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Political Attitudes
Computational and Simulation Modelling

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To My Parents, Puica and Martinel
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Preface

Political Science …

Once strongly conceived by both its schoolmasters and apprentices as an exclusive area of qualitative research, political science nonetheless developed during the twentieth century on experimental research dimensions. This systematic orientation took almost one century to get established on solid methodological and epistemological backgrounds. Though quite long, this process has proved wrong all those who either occasionally or systematically blamed, contested or doubted that political science had tremendous potential for quantitative analysis and an ever-increasing appetite for paradigmatic change.

Otherwise unavoidable, this process of change was sustained and reinforced by technological advances which enhanced the use of artificial media from single computer platforms to computer networks and the Internet. Huge volumes of public survey data put considerable pressure on the capacity of political science methodology to face the challenge of data processing. This kind of pressure demanded a powerful response. All this transformed the exquisite analytical machine, developed and refined over the entire past century, into what has only lately been established as Experimental Political Science (Druckman et al., 2011). This has revealed, first and foremost, how political science has employed experimental research and rich analytical resources to understand, explain and predict political phenomena, no matter if we talk about the outcomes of elections, about the variability of public opinion or about the public perception and the sustainability of governmental policies. This is but one of the trends which explain the methodological and paradigmatic shift toward enforcing experimental research. This has placed the utility of experimental and analytical research beyond doubt. However, utility alone would not be able to describe the ever-increasing research methodological needs in political science. In fact, it has not. Instead, it has complicated the methodology picture in one particular area of political science research: modelling.

It was precisely in the modelling area that the sociological and political methodology research based on empirical data had its golden age: the age of the nomothetic modelling approach working on model-invariant patterns in huge volumes of empirical data. However, it was also here where its decline started.

The modelling area, especially the realm of the nomothetic theory of modelling, proved to be a true battlefield for two competing methodological approaches: while one, namely Experimental Political Science, seems to have lost terrain and prestige as its performances diminish after a century-long dominance and a stable
period of development, the other one, namely *Computational Political Science*, seems to have currently emerged in a sustained (and sustainable) effort to replace the nomothetic modelling paradigm with the complexity-oriented paradigmatic alternatives reinforced by the new artificial life technologies. The nomothetic view in the political science methodological picture has finally run out of breath, crashed by mountains of survey data, rigidly anchored in determinism and model-invariant patterns, stiffened in too static a paradigm.

Notwithstanding high recognition, survey analytical research has been the target of harsh criticism. The reasons, now and then, concern not only measurement issues, but mainly the true capacity of survey data to provide for the modelling of real-world phenomena on large scales and in highly complex contexts. One of the long-standing criticisms against the experimental methods and their analytical approach targets the static perspective provided by the empirical models. In political science research, this issue has a particular relevance, since political phenomena show not only high variability, but also sophisticated degrees of context dependency whose complexity could hardly be captured by empirical data and theoretical modelling. Panel techniques as well as longitudinal analytical studies have thus forced penetration of the mathematical–statistics theories and instruments aimed at overcoming this weakness. Moreover, the subsequently developed mathematical design of dynamic nonlinear variable-based modelling has added value to the analytical power of the theoretical models. Besides the strong requirements for the processing of massive amounts of survey data in empirical research, the study of the space–time unfolding of political phenomena raised one more challenge: complexity. To cope with it, a new modelling paradigm was needed. And this reinforced the demands for a change in political modelling methodology.

In this book we are concerned with this change, which started emerging in political science more than half a century ago. Once initiated, the main problem is to understand where it is heading to.

This change process started in the early 1950s and is still going on. It has merged two modelling schools of thought: modelling in social and political sciences, on the one hand, and computational modelling and simulation, on the other hand. What has resulted from this blending is, perhaps, the most important question so far. Answering this question is not a trivial task, and reflection on this issue has guided the project of writing this book.

In order to answer this question, we need to assume a conceptual perspective on social and political modelling in general and on political attitude modelling in particular. Research in these two areas has met a common boundary.

Let us take a look at their separate histories and the side effects of their merging into a paradigm of evaluation for political attitude phenomena.

