted with the PASS model (see chapter 4).

With regard to the bin type model of memory neglecting any interrelations between the considerations, one could argue that the model is too simple to account for the richness of cognitive processes of citizens. Zaller anticipates this critique and argues as follows:

“The reason that I have left so much that I believe to be true out of the RAS model is, quite simply, that there has been no pressing need to include it. The machinery of the current model has been able to explain a large part of the variance in the existing survey evidence that seems presently amenable to systematic explanation, and I have been loathe to make the RAS model any more elaborate than necessary to do this.” (Zaller, 1992, p. 280)

Furthermore, in the current context of reviewing models of serial information integration, Zaller’s critique of the on-line model is noteworthy. He presents three arguments against the application of the on-line model in the political sciences. First, he doubts that the on-line model is applicable in the domain of political attitudes since most of the evidence cited in the review of Hastie et al. (1986) comes from experiments focusing on personality perception. Second, he argues that it is unrealistic that each persuasive message is immediately used to update all the attitudes it is relevant to.

“Thus, for example, a news story about the suffering of homeless people would, in the idealized world of on-line processing, require updates of attitudes toward the welfare system, the value of big government, the efficiency of capitalism, the president’s attempts to trim welfare spending, voluntary charity, the American way of life, among others – which is to say, many more subjects that a person could possibly rethink at the moment of encountering each new piece of political information.” (Zaller, 1992, p. 50)

The third argument interprets the on-line model as a theoretical regression back to the “true” attitude model. In Zaller’s view, the “true” attitude model cannot account for the considerable instability and context sensitivity of most of the political attitudes and has to be replaced by the perspective of constructing attitudes from accessible considerations.

## **The Procedural Model of Candidate Evaluation by Lodge**

Lodge and his colleagues have developed a procedural “on-line” model of citizens forming their impressions of political candidates (Lodge et al., 1989; Lodge & Stroh, 1993; Lodge, 1995; Lodge, Steenbergen, & Brau, 1995; Boynton & Lodge, 1996; Lodge & Taber, 2000). Nearly all the pivotal premises of the model are inspired by the assumption that instead of carefully evaluating and integrating political information about candidates, most citizens form holistic and rather affect-laden impressions.

The basic motivation of Lodge and his colleagues has been their skepticism towards the high correlations between the actual vote and the underlying reasons people report if they are prompted to (Kelley et al., 1974; Enelow et al., 1984). In Lodge’s view, most of the answers have to be re-interpreted as post hoc rationalizations (Anderson & Hubert, 1963; Nisbett & Ross, 1980) that are quite different from the true causes behind the voting decision. In a couple of laboratory experiments, subjects were presented with information material (pictures, slogans, policy statements etc.) from an artificial campaign. The amount of explicit recollections of argumentative details and even the retrieval of more general candidate positions was found to be very poor (Lodge et al., 1989; Lodge et al., 1995). Amazingly, in spite of their incomplete recollections, most of the subjects were able to choose the “right” candidate that was objectively closest to their issue positions. To solve this paradox, Lodge has introduced the on-line model of serial information integration into political psychology. Indeed, the on-line model is a valuable theoretical element within the explanation of the fact that the subjects were still capable to select the “right” candidate although they could hardly recollect any of the arguments provided in the raw material they were presented with. The basic idea behind the introduction of the on-line model in the context of citizen information processing was formulated first by Graber (1988):

“The fact that so little specific information can be recalled from a [news] story does not mean that no learning has taken place. The information base from which conclusions are drawn may be

forgotten, while the conclusions are still retained. This seems to happen routinely. Voting choices, for instance, often match approval of a candidate's positions even when citizens cannot recall the candidate's positions or the specifics of the policy. In such cases, media facts apparently have been converted into politically significant feelings and attitudes and the facts themselves are forgotten.”  
[cited in (Lodge et al., 1995, p. 113)]

Interestingly, Lodge combines the on-line model with the general framework of knowledge representation in associative networks (Anderson & Bower, 1973; Collins & Loftus, 1975) and with the assumption that the whole associative network is affect-laden (Fazio, 1986; Kunda, 1990; Damasio, 1994). The following is a description of the structural elements of his integrated model. Central to the network are the focal candidate nodes. They are linked to a set of “associative” sub-nodes that represent the information related to a particular candidate. The sub-nodes represent the rapidly decaying pieces of original information about the candidate's issue positions, specific behavioral traits and the most representative characteristics of the candidate's party. Each sub-node is associated with an affective tag reflecting the affective component of the sub-node's content. The affective tags are extracted from the original message and attached to each sub-node just at the moment of establishing the sub-node in the network. In contrast to the rapid decay of the original information, the valences of the affective tags are more enduring. The specific affective tags of the candidate nodes are referred to as “on-line tallies”.

The candidate-evaluation process is divided into four phases that are passed through after the citizen has encountered new information. First, new evidence related to a candidate is categorized according to the familiarity of that candidate. If just a few details of the candidate are known, the citizen looks for an available stereotype matching these details best. Subsequently, a copy from that stereotype including all the default sub-nodes forms the initial candidate node. If additional information of this candidate is encountered, the sub-nodes are adjusted and specified. In contrast, if the candidate is well known, the information is attached to the existing focal candidate node. If the candidate is unknown, an empty candidate node has to be built first.

At the moment of updating the evaluation of a particular candidate, the corresponding candidate node is activated. Following the associative network paradigm, some part of the activation spreads through the links of the network into the associative nodes and the most activated associations are retrieved into Working Memory (WM). The WM is considered as the locus of averaging the set of associations that have been

retrieved into the WM. The crucial assumption of the model is that the averaging process only integrates the *affective tags* attached to the sub-nodes and *not* the cognitive content of the sub-nodes themselves. This assumption is directly derived from the hypothesis formulated by Graber (1988) that most of the specific details underlying the affective tags are rapidly “forgotten” and cannot be retrieved for the process of information integration anymore. The result from the averaging process is the update of the on-line tally representing the global assessment of the candidate.

The model is not very explicit about the integration rule that is active in working memory. The main process is circumscribed as “averaging the affective weights of each association now ‘residing’ in working memory to the pre-existing affective tag attached to the candidate node” (Lodge et al., 1995, p. 126). The averaging rule “weighs one’s prior experience heavily”. Unfortunately, the model is not specific about the processes changing the weights of the links to the sub-nodes and the particular relative weight of the central on-line tally when building the average of all weights in WM. “On each cycle through WM, each concept node, as well as its connections, is strengthened, and thereby made more easily activated later. Conversely, of course, memory traces weaken over time, if not reactivated later.” (Lodge et al., 1995, p. 135)

As the last part of the model, when reporting the current judgement, citizens are supposed to apply the “how-do-I-feel” heuristic. In contrast to the memory-based model, they are not expected to retrieve and integrate all the “raw” content of the sub-nodes from scratch. Rather, they simply retrieve the ready-made on-line tally of the requested candidate and report its valence.

## **Summary**

This brief review of three influential models of serial information integration in political psychology (Abelson et al., 1963; Zaller, 1992; Lodge, 1995) demonstrates that the model to be developed in the following chapters can start from rich repository of ideas and empirically tested hypotheses.

Each of the three models presents some sort of mental representations and memory decay, and, in regard to the latest version of Lodge’s model, a mechanism of bolstering attitudes by discrediting uncongenial persuasive messages. Affective components are the main ingredients of the Lodge model. Nevertheless, the early Abelson/Bernstein model offers an amazing variety of motivational structures and processes. In

comparison, Zaller's RAS model mainly concentrates on the cognitive components of attitudes.

The question of interpersonal attitude exchange between citizens was only tackled in the Abelson/Bernstein model. Therefore, one of the main tasks of this PhD thesis will be to make the individual citizen's mind presented in the Zaller and Lodge model more social by explicitly simulating interpersonal communication.

The second task will be to bring the ideas from attitude strength from the discipline of social psychology into models of serial information integration in political psychology. In spite of the fact that the construct of attitude strength has started an exceptional "career" in social psychology, the models summarized above do not contain explicit treatments of the formation and change of the strength of attitudes.



### 3 Components of the Political Attitude Strength Simulation (PASS) Model

In this chapter, the pivotal theoretical cornerstones of the PASS model are presented. Additionally, in each section, a short sketch of the translation into the PASS model is described. The goal is to provide a general synopsis of the paradigms and theories underlying the specific assumptions of the PASS model. Since the present thesis does not include empirical studies carried out by the author himself, it is important to ground the model on empirically validated theorems and stylized facts that are widely accepted in the disciplines of social psychology and cognitive psychology.

#### **Micro-macro link**

The formation of political attitudes is an inherently social process. Citizens are not only *impersonally* influenced via the mass media and party advertising activities (Zaller, 1992; Bartels, 1993; Zaller, 1996; Dalton, Beck, & Huckfeldt, 1998; Schmitt-Beck, 2000; Curtice, Schmitt-Beck, & Schrott, 2002) but also *personally* via interpersonal political discussions (MacKuen & Brown, 1987; Knoke, 1990; Kenny, 1994; Huckfeldt & Sprague, 1995; Kenny, 1998; Nieuwbeerta & Flap, 2000; Schmitt-Beck, 2000).

The interdependence between mass media communication and party advertising on the macro level and interpersonal communication on the micro level has been widely neglected in research (Chaffee & Mutz, 1988; Reardon & Rogers, 1988). Most studies concentrated on the investigation of the relative dominance of one of the sources (Lazarsfeld, Berelson, & Gaudet, 1944; Robinson, 1976; Lenart, 1994; Schenk, 1995; Schmitt-Beck, 2000). In contrast, the PASS model entwines the attitude formation processes on the level of the individual citizen and the interpersonal exchange of these attitudes on the social level. The only computer simulation model known to the author that explicitly links the individual and the social component of attitude formation is the Abelson/Bernstein model (Abelson et al., 1963) described above.

#### **Low-involved mind-set**

The most fundamental assumption of the PASS on the level of the simulated cognitive processes is the assumption that citizens do not care much about their vote at voting

day. There is a growing body of evidence that citizens do not carefully evaluate the pros and cons of candidates and political parties (e.g. Hastie, 1986; Carmines & Kuklinski, 1990; Lodge & Taber, 2000). Two reasons may explain the minimal political involvement of citizens: First, the consequences of voting the “wrong” candidate are extremely weak. This gets obvious when contrasting the consequences of voting with the consequences of buying the wrong consumer product, accepting the wrong job, or marrying the wrong partner. Clearly, in these spheres of human life where stakes are high, the involvement in evaluating the available evidence is much higher. Second, voting issues often confront the citizen with a bulk of contradicting arguments from different sources. This impenetrable amount of (partly contradicting) information additionally causes resignation or at least activates heuristic strategies of decision-making (Chaiken, Liberman, & Eagly, 1989).

### **Motivational cognition**

The citizen’s political involvement mediates a great deal of cognitive processes in the PASS model. The notion of political involvement has been defined as the “interest in public affairs validated by keeping informed and expressed through participation in civic action” (Inkeles, 1974, p. 218). Following this definition, the initial involvement at the start of the simulated time period of 365 days before voting day is equated with the chronic or habitual interest of the citizen into the issue of elections. The chronic involvement is used as a measure of the amount of information that a particular citizen perceives during the simulated time span. Furthermore, it determines the level of resistance towards uncongenial persuasive messages [see the resistance axiom of Zaller (1992)]. Departing from the initial involvement, the level of the actual involvement gradually increases towards voting days according to the increasing frequency of campaign-related persuasive messages.

In the PASS model, at the moment of perception of a persuasive message, the current citizen involvement determines the decay speed of the trace left in the citizen memory. In other words, if the citizen has been in a highly involved mind-set at the moment of encountering some persuasive message, the accessibility of this persuasive message fades quite slowly. However, if the citizen has been in a weakly involved mind-set, the accessibility of the persuasive message is supposed to decay very rapidly (Burnkrant & Sawyer, 1983; Greenwald & Leavitt, 1984; Park & Hastak, 1994) (Lingle & Ostrom,

1979; Lichtenstein & Srull, 1985; Baker & Lutz, 1987; Lynch, Marmorstein, & Weigold, 1988; Park et al., 1994). In summary, since the citizen involvement generally grows towards voting day, the elaboration depth of the citizen memory steadily increases. As another consequence of this conceptualization, persuasive messages that are perceived in a low involved mind-set are difficult to retrieve at a later point in time, even if in the meantime, the involvement has grown considerably.

### **Focus on affective attitude components**

Attitudes can be divided in a more affective (emotion-based) and a more cognitive (belief-based) component (Breckler & Wiggins, 1989). Yet, the effect of the cognitive attitude component is not treated explicitly in the PASS model. In parallel to the Lodge model (Lodge et al., 1989; Lodge, 1995), at the moment of encountering a particular persuasive message, only its main affective components (the affective valence and the credibility) are “extracted” and encoded in long-term memory. There are four reasons justifying the focus on the affective attitude component:

When a persuasive message from the campaign is encountered (watching TV, reading newspapers or passing a poster), the affective component is formed almost instantaneously whereas the cognitive component requires some minimal time and motivation to be established (Zajonc, 1980). Under the low involvement condition typical for the reception of political information, the cognitive component is often poorly elaborated and tends to be forgotten very rapidly (Lodge, 1995) (Verplanken, Hofstee, & Janssen, 1998). In contrast, the affective evaluation tends to remain highly accessible for a long time. After a few days or weeks, the results is a clear dominance of the affective memory traces over the cognitive memory traces.

Frequently, the affective and the cognitive component are highly correlated and partly redundant (Ostrom, 1969; Bagozzi & Burnkrant, 1979; Breckler, 1984; Breckler et al., 1989; Esses, Haddock, & Zanna, 1993). However, if there is affective-cognitive inconsistency (Abelson, Kinder, Peters, & Fiske, 1982) (Stangor, Sullivan, & Ford, 1991) (Thompson, Zanna, & Griffin, 1995b; Jackson, Hodge, Gerard, Ingram, Ervin, & Sheppard, 1996; Cacioppo, Gardner, & Berntson, 1997), the primacy of affect hypothesis might come into play: “(...) when affect and cognition have conflicting evaluative implications, individuals will rely to greater extent on their emotional reactions to an attitude object than on their beliefs about an attitude object’s attributes in

determining their overall attitudes and attitude-relevant behavior.” (Lavine, Thomson, Zanna, & Borgida, 1998, p. 402). The primacy of affect hypothesis is expected to be particularly valid under the condition of low involvement.

Closely related to the primacy of affect hypothesis is the „how-do-I-feel“ heuristic pointing to the *deliberative* and *strategic* use of affective information in decision-making (Schwarz & Clore, 1988) (Lodge et al., 1989). People apparently trust in their feelings as an important source of information not only if they are weakly involved, but also if they are highly involved.

- The private atmosphere of the voting-booth reduces social desirability effects on behavior to a minimum. Citizens are not motivated to adapt their immediate „how-do-I-feel“ heuristics in the direction of a more rational attitude that might be more easy to justify in public. They feel free to express their judgement even if they would not be able to recollect any explicit argument.

In summary, considering the principle of parcimony in modeling, the focus on the affective component of citizen’s attitudes might provide an elegant first approximation of the citizen’s mental processes.

### **Explicitness of memory decay and implicit memory effects**

In the PASS model, the extract of every persuasive message is individually represented and leaves some explicitly simulated trace in memory. This trace steadily decays and its accessibility approximately approaches zero. Translated into reality, very weakly accessible traces would be out of the reach of introspection or self-report (Kihlstrom, 1987) and were subjectively felt as “forgotten”. However, such “forgotten” traces have proved to have still an effect on judgements (Greenwald & Banaji, 1995; Dovidio, Kawakami, Johnson, Johnson, & Howard, 1997). Therefore, the PASS model does not include a mechanism of cutting off very weakly accessible memory traces. Rather, every memory trace is individually simulated even if its isolated impact could be neglected. The gist of this way of modeling the citizen’s memory is that a great number of very old “forgotten” persuasive messages can outweigh a single, but recent opposite persuasive message.

## **Attitudes as ad hoc constructions**

The attitude-as-constructed perspective (Wilson & Hodges, 1992; Erber, Hodges, & Wilson, 1995; Schwarz & Bohner, 2001) considers attitudes as ad-hoc constructions composed of currently salient basic beliefs that are sampled from long-term and working memory. That is, the instability of attitudes is reduced to the instability of salient beliefs or “considerations”. There is not necessarily a measurement error (Achen, 1975) or a random answer out of nowhere (Converse 1970) explaining the instability of political attitudes (Tourangeau, Rasinski, Bradburn, & D'Antrade, 1989). Rather, according to the accessibility perspective, there is simply an underlying set of beliefs which are differently accessible at different points in time.

There is a weak and a strong version of the attitudes-as-constructed perspective. The weak version argues that only weak attitudes are constructed from currently accessible beliefs. In this view, strong attitudes are well-crystallized ready-made “files” that can be retrieved from long-term memory if some judgement is requested. Such “true” attitudes are conceptually close to the traditional attitude concept (Abelson, 1988; Boye, Slora, & Britton, 1990; Prislin, 1996).

The strong version goes one step further and proposes that even strong attitudes (e.g. consistent, extreme, highly accessible, and embedded in the self-concept) are re-constructed from scratch if some judgement is requested. As Schwarz (Schwarz et al., 2001) clearly points out, the current evidence is in accordance with both versions:

- The conclusion that at least *strong* attitudes are ready-made attitudes cannot be derived from the observation that specifically strong attitudes are stable over time. First, the strong attitudes-as-constructed perspective simply supposes that the underlying belief accessibilities have been stable over time. Second, the strong attitudes-as-constructed perspective assumes that the underlying belief structure of strong attitudes is larger than that of weak attitudes. Hence, an additional piece of information has a larger impact on the small belief structure of weak attitudes than on the extended belief structure of strong attitudes.

The conclusion that attitudes are retrievable files cannot be derived from “very fast” response times found especially if subjects are asked for strong attitudes (Fazio & Williams, 1986). First, even if the responses are categorized as “fast” on some scale of every day experience, the underlying integration processes can simply be faster. Second,

the belief structure of most strong attitudes has been found to be highly consistent, well-elaborated and densely knit (Bassili, 1996; Krosnick, Boninger, Chuang, Berent, & Carnot, 1993). Thus, referring to the spreading activation model of memory, the strong attitudes-as-constructed perspective agrees that strong attitudes be activated “very fast”. The implementation of the attitude revision process in the PASS model is closely related to the strong version of the attitudes-as-constructed perspective. As soon as a new persuasive message is encountered, a sequence of bottom-up integration steps is activated starting from the current memory traces of the extracted persuasive messages. That is, the PASS model revises the attitude from scratch when ever new evidence is added to the memory (see the following section).

### **Continuous judgement revision**

The crucial assumption behind this principle is that updating judgements does not necessarily require conscious control. There is growing evidence from research on implicit cognition (Kihlstrom 1987, Bargh 1992, Greenwald 1995) that the unconscious is “conscious” in the sense that it is not restricted to simple feature detection and pattern recognition. Rather, at least simple semantic contents can be evaluated automatically (Greenwald & Liu, 1985). In his review on the relationship between conscious and unconscious mental processes, Kihlstrom puts it like this:

“One thing is now clear: consciousness is not to be identified with any particular perceptual-cognitive functions such as discriminative response to stimulation, perception, memory, or the higher mental processes involved in judgment or problem-solving. All of these functions can take place outside of phenomenal awareness. Rather, consciousness is an experiential quality that may accompany any of these functions.” (Kihlstrom, 1987, p. 237)

The frequency of attitude revisions in the PASS model is relatively high (almost in every time step, i.e. almost daily). This is certainly implausible if the revision process is allocated in the realm of conscious processes. People do not interrupt their activities every day in order to think for some minutes about politics. However, if the majority of the attitude revisions are conceived as performed in the unconscious, high revision frequencies are conceivable.

### **Attitude strength**

Not all attitudes are held with the same conviction (Abelson, 1988). Some attitudes are based on a relatively large network of beliefs (Davidson, Yantis, Norwood, & Montano,

1985), are highly elaborated in terms of a high level of internal consistency (Norman, 1975; Thompson et al., 1995b) and therefore rather extreme (Judd & Johnson, 1981). Other attitudes rely on rather fragmented pieces of knowledge that are insufficiently embedded in the self-concept (Scott, 1969) or value system (Rokeach, 1968). Such weak attitudes tend to be subjectively judged as unimportant (Krosnick, 1988), uncertain (Fazio & Zanna, 1978; Gross, Holtz, & Miller, 1995) and are not highly accessible (Fazio et al., 1986; Bargh, Chaiken, Govender, & Pratto, 1992). Additionally, subjects do not feel much emotional commitment (Pomerantz & Chaiken, 1995) that would be required to defend weak attitudes against uncongenial evidence.

Attitude researchers have tried to tackle the bewildering variety of dimensions that have been proposed to characterize attitude strength. The first factor analysis was conducted by Abelson (1988) resulting in three main components of attitude strength: ego preoccupation, emotional commitment, and cognitive elaboration. A similar analysis found that the more cognitive component of embeddedness subsumes the dimensions of importance, knowledgeability, value representativeness, and centrality within the self-concept, whereas the more affective component of commitment subsumes the dimensions of certainty and extremity (Pomerantz et al., 1995). However, there is still an ongoing discussion about the dimensionality of the antecedents of attitude strength.

In contrast to the *antecedents* of attitude strength, there is some consensus regarding the *consequences* of attitude strength. For example, attitude strength is positively correlated with attitudinal effects on thought and behavior (Fazio et al., 1986; Krosnick & Abelson, 1992; Krosnick et al., 1993). Strong attitudes are more resistant to social influence (Borgida & Howard-Pitney, 1983) and cause a tendency towards all forms of confirmation biases in information processing (Lord, Ross, & Lepper, 1979; Fazio et al., 1986). In summary, following the definition of Krosnick and Petty (1995), strong attitudes i) lead to selective information processing, ii) are resistant to change, iii) are persistent over time, and iv) are predictive of behavior. The comprehensive scope of this definition is the reason to make the additional effort of simulating attitude strength in the present model of citizen information integration and behavior. Given that strength-related aspects of attitudes are indeed decisive for the understanding of attitude change and behavior, the explicit simulation of attitude strength is a necessary part of models of advertising effectiveness.

In the PASS model, the levels of citizen involvement (Krosnick, 1988; Liu et al., 1998; Lavine et al., 2000; Bizer et al., 2001), attitudinal ambivalence (Thompson et al., 1995b; Huckfeldt et al., 2000; Lavine, 2001), and attitudinal extremity (Miller, Mchoskey, Bane, & Dowd, 1993; Liu et al., 1998) are used to estimate the level of attitude strength. Citizen involvement has already been defined above as “interest in public affairs validated by keeping informed and expressed through participation in civic action” (Inkeles, 1974, p. 218). The dimension of attitudinal extremity is conceptualized as the distance of the attitude valence from the zero point of perfect indifference between extreme disfavor and extreme favor. The subjectively felt ambivalence is circumscribed as “the result of multiple response alternatives that are perceived as being equally available and attractive, with nonetheless have contradictory implications” (Thompson & Zanna, 1995a, 260-261). In summary, persuasive messages are likely to change tempered and highly ambivalent attitudes of weakly involved citizens. On the other hand, persuasive messages probably will have marginal effects on extreme and highly consistent attitudes of highly involved citizens.

### **Individual anchoring**

Primacy effects occur if pieces of information encountered early in a temporal sequence have a greater impact on the final judgement than pieces of information encountered later. The assumption of a temporal sequence is true for the great majority of judgmental tasks like long-term impression formation of persons, of a product innovation or, like in the PASS model, of political parties. Forming an impression of a person, a consumer product, or a political party is a continuous revision process extending over days, weeks, years or even a longer time.

Since several decades, the biased nature of this revision process (if the Bayesian belief revision is taken as the reference) has captured the attention of cognitive psychologists. Early experiments detected primacy effects in forming personality impressions of persons (Asch, 1946; Luchins, 1957; Anderson & Barrios, 1961). Apart from these initial studies, later experiments found a broad range of confirmation biases as a subtype of primacy effects. The variety of confirmation biases can be categorized into two major groups (Klayman, 1995): i) confirmation biases due to biased *search* for new evidence and ii) confirmation biases due to biased *interpretation* of new evidence.



The first group comprises evidence demonstrating that humans selectively look for information that is promising for the verification of their initial hypothesis (the so called “positive test strategy”) (Wason, 1960; Klayman & Ha, 1987). Selective perception was not found to play a major role in the domain of political persuasion (Zaller, 1992; Huckfeldt & Sprague, 1993; Schmitt-Beck, 2000). Therefore, for the sake of parcimony, this type of confirmation bias is neglected in the PASS model and will not be followed up here.

The second group of studies provides evidence for the effect that people evaluate the credibility of new information in a manner that preserves their initial hypothesis (Nisbett et al., 1980; Kunda, 1990; Edwards & Smith, 1996). As a rule, the credibility of congenial information is judged to be higher than the credibility of information that is inconsistent with their initial hypothesis. This principle of adjusting the credibility is contingent on the congeniality between the affective message extract and the current attitude is implemented in the PASS model. Recently, the “disconfirmation model” was proposed as an account for these effects (Edwards et al., 1996). When people are presented an argument, they are supposed to perform an automatic memory search yielding an initial judgement of the compatibility of the argument with some prior beliefs. If the argument turns out to be incompatible, the person engages in an additional deliberative memory search that is aimed at finding useful material for undermining the repudiated argument. Finally, the quality of the argument is judged in the light of the material from this additional memory search. The prediction is that the incompatible argument clearly will be discredited, hence producing the (dis-) confirmation bias. On the other hand, if the argument is compatible at face value, no further memory search is performed and the argument is confirmed. The hypotheses of this model is that i) it takes significantly longer to evaluate incompatible arguments and that ii) more thoughts and arguments are produced because of the extra memory search. In their experiments on issues like death penalty, striking children, and blood alcohol level checks, Edwards and Smith (Edwards et al., 1996) found clear support for both hypotheses.

There are several theoretical candidates for the motives driving this type of confirmation bias. For example, people generally seek for consistency (Festinger, 1957; Abelson, Aronson, McGuire, Newcomb, Rosenberg, & Tannenbaum, 1968), try to protect their self-esteem (Greenwald et al., 1995) and want to maintain existing cognitive closure (Kruglanski, Freund, & Shpitzajzen, 1985).

## **Ego-centric network homogeneity and social anchoring**

The PASS explicitly includes the size and composition of political discussion networks as found in empirical studies (Schenk1995, Schmitt-Beck 2000).

The composition of the discussion environment of a specific citizen (her/his political ego-centric network) is crucial for the evaluative composition of persuasive messages from the mass media and the party advertising that ultimately get in touch with that citizen (Schenk1995, Schmitt-Beck 2000). The underlying assumption is that the contents treated in the mass media and the party advertising activities serve as the main input for the specific content treated in interpersonal discussions about political issues (Troidahl & van Dam, 1965; Atwood, Sohn, & Sohn, 1978; Kepplinger & Martin, 1986). This assumption is known as the “secondary diffusion hypothesis” (MacKuen et al., 1987; Mondak, 1995; Schmitt-Beck, 2000). The core implication from this hypothesis is that asymmetric media coverage increases the number and quality of the arguments of the partisans that support the party that is preferred by the media coverage. *Visa versa*, the supporters of the neglected party are largely missing good arguments for their position. The first systematic test of this mechanism was conducted based on data from the Comparative National Elections Project (CNEP) which encompasses data material from five nations. In spite of the plausible assumptions, the analysis did not find supporting evidence for the hypothesis of secondary diffusion (Schmitt-Beck, 2000).

The “filter hypothesis” (Katz & Lazarsfeld, 1955) proposes the opposite causal direction between interpersonal communication and the mass media. The social environment of the citizen is seen as a filter for persuasive messages coming from the mass media. That is, the composition of the individual political discussion network determines the degree of acceptance or refusal of the arguments from media coverage.

There is sparse but unanimous evidence in the literature that ego-centric networks are composed significantly more homogeneously than they would be if they were composed by a random principle (Berelson, Lazarsfeld, & McPhee, 1954; Rogers & Bhowmik, 1970; Schenk, 1995; Schmitt-Beck, 2000).

According to the filter hypothesis, individuals tend to have ego-centric networks with homogeneous and concordant discussants and are socially bolstered against uncongenial

persuasive messages. There are three possibilities that citizens are likely to get in contact with uncongenial arguments:

- the citizen has no discussant network at all
- the citizen has an ego-centric network with only neutral discussants
- the citizen has an ego-centric network with heterogeneous discussants.

These networks and the non-network are seen as “open flanks”, where persuasion can “break in” (Berelson et al., 1954). The specific mechanism behind the filter hypothesis proposes that individuals evaluate messages perceived directly from the mass media and political advertising by discussing them with the citizens included in the ego-centric network. If the ego-centric network is homogeneous and concordant with the focal citizen, congenial messages will be evaluated positively and uncongenial messages will be evaluated negatively in all discussions. In contrast, if the ego-centric network is heterogeneous, there is some probability that a congenial message is evaluated negatively and that an uncongenial message is evaluated positively.

The following tables provide a synopsis of the effects of different ego-centric network compositions. The first table summarizes the effects if a message is released that is concordant (see table 3.1) with the party identification of the focal citizen. The second table summarizes the effects if a message is discordant (see table 3.2) with the party identification of the focal citizen. The same effects are expected, simply *visa versa*.

Table 3.1: The evaluative content of the message is pro A (*concordant* with the predisposition of the focal citizen).

		composition of ego-centric network		
	no discussants, discussants without party identification	homogeneous ego-centric network pro A	heterogeneous ego-centric network	homogeneous ego-centric network pro B
evaluation of message by discussants within ego network	no evaluation	positively	positively and negatively	negatively
ultimate effect of the message on focal citizen	open flank; direct impersonal influence	reinforcement; strong influence to accept message	open flank; mixed influence to accept resp. refuse message	blockade; strong influence to discard the message

Table 3.2: The evaluative content of the message is contra A (*discordant* with the predisposition of the focal citizen).

		composition of ego-centric network		
	no discussants, discussants without party identification	homogeneous ego-centric network pro A	heterogeneous ego-centric network	homogeneous ego-centric network pro B
evaluation of message by discussants within ego network	no evaluation	negatively	positively and negatively	positively
ultimate effect of the message on focal citizen	open flank; direct impersonal influence	blockade; strong influence to discard the message	open flank; mixed influence to accept resp. refuse message	reinforcement; strong influence to accept message

The empirical background of the filter hypothesis is based on very few but highly significant studies. At least, citizens with homogeneous ego-centric networks (in regard to the party preference, party memberships, and other indicators like religious groups) appear to have more stable attitudes than citizens with more heterogeneous social environments (Zuckerman, Valentino, & Zuckerman, 1994). Additionally, Schmitt-

Beck found significant support for the filter hypothesis in the CNEP data (Schmitt-Beck, 2000).

In the PASS model, the social anchoring effect is yielded as the citizens exchange their current party preference within their individual political discussion network. That is, neither the precise mechanisms of the secondary diffusion nor the mechanisms of the filter hypothesis are implemented in the PASS model. Rather, the focus is on capturing the general effects of different compositions of ego-centric networks as they are presented in the bottom rows of the tables 3.2 and 3.3. It is supposed that these final effects are similar for both the secondary diffusion and the filter hypothesis.

Importantly, because the ultimate effects of persuasive messages are contingent on the composition of the micro-environments, the virtual citizens in the PASS model are interconnected non-randomly according to available data sets on the homogeneity of political discussant networks (Weigelt, 2001).

## 4 Towards Optimal Temporal Resource Allocation of Advertising Activities in Election Campaigns

### Introduction

As an important part of any campaign strategy, political parties have to think about the most cost-effective way of timing their campaign activities. Surprisingly, the issue of optimizing temporal resource allocation is not treated explicitly in any of the most common handbooks and guidelines on campaigning (Radunski, 1980; Wolf, 1980; Newman, 1994; Kavanagh, 1995; Thurber & Nelson, 1995; Althaus, 2001). They are more or less descriptive in style and do not systematically discuss or test the psychological effects of different ways of temporally allocating political advertising resources. Rather, the authors leave the question of allocation to the intuition and personal experience of the party strategist. In contrast, during the last decades, researchers in consumer product advertising have clearly recognized the importance of systematically investigating optimizing temporal resource allocation given a certain advertising budget (Zielske & Henry, 1980; Baker et al., 1987; Reichel & Wood, 1997; Naik, Mantrala, & Sawyer, 1998).

We have developed an agent-based computer simulation model which is able to conduct several thousand competitive election campaigns. The model is one of the first steps to bring the research field of optimizing temporal resource allocation from product advertising into the field of political advertising during election campaigns. The specific goal of this chapter is to use this model to explore the relative effects of different degrees of accumulating political campaign activities towards voting day. The compared strategy patterns have the general form of “*when* to advertise with *what* intensity” (see figure 4.2 on p. 44).

The central concept capturing the effectiveness of different advertising patterns are the citizens’ final attitudes towards two opposite parties on voting day. Attitudes are commonly defined as “a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor” (Eagly & Chaiken, 1993, p. 1). Thus, an attitude comprises of its valence (in terms of favor or disfavor) and its extremity (in terms of the degree of favor or disfavor).

Every model aimed at integrating the effects of a given temporal advertising pattern on attitudes requires some explicit component that represents human memory decay and produces *recency* effects. These effects are present if information encountered more recently is more dominant in the final judgement than earlier information. The second (complementary) component is the simulation of *primacy* effects induced by the human tendency of confirming congenial evidence and disconfirming uncongenial evidence during sequential information integration (Edwards et al., 1996). This sort of confirmation bias results in a temporal stabilization of attitudes. The third component we consider as indispensable in the context of political attitude formation is the simulation of interpersonal influence within relatively *homogeneous* social networks as another mechanism of stabilizing attitudes (Schenk, 1995). The concurrence of these three basic components of human information processing constitutes the primacy-recency dilemma of optimal timing which has been debated in consumer advertising research since the 1960s (for a review, see Reichel et al., 1997). In the shortest form, this dilemma is as follows: early advertising efforts profit from individual and social attitude stabilization effects, whilst late advertising efforts profit from less advanced memory decay.

Since the success or failure of a party's resource allocation strategy is eventually measured by the success or failure of that party on voting day, the model has to include at least some rudimentary sub-model of the citizen's voting behavior on voting day. Regarding this requirement, the components introduced above exclusively focusing on attitude formation are insufficient. There is a well-documented gap between knowing what people think in terms of attitudes and what they do in a particular situation. Confronted with this predictive validity problem for attitudes, attitude research has started to focus on the *strength* of attitudes (e.g. Doll & Ajzen, 1992; Petty & Krosnick, 1995; Eagly & Chaiken, 1998). The aim of attitude strength research is to reduce the explanatory gap between attitudes and behavior (Kokkinaki & Lunt, 1997; Franc, 1999). The underlying assumption is that attitudes with characteristics like high extremity, intensity, certainty, importance, accessibility, or consistency have strong effects on intentions and behaviors (e.g. Fazio & Zanna, 1978; Bargh, Chaiken, Gollwitzer, & Pratto, 1992; Vallacher, Nowak, & Kaufman, 1994). Furthermore, strong attitudes with these characteristics have been shown to be more resistant towards external influence and thus are more persistent over time (Krosnick et al., 1992). In this chapter, attitude

strength is modeled by simulating the attitudinal extremity, the attitudinal involvement, and the attitudinal ambivalence. The attitudinal extremity captures the distance of the valence of the attitude from the zero-point of perfect indifference between extreme favor and disfavor (Miller et al., 1993). The attitudinal involvement is equated with the political involvement of the citizen and is defined as the “interest in public affairs validated by keeping informed and [is] expressed through participation in civic action” (Inkeles, 1974, p. 218). The attitudinal ambivalence expresses “the result of multiple response alternatives that are perceived as being equally available and attractive, which nonetheless have contradictory implications” (Thompson & Zanna, 1995 p. 260-261). The benefit of simulating these three attitude characteristics is the possibility to distinguish between citizens that will participate and bring their attitude into play and citizens that will not participate on voting day. Thus, besides simulating citizen conversion in terms of attitude valence formation, the model also addresses the question of citizen activation (Lazarsfeld et al., 1944) in terms of attitude strength formation.

## **Model description**

After a short presentation of the guiding principles during the model building process, this chapter provides a short outline of the structures and processes upon which the model is based. The chapter proceeds in a top-down manner. In the first part, the central actors and processes on the *social* level are portrayed. The second part describes the cognitive units and the cognitive processes of revising the citizen’s attitude if new evidence is encountered on the *mental* level.

## ***Principles of the model developing process***

In this section, the principles that have guided the model construction are discussed.

The first principle is necessity. The primacy-recency dilemma of optimally timing campaign resources cannot be solved by paper-and-pencil contemplation about the social psychology of human information processing, about interpersonal communication, and about political advertising. The literature presents rather contradicting arguments related to the temporal formation of advertising effects. Additionally, the problem includes many characteristics to which human cognition is rather poorly adapted like dealing with positive feedback, temporal evolution, and predicting macro level behavior from micro processes (Frensch & Funke, 1995). To be



sure, implementing a computational simulation model is time-consuming and requires quite advanced programming skills. Whenever the problem can be solved without the aid of computers, computational models should be avoided. If however, as here, the problem is too hard to be addressed by working on theorems from the literature and applying the paper-and-pencil approach, the simulation method should be tried.

The second principle is conceptual parsimony. Even if our model may appear complex, it is quite simple compared to the complexity of the real system. However, sensitivity analyses will bring to light which modules of the model can be turned off without significant changes of the model behavior.

The third principle is modularity. It can be derived from the second: the model should be constructed as a network of interdependent modules that can be separately switched on and off. For example, if a simulation result is surprising, rendering specific modules inactive can help find the underlying causes. The same procedure can be used to efficiently detect the location of “bugs” in the computer code.

The fourth principle is, where ever possible, to base the model on empirical data. Elections belong to the best-investigated areas of research on attitude formation and change. The relative richness of data sources including data of the social network structure of citizens from the CNEP (Schmitt-Beck, 2000), allows to sufficiently estimate most of the model parameters, although there are still some parameters that had to be assumed without data (see Appendix I on p. 77ff.).

The fifth principle aims at meaningful model behavior on the micro level of mental processes. The main advantage of meaningful model behaviors on the micro level is that the modeler can trace back emerging patterns on the macro level to micro processes on the level of cognitive psychology. If our model would be based on a neural network that would produce the same aggregate output from the same input parameter the modeler could not explain the results in the language of cognitive psychology. The modeler could only talk about the weights of the network nodes, the learning algorithm and other technical details. In our view, the gist of computational models in social psychology is not that they simply reproduce well-known patterns on the aggregate level. Rather, the models should help to find meaningful sets of assumptions that help to explain the patterns on the macro level. After this review of the model building guidelines, the end product of the development process is described in the next sections.

### The social level

Since the formation of attitudes has been documented to be an inherently social phenomenon (Lenart, 1994), it is necessary to include the social level in a model of citizen behavior. The model comprises of three different types of social actors: the party strategists, the mass media, and the citizens.

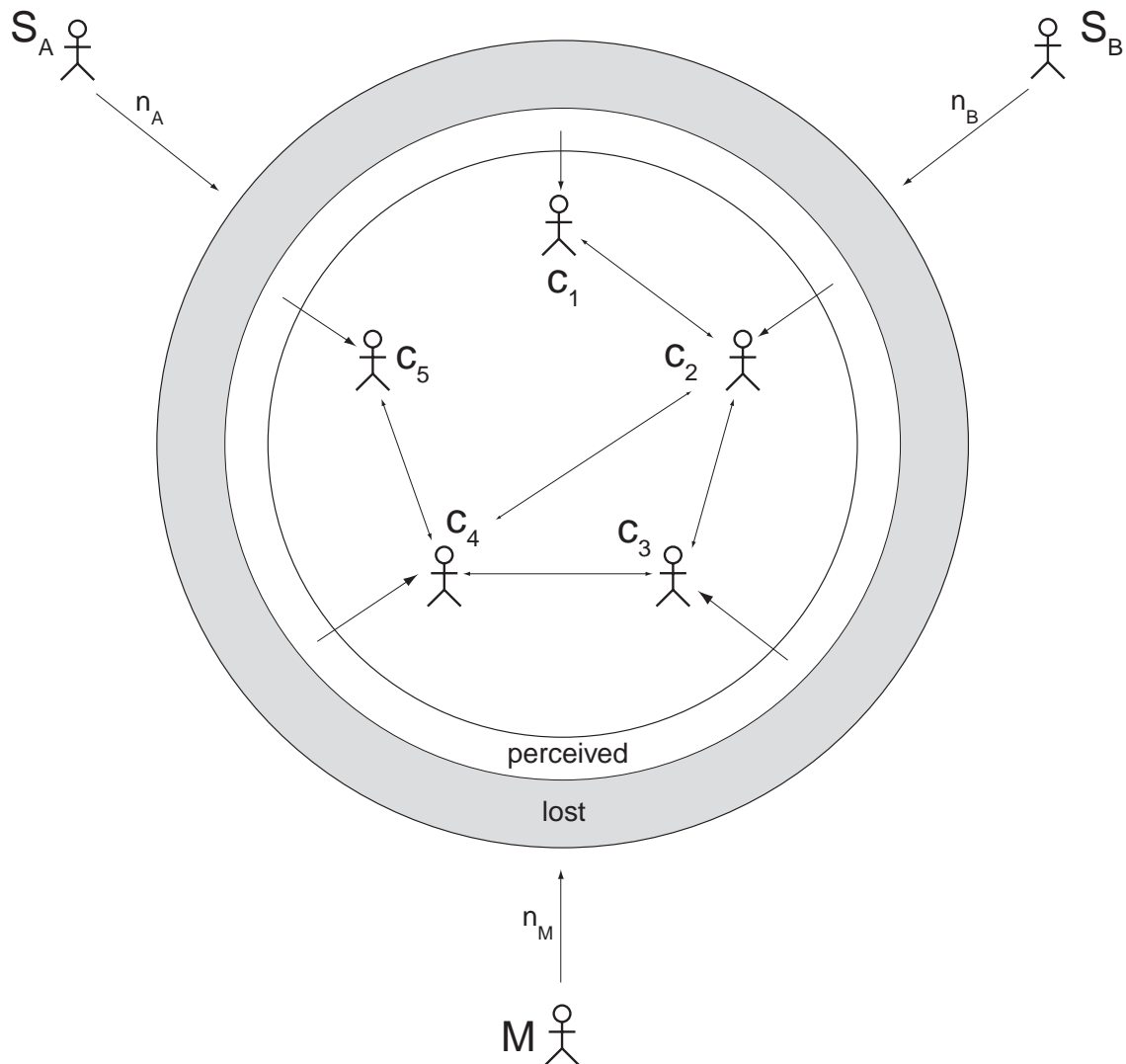


Figure 4.1: Overview of the social level. The center of the graph depicts a citizen network representing five citizens  $c_1$  to  $c_5$ . In each time step, the citizens perceive a fraction of persuasive messages from the “campaign arena” depending on their habitual interest in the elections (the light ring denotes “perceived” messages, whereas the dark ring denotes “lost” resp. not perceived messages). In each time step, the strategists  $S_A$  and  $S_B$  and the mass media  $M$  post a specific number  $n_i$  of persuasive messages on the campaign arena according to their temporal campaign strategy.