... *and Computational Modelling*

Starting with the early 1940s, the computational modelling approach began to take shape in both theoretical and experimental research. John von Neumann and Oskar Morgenstern’s ([1944][2007]) work on economic behaviour laid the foundations of
game theory, but also the foundations of a new approach in modelling theory: computational modelling. The decade between the mid-1940s and the mid-1950s brought the fastest, the deepest and the most amazing advances in computer technology, memory storage capacity and computational speed (Forrester, 1989). It was also the time when digital computation techniques, though in their infancy, suddenly got a modelling flavour, making the same decade and the next one appear as a time of explosive computational modelling development. Jay Forrester laid the theoretical and experimental foundations of the computational modelling of complex systems like organizational, economic and social systems (Forrester, [1956]2003, 1958, 1961, 1964). As theorized by Forrester in the early 1960s (Lane and Sterman, 2011), system dynamics was the first computational modelling paradigm which applied to the study of structural and behavioural dynamics of social systems. In this paradigm, computational modelling is approached in terms which distinguish between three fundamental concepts, that is, the real-world system as the modelled system, the computational model and the simulation of a computer model, which is necessary in order for the model to exhibit its (designed) behaviour and provide (expected or unexpected) outcomes to be evaluated.

The same period of time covers some other famous theories which marked the later development of computational modelling theories, like Simon’s (1957, 1972) works on bounded rationality as a modelling theory of decision-making, and the works in social communication and persuasion developed by Carl Hovland and his collaborator, Milton Rosenberg, in the Yale Team (Rosenberg and Hovland, 1960).

It was against this background that electoral studies in general and political attitude studies in particular employed computational modelling as a research methodology. It was perhaps too soon for doing so in political science.

In political science research, the process of paradigmatic change, going from qualitative to analytical and experimental, started to diversify itself. The preferred area was that of electoral studies. At a glance, the history of the American presidential election studies offers a picture of the first challenge: it was during the 1950s that a computational modelling approach seemed to raise for the first time a serious methodological challenge. Two decades later, it became a prevailing one, taking the community somehow by surprise, since very few political science researchers were mastering computer skills in order to face the challenge. By the end of the 1970s, computational modelling research finally took an independent position from the empirical and experimental branch, and issued some true characteristics of a new branch within classic political science. The beginning of the twenty-first century found the political science community facing a delicate question: Is there a ‘Computational Political Science’ about to be born?

The boost in computational modelling on relevant political science issues appears to be a puzzle in which the computational modelling of political attitudes is but one of the numerous (known or still unknown) pieces: would this turn into a labyrinth-like puzzle? The computational modelling of political attitudes is but the thread which helps any wanderer achieve a map of this quite sophisticated world and, eventually, find a way out. It is this puzzle that has challenged the construction of this book such that it could achieve its specific structural, explanatory, and prospective goals.
Out of the Shadow

Political attitude modelling might seem to many a quite narrow area of research. Often included in public opinion survey research, individual and collective behaviour research, or in research on beliefs, values or normative systems, political attitudes have always represented a very sensitive poll subject and a too-complex modelling issue for the analytical power of empirical research. No matter how strong or weak such research approaches are, they are meant to provide answers to the questions concerning the dynamics of political attitudes and the role they play in understanding the short-, mid- and long-term evolutions of political regimes, governance strategies or policies. The societal demand for these answers is continuously increasing, and the pressure it exerts on political regimes is considerable. Political, social and economic crises, as Europe and the world at large have known during the past years, have emphasized once more the strong societal need for preventing political deadlocks by modelling polity dynamics and predicting its potential contextual evolutions.

As an area of research, the political attitudes domain is anything but narrow. As a matter of fact, its complexity has often narrowed the type of research approach, making it, for quite a long time, a preferred issue for the development of measurement theories and methodologies in public survey research. It is only lately that political attitude modelling research has employed computer technologies and computational methodologies. This has increasingly and considerably opened this subject to sophisticated modelling research.

It is the computational modelling of political attitudes that has effectively got this issue out of the shadow in which it was waiting for more than half a century. Offered thus plainly for a much wider range of research instruments and complex types of investigation, the issue has proved unexpectedly precious for a number of research areas with a quite huge social and political impact: political psychology, political marketing, political persuasion and political communication in electoral campaigns. Not to mention its being highly valuable in impact studies over the high-risk investment and financial sectors and in financial market research. But first and foremost, it has proved far more valuable for an area of political science research that has been regarded for a long time as a Cinderella: political culture research.

Past Challenges and Answered Questions

This book aims to reveal the power of computational modelling of political attitudes to contribute and to reinforce political science research in facing two fundamental challenges.