The strategists and the mass media represent external sources of persuasive messages released in the form of TV news, TV spots, newspaper articles and ads, posters, brochures, bumper stickers etc. These persuasive messages permanently affect the attitude formation and communication process of the citizens (see figure 4.1).

### The Parties and the Mass Media

Two opponent strategists constitute the competitive setting in the model. They represent parties like the Democrats and Republicans in the USA, the Labour Party and the Conservative Party in Great Britain, or temporary party blocks like the CDU-CSU-FDP *Parteilager* and the SPD-Grüne *Parteilager* in Germany. To keep the model general, the two parties or party blocks are just called party *A* and party *B* in the remainder of the chapter.

At the start of the simulation ( $H$  days previous to voting day), the parties make the strategic decisions of choosing between different degrees  $\psi$  of accumulating campaign resources toward voting day (see figure 4.2).

The strategists are assumed to be completely ignorant and independent of the decision-making of the competitor. The design of independence has been selected to systematically explore the whole space of possible strategy encounters between party *A* and party *B* even if the extremes are quite unrealistic (e.g.  $\psi = 0$  or  $\psi = 64$ ). As a second modeling assumption, both parties have an identical budget  $Y$  and an identical level of permanent advertising activities  $\rho$ . They are enforced to expend all of  $Y$  during the campaign. The budget restriction is essential to isolate the effects of different temporal resource allocations from the effects of simply varying the campaign spending.

Apart from the parties, the mass media are the second actor type present in the public sphere. This actor is used to model the non-commercial coverage in the newspapers, television, broadcast, and the Internet. Importantly, their coverage is not supposed to be neutral. Rather, the predominance of coverage on party *A* or party *B* reflects the current campaign activities of the parties. This automatic amplification effect of party activities is explicitly modeled, since parties have proven to be successful in deliberately launching pseudo-events designed to become news stories in the mass media (Schmitt-Beck & Pfetsch, 1994).

*Release of persuasive messages*

In each time step, the parties *A* and *B* put a certain number of persuasive messages on a virtual “campaign arena” according to their accumulation strategy (see eq. 4.1 and figure 4.2).

$$n_{r,j}(t_k) = (t_k + 0.5)^{\psi_j} \cdot \frac{Y_j \cdot (1 - \rho) \cdot (1 + \psi_j)}{H^{1 + \psi_j}} + \frac{Y_j \cdot \rho}{H} \quad \text{with } j \in \{A, B, M\} \quad [\text{eq. 4.1}]$$

The number of released persuasive messages  $n_{r,j}(t_k)$  is a relative measure of the level of campaign activities of party *j*. For example, three persuasive messages in time step  $t_k$  in relation to six persuasive messages in time step  $t_{k+1}$  means doubling the campaign activities in time step  $t_{k+1}$ , i.e. doubling the level of advertisements in newspapers and TV channels, doubling the level of distributing posters and brochures, doubling the level of launching PR events and broadcasting political speeches etc. At the end of each time step  $t_k$ , all persuasive messages on the campaign arena are cleared for the new persuasive messages released within the next time step.

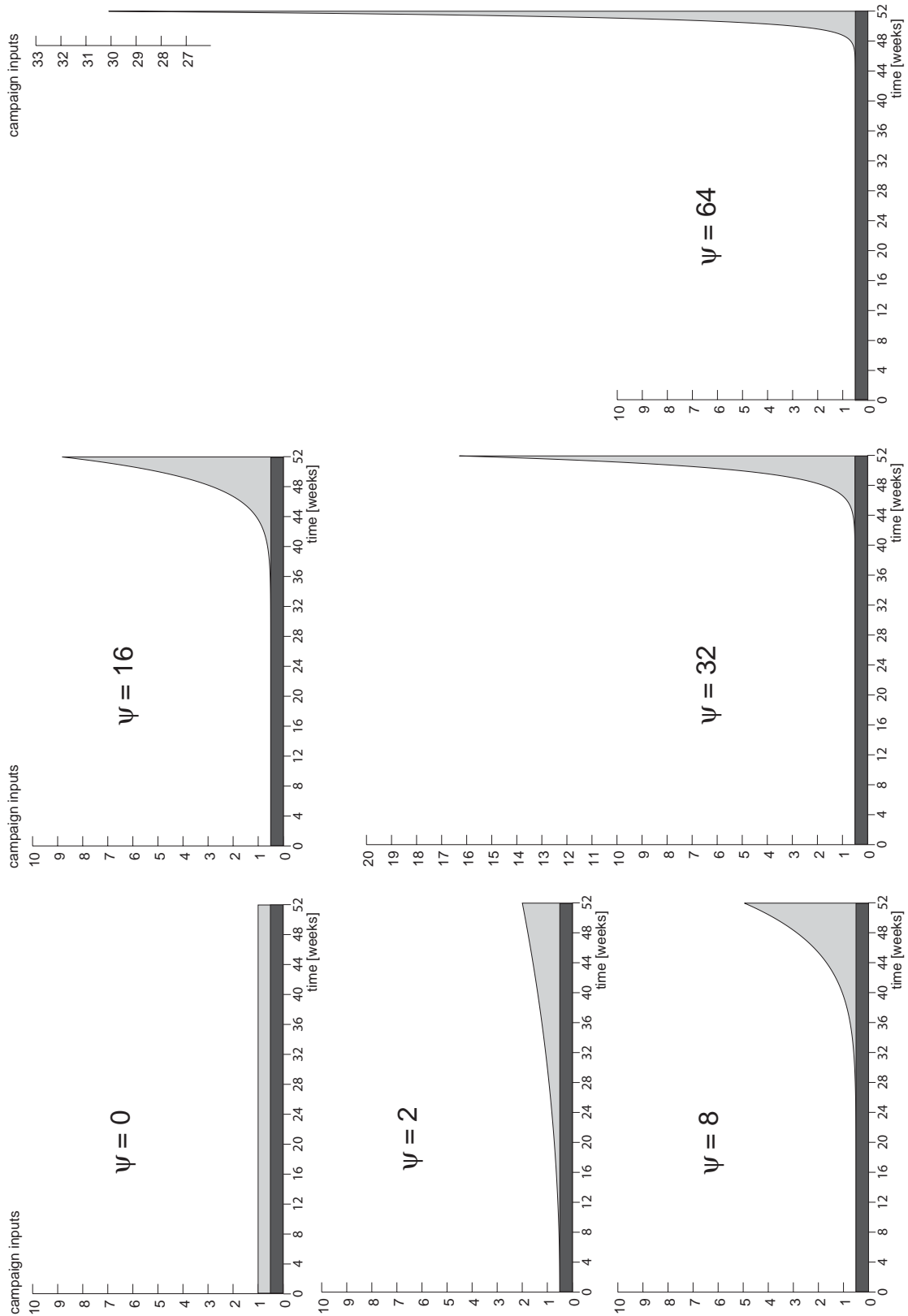


Figure 4.2: Increasing degrees  $\psi$  of accumulating half of the budgeted party advertising activities (light area) during one year before voting day. The other half of the budget (dark area) is spent for permanent party advertising activities (baseline campaigning).

The mass media  $M$  put a more or less one-sided coverage for and against both parties on the campaign arena. They accumulate at the degree of  $\psi = 2.0$  assuming a relatively permanent, but slightly increasing coverage towards voting day. The coverage from the media is distorted according to the automatic amplification effect of party activities. The modeler can set the maximum distortion level  $\varpi$  of the media coverage. For example, if  $\varpi = 0.15$  and party  $A$  is extremely active while party  $B$  is totally inactive, the distortion of the media coverage  $A:B$  is maximal at the level of  $(0.5+\varpi) : (0.5-\varpi) = 65:35$ . In less extreme cases, the distortion is somewhere between the maximum distortion and the 50:50 neutral coverage.

## The Citizens

The simulation comprises of a population of citizens in a social network representing a basic cell of the real population. The citizens' minds are boundedly rational in a double sense: i) they do not have access to every piece of information available on the campaign arena and ii) the information integration process is biased itself. The biases this model takes into account in the integration process are the *availability bias* (Tversky & Kahnemann, 1974) due to the decay of memory content, the *confirmation bias* (Klayman, 1995) due to the tendency of bolstering attitudes, and the *homogeneity bias* (Berelson et al., 1954; Schenk, 1995) due to the relatively homogeneous social networks of political discussants. The specific mental processes will be discussed in the section "The cognitive level".

### *Citizen perception*

Different citizens are more or less interested in elections (see section "Citizen initialization" on p. 60ff.). The individual number of persuasive messages  $n_{p,c}(t_k)$  perceived out of the whole set of inputs  $n_{r,tot}(t_k)$  on the campaign arena is proportional to the individual level  $I_c(t_k=0)=I_{0,c}$  of habitual interest into elections of citizen  $c$  (see eq. 4.2) (Zaller, 1992; Semetko & Schönbach, 1994; Schmitt-Beck, 2000). The somewhat counter-intuitive picture from the literature is that people in general (not only the apartisans) are not particularly selective in choosing TV channels and newspapers according to their attitudes. Possible accounts for this finding are that i) the advertising activities of the parties in the public sphere (like posters in the streets) are inadvertently and unwillingly perceived by all types of citizens, and ii) political attitudes are probably

not the only criterion people base their selection of TV channels and newspapers (Zaller, 1992; Huckfeldt & Sprague, 1993; Schmitt-Beck, 2000). For these reasons, we do not model the process of perception as selective. Yet, selectivity is modeled in the process of judgement and in the process of communicating within relatively homogeneous social networks.

$$n_{p,c}(t_k) = I_{0,c} \cdot n_{r,tot}(t_k) \quad [\text{eq. 4.2}]$$

The credibility of a particular persuasive message from the public sphere depends on its source. It is assumed to be higher for the mass media than for the parties since citizens generally consider the media as more independent and trustworthy (Eagly et al., 1978).

#### *Citizen communication*

Embedded in a social network, citizens exchange their current views about the parties. The probability  $p_{ex,c}(t_k)$  of initiating an interpersonal exchange of attitudes at time step  $t_k$  increases with the citizen's involvement at  $t_{k-1}$  (see eq. 4.3) (Zaller & Feldman, 1992; Schmitt-Beck, 2000). The constant  $\zeta_c$  is the general tendency of citizen  $c$  to begin an attitude exchange (the personal communicativeness).

$$p_{ex,c}(t_k) = \zeta_c \cdot I_c(t_{k-1}) \quad [\text{eq. 4.3}]$$

Considering a widely accepted norm of conduct, the simulated target citizen responds even if her/his current involvement is very low. The content of the exchange both on the side of the person beginning the exchange and the person responding depends on the attitude certainty of the participants (see revision step 7 on p. 58f.). If the citizen belongs to the subset of "certain" citizens, his/her argumentation is modeled as one-sided. If the citizen belongs to the subset of "uncertain" citizens, his/her argumentation is modeled as double-sided (Latane, 1981). In the case of one-sided argumentation, the citizen tells the valence of his/her current attitude. In the case of double-sided argumentation, the citizen expresses his/her ambivalence by telling

arguments for *and* against both parties. The credibility  $\varepsilon_c(t_k)$  of the communication partner is derived from her/his involvement  $I_c(t_{k-1})$  in the last time step (see eq. 4.4) and normalized between 0.0 and 1.0 by the constant  $const_1$ .

$$\varepsilon_c(t_k) = const_1 \cdot (1 + I_c(t_{k-1})) \quad [\text{eq. 4.4}]$$

### *Citizen voting behavior*

According to the dominant effects of strong attitudes on behavior (Fazio et al., 1978; Fazio et al., 1986; Krosnick, 1988; Bargh et al., 1992; Bassili, 1995; Jonas, Broemer, & Diehl, 2000), the involvement, the ambivalence, and the extremity of a citizen's attitude are modeled as the determinants of participation in the election. Only the citizens with the strongest attitudes will participate in the elections. The percentage of participants is given by the level of the simulated turn out which is derived from the average attitude strength within the population on voting day (see the Appendix I on p. 77ff.). The other citizens with weaker attitudes will "stay at home" and will not have an impact on the outcome of the election. The level of attitude strength underlying a particular vote does not influence its weight relative to the other ballots. Like in real elections, there is a simple count of the votes for party *A* and of the votes for party *B* in the model.

### ***The cognitive level***

This section describes the modeling assumptions underlying the integration of the persuasive messages that have been perceived from the campaign arena until a particular moment. Essentially, the task has been to find a parsimonious set of (as far as possible) empirically verified mental structures and processes that link the temporal evolution of the citizen's memory to the temporal evolution of the citizen's attitude. In the following, our model is called the *Political Attitude Strength Simulation (PASS)* model.

The main sources of empirically tested assumptions have been the Receive-Accept-Sample (RAS) model (Zaller, 1992) and the impression formation model developed by Lodge and his colleagues (Lodge, 1995). In many views, these two models represent the "state-of-the-art" of information integration models in political psychology. Whenever



assumptions are taken from these two models, these are clearly indicated within our model by citing the corresponding authors. Additionally, our model encompasses an explicit treatment of the dimension of attitude strength (Krosnick et al., 1995). This construct is missing in both the RAS and the Lodge model in spite of the fact that in the field of social psychology (and consumer psychology) the focus on attitude strength has already proved to be indispensable for thinking about the determinants of attitude stability and change.

The additional component of attitude strength requires the PASS model to explicitly simulate a minimal set of strength-related characteristics. We have somewhat arbitrarily concentrated on the citizen involvement, the attitudinal ambivalence, and the attitudinal extremity. However, we contend that these characteristics capture three important facets of attitude strength that are relevant in the context of voting behavior. In the following section, an appropriate substructure of the attitude is presented which is capable of modeling the dynamics of these components of attitudinal strength.

Theories of mental accounting predict that the content in the citizen memory is organized around separated accounts (Henderson & Peterson, 1992). The simplest form of mental accounting is the separation of a positive and a negative account towards the judgmental target. Therefore, the attitude is divided into the party *A* account and the party *B* account (see figure 4.5 on p. 51). Newly encountered persuasive messages are associated with one of these accounts according to their affective tag. The affective tag reflects the subjective impression of the main thrust of the arguments, pictures, slogans and jingles contained in the original persuasive message and is considered to be easily extractable under the condition of very low citizen involvement (Lodge et al., 1989) (see figure 4.3). Although the detailed content of the arguments presented in the original message may be memorized for a limited time span, the empirical evidence clearly demonstrates that after a few days, the recall performance of the raw material is much better than the recall performance of the extracted general affective tag (Lodge et al., 1995). Therefore, for the sake of parsimony, the PASS model neglects the explicit simulation of the memory traces of the full original messages and focuses on the memory decay of the much more relevant affective extract (similar to the Lodge model).

The process of “boiling down” the original persuasive message is *not* modeled explicitly. The affective tags of the persuasive messages are pre-defined by the modeler. That is, all the extracts derived from the persuasive messages coming from party *A* are *a*

*a priori* assigned the affective tag *A* and all the persuasive messages coming from party *B* are *a priori* assigned the affective tag *B*. Similarly, if a persuasive message comes from the mass media and is univocal, the citizens supposedly find out the affective tag correctly. Sometimes, however, the persuasive message comes from ambivalent mass media coverage or from interpersonal communication with an uncertain citizen. In this case, the persuasive message is split into two contradicting sub-messages with the univocal affective tags *A* resp. *B*. Since this would double the impact of ambivalent messages, the judgmental weight of these sub-messages is halved.

In contrast to the Lodge model, there is a second attribute that is derived from the original persuasive message: the credibility of the message source. Similar to the affective tag, this attribute is considered to be easily extractable even under low levels of involvement and to be much more decay-resistant than the raw material. The underlying assumptions are i) that the source of every persuasive message is correctly identifiable and ii) that the citizens have subjective *a priori* credibility levels assigned to the different sources (Hovland & Weiss, 1951).

The resulting essence of the persuasive message is called a Persuasive Message Extract (PME). Every PME combines the extracted affective tag and the credibility of the original persuasive message (see figure 4.3). The PME's are the basic knowledge units in the PASS model.

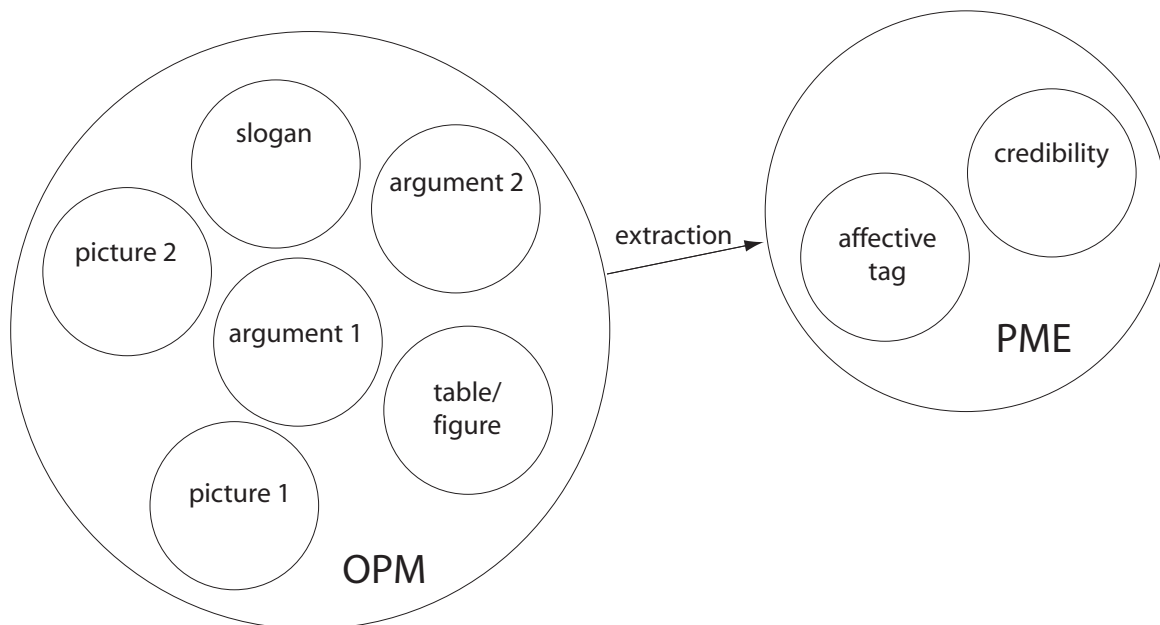


Figure 4.3: At the moment of perceiving an Original Persuasive Message (OPM), its full content is translated into the Persuasive Message Extract (PME).

## Steps of Integrating the Persuasive Message Extracts

The attitude of a citizen at a particular moment in time is the result of a bottom-up integration procedure starting from all the PME's available at that particular moment in time. The following sections describe the various steps of the integration procedure. Because of the basic assumption of low involvement, most of the steps in a real citizen's mind are supposed to be out of the reach of introspection and self-report. That is, the processes revising the attitude are unconscious for most of the time (Kihlstrom, 1987).

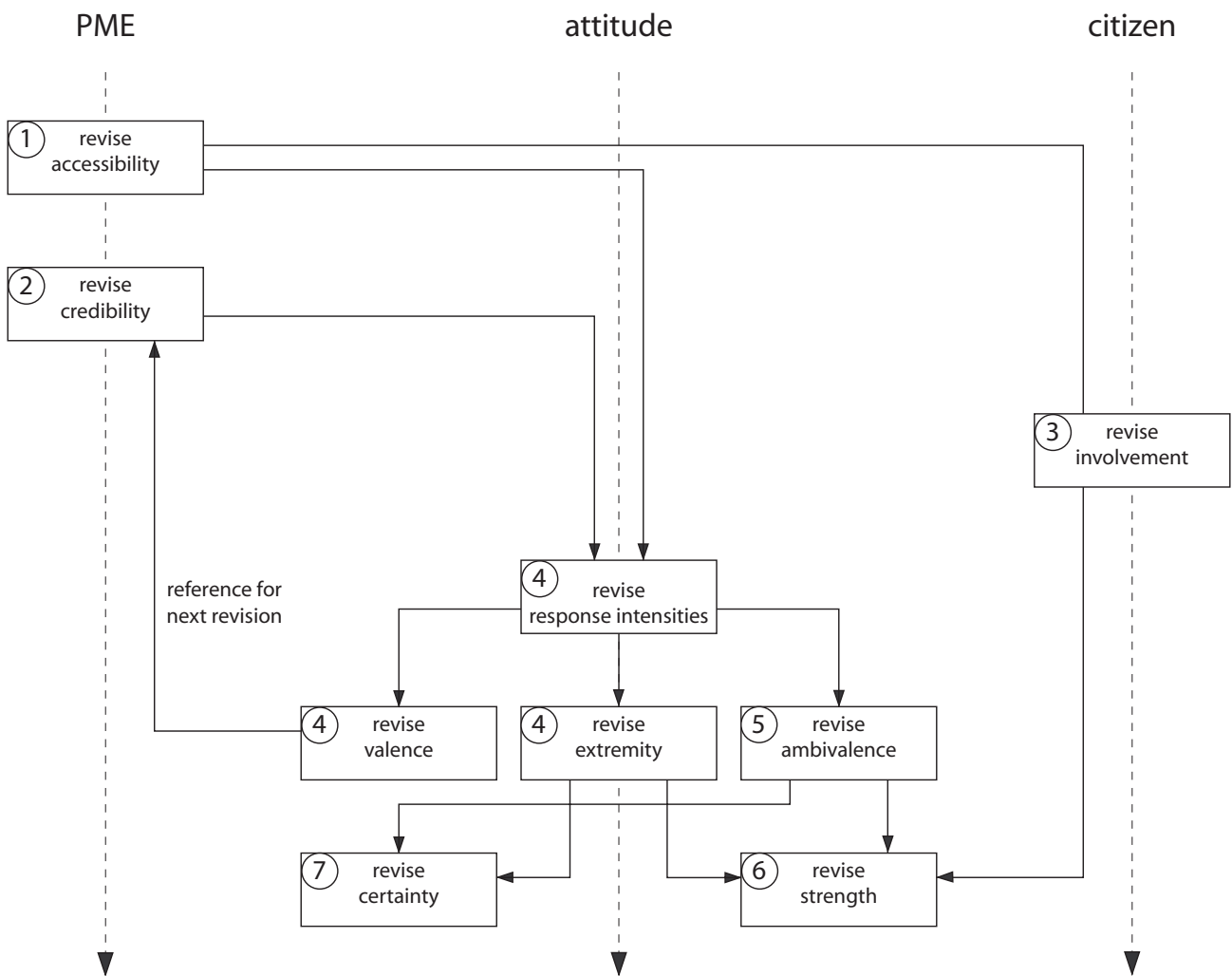


Figure 4.4: Overview of the temporal sequence of the various steps that are performed if a citizen has encountered new evidence. The numbers of the boxes correspond to the numbers of the steps used in the section headers in the text. The dashed lines denote the temporal evolution at the three levels of the Persuasive Message Extracts (PMEs), the citizen's attitude and the citizen. The arrows denote the inputs required for a particular step.

In the PASS model, the sequence of revision steps is only performed if some new persuasive message from the campaign arena has been perceived. Simulating the preference revision process as a bottom-up integration starting from some basic knowledge units is conceptually related to the Response Axiom of the RAS model (Zaller, 1992) and more generally, to the attitudes-as-constructed perspective that has been proposed in attitude theory (Tourangeau, 1992; Wilson et al., 1992). The continuous revision of the attitude in the light of new evidence is a core element of the on-line relationship between memory and judgement (Hastie et al., 1986) (cf. the “on-line tally” in the Lodge model on p. 20ff.).

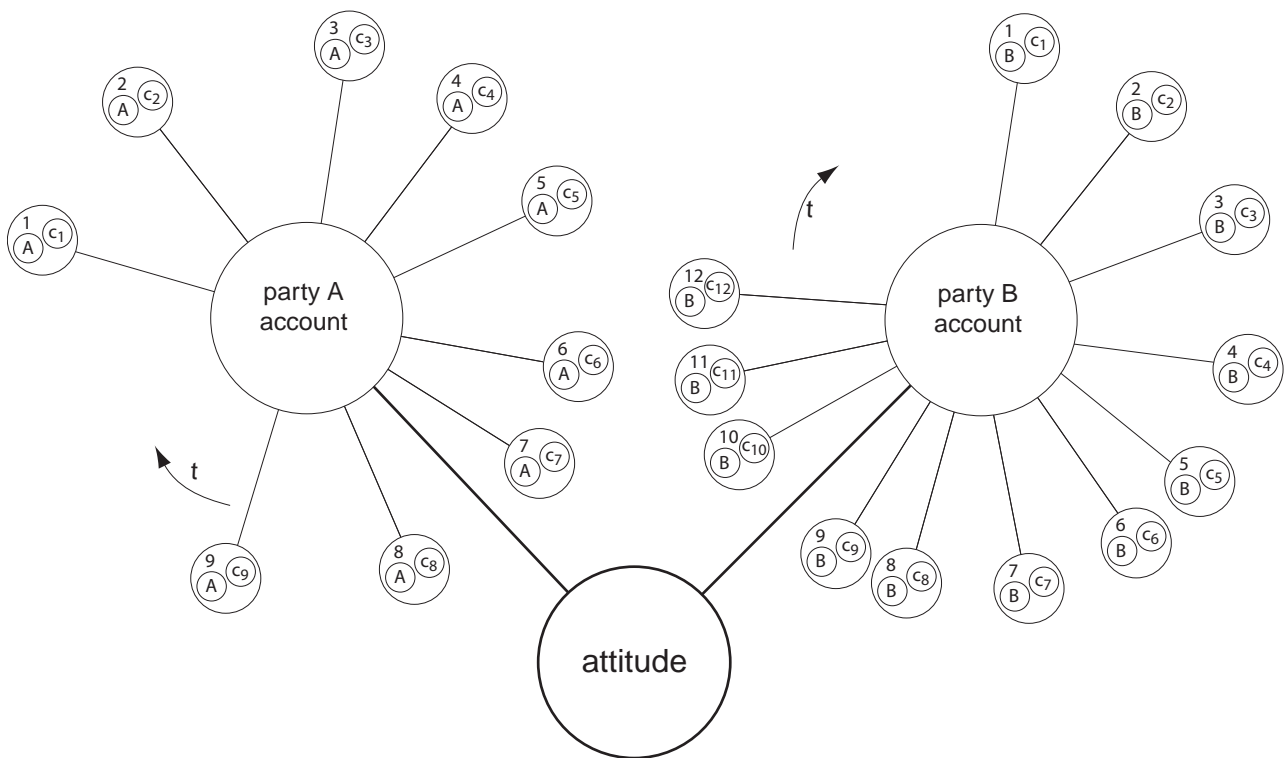


Figure 4.5: The attitude unit is divided into two basic memory accounts. Every account is associated to steadily growing sets of PME's (circles at the end of the spokes) that have been perceived during the ongoing campaign. The affective valences  $A$  or  $B$  and the credibility  $c_i$  of PME  $i$  are indicated as two small circles within the circle indicating the PME.

*Step 1: Revising the PME accessibilities*

The temporal decay of human memory content is best approximated by a power law (Anderson & Schooler, 1991; Wixted & Ebbesen, 1991). Generally, the level  $I_c(t_{p,m})$  of the involvement of citizen  $c$  at the moment  $t_{p,m}$  of perceiving a certain original

persuasive message  $m$  mediates the accessibility  $a_i(t_k)$  of the persuasive message extract  $i$  (see eq. 4.5a and 4.5b) (Burnkrant et al., 1983; Greenwald et al., 1984; Park et al., 1994). The accessibility of a PME at time step  $t_k$  is a measure of its probability to have an effect on the outcome of the attitude revision at time step  $t_k$ . If the citizen has been in a highly involved mind set when perceiving the original persuasive message, the decay of the PME is slower than if the citizen has been in a low involvement mind set. Here, the process of decay is translated into the continuously decreasing accessibility of the PME. The constant  $\nu_c$  determines the general memory decay speed of citizen  $c$ .

$$a_i^*(t_k) = [\nu_c \cdot (t_k - t_{p,m}) + 1]^{-\frac{1}{\tau_c(t_{p,m})}} \quad [\text{eq. 4.5a}]$$

$$a_i(t_k) = \begin{cases} \omega_{IPC} \cdot a_i^*(t_k) & \text{if } source = citizen \\ a_i^*(t_k) & \text{if } source \neq citizen \end{cases} \quad [\text{eq. 4.5b}]$$

There are three important model assumptions in the context of the explicit modeling of the accessibility of each PME. First, in an interpersonal setting, the maximal accessibility of a PME is modeled to be considerably higher than in a setting of impersonal mass media or party campaign perception (see the weight of the interpersonal communication  $\omega_{IPC}$  in the Appendix I on p. 77ff.). Two reasons can be found for this situation-dependent treatment: i) when communicating face-to-face, the recipient's attention and understanding can continuously be controlled and the message can easily be „customized“ (Katz & Lazarsfeld, 1955); ii) the interpersonal setting provides numerous retrieval cues facilitating later retrieval of the communication act (Avery et al., 1986).

Second, the citizen memory is not selective on congeniality, i.e. does not hold congenial PMEs (matching the valence of the current attitude) on higher levels of accessibility than uncongenial PMEs. The results from empirical studies on memory selectivity are still controversial. However, at least some recent experiments point to the direction of non-selectivity (Eagly et al., 2000).

Third, the PASS model adopts the assumption that memory traces that cannot be accessed by self-report and introspection anymore have nevertheless an effect on the judgement (Kihlstrom, 1987; Greenwald et al., 1995). In other words, the models does

not ignore memory traces that would be subjectively felt as “forgotten” in the mind of a real citizen. On the contrary, it revises the accessibility and credibility of every PME even if its accessibility is nearly zero. This allows for the simulation of the effect that a large number of old “forgotten” traces might out-balance a small number of fresh memory traces from recently encoded persuasive messages. Thus, the PASS is able to explicitly capture the nature of the citizen’s unconscious.

*Step 2: Revising the PME credibilities*

People tend to bolster their previous attitudes if they encounter new evidence (Lord et al., 1979; Houston & Fazio, 1989; Pomerantz et al., 1995). This type of confirmation bias is expected to prevail if the perceiver is in a low-involved mind-set as supposed throughout the PASS model. According to the second axiom of the Receive-Accept-Sample model (RAS-A2 for short) (Zaller, 1992), the strength of the confirmation bias is positively related to the citizen’s habitual interest  $I_{0,c}$  into elections and the general need of confirmation  $\chi_c$  of citizen  $c$  (see eq. 4.6a). Basically, the confirmation bias increases or decreases the original credibility level  $c_{0,i}$  of the PME  $i$ . If the affective tag  $\delta_i$  of PME  $i$  corresponds to the valence of the attitude in the last step  $t_{k-1}$ , the PME credibility is multiplied by the factor  $1 + I_{0,c} \cdot \chi_c$ . If the affective tag of a PME does not correspond to the valence of the attitude in the last step  $t_{k-1}$ , the credibility of that PME is divided by the same factor. Equation 4.6b is the reformulation of eq. 4.6a if the RAS-A2 is absent, i.e. if the strength of the confirmation bias is independent of the individual level of  $I_{0,c}$ . The dependence is replaced by the average initial involvement  $I_{0,avg}$ . The difference between eqs. [6a] and [6b] is part of the Monte Carlo Experiments reported later in this chapter.

$$c_i(t_k) = \begin{cases} c_{0,i} \cdot (1 + I_{0,c} \cdot \chi_c) & \text{if } \text{sign}[A_c(t_{k-1})] = \text{sign}(\delta_i) \\ \frac{c_{0,i}}{1 + I_{0,c} \cdot \chi_c} & \text{if } \text{sign}[A_c(t_{k-1})] \neq \text{sign}(\delta_i) \end{cases} \quad [\text{eq. 4.6a}]$$

$$c_i^{avg}(t_k) = \begin{cases} c_{0,i} \cdot (1 + I_{0,avg} \cdot \chi_c) & \text{if } \text{sign}[A_c(t_{k-1})] = \text{sign}(\delta_i) \\ \frac{c_{0,i}}{1 + I_{0,avg} \cdot \chi_c} & \text{if } \text{sign}[A_c(t_{k-1})] \neq \text{sign}(\delta_i) \end{cases} \quad [\text{eq. 4.6b}]$$

Because of this reference to the last attitude, the credibilities of an account’s PMEs synchronously flip from suppressed to elevated (or visa versa) if the attitude valence crosses the zero-line during the model run. That is, from one moment to another, all

evidence in the citizen memory is seen “in a new light”. In spite of its face validity, there is currently no empirical study on the phenomenal experience of this effect.

*Step 3: Revising the citizen involvement*

The notion of political involvement is defined here as the “interest in public affairs validated by keeping informed and [is] expressed through participation in civic action” (Inkeles, 1974, p. 218). The specific level of citizen involvement  $I_c(t_k)$  regarding the upcoming elections during the simulated time period depends on the recent frequency of encoding persuasive messages related to the elections (see eq. 4.7a-c and figure 4.6).

$$I_{0,c}^* = I_{0,c} - \frac{1 - I_{0,c}}{e^{-\sigma_c}} \quad [\text{eq. 4.7a}]$$

$$\sigma_c^*(t_k) = \sigma_c \cdot \left( 1 - \frac{\beta_c(t_k)}{\beta_{att,c}} \right) \quad [\text{eq. 4.7b}]$$

$$I_c(t_k) = \frac{1 - I_{0,c}^*}{1 + e^{-\sigma_c^*(t_k)}} + I_{0,c}^* \quad [\text{eq. 4.7c}]$$

The summed accessibilities  $\beta_c(t_k)$  of the PME of both accounts provide a useful index that integrates both the recency and frequency of encoding PMEs in memory (for recent evidence of the relationship between accessibility and involvement see Kokkinaki et al., 1997). At a specific individual threshold of accessibility  $\beta_{att,c}$ , the growth of involvement per time step is at its maximum, i.e. the citizen “wakes up” and gets significantly aware and interested in the campaign. Another parameter  $\sigma_c$  varies the “sharpness” of the involvement increase around this threshold. With increasing total account accessibility, the involvement curve reveals the typical stimulus-response ceiling effect (McCombs & Shaw, 1972; Semetko et al., 1994).

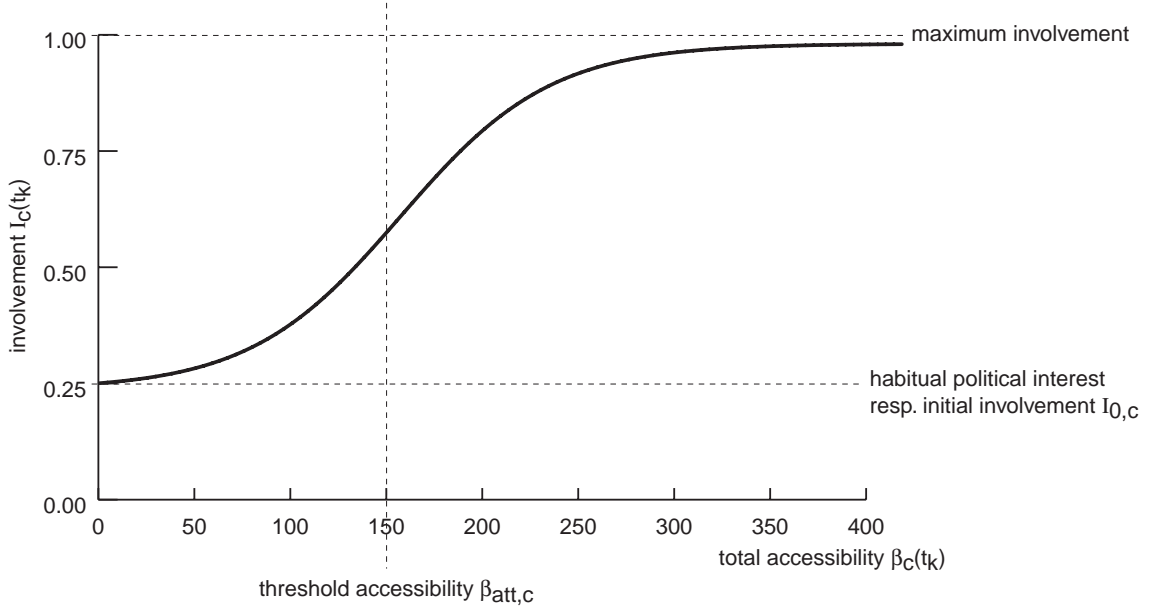


Figure 4.6: If citizens perceive persuasive messages with some minimal frequency, the total accessibility of all PME's  $\beta_c(t_k)$  in the accounts is steadily growing. This overall measure for the recent frequency of campaign activities in the campaign arena is translated into the citizen involvement. Each citizen has an individual threshold of accessibility  $\beta_{att,c}$  that determines the moment of getting significantly attentive to the campaign activities.

*Step 4: Revising the response intensities, the attitude valence, and the attitude extremity*

The total number  $n_{A,c}(t_k)$  of PME's that are associated with account  $A$  of citizen  $c$  at time step  $t_k$  and the total number  $n_{B,c}(t_k)$  of PME's that are associated with account  $B$  have to be separately translated into two antagonistic responses which form the building blocks of the final attitude (see eq. 4.8a and 4.8b). First, every PME  $i$  is assigned a weight according to its accessibility  $a_i(t_k)$  and its credibility  $c_i(t_k)$ . Second, the weights of all PME's are separately summed up for account  $A$  and account  $B$ , and added to the initial account accessibilities  $a_{0A,c}$  and  $a_{0B,c}$ , respectively. For each citizen  $c$ , this procedure yields two response intensities  $R_{A,c}(t_k)$  and  $R_{B,c}(t_k)$ . That is, the more highly accessible and highly credible PME's are associated with an account, the higher is its response intensity.

$$R_{A,c}(t_k) = a_{0A,c} + \sum_{i=1}^{n_{A,c}(t_k)} a_i(t_k) \cdot c_i(t_k) \quad [\text{eq. 4.8a}]$$

$$R_{B,c}(t_k) = a_{0B,c} + \sum_{i=1}^{n_{B,c}(t_k)} a_i(t_k) \cdot c_i(t_k) \quad [\text{eq. 4.8b}]$$



The relative imbalance of the initial account accessibilities represents the initial attitude (or party identification) of each citizen at the beginning of the simulated time window. The initial account accessibilities do not decay during the simulation since they represent the political pre-disposition previously established over years. The valence and the extremity of the attitude (both incorporated in  $A_v(t_k)$  with the valence =  $sign [A_v(t_k)]$  and the extremity =  $|A_v(t_k)|$ ) are derived from a simple integration of the two antagonistic response intensities normalized on a scale between  $-1$  (completely pro  $B$ ) and  $+1$  (completely pro  $A$ ) (see eq. 4.9). The implicit assumption underlying this way of normalization is that the effect of a change in the imbalance of the responses  $R_{A,c}(t_k)$  and  $R_{B,c}(t_k)$  from 10:20 to 10:30 does have a larger effect on the attitude, than a change from 10:30 to 10:40. In other words, the assumption is that more extreme attitudes are more resistant against change (Feldman, 1989).

$$A_c(t_k) = \frac{R_{A,c}(t_k) - R_{B,c}(t_k)}{R_{A,c}(t_k) + R_{B,c}(t_k)} \quad [\text{eq. 4.9}]$$

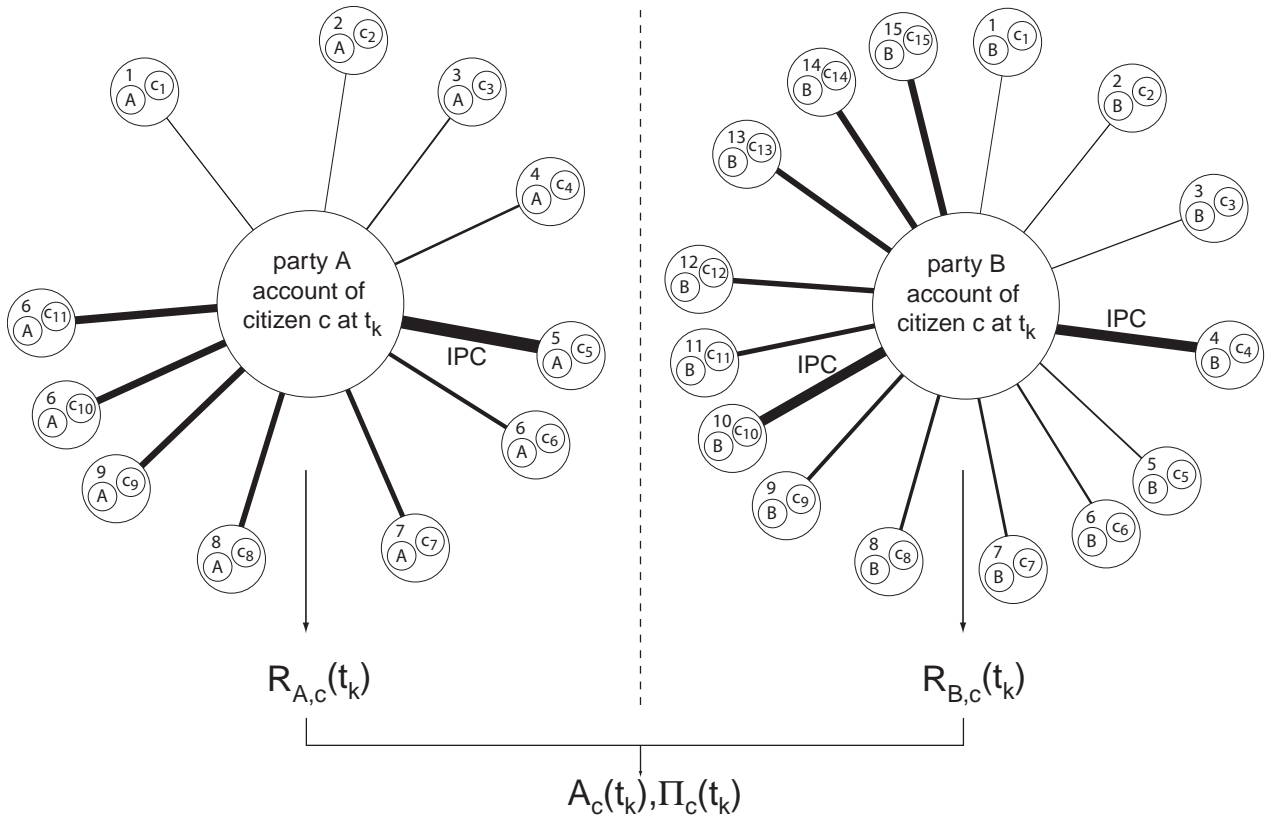


Figure 4.7: Processes involved in the revision of the attitude  $A_c(t_k)$  of citizen  $c$  at time  $t_k$  after some new evidence has been encountered from the campaign arena. The two circles represent the two party accounts. The index  $i$  of each PME denotes its position within the temporal sequence of perception (high numbers for recent PME). The most recent PMEs are more accessible (bold lines), whereas older PMEs are less accessible (thin lines). Episodes that were perceived in situations of interpersonal communication (IPC) are most accessible. According to their accessibilities  $a_i(t_k)$  and credibilities  $c_i(t_k)$ , the PMEs of each account are separately integrated into the response intensities  $R_{A,c}(t_k)$  and  $R_{B,c}(t_k)$ . Finally, the response intensities are transformed into the attitude  $A_c(t_k)$  and the party ambivalence  $\Pi_c(t_k)$ .

### Step 5: Revising the attitudinal ambivalence

Empirical studies suggest that the subjectively felt ambivalence during the election campaigns is a pivotal component of attitudinal strength (Erber et al., 1995; Cacioppo et al., 1997; Meffert et al., 2000). There are several quantitative models of ambivalence in the literature. We have selected the model from Thompson and Zanna (1995) because of its parsimony and frequent use in empirical studies (see eq. 4.10a and 4.10b). Thompson and Zanna propose that ambivalence is high if both responses have similar intensities and if the absolute intensities of both responses are high. Due to the non-bounded nature of the response intensities, eq. 4.10a produces levels of ambivalence between  $-70$  and

20. Yet, 92% of the values are between  $-3$  and  $3$  with a mean close to zero. Equation 4.10b is used for normalizing the ambivalence between  $-1$  and  $1$  whilst maintaining a maximum sensitivity of  $\Pi_c(t_k)$  if  $\Pi_c^*(t_k)$  is between  $-3$  ( $\Pi_c(t_k) = 0.1$ ) and  $3$  ( $\Pi_c(t_k) = 0.9$ ).

$$\Pi_c^*(t_k) = \frac{R_{A,c}(t_k) + R_{B,c}(t_k)}{2} - |R_{A,c}(t_k) - R_{B,c}(t_k)| \quad [\text{eq. 4.10a}]$$

$$\Pi_c(t_k) = \frac{1}{1 + e^{(-\text{const}_2 \cdot \Pi_c^*(t_k))}} \quad [\text{eq. 4.10b}]$$

*Step 6: Revising the attitudinal strength*

The overall attitude strength  $\alpha_c(t_k)$  is the product of the involvement  $I_c(t_k)$ , attitudinal extremity  $|A_c(t_k)|$ , and attitudinal consistency (the inverse of the attitudinal ambivalence  $\Pi_c(t_k)$ ). The reason for this conceptualization is the assumption that if one of the attributes approaches zero, the attitude strength approaches zero as well (see eq. 4.11a). For example, if a citizen feels strongly involved in the election, but at the same time feels strongly ambivalent because of nearly identical response intensities, the overall attitudinal strength is supposed to be low.

$$\alpha_c(t_k) = I_c(t_k) \cdot [1 - \Pi_c(t_k)] \cdot |A_c(t_k)| \quad [\text{eq. 4.11a}]$$

The attributes are more or less positively interrelated. Empirical studies suggest that high extremity commonly is related to low ambivalence, and involvement correlates with extremity (Krosnick et al., 1993). However, since the level of attitudinal strength is a relative measure, the multiplication just amplifies the relative differences within the population of artificial citizens with regard to attitude strength.

*Step 7: Revising the attitudinal certainty*

Not all citizens are able to answer the question “If voting day were today, which party would you vote for?” at every moment before voting day. There are always some uncertain citizens giving answers like “I don’t know” or “I feel ambivalent”. The number of these citizens has been found to steadily decrease during the time before voting day at least for the German General Elections 1994. The percentage of non-respondents declined from 23% to 14% within the 40 weeks before voting day (Erhardt,

1998). Since our simulation covers one year before voting day, we had to extrapolate the percentages for the weeks 52 to 41 using the simplest (linear) trend in the data (see figure 4.8).

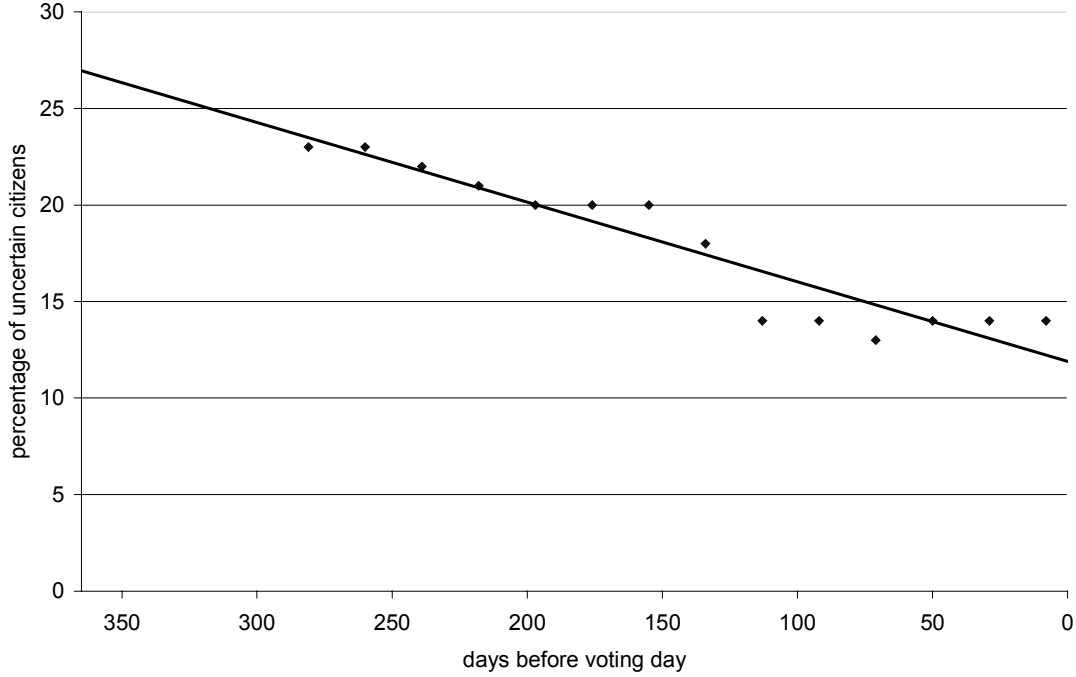


Figure 4.8: Decreasing percentage  $\Delta(t_k)$  of uncertain citizens when asked which party they would vote for if voting day were today. Data (dots) from Erhardt (1998), extrapolation (line) by the author.

In each time step, the model differentiates between citizens with certain attitudes and citizens with uncertain attitudes. The certainty  $\xi_c(t_k)$  of the attitude is determined by multiplying the attitudinal extremity and the attitudinal consistency (see eq. 4.11b). In contrast to the full construct of attitudinal strength, the certainty construct does not contain the motivational component of involvement required for the distinction between citizens going to vote and citizens not going to vote.

$$\xi_c(t_k) = [1 - \Pi_c(t_k)] \cdot A_c(t_k) \quad [\text{eq. 4.11b}]$$

The state label “uncertain” is attached to the  $\Delta(t_k)$  percent out of all citizens with the lowest certainty at time step  $t_k$ . Due to this categorization mechanism, an attitude of a particular citizen can flip between “certain” and “uncertain” several times during the simulated year depending on her/his position in certainty ranking.

### **Citizen typology**

The Dalton citizen typology divides the electorate along the two dimensions of party identification strength and cognitive mobilization, encompassing the level of formal education and the level of interest in politics (Dalton, 1984). The implicit assumption of crossing the dimensions is that they are approximately independent. As a useful idealization, we adopt the general character of the dimensions and the assumption of independence proposed by Dalton. Since we do not include the citizen attribute of formal education, we put habitual political interest as the only component contributing to the dimension of cognitive mobilization (see figure 4.9).

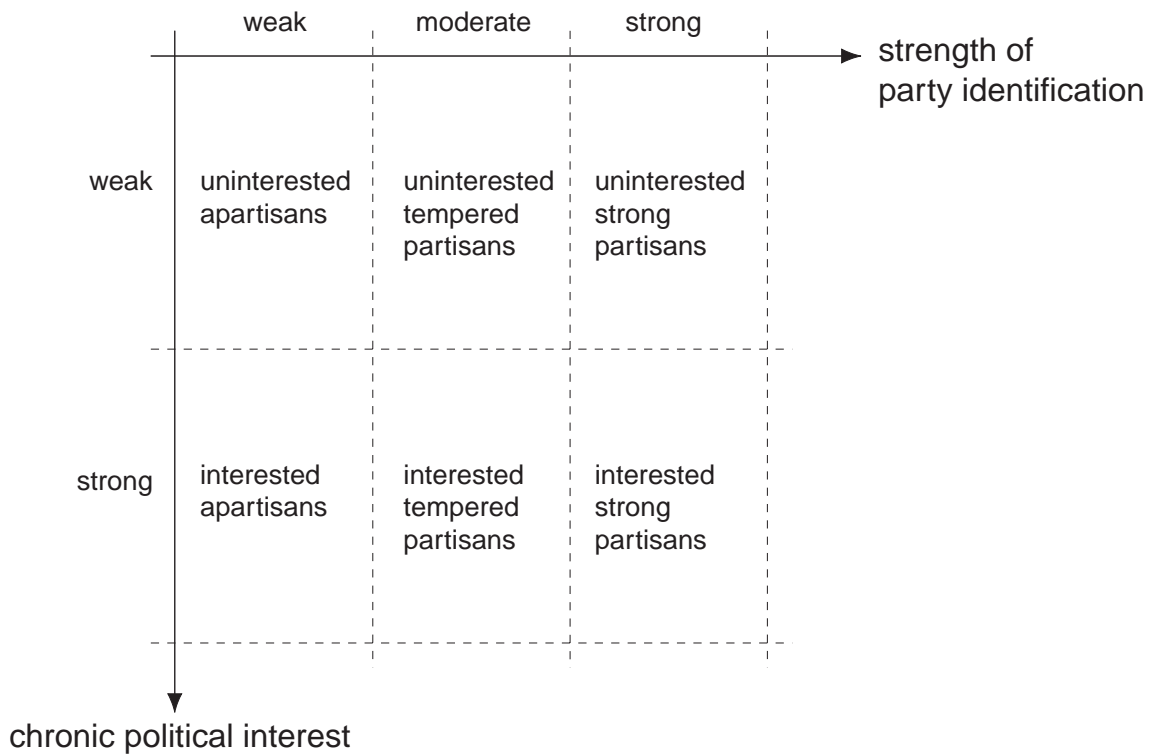


Figure 4.9: Citizen types distinguished in the model. The two dimensions are related to the Dalton (1984) typology of citizens.

### Citizen initialization

This section describes the procedure required to set up an initial population of artificial citizens before the model is run. All required data are taken from empirical studies conducted in the context of German General Elections.

The simulated populations encompass  $N = 100$  citizens. In the first step of the citizen initialization, the party identification in terms of the initial valence and extremity of the attitude  $A_{\theta,c}$  is attributed to each citizen  $c$ . The underlying frequency distribution of different strengths of party identification is derived from data yielded in Germany in 1994 and 1998 (Falter, Schoen, & Caballero, 2000). In another study conducted in Germany, Schmitt-Beck (2000) demonstrates that in 1990 the strength of party identification is equally distributed in both *Parteilager* (CDU/CSU/FDP and SPD/Grüne). Reflecting the available evidence, the initial attitudes  $A_{\theta,c}$  in each model run are distributed as depicted in figure 4.10.

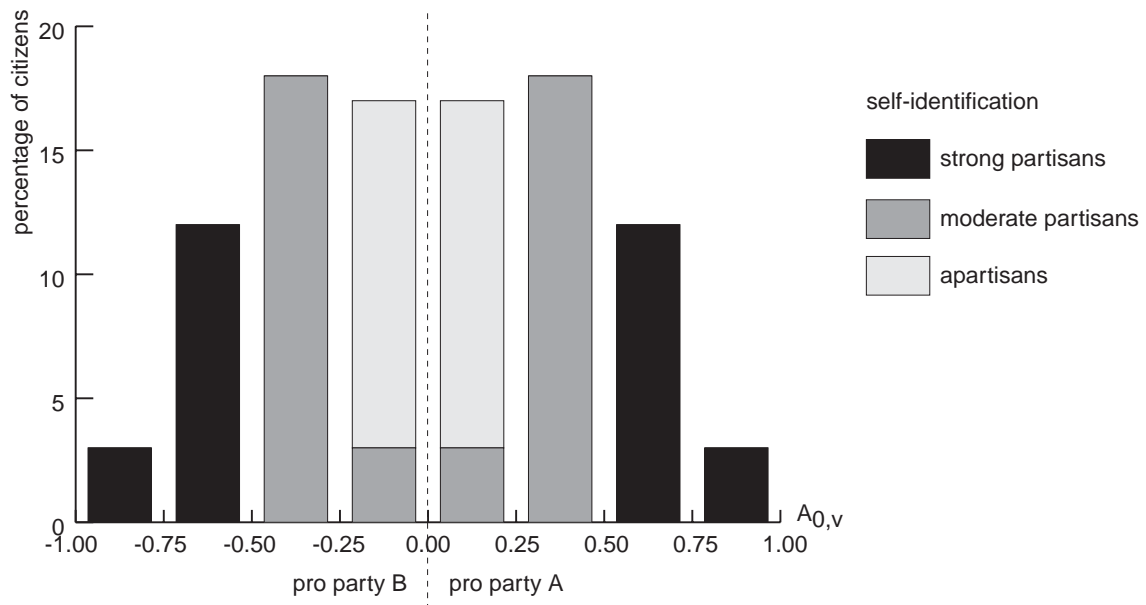


Figure 4.10: Distribution of initial attitudes among 100 citizens in the simulation experiments. Reading example: 17% of the citizens have an initial attitude extremity between 0.00 and 0.25 and a pro party A valence. When asked for their party identification, 14 % of them report that they do not identify themselves with any party, whereas only 3% translate the relatively small extremity into the answer “tempered partisan”.

In the second step, due to the independence of dimensions in the citizen typology, different levels of habitual political interest  $I_{\theta,c}$  are attributed to the citizens independent

of the extremity of the initial attitude. According to the aggregated ALLBUS dataset 1980-1998 (GESIS, 1996), the frequencies of five different interest levels (not at all, low, medium, strong, very strong) can be approximated by a normal distribution. Since involvements are typically very low one year before voting day, the values attached to the citizens are normally distributed between 0.0 and 0.25. Thus, citizens with initial citizen involvements between 0.0 and 0.125 are rather uninterested citizens, whereas citizens with initial citizen involvements between 0.125 and 0.25 are rather interested citizens.

In the third step, the total initial accessibility  $\beta_{0,c}$  of the attitude is determined on the basis of the extremity of the initial attitude  $|A_{0,c}|$ , the initial involvement  $I_{0,c}$ , the maximum value  $\beta_{0,max}$ , and two constants  $const_3$  and  $const_4$  for keeping the maximal contribution from the initial involvement and the initial attitude equal (see eq. 4.12).

$$\beta_{0,c} = \beta_{0,max} \cdot (const_3 \cdot I_{0,c} + const_4 \cdot |A_{0,c}|) \quad [\text{eq. 4.12}]$$

The underlying assumption is that strong partisans with a high level of habitual interest in the elections have the most accessible attitudes. Strongly interested apartisans (with  $|A_{0,c}|$  close to zero) are assigned half of the maximum accessibility since they probably have, due to their interest, extended but two-sided knowledge about the parties in their minds (see eq. 4.13). Weakly interested partisans have little but one-sided knowledge about parties. These citizens are assigned a medium level of initial accessibility as well. Apartisans with little interest in politics yield a minimum initial accessibility. Their attitudes are closely related to “non-attitudes” in the sense of Converse (1970).

In the last step, the initial accessibility  $\beta_{0,c}$  is divided into the two initial accessibilities of the basic party accounts  $a_{0A,c}$  and  $a_{0B,c}$  according to the initial attitude (see eq. 4.14).

$$a_{0A,c} = 0.5 \cdot \beta_{0,c} \cdot (A_{0,c} + 1) \quad [\text{eq. 4.13}]$$

$$a_{0B,c} = \beta_{0,c} - a_{0A,c} \quad [\text{eq. 4.14}]$$

The other individual citizen characteristics (the speed of memory decay, the probability of beginning an attitude exchange and the weight of interpersonal communication, the level of the confirmation bias, the accessibility threshold, and the

sharpness of this threshold) are uniformly distributed within the boundaries presented in the Appendix.

## **Results**

This chapter is divided into two parts. The first part presents some pre-studies on the plausibility of the model at the individual level. In the second part, some statistically significant results from two Monte Carlo experiments are reported. They address the original question of optimal resource allocation in election campaigns raised in the introduction.

### ***Pre-Studies on the individual level***

The goal of this section is to demonstrate that the simulated citizen behavior on the individual level is plausible in spite of the fact that the model parameters were estimated exclusively on the aggregate level. In fact, the dynamics of the one-year traces of the three components of attitude strength simulated here (extremity, involvement and ambivalence) and the trace of the overall attitudinal strength itself are quite insightful and comprehensible on the background of the implemented model assumptions (see figure 4.11 on p. 65). Furthermore, surveying the individual temporal traces of attitude valence and certainty of all the 100 simulated citizens, the more stable and the more volatile zones within the electorate are clearly visible (see figure 4.13 on p. 68).

#### **Individual level**

The example depicted in figure 4.11 is aimed at demonstrating the temporal effects of different types of interpersonal communication at the level of one particular citizen. In order to isolate the effects from interpersonal communication, the accumulation level of both parties is set at the level of  $\psi = 0$ . That is, over the simulated time period, the effects of the parties cancel each other out and are only visible as the allover micro-shakiness of the time plots. Because of the balanced party activities, the mass media coverage is neutral as well. However, since the credibility of the mass media is higher than the credibility of the party advertising, the impact of the mass media on the citizen's attitude is visible as small perturbations in the traces (see bullets 1 and 3).

The citizen starts as a partisan temperately supporting party *A* (see the initial attitude at 0.37). The first significant event is when at time step 93 another citizen



communicates with the citizen presented here (see bullet 2). The discussant is a supporter of party *B* with a relatively strong attitude and, consequently, is treated as “certain” in the model. This means that she will argue univalently for party *A*. Additionally, she is highly involved and therefore highly credible (this cannot be seen in the plot, but see eq. 4.4 on p. 47). Consequently, the PME derived from this uncongenial and univalent communication event abruptly pulls the attitude of the focal citizen on the side of party *B*. In other words, the citizen was efficiently convinced of the merits of party *A* changes from a tempered partisan to a partisan of party *B*. Simultaneously, the ambivalence drops due to the new level of consistency subjectively felt under the salient impression of the recent persuasive communication act. In the following time steps, the memory trace of the PME derived from the communication act slowly decays, and, accordingly, the subjectively felt level of ambivalence. Between communication act 2 and 5, there are no further persuasive attempts of party *B* discussants to keep the focal citizen on the side of the party *B* partisans. After some time (around time step 250), the attitude has indeed returned to the initial level of extremity and valence. Put metaphorically, the anchor of the initial attitude has outrun the “ephemeral intermezzo” on the side of the partisans of party *A*.

Another interesting effect can be taken from the time plots in figure 4.11. At time step 180, the attitude crosses the zero-line (and the ambivalence is at its maximum, see bullet 4). Just after the zero-line is crossed, the credibilities of the PMEs attached to the party *A* account synchronously flip from suppressed to elevated and the credibilities of the PMEs attached to the party *B* account synchronously flip from elevated to suppressed (see eq. 4.6a and eq. 4.6b on p. 53). Due to the working mechanism of the confirmation bias, the PMEs are seen in a different light from one moment to the other. Consequently, feeling “back home” near the initial attitude, the level of ambivalence drops and the attitude strength increases a little bit.

At time step 284, an attitude exchange with an uncertain discussant arguing pro and contra both parties (see bullet 5). The result is, at the moment of communication, that the ambivalence of the recipient is strongly elevated, whilst the attitude does not respond sensitively.

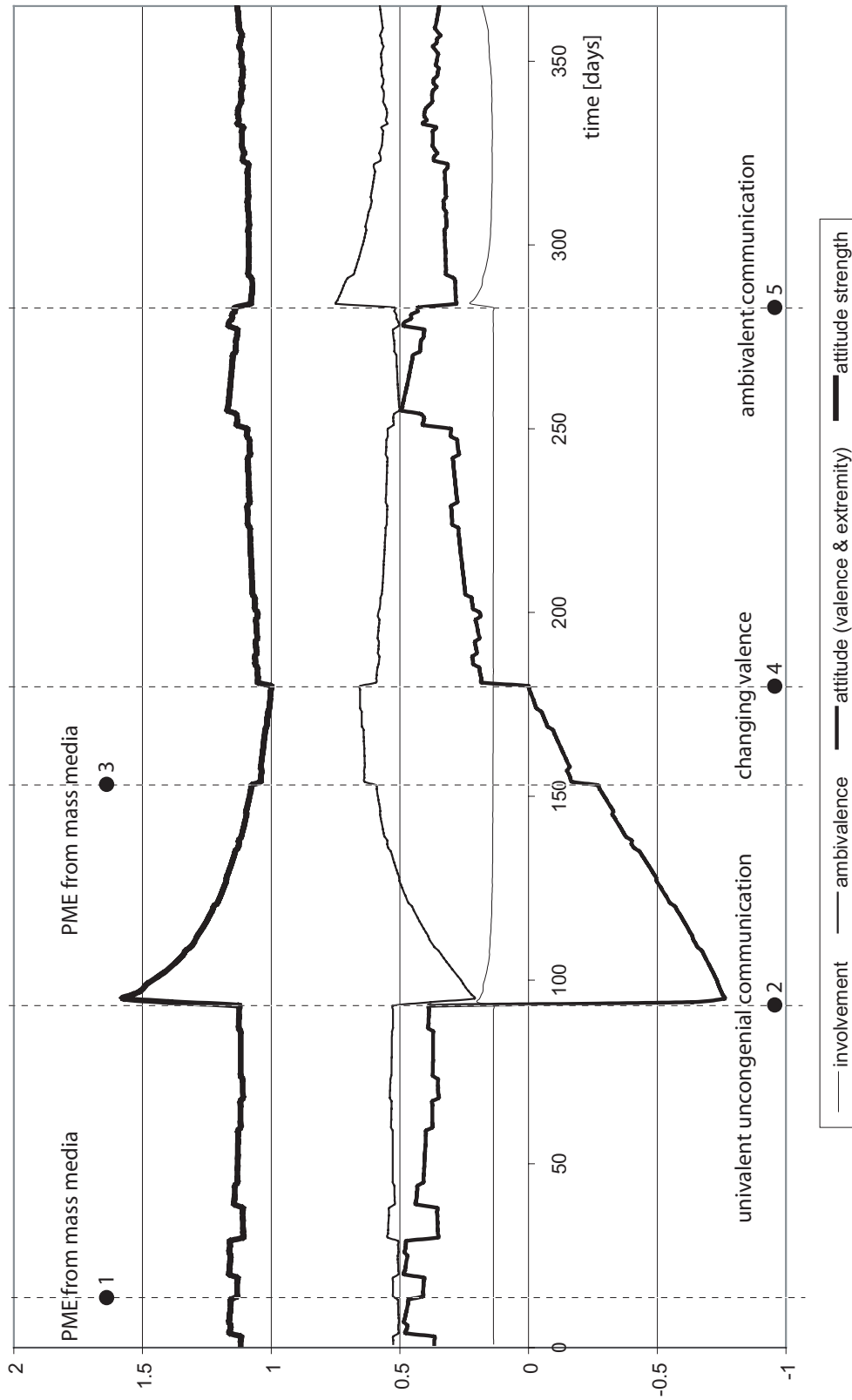


Figure 4.11: Time plots of the various characteristics of attitude strength and the attitude strength itself.

### Aggregate Level

The effects of different party strategies on the level of the electorate can be seen in three example model runs in figure 4.12. In each run, the accumulation level of party  $A$  is  $\psi = 0$  (no accumulation) and the accumulation level of party  $B$  is  $\psi = 32$  (high accumulation).

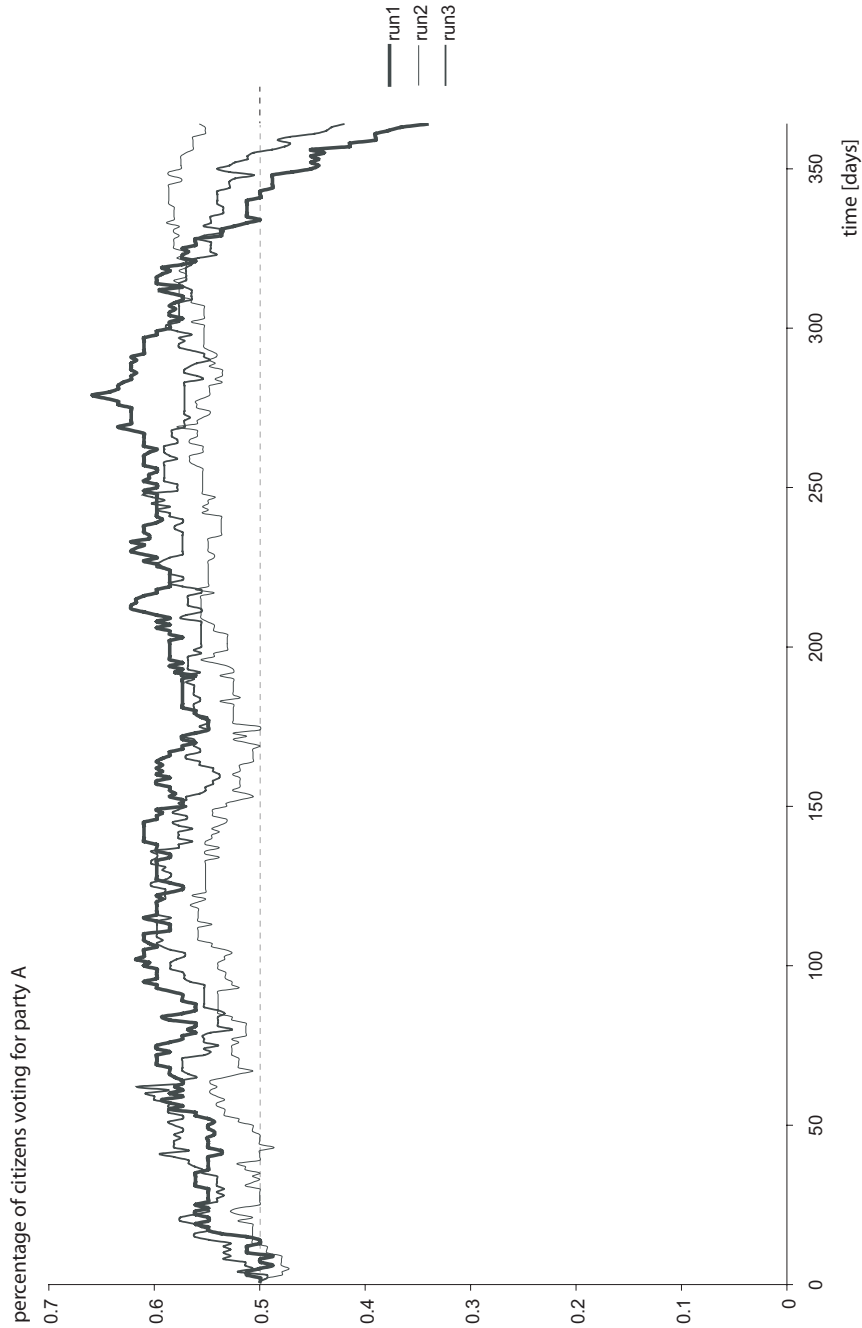


Figure 4.12: Outcomes of elections at hypothetical earlier voting days for three randomly selected model runs.

As a general pattern, in the first 300 days, the number of party *A* partisans increases due to the double advertising activities of party *A* (see figure 4.2 on p. 44). In the runs 1 and 3, the final burst of party *B* advertising in the last weeks before voting day re-converts the citizens that were earlier converted by party *A*. Only in run 2, the attitude bolstering effect and the homogeneity-induced social stabilizing effect are too strong to regain the lost citizens.

Still another look at the model dynamics is provided by figure 4.13. Again, party *A* does not accumulate ( $\psi = 0$ ) whereas party *B* does strongly accumulate ( $\psi = 32$ ). The 100 simulated citizens are aligned horizontally according to the valence and extremity of their initial attitude. The strongest partisans of party *A* are at the upper edge of each graph, whereas the strongest partisans of party *B* are at the lower edge. The apartisans are positioned around the zero-line. At every time step, the hypothetical vote of each citizen is depicted resulting in a trace over time. Dark states encode for votes pro party *B*, light states encode for votes pro party *A*. Blank states denote that this citizen would not have participated in the elections. The turnout underlying these examples was set at 82%. The emerging picture fits into one of the most stylized facts of citizen psychology. Obviously, the initial apartisans in the middle of the figure are mostly affected by the advertising activities. This is visible as frequent changes of the party preference (changing from dark to light states and visa versa) and long periods of undecidedness (blank states). These undecided voters have been identified as the main target group in political advertising (Moffitt, 1999). Indeed, some weak partisans of party *B* are converted (their states becoming light). This process is observable after time step 50 (see box 1 in figure 4.13) and can be attributed to the early dominance of party *A* due to its zero accumulation strategy. The re-conversions of party *B* within the last two weeks before voting day are visible in box 2. An interesting effect is the rapidly growing uncertainty of the supporters of party *B* at the beginning of the model run (increasing number of blank traces).

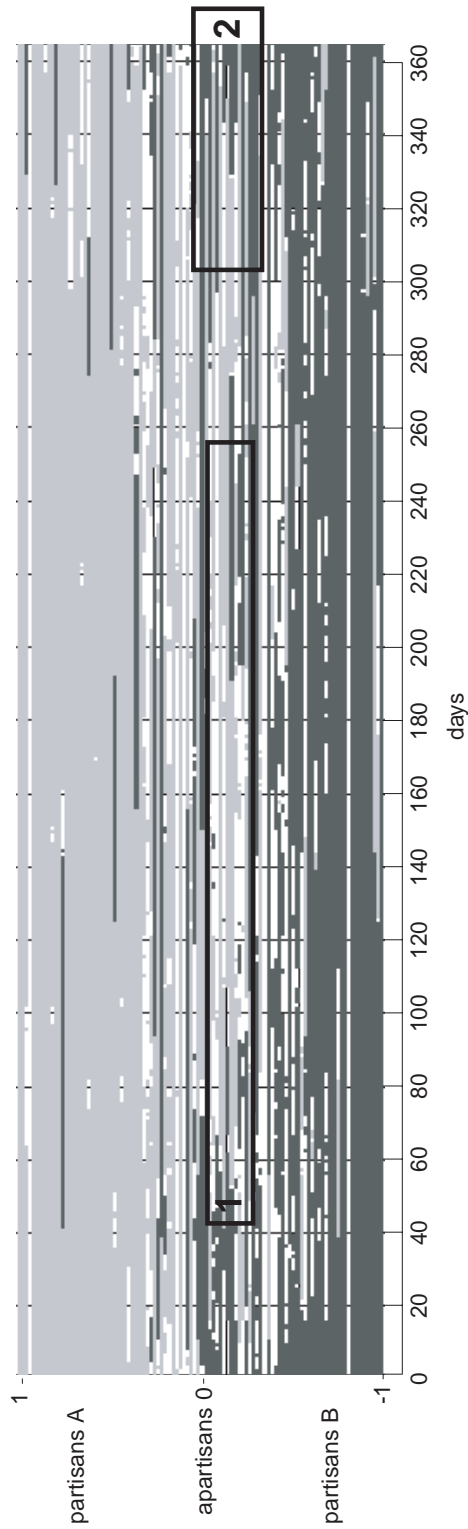


Figure 4.13: Overview of the volatility of the electorate encompassing 100 citizens (the temporal trace of the preference of each citizen is represented as a horizontal line) during the 365 days before voting day. The vertical position of every citizen depends on his/her initial attitude valence and extremity (between  $-1$  for extreme support of party  $B$ ,  $+1$  for extreme support of party  $A$ , and near  $0$  for apartisans). The run corresponds to the run 1 in figure 4.12.

### **Monte Carlo Experiments**

Four experiments were conducted to answer the initial question of finding the optimal degree  $\psi_{opt}$  of accumulating campaign resources towards voting day. The goal of these Monte Carlo experiments was to find out if there is one single optimal accumulation degree or if there are many optimal degrees that are valid under different parameter settings. In this chapter, we test the sensitivity of the optimal accumulation degree against one metrical parameter (speed of memory decay) and one structural parameter (the presence or absence of a model assumption). This model assumption is the second axiom of Zaller's Receive-Accept-Sample (RAS) model (Zaller, 1992, p. 44). This axiom (RAS-A2 for short) predicts that citizens that are habitually more interested in politics are more resistant against uncongenial persuasive messages because they can access more knowledge to find out if a given message is congenial or uncongenial. Technically, the presence of the RAS-A2 is implemented as a module of the citizen initialization process that can be switched on or off. If the module is on (presence of the RAS-A2), the individual strength of the confirmation bias  $\chi_c$  is derived from the individual level of involvement  $I_{0,c}$  (see eq. 4.6a on p. 53). If the module is off (absence of the RAS-A2), the strength of the confirmation bias is set independently of the individual involvement (see eq. 4.6b on p. 53).

The evidence for relatively low levels of memory decay (between 0.0015 and 0.0035) comes from data gathered in a study on the effectiveness of TV ads in consumer product marketing (Zielske et al., 1980). The evidence for relatively high levels of memory decay (between 0.0035 and 0.0055) is taken from a study on issue saliences in response to media coverage (Watt, Mazza, & Snyder, 1993) and a study on brand awareness depending on advertising intensity (West & Harrison, 1997)(see the Appendix I for parameter estimation on p. 77). Crossing the dimension of the decay parameter with the structural dimension of the RAS-A2 results in the following 2x2 matrix of the four experiments:

Table 4.1: Structural and parametrical attributes of the experiments 1 to 4.

speed of memory decay	RAS-A2 absent	RAS-A2 present
high	experiment 1; $\psi_{opt,1}$	experiment 2; $\psi_{opt,2}$
low	experiment 3; $\psi_{opt,3}$	experiment 4; $\psi_{opt,4}$

In each experiment  $i$ , the optimal degree of accumulation  $\psi_{opt,i}$  for party  $A$  is determined. The central expectation with regard to the outcomes is (see eq. 4.15):

$$\psi_{opt1} > \psi_{opt2} \cong \psi_{opt3} > \psi_{opt4} . \quad [\text{eq. 4.15}]$$

Before this expectation is explicated, it is important to remember that a high level of accumulation (for example  $16 \leq \psi \leq 64$ ) means to release the majority of persuasive message *relatively late* within the time period of one year previous to voting day. In contrast, a low level of accumulation (for example  $0 \leq \psi \leq 8$ ) means to release the majority of persuasive message *relatively early* (see figure 4.2 on p. 44).

The rationale of the above expectation is as follows: high memory decay speed will push the optimal degrees of accumulation towards high values since the traces of persuasive messages released early are rapidly forgotten and easily overwritten by the competitor. Low memory decay speed will push the optimal degrees of accumulation towards low values. Persuasive messages released early have the effect to persuade initially uncertain supporters of the opponent party (bring them across the zero-line) and to prevent the initially uncertain supporters of the own party to cross the zero-line. Once a former uncertain supporter from the opponent party has crossed the zero-line, the confirmation bias reinforces this change in the valence of the attitude conversion and helps to strengthen this attitude (increasing its extremity and decreasing its ambivalence). In the following, this effect is called the “early-conversion-and-stabilizing effect”.

In contrast, if the memory decay speed is high, the early-conversion-and-stabilizing effect cannot establish properly because the early released persuasive messages just peter out too rapidly in the citizens’ memories. That is, the same temporal density of persuasive messages that is sufficient for the early-conversion-and-stabilizing effect under the condition of low memory decay does not suffice under the condition of high memory decay.

The presence of the RAS-A2 will push the optimal degrees of accumulation towards low values, since citizens highly interested in politics perceive more persuasive messages from the campaign arena (see eq. 4.2 on p. 46) and evaluate them more carefully with regard to their congeniality (see eq. 4.6a on p. 53). The resulting attitudes

are based on numerous PME's that are, additionally, strongly evaluated for their credibility. In the following, this effect is called the "supporter-stabilizing effect". One could argue that this mechanism, fostering the early-conversion-and-stabilizing effect would be exactly outweighed by the effect of the RAS-A2 on citizens that are weekly interested in politics. These citizens are expected to be less discerning between congenial and uncongenial persuasive messages and are less efficient in bolstering their attitudes. However, the symmetry of the effects of the RAS-A2 will not become visible on voting day, since the more resistant citizens will develop stronger (more extreme, less ambivalent) attitudes and are therefore more likely to participate in the election (see the section on citizen voting behavior on page 47f.).

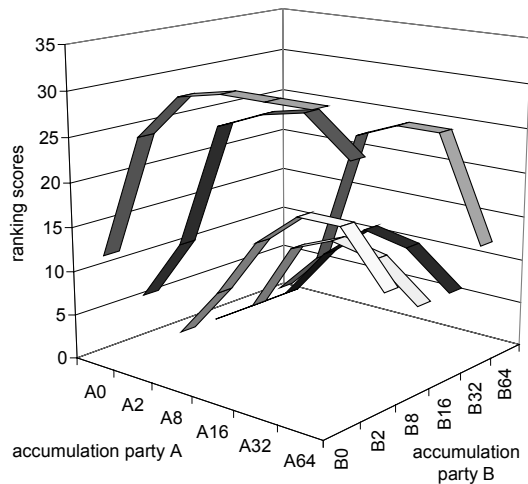
The expectation (see eq. 4.15 on p. 70) can now be substantiated with the above rationale in mind. In experiment 1, the structural effect (absent supporter stabilizing effect) and the parameter effect (absent early-conversion-and-stabilizing effect) are synergetic and push the optimal degree of accumulation towards high values. In experiment 4, the effects are synergetic as well, but in the opposite direction, i.e. towards low values. In the experiments 2 and 3, the effects tend to annihilate each other. The medium degree of accumulation is optimal. If, however, the model sensitivity against the memory decay speed dominates the model sensitivity against the presence or absence of the RAS-A2, the optimal degree of accumulation will be *higher* in experiment 2 than in experiment 3. If the structural sensitivity is dominant, the optimal degree of accumulation will be *lower* in experiment 2 than in experiment 3.