One such challenge is the renewal of political methodology, long requested, explained and particularly voiced by Charles Tilly (Tilly, 1995, 2001; McAdam et al., 2001; Goodin and Tilly, 2006). This book aims to present the history and
arguments of how political attitude computational modelling has provided the means for methodological advances in political methodology. Each chapter in the book approaches such a research methodological dimension. This is meant to explain the roots of methodological change in political attitude modeling research and what it is heading to.

Another strong challenge is the emergence of a new discipline, namely, Computational Political Science. This might happen in much the same way as Computational Sociology emerged in less than two decades of social simulation research (Squazzoni, 2012). This book tries to aggregate the available research literature and technical reports in searching for the critical mass of qualitative contributions which could provide for a new appearance in the political science range of disciplinary fields.

Both challenges are meant to show that political attitudes – important as they are in political psychology research, with all its implications in areas connected to political participation and collective action – are far more important in political science research for their potentially major implications in explaining both micro-to-macro and macro-to-micro polity phenomena.

The construction of an artificial polity model has already been approached by several authors all over the world. However, so far it has not proved as effective or as robust as the artificial society model. The explanation we are trying to provide is that a macro polity model and an artificial polity research instrument could hardly be effective without a political attitude and, by extension, a political culture basis. To this end, this book on political attitude computational modelling provides the first brick.

**Approach**

First, the book follows this process of transformation in conceptual and operational details such that it can reveal the substance of this major paradigmatic change from empirical to computational type.

Second, it evaluates the relevance of the main modelling approaches to political attitude. Political attitudes prove their relevance to two fundamental areas in political science: political psychology and political culture. Both are relevant for modelling political participation and decision-making in mass publics. Moreover, political culture seems to play a role which might prove essential in feeding the macro (emergent) phenomena back into the micro level of individual behaviours, preferences and choices. The evaluation of the relevance goes from the conceptual level to the operational and the simulation levels of the model.

In order to emphasize the way in which political attitude modelling research has discovered computational technologies and employed them in the working methods, a few basic details are provided about each dimension of this subject: the political attitude dimension and the computational modelling dimension.
Goals

The goals of this book are many: structural, explanatory and prospective.

Structural goals are working goals; they guided the structuring of the initial puzzle of political attitudes modelling approaches as a collection organized on several explicit dimensions which have divided it in ‘parts’. Each ‘part’ thus includes a collection of modelling approaches which satisfies requirements concerning (i) some fundamental contribution to political science research (either conceptual or methodological, or both) and (ii) the relevance of the approach for political science in general and for political attitude and culture research in particular.

The structural goals are meant to organize the initial puzzle of models on several dimensions: historical (temporal dimension), theoretical (conceptual dimension) and operational (methodological dimension). Structuring it, however, is not an easy task. The structural dimensions have been identified and approaches have been selected such that each modelling approach satisfies all criteria (all requirements concerning history, concept, method and relevance).

The chronological dimension was meant to emphasize the history of the development of both conceptual and technological aspects. These two classes of aspects – conceptual and technological – concern both political attitude modelling research and computational modelling research. Moreover, the issue of ‘computational modelling of political attitudes’ involves the ‘merging’ of different (and often independently developed) conceptual and paradigmatic approaches into a single unifying approach, like, for example, the JQP model, which integrates in a single unifying modelling approach several conceptual models developed in attitude research (political information processing, remembering and cognition), on the one hand, and in the artificial intelligence and semantic networks, on the other hand.

Explanatory goals are meant to explain the outcome of a particular combination between concept and method in the computational modelling of some political attitude issue, like change. Such combinations are usually constrained by the fundamental modelling requirement of analogy between model and real-world phenomenon. It is based on the capacity of the model to represent and reproduce or replicate the real-world phenomenon which the modelling approach is actually addressing.

The combinations between mechanisms in political and social science modelling, on the one hand, and the mechanisms in computational modelling, on the other hand, constitute one of the subject matter of our approach in this book. Such combinations are subjects of endless debate in the philosophy of science as well as in political philosophy. What is truly relevant to the approach in this book regards a particular, however essential, characteristic of computational modelling: models, no matter if computer models, artificial intelligence models, semantic networks, neural networks, agent-based models or cellular automata, need simulation in order to produce outcomes. These outcomes are used to evaluate the model’s relevance, validity and effectiveness. Extending and adapting from the way Hartmann (1996: 82) put it, modelling such combinations of psychological, cognitive, social and political
mechanisms is a matter of simulation, that is, a matter of reproducing some mechanism(s) by other mechanism(s).