We have conducted 36'000 model runs for each of the four experiments required to isolate statistically significant patterns. At the start of each run, the party *A* and party *B* were randomly assigned a certain degree of accumulation out of six possibilities (0, 2, 8, 16, 32, and 64, see figure 4.2 on p. 44). This resulted in a matrix of  $6 \times 6 = 36$  possible strategy encounters between the parties. Consequently, for each of these encounters, 1'000 runs were collected. In each run, either party *A* or party *B* emerged victorious. In the runs ending in a indeterminate condition of equal numbers of party supporters on both sides (9% of all runs on average), the victory was randomly assigned to one of the parties. The specific number of victories of party *A* was counted separately for each strategy encounter and was transformed into the winning probability of party *A* for each of the  $6 \times 6$  strategy encounters. Next, the probability estimates were transformed into ranking scores. Each combination of party strategies is scored according to its

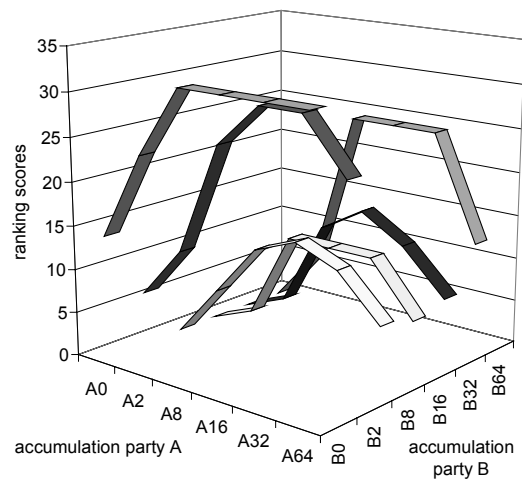


statistically significant ( $p=0.05$ ) superiority to the other 35 strategy encounters (still from the viewpoint of party *A*). That is, if the winning probabilities of two strategy encounters do not differ significantly, their ranking scores are identical. As a reading example taken from experiment 1, the strategy encounter (party *A* = 0; party *B* = 2) is superior to six other strategy encounters, whereas the strategy encounter (party *A* = 32; party *B* = 64) is superior to 23 other strategy encounters.

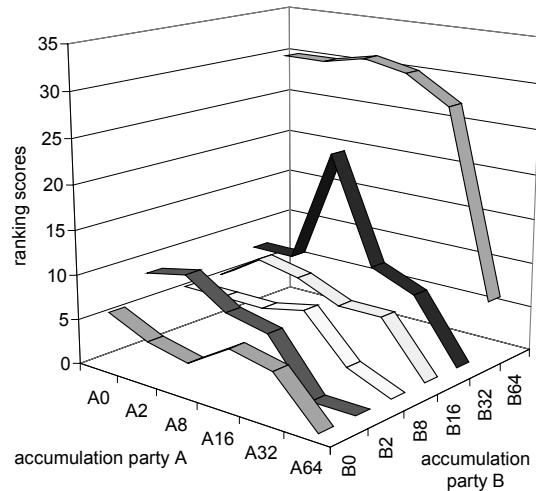
experiment 1: decay speed high, RAS-A2 absent



experiment 2: decay speed high, RAS-A2 present



experiment 3: decay speed low, RAS-A2 absent



experiment 4: decay speed low, RAS-A2 present

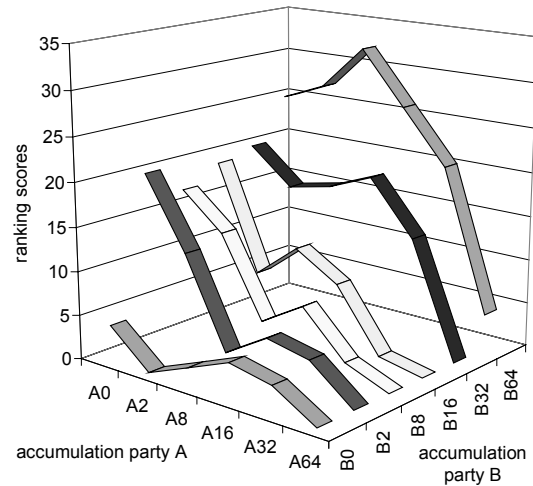


Figure 4.14: Strategy ranking scores for the 6x6 strategy encounters in each of the four experiments. Generally, the higher the winning probability of party *A* under a specific strategy encounter of the opposite parties *A* and *B*, the higher is the relative ranking score for that strategy encounter (see text).

## Discussion

In the first part of this chapter, the results from figure 4.14 are interpreted in order to answer the question of the sensitivity of the optimal accumulation degree  $\psi_{opt}$  as the focal output variable of the model. In the second part, we focus on the results from experiment 2, because strong empirical evidence suggests that the RAS-A2 is present and at least the majority of the evidence regarding the speed of memory decay points to a rather high memory decay speed.

The most salient result is that the model is only sensitive against the presence or absence of the second axiom of Zaller's RAS model (RAS-A2), if the speed of memory decay is assumed to be *low*. The reason for this pattern is that if memory decay speed is supposed to be high, the "supporter-stabilizing effect" from the RAS-A2 cannot establish because any stabilization is impossible under high memory decay speed. In contrast, under the condition of the low memory decay, the "supporter-stabilizing effect" does clearly work.

The experiments confirm the expectation that in experiment 1 and 4 (see table 4.1 on p. 69) the optimal degrees of accumulation are most extreme (although experiment 2 is very close to experiment 1). If both the decay speed is low and the RAS-A2 is present (experiment 4), low degrees of accumulation appear to be highly efficient since interested citizens can be stabilized and undecided citizens can be converted and stabilized. If the opposite party *B* does accumulate between the levels 2 and 32, the losses of effect in terms of memory decay seem to be negligible. If, however, the opposite party does strongly accumulate on the maximum level of 64, it is risky for party *A* not to accumulate at all (level 0 or 2). Under this condition, the maximum ranking scores are found at levels of 8 and 16. An interesting situation for party *A* arises if it is known that the opponent takes the otherwise optimal general strategy of party *A*, i.e. no accumulation (see the B0 segment). Then, the best thing party *A* can do is to accumulate between levels 8 and 32, but again, not on level 64.

In experiment 1, the general rule for party *A* is to accumulate just below the maximum, but not above, as is reflected by the inferior results at the accumulation level of 64. The more party *B* is accumulating, the less efficient is it for party *A* to imitate that strategy. Only if party *B* is not accumulating at all, it is good advice for party *A* to accumulate even at the maximum level of 64. The results of experiment 2 are qualitatively equivalent to the results of experiment 1. This illustrates the model's

insensitivity against the presence/absence of the RAS-A2 if memory decay speed is high.

In experiment 3, ranking scores do not differ very much from each other and characterize a sort of trade-off “plateau” if both parties do not accumulate at the highest level of 64. Under the condition of these strategy encounters, the benefits from stabilizing attitudes and the benefits of recency effects on the PME accessibilities largely cancel each other out. The peak at A8-B32 is not visible in the winning probabilities and is probably caused by the small differences between the winning probabilities and the specific method of translating winning probabilities into ranking scores.

At first sight, it might seem that there is no clear answer to the initial question of the optimal degree of accumulation campaign activities towards voting day simply because the model is too sensitive against the model parameters of memory decay speed and the presence or absence of the RAS-A2. However, the current support from empirical studies is not equally strong for all of the four the boundary conditions of the four experiments. If we trust in the empirical studies suggesting that the resistance axiom from Zaller’s theory is true (Zaller, 1992), we can direct our attention to the experiments 2 and 4 from the analysis. Furthermore, if the low memory decay speed supported only by one of the marketing studies (Zielske et al., 1980) is neglected in the light of the other studies pointing unanimously to a higher speed of memory decay (Watt et al., 1993; West et al., 1997), the subsequent discussion can completely concentrate on the boundary conditions framing experiment 2. Combining the RAS-A2 with a high memory decay speed seems to be the most relevant experimental setting for answering our initial question of optimal temporal resource allocation during political campaigns. In summary, looking at the ranking scores yielded in experiment 2, the answer that can be derived from the set of experiments performed in this chapter is *to accumulate between at levels of  $\psi = 8$ ,  $\psi = 16$  or  $\psi = 32$  independently of the expected level of accumulation of the competitor*. To illustrate this range of optimal degrees of accumulating, the average of the corresponding accumulation curves from figure 4.2 on page 44 is depicted in figure 4.15. It is important to see that the sensitivity analysis (experiments 1 to 4) is required to know that this final result is sensitive to the assumption that memory decay is high and that the second Axiom of Zaller’s Receive-Accept-Sample (RAS) theory (Zaller, 1992) is true.

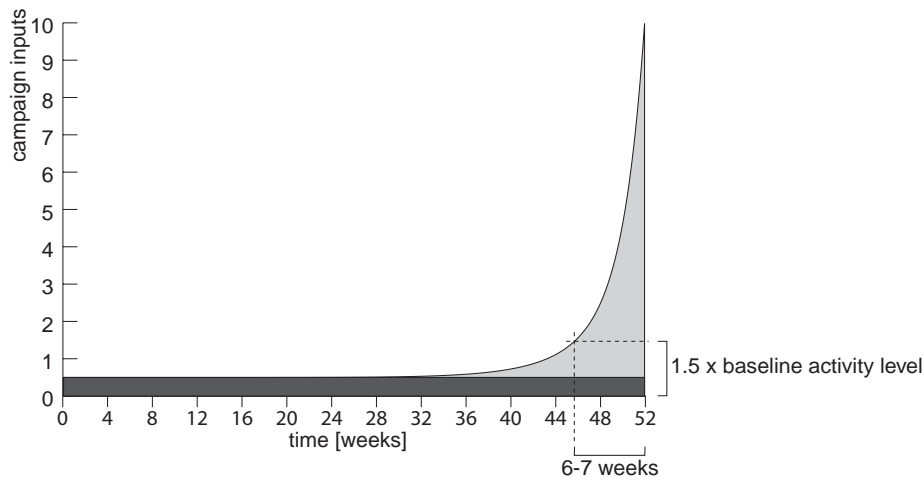


Figure 4.15: The optimal degree of accumulating campaign resources towards voting day under the condition of high memory decay and the presence of the second axiom from the Receive-Accept-Sample (RAS-A2) model (Zaller, 1992).

## Implications and Conclusions

Our results are surprisingly coherent but not totally congruent with the real world practice. In the German General Elections, the “hot phase” of the elections starts between three and six weeks before voting day (Finkel & Schrott, 1995). If in our model the threshold for perceiving the start of the hot phase is set at the threefold baseline activity level of  $3 \times 0.5 = 1.5$  (as assumed to be perceived as the start of the hot phase by almost every citizen, see figure 4.15 on p. 75), the current practice corresponds to accumulation levels of  $\psi = 16$  (the hot phase lasting six weeks, see figure 4.2 on p. 44),  $\psi = 32$  (the hot phase lasting four weeks), and  $\psi = 64$  (the hot phase lasting three weeks). In the light of our simulation results, this means that the practitioners generally have a good intuition about the optimal degree of accumulation with a slight tendency to accumulate too much. This fits nicely into the current debate on the benefits of permanent campaigning (Ornstein & Mann, 2000). The strategy of permanent campaigning strongly recommends parties (especially the party of the incumbent) not to suspend their advertising activities in the inter-election period and to rely too much on the effect of the final burst placed there weeks before voting day (represented by  $\psi = 64$ ). Permanent campaigning has become a widely used strategy model in the USA since the first permanent campaigning of Ronald Reagan in the 1980s. In Europe, countries like Germany, Austria or Great Britain increasingly adopt and test the idea of permanent

campaigning. For example, in the German General Election in 1998, the successful campaign of the SPD was visible in public largely half a year before the campaign of its competitor (the CDU) started. It is important to see that if the factor of 1.5 indicating the start of the final burst is reduced to 1.0, the statement that the practitioners have a slight tendency to accumulate too much is even strengthened. That is, the threshold value of 1.5 has deliberately been chosen at 1.5 to secure that the statement really holds.

However, in spite of the credibility and face validity of the results, an important limitation of our study is the level of uncertainty of the value ranges we have used for varying the input parameters in the simulation runs performed in the Monte Carlo experiments (see Appendix I on p. 77). This is a general problem of computer models with a large parameter space that cannot be totally explored in the sense that every combination of parameters is systematically testable (Abelson, 1968; Hegselmann et al., 1996). In this chapter, we have conducted a sensitivity analysis which focuses on a parametrical (memory decay speed) and a structural (presence or absence of the second axiom of the RAS model) sensitivity of the model result. The selection of these parameters was guided by the principle of looking first at the parameters and model assumptions with the largest expected impacts on the focal output variable (the optimal degree of accumulation). However, one can argue that there are many other parameters and model assumptions with similar impacts on the output. For example, the level of the permanent party advertising activities (the dark areas in figure 4.2 on p. 44) might have some impact on the optimal accumulation degree. If the permanent advertising level is assumed to be very low (say, at 20% of the total budget in contrast to the level of 50% in the current experiments), the effects of the different strategies will be amplified. If a party that does not accumulate encounters a party that does strongly accumulate campaign resources towards voting day, the party not accumulating is virtually the only source of persuasive messages at the beginning of the simulated time window (the competitor does only release messages at the 20% permanent level for a long time). If, however, this competitor starts to advertise with the planned final burst (with strong accumulation), the dominance of the final burst over the still continuously advertising competitor (with no accumulation) will be amplified as well. However, this does not mean that the optimal degree of accumulation remains unchanged in this 20% permanent campaigning scenario. It will depend on the specific data-based estimation of the memory decay speed parameter, of the strength of interpersonal communication and

of the strength of the confirmation bias, if the amplified primacy effect will outweigh the amplified recency effect. In other words, the question will be answered by running specific Monte Carlo Experiments testing the sensitivity of the model against different levels of permanent campaigning.

Another interesting question would be to test for the effect of lower levels of turn-out than in Germany. What if only half of the population (like in the recent U.S. Presidential Elections) participates in the election? According to the voting behavior assumption in the PASS model, this would mean that only the 50% citizens with the strongest final attitudes participate in the election. Since citizens with especially strong attitudes are more difficult to convert, our central expectation is that the differences between the effects of the strategies in terms of winning probabilities will be damped but that the optimal degree of accumulation will remain unchanged.

In this vein, the model could be applied to the two party system of the USA. Currently, the bottleneck is the availability of the data sets required for parameter estimation. We have tested the model using data from German General Elections because of existing personal contacts to the authors of the original empirical studies. The contacts facilitated the proper use of the data published in the literature. However, comparing the results from this study with results of the same model based on US data would allow a fascinating comparison of optimal allocation strategies in these two nations.

A very interesting next experiment would be to confront Fast-Finish-Strategies (as tested in this chapter) with Sprint-Strategies. The latter type means to start with a burst and finish with a burst and to save resources in between.

On the level of the model structure and model processes, one of the most fascinating next steps would be to enable the strategist to continuously react to the unfolding effects of their advertising strategy (Kollman, Miller, & Page, 1998). Yet, the development of more realistic responsive strategists would be a major step that would considerably enlarge the complexity of the model.

## **Appendix I: Parameter estimation**

This appendix is divided into two major groups of parameters: i) parameters directly and inversely estimated from data, and ii) parameters directly estimated and inversely estimated from assumptions. All the parameters were estimated running the model with

intermediate degree of accumulations ( $\psi = 8, 16, \text{ or } 32$ ) that are considered to be closest to the current practice of campaigning (for a definition of “current practice”, see the last section on Implications and Conclusions on p. 75). The extreme degrees ( $\psi = 0, 2, \text{ or } 64$ ) were not used for parameter estimation since the data from the literature are supposed to be measured in the context of intermediate degrees of accumulation.

### Directly and inversely estimated parameters from data

**Turn out** On voting day, only the  $T$  percents of the citizens with the strongest attitudes will participate in the simulated election. The turn out  $T$  is dependent on the average attitude strength  $\alpha_{avg}$  of the citizens. The boundary condition for the function  $T = f(\alpha_{avg})$  are four estimated points. In the first row of table 4.2 the *observed* range of  $\alpha_{avg}$  is indicated after 36'000 model runs with all the other model parameters estimated before.

Table 4.2: Data points required for the functional relationship between turn out and average attitude strength.

	min	avg	max	asymptotic behavior
$\alpha_{avg}$	0	0.15	0.4	1000 (extreme value)
T	0.65	0.81	0.95	1.00 (extreme value)

The value of 1000 is a hypothetical extreme value which is never reached but which is necessary for the asymptotic behavior of the function. The second row contains two educated guesses of the minimal (65%) and the maximal (95%) turn out that are expected for all the future General German Elections.

The average turn out of 81% is equivalent to the average turnout in the German General Elections between 1949 and 1998. The four estimated points describing a convex asymptotic trend are best fitted ( $r^2=0.9998$ ) with an exponential function (see eq. 4.16):

$$T = \frac{1}{1 + e^{-5.68 \cdot \alpha_{avg} - 0.61}} \quad [\text{eq. 4.16}]$$

**“Speed” of memory decay** There is only one study which is adequate for estimating the decay speed of political information perceived under low involvement and under

non-laboratory settings. This study has investigated the temporal change of the saliences of two unobtrusive issues (foreign policy in Iran and the Soviet Union) in relation to the temporal change of the intensity of coverage on each issue (Watt et al., 1993). The authors have developed a simple exponential decay model based on a single forgetting parameter  $k$  that sufficiently matches the data.

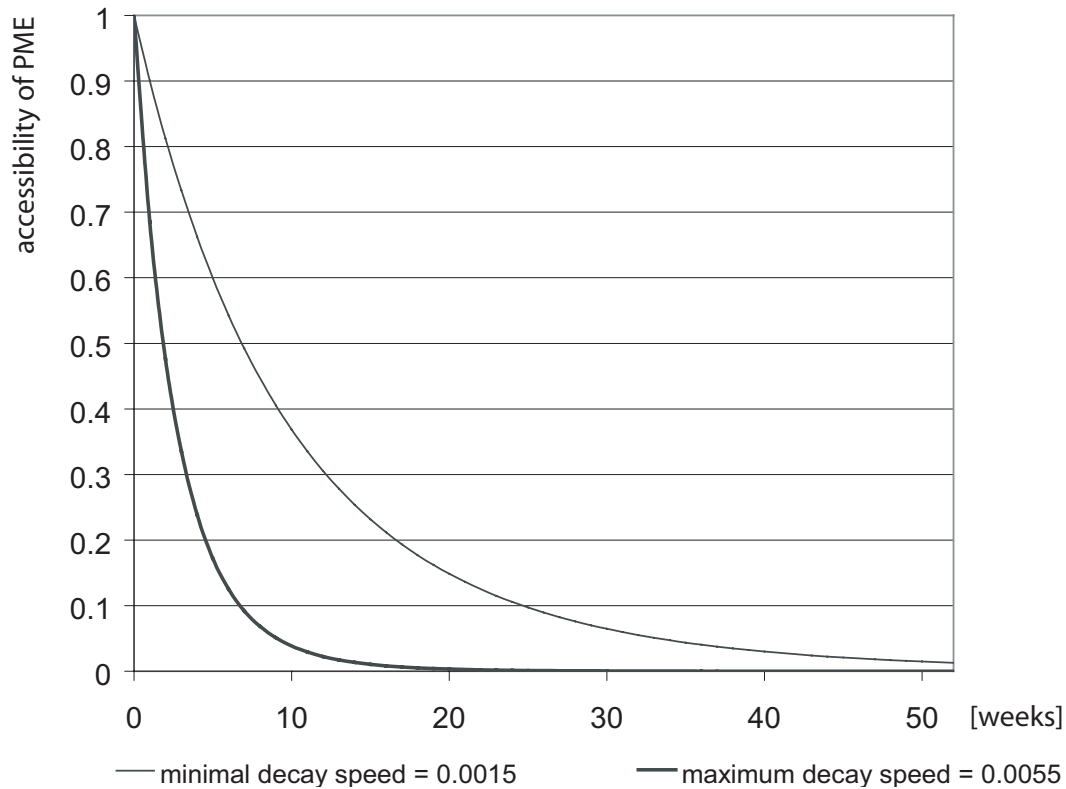


Figure 4.16: Remaining accessibility of a persuasive message extract (PME) after some weeks.  
The involvement at the moment of perception is set at 0.1 (very low).

They find  $k$  at a level of 0.05 (dimensionless scaling parameter) which is similar to former studies (Salwen, 1988; Eaton, 1989). We have reproduced this model with the slightly different power law of forgetting (yielding a match of  $r^2=0.9981$  between the two models) and get an equivalent decay speed parameter value of 0.0055 with the involvement  $I_c(t_{p,m}) = 0.1$  (very low) at the moment  $t_{p,m}$  of perceiving a certain original persuasive message  $m$  (see figure 4.16). Missing similar non-laboratory studies in the political sciences, we had to estimate additional memory decay speeds using data from two studies in a marketing context. The data were collected in non-laboratory settings and the recipients were in the very low involved mind-set of watching TV ads. In the first study (Zielske et al., 1980), subjects were asked to remember ads (free recall) that



have been broadcast on TV some weeks ago. In the second study, the effects of a cereal brand's weekly advertising schedule on advertising awareness was measured during 72 weeks (West et al., 1997). Again with  $I_c(t_{p,m}) = 0.1$ , the estimation yielded comparable high decay speeds of 0.004266 for the West study and a relatively low value of 0.0015 for the Zielske study.

**Sizes of Ego-Networks** There are two studies on the frequency distribution of different sizes of political discussion networks. One of them was conducted in West Germany (Schenk, 1995). In 1990, Schenk found an average size of 2.4 (N=899) in political discussion networks. The other study (Schmitt-Beck, 2000) found an average network size of 1.9 (N=1335) in the same year and also in West Germany. Since the particular name generator applied in the Schmitt-Beck study tended to overlook spouses as important discussants, we build on the distribution of ego-network sizes found in the Schenk study where this problem did not arise.

**Network heterogeneities** The model distinguishes between partisans of party A, partisans of party B and apartisans. If citizens with  $|A_{0,c}| < 0.2$  after the distribution of initial attitudes (see citizen initialization on p. 60) are categorized as apartisans, approximately 28 citizens from the model electorate belong to this group. This number matches the percentage of apartisans found in empirical studies conducted in West Germany between 1990 and 1998 (Falter et al., 2000; Schmitt-Beck, 2000). The remaining citizens are divided into 36 partisans of party A and 36 partisans of party B. Data on heterogeneities within networks of political discussants were taken from the Comparative National Elections Project (CNEP) data for West Germany in 1990 (Schmitt-Beck, 2000). The 100 citizens are linked according to the heterogeneity reference table of a "naturally heterogeneous" network derived from data provided by Schmitt-Beck (Weigelt, 2001) (see table 4.3). Starting from the CNEP data, a second reference table can be derived (Weigelt, 2001) presenting the percentage of different linkage classes within the network (see table 4.4). At the beginning of each model run, the linkages of a random network are optimized until the network matches these numbers (Weigelt, 2001). Data derived from CNEP (Schmitt-Beck, 2000).

Table 4.3: The numbers in the cells denote the number of partisans A, partisans B, and apartisans with a particular composition of network neighbors in the simulated electorate of 100 citizens.

Reading example: 16 partisans of party B have homogeneous and concordant discussant networks.

		party identification of the discussants within ego-networks				
		no discussant	only partisans A	only partisans B	only apartisans	both partisans A and B
partisan A	3	17	3	5	8	
partisan B	3	2	16	6	9	
apartisan	3	4	4	10	7	

Table 4.4: Percentages of different linkage classes within the simulated citizen networks.

partisan A - partisan A	partisan B - partisan B	partisan A - partisan B	apartisan - partisan A	apartisan - partisan B	apartisan - apartisan
20%	20%	17%	15%	15%	13%

**Initial account accessibilities and the general need for confirmation** The average percentage of converted citizens during the ongoing campaigns was found in two different panel studies at a level around 10%. During the last six months before voting day, Finkel & Schrott (1995) discovered 11.4% of the electorate changing their vote intention in the context of the German General Election 1990. In the same year, another study (Schmitt-Beck & Schrott, 1994) found 8.6% of the electorate switching their vote intention between the CDU/CSU/FDP and the SPD/Grüne (*Lagerwechsel*) in the period from October until voting day at 2<sup>nd</sup> December. Varying the maximum of the initial account accessibilities  $a_{0A,c}$  and  $a_{0B,c}$  between 0.0 and 9.0 and the general need for confirmation  $\chi_c$  between 0.0 and 0.5, the average percentage of converted citizens was at 7.7% for the six month period of the first study and at 4.3% for the two month period of the second study. The percentages of converted citizens from the German General Election in 1990 are expected to be relatively high due to the special circumstances of the first elections after the unification of East and West Germany (Finkel et al., 1995). Therefore, for the estimation, we have chosen target values which are slightly below the empirical values.

**Probability of beginning attitude exchange** Two studies measured the percentage of persons in the electorate that report to have recently met somebody who tried to persuade them to vote for a certain party (Noelle-Neumann & Reitzle, 1991; Noelle-

Neumann, 1999). The question was asked every week during the last two months before the voting days of the five German General Elections between 1983 and 1998. For the estimation of the probability of beginning an attitude exchange, we selected the averages of the percentages yielded at two months, one month, and one week before voting day.

Table 4.5: Average percentage of citizens who have recently been the target of somebody trying to convince them to vote for a particular party (Noelle-Neumann et al., 1991; Noelle-Neumann, 1999).

time before voting day	mean	sdev	N
2 months	15.6	3.6	5
1 month	16.4	2.9	5
1 week	20.2	5.7	5

Defining “recently” as a time window of one month and varying the probability of beginning attitude exchange between 0.0125 and 0.0225, we found the percentage of citizens reporting persuasion attempts at 17.9% for two months, at 19.5% for 1 month, and at 21.5% for 1 week before voting day. These settings yielded an average accumulated number of deliberately initiated attitude exchanges at the plausible value of 2.5 per citizen over the simulated year before voting day.

**Judgmental weights of different information sources** Starting from data on the relative weights of different information sources during the revision of the attitude, several parameters can be estimated inversely (see table 4.6). As a measure for the relative weight of a particular source we use the explanatory power given by the measurements of the perception of that source (independent variable) for the prediction of the voting behavior (dependent variable). For the Logit Model applied in the analysis of the CNEP data, the explanatory power was captured by the corrected Pseudo-R<sup>2</sup> index KPR<sup>2</sup> (Andress, Hagenaaars, & Kühnel, 1997). Since the weights of the different sources are simply added in the formation of the judgmental responses, we have to use the KPR<sup>2</sup> values yielded from putting each source as the *only* independent variable for predicting voting behavior.

Table 4.6: Relative explanatory power of information perceived from different sources for the prediction of the voting decision. Data from Schmitt-Beck (2000).

source	KPR <sup>2</sup>	relative response weight	parameter inversely estimated	estimate
party identification	0.45	52%	maximum of the initial account accessibilities $a_{0A,c}$ and $a_{0B,c}$	[0.0 .. 9.0]
interpersonal communication	0.245 (for CDU/CSU and SPD citizens)	28%	the weight of interpersonal communication $\omega_{IPC}$	[30.0 .. 40.0]
party advertising	0.14 (interpolated)	16%	credibility of the strategists	[0.06 .. 0.14]
mass media	0.034 (for CDU/CSU and SPD citizens)	4%	relative “activity budget” $Y_M$ of the mass media: percentage of the total activity budget of both parties	[10 .. 15%]

The KPR<sup>2</sup> for the strategist advertising was interpolated from values of interpersonal communication and mass media. If asked for the most important information sources during election campaigns, most of the citizens place the party advertising between interpersonal communication and the mass media (Schulz & Blumler, 1994; Semetko et al., 1994; Zeh & Hagen, 1999). The resulting non-minimal response weight is consistent with the evidence from empirical studies that political campaigns significantly affect the citizen’s votes (Finkel et al., 1995; Shaw & Roberts, 2000). The assumption that the mass media are less effective in shaping citizen preference formation as interpersonal communication has been formulated in several studies before (Chaffee et al., 1988; Lenart, 1994), but was never tested with satisfying methodological scrutiny.

### Directly and inversely parameters estimated from assumptions

Table 4.7 presents the assumptions about the lower and upper bounds of parameters where there is no data from the literature. The boundaries of these parameters had to be estimated directly or inversely from the estimation of another parameter.

Table 4.7: Directly and inversely estimated parameters from assumptions

Parameter	estimate
Total spending of the of the parties $A$ and $B$ with $Y_A = Y_B$	365.0
Level of the baseline advertising activity of the parties	0.5
The true level of the baseline could not be estimated from empirical studies. Even the very detailed campaign reports of the German parties (e.g. CDU, 1987) do not provide sufficient data.	
Average involvement on voting day	0.375
Rationale: all PME's with an accessibility larger than 95% of their maximum initial accessibility just at the moment of perception are perceived to one subjectively felt "block of simultaneous perception". That is, events that occur within this block are all equally aware in the citizen's mind. The assumption is that under low involvement, this block encompasses two days. All events happening within two days are equally "present". If the decay speeds is varied between 0.0015 and 0.0055, the average initial involvement of the citizens has to be at 0.125 in order to adjust the "block of simultaneous perception" to a length of 1.8 days. If we assume that, on voting day, this subjectively felt block enlarges up to a length of approximately one week, the involvement has to grow to a value of 0.375.	
Threshold of accessibility $\beta_{att}$ at the inflexion point of the involvement growth curve (see figure 4.6 on p. 55).	[60.0 .. 70.0]
Inversely estimated from the condition that the final average involvement is expected to be 0.375 (see above)	
Reference credibility for the mass media (given a priori just as a reference). It is assumed to be between the credibility of the parties (maximally 0.14, see above) and the credibility of a maximally involved communication partner (maximally 1.0).	0.5
Qualitative differentiation between extremely smooth (max) and extremely sharp (min) threshold of attention (see figure 4.6 on p. 55)	[-8.0 .. 0.0]

## Appendix II: Survey of the PASS model parameters

### Actor Symbols and Indexes

These symbols and indexes are used in the model description and in the equations.

Symbol	value range	description
$S_A$ and $S_B$	nominal	strategists of the parties $A$ and $B$
$M$	nominal	the mass media
$c$	N	index of different citizens
$m$	N	index of different original persuasive messages
$i$	N	index of different persuasive message extracts (PME)
$j$	nominal	index of the opponent parties $j \in \{A, B\}$
$\delta_i$	$\{A, B\}$	affective tag of PME $i$ ; $A$ means pro party $A$ /contra party $B$ , $B$ means pro party $B$ /contra party $A$
$sign(\delta_i)$	$\{-1, 1\}$	transformation of the affective tag into numerical format; $A \rightarrow 1, B \rightarrow -1$

### Input parameters

These parameters are required to initialize the model.

Symbol	value range	description
$N$	N	number of citizens
$H$	N	simulated time period before voting day [days]
$Y_j$	$\mathbb{R}^+$	predefined campaign budget of the parties
$Y_M$	$\mathbb{R}^+$	predefined campaign budget of the mass media
$\varepsilon_S$	[0..1]	credibility of the strategists
$\varepsilon_M$	[0..1]	credibility of the mass media
$c_{0,i}$	[0..1]	original credibility level of the PME $i$
$\omega_{IPC}$	$\mathbb{R}^+$	weight of the interpersonal communication parameter
$\rho$	[0..1]	predefined level of permanent advertising activities
$\psi$	$\mathbb{R}^+$	degree of accumulation of campaign resources toward voting day
$\varpi$	[0..1]	maximum distortion level of the media coverage
$I_c(t_k=0)=I_{0,c}$	[0..1]	level of the habitual interest into elections of citizen $c$
$\beta_{att,c}$	$\mathbb{R}^+$	individual threshold of accessibility of citizen $c$ where the growth of involvement per time step is at its

		maximum
$\sigma_c$	$R^-$	the “sharpness” of the involvement increase of citizen $c$ around $\beta_{att,c}$
$\zeta_c$	$R^+$	individual general tendency of beginning an attitude exchange of citizen $c$
$\nu_c$	$R^+ \setminus \{0\}$	the individual memory decay speed of citizen $c$
$\chi_c$	$R^+$	the strength of the confirmation bias
$a_{0A,c}$ $a_{0B,c}$	$R^+$	initial accessibilities of the mental accounts for party $A$ resp. $B$
$\beta_{0,c}$	$R^+$	initial accessibility of the attitude of citizen $c$
$\beta_{0,max}$	$R^+$	maximum initial accessibility of the attitude
$A_{0,c}$		initial attitude of citizen $c$
$const_1$	[0..1]	constant required for normalization of credibility
$const_2$	[0..1]	constant required for the normalization of ambivalence between [0..1]
$const_3$ $const_4$	$R^+$	constants for keeping the maximal contribution from the initial involvement and the initial attitude equal

### Throughput Parameters

These parameters are used to transform the input parameters into the output parameters.

Symbol	value range	description
$t_k$	N	time (after $k$ model steps or periods)
$n_{r,j}(t_k)$	N	number of released persuasive messages of party $I$ at time step $t_k$
$n_{r,tot}(t_k)$	N	the whole set of inputs on the campaign arena at time step $t_k$
$n_{p,c}(t_k)$	N	number of persuasive messages perceived out of $n_{r,tot}(t_k)$ at time step $t_k$
$I_c(t_{p,m})$	[0..1]	level of the involvement of citizen $c$ at the moment $t_{p,m}$ of perceiving a certain original persuasive message $m$
$p_{ex,c}(t_k)$	[0..1]	probability of initiating an interpersonal exchange of attitudes at time step $t_k$
$\varepsilon_c(t_k)$	[0..1]	credibility of the communication partner $c$ at time step $t_k$
$a_I(t_k)$	[0..1]	the accessibility of the persuasive message extract $I$ at time step $t_k$
$c_I(t_k)$	[0..1]	credibility of PME $I$ at time step $t_k$
$n_{A,c}(t_k)$	N	total number of PMEs that are associated with the mental account of party $A$ of citizen $c$ at time step $t_k$

$n_{B,c}(t_k)$	N	total number of PME's that are associated with the mental account of party <i>B</i> of citizen <i>c</i> at time step $t_k$
$\beta_c(t_k)$	$R^+$	summed accessibilities of the PME's of both attitudinal accounts
$R_{A,c}(t_k)$ $R_{B,c}(t_k)$	$R^+$	response intensities from the mental accounts for party <i>A</i> resp. <i>B</i> at time step $t_k$
$\alpha_{avg}(t_k)$	$R^+$	average attitude strength of the citizens
$\xi_c(t_k)$	$R^+$	certainty of citizen <i>c</i> at time step $t_k$
$\Delta(t_k)$	[0..1]	percentage of uncertain citizens

### Output Parameters

These parameters are related to the construct of attitude strengths and voting behavior.

Symbol	value range	description
$sign[A_c(t_k)]$	{-1,1}	valence of the attitude of citizen <i>c</i> at time step $t_k$
$ A_c(t_k) $	[0..1]	extremity of citizen <i>c</i> at time step $t_k$
$A_c(t_k)$	[-1..1]	attitude (valence and extremity) of citizen <i>c</i> at time step $t_k$
$I_c(t_k)$	[0..1]	level of involvement of citizen <i>c</i> at time step $t_k$
$\Pi_c(t_k)$	R	intra-attitudinal ambivalence of citizen <i>c</i> at time step $t_k$
$\alpha_c(t_k)$	$R^+$	attitude strength of citizen <i>c</i> at time step $t_k$
$T$	[0..1]	turnout
$\psi_{opt}$	$R^+$	optimal degree of accumulation of campaign resources toward voting day



### Appendix III: Glossary of the most important technical terms

term	description
accessibility	a measure of the probability of a PME to have an effect on the outcome of the attitude revision at a particular time ste
affective tag	reflects the subjective impression of the main thrust of the arguments, pictures, slogans and jingles etc. contained in the → original persuasive message and is considered to be easily extractable under the condition of very low citizen involvement
ambivalence	the result of multiple response alternatives that are perceived as being equally available and attractive, with nonetheless have contradictory implications
attitude	a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor
attitude strength	concept defined via a variety of antecedents and a variety of consequences  antecedents: → extremity, → ambivalence, → involvement  consequences: strong attitudes i) lead to selective information processing, ii) are resistant to change, iii) are persistent over time, and iv) are predictive of behavior.
automatic amplification effect	the predominance of the coverage on party <i>A</i> or party <i>B</i> determined by the current campaign activities of the parties
availability bias	more recent an therefore more accessible PMEs have a greater effect on the final judgment
campaign activities	mass media reporting, commercial TV spots and newspaper ads, speeches, pseudo-events, interviews, posters, brochures, bumper stickers etc.
campaign arena	hypothetical space for → original persuasive messages
certainty	mental construct comprising → attitude extremity and → attitude ambivalence
confirmation bias	biased interpretation of new evidence; if the new evidence is congenial with the attitude → valence, the credibility of the evidence is increased; if the new evidence is uncongenial with the attitude → valence, the credibility of the evidence is suppressed
extremity	degree of favor or disfavor distance of the attitude → valence from the zero point of

	perfect indifference between extreme disfavor and extreme favor
Fast Finish Strategy	common type of advertising strategy in political campaigns: start slowly and save resources for a big final burst close to voting day
homogeneity bias	people tend to have homogeneous ego-network; homogeneous ego-networks are affirmative “filters” confirming the congenial → OPMs coming from the → mass media and disconfirming uncongenial OPMs coming from the mass media
involvement	interest in public affairs validated by keeping informed and expressed through participation in civic action
mass media	represent the external source of the non-commercial coverage in the newspapers, television, broadcast, and the Internet
mental account	mental representation separating the positive from negative evidence towards a judgmental target
original persuasive message (OPM)	“full-fledged” campaign event (encompassing the full perceptual richness of pictures, arguments, tables, slogans, jingles etc.)
party strategists	represent the external sources of commercial persuasive messages released in the form of TV spots, newspaper ads, speeches, pseudo-events, interviews, posters, brochures, bumper stickers etc.
persuasive message extract (PME)	basic knowledge units in the PASS model; resulting essence of the → OPM; combines the extracted → affective tag and the credibility of the → original persuasive message
RAS-A2	The second axiom (Resistance Axiom) of the Receive-Accept-Sample (RAS) Model: citizens that are habitually more interested in politics are more resistant against uncongenial persuasive messages because they can access more knowledge to find out if a given message is congenial or uncongenial.
response intensity	integrated judgmental weight (→ accessibility x credibility) of all the → PMEs attached to one → mental account
Sprint Strategy	common type of advertising strategy in political campaigns: start with a burst and finish with a burst and save resources in between
valence	bimodal parameter of the attitude (either favor or disfavor)

## 5 Validation of the PASS Model

This chapter gives an overview of the efforts that have been made to validate the PASS model. The first section defines the concept of validation and explores its fundamental relativity and subjectivity. The second section presents four common perspectives of validating models. They will serve as a frame of reference for the rest of the chapter. Next, for each validation perspective, the specific validation techniques that have been applied are described and discussed. Where required, references to other parts of this PhD work are made. Finally, the current state of the PASS model in regard to its degree of being validated is summarized.

### **Relativity and Subjectivity**

The question of the “correctness” of a computer simulation model with reference to “reality” is a legitimate question. It may be posed by all kinds of model users reaching from governmental decision-makers to people affected by the decisions to scholars using the model for theory building. However, in spite of its legitimacy, answering the correctness question is one of the most awkward tasks a modeler has to tackle (Carson, 1986). The reason is that the answer can never be fully satisfying, neither for the modeler nor for the user. It is principally impossible to validate a model in an all or none manner. The pragmatic goal of validation is to enhance the credibility and plausibility of the model and not to “prove” the correctness of the model (Shannon, 1975; Schruben, 1980; Sargent, 1984; Balci, 1998). There are only relative degrees of validity that can be obtained (Law & Kelton, 1991). Put differently, the validation process is an infinite “confidence building activity” (Balci, 2002) only limited by time and money. The process is largely a process of falsification, and not a process of verification. A series of tests that do not show that the model is incorrect enhance the level of confidence in the model (Robinson, 2002).

Figure 5.1 illustrates the presumed non-linear trade-off between an additional unit of model confidence (or model value, resp.) gained by an additional unit of validation cost. The difficult task of the parties involved in the model development project is to arrive to an intuitive agreement of the most cost-efficient degree of validation without knowing the exact runs neither of the value curve nor of the cost curve.

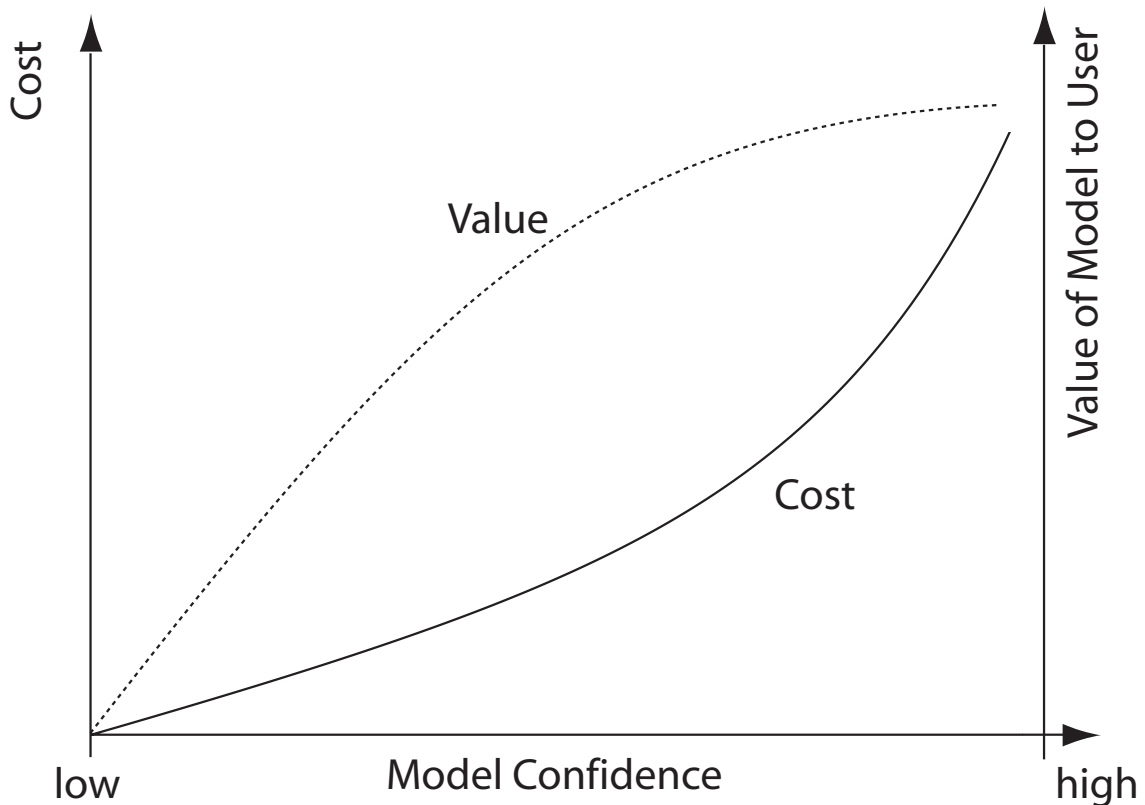


Figure 5.1: Trade-off between cost for model validation and model value for the users. Adapted from Sargent (1998).

Unfortunately, standardized accreditation procedures encompassing a list of “sufficient validation” criteria are neither available nor desirable. The criteria themselves would have to be subjectively determined and would mimic a false objectivity that would provoke overconfidence in the model results (Sargent, 1998).

Facing the relative and subjective nature of validating models, the notion of “model validation” is commonly defined as „the substantiation that a computerized model within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the model“ (Schlesinger, Crosbie, Gagne, Innis, Lalwani, Loch, Sylvester, Wright, Kheir, & Bartos, 1979). This definition points out that considering a particular degree of validity as “satisfying” is i) relative to the purpose of the model and ii) relative to the perception of the jury.

### **Validation perspectives**

The following section presents an overview of various validation steps that have already been applied to the PASS model. As with every validation procedure, the goal

has been to develop the confidence in potential model users to apply the model and to develop trust in the information provided by running the model.

First, four perspectives of validation have to be distinguished (see table 5.1). The definitions of the validation perspectives are taken from Sargent (1998), but see also the similar perspectives proposed by Knepell et al. (1993).

Table 5.1: Computational models can be validated from four basic perspectives. All definitions cited from Sargent (1998), p. 108.

Perspective	Definition
Conceptual Model Validation	Determining that the theories and assumptions underlying the conceptual model are correct and that the model representation of the problem entity is “reasonable” for the intended purpose of the model
Data Validity	Ensuring that the data necessary for model building, model evaluation and testing, and conducting the model experiments to solve the problem are adequate and correct
Computerized Model Verification	Assuring that the computer programming and implementation of the conceptual model is correct
Operational Validation	Determining that the model’s output behavior has sufficient accuracy for the model’s intended purpose over the domain of the model’s intended applicability

In the following sections, the perspectives in table 5.1 are used as a frame of reference. Two terminological clarifications have to be added here. The term “conceptual model” denotes the outcome of analyzing and modeling the problem entity. In the PASS model, the problem entity is a social network of 100 communicating citizens which form each a political attitude in response to the activities of the mass media and two competitive parties. The notion of a “computerized model” is defined as the result of implementing the conceptual model in the symbol system of computer code.

### **Conceptual Model Validation**

This validation perspective has been taken in chapter 3 (p. 24ff.) where the main theoretical components of the PASS model are discussed in the context of psychological and sociological theories. This perspective is also present in the model description in

chapter 4 (p. 37ff.). For example, the theory of mental accounting (Henderson et al., 1992) predicts that human beings encode incoming information according to an internal categorization or grouping process. The specific implemented design of two separated accounts (pro party A/contra party B and pro party B/contra party A) is deduced as a specific case from the general theory of mental accounting. At this point, the relativity of validation comes in again. It would be desirable to deduce the implementation design from a tailor-made study reporting two-party mental accounting with German citizens previous to the voting day of the German General Elections (for the purpose of establishing a model of the attitude strength formation process of German citizens previous to the voting day of the German General Elections). However, this study has not been conducted as yet. Unfortunately, the wider the gap between the context of the available study and the context of the intended system to be modeled, the more debatable is this sort of deduction process. In the extreme case, if there is no study at all to deduce the implemented design from, the “gap” is infinite and the need for theoretical debate as well. In other words, if the aforementioned theory of mental accounting had not been established, I would have had to propose the two-party account design from scratch or from common sense. Discarding the design of two accounts, I could not have modeled the phenomenon of ambivalence, since *by definition* the phenomenon means to vacillate between (at least) two different valences. If some future argument will show that the gap between the two-party mental accounting design implemented in the PASS model and the general theory of mental accounting is too big, two answers are possible. First, the more cautious answer would be to suspend modeling the phenomenon of ambivalence of citizens until better studies on citizen ambivalence are available. The simple argument would be, given the available studies up to now, that modeling ambivalence is an unreasonable scientific goal and should not be pursued from a normative view of “good” science.

The other strategy would be to invent an implementational design for ambivalence from scratch, but to make the underlying assumptions explicit. This strategy was selected in the PASS model when modeling the construct of attitudinal certainty (see p. 59) as the product of attitudinal extremity and attitudinal ambivalence. The theoretical step from the full attitude strength concept (encompassing additionally the level of attitudinal involvement) to the “reduced”, involvement-free concept of attitudinal certainty cannot be grounded in any empirical study. The purpose of the conceptual

distinction is that the concept of attitudinal certainty is designed to express the “pure” uncertainty aspect of the attitude without being “contaminated” by the motivational component of involvement. That is, if citizens are asked in a representative opinion poll which party they would vote for if voting day were today, the involvement component is provided by the situation of being asked itself (extrinsic involvement). Considering the intrinsic involvement component (not induced from outside) is only necessary if the actual participation at voting day is to be modeled. In summary, although the differentiation between attitude certainty and attitude strength has not been substantiated in an empirical study up to now, I have included this differentiation in the PASS model. For a justification of this step, I have presented some arguments making the distinction plausible. Notably, this differentiation is the only theoretical assumption in the PASS model without any underlying empirical evidence. In relation to the number of empirically (more or less) grounded assumptions, the model can be viewed as *relatively well* validated from the perspective of Conceptual Model Validation (see table 5.1 on p. 92). This estimation is generally endorsed by the feedback from numerous proof readings, oral presentations, and discussions of the model assumptions. The readers (resp. the listeners) included experts in cognitive psychology from the Psychological Institute of the University of Zurich (UniZH) and from the Chair of Natural and Social Science Interface at the Swiss Federal Institute of Technology (ETHZ), experts in political campaigning from the Institute of Political Science at UniZH, and experts in media reception from the Institute of Mass Communication and Media Research (IPMZ) at the UniZH, including visiting lecturer PD Dr. Rüdiger Schmitt-Beck from the ZUMA Mannheim. The interaction with the experts was not guided by a standardized knowledge elicitation technique (e.g. Ford & Sterman, 1997). Instead, communication was mainly personal in verbal or in written form. This third-party process is termed in the literature as Simulation Model Assessment. It is defined as “a process by which interested parties (who were not involved in a model’s origins, development and implementation) can determine, with some level of confidence, whether or not the model’s results can be used for decision-making” (Gass, 1983).

In spite of the relatively high degree of conceptual model validity due to a variety of empirical studies and judgments from experts, the question arises how valid the studies are themselves. How valid and reliable was the measurement of the data? Was the

subsequent analysis of the data correct? The perspective of data validity is discussed in the following section.

## **Data Validity**

The quality of the Conceptual Model Validation process is largely dependent on the quality of the empirical research underlying the assumptions and theories that have been implemented in the computer model. The primary source of uncertainty here is the reliability and the validity of the original studies. Reliability is the degree of stability exhibited when a measurement is repeated under identical conditions. Validity is the extent to which a measurement, test or study measures what it purports to measure (Sydenham, Hancock, & Thorn, 1989).

The PASS model is not based on self-conducted empirical studies, i.e. it is completely based on published studies from other research groups. In a scientific paper, the limitations of the reliability and validity of the data measurement is usually discussed in the Method, Results and Discussion chapters. My pragmatic attitude towards using the published data was to trust in the quality assurance provided by the review process of the journals. The reason is that I am not sufficiently educated in the methodology of empirical field studies to appreciate the reliability and validity of the data measurements.

Another source of uncertainty related to the use of published studies is the validity of the reported process of hypothesis testing and model building. Again, my position is to trust in the work done by the reviewers working for the journals.

## **Computerized Model Verification**

Identifying errors in the computer code is time-consuming but nevertheless one of the most important tasks every modeler has to face. To verify the correctness of the computer code, I have mainly applied two strategies. The first is to run the model and observe the time traces of as many of the parameters as possible. Three examples might illustrate this kind of debugging:

- If the attitudinal extremity exceeds the interval of  $[-1.0 .. 1.0]$ , the implemented formula (see equation 4.9 in chapter 4 on p. 56) must be wrong.



- If, under the condition that both parties choose the same strategy, the confidence interval of the winning probability of party A does not include the value of 0.5, something is wrong with the internal symmetry of the parties.
- If the credibilities of the PME's are suppressed if they are congenial and vice versa, the if-statement is obviously erroneous.

The second strategy is extremely time-consuming (and cumbersome) but returns one of the highest levels of certainty that the code is valid. The strategy is to walk through the (printed) computer code of the model performing all the calculations assisted by a simple pocket calculator (so-called "hand-walks"). Similarly, the logical statements are followed code line by code line. The expected results (the logical branching points and the calculations) are compared with the results of running the model step by step. In this vein, the PASS model has been validated up to a "depth" of five steps. One could argue that in the sixth step, a fatal error had occurred. Here once more the relativity of the validation process has to be reminded. Given certain limitations in time and money, hand-walks with a length of  $n$  steps can be performed. Unfortunately, there is no guarantee that a fatal error would have been found in the  $n+1$ th step. However, the combination of performing hand-walks (over very few steps) with evaluating time traces (over the full modeling period and over many model runs) seems to be a powerful approach to detect as many programming errors as possible per unit of time.

## **Operational Validation**

The PASS model is primarily provided as a tool to develop the theory of the formation and change of the strength of political attitudes. The model has not been developed with the purpose to give concrete advice to political strategists. This initial statement is crucial to determine the "appropriate" level of Operational Validation. A helpful distinction in this context is the one between intellectual vs. emulation models (Carley, 1996). *Intellectual* models are aimed at analyzing the implications of the complex entanglement of several psychological or social mechanisms proposed in the literature. Their general purpose is not to predict but to understand. In contrast, *emulation* models are frequently constructed in an engineering context (e.g. wind tunnel models). They are aimed at providing pragmatic advice on a specific problem proposed by customers. The general purpose of emulation models is to predict rather than to understand.

The crucial point is now that these two types of models need not to be validated in the same manner. The main task for the author of intellectual models is to provide a substantiation of grounding (as has been done, see the section on Conceptual Model Validation on p. 92ff.), whereas the authors of emulation models have the additional task to calibrate the model (Carley, 1996).

The PASS model is mainly a tool of theory building. The most important target group of the confidence building process are scholars working in the field of attitude theory. The target group of campaign practitioners is addressed with secondary priority. Therefore, it predominantly belongs to the intellectual category. However, the PASS model also has some characteristics of an emulation model since various parameters are calibrated. Calibrating is defined as “the process of tuning a model to fit detailed real data” (Carley, 1996, p.13). The specific calibration process is not discussed in this chapter since it is described step by step in the sections “Citizen Typology” on p. 60f. and “Citizen Initialization” on p. 60f., and in the Appendix I of chapter 4 on p. 77ff.

In some regards, the Monte Carlo experiment performed in chapter 4, p. 69ff., can be considered as an additional test of Operational Validation of the PASS model. The experiment was designed to estimate the winning probabilities of party A depending on the strategy of party A, the strategy of party B, the rate of memory decay and the absence or presence of the second axiom of Zaller’s Receive-Accept-Sample (RAS) model. Under the boundary conditions suggested by the empirical studies (the “true” decay rate is high and Zaller’s axiom is present), the optimal degree of accumulation for party A partly matches the degree of accumulation found in the current practice of the parties. Importantly, this experiment has been run *after* the parameters of the model were calibrated. Thus, the Monte Carlo experiment provides further evidence that – based on the model calibration - model outputs can be produced which at least partly fit into empirical data.

In summary, in spite of the calibration process based on a *relatively* rich basis of empirical data (election research is known as the most data-rich domain in social psychology, particularly when looking for panel data), the model cannot be regarded as calibrated on a satisfying level. In consequence, the simulation results (e.g. the optimal degree of accumulating campaign resources) should not be rashly translated into a full-grown advice for political practitioners. There are still severe limitations preventing the

PASS model from generating practical advice. The following list might illustrate the reasons for this modest estimation of the level of Operational Validation:

- The *number* of relevant empirical studies is limited. Often, there is only one single study that supports the modeled assumption. In a modeler's ideal world, there were numerous comparable reproductions of the original experiment in the literature. These would allow for the estimation of the "true" value distribution of the parameter (mean, standard deviation) with an acceptable level of uncertainty. In reality, even if more than one single study is available with a comparable experimental design, the results are often inconsistent (see, for example, the estimation of the memory decay rate in the Appendix I of chapter 4 on p. 77). In the less preferable case, where only one single study is available, the uncertainty of the "true" value distribution underlying the parameter to be estimated is even greater (see, for example, the estimation of the judgmental weights of different information sources in the Appendix I of chapter 4 on p. 77).
- Several parameters are *covert*, i.e. cannot be measured directly. For example, the maximum of the initial account accessibilities  $a_{0A,c}$  and  $a_{0B,c}$  or the weight of interpersonal communication  $\omega_{IPC}$  cannot be measured directly. These parameters had to be estimated inversely starting from the KPR<sup>2</sup> values reported in the CNEP study (Schmitt-Beck, 2000).
- Some parameters (e.g. the baseline level of advertising activities) had to be estimated *without data*. Of course, the uncertainty of these parameters is particularly high.

## Summary

Despite these limitations of Operational Validation, the PASS model can be seen as sufficiently validated when viewed from the perspective of Conceptual Model Validation. The careful conceptual grounding of many model assumptions is probably one of the strengths of the PASS model since many models of opinion dynamics are only weakly grounded in psychological and sociological theories (e.g. Regenwetter, Falmagne, & Grofman, 1999; Hegselmann, Flache, & Möller, 2000; Hoylst, Kacperski, & Schweitzer, 2001). The weak degree of Conceptual Model Validation is clearly detrimental for the reputation of the discipline of social simulation. The insufficient methodological discipline is often caused by the pressure to publish computational

models, even if the validation process has not been initiated. Numerous modelers plan to validate the model in a second phase after they have implemented the model's conceptual structures in a first phase. Unfortunately, due to constraints in time, money, and – last but not least – motivation, the second phase is frequently neglected (Carley, 1996).

Table 5.2: Synopsis of the current validation degree of the PASS model.

Perspective	Applied validation techniques	Current degree of validation
Conceptual Model Validation	empirical studies, expert judgments	high
Data Validity	based on scientific review process	--
Computerized Model Verification	time traces, hand-walks	medium - high
Operational Validation	empirical studies, expert judgments	low - medium

Table 5.2 summarizes the major results of this overview of the validation of the PASS model. Again, the four validation perspectives are taken as a frame of reference. The estimation of the current degree of validation of each perspective (last column) underlies my own subjectivity. Apart from the deliberately neglected perspective of Data Validity, the weakest link in the chain is clearly the Operational Validation. As has already been noted above, improving the degree in this validation perspective encounters a lot of difficulties (limited number of studies, covert parameters, guesses without data) that cannot be solved within this PhD study.

## 6 The Relevance of the PASS Model for Environmental Psychology

This chapter presents two possible domains for applying the PASS model in the context of environmental psychology. The first section analyses the position of the PASS model within the long debate around the predictive validity of the attitude construct. The hypothesis that can be strongly supported by applying (i.e. “running”) the PASS model is that measuring attitudinal involvement and ambivalence adds non-redundant information to the estimation of the strength of attitudes (Krosnick et al., 1993; Wegener, Downing, Krosnick, & Petty, 1995). Notably, this hypothesis can be *computationally* deduced from the assumptions implemented in the PASS model.

The second section demonstrates the theoretical value of the PASS model when it comes to understanding the effectiveness of different tools that are applied in public campaigns aimed at changing environmental behaviors.

### **Demonstrating the importance of refining survey questions on environmental attitudes**

This section starts with a description of the general problem of predicting human behavior from attitudes (the predictive validity problem). It is now widely accepted that applying the specificity principle in attitude measurement to solve the predictive validity problem turns out to be a fallacy. The introduction of the concept of *attitude strength* is presented as a new approach of solving the prediction problem without falling back into the fallacy of the specificity principle again.

#### ***The predictive validity problem***

Intentions to foster environmentally friendly behaviors have fuelled a variety of attempts to develop better understandings of *why* certain citizens behave more environmentally friendly than others. Initial research has focused on demographic and socioeconomic antecedents like age, gender, occupation, education or religion. However, the findings have been highly confusing and inconclusive (Anderson & Cunningham, 1972; Kinnear, Taylor, & Ahmed, 1974; Balderjahn, 1988; Pickett, Kangun, & Grove, 1993; Cornwell & Schwegker, 1995). Meanwhile considerable

evidence has established that demographic and socioeconomic variables alone are strongly limited in explaining the variation of environmentally friendly behavior. Kinnear, Taylor and Ahmed (1974) were the first to suppose that *attitudes* (and other socio-psychological variables) are generally more powerful predictors than socioeconomic parameters.

Although the shift from socio-economic parameters to attitudes improved the capacity of predicting environmental behaviors to some degree, the general puzzle of how to predict behavioral intention and final behavior was nonetheless far from being solved. Some recent general reviews have shown that on average attitudes can explain only 10 - 15% of the behavioral variance (Kraus, 1995; Six & Eckes, 1996; Sutton, 1998). The situation seems to be even more acute in the context of environmental attitudes where the percentages of explained behavioral variance are still lower (Weigel, 1983; Hines, Hungerford, & Tomera, 1986; Langeheine & Lehmann, 1986; Schahn, 1990; Spada, 1990; Diekmann & Preisendörfer, 1992; Fuhrer, 1995; De Haan & Kuckartz, 1996; Diekmann & Preisendörfer, 1998).

### ***The fallacy of the specificity principle***

Pro-environmental behaviors (energy saving, recycling, green consumption, use of public transport) are not highly interrelated (De Haan and Kuckartz 1996; Diekmann and Preisendörfer 1992; Pickett, Kangun, and Grove 1993; Tracy and Oskamp 1983-1984). Empirical studies on ecological lifestyles support this perception of „patchwork lifestyles“ (Lüdtke, Matthael, and Ulbrich-Herrmann 1996; Reusswig 1994). In their review of studies investigating personal and situational factors motivating citizens to recycle, Schultz et al. (1995) found the following tendency: where global environmental attitudes proved as significant but generally weak predictors of recycling behavior, specific beliefs (related to the issue of recycling) performed better. This effect was called the “specificity principle”. Attitudes and behavior should have the same specificity in action, target, time, and context to yield powerful predictions (Ajzen, 1977). The value of the theoretical contribution provided by the specificity principle has been hotly debated. At first sight, taking the correspondence between the specificity of the attitude measurements and the specificity of the behavioral measurement into account seems to be a helpful recommendation for achieving better attitude-behavior correlations. However, the principle is a fallacy. If attitudes are measured too

specifically, their content gets very close to the behavior in question. High correlations make believe the predictive power of the model is high. If not handled with care, the recommendation for specificity easily perverts into a shift of the problem. The smaller the specificity gap between attitudes and behavior, the higher the redundancy between the measurements, and the more important it gets to find the precedent variables that might influence the specific attitudes already measured (Engel 1998). However, it is exactly these non-trivial precedents which are indispensable to know for preventive politics and pro-environmental regulations.

Recent theories of the attitude-behavior link propose to overcome these limitations by supplementing the measurements of attitudes with measurements of additional constructs. One of these general models is the Theory of Planned Behavior (TOPB) (Ajzen 1985). It has proven to be considerably successful in predicting human behavior (Jonas and Doll 1996; Six and Eckes 1996; Sutton 1998), notably in studies investigating the link between environmental concern and environmentally benign behavior (Bamberg & Schmidt, 1994; Gloor, 1997; Lüdemann, 1997; Taylor & Todd, 1997; Kaiser, Wölfing, & Fuhrer, 1999). Additionally to the measurement of *attitudes*, it includes the additional concepts of *social norms* (the perceived social pressure towards avoiding or implementing the behavior) and *perceived behavioral control* (the perceived ease or difficulty of behaving in a certain way depending on skills, knowledge, experience, money, time, obstacles etc).

### ***Introducing and measuring attitude strength***

Despite of the success of the TOPB which brought in the measurement of social norm and perceived behavioral control as important supplements to the measurement of attitudes, the *practice* of measuring the original attitude component has remained largely unchanged. The most frequent attitude dimensions that are elicited in social surveys are the valence and the extremity (captured by the location of the respondent's "cross" on an ordinary Likert scale) (Schwarz & Sudman, 1996; Sudman, Bradburn, & Schwarz, 1996; De Vaus, 2001). However, in the last decade, the measurement of specific strength-related attributes has proven to enhance the predictive validity of attitudes (e.g. Fazio et al., 1986; Krosnick & Abelson, 1992; Krosnick et al., 1993). As a consequence, an increasing number of studies does not only measure the valence and extremity of the respondent's attitudes but also the underlying *importance* (Schuman &

Presser, 1981; Jaccard & Becker, 1985; Howard-Pitney, Borgida, & Omoto, 1986; Krosnick, 1988; Kokkinaki et al., 1997; Lavine et al., 2000) and *ambivalence* (Bassili, 1996; Jonas et al., 2000; Sparks, James, Conner, Shepherd, & Povey, 2001).

In the PASS model, the time traces of the attitude valence, attitude extremity, attitudinal ambivalence, and the attitudinal involvement are simulated (the construct of the attitudinal involvement can be equated with the construct of attitudinal importance).

The relevance of the PASS model in the context of environmental psychology lies in illustrating the common antecedents of the components of attitude strength (extremity, involvement, and ambivalence). These theoretical antecedents can be found in the changing clusters of more or less accessible persuasive message extracts (PMEs) attached to the two basic accounts (see the section “The cognitive level” of chapter 4 on p. 47ff.). Because of the common roots in the PMEs, the model provides a parsimonious set of interrelated mechanisms (and thereby a procedural account) *why* these three strength-related constructs are more or less interrelated. The crucial point is that these mechanisms are grounded in existing theories and assumptions about low-motivated cognition, memory decay, implicit memory effects, attitudes as ad-hoc constructions, continuous judgment revision, individual anchoring etc (see chapter 3 on p. 24ff.).

A great many of empirical studies have reported that attitudinal involvement (resp. importance) is positively correlated with attitudinal extremity (Knowler, 1936; Lemon, 1968; Converse & Schuman, 1970; Cialdini, Levy, Herman, Kozlowski, & Petty, 1976; Brent & Granberg, 1982; Borgida et al., 1983; Granberg & Burlison, 1983; Rholes & Bailey, 1983; Howard-Pitney et al., 1986; Krosnick, 1988). Another group of experiments shows that extremity is inversely related to ambivalence (Allport & Hartman, 1925; Johnson, 1940; McDill, 1959; Mehling, 1959; Fazio et al., 1978), though see Lemon (1968). Finally, a limited number of studies has found negative correlations between levels of importance and ambivalence (Raden, 1985; Tourangeau et al., 1989), though see Budd & Spencer (1984). Interestingly, the reported correlations can be reproduced within the PASS model (see table 6.1). This reproduction is an example of deriving possible implications from the assumptions implemented in a computer model (here in the form of correlations). For the calculation of the correlations in table 6.1, the model was run 300 times simulating 100 citizen's attitudes. This provided 30'000 quadruples of individual levels of attitudinal involvement, extremity, ambivalence, and overall attitude strength at voting day. Since the scales of these



components are ordinal, the Spearman rank order correlation coefficient  $R$  was calculated for all pairs.

Table 6.1: Spearman rank order correlation coefficients between the attitude strength components and the overall attitude strength simulated in the PASS model

	involvement	extremity	ambivalence	strength
involvement		0.38	-0.20	0.77
extremity			-0.88	0.81
ambivalence				-0.67
strength				

The most important conclusion from these correlations is – given our best theories about political attitudes – that measuring the extremity of the attitude in ordinary surveys is a weak predictor of attitude strength. Figure 6.1 illustrates the “cloud of uncertainty” ( $R = 0.81$ ) for estimating the overall attitude strength which remains when only attitude extremity is measured. For every level of extremity (except for the extremity levels close to 1.0) there exist a broad variation of attitude strengths. This variation is due to the incomplete correlations between extremity and involvement ( $R = 0.38$ ) and extremity and ambivalence ( $R = -0.88$ ). For example, if the attitude extremity of a particular citizen is at a rank 20'000 within the population of 30'000 virtual citizens, the rank of this citizen's attitude strength can still vary between rank 8'000 and nearly 30'000.

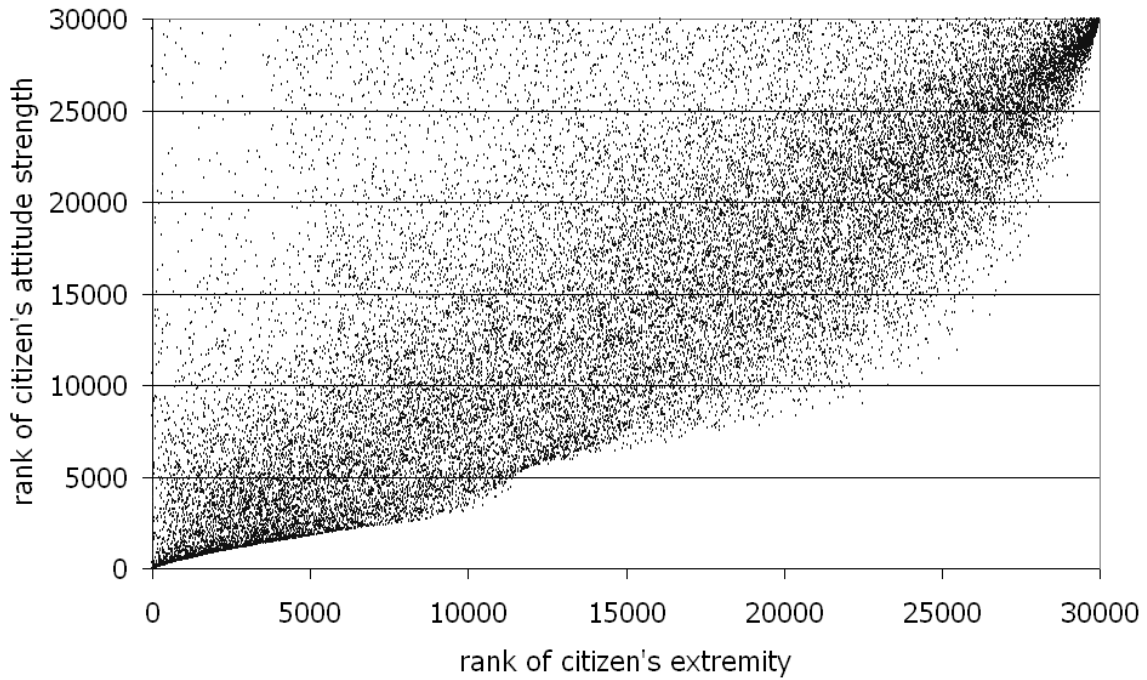


Figure 6.1: Simple measurements of individual attitude extremities do not fully predict the individual levels of attitude strength.

The incomplete correlation between citizen extremity and involvement is due to three reasons:

- During the simulation run, the involvement is dependent on the habitual political interest  $I_{0,c}$ , the summed accessibilities of the PME's of both attitudinal accounts  $\beta_c(t_k)$ , the individual threshold of accessibility  $\beta_{att,c}$  of citizen  $c$  (where the growth of involvement per time step is at its maximum) and the “sharpness”  $\sigma_c$  of the involvement increase of citizen  $c$  around  $\beta_{att,c}$  (see eq. 4.7a-c on p. 54).
- Because of the citizen typology according to Dalton, the habitual political interest  $I_{0,c}$  is initialized as completely independent of the initial extremity  $|A_{0,c}|$  (see figure 4.9 on p. 60).
- The individual threshold of accessibility  $\beta_{att,c}$  of citizen  $c$  and the “sharpness”  $\sigma_c$  of the involvement increase of citizen  $c$  around  $\beta_{att,c}$  are also independent of the initial attitudinal extremity. That is, extreme citizens are not easier to make attentive to political information and are not faster in getting attentive than less extreme citizens.

Nevertheless, the extremity is still weakly correlated with the involvement because of two mechanisms:

- The confirmation bias (which characteristically leads to more extreme attitudes) is dependent on the habitual interest  $I_{\theta,c}$  (see eq. 4.6a on p. 53), at least if the RAS-A2 (see revision step 2 on p. 53) is present. Higher habitual interest results in higher final levels of citizen involvement. This mechanism explains the correlation between extremity and involvement.
- Higher habitual interest  $I_{\theta,c}$  leads to a faster increasing involvement (since higher involvement means a higher reception rate of PME's which increase the involvement etc.). A higher involvement level leads to more interpersonal communication within relatively highly homogeneous ego-networks. In summary, the assumed homogeneity bias of the social networks (see chapter 3 on p. 33) finally results in the increased extremity of initially more involved citizens.

The correlation  $< 1.0$  between citizen extremity and citizen ambivalence is due to the specific assumptions behind the equation for the attitudinal ambivalence (see eq. 4.10a and 4.10b on p. 58). If the two opposite responses have the same intensity, the ambivalence depends on the absolute level of this opposition. For example, if the two responses  $R_{A,c}(t_k) = R_{B,c}(t_k) = 10.0$ , the ambivalence is higher than if the two responses  $R_{A,c}(t_k) = R_{B,c}(t_k) = 2.0$ . In contrast, the equation of the attitudinal extremity (see eq. 4.9 on p. 56) yields the same result for both levels of opposition: the resulting extremity is 0.0 in both cases. However, if the responses get more and more imbalanced, the attitude simultaneously gets less and less ambivalent and more and more extreme. That is, in spite of the differences of the two attitude characteristics near the balance point, the attitude ambivalence and the attitude extremity are correlated in the overall picture.

In consequence, political psychologists gain an specific argument from running the PASS model: Given our best theories about the formation and change of political attitudes (supposed to be implemented in the PASS model), measuring the citizen's attitudinal ambivalence and attitudinal involvement are indeed indispensable co-factors of attitude strength that must be measured *separately* with additional survey questions. A practical guide to valid and reliable survey questions for the measurement of attitudinal ambivalence and attitudinal involvement can be found in Wegener et al. (Wegener et al., 1995).

## **Fostering the Understanding of the Effectiveness of Environmental Campaign Techniques**

In the last decades, the general experience of campaign planners has been that information-intense mass-media campaigns targeted at creating environmental attitudes and behaviors have little effect (Geller, 1981; Geller, Erickson, & Buttram, 1983; Costanzo, Archer, Aronson, & Pettigrew, 1986; Finger, 1994). As a response, the campaign planners started to find out pragmatic strategies that were inspired much more by common wisdom and intuition than by careful deduction from psychological theories. The resulting “down-to-earth approach” is partly characterized by taking advantage of some of the good old educational tricks of influencing people. There is now a rich toolbox available for the design and execution of effective environmental or health programs (see table 6.2) (Kotler & Zaltman, 1971; Geller, 1989; McKenzie-Mohr & Smith, 1999; Bator & Cialdini, 2000).

However, the *embedding* of these pragmatic strategies in the existing psychological framework (basic notions, concepts, mechanisms etc.) is largely missing, for example in social marketing textbooks. In explaining the effectiveness of pragmatic tools by the means of basic theories from social psychology, the PASS model might provide a helpful repository of the most relevant theories. The PASS model could also be used as an educational tool for demonstrating *the theoretical underpinnings of the effectiveness* of the various tools. The audience could be students or professionals in social psychology or social marketing. The specific additional value of this explaining process assisted by the PASS model is to isolate the *minimal* set of statements required for explaining the workability of the campaign tools. In other words, the model assumptions discussed in chapter 3 (p. 24ff.) and their dynamic entanglement illustrated by the model implementation can be used as a theoretical background for better *understandings* of possible persuasive mechanisms behind the campaign tools. Table 6.2 is an attempt to interpret the tools of the campaign planner within the specific theoretical framework of attitude strength *dynamically* represented in the PASS model.

Seen in this light, all the tools foster more or less the *strength* of attitudes (either increasing the involvement and/or the extremity, and/or decreasing the ambivalence). One of the tools is to get people making a public commitment to engage with a specific environmental behavior. If the commitment is translated into a sort of anchoring or initial attitude (a concept implemented in the PASS model), the effectiveness of public

self-commitments can be demonstrated by the PASS model. The attitude bolstering mechanism implemented in the PASS model enhances the credibility of congenial PME's and suppresses the credibility of uncongenial PME's. Accordingly, like a sort of mental anchor, the commitment helps the person to elevate cognitions congenial with the commitment and to suppress cognitions uncongenial with commitment. Finally, the person gets less ambivalent. Moreover, the publicity of the commitment increases the involvement to hold the commitment in comparison to a private commitment.

In summary, because of the enhanced attitudinal involvement and the enhanced consistency, environmental attitudes are strengthened if the tool of commitment is applied.

Table 6.2: Main effects of different campaign tools on the strength of attitudes. Up (down) arrows denote increasing (decreasing) the level of a component of attitude strength.

Campaign Tool	Effect on component(s) of attitude strength
public self-commitment	involvement ↑, ambivalence ↓
persuasive messages: captivating information, vivid presentation, tailor-made for target groups, high source credibility, embedded in interpersonal communication	involvement ↑, extremity ↑, ambivalence ↓
public agenda setting (reports in the mass media, integrating of the issue into folk festivals)	involvement ↑
setting a social norm (public visibility of the active participants)	involvement ↑, ambivalence ↓, extremity ↑
prompts (flags and posters as reminders)	involvement ↑
model persons (business or political leaders)	ambivalence ↓, extremity ↑
demonstrating the desired behavior in public (modeling)	ambivalence ↓, extremity ↑
feedback (reports of the achieved speed reduction)	involvement ↑
removing external barriers	ambivalence ↓, extremity ↑

A majority of the tools is aimed at enhancing the involvement of the target persons. In the PASS model, an increase of involvement means that people are more attentive (perceive more), have better memories for campaign events, and engage in more interpersonal communication. Persuasive messages in TV or radio spots and public

advertising (brochures, posters) contribute to setting the campaign on the cognitive agenda of the individuals (in the PASS model: the PMEs form the mass media and the parties increase the total accessibility of the accounts). If there is only one source of persuasive messages (i.e., only the environmental campaign is going on without a contra-campaign), the number of PMEs attached to the pro-environmental account will increase and rapidly outstrip the number of PMEs that were initially attached to the contra-environmental account. Furthermore, because of the recency of the PMEs coming from the pro-environmental campaign, the accessibility of the PMEs attached to the pro-environmental account is high in contrast to the accessibility of the PMEs attached to the contra-environmental account. Consequently, the campaign shifts the balance of the responses from the accounts. The attitudinal ambivalence is lowered and attitudes get more extreme. The increase of the accessibility of the pro-environmental account increases the total accessibility of both the pro- and the contra-environmental account and, consequently, the involvement increases. In other words, the campaign enhances the interest in environmental issues.

Well-positioned prompts have a similar function. They are persuasive messages on their own and have the function of keeping the campaign on the cognitive agenda. Again, prompts generate persuasive message extracts (PMEs) that enhance the total account accessibility and – via the attitudinal involvement – the strength of the attitude. Even the provision of feedback can be seen in this perspective. Every feedback message (negative and positive) generates a PME that enhances attitude strength. The characteristic of positive feedback messages is to additionally increase the involvement of the receiver. This mechanism, however, is not implemented in the PASS model. Establishing a strong social norm is another tool for fostering attitudinal involvement. If the desired behavior is noticeable in public and the number of converted people increases, the social pressure to act in accordance with the campaign's desired behaviors is reinforced and generates some involvement required for monitoring the actual compliance of one's own behavior. The mechanism of social norms is partly implemented in the PASS model. Interpersonal communication can be interpreted as one component of the perception of a social norm. In the PASS model, interpersonal communication generates highly accessible PMEs whose valences have a strong effect on the balance of the accounts and generate additional involvement. Even observations of other persons acting in a way that is congruent with the campaign's aims could be

interpreted as a source of PME's with a high level of credibility (due to the immediate perceptual situation) and a high impact on the balance of the accounts. Yet, non-communicative interpersonal influence is not implemented in the PASS model.

Demonstrating the propagated behavior in public and presenting credible model persons both are tools for generating highly credible and highly accessible PME's that are attached to the pro-environmental account. The campaign tool of public demonstrating is aimed at making the gains of the environmentally friendly behavior an object of direct experience. Direct experience in turn can be expected to be associated with high credibility and high accessibility. And, as a truism, PME's presented by credible persons are highly credible.

Removing external barriers is primarily aimed at reducing PME's that would be attached to the contra-environmental account. The effect is that the ambivalence towards the behavior is reduced and that the attitude gets more extreme.

Concluding this chapter, it is important to say that the PASS model does not provide the campaign strategists with *qualitatively* novel tools in the sense of extending the list in table 6.2 or in the sense of comparing the effectiveness of two different tools. From a pragmatic viewpoint, the PASS model was designed to help campaign strategists to find the optimal *temporal* allocation of the campaign resources *independent* of the specific tools the resources are invested in at a particular moment in time. For example, comparing the effectiveness of self-commitment vs. setting a social norm would have required a completely different model.

In the opposite direction (pragmatic campaign know-how → theory), the psychological richness of the diverse campaign tools does confirm the basic assumption of the PASS model (and general recent models of attitudes) that additional subcomponents of attitudes (i.e. primarily the involvement and the ambivalence) should not be neglected when it comes to understand success or failure of different strategies.

## 7 An Algorithm for the Generation of Artificial Social Networks with Data-Based Attribute Heterogeneity

### Introduction

It is now widely accepted that the formation and change of attitudes (e.g. towards product innovations or political parties) is an inherently social process (Deutsch & Gerhard, 1955; Latane, 1981). For example, in the context of political persuasion, individuals are not only directly influenced by the mass media (Bartels, 1993; Zaller, 1996; Schmitt-Beck, 2000) but also indirectly through the discussion of the contents of the mass media with a small group of discussion partners (MacKuen et al., 1987; Knoke, 1990; Kenny, 1994; Huckfeldt et al., 1995; Kenny, 1998; Nieuwbeerta et al., 2000; Schmitt-Beck, 2000). In the following, this group of discussion partners is called the (political) *ego-network* of a particular individual. Ego-networks are heterogeneous or homogeneous with regard to a particular characteristic of individuals (nationality, gender, religion, education etc.). The focal attribute in this chapter is the individual's party identification. The ego-network is heterogeneous related to this attribute if not all its members share the same party identification, whereas the ego-network is homogeneous if all its members share the same party identification (see Nieuwbeerta et al., 2000). The ego-network is considered as a "filter" of the persuasive messages coming from the mass media. For example, if an individual receives a congenial persuasive message from the mass media and discusses it within an ego-network that is homogeneous with respect to the party identifications of the discussants, the social influence will strongly confirm the persuasive message. In another example, if the same congenial persuasive message is discussed within a heterogeneous ego-network, some of them will agree with the message and confirm the receiver in accepting the message, whereas some of the discussants will disagree with the message and push the receiver towards discrediting the message.