Finally, the prospective dimension of this approach is far-reaching; it is meant to reveal the role and the contribution that computational modelling of political attitudes might have on the emergence of a new (inter)disciplinary field within political science. Social simulation and computational sociology have become a fundamental reference in this respect; this reference suggests that political science might experience the same phenomenon of disciplinary diversification by the emergence of a new discipline able to involve new (computational and/or artificial life) technologies as support for new research methodologies and new philosophy of modelling approaches.

The Picture

This book is meant to offer a comprehensive picture of the past 80 years in the computational modelling of political attitude research. The book aggregates, for the first time, an overall picture of this field of research by including several most relevant modelling approaches of political attitude phenomena, including various references to the connected issues of (political) belief, value, knowledge, information processing, cognition and behaviour research.

This picture includes different pieces of interest in political attitude research, from the original social attitude measurement research initiated at the beginning of the twentieth century to the highly sophisticated political attitude change models elaborated at the beginning of the twenty-first century. It is meant to reveal the main orientations in political attitude research by uncovering the conceptual roots, the influences induced by other disciplines, and the tendencies emphasized before and, especially, after the computational modelling technologies were adopted and included in the political attitude research methodologies. Besides a state-of-the-art of this field of research, the book aims to reveal the type of contribution this field might have to political science research in general and to polity modelling in particular.

Since the early days of social and political psychology research, political attitude research has been traditionally developed on an empirical basis. Computer technologies as well as modelling theory offered during the 1950s the necessary support and motivation for approaching classic political science research issues. The best example is represented by the issues usually approached in electoral studies, like the aggregation of voting preferences during electoral campaigns. Computational modelling has transformed political attitude research, traditionally anchored in the public survey paradigm, into a spearhead of political methodology change.

Political attitude research has succeeded in overcoming its own limitations, long induced by the intensive use of self-report methodology used in collecting survey data, by the early inclusion of explicit modelling aspects, like the evaluation of patterns in the aggregate data which were aimed at serving explanatory purposes, and prediction. The computational modelling era in political science research, in particular in political attitude studies, was initiated during the 1950s, when the
computational modelling methodologies were introduced in the American universities and research laboratories with a special focus on electoral studies. This difficult transformation from a qualitative type of research to the experimental and, finally, to the computational type has materialized in a long list of paradigms, both conceptual and methodological, which have been employed in this area of research. The results are not fully obvious, and the long-term effects of this change process are still to be evaluated.

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References


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Introduction

A Half-Century-Long History

Attitude is one of the fundamental concepts in social psychology. A long and complicated conceptual elaboration process was needed to define it. As a late outcome of the philosophical debate on the ‘mind–body’ problem, it goes beyond this classic separation, identifying a *locus* of human choice and action. Around the mid-nineteenth century, scholars began thinking of it as a sophisticated concept which combines issues from psychology and sociology, philosophy of mind and philosophy of cognition, emotion and rationality, moral and action. Associating it with the complex process of the historical separation of psychology from philosophy, attitude has become the fundamental concept of a new discipline which emerged at the beginning of the twentieth century: social psychology.

Social psychology has aggregated various research interests in concentrating on attitude studies. As previously spread in various scientific areas going from experimental psychology and psychophysics to sociology or philosophy of mind, this multidimensionality richly endowed it with a strong and deep interdisciplinary character. At the beginning of the twentieth century, when the fundamental research on attitudes started being systematically developed, it was basically focused on definition and measurement (Thurstone, 1928; Thurstone and Chave, 1929; Allport, 1935).

Along with the social psychology research developed in this very period, another domain has addressed the issue of attitude: political psychology. Social psychology has approached attitudes in a more quantitative fashion induced by the strong orientations towards behaviour, experiment and measurement inherited from the psychological research framework of the time. As a noticeable difference, political psychology has approached the concept from the perspective of the individual personality, much dominated by Freudian psychoanalysis and moral evaluations (Lasswell, 1936, 1948).

In a short while after their foundation, both social psychology and political psychology underwent drastic paradigmatic changes. The first wave of change came during the 1950s and was induced by the ‘behavioural revolution’, which seized voting behaviour modelling research for a long time. Despite its indisputable supremacy, the behaviourist paradigm fell into disfavour by the end of the 1970s. It has never truly recovered, though it has never truly surrendered either.
The second wave of change came with the ‘cognitive revolution’. Under the strong impact of the New Look, both social psychology and political psychology changed views. Social psychology replaced the functional paradigm based in behaviourist thinking with the cognitive consistency paradigm, and the Pavlovian ‘stimulus–response’ (S-R) model of behavioural response to stimuli with the force field model (Katz, 1989). The New Look had a strong impact on political psychology as well, such that the domain opened up for the age of electoral studies: voting behaviour and political belief studies dominated the political science stage until the late 1980s when the issues of political information processing, political judgement and political cognition took the lead. Sustained and stimulated by the influence exerted by social psychology experimental research, political psychology re-emerged during the 1970s and redefined its domain by including an orientation towards empirical experimentation (Kuklinski, 2009; Druckman et al., 2011; Holbrook, 2011; Iyengar, 2011).