If it is true that the composition of the ego-networks determines the final persuasive effect of the original persuasive messages from the mass media, modelers of artificial social systems should pay attention to the way they network the artificial individuals in their experiments. Still, in the majority of simulation models focusing on the formation



of public opinion (Nowak et al., 1990; Latane et al., 1994; Hegselmann et al., 1996; Regenwetter et al., 1999; Nowak et al., 2000; Mosler et al., 2001), the geometry of influence is based on an abstract grid-like geometry of neighborhood and not on characteristic sizes and heterogeneities of ego-networks found in empirical studies. However, the practice of conceptualizing social influence based on abstract designs like grids is suspected to produce severe artifacts regarding the emerging behavior of the system on the social level. It is a well-known fact that in regard to various attributes the majority of the ego-networks within real social networks are homogeneous (Berelson, Lazarsfeld, & McPhee, 1954; Rogers & Bhowmik, 1970; Schenk, 1995; Schmitt-Beck, 2000; see also table 7.7). Additionally, social networks have typical frequency distributions of the ego-network sizes of the individuals. Therefore, simulating populations grounded in a data-based structure of heterogeneity and data-based ego-network sizes is expected to be an important requirement in the field of social simulation. This expectation has been confirmed by a dozen affirmative replies to a message we recently posted on the SOcNET newsgroup<sup>1</sup>.

The goal of this chapter is to present an algorithm for generating artificial political discussion networks based i) on data about network heterogeneities with regard to the attribute of party identification and ii) on data about the average size of ego-networks. The current algorithm works with every bi- or tripolar attribute of individuals, e.g. {male, female} or {education low, education medium, education high}.

There were three important sub-goals to the development of the algorithm. First, the algorithm should be general enough to be used with data that can be derived from common empirical studies addressing the composition of political discussion networks. Second, the algorithm should represent the output in the standard matrix format which is requested by most of the network analysis tools (e.g. UCINET, NetMiner or SocioMetrica). Third, the algorithm should be fast relative to the runtimes of most social simulation models.

In the first section, the terminology and notation used in the chapter is introduced. The second section presents a survey of the minimal dataset required for running the algorithm. In the core part of the chapter, the working mechanism of the algorithm is described in detail (down to the level of pseudo-code that is required for re-

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<sup>1</sup> <http://www.heinz.cmu.edu/project/INSNA/socnet.html>

implementation). The algorithm is then tested and evaluated using an illustrative data set in the context of German General Elections. Finally, we will discuss the generalizability of the algorithm and present some avenues for further development.

## Total networks and ego-networks

A *total* social network can be represented as a graph  $\Gamma(N, \Lambda)$  comprising of a set  $N = \{n_1, n_2, \dots, n_g\}$  of  $g$  nodes and a set  $\Lambda = \{l_1, l_2, \dots, l_L\}$  of  $L$  lines (the specific notation refers to Wasserman & Faust, 1994). The nodes represent individuals that are connected according to a set of lines  $l_k = (n_i, n_j)$  between the individual  $n_i$  (the ego) and the individual  $n_j$  (the alter). The algorithm presented here can only handle undirected lines for which applies  $(n_i, n_j) \equiv (n_j, n_i)$ .

In the following, pairs of individuals are called *dyads*. Furthermore, the terms of *total network* and *graph* are used interchangeably. Apart from the perspective on the *total network*, there is also the *ego-centric* perspective for the individual  $n_i$ . This perspective encompasses the sub-graph  $\Gamma_s(i)$  with the set of alteri  $N_s(i) \subseteq N \setminus \{n_i\}$  that are directly linked to the ego  $n_i$ , i.e. the ego-network of  $n_i$ .

The size of the total network is  $g$ . Starting from the size  $g_s(i)$  of the ego-network of individual  $n_i$ , the average ego-network size  $g_{s,avg}$  can be calculated as an index of the total network:

$$g_{s,avg} = \frac{1}{g} \sum_{i=1}^g g_s(i).$$

## Required data

The goal of the algorithm presented here is to generate artificial political discussion networks of citizens. The generated networks have to meet i) empirically found levels of heterogeneity with regard to the party identifications and ii) empirically found frequency distributions of the sizes of ego-networks.

There are several studies on the heterogeneity of political discussant networks (e.g. Knoke, 1990; Schenk, 1995; Nieuwbeerta et al., 2000; Schmitt-Beck, 2000). They use some form of the Burt name generator to elicit a set of names of discussants (Burt, 1984). In a first step, each subject is asked to name the persons with whom she or he has discussed important issues within the last six months. In a second step, the persons with whom she or he has discussed political issues are selected from the initially reported set.

Subsequently, using a name interpretator, the subjects are asked to report the party identification of the discussant partners they have just mentioned. The party identification (PID) of an individual can be defined as a relatively enduring attachment to a political party that is cognitively and affectively rooted in the self-concept (Campbell, Converse, & Miller, 1960; Schmitt-Beck, 2000). The above two-step procedure yields one network characteristic related to the ego-network sizes and two characteristics capturing the heterogeneity of the total network:

- frequency distribution of different classes of ego-network sizes
- frequency distribution of all possible pairs of individuals with regard to the party identification of the involved pair of individuals (dyad classes)
- frequency distribution of different compositions of ego-networks with regard to the party identification of the discussants (alteri classes)

The algorithm presented here distinguishes three basic types of party identification. There are two reasons for this tripartite classification. First, there are always some neutral or undecided persons who do not report a party identification. Second, it is supposed that the parties of political systems can be divided into a group of parties A, and an opposite group of parties B. These groups might reflect very stable complementary parties like the Democrats and Republicans in the USA, the Labour Party and the Conservative Party in Great Britain, or temporary party blocks like the CDU-CSU-FDP *Parteilager* and the SPD-Grüne *Parteilager* in Germany. In the following, undecided individuals are labeled *U*, whereas the partisans of party group A are labeled *A* and the partisans of party group B are labeled *B*. Consequently, distinguishing three types *t* of individuals with  $t \in \{A, B, U\}$ , there are six possible dyad classes *d* with  $d \in \{AA, BB, AB, UA, UB, UU\}$  and five different alteri classes *a* (different composition of ego-networks) with  $a \in \{Iso, Neut, HomA, HomB, Het\}$ . *Iso* denotes an empty ego-network, i.e. isolated individuals. *Neut* labels homogeneous ego-networks consisting only of undecided alteri of type *U*. *HomA* and *HomB* encodes homogeneous ego-networks exclusively composed of alteri of type *A* or type *B*, respectively. Importantly, homogeneous ego-networks may comprise one or more individuals of type *U*. Finally, *Het* is the label of heterogeneous networks consisting of a mixture of alteri of type A and B. For every type *t* of individuals, there are the five

frequencies  $f(a|t)_{igt}$  that this type belongs to a certain alteri class  $a$ . The tables 1 to 4 provide a synopsis of the target data required for running the algorithm.

Table 7.1: Required frequencies  $f(t)_{igt}$  of different types  $t$  of individuals.

type of individual		
A	B	U
$f(A)_{igt}$	$f(B)_{igt}$	$f(U)_{igt}$

Table 7.2: Required target frequencies  $f(s)_{igt}$  of different classes  $s$  of ego-network sizes.

size of ego-network							
S <sub>0</sub>	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	..	S <sub>max-2</sub>	S <sub>max-1</sub>	S <sub>max</sub>
$f(S_0)_{igt}$	$f(S_1)_{igt}$	$f(S_2)_{igt}$	$f(S_3)_{igt}$	..	$f(S_{max-2})_{igt}$	$f(S_{max-1})_{igt}$	$f(S_{max})_{igt}$

Table 7.3: Required target frequencies  $f(a|t)_{igt}$  of individuals with party identification  $t$  and belonging to alteri class  $a$ .

PID $t$	composition of the ego-network (alteri class $a$ )				
	isolated ( <i>Iso</i> )	neutral ( <i>Neut</i> )	homogeneous ( <i>HomA</i> )      ( <i>HomB</i> )		hetero- geneous ( <i>Het</i> )
$A$	$f(Iso A)_{igt}$	$f(Neut A)_{igt}$	$f(HomA A)_{igt}$	$f(HomB A)_{igt}$	$f(Het A)_{igt}$
$B$	$f(Iso B)_{igt}$	$f(Neut B)_{igt}$	$f(HomA B)_{igt}$	$f(HomB B)_{igt}$	$f(Het B)_{igt}$
$U$	$f(Iso U)_{igt}$	$f(Neut U)_{igt}$	$f(HomA U)_{igt}$	$f(HomB U)_{igt}$	$f(Het U)_{igt}$

Table 7.4: Required target frequencies  $f(d)_{igt}$  of different dyad classes  $d$  within the total network.

If there are  $L$  lines in the total network, the corresponding numbers  $m_L(d)_{igt}$  per dyad class  $d$  are indicated in the second row.

dyad class					
AA	BB	AB	UA	UB	UU
$f(AA)_{igt}$	$f(BB)_{igt}$	$f(AB)_{igt}$	$f(UA)_{igt}$	$f(UB)_{igt}$	$f(UU)_{igt}$
$m_L(AA)_{igt}$	$m_L(BB)_{igt}$	$m_L(AB)_{igt}$	$m_L(UA)_{igt}$	$m_L(UB)_{igt}$	$m_L(UU)_{igt}$

## Working mechanism of the algorithm

The basic idea underlying the algorithm is to start from a random network  $\Gamma_0$  and, in a series of iterations, to add and delete selected lines until the target graph  $\Gamma_{igt}$  is

reached. As an important part of the strategy, the algorithm does not optimize all target dimensions (frequencies of ego-network sizes, dyad classes, alteri classes) at the same time. In each iteration  $k$ , either the frequencies of the dyad classes or the frequencies of the alteri classes are optimized (the frequencies of the ego-network size classes are optimized as a sub-goal of the dyad class optimization, see below).

To find out which of the two target dimension to optimize in each step, the index  $dyadOpt_k$  capturing the distance of the actual dyad class frequencies from the target values is calculated in each iteration step as a quality measure. Similarly, the distance of the actual alteri class frequencies  $alteriOpt_k$  from the target values is continuously updated. If in step  $k$  the value of  $dyadOpt_k$  is lower than  $alteriOpt_k$ , in the next step the dyad classes are optimized. In contrast, if in step  $k$  the value of  $alteriOpt_k$  is smaller than  $dyadOpt_k$ , then the frequencies of the alteri classes are optimized in the following step. This sensitive optimization strategy has proved to be very efficient. An alternative would have been to first fully optimize the initial graph  $\Gamma_0$  for the frequency of the dyad classes, and then to fully optimize for the alteri class frequencies. However, this strategy destroys the level of optimization previously achieved with regard to the dyad classes. The algorithm oscillates between the full optimization of either the dyad or the alteri class frequencies but never reaches the target state of simultaneous optimization. Yet, the strategy of sensitively determining the target dimension in each iteration step was not expanded to the target frequencies of ego-network sizes. When we employ a strategy alternating between three optimization phases (alteri classes, dyad classes, and size classes), the original efficiency of the two-phase alternation between the dyad and the alteri classes was not reached. The best results are obtained if the optimization of the size class frequencies is subordinated to the optimization of the dyad class frequencies. Although the size class optimization is dependent on the dyad class optimization process, the final frequency distribution of ego-network sizes is still remarkably close to the target frequencies (see figure 7.5). Obviously, there is no trade-off between the optimization of the frequencies of dyad classes and size classes.

### **Initialization**

The size of the global network was arbitrarily set at  $g = 100$  individuals for a sufficient capacity of the network to resolve the target frequencies from table 7.7 and 7.8. In the first step,  $h_A = gf(A)$  individuals are labeled as partisans of party group A,  $h_B$

$= gf(B)$  individuals are labeled as partisans of party group B, and  $h_U = gf(U)$  individuals are labeled as undecided partisans. Since network nodes (individuals) are neither added nor deleted in any of the optimization procedures, the target frequencies of types  $f(t)_{tgt}$  are not changed (and, of course, have not to be optimized). The next step is to network the individuals randomly in order to obtain the initial network  $\Gamma_0$ . The number of dyads  $L$  that have to be set in the linking process is dependent on the total network size  $g$  and the target frequencies of ego-networks sizes:

$$L = \frac{g}{2} \cdot \sum_{i=0}^{\max} f(s_i)_{tgt} \cdot i .$$

In the following sections, the dyad class optimization is presented followed by the alteri class optimization.

### **Optimization of the dyad class frequencies**

The optimization of the target frequencies  $f(d)_{tgt}$  of the dyad classes  $d$  is straightforward. The algorithm works on the level of the target numbers  $m_L(d)_{tgt}$  of the dyad classes. This allows to reach the target frequencies and to keep the number of lines  $L$ . In other words, if the target numbers  $m_L(d)_{tgt}$  are reached the target frequencies  $f(d)_{tgt}$  are reached as well and the number of lines is exactly  $L$ .

At the beginning of each iteration, the dyad class  $d_{corr}$  with the largest distance  $\Delta m_L(d_{corr}) = |m_L(d_{corr})_{act} - m_L(d_{corr})_{tgt}|$  from the target frequency is determined.

If the actual number  $m_L(d_{corr})_{act}$  of dyads pertaining to  $d_{corr}$  exceeds the target number  $m_L(d_{corr})_{tgt}$ , a line of a dyad of the type  $d_{corr}$  has to be deleted. If the actual number of individuals pertaining to the dyad class  $d_{corr}$  is below the target number, two individuals have to be linked that form a dyad of the type  $d_{corr}$ .

The specific pair of nodes for deleting or adding a line within the network is determined by the simultaneous optimization of the frequencies of the ego-network sizes. If a line is to be added, in a first step, the most under-represented ego-network size class  $s_{corr}$  is determined (with the biggest difference  $\Delta f(s_{corr}) = f(s_{corr})_{tgt} - f(s_{corr})_{act}$  from the target frequency). If there are several network classes with the same distance from the target frequency, one of them is randomly selected. Next, the algorithm connects two selected individuals, which would yield a new dyad of type  $d_{corr}$  if connected and which have one alter less than the individuals belonging to the size class  $s_{corr}$ . This produces two additional individuals belonging to the size class  $s_{corr}$ . If the line

of a dyad is to be deleted, the algorithm first selects the most over-represented ego-network size class  $s_{corr}$ . Subsequently, it deletes the line of a dyad of type  $d_{corr}$  whose individual nodes have one alter more than the individuals belonging to the size class  $s_{corr}$ .

The steps of the algorithm are recapitulated in the following section of pseudo-code:

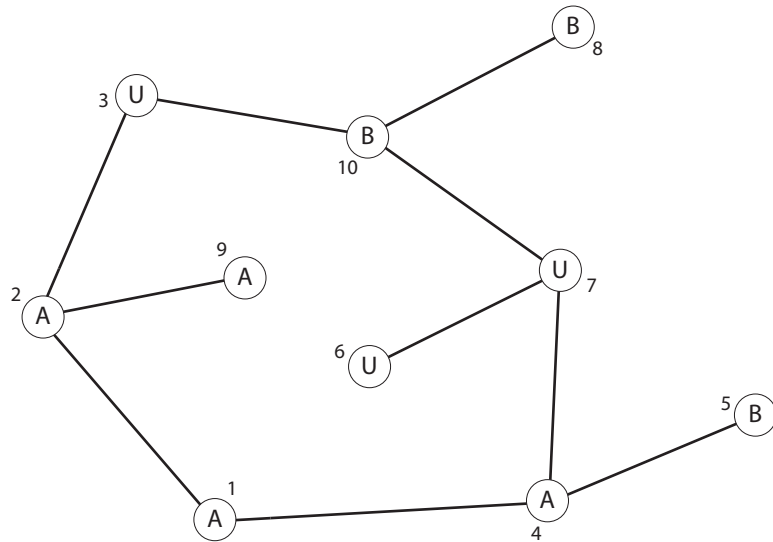
```

subAlgorithm OptimizeDyadClasses () {
    Select dyad class  $d_{corr} \in \{AA, BB, AB, UA, UB, UU\}$  with maximal
    distance from the target  $|m_L(d_{corr})_{act} - m_L(d_{corr})_{tgt}|$  in the current graph  $\Gamma_k$ 
    IF ( $m_L(d_{corr})_{act} < m_L(d_{corr})_{tgt}$  )
        Select ego-network class  $s_{corr}$  with maximal  $\Delta f(s_{corr}) = f(s_{corr})_{tgt} - f(s_{corr})_{act}$ 
        Add a line between two nodes belonging to the size class  $s_{corr-1}$ 
        creating a dyad of dyad class  $d_{corr}$ 
    ELSE
        Select ego-network class  $s_{corr}$  with maximal  $\Delta f(s_{corr}) = f(s_{corr})_{act} - f(s_{corr})_{tgt}$ 
        Delete the line of a dyad of dyad class  $d_{corr}$  between two nodes
        belonging to the size class  $s_{corr+1}$ 
}

```

### **Optimization of the alteri class frequencies**

The steps within the optimization process of the alteri classes  $a$  with  $a \in \{Iso, Neut, HomA, HomB, Het\}$  are illustrated by the following graph example:



Generally, in each iteration step, the algorithm tries to improve the frequencies of the alteri classes for one randomly selected type  $t \in \{A, B, U\}$  of individuals. By adding and deleting lines, it is possible to shift every individual from its alteri class  $a_{from}$  into any other alteri class  $a_{to}$ . The corresponding shift is denoted as  $sft = (a_{from}, a_{to})$ . In the example graph above, it is simple to change the environment of individual 4 from *Het* to *HomA* by deleting the line (4,5). Definitively more disruptive to the network structure is the shift of individual 2 into the alteri class *HomB*: The lines to individuals of type *A* have to be deleted and at least one line to an individual of type *B* has to be generated. Similarly expensive is the shift of individual 7 towards the alteri class *Iso*: All lines to the alteri 4,6, and 10 have to be deleted.

These examples illustrate that the specific shifts require modifications that have different impacts. On the one hand, costs depend on the original and the desired alteri class involved in the shift. It is sufficient to add one single line for a shift from *HomA* to *Het*, whereas at least two lines have to be added for a shift from *Neut* to *Het*. On the other hand, the costs for a particular shift depend on the specific neighborhood of an individual. Whilst for a shift of individual 9 to *HomB* only one line has to be deleted (between individuals 2 and ego), the shift of individual 2 to *HomB* requires to delete two lines (between the ego and the individuals 1 and 9, respectively). Table 7.5 presents a synopsis of the steps required for all possible shifts.



Table 7.5: Operations required for all possible shifts between two alteri classes. The command  $\text{add}(t)$  means to add one or more lines to an individual with party identification  $t \in \{A, B, U\}$ . The command  $\text{rA}(t)$  means to delete all lines connecting to an individual with party identification  $t$ ;  $\text{rA}$  means to delete the whole ego-network of the focal individual. The abbreviation *ifns* means “if necessary”.

$a_{\text{from}}$	$a_{\text{to}}$	<i>Iso</i>	<i>Neut</i>	<i>HomA</i>	<i>HomB</i>	<i>Het</i>
<i>Iso</i>	-		$\text{add}(U)$	$\text{add}(A)$	$\text{add}(B)$	$\text{add}(A),$ $\text{add}(B)$
<i>Neut</i>	$\text{rA}$	-		$\text{add}(A)$	$\text{add}(B)$	$\text{add}(A),$ $\text{add}(B)$
<i>HomA</i>	$\text{rA}$	$\text{rA}(A) + \text{ifns}$	$\text{add}(U)$	-	$\text{rA}(A),$ $\text{add}(B)$	$\text{add}(B)$
<i>HomB</i>	$\text{rA}$	$\text{rA}(B) + \text{ifns}$	$\text{add}(U)$	$\text{rA}(B),$ $\text{add}(A)$	-	$\text{add}(A)$
<i>Het</i>	$\text{rA}$	$\text{rA}(A), \text{rA}(B) + \text{ifns}$	$\text{add}(U)$	$\text{rA}(B)$	$\text{rA}(A)$	-

There are three important types of side-effects of shifting an individual from a particular alteri class to another:

- change of the ego-network sizes of the focal individual, of the old alter (or alteri) and of the new alter (or alteri).
- change of the alteri class of the old alter (or alteri) and of the new alter (or alteri).
- change of the dyad class frequencies

For example, if individual 2 is shifted from alteri class *HomA* to alteri class *HomB* by connecting it to individual 10, its ego-network size and the ego-network sizes of individual 1 and 9 are decreased by one, and the ego-network size of individual 10 is increased by one. Second, the alteri class of the old alter 9 is changed from *HomA* to *Iso* and the alteri class of the old alter 1 remains unchanged. The alteri class of the new alter 10 are changed from *HomB* to *Het*. Third, the frequency of the dyad class AA is decreased and the frequency of the dyad class AB is increased.

These side-effects suggest that the algorithm will end in a “one-step-forward-two-step-backward” loop. However, if the algorithm is able to prefer shifts that require a minimal number of added or deleted lines, the algorithm finds a way out of the loop. For this purpose, in a first step, the algorithm uses a table that helps to select the cheapest shift out of a set of possible shifts (see table 7.6). If there are several shifts with the same impact factor, one of the shifts is randomly selected. In a second step, the

algorithm selects an individual  $n_i$  belonging to type  $t$  and alteri class  $a_{from}$ , that can be shifted to the alteri class  $a_{to}$  with minimal costs.

Table 7.6: Different shifts from one alteri class to another are categorized according to their impact factor. The abbreviation *ifns* means “if necessary”.

impact factor (computational cost and undesired side-effects)	steps required for the shift
1	1-2 add(t)
2	1 rA(t) + <i>ifns</i> 1 add(t)
3	1 rA(t) + 1 add(t)
4	2 rA(t) + <i>ifns</i> 1 add(t)
5	1 rA

The pseudo-code for the optimization of alteri class frequencies looks like this:

```

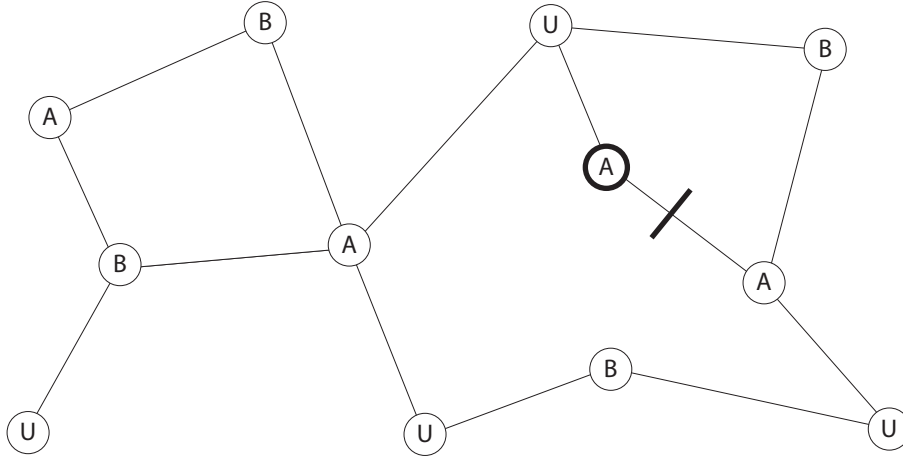
subAlgorithm OptimizeAlteriClasses () {
  Select randomly some type  $t \in \{A, B, U\}$ 
  IF ( $f(a|t)_{act} \neq f(a|t)_{tgt}$  for at least one alteri class  $a \in R := \{Iso, Neut, HomA, HomB, Het\}$  in the current graph  $\Gamma_k$ ) {
    define the set  $U = \{a \in R \mid f(a|t)_{act} > f(a|t)_{tgt}\}$  of the over-represented alteri classes
    define the set  $V = \{a \in R \mid f(a|t)_{act} < f(a|t)_{tgt}\}$  of the under-represented alteri classes
    define the set  $W = U \times V$  of the possible shifts improving the network
    select the shift  $sft \in W$ ,  $sft = (a_{from}, a_{to})$  with the minimal impact factor
    select an individual  $n_i$  of type  $t$  and of alteri class  $a_{from}$ , that can be shifted to the alteri class  $a_{to}$  with minimal costs
    shift the individual  $n_i$  from alteri class  $a_{from}$  to alteri class  $a_{to}$ 
  }
}

```

To illustrate the mechanism of the alteri class optimization, figure 7.1 shows a simple initial random graph  $\Gamma_0$ . For the sake of simplicity, the first step of the algorithm is

omitted. That is, the actual frequencies  $f(a|t)_{act}$  and the target frequencies  $f(a|t)_{igt}$  are lumped together into a total target frequency  $f_{tot}(a)_{igt}$  independent of the types of the egos (for example  $f_{tot}(Iso)_{igt} = f(Iso|A)_{igt} + f(Iso|B)_{igt} + f(Iso|U)_{igt}$ , see table 7.3). Additionally, the resulting total actual frequency is indicated as an absolute number  $q(a)_{act}$  and the resulting total target frequency is indicated as an absolute number  $q(a)_{igt}$ .

Figure 7.1: Example graph showing the mechanism of alteri class optimization. The short bold line between two individuals of type *A* indicates the first optimization step.



In this graph, the actual values for the alteri classes are quite distant from some assumed target values:

	<i>Iso</i>	<i>Neut</i>	<i>HomA</i>	<i>HomB</i>	<i>Het</i>
$q(a)_{act}$	0	1	4	4	3
$q(a)_{igt}$	1	2	3	4	2

The sets  $U$ ,  $V$ , and  $W$  are chosen as follows:

$$U = \{HomA, Het\}$$

$$V = \{Iso, Neut\}$$

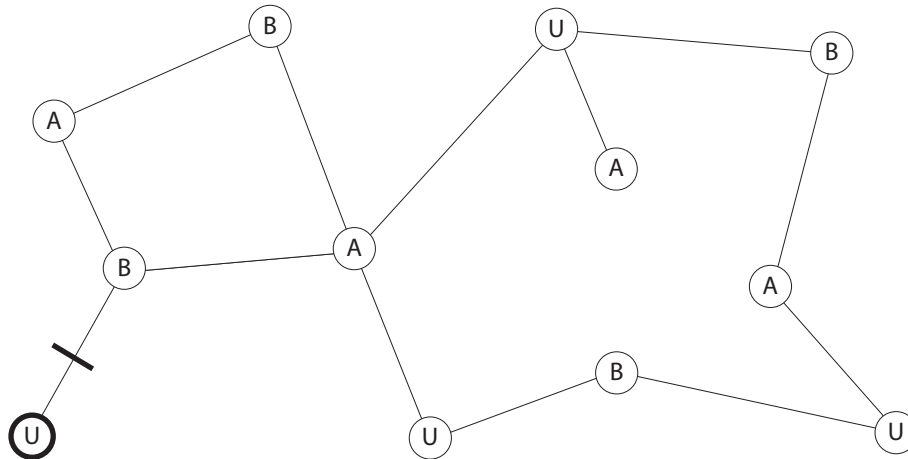
$$W = \{(HomA, Iso), (HomA, Neut), (Het, Iso), (Het, Neut)\}$$

$$W_{impact} = \{5, 2, 5, 4\}$$

Among the possible shifts improving the network, the shift from *HomA* to *Neut* is clearly the cheapest. The algorithm shifts the specific individual of alteri class *HomA*

that is connected to the minimal number of alteri with type *A* (bold individual of type *A*). This results in the following graph  $\Gamma_I$ :

Figure 7.2: The example graph after one step of optimization. The second optimization step is indicated by the short line crossing the *UB* line on the left side.



	<i>Iso</i>	<i>Neut</i>	<i>HomA</i>	<i>HomB</i>	<i>Het</i>
$q(a)_{act}$	0	2	3	5	2
$q(a)_{igt}$	1	2	3	4	2

The table reports the side effects of the performed shift: The individual of type *A* that was connected to the now optimized individual was shifted from the alteri class *Het* to the alteri class *HomB*. First, this means that the alteri class *HomB* is now over-represented, although it has been optimal in the previous step. Second, the alteri class *Het* has been optimized as a side-effect.

The next iteration starts again with the definition of the sets *U*, *V*, and *W*:

$$\begin{aligned}
 U &= \{HomB\} \\
 V &= \{Iso\} \\
 W &= \{(HomB, Iso)\}
 \end{aligned}$$

Now, there is only one shift available for the improvement of the network structure. The individual among the alteri class *HomB* that is connected to the minimal number of

alteri is detected. In the next step, the lines to the alteri of this individual are deleted and it becomes isolated. This shift produces no side-effects.

As a general pattern, more lines are deleted than are added (see the disequilibrium between remove all *rA()* commands and the *add()* commands in table 7.5). In order to correct this bias, every time when performing the command *add()*, the number of added lines should equal the number of lines that were deleted in the iterations since the last *add()* command. However, if for example there was a sequence of three remove all commands *rA()* with a total of ten lines deleted in the last three iterations, the correction is not to add ten lines to a single individual if the next *add()* command is executed. This would lead to an individual with a big increase of its ego-network size which is likely to distort the distribution of the ego-network sizes. It turned out to be a good rule of thumb to limit the number of added lines to three even if the number of deleted lines in the last iterations has exceeded this number.

## **Tests of the algorithm**

The tests were conducted starting from random graphs encompassing 100 individuals. For each test, a sample of 1000 optimizations was run in order to find robust quality indexes.

### ***Data Example***

Data collected in West Germany in the context of the German General Elections (from 1990, 1994 and 1998) serve as examples to illustrate the data that are required as target values of the algorithm and to render the test of the algorithm more concrete.

In West Germany, the frequency of apartisans has varied between 20 and 30 percent during the last fifteen years. For the sake of consistency, we refer to the 28.6 percent published in the Schmitt-Beck study because the target values for the heterogeneity indexes are taken from this study as well (see below). That is, 28 individuals are assigned the label *U*, 36 individuals the label *A*, and 36 individuals the label *B*.

There are two studies on the frequency distribution of the ego-network sizes  $g_s(i)$  in West Germany (Schenk, 1995; Schmitt-Beck, 2000) (see figure 7.3). Unfortunately, the data derived from the Comparative National Elections Project (CNEP) suffer from the deficiency of the specific network generator applied in West Germany. This network generator tended to neglect spouses as discussant partners (Schmitt-Beck, 2000, p.168).

Consequently, the ego-networks from this study are biased towards small values (see figure 7.3). For example, the frequency of isolated individuals without any network partner was 22.8%, whereas in the Schenk study, this frequency was 9%. In the following, the target values  $f(s)_{tgt}$  for different network sizes  $s$  are taken from the study from Schenk.

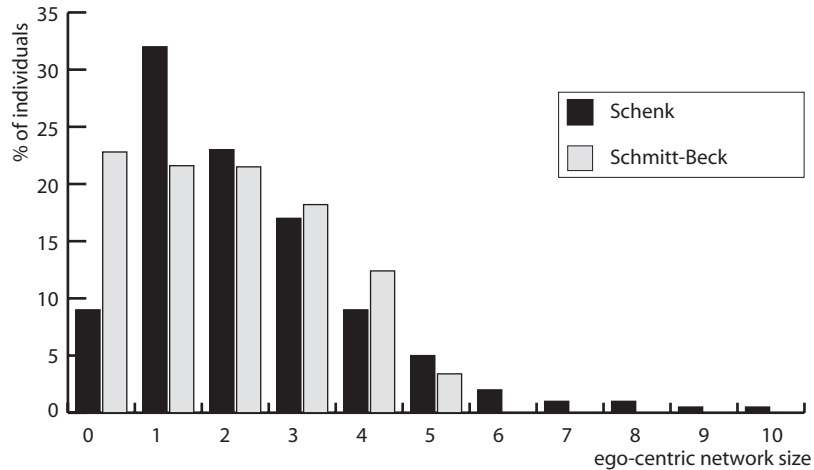


Figure 7.3: Distribution of ego-network sizes in the studies from Schenk (1995) and Schmitt-Beck (2000).

The heterogeneity-related target frequencies are derived from an analysis of data collected in the context of the CNEP (Schmitt-Beck, 2000). This analysis provides datasets of the dyad classes and alteri classes for West and East Germany, Great Britain, Spain, and the USA. For this example, the four main parties in Germany are divided into the two *Parteilager* SPD/Grüne and CDU/CSU/FDP. The SPD/Grüne *Parteilager* is encoded as party A, whereas the CDU/CSU/FDP *Parteilager* is encoded as party B (see tables 7.7 and 7.8). For details of the data preparation see Weigelt (2001).

Table 7.7: Example for the target frequencies  $f(a|t)_{tgt}$  of individuals with party identification  $t$  to be linked to an alteri class  $a$ . Data derived from Schmitt-Beck (2000) for West Germany in 1990 (rounded).

PID $t$	composition of the ego-network (alteri class $a$ )				
	isolated ( <i>Iso</i> )	neutral ( <i>Neut</i> )	homogeneous ( <i>HomA</i> )    ( <i>HomB</i> )		heterogeneous ( <i>Het</i> )
$A$	0.09	0.12	<b>0.46</b>	0.09	0.24
$B$	0.09	0.16	0.06	<b>0.43</b>	0.26
$U$	0.09	<b>0.35</b>	0.16	0.16	0.24

Table 7.8: Example for the target numbers  $m_L(d)_{tgt}$  of different dyad classes  $d$  within the total network with  $g = 100$ . Data derived from Schmitt-Beck (2000) for West Germany in 1990 (rounded).

dyad class					
AA	BB	AB	UA	UB	UU
20	20	16	15	15	14

### **Variation of deviation from the target values**

The algorithm was tested varying the level  $\varepsilon$  that expresses the deviation from the target values. Under the condition of  $\varepsilon = 0$ , the whole set of target values of the 6 dyad classes and 15 alteri classes in the tables 7 and 8 has to be reached without deviation. If  $\varepsilon$  is set at 0.1 (resp. 0.2), the deviations from the target value have to be below 10% (resp. 20%) for all dyad or alteri class frequencies. Since the optimization of the frequencies of the network sizes does not have the first priority in this algorithm,  $\varepsilon$  is not applied to the corresponding target values. In table 7.9, for each level of  $\varepsilon$  the percentage of full optimizations, the average number of required iterations, the standard deviations of the required iterations, and the average calculation time are indicated.

Table 7.9: Properties of the algorithm if different levels of  $\varepsilon$  are required

$\varepsilon$	percentage of full optimizations	average number of iterations $k_{avg}$ required	standard deviation of $k$	average calculation time [ms]
0	100 %	454.3	262.4	75.6
0.1	100 %	248.8	143.3	42.9
0.2	100 %	174.4	83.7	31

The most remarkable result is that the algorithm always finds an optimal graph even under the requirement of  $\varepsilon = 0$ . Importantly, although all the optimized networks fulfill the required level of  $\varepsilon$ , they are not identical. Based on a large random sample of optimized networks we never got the same structure twice. The algorithm has been implemented in the JAVA programming language and is quite fast. A standard personal computer with two 400MHz CPUs and 256MB RAM requires 75.6 milliseconds for the average number of 454.3 iterations. The speed of the algorithm is an important characteristic if thousands of simulation runs have to be performed in a large Monte Carlo experiment.

The standard deviation of the number of required iterations is relatively high for all levels of  $\varepsilon$ . That is, there are some random initial graphs that take a large number of iterations (between 1000 and 2000) until the required level of quality is reached. Nevertheless, because of the linearly growing calculation times, this does not have a big effect (calculation times of 166 resp. 332 ms for 1000 resp. 2000 iterations).

The following figure 7.4 shows an example of an optimal graph. The visualization was assisted by the NetMiner for Web v.0.99b ([www.netminer.com](http://www.netminer.com)) based on a  $g \times g$  matrix generated by the algorithm. Unfortunately, NetMiner allows only for the representation of  $g = 60$  individuals. However, all the target frequencies of the example are met.



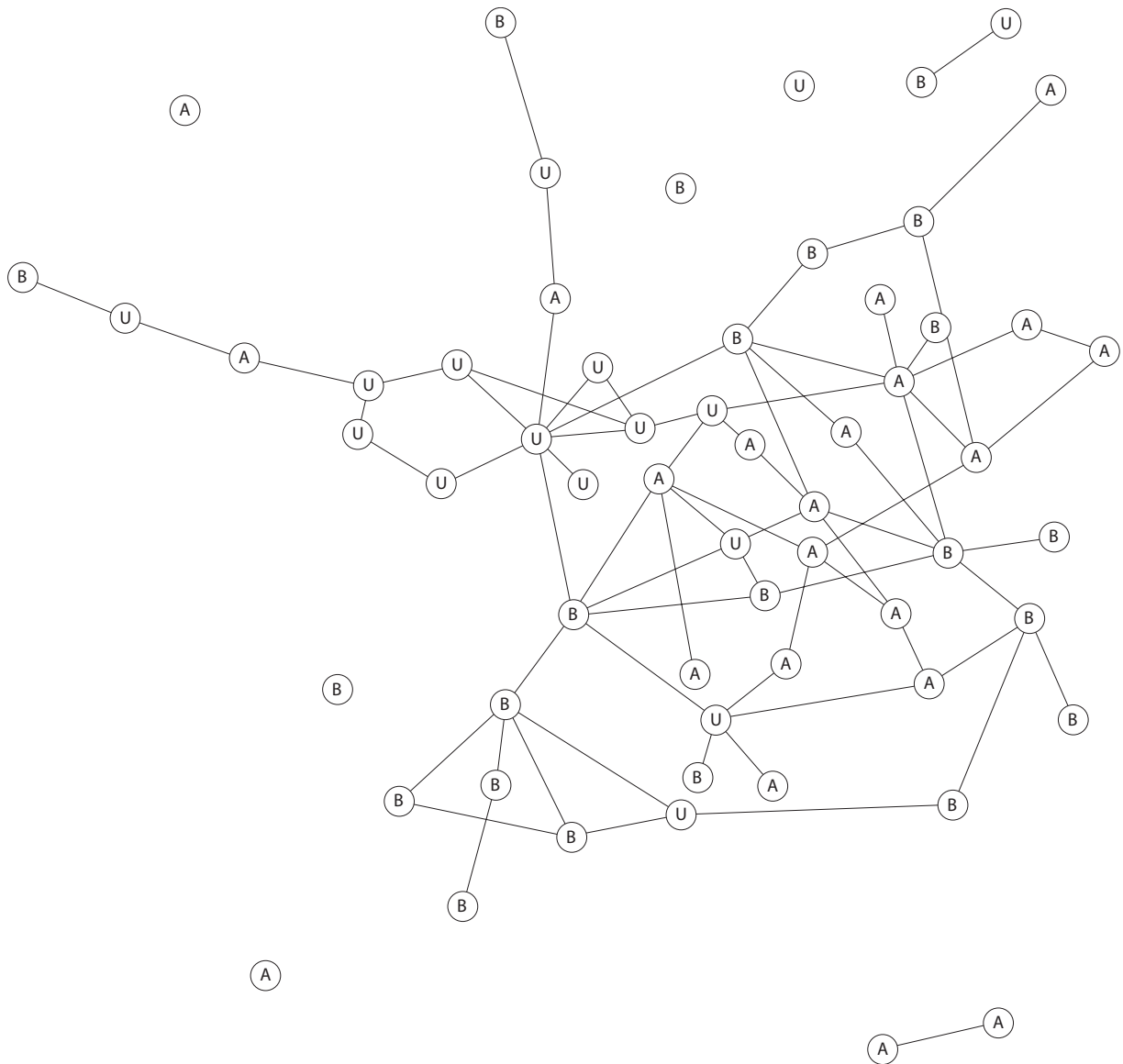


Figure 7.4: Visualization of an optimal graph with a number of  $g = 60$  citizens based on a  $g \times g$  matrix produced by the algorithm based on data from West Germany between 1990 and 1998.

### ***Ego-network sizes of optimized graphs***

The optimization of the dyad classes at the same time optimizes the target values  $f(s)_{igt}$  for different network sizes  $s$  (see the section on the optimization of the dyad class frequencies on p. 117ff.). Notably, the focus of this chapter is on the optimization of heterogeneity indexes. The full optimization of the ego-network sizes has secondary priority. However, the target distribution taken from the Schenk data is approximated sufficiently (see figure 7.5) taking into account the uncertainty of the empirical data.

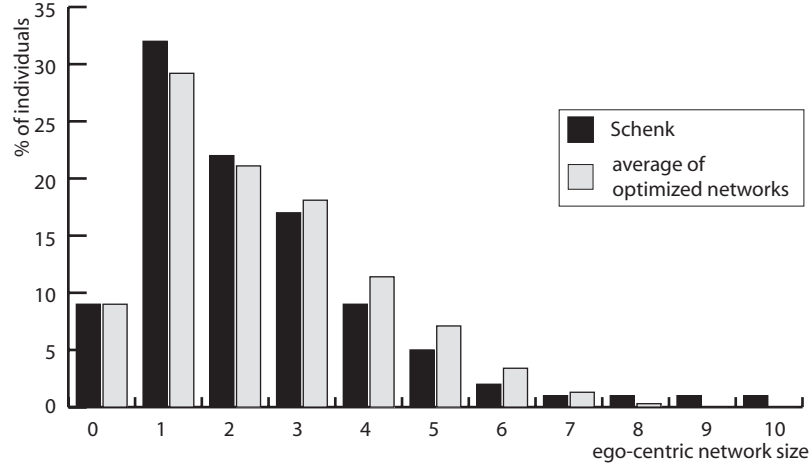


Figure 7.5: Average distribution of the ego-network sizes based on 1000 optimizations (with  $\varepsilon = 0$ ) in comparison to the target values from Schenk (1995).

### The performance of the algorithm

To test the performance of the algorithm, the two optimality indexes of the dyad classes and the alteri classes have to be expressed more explicitly:

$$dyadOpt_l = 1 - \frac{1}{6} \sum_d \left| \frac{act(d) - tgt(d)}{tgt(d)} \right| \quad \text{with } d \in \{AA, BB, AB, NA, NB, NN\}$$

$$alteriOpt_l = 1 - \frac{1}{15} \sum_a \sum_t \left| \frac{act(a|t) - tgt(a|t)}{tgt(a|t)} \right| \quad \text{with } a \in \{Iso, Neut, Homa, HomB, Het\} \text{ and } t \in \{A, B, N\}$$

For  $\varepsilon = 0$ ,  $dyadOpt_l$  and  $alteriOpt_l$  is 1.0 after the optimum has been reached. Within a sample of 1000 initial random networks, the average level of  $dyadOpt_l$  is 0.585 and the average level of  $alteriOpt_l$  is 0.186.

The tables 10 and 11 indicate how many percents on average the target frequency deviates from the initial frequency. Regarding the alteri classes, homogeneous concordant ego-networks are strongly under-represented in the initial random networks. For example, 22.8% more individuals with party identification A and concordant homogeneous ego-networks have to be generated. Visa versa, the homogeneous discordant ego-networks are over-represented and have to be reduced.

The required corrections in the alteri class frequencies are reflected in the required shifts in the dyad class frequencies. Homogeneous dyads AA, BB, and NN have to be

created, whereas the frequencies of heterogeneous dyads AB, NA, and NB have to be diminished.

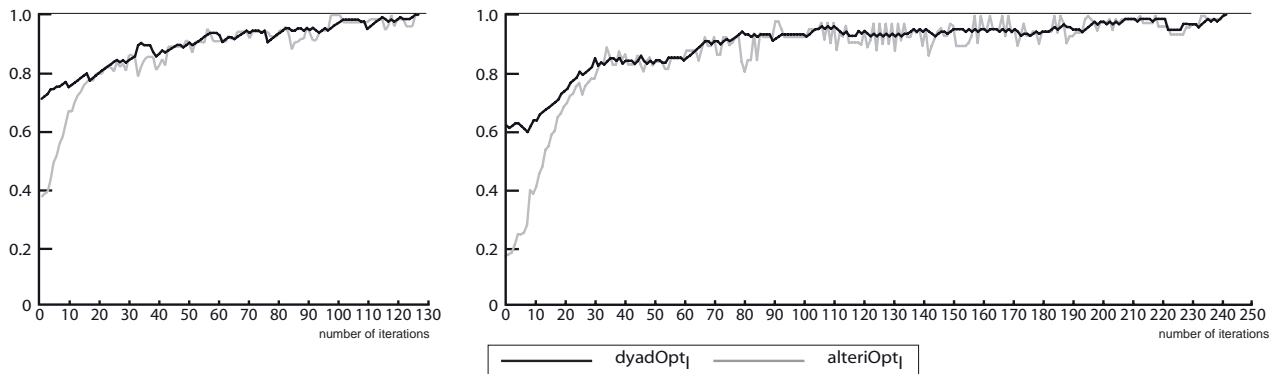


Figure 7.6: Traces of the optimality indexes for the dyad classes and the alteri classes during two runs of the algorithm.

In figure 7.6, two examples of the temporal development of  $dyadOpt_t$  and  $alteriOpt_t$  are depicted. In the first example, the final condition of  $dyadOpt_t = alteriOpt_t = 1$  is reached faster than in the second example. In both examples there is a remarkable volatility of  $alteriOpt_t$  that can be traced back to the unintended side effects of shifting individuals into another alteri class (see the optimization example above).

Table 7.10: Difference between the target frequencies  $f(a|t)_{tgt}$  in table 7.7 and the average frequencies in the randomly generated initial networks. The difference is indicated in percents.

PID $t$	composition of the ego-network (alteri class $a$ )				
	isolated ( <i>Iso</i> )	neutral ( <i>Neut</i> )	homogeneous ( <i>HomA</i> )    ( <i>HomB</i> )		heterogeneous ( <i>Het</i> )
<i>A</i>	-0.3	+5.4	+22.8	-16.4	-11.6
<i>B</i>	-2.6	+8.0	-19.0	+21.7	-8.1
<i>U</i>	+2.6	+27.2	-10.5	-9.1	-10.2

Table 7.11: Difference between the target numbers  $m_L(d)_{tgt}$  in table 7.8 and the average numbers in the randomly generated initial networks. The difference is indicated in percents.

dyad class					
AA	BB	AB	UA	UB	UU
+7.1	+7.7	-9.3	-5.8	-5.3	+5.5

## Discussion and Conclusion

The task described in this chapter was to develop an algorithm that is capable of generating artificial political discussion networks. The first priority was to generate networks with “natural” heterogeneities in respect to the specific attribute of the party identification supposed under the condition of a two party system (partisan A, partisan B, undecided). The second priority was to approximate the distribution of ego-network sizes given in the data. Three fundamental requirements from the perspective of the modeler were identified. First, the algorithm should be able to handle the particular format of homogeneity data from empirical studies. Second, the algorithm should be fast relative to the runtimes of most social simulation models. Third, the output should be formatted in the standard  $g \times g$  matrix encoding the lines between  $g$  nodes.

First tests of the algorithm with empirical data from West Germany and 100 artificial individuals demonstrate that all these goals have been reached. Both the network heterogeneities in terms of the target frequencies of six types of dyads and in terms of the target frequencies of 15 different ego-network compositions (three types of individuals, five alteri classes) could be translated into a great many of different “naturally” heterogeneous social networks. The frequency distribution of the ego-network sizes was quite close to the empirical studies although not optimized with the highest priority. If one takes into account the uncertainty of the empirical network size data, the second priority goal of network size optimization can be considered as reached as well. If there is an uncertainty of, say, 30% in the size frequencies, it is not necessary to fully optimize the size frequencies of the ego-networks. The same is true for the heterogeneity-related target frequencies. This means that it is not necessary to set  $\varepsilon = 0$  although the algorithm is capable of achieving this extreme level. As long as the algorithm is based on singular data points and there is no information about their uncertainty (e.g. standard deviation), the uncertainty has to be estimated and transposed into a meaningful level of  $\varepsilon$ . Our intuition is to run the algorithm with a deviation of 20% ( $\varepsilon=0.2$ ). However, if the accuracy of the respondent reports about the party

identification of their alteri is taken into account (Knoke, 1990),  $\varepsilon$  might even be shifted towards levels of  $\varepsilon=0.3$  or even  $\varepsilon=0.5$ . The problem is that the degree of accuracy is largely unknown. Perhaps, as put forward by Krackhardt and Porter (Krackhardt & Porter, 1985), from a constructivist perspective the subjectively perceived attributes of the alteri have the same effect for the ego even if the perception is wrong.

Based on the heterogeneity and network size data from the CNEP published in (Schmitt-Beck, 2000), the algorithm could easily be applied for the generation of political discussant networks in other political systems like Great Britain and the USA. The only essential condition when using the current algorithm is to justify the categorization of the main parties of each country into two groups (most frequently along the left-right dimension).

The algorithm is not limited to the attribute of party identification. Whenever an attribute on the individual is bimodal or trimodal and the attribute-related heterogeneities and network size data are available, the algorithm is appropriate. For example, it is conceivable to generate naturally heterogeneous networks based on the metrical attribute of income (low, medium, high) or based on the nominal attribute of religion (Christian, Muslim, and Others).

Yet, there are several avenues for further development. First, at least for theoretical purposes, it would be fascinating to find an algorithm that is able to synchronously optimize the target frequencies of the dyad classes, the alteri classes, *and* the network sizes at the level of  $\varepsilon=0$ . However, as has been argued regarding the inherent uncertainty of the target frequencies, this is not a primary goal of further development. The extension of the algorithm for handling more than tripolar individual attributes would be fruitful. In our view, an extension to penta- or septapolar attributes (attributes can take one of five or seven different values) would considerably enlarge the scope of application of the algorithm. Introducing the distinction between strong and weak lines would be another promising way of further development if there are network data encompassing different degrees of tie strength.

## 8 General Conclusion

The goal of this PhD thesis has been to develop an empirically grounded simulation model of the formation of political attitude strength within interpersonal political discussion networks. The motivation for the focus on attitude strength is derived from the almost trivial dictum that what counts in elections are not only *converted* citizens but also *activated* citizens (Berelson et al., 1954). That is, only party (or candidate) supporters that finally cast their vote on voting day have a measurable effect on the direction of politics. The relevant questions are therefore: how does a *converted* citizen become an *activated* citizen? How does a weak attitude without behavioral consequences become a strong attitude with behavioral consequences? The latter question addresses the well-known problem of the attitude-behavior relationship (Zanna & Fazio, 1982; Fazio, 1986; Fazio, Powell, & Williams, 1989; Kraus, 1995). Regarding the still growing body of empirical studies confirming the intervening character of attitude strength within the attitude-behavior relationship, this work is not only about the simulation of attitude *change* (in terms of attitudinal valence and attitudinal extremity) but also about the simulation of attitude *strength*.

The most salient *benefits* of simulating mental representations related to attitude strength are the following:

- at each time step the model distinguishes between *certain* citizens that communicate univalent arguments and *uncertain* citizens that communicate ambivalent arguments. That is, not every attitude exchange does a priori persuade the communication partners. The persuasive effect on the side of the receiver is dependent on the certainty of the citizen representing the source.
- on voting day the model distinguishes between citizens with a relatively high level of attitude strength (participating in the elections) and citizens with a relatively low level of attitude strength (abstaining from the elections).

The *cost* of tackling the problem of simulating attitude strength has been to implement the complexities of the strength-related components into the computer model. For example, in order to simulate the temporal formation of the attitudinal ambivalence component, it is required that at least two psychological responses towards the attitude target are kept separate.

## **Main Results**

This PhD thesis has been innovative in three fields of research: i) the theory of attitudes, ii) the methodology of social simulation, and iii) the optimization of advertising strategies in political campaigns.

### ***Advancement in attitude theory***

In the context of attitude theory, this work provides a procedural model of serial information integration which is implemented as a “mechanism” that can be inspected while running on a computer. The mechanism (or model) integrates the attitude strength construct with existing models of attitude formation and change in political psychology. The model is called *Political Attitude Strength Simulation (PASS)* model. The PASS model grapples with all the fundamental question of cognitive psychology: the storage and organization of information in memory, the effect of the stored information on the interpretation of new information, and the formation and change of mental representations integrating the information in memory (McGuire, 1969). Including the concept of involvement, the model addresses research in the field of affective cognition that was reinvigorated in the 1980s (Zajonc, 1980; Schwarz et al., 1988; Edwards, 1990; Kunda, 1990; Breckler & Wiggins, 1991; Lavine et al., 1998). This model encompasses existing theories from cognitive science and social psychology that are, as far as possible, validated by a number of empirical studies (see chapter 3, p. 24ff, for an overview of the theoretical components of the model). It is important to note that the set of implemented theories does not represent some well-confined set of assumptions of an already existing theory. Rather the way the assumptions are connected is the core advancement of the PASS model.

### ***Advancement in the Methodology of Social Simulation***

In the PASS model, the simulated citizens exchange their attitudes within a social network characterized by data-based levels of homogeneity. The motivation were the empirical findings that the compositions of the ego-centric networks of citizens probably matter in the context of persuasion processes. The composition of an ego-network represents a characteristic filter for the persuasive messages coming from the mass media or party advertising. In spite of the acknowledgement of this effect in the literature, in all the models simulating the diffusion of attitudes the author is aware of

(Nowak et al., 1990; Latane et al., 1994; Regenwetter et al., 1999; Hegselmann et al., 2000; Nowak et al., 2000; Mosler et al., 2001) the social entities exchange their attitudes within a random set of neighbors.

The methodological advancement of the model consists of an algorithm (see chapter 7) that generates political discussion networks according to data-based homogeneity levels (in regard to the citizen characteristic of party identification). This prevents the model from producing artifacts on the aggregate level due to randomly linking the citizens.

### ***Advancement in Optimal Political Advertising***

In the context of the optimization of advertising strategies in political campaigns, this work is the first attempt to transfer the question of optimal resource allocation from consumer product marketing to the field of political marketing. The main result of the Monte Carlo Experiments conducted in chapter 4 was that the current practice does not deviate substantially from the optimal timing of campaign activities. However, the small deviation of the optimum found in the computer experiments from the current practice in the real world supports the argument that frequently observed extreme final bursts (e.g. concentrating half of the budget in the last *three* weeks before voting day) are not as efficient as more continuous strategies that are less frequently observed in reality (like concentrating half of the budget in the last *nine* weeks before voting day). The reason for the superiority of more continuous strategies is that citizens bolster their attitudes against uncongenial persuasive messages (confirmation bias) and tend to discuss political issues in relatively homogeneous peer networks. These networks act like “filters” (Katz et al., 1955) that reinforce congenial persuasive messages coming from the mass media or the party advertising activities and block the effect of uncongenial persuasive messages (see table 3.2 in chapter 3). In discussions on the issue of optimal timing in political campaigns, this social bolstering mechanism combined with the confirmation bias on the individual level should be kept in mind as arguments supporting more continuous strategies.

### **Uncertainty analysis**

One of the main goals of this project was to keep the model structure and processes grounded in the empirical evidence and, therefore, to test it in a data-rich domain. The



field of election research is one of the fields with a large stock of empirical data regarding citizen attitude formation and change. However, even if this field is one of the richest reservoirs of empirical data related to attitudes, there are still many uncertainties in the results related to optimal timing recapitulated in the previous section. The following overview of different sources of uncertainties with corresponding examples from the PASS model is based on a scheme provided by Van der Sluijs (1997, p. 206).

### ***Input data***

The estimation of the frequency distribution of model input parameters for conducting the Monte Carlo Experiments is the most often mentioned source of uncertainty. In the latter case, the uncertainty can be devised in the uncertainty of the form of the frequency distribution (uniform, normal, bimodal, binomial etc.), the uncertainty of the mean value and the uncertainty of the variance around the mean value. For example, when estimating the parameters of the PASS model, the question did arise if three studies on issue salience formation depending on media coverage are sufficient for estimating the frequency distribution of the central memory decay input parameter. Does it help to additionally consult data from brand recall studies? Or do these data from a different domain rather distort the original estimate that was restricted to data from political psychology? Still another type of questions address the reliability of the data: can we trust the self-reports of citizens when prompted to ask the question of how many times they have “recently” discussed election-related issues with other citizens? What did “recently” mean for each of the interviewed citizens? One week, two weeks, one month or half a year? Here, a sort of pragmatic “art” of taking assumptions came into play: In the above example, the assumption was that “recent” means a time period of one month. This assumption was gained by mentally simulating the situation of being asked the original question and also by asking colleagues to mentally simulate the situation. Only with the mean value of this “mini-experiment” of “recently = 1 month” in mind, it became possible to fit the model to the data. On the other hand, every modeler in social psychology feels happy if there are *any* data available. If Elisabeth Noelle-Neumann would not have asked the question of the frequency of political discussions in five subsequent General German Election during 1983 and 1998 (motivated by her own research question), I would have had to guess the discussion frequency based on my own sense of plausibility.

### ***Conceptual model structure and model completeness***

Another source of uncertainty is the selection of the structural elements and the selection of the processes (functional relations between the structural elements) that are finally built in the model. This is equivalent to the question of the optimal model boundaries in regard to the research question or the question whether the model is complete or still incomplete. My first approach to this problem was to screen existing empirically tested theories of human attitude formation and change and the theories on the characteristics of attitude strength. The result was a long list of more or less reliable assumptions from empirical studies. This list provided a useful repository of possible structures and processes that might become part of the PASS model or not. The first step was to separate almost unanimously confirmed empirical findings (stylized facts) from more speculative findings taken from isolated empirical studies. The next step was to ask which of the structures and processes are *too specific* in relation to the task of this PhD. For example, is it necessary to distinguish the difference in the encoding of vivid vs. pallid messages in the citizen's memory for giving an answer of optimal timing advertising activities? Is it necessary to distinguish different levels of argument strength in the persuasive messages? The converse process was to find auxiliary assumptions to render too generally stated theories more specific. For example, an important auxiliary assumption in the PASS model is the dependence of the citizen's involvement on the total accessibility of the Persuasive Message Extracts (PMEs) in the mental accounts. The theory of agenda-setting just proposes that the shape of the involvement curve is probably sigmoid. The theoretical bridge between the accessibilities of the PMEs and the citizen involvement is an ad hoc hypothesis that is not empirically validated yet.

### ***Technical model structure***

The selection of the final components of the model is coupled with uncertainty of *process errors*. This type of uncertainty is about whether the specific way of simplifying too specific theories or the specific way of specifying too general theories introduces unintended processes (artifacts) into the model. Regarding the PASS model, this type of uncertainty has not yet been systematically investigated. Further experiments with different functional designs between model structures are clearly required. As an

example, an interesting question would be to test for the effects of prescribing the shape of the involvement curve (make it independent of the total accessibilities of the PMEs).

Uncertainty originates also from the question of the optimal degree of *model resolution*. With regard to the PASS model: how many citizens have to be modeled minimally? This uncertainty has been tackled by looking for the minimal number of simulated citizens that produces no significant difference between simulation runs conducted with 1000 citizens. The number of 1000 citizens was taken as a reference point because a bigger number of citizens would have rendered the calculation times of the Monte Carlo Experiments unmanageable anyway. The result was that 100 citizens was the minimal number that did not produce significant deviations in the party winning probabilities compared to the reference case of 1000 citizens.

The temporal resolution of the model was found to be optimal when representing one day of “real” time per model time step. If the resolution is set at two or more days or even weeks, the effect of the extreme final bursts occurring within three or four weeks is insufficiently represented because of the low temporal resolution. Higher temporal resolutions (half-days) did not produce significantly different results. That is, the extreme bursts are sufficiently represented with one-day resolution.

The uncertainty from *aggregation errors* when aggregating the individual party preferences on voting day into the victory or failure of the parties was reduced (or even eliminated) in the PASS model by keeping the simulated procedure of voting as close as possible to the “true” procedure of voting. The subset of voters is extracted from the population of simulated citizens according to the simulated turnout. The turnout is determined by the average attitude strength of the population on voting day. Second, the number of citizens voting for one or the other party are separately counted. Importantly, the votes of the “participants” are not weighted according to her/his attitude strength. Like in the real world, there is just a simple count of votes in the model. Nevertheless, the premise of this way of modeling is the validity of the assumption that attitude strength is indeed crucial in distinguishing participants from non-participants.

Another source of uncertainty are the effects of “*model-fixes*”. Model-fixes occur for example if the modeler artificially tries to limit the value range of variables that would otherwise take “unnatural” values. In the PASS, model-fixes were not necessary to keep variables within certain limits. However, one model-fix was necessary to resolve the situation of an exactly balanced number of votes for both parties. On average, this

situation occurs in 9% of all simulation runs. Since it is extremely unlikely that any German General Election will end in an exact balance of votes, in this situation, the computer decides randomly which party has won the election. As far as I can judge, the effect of this model-fix does not produce uncertainty in the model results.

### **Bugs**

Uncertainty can also arise from *numerical errors*. These are produced by the limited numerical precision (number of digits) of the numbers represented in the computer. For example, I had to introduce look-up tables for the parties to determine their daily level of advertising activity since it was not possible to calculate the power function of the corresponding equation precisely enough in JAVA.

A much more harmful source of bugs are *software errors*. Most of the modeling time is required for detecting bugs in the computer code. There is no methodology to eliminate software bugs *completely*. One possibility to reduce their number is to watch the traces of as many model variables as possible. This procedure is very time consuming but it is definitively worth doing it. An important pre-requisite is a powerful modeling framework with a convenient feature for displaying the numerical values of model parameters and variables or with a feature for generating x-y-plots for temporal traces. Another possibility of bug reduction is to execute “hand-walks”, i.e. to calculate a limited number of model steps *manually* (using a pocket calculator) and to compare the results with the calculations of the model. This is one of the most exhaustive approaches to limit the effects of software errors. The approach has been applied for five time steps for the PASS model in order to secure that the attitude revision processes are correct.

Last but not least, there is always the possibility of *hardware errors* (like the early version of the Pentium processor for personal computers). However, since no hardware warnings have been released in the last years, I have trusted in the hardware of the server that conducted the Monte Carlo experiments.

### **Sensitivity analysis**

The uncertainty of the model results has been explored by conducting a sensitivity analysis comprising a specific model parameter on the one hand and a specific structural characteristic of the model on the other hand. The selected model parameter was the

speed of memory decay and the selected structural characteristic the second axiom of Zaller's Receive-Accept-Sample (RAS) model (the RAS-A2 for short, see the Monte Carlo Experiments in chapter 4, p. 69ff.) (Zaller, 1992). The sensitivity analysis showed that the model results are not sensitive to the presence or absence of the RAS-A2 *as long as the memory decay speed is supposed to be high*. If the memory decay speed is low, the optimal resource allocation strategies are shifted towards less accumulation of activities in the final phase of the campaign (see figure 4.14 in chapter 4). That is, conceiving the possibility that future experiments will reveal that memory decay speed is not as fast as supposed by the currently available studies, the proponents of more continuous strategies would get more support from the PASS model.

This sensitivity analysis is the very first out of host of planned analyses. It is important to keep in mind that the gist of the PhD thesis was definitely on the advancement of the theory of political attitudes and not on the derivation of waterproof advises for the practitioner. The impossibility of exhaustively performing all the sensitivity analyses required for specifying the uncertainty of the model results is still an important drawback of the social simulation method. On the other hand, from a pragmatic perspective, it is not possible to run a large enough number of experimental German General Elections to find out the "true" winning probabilities depending on the party strategies. At least, the PASS model can be taken as a "derivation machine" which derives possible implications at least from the set of assumptions that are implemented. If there is an honest colleague who disagrees with the specific selection and composition of assumptions of the PASS model, she or he should at least be interested in *adapting the model* in the direction of her/his ideas. This would allow for finding specific implications enclosed in her/his assumptions in terms of the difference in the model behavior. If the PASS model can initiate this sort of computer-assisted discussion about the implications of changing the set of assumptions, the contribution of computer models as heuristic devices might come into play.

## **Outlook**

The following sections give an overview of possible steps of further research. The transfer of the model to the American Presidential Election or the transfer to the field of consumer product marketing is certainly the most valuable perspective for the PASS model.

### ***Testing for the Impact of Interpersonal Communication***

A simple but interesting experiment would be to explore the effects of the social network in regard to the optimal degree of accumulating campaign resources towards voting day. In a first experiment, the probability of beginning attitude exchanges will simply be set to zero. This will isolate the simulated citizens completely from each other. The hypothesized result is that the accumulation optimum goes into the direction of more accumulation in comparison to the results of the experiment 2 in chapter 4. The reason is that the simulated social network is non-randomly homogeneous (see chapter 7). If the citizens are allowed to communicate with each other, the homogeneous composition of most ego-networks produces a shield against uncongenial persuasive messages. In the beginning of the simulated period of time, the party which is relatively early can very efficiently secure that the “social nests” of supporters are not made ambivalent or even converted by the stronger final burst of the opposite party. However, the PASS model is too complex to simply derive the true consequences of disabling interpersonal communication. Running the experiment will help to think about the impact of social networks in political marketing.

### ***Transferability to the American Presidential Elections***

Since Presidential Elections can reasonably be reduced to two-person races between the incumbent and the most prominent challenger, nearly the identical structure of the PASS model could be applied to assess campaign resource allocation strategies in the context of American Presidential Elections. Probably the most severe bottleneck of the transfer would be the access to the data required to set up the artificial citizens before running the PASS model. The following table of parameters provides a survey of the data required for parameter estimation that are already available from the literature and data that have not been found in the literature.

Table 8.1: Comparison of the current data availability for estimating the parameters if the PASS model were transferred to the U.S. Presidential Elections

data already available	data not available yet
average turn out	number of converted citizens during the campaign (required for the estimation of the initial account accessibilities and the general need for confirmation)
speed of memory decay (supposed to be an universal human parameter)	frequency of interpersonal political discussions about the elections during the campaign
general need for confirmation (supposed to be an universal human parameter)	frequency distribution of different strengths of party identifications (required for the estimation of initial account accessibilities)
size of ego-centric networks from the CNEP (Schmitt-Beck, 2000)	distribution of different levels of habitual political interest
degrees of network homogeneity from the CNEP (Schmitt-Beck, 2000)	
judgmental weights of different sources of persuasive messages from the CNEP (Schmitt-Beck, 2000)	percentage of uncertain citizens towards voting day
frequency distribution of party identifications from the CNEP (Schmitt-Beck, 2000)	credibilities towards mass media in comparison to political parties

From a standpoint of reducing the cost of further empirical investigations there are reasons to think about the use of German data in the American context. For example, one might argue that the distribution of different levels of habitual political interest is likely to be similar to Germany. There are always some extremely interested and extremely uninterested minorities and some moderately interested majority. However, because of the lower levels of turnout in the American Presidential Elections, original data from the American population would be valuable. For example, according to the metaphor of the “the country of the extremes”, the distribution might be bimodal: A “peak” of uninterested people is confronted with another “peak” of an interested elite. The moderately interested citizens would be the minority between. However, it would be crucial to use the same question like in Germany to secure the comparability of the resulting percentages of interest classes. Moreover, the different understandings of the word “political interest” vs. “Politisches Interesse” could be a major difficulty for comparison. In the same vein, the relative credibilities towards mass media and political

parties could also be subjected to cultural differences. One could argue that the difference between the mass media credibility and the credibility of the political parties is smaller or even non-existent in the USA because of the very aggressive coverage from tabloids and the close entwinement between politics and mass media (Patterson, 1990).

### ***Transferability to consumer psychology***

The PASS model is suited for research projects that are targeted at simulating the formation of attitudes in social networks with individuals in a *low-involved* mind set. The model is not suited for all projects simulating attitudes that are formed under the condition of high involvement. Such projects would be attitude formation towards buying an expensive car or not, starting a new job or not, moving to a foreign country or not, adopting a new technology or not, or to contract insurance or not. For example, the assumptions of extracting only the affective content from original persuasive messages, of forgetting relatively rapidly, or of applying the “how do I feel heuristic” do not hold in these domains of high involvement human decision making. In these situations, the affective and holistic response is partly overwritten by a more cognitive, data-driven and systematic response (Bobrow & Norman, 1975; Petty & Cacioppo, 1986; Chaiken et al., 1989; Breckler et al., 1991; Dulany, 1991; Epstein, 1991). Processes of mental correction (Petty & Wegener, 1993; Wilson & Brekke, 1994; Wegener & Petty, 1997) are activated to avoid cognitive biases that might be deleterious for the individual.

According to the low-involvement condition, the model could be easily adapted to the field of preconscious formation of attitudes towards low involvement consumer products like tooth paste or soap powder (Janiszewski, 1988; Shapiro, 1999; Shapiro & Krishnan, 2001). Since the model was put forth in a two-party setting, it is applicable to simulate the effects of the advertising schedules of two competitive brands (e.g. Elmex vs. Colgate tooth paste). One of the most advanced (and award-winning) models in the field of consumer product advertising (Naik et al., 1998) does explicitly mention the requirement to extend the model by including competition between two products.

### ***Responsive Social Networks***

The current version of the PASS model does not encompass changes in the structure of the social network after it has been generated by the network algorithm described in



chapter 7. One could argue, however, that once people are converted they change the composition of their micro-environment of political communication. The measured homogeneity of social networks in regard to the characteristic of party identification clearly demonstrates that in the long run, most people actually *do* maintain a certain non-random level of homogeneity. The relevant question for extending the PASS model in the direction of dynamic social networks is whether network changes can be expected on a time scale relevant to the simulated time period of one year.

One argument for a fast change rate is predicted by the theory of dissonance reduction (Festinger, 1957). It has been shown in a great deal of experiments that dissonance reduction is a very basic human concern. That is, according to the dissonance theory, people will strongly suffer from discussions in the “old” network (from before the conversion) because these would produce a lot of cognitive dissonance.

On the other hand, there is strong evidence of the multiplexity of social relationships (Schenk, 1995; Schmitt-Beck, 2000). Most of the political discussion partners are not selected because of their congenial party identification. Rather, many social relationships are rooted in partnership and kinship or in sharing the same working place or simply the neighborhood of housing. This would also explain the considerable remaining heterogeneity of political discussion networks. The argument from multiplexity predicts rather a slow change rate of political discussion networks and would support the current approximation of static networks in the PASS model.

Additionally, it is almost a stylized fact that the percentage of people that convert from one party to the other during one year is low (Finkel et al., 1995). Thus, even if the converted citizens would change their networks immediately, it is likely (just because of their low number) that the effect of this change would not significantly change the winning probabilities of the parties. Regarding the considerable effort of introducing mechanisms continuously restructuring the social network in the model and regarding the controversial arguments about the theoretical appropriateness of such a model adaptation, it is not planned to change the modeling of the social network.

## 9 Bibliography

- Abelson, R. P. (1968). Simulation of Social Behavior. In G. Linzey & E. Aronson (Eds.), *Handbook of Social Psychology*. Reading: Addison-Wesley.
- Abelson, R. P. (1988). Conviction. *American Psychologist*, 43, 267-275.
- Abelson, R. P., Aronson, E., McGuire, W. J., Newcomb, T. M., Rosenberg, M. J., & Tannenbaum, P. H. (1968). *Theories of cognitive consistency: A sourcebook*. Chicago: Rand McNally.
- Abelson, R. P., & Bernstein, A. (1963). A Computer Simulation Model of Community Referendum Controversies. *Public Opinion Quarterly*, 27(1), 93-122.
- Abelson, R. P., Kinder, D. R., Peters, M. D., & Fiske, S. T. (1982). Affective and semantic components in political person perception. *Journal of Personality and Social Psychology*, 42, 619-630.
- Achen, C. H. (1975). Mass Political Attitudes and the Survey Response. *American Political Science Review*, 69, 1218-1231.
- Ajzen, I. (1977). Attitude-behaviour relations: a theoretical analysis and review of empirical research. *Psychological Bulletin*, 84, 888-918.
- Ajzen, I. (1985). From Intentions to Actions: A theory of planned behavior. In J. Kuhl & J. Beckmann (Eds.), *Action-control: From cognition to behavior* (pp. 11 - 39). Heidelberg: Springer.
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50, 179 - 211.
- Allport, F. H., & Hartman, D. A. (1925). The measurement and motivation of atypical opinion in a certain group. *American Political Science Review*, 19, 735-760.
- Althaus, M. (Ed.). (2001). *Kampagne! Neue Strategien für Wahlkampf, PR und Lobbying* ( Vol. 1). Münster: Lit Verlag.
- Anderson, J. R., & Bower, G. (1973). *Human associative memory*. Washington: Winston & Sons.
- Anderson, J. R., & Schooler, L. J. (1991). Reflections of the Environment in Memory. *Psychological Science*, 2(6), 396-408.
- Anderson, N. H. (1971). Integration theory and attitude change. *Psychological Review*, 78(171-206).
- Anderson, N. H., & Barrios, A. (1961). Primacy Effects in Personality Impression Formation. *Journal of Abnormal and Social Psychology*, 63, 346-350.
- Anderson, N. H., & Hubert, S. (1963). Effects on Concomitant Recall on Order Effects in Personality Impression Formation. *Journal of Verbal Learning and Verbal Behavior*, 2, 379-391.
- Anderson, W. T., & Cunningham, W. H. (1972). The Socially Conscious Consumer. *Journal of Marketing*, 36(July), 23-31.
- Andress, H.-J., Hagenars, J., & Kühnel, S. (1997). *Analyse von Tabellen und kategorialen Daten. Log-lineare Modelle, latente Klassenanalyse, logistische Regression und GSK-Ansatz*. Berlin: Springer.
- Asch, S. (1946). Forming Impressions of Personality. *Journal of Abnormal and Social Psychology*, 41, 258-290.
- Atwood, L. E., Sohn, A. B., & Sohn, H. (1978). Daily Newspaper Contributions to Community Discussion. *Journalism Quarterly*, 55, 570-576.
- Avery, R. K., & McCain, T. A. (1986). Interpersonal and Mediated Encounters: A Reorientation to the Mass Communication Process. In G. Gumpert & R. Cathcart (Eds.), *Inter/media. Interpersonal Communication in a Media World* (pp. 120-131). New York: Oxford University Press.
- Bagozzi, R. P., & Burnkrant, R. E. (1979). Attitude organization and attitude-behavior relationship. *Journal of Personality and Social Psychology*, 37, 913-929.
- Baker, W., & Lutz, R. J. (1987). The Relevance-Accessibility Model of Advertising Effectiveness. In S. Hecker & D. W. Steward (Eds.), *Nonverbal Communications in Advertising* (pp. 59-84). Lexington, MA: Lexington.
- Balci, O. (1998). Verification, Validation, and Testing. In J. Banks (Ed.), *The Handbook of Simulation* (pp. 335-393). New York: John Wiley.
- Balci, O. (2002). Expanding our horizons in verification, validation, and accreditation research and practice. Paper presented at the 2002 Winter Simulation Conference, San Diego.
- Balderjahn, I. (1988). Personality Variables and Environmental Attitudes as Predictors of Ecologically Responsible Consumption Patterns. *Journal of Business Research*, 17(August), 51-56.
- Bamberg, S., & Schmidt, P. (1994). Auto oder Fahrrad? Empirischer Test einer Handlungstheorie zur Erklärung der Verkehrsmittelwahl. *Kölner Zeitschrift für Soziologie und Sozialpsychologie*, 46(1), 80 - 102.
- Bargh, J. A., Chaiken, S., Govender, R., & Pratto, F. (1992). The generality of the automatic attitude activation effect. *Journal of Personality and Social Psychology*, 62, 893-912.
- Bartels, L. M. (1993). Messages Received: The Political Impact of Media Exposure. *American Political Science Review*, 87(2), 267-285.
- Bassili, J. N. (1995). Response latency and the accessibility of voting intentions: What contributes to accessibility and how it affects vote choice. *Personality and Social Psychology Bulletin*, 21, 686-695.
- Bassili, J. N. (1996). Meta-judgmental versus operative indexes of psychological attributes: The case of measures of attitude strength. *Journal of Personality and Social Psychology*, 71, 637-653.

- Bator, R. J., & Cialdini, R. B. (2000). The Application of Persuasion Theory to the Development of Effective Proenvironmental Public Service Announcements. *Journal of Social Issues*, 56(3), 527-541.
- Berelson, B. R., Lazarsfeld, P. F., & McPhee, W. N. (1954). *Voting. A Study of Opinion Formation in a Presidential Campaign*. Chicago: University of Chicago Press.
- Bizer, G. Y., & Krosnick, J. A. (2001). Exploring the structure of strength-related attitude features: The relation between attitude importance and attitude accessibility. *Journal of Personality and Social Psychology*, 81(4), 566-586.
- Bobrow, D. G., & Norman, D. A. (1975). Some principles of memory schemata. In D. G. Bobrow & A. Collins (Eds.), *Representation and understanding*. New York: Academic Press.
- Borgida, E., & Howard-Pitney, B. (1983). Personal involvement and the robustness of perceptual salience effects. *Journal of Personality and Social Psychology*, 45, 560-570.
- Boye, M., Slora, K. B., & Britton, C. S. (1990). Temporal stability of a safety attitude inventory. *Psychological Reports*, 67(2), 467-470.
- Boynton, G. R., & Lodge, M. (1996). J.Q.PUBLIC: A Computational Model of Candidate Evaluation. Paper presented at the Annual Meeting of the American Political Science Association, San Francisco.
- Breckler, S. J. (1984). Empirical validation of affect, behavior, and cognition as distinct components of attitude. *Journal of Personality and Social Psychology*, 47, 1191-1205.
- Breckler, S. J., & Wiggins, E. C. (1989). Affect versus evaluation in the structure of attitudes. *Journal of Experimental Social Psychology*, 25, 253-271.
- Breckler, S. J., & Wiggins, E. C. (1991). Cognitive Responses in Persuasion: Affective and Evaluative Determinants. *Journal of Experimental Social Psychology*, 27, 180-200.
- Brent, E., & Granberg, D. (1982). Subjective agreement and the presidential candidates of 1976 and 1980. *Journal of Personality and Social Psychology*, 42, 393-403.
- Bruner, J. S. (1957). On perceptual readiness. *Psychological Review*, 64, 123-152.
- Budd, J. R., & Spencer, C. (1984). Latitude of rejection, centrality, and certainty: Variables affecting the relationship between attitudes, norms, and behavioral intentions. *British Journal of Social Psychology*, 23, 1-8.
- Burnkrant, R. E., & Sawyer, A. G. (1983). Effects of involvement and message content on information processing intensity. In R. J. Harris (Ed.), *Information processing research in advertising*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Burse, J. (2000). Quicksilver: A Component-Based Environment for Agent-Based Computer Models and Simulations. Paper presented at the Computational Social Organisational Science Conference, CASOS, Pittsburgh, PA.
- Burt, R. S. (1984). Network Items in the General Social Survey. *Social Networks*, 6, 293-339.
- Cacioppo, J. T., Gardner, W. L., & Berntson, G. G. (1997). Beyond bipolar conceptualizations and measures: The case of attitudes and evaluative space. *Personality and Social Psychology Review*, 1, 3-25.
- Campbell, A., Converse, P. E., & Miller, W. E. (1960). *The American Voter*. New York: Wiley.
- Carley, K. M. (1996). Validating Computational Models. Unpublished manuscript, University of Pittsburgh.
- Carmines, E. G., & Kuklinski, J. H. (1990). Incentives, Opportunities, and the Logic of Public Opinion in American Political Representation. In J. A. Ferejohn & J. A. Kuklinski (Eds.), *Information and Democratic Processes* (pp. 240-268). Urbana/Chicago: University of Illinois Press.
- Carson, J. S. (1986). Convincing users of model's validity is challenging aspect of modeler's job. *Industrial Engineering*, 18(6), 74-85.
- CDU. (1987). *Wahlkampfbericht der Bundesgeschäftsstelle zum Bundestagswahlkampf 1986/87*.: Christlich Demokratische Union (CDU) Deutschland.
- Chaffee, S. H., & Mutz, D. C. (1988). Comparing Mediated and Interpersonal Communication Data. In R. Hawkins & J. Wiemann & S. Pingree (Eds.), *Advancing Communication Science: Merging Mass and Interpersonal Processes* (pp. 19-43). Newbury Park: Sage.
- Chaiken, S., Liberman, A., & Eagly, A. H. (1989). Heuristic and systematic processing within and beyond the persuasion context. In J. S. Uleman & J. A. Bargh (Eds.), *Unintended thought* (pp. 212 - 252). New York: Guilford.
- Cialdini, R. B., Levy, A., Herman, C. P., Kozlowski, L., & Petty, R. E. (1976). Elastic shifts of opinion: Determinants of direction and durability. *Journal of Personality and Social Psychology*, 34, 663-672.
- Collins, A., & Loftus, E. F. (1975). A spreading activation theory of semantic memory. *Journal of Verbal Learning and Verbal Behavior*, 8, 240-247.
- Converse, P. E. (1962). Information flow and the stability of partisan attitudes. *Public Opinion Quarterly*, 26, 578-599.
- Converse, P. E. (1970). Attitudes and non-attitudes: Continuation of a dialogue. In E. R. Tufte (Ed.), *The quantitative analysis of social problems* (pp. 168-189). Reading: Addison-Wesley.
- Converse, P. E., & Schuman, H. (1970). Silent majorities and the Vietnam war. *Scientific American*, 17-25.
- Cornwell, T. B., & Schwepker, C. H. (1995). Ecologically Concerned Consumers and Their Product Purchases. In M. J. Polonsky & A. T. Mintu-Wimsatt (Eds.), *Environmental Marketing. Strategies, Practice, Theory, and Research* (pp. 119 - 153). New York, London: The Haworth Press.
- Costanzo, M., Archer, D., Aronson, E., & Pettigrew, T. (1986). Energy-conservation behavior - the difficult path from information to action. *American Psychologist*, 41(5), 521-528.
- Curtice, J., Schmitt-Beck, R., & Schrott, P. (2002). Do the Media Matter? In P. A. Beck & J. Curtice (Eds.), *Filtered Choices: Intermediaries and the Vote in Contemporary Democracies*.