Political attitudes were included in the early experimental developments within social psychology research as a particular kind of attitude traditionally associated with the political space, and especially with the area of electoral studies. Studies of electoral campaigns, candidates and voting behaviour proved, however, that along with social contextual variability, political attitudes underlie the variability arising from both the individuals’ cognitive characteristics and the way they relate to the issues of social and political life. As attitudes address the most basic as well as the most elevated dimensions of social and political life, the interest in political attitudes has thus generated new frontiers in both social and political sciences’ fundamental research by adopting, among others, new methodologies able to cope with the challenging aspects of studying political attitudinal phenomena at the mass level. Modelling, in particular computational modelling, provides for such a methodology. Its impact on political attitude research increased while stimulated by the modelling approaches developed in psychology, sociology and social psychology.

In social sciences, modelling has been used to explain and test theories, improve old ones and build up new theories. To put it in just a few words, the classic nomothetic modelling paradigm is basically a reductionist method to achieve a representation of a real-world phenomenon. This representation employs a universal principle able to explain why a real-world phenomenon looks as it looks and not otherwise, and why it behaves as it behaves. It has been intensively, and for a long while almost exclusively, used in the empirical research for acquiring causality-based explanations of a given phenomenon by identifying the universal law which governs its behaviour. Computational modelling has pushed classic modelling beyond its traditional concepts and limits. The explicit purpose has always been that of achieving more believable models and better explanations.

The computational modelling paradigms have been appreciated for their capacity to bring forth an optimal compromise between the model’s complexity and the complexity of the real world: models succeeded in preserving as much as possible from the complexity of the real-world phenomena such that their relevant aspects could still be replicated and systematically varied.

In political science, modelling has been employed in its classic mathematical form as a way of expressing a theory by means of a system of equations. Such a model takes
on what is relevant about a real-world phenomenon so as to explain one or more of its structural, functional or behavioural aspects. As a fundamental difference, computational modelling allows for the translation of a theory (mathematical model) to a computational form, thus making possible the model construction and operation in virtual media. The main advantage of virtual experiments resides in their considerable power to tackle data and complexity without the need to involve human subjects in time- and resources-consuming, error-prone field experiments as traditional empirical research does. Computational media allow for virtual experiments which could be repeated as many times as needed without requiring human intervention and the repeated exposure of human respondents. Moreover, simulation modelling technologies which are often associated with computational modelling allow the replacement of empirical data with generated data, thus reducing the field work or simply avoiding the traditional empirical data collection aimed at model testing. The simulation modelling of the real phenomena provides for both top-down designs, which are more appropriate to rationalistic models, and bottom-up designs, which are appropriate to the models based on self-organization and emergence.

There are other aspects, however, which have fuelled the endless hot debates concerning the meaning of the patterns and of the type of outcomes such simulations provide. Epistemological considerations have long been the battlefield for the pros and cons with regard to the appropriateness of the method for the study of the dynamics of political attitude phenomena in artificial social systems. Though contested and criticized from both inside and outside of social and political methodology areas, the computational modelling of political attitudes (with or without simulation modelling) has provided the proper means to achieve considerable advances in explaining the phenomena generated by political attitude formation and change processes. Such advances would not have been possible on an empirical basis alone.

Emergent Area

Computational modelling has appeared in political attitude research as an auxiliary means of supporting the necessary calculations in the analytical data processing. The first goal it has served is that of increasing the efficiency in the processing of huge amounts of survey and panel data. Thus, from the very beginning, it has played a constant role in enhancing the explanatory and predictive power of an empirical model of individuals’ political preferences and voting choices. Such descriptions were employed by the Columbia Model, the first model to be translated into a computer simulation model of political attitudes, aimed at predicting the political voting choices in U.S. presidential elections. With time, the range of such phenomena has been extended and diversified so as to include not only the relationship between political attitudes and voting behaviour but also their relationships to political beliefs as in the Michigan Model, or political information processing, judgement and cognition as in the John Q. Public (JQP) Model. It has also diversified as a reaction to the fast technological and methodological advances, but also for raising
awareness of the increased relevance of the role it could play in providing accounts on the complexity of political attitude phenomena and explaining their dynamics.