- Dalton, R. J. (1984). Cognitive Mobilization and Partisan Dealignment in Advanced Industrial Democracies. *Journal of Politics*, 46(February), 264-284.
- Dalton, R. J., Beck, P. A., & Huckfeldt, R. (1998). Partisan Cues and the Media: Information Flows in the 1992 Presidential Election. *American Political Science Review*, 92, 111-126.
- Damasio, A. R. (1994). *Descartes' error. Emotion, reason, and the human brain*. New York: Putnam.
- Davidson, A. R., Yantis, S., Norwood, M., & Montano, D. E. (1985). Amount of information about the attitude object and attitude-behavior consistency. *Journal of Personality and Social Psychology*, 49, 1184-1198.
- De Haan, G., & Kuckartz, U. (1996). *Umweltbewusstsein. Denken und Handeln in Umweltkrisen*. Opladen: Westdeutscher Verlag.
- De Vaus, D. (2001). *Surveys in social research (5th ed.)*. London: Routledge.
- Deutsch, M., & Gerhard, H. B. (1955). A study of normative and informational social influences upon individual judgment. *Journal of Abnormal and Social Psychology*, 51, 629-636.
- Diekmann, A., & Preisendörfer, P. (1992). Persönliches Umweltverhalten. Diskrepanzen zwischen Anspruch und Wirklichkeit. *Kölner Zeitschrift für Soziologie und Sozialpsychologie*, 44, 226 - 251.
- Diekmann, A., & Preisendörfer, P. (1998). Environmental Behavior: Discrepancies between Aspirations and Reality. *Rationality and Society*, 10(1), 79-102.
- Doll, J., & Ajzen, I. (1992). Accessibility and stability of predictors in the theory of planned behavior. *Journal of Personality and Social Psychology*, 63, 754-765.
- Dovidio, J. F., Kawakami, K., Johnson, C., Johnson, B., & Howard, A. (1997). On the nature of prejudice: Automatic and controlled processes. *Journal of Experimental Social Psychology*, 33, 510-540.
- Draaisma, D. (2000). *Metaphors of memory : a history of ideas about the mind*. Cambridge: Cambridge University Press.
- Dulany, D. E. (1991). Conscious representation and thought systems. In R. S. Wyer & T. K. Srull (Eds.), *Advances in Social Cognition (Vol. 4, pp. 97-120)*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes*. Fort Worth, Tex. (etc.): Harcourt Brace Jovanovich.
- Eagly, A. H., & Chaiken, S. (1998). Attitude structure and function. In D. T. Gilbert & S. T. Fiske & G. Lindzey (Eds.), *The handbook of social psychology (pp. 269-322)*. New York: McGraw-Hill.
- Eagly, A. H., Kulesa, P., Brannon, L. A., Shaw-Barnes, K., & Hutson-Comeaux, S. (2000). Why counterattitudinal messages are as memorable as proattitudinal messages: The importance of active defense against attack. *Personality and Social Psychology Bulletin*, 26(11), 1392-1408.
- Eagly, A. H., Wood, W., & Chaiken, S. (1978). Causal inferences about communicators and their effect on opinion change. *Journal of Personality and Social Psychology*, 36, 424-435.
- Eaton, H. (1989). Agenda-setting with biweekly data on content of three national media. *Journalism Quarterly*, 66, 942-949.
- Edwards, K. (1990). The interplay of affect and cognition in attitude formation. *Journal of Personality and Social Psychology*, 59, 212-216.
- Edwards, K., & Smith, E. E. (1996). A disconfirmation bias in the evaluation of arguments. *Journal of Personality and Social Psychology*, 36, 224-235.
- Enelow, J. M., & Hinich, M. (1984). *The Spatial Theory of Voting: An Introduction*. New York: Cambridge University Press.
- Epstein, S. (1991). Cognitive-experimental self-theory. In R. Curtis (Ed.), *The relational self: Convergences in psychoanalysis and social psychology (pp. 111-137)*. New York: Guilford Press.
- Erber, M. W., Hodges, S. D., & Wilson, T. D. (1995). Attitude strength, attitude stability, and the effects of analyzing reasons. In R. E. Petty & J. A. Krosnick (Eds.), *Attitude strength: Antecedent and consequences (pp. 433-454)*. Hillsdale: Erlbaum.
- Erhardt, K. (1998). Die unentschlossenen Wähler als Motor zyklischer Wahlabsichtsverläufe. Eine Untersuchung am Beispiel der Rückgewinnung der Wähler durch die CDU im Frühjahr 1994. In C. Dörner & K. Erhardt (Eds.), *Politische Meinungsbildung und Wahlverhalten (Vol. 84, pp. 15-118)*. Opladen: Westdeutscher Verlag.
- Esses, V. M., Haddock, G., & Zanna, M. P. (1993). Values, stereotypes, and emotions as determinants of intergroup attitudes. In D. L. Hamilton & D. M. Mackie (Eds.), *Affect, cognition, and stereotyping: Interactive processing in group perception*. San Diego: Academic Press.
- Falter, J. W., Schoen, H., & Caballero, C. (2000). Dreissig Jahre danach: Zur Validierung des Konzepts 'Parteiidentifikation' in der Bundesrepublik. In M. Klein & W. Jagodzinski & E. Mochmann & D. Ohr (Eds.), *50 Jahre Empirische Wahlforschung in Deutschland. Entwicklung, Befunde, Perspektiven, Daten*. Wiesbaden: Westdeutscher Verlag.
- Fazio, R. H. (1986). How Do Attitudes Guide Behavior? In R. M. Sorrentino & T. E. Higgins (Eds.), *The handbook of motivation and cognition: Foundations of social behavior (pp. 204-243)*. New York: Guilford Press.
- Fazio, R. H., Powell, M. C., & Williams, C. J. (1989). The role of attitude accessibility in the attitude to behavior process. *Journal of Consumer Research*, 16, 280-288.
- Fazio, R. H., & Williams, C. J. (1986). Attitude Accessibility as a Moderator of the Attitude-Perception and Attitude-Behavior Relations: An Investigation of the 1984 Presidential Election. *Journal of Personality and Social Psychology*, 51(3), 505 - 514.
- Fazio, R. H., & Zanna, M. P. (1978). Attitudinal qualities relating to the strength of the attitude-behavior relationship. *Journal of Experimental Social Psychology*, 14(398-408).
- Feldman, S. (1989). Measuring Issue Preferences: The Problem of Response Instability. *Political Analysis*, 1, 25-60.

- Festinger, L. (1957). *A theory of cognitive dissonance*. Evanston, IL: Row, Peterson.
- Finger, M. (1994). From knowledge to action - exploring the relationships between environmental experiences, learning, and behavior. *Journal of Social Issues*, 50(3), 141-160.
- Finkel, S. E., & Schrott, P. (1995). Campaign Effects on Voter Choice in the 1990 German Bundestag Elections. *British Journal of Political Science*, 25(July), 349-377.
- Fishbein, M. (1963). An investigation of the relationships between beliefs an object and the attitude toward that object. *Human Relations*, 16, 233-240.
- Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior*. Reading: Addison-Wesley.
- Ford, D. N., & Serman, J. D. (1997). Expert Knowledge Elicitation to Improve Mental and Formal Models. *System Dynamics Review*, 14(4), 309-340.
- Franc, R. (1999). Attitude strength and the attitude-behavior domain: Magnitude and independence of moderating effects of different strength indices. *Journal of Social Behavior and Personality*, 14(2), 177-195.
- Frensch, P. A., & Funke, J. (Eds.). (1995). *Complex problem solving: The European Perspective*. Hillsdale, NJ.
- Fuhrer, U. (1995). Sozialpsychologisch fundierter Theorierahmen für eine Umweltbewusstseinsforschung. *Psychologische Rundschau*, 46, 93-103.
- Gardner, H. (1985). *The mind's new science : a history of the cognitive revolution*. New York: Basic Books.
- Gass, S. I. (1983). Decision-Aiding Models: Validation, Assessment, and Related Issues for Policy Analysis. *Operations Research*, 31, 603-631.
- Geller, E. S. (1981). Evaluating energy-conservation programs - is verbal report enough? *Journal of Consumer Research*, 8(3), 331-335.
- Geller, E. S. (1989). Applied Behavior Analysis and Social Marketing: An Integration for Environmental Preservation. *Journal of Social Issues*, 45(1), 17-36.
- Geller, E. S., Erickson, J. B., & Buttram, B. A. (1983). Attempts to promote residential water conservation with educational, behavioral and engineering strategies. *Population and Environment*, 6(2), 96-112.
- GESIS. (1996). *Allgemeine Bevölkerungsumfrage der Sozialwissenschaften (ALLBUS). Kumulierter ALLBUS 1980-96. Gesellschaft Sozialwissenschaftlicher Infrastruktureinrichtungen (GESIS)*.
- Gloor, M. (1997). *Rationale Wahl und Verkehrsmittelwahl*. Unpublished Diploma thesis, Universität Zürich, Zürich.
- Graber, D. A. (1988). *Processing the News: Taming the Information Tide*. New York: Longman.
- Granberg, D., & Burlison, J. (1983). The abortion issue in the 1980 elections. *Family Planning Perspectives*, 15, 231-238.
- Greenwald, A. G., & Banaji, M. R. (1995). Implicit social cognition: Attitudes, self-esteem, and stereotypes. *Psychological review*, 102, 4-27.
- Greenwald, A. G., & Leavitt, C. (1984). Audience involvement in advertising: Four levels. *Journal of Consumer Research*, 11(June), 581-592.
- Greenwald, A. G., & Liu, T. J. (1985). Limited unconscious processing of meaning. *Bulletin of the Psychonomic Society*, 23, 292-313.
- Gross, S. R., Holtz, R., & Miller, N. (1995). Attitude certainty. In R. E. Petty & J. A. Krosnick (Eds.), *Attitude strength: Antecedent and consequences* (pp. 215-245). Hillsdale: Erlbaum.
- Harris, R. J. (1976). The Uncertain Connection between Verbal Theories and Research Hypotheses in Social Psychology. *Journal of Experimental Social Psychology*, 12, 210-219.
- Hastie, R. (1986). A Primer of Information Processing for the Political Scientist. In R. Lau & D. O. Sears (Eds.), *Political Cognition* (pp. 11-39). Hillsdale: Lawrence Erlbaum.
- Hastie, R., & Park, B. (1986). The Relationship Between Memory and Judgment Depends on Whether the Judgment Task is Memory-Based or On-Line. *Psychological Review*, 93(3), 258-268.
- Hastie, R., & Pennington, N. (1989). Notes on the Distinction Between Memory-Based Versus On-Line Judgments. In J. N. Bassili (Ed.). Hillsdale: Lawrence Erlbaum.
- Hegselmann, R., Flache, A., & Möller, V. (2000). Cellular Automata as a Modelling Tool: Solidarity and Opinion Formation. In R. Suleiman, K.G. Troitzsch, N. Gilbert (Ed.), *Tools and Techniques for Social Science Simulation* (pp. 151-178). Heidelberg: Physica.
- Hegselmann, R., Müller, U., & Troitzsch, K. G. (1996). *Modelling and simulation in the social sciences from the philosophy of science point of view*. Dordrecht [etc.]: Kluwer.
- Henderson, P. W., & Peterson, R. A. (1992). Mental accounting and categorization. *Organizational Behavior and Human Decision Processes*, 51, 92 - 117.
- Higgins, E. T., & King, G. (1981). Accessibility of social constructs: Information processing consequences of individual and contextual variability. In N. Cantor & J. Kihlstrom (Eds.), *Personality, cognition, and social interaction* (pp. 69 - 121). Hillsdale: Erlbaum.
- Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1986). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *The Journal of Environmental Education*, 18(2), 1-8.
- Houston, D. A., & Fazio, R. H. (1989). Biased processing as a function of attitude accessibility: Making objective judgments subjectively. *Social Cognition*, 7, 51-66.
- Hovland, C. I., & Weiss, W. (1951). The influence of source credibility on communication effectiveness. *Public Opinion Quarterly*, 15, 635-650.
- Howard-Pitney, B., Borgida, E., & Omoto, A. M. (1986). Personal involvement: An examination of processing differences. *Social Cognition*, 4, 39-57.

- Hoyle, J. A., Kacperski, K., & Schweitzer, F. (2001). Social impact models of opinion dynamics. *Annual Review of Computational Physics*, 9, 253-273.
- Huckfeldt, R., & Sprague, J. (1995). *Citizens, Politics, and Social Communication. Information and Influence in an Election Campaign*. Cambridge: Cambridge University Press.
- Huckfeldt, R., & Sprague, J. (2000). Political Consequences of Inconsistency: The Accessibility and Stability of Abortion Attitudes. *Political Psychology*, 21(1), 57-79.
- Inkeles, A. (1974). Participant Citizenship in six Developing Countries. In L. Bowman & G. R. Boynton (Eds.), *Political Behavior and Public Opinion. Comparative Analyses*. New York: Englewood Cliffs.
- Jaccard, J., & Becker, M. A. (1985). Attitudes and behavior: An information integration perspective. *Journal of Experimental and Social Psychology*, 21, 440-465.
- Jackson, L. A., Hodge, C. N., Gerard, D. A., Ingram, J. M., Ervin, K. S., & Sheppard, L. A. (1996). Cognition, affect, and behavior in the prediction of group attitudes. *Personality and Social Psychology Bulletin*, 22, 306-316.
- Janiszewski, C. (1988). Preconscious Processing Effects: The Independence of Attitude Formation and Conscious Thought. *Journal of Consumer Research*, 15(September), 199-209.
- Johnson, D. M. (1940). Confidence and the expression of opinion. *The Journal of Social Psychology, Society for the Psychological Study of Social Issues Bulletin*, 12, 213-220.
- Jonas, K., Broemer, P., & Diehl, M. (2000). Experienced Ambivalence as a Moderator of the Consistency between Attitudes and Behaviors. *Zeitschrift für Sozialpsychologie*, 31(3), 153-165.
- Judd, C. M., & Johnson, J. T. (1981). Attitudes, polarization and diagnosticity. Exploring the effect of affect. *Journal of Personality and Social Psychology*, 41, 26-36.
- Kaiser, F. G., Wölfling, S., & Fuhrer, U. (1999). Environmental attitudes and ecological behaviour. *Journal of Environmental Psychology*, 19(1), 1-19.
- Katz, E., & Lazarsfeld, P. F. (1955). *Personal Influence. The Part Played by People in the Flow of Mass Communication*. Glencoe: Free Press.
- Kavanagh, D. (1995). *Election Campaigning. The New Marketing of Politics*. Oxford: Blackwell.
- Kelley, S., & Mirer, T. (1974). The Simple Act of Voting. *American Political Science Review*, 61, 572-591.
- Kenny, C. B. (1994). The Microenvironment of Attitude Change. *Journal of Politics*, 56, 715-728.
- Kenny, C. B. (1998). The Behavioral Consequences of Political Discussion: Another Look at Discussant Effects on Vote Choice. *Journal of Politics*, 60, 231-244.
- Kepplinger, H. M., & Martin, V. (1986). Die Funktionen der Massenmedien in der Alltagskommunikation. *Publizistik*, 31, 118-128.
- Kihlstrom, J. (1987). The Cognitive Unconscious. *Science*, 237(September), 1445-1452.
- Kinney, T. C., Taylor, J. R., & Ahmed, S. A. (1974). Ecologically Concerned Consumers: Who Are They? *Journal of Marketing*, 38(April), 20-24.
- Klayman, J. (1995). Varieties of Confirmation Bias. In J. Busemeyer & D. L. Medin & R. Hastie (Eds.), *Decision Making from a Cognitive Perspective (Vol. 32)*. San Diego (etc.): Academic Press.
- Klayman, J., & Ha, Y. (1987). Confirmation, disconfirmation and information in hypothesis testing. *Psychological Review*, 94, 211-228.
- Knepell, P. L., & Arango, D. C. (1993). *Simulation Validation: A Confidence Assessment Methodology*. Los Alamitos: IEEE Computer Society Press.
- Knoke, D. (1990). *Political Networks. The Structural Perspective*. Cambridge: Cambridge University Press.
- Knower, F. H. (1936). Experimental studies of changes in attitude-III: Some incidence of attitude changes. *Journal of Applied Psychology*, 20, 114-127.
- Kokkinaki, F., & Lunt, P. (1997). The relationship between involvement, attitude accessibility and attitude-behaviour consistency. *British Journal of Social Psychology*, 36(4), 497-509.
- Kollman, K., Miller, J. H., & Page, S. E. (1998). Political parties and electoral landscapes. *British Journal of Political Science*, 28(January), 139-158.
- Kotler, P., & Zaltman, G. (1971). Social marketing: An approach to planned social change. *Journal of Marketing*, 35, 3-12.
- Krackhardt, D., & Porter, L. W. (1985). When friends leave: a structural analysis of the relationship between turnover and stayers' attitudes. *Administrative Science Quarterly*, 30, 242-261.
- Kraus, S. J. (1995). Attitudes and the Prediction of Behavior: A Meta-Analysis of the Empirical Literature. *Personality and Social Psychology Bulletin*, 21, 58-75.
- Krosnick, J. A. (1988). The role of attitude importance in social evaluation: A study of policy preferences, presidential candidate evaluations, and voting behavior. *Journal of Personality and Social Psychology*, 55, 196-210.
- Krosnick, J. A., & Abelson, R. P. (1992). The case for measuring attitude strength in surveys. In J. Tanur (Ed.), *Questions about questions (pp. 177-203)*. New York: Russell Sage.
- Krosnick, J. A., Boninger, D. S., Chuang, Y. C., Berent, M. K., & Carnot, C. (1993). Attitude strength: One construct or many related constructs? *Journal of Personality and Social Psychology*, 65, 1132-1151.
- Krosnick, J. A., & Petty, R. E. (1995). Attitude strength: An overview. In R. E. Petty & J. A. Krosnick (Eds.), *Attitude strength: Antecedent and consequences*. Hillsdale: Erlbaum.
- Kruglanski, A. W., Freund, T., & Shpitzajzen, A. (1985). The freezing and unfreezing of impression primacy: Effects of the need for structure and the fear of invalidity. *Personality and Social Psychology Bulletin*, 11, 479-487.

- Kunda, Z. (1990). The case for motivated reasoning. *Psychological Bulletin*, 108, 480-498.
- Langeheine, R., & Lehmann, J. (1986). Ein neuer Blick auf die soziale Basis des Umweltbewusstseins. *Zeitschrift für Soziologie*, 15, 378 - 384.
- Latane, B. (1981). The Psychology of Social Impact. *American Psychologist*, 36(4), 343-356.
- Latane, B., Nowak, A., & Liu, J. H. (1994). Measuring emergent social phenomena: Dynamism, polarization, and clustering as order parameters of social systems. *Behavioral Science*, 39(1), 1-24.
- Lavine, H. (2001). The electoral consequences of ambivalence toward presidential candidates. *American Journal of Political Science*, 45(4), 915-929.
- Lavine, H., Borgida, E., & Sullivan, J. L. (2000). On the Relationship between Attitude Involvement and Attitude Accessibility: Toward a Cognitive-Motivational Model of Political Information Processing. *Political Psychology*, 21, 81 - 106.
- Lavine, H., Thomson, C. J., Zanna, M. P., & Borgida, E. (1998). On the Primacy of Affect in the Determination of Attitudes and Behavior: The Moderating Role of Affective-Cognitive Ambivalence. *Journal of Experimental Social Psychology*, 34, 398-421.
- Law, A. M., & Kelton, D. (1991). *Simulation Modeling and Analysis* ( 2 ed.). New York: McGraw-Hill.
- Lazarsfeld, P. F., Berelson, B., & Gaudet, H. (1944). *The People's Choice. How the Voter Makes Up his Mind in a Presidential Campaign*. New York: Columbia University Press.
- Lemon, N. F. (1968). A model of the extremity, confidence and salience of an opinion. *British Journal of Social Clinical Psychology*, 7, 106-114.
- Lenart, S. (1994). *Shaping Political Attitudes. The Impact of Interpersonal Communication and Mass Media*. Thousand Oaks: Sage.
- Lichtenstein, M., & Srull, T. K. (1985). Conceptual and methodological issues in examining the relationship between consumer memory and judgment. In L. F. Alwitt & A. A. Mitchell (Eds.), *Psychological processes and advertising effects: Theory, research and application* (pp. 113-128). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Lindenberg, S. (1971). Simulation und Theoriebildung. In H. Albert (Ed.), *Sozialtheorie und soziale Praxis* (Vol. 3, pp. 78-113). Meisenheim am Glan: Hain.
- Lingle, J. H., & Ostrom, T. M. (1979). Retrieval Selectivity in Memory-based Impression Judgements. *Journal of Personality and Social Psychology*, 37(February), 180-194.
- Liu, J. H., & Latane, B. (1998). The catastrophic link between the importance and the extremity of political attitudes. *Political Behavior*, 20(2), 105-126.
- Lodge, M. (1995). Toward a Procedural Model of Candidate Evaluation. In M. Lodge & K. M. McGraw (Eds.), *Political Judgment: Structure and Process*. Ann Arbor: The University of Michigan Press.
- Lodge, M., McGraw, K. M., & Stroh, P. (1989). An Impression-Driven Model of Candidate Evaluation. *American Political Science Review*, 83(399-419).
- Lodge, M., Steenbergen, M. R., & Brau, S. (1995). The responsive voter: Campaign information and the dynamics of candidate evaluation. *American Political Science Review*, 89(2), 309-326.
- Lodge, M., & Stroh, P. (1993). Inside the Mental Voting Booth: An Impression-driven Model. In S. Iyengar & W. McGuire (Eds.), *Explorations in Political Psychology* (pp. 225-263). Durham, DC: Duke University Press.
- Lodge, M., & Taber, C. (2000). Three Steps Toward a Theory of Motivated Political Reasoning. In A. Lupia & M. McCubbins & S. Popkin (Eds.), *Elements of Political Reason: Understanding and Expanding the Limits of Rationality*. Lonsdon: Cambridge University Press.
- Lord, C. G., Ross, L., & Lepper, M. R. (1979). Biased assimilation and attitude polarization: The effects of prior theories on subsequently considered evidence. *Journal of Personality and Social Psychology*, 37, 2098-2109.
- Luchins, A. S. (1957). Primacy-Recency in Impression Formation. In C. I. Hovland (Ed.), *The Order of Presentation in Persuasion*. New Haven: Yale University Press.
- Lüdemann, C. (1997). *Rationalität und Umweltverhalten. Die Beispiele Recycling und Verkehrsmittelwahl*. Wiesbaden: DUV.
- Lynch, J. G., Marmorstein, H., & Weigold, M. F. (1988). Choices from Sets including Remembered Brands: Use of Recalled Attributes and Prior Overall Evaluations. *Journal of Consumer Research*, 15(September), 169-184.
- MacKuen, M., & Brown, C. (1987). Political Context and Attitude Change. *American Political Science Review*, 91, 471-490.
- McCombs, M. E., & Shaw, D. L. (1972). The agenda-setting function of the media. *Public Opinion Quarterly*, 36, 176-187.
- McDill, E. L. (1959). A comparison of three measures of attitude intensity. *Social Forces*, 38, 95-99.
- McGuire, W. J. (1969). The Nature of Attitudes and Attitude Change. In G. Lindzey & E. Aronson (Eds.), *The Handbook of Social Psychology* (Vol. III: The Individual in the Social Context, pp. 136-314). Reading: Addison-Wesley.
- McKenzie-Mohr, D., & Smith, W. (1999). *Fostering sustainable behavior : an introduction to community-based social marketing*. Gabriola Island B.C.: New Society Publishers.
- Meffert, M. F., Guge, M., & Lodge, M. (2000). Good, Bad, Indifferent, and Ambivalent: The Consequences of Multidimensional Political Attitudes. In W. Saris & P. Sniderman (Eds.), *The Issue of Belief: Essays in the Intersection of Non-Attitudes and Attitude Change* (pp. 69-100). Amsterdam: University of Amsterdam Press.
- Mehling, R. (1959). A simple test for measuring intensity of attitudes. *Public Opinion Quarterly*, 23, 576-578.

- Miller, A. G., Mchoskey, J. W., Bane, C. M., & Dowd, T. G. (1993). The attitude polarization phenomenon - role of response measure, attitude extremity, and behavioral consequences of reported attitude-change. *Journal of Personality and Social Psychology*, 64(4), 561-574.
- Moffitt, M. A. (1999). *Campaign Strategies and Message Design. A Practitioner's Guide from Start to Finish*. New York: Praeger Publishers.
- Mondak, J. J. (1995). *Nothing to Read. Newspapers and Elections in a Social Experiment*. Ann Arbor: University of Michigan Press.
- Mosler, H. J., Schwarz, K., Ammann, F., & Gutscher, H. (2001). Computer simulation as a method of further developing a theory: Simulating the elaboration likelihood model. *Personality and Social Psychology Review*, 5(3), 201-215.
- Naik, P. A., Mantrala, M. K., & Sawyer, A. G. (1998). Planning Media Schedules in the Presence of Dynamic Advertising Quality. *Marketing Science*, 17(3), 214-235.
- Newman, B. I. (1994). *The Marketing of the President. Political Marketing as Campaign Strategy*. Thousand Oaks: Sage Publications.
- Nieuwbeerta, P., & Flap, H. (2000). Crosscutting social circles and political choice. Effects of personal network composition on voting behavior in The Netherlands. *Social Networks*, 22, 313-335.
- Nisbett, R., & Ross, L. (1980). *Human Inference: Strategies and Shortcomings of Social Judgment*. Engelwood Cliffs: Prentice-Hall.
- Noelle-Neumann, E. (1999). Die Wiederentdeckung der Meinungsführer und die Wirkung der persönlichen Kommunikation im Wahlkampf. In E. Noelle-Neumann & H. M. Kepplinger & W. Donsbach (Eds.), *Kampa. Meinungsklima und Medienwirkung im Bundestagswahlkampf 1998* (pp. 181-214). Alber, S.: Freiburg, München.
- Noelle-Neumann, E., & Reitzle, M. (1991). Was man aus der Budestagswahl von 1987 lernen kann. In H.-J. Veen & E. Noelle-Neumann (Eds.), *Wählerverhalten im Wandel* (Vol. 16). Paderborn (etc.): Ferdinand Schöningh.
- Norman, R. (1975). Affective-cognitive consistency, attitudes, conformity, and behavior. *Journal of Personality and Social Psychology*, 32, 83-91.
- Nowak, A., Szamrej, J., & Latane, B. (1990). From private attitude to public opinion. A dynamic theory of social impact. *Psychological Review*, 97(3), 362-376.
- Nowak, A., Vallacher, R. R., Tesser, A., & Borkowski, W. (2000). Society of self: The emergence of collective properties in self-structure. *Psychological Review*, 107(1), 39-61.
- Ornstein, N. J., & Mann, T. E. (2000). *The Permanent Campaign and Its Future*. Washington: AEI Press.
- Ostrom, T. M. (1969). The relationship between the affective, behavioral and cognitive components of attitude. *Journal of Experimental Social Psychology*, 5, 12-30.
- Park, J.-W., & Hastak, M. (1994). Memory-based Product Judgments: Effects of Involvement at Encoding and Retrieval. *Journal of Consumer Research*, 21(December), 534-547.
- Patterson, T. E. (1990). *The American democracy*. New York: McGraw-Hill.
- Petty, R. E., & Cacioppo, J. T. (1986). The Elaboration Likelihood Model of Persuasion. In L. Berkowitz (Ed.), *Advances in Experimental Social Psychology* (Vol. 19, pp. 123-205). Orlando, FL: Academic Press.
- Petty, R. E., & Krosnick, J. A. (Eds.). (1995). *Attitude strength: Antecedent and consequences* ( Vol. 4). Mahwah, N.J.: Lawrence Erlbaum Associates.
- Petty, R. E., & Wegener, D. T. (1993). Flexible correction processes in social judgment: Correcting for context-induced contrast. *Journal of Experimental Social Psychology*, 29, 137-165.
- Pickett, G. M., Kangun, N., & Grove, S. J. (1993). Is There a General Conserving Consumer? A Public Policy Concern. *Journal of Public Policy and Marketing*, 12(2), 234 - 243.
- Pomerantz, E. M., & Chaiken, S. (1995). Attitude strength and resistance processes. *Journal of Personality and Social Psychology*, 69, 408-419.
- Prislin, R. (1996). Attitude stability and attitude strength: One is enough to make it stable. *European Journal of Social Psychology*(26), 447-477.
- Raden, D. (1985). Strength-related attitude dimensions. *Social Psychological Quarterly*, 48, 312-330.
- Radunski, P. (1980). *Wahlkämpfe. Moderne Wahlkampfführung als politische Kommunikation*. München: Olzog.
- Reardon, K. K., & Rogers, E. M. (1988). Interpersonal Versus Mass Media Communication. A False Dichotomy. *Human Communication Research*, 15, 284-303.
- Regenwetter, M., Falmagne, J. C., & Grofman, B. (1999). A stochastic model of preference change and its application to 1992 presidential election panel data. *Psychological Review*, 106(2), 362-384.
- Reichel, W., & Wood, L. (1997). Recency in Media Planning - Re-Defined. *Journal of Advertising Research*, 37(Special Issue: Expanding Media Planning Options through Research), 66-74.
- Rholes, W. S., & Bailey, S. (1983). The effects of level of moral reasoning on consistency between moral attitudes and related behaviors. *Social Cognition*, 2, 32-48.
- Robinson, J. P. (1976). Interpersonal Influence in Election Campaigns: Two-Step-Flow Hypotheses. *Public Opinion Quarterly*, 40, 304-319.
- Robinson, S. (2002). General concepts of quality for discrete-event simulation. *European Journal of Operational Research*, 138, 103-117.
- Rogers, E. M., & Bhowmik, D. K. (1970). Homophily-Heterophily: Relational Concepts for Communication Research. *Public Opinion Quarterly*, 34, 523-538.
- Rokeach, M. J. (1968). *Beliefs, Attitudes and Values*. San Francisco: Jossey Bass.



- Salwen, M. B. (1988). Effect of accumulation of coverage on issue salience in agenda-setting. *Journalism Quarterly*, 65, 100-106, 130.
- Sargent, R. G. (1984). Simulation Model Validation. In T. I. Oren & B. P. Zeigler & M. S. Elzas (Eds.), *Simulation and Model-Based Methodologies: An Integrative View*. Heidelberg: Springer.
- Sargent, R. G. (1998). Verification and Validation of Simulation Models. Paper presented at the 1998 Winter Simulation Conference.
- Schahn, J. (1990). Die Kluft zwischen Einstellung und Verhalten beim individuellen Umweltschutz. In J. Schahn & T. Giesinger (Eds.), *Psychologie für den Umweltschutz* (pp. 29-49). Weinheim: Psychologie Verlags Union.
- Schenk, M. (1995). *Soziale Netzwerke und Massenmedien*. Tübingen: Mohr.
- Schlesinger, S., Crosbie, R. E., Gagne, R. E., Innis, G. S., Lalwani, C. S., Loch, J., Sylvester, R. J., Wright, R. D., Kheir, N., & Bartos, D. (1979). Terminology for Model Credibility. *Simulation*, 32(3), 103-104.
- Schmitt-Beck, R. (2000). Politische Kommunikation und Wählerverhalten. Ein internationaler Vergleich. Wiesbaden: Westdeutscher Verlag.
- Schmitt-Beck, R., & Pfetsch, B. (1994). Politische Akteure und die Medien der Massenkommunikation. Zur Generierung von Öffentlichkeit in Wahlkämpfen. In F. H. Neidhardt (Ed.), *Öffentlichkeit, öffentliche Meinung, soziale Bewegungen*. Opladen: Westdeutscher Verlag.
- Schmitt-Beck, R., & Schrott, P. (1994). Dealignment durch Massenmedien? Zur These der Abschwächung von Parteibindungen als Folge der Medienexpansion. In H.-D. Klingemann & M. Kaase (Eds.), *Wahlen und Wähler - Analysen aus Anlaß der Bundestagswahl 1990* (pp. 543-572). Opladen: Westdeutscher Verlag.
- Schnell, R. (1990). Computersimulation und Theoriebildung in den Sozialwissenschaften. *Kölner Zeitschrift für Soziologie und Sozialpsychologie*, 7, 109-128.
- Schruben, L. W. (1980). Establishing the credibility of simulations. *Simulation*, 34(4), 101-105.
- Schultz, P. W., Oskamp, S., & Mainieri, T. (1995). Who Recycles and When? A Review of Personal and Situational Factors. *Journal of Environmental Psychology*, 15, 105 - 121.
- Schulz, W., & Blumler, J. G. (1994). Die Bedeutung von Kampagnen für das Europa-Engagement der Bürger. Eine Mehr-Ebenen-Analyse. In O. Niedermayer & H. Schmitt (Eds.), *Wahlen und europäische Einigung* (pp. 199-223). Opladen: Westdeutscher Verlag.
- Schuman, H., & Presser, S. (1981). Questions and answers in attitude surveys: Experiments on question form, wording, and context. San Diego: Academic Press.
- Schwarz, N., & Bohner, G. (2001). The Construction of Attitudes. In M. Hewstone (Ed.), *Blackwell Handbook of Social Psychology: Intrapersonal processes*. Oxford, UK: Blackwell.
- Schwarz, N., & Clore, G. L. (1988). How do I feel about it? Informative functions of affective states. In K. Fiedler & J. Forgas (Eds.), *Affect, cognition, and social behavior* (pp. 44-62). Toronto: Hogrefe International.
- Schwarz, N., & Sudman, S. (Eds.). (1996). *Answering questions : methodology for determining cognitive and communicative processes in survey research*. San Francisco: Jossey-Bass Publishers.
- Scott, W. A. (1969). Structure of natural cognitions. *Journal of Personality and Social Psychology*, 12, 261-278.
- Semetko, H., & Schönbach, K. (1994). Germany's 'unity election'. Voters and the media. Cresskill: Hampton Press.
- Shannon, R. E. (1975). *System Simulation: The Art and the Science*. Englewood Cliffs: Prentice-Hall.
- Shapiro, S. (1999). When an ad's influence is beyond our conscious control: Perceptual and conceptual fluency effects caused by incidental ad exposure. *Journal of Consumer Research*, 26(1), 16-36.
- Shapiro, S., & Krishnan, H. S. (2001). Memory-based measures for assessing advertising effects: A comparison of explicit and implicit memory effects. *Journal of Advertising*, 30(3), 1-13.
- Shaw, D. R., & Roberts, B. E. (2000). Campaign events, the media and the prospects of victory: The 1992 and 1996 US presidential elections. *British Journal of Political Science*, 30(April), 259-289.
- Six, B., & Eckes, T. (1996). Metaanalysen in der Einstellungs-Verhaltens-Forschung. *Zeitschrift für Sozialpsychologie*, 1996, 7 - 17.
- Spada, H. (1990). Umweltbewusstsein: Einstellung und Verhalten. In L. Kruse & C.-F. Graumann & E.-D. Lantermann (Eds.), *Ökologische Psychologie* (pp. 623-631). München: Psychologie-Verlags-Union.
- Sparks, P., James, R., Conner, M., Shepherd, R., & Povey, R. (2001). Ambivalence about health-related behaviours: An exploration in the domain of food choice. *British Journal of Health Psychology*, 6, 53-68.
- Stangor, C., Sullivan, J. A., & Ford, T. E. (1991). Affective and cognitive determinants of prejudice. *Social cognition*, 9, 359-380.
- Sudman, S., Bradburn, N. M., & Schwarz, N. (1996). *Thinking about answers: The application of cognitive processes to survey methodology*. San Francisco: Jossey-Bass.
- Sutton, S. (1998). Predicting and Explaining Intentions and Behavior: How Well Are We Doing? *Journal of Applied Social Psychology*, 28(15), 1317 - 1338.
- Sydenham, P. H., Hancock, N. H., & Thorn, R. (1989). *Introduction to measurement science and engineering*. Chichester [etc.]: Wiley.
- Taylor, S., & Todd, P. (1997). Understanding the Determinants of Consumer Composting Behavior. *Journal of Applied Social Psychology*, 27(7), 602 - 628.
- Thompson, M. M., & Zanna, M. P. (1995a). The conflicted individual: Personality-based and domain-specific antecedents of ambivalent social attitudes. *Journal of Personality*, 63, 259-288.
- Thompson, M. M., Zanna, M. P., & Griffin, D. W. (1995b). Let's not be indifferent about (attitudinal) ambivalence. In R. E. Petty & J. A. Krosnick (Eds.), *Attitude strength: Antecedents and consequences* (pp. 361-386). Mahwah: Erlbaum.

- Thurber, J. A., & Nelson, C. J. (Eds.). (1995). *Campaigns and Elections*. American Style. Oxford: Westview Press.
- Tourangeau, R. (1992). Attitudes as memory structures: Belief sampling and context effects. In N. Schwarz & S. Sudman (Eds.), *Context effects in social and psychological research* (pp. 35-47). New York: Springer.
- Tourangeau, R., Rasinski, K. A., Bradburn, N., & D'Antrade, R. (1989). Belief accessibility and context effects in attitude measurement. *Journal of Experimental Social Psychology*, 25, 401-421.
- Troldahl, V. C., & van Dam, R. (1965). Face-to-Face Communication about Major Topics in the News. *Public Opinion Quarterly*, 29, 626-634.
- Tversky, A., & Kahnemann, D. (1974). Judgment Under Uncertainty: Heuristics and Biases. *Science*, 185, 1124-1131.
- Vallacher, R. R., Nowak, A., & Kaufman, J. (1994). Intrinsic dynamics of social judgment. *Journal of Personality and Social Psychology*, 67, 20-34.
- Van der Sluijs, J. P. (1997). Anchoring amid uncertainty. On the management of uncertainties in risk assessment of anthropogenic climate change. Utrecht: University of Utrecht.
- Verplanken, B., Hofstee, G., & Janssen, H. J. W. (1998). Accessibility of affective versus cognitive components of attitudes. *European Journal of Social Psychology*, 28, 28-35.
- Wason, P. C. (1960). On the failure to eliminate hypotheses in a conceptual task. *Quarterly Journal of Experimental Psychology*, 12, 129-140.
- Wasserman, S., & Faust, K. (1994). *Social Network Analysis: Methods and Applications*. Cambridge: Cambridge University Press.
- Watt, J. H., Mazza, M., & Snyder, L. (1993). Agenda-Setting Effects of Television News Coverage and the Effects Decay Curve. *Communications Research*, 20(3), 408-435.
- Wegener, D. T., Downing, J., Krosnick, J. A., & Petty, R. E. (1995). Measures and manipulations of strength-related properties of attitudes: Current practice and future directions. In R. E. Petty & J. A. Krosnick (Eds.), *Attitude strength: Antecedents and consequences* (pp. 455-487). Hillsdale: Erlbaum.
- Wegener, D. T., & Petty, R. E. (1997). The flexible correction model: The role of naive theories of bias in bias correction. In M. P. Zanna (Ed.), *Advances in experimental social psychology* (Vol. 29, pp. 141-208). San Diego: Academic Press.
- Weigel, R. H. (1983). Environmental Attitudes and the Prediction of Behavior. In N. R. Feimer & E. S. Geller (Eds.), *Environmental Psychology* (pp. 257-287). New York: Praeger.
- Weigelt, N. (2001). *Interpersonale politische Kommunikation. Ein Algorithmus zur Generierung simulierter sozialer Netzwerke auf Grundlage datenbasierter Heterogenitätsmasse*. Unpublished Diploma Thesis, ETH, Zürich.
- West, M., & Harrison, J. (1997). *Bayesian Forecasting and Dynamic Models*. New York (etc.): Springer.
- Wilson, T. D., & Brekke, N. (1994). Mental Contamination and Mental Correction: Unwanted Influences on Judgments and Evaluations. *Psychological Bulletin*, 116(1), 117-142.
- Wilson, T. D., & Hodges, S. D. (1992). Attitudes as temporary constructions. In L. L. Martin & A. Tesser (Eds.), *The construction of social judgments* (pp. 37-65). Hillsdale: Erlbaum.
- Wixted, J. T., & Ebbesen, E. B. (1991). On the Form of Forgetting. *Psychological Science*, 2(6), 409-415.
- Wolf, W. (1980). *Der Wahlkampf. Theorie und Praxis*. Köln: Verlag Wissenschaft und Technik.
- Wyer, R. S., & Srull, T. K. (1989). *Memory and Cognition in its Social Context*. Hillsdale: Lawrence Erlbaum.
- Zajonc, R. B. (1980). Feeling and thinking: Preferences need no inferences. *American Psychologist*, 35(2), 151-175.
- Zaller, J. (1987). Diffusion of Political Attitudes. *Journal of Personality and Social Psychology*, 53, 821-833.
- Zaller, J. (1996). The Myth of Massive Media Impact Revived: New Support for a Discredited Idea. In D. C. Mutz & P. M. Sniderman & R. A. Brody (Eds.), *Political persuasion and attitude change*. Ann Arbor: University of Michigan Press.
- Zaller, J. R. (1992). *The Nature and Origins of Mass Opinion*. Cambridge: Cambridge University Press.
- Zanna, M. P., & Fazio, R. H. (1982). The attitude-behavior relation: Moving toward a third generation of research. In M. P. Zanna & E. T. Higgins & H. C.P. (Eds.), *Consistency in Social Behavior: The Ontario Symposium* (Vol. 2, pp. 283-301). Hillsdale: Erlbaum.
- Zeh, R., & Hagen, L., M. (1999). "Nun zum Sport..." und andere kurzfristige Effekte von Fernsehnachrichten auf die Wahlabsicht im Bundestagswahlkampf 1998. In C. Holtz-Bacha (Ed.), *Wahlkampf in den Medien - Wahlkampf mit den Medien* (pp. 188-217). Opladen: Westdeutscher Verlag.
- Zielske, H. A., & Henry, W. A. (1980). Remembering and Forgetting Television Ads. *Journal of Advertising Research*, 20(2), 7-13.
- Zuckerman, A. S., Valentino, N., & Zuckerman, E. (1994). A Structural Theory of Vote Choice: Social and Political Networks and Electoral Flows in Britain and the United States. *Journal of Politics*, 56, 1008-1033.

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