Nowadays, political attitude computational modelling research is meant to provide answers to rather complicated questions concerning the political preferences, choices, behaviours, judgements and cognition in individuals, groups and entire societies. The computational aspects combine more often and in increasingly sophisticated ways with simulation modelling technologies and employ sophisticated simulation instruments and media. During the past decade, this mix has offered the most interesting suggestions for understanding what roles information, communication, persuasion, symbols and emotions play in shaping, influencing or changing individuals’ and groups’ political evaluations, judgements, deliberations, action choices and attitudes.

Notwithstanding its impressive, though rather short history, political attitude computational modelling appears as an advanced area of research with powerful approaches in almost all political science aspects from elections, ideology, decision making and polity to interaction, information processing, communication and cognition.

However, one thing should be noted in the first place: political attitude computational modelling is not properly what one might call an established area of research. It might rather be viewed as one which is currently emerging from a puzzle of modelling approaches spread in many areas of psychological, sociologic, social-psychological, political and economic research. Accumulating a considerable amount of knowledge and methods, political attitude computational modelling seems to make a political science dream come true, that of endowing political science research with a methodology able to provide appropriate support for modelling the complexity of political phenomena. Though not the only one, but perhaps one of the most advanced, it undoubtedly represents a potentially relevant component of a newly emerging discipline of research within the political science domain: a computational counterpart to the already established and highly recognized Experimental Political Science.

First and foremost, political attitude computational modelling brings forth a precious modelling experience and methodology in a political science area which has long proved resistant to change: political methodology. It has been a long while since several political science scholars, especially Charles Tilly, strongly argued and voiced their demands with regard to the necessity of methodological change from the classic nomothetic to other modelling paradigms able to cope with the variability, complexity and dynamics of political phenomena.

Now and Then: Methodology Inertia

The experimental approach has long been a disputable aspect in political science research and remains debatable notwithstanding its impressive advances and the paradigmatic changes it has induced. The experimental research methodology took more than a century to get accepted and systematically employed in political methodology. It is only a couple of years ago that experimental political science acquired an established, highly recognized status and confirmed the decisive role it plays in political science (Druckman et al., 2011).
Its massively dominant status has nevertheless been ‘threatened’ during the past half-century by a different kind of methodology and epistemology: the arsenal of computational technologies and methodologies based on the virtual experiment, complexity and generative data has undermined the strong, dominant position of the empirical tradition in both experimental and modelling research. The introduction of the new methodology has faced strong opposition. Now and then, ‘methodology inertia’ manifests itself in the same way.

For the particular area of political attitude research, experimentation has been fostered by a massive influence from social psychology research methodology.

Notwithstanding formal agreement of the political science research community on the concept and acknowledgement of its utility, experimental research has often faced opposition from scholars who proved resistant to accepting the new methods and techniques of quantitative evaluations. Their opposition was rooted in a traditional qualitative style of scientific investigation. The opposition to the challenge of methodological change has usually been approached with interdisciplinary training programmes aimed at stimulating methodological interest and training those interested to get new skills and to make use of them. In the political psychology of the 1970s, for example, the opposition towards the experimental research approach was tackled with consistent long-term programmes of interdisciplinary training of doctoral and post-doctoral fellows, a tradition initiated at Yale University with an interdisciplinary psychology–politics programme (Iyengar, 2011). Things are not much different nowadays: the same kind of concerns are given academic support in undergraduate and graduate programmes to both students in political science and mature scholars willing to use the computational and simulation tools (Yamakage et al., 2007). This book is aimed at serving this purpose and enduring initiative.

Computational modelling, as well as computational simulation research, has faced this challenge too. The difficulties in getting accepted as modelling research methodologies in political science have concerned the high levels of demanding skills and knowledge about computational technologies. Evaluating the research community’s response to this challenge, Paul Johnson identified a phenomenon which was generalized in social and political sciences during the 1950s and the 1960s: the methodological background of many political science researchers was consistently based in survey methods and analytical tools and much less in computer science, programming skills and even less in computer simulation (Johnson, 1999, pp. 1511–1512).

Approached mainly in the context of theories of democracy, the modelling of political change phenomena required, in the early 1990s, a modelling paradigm change, extensively explained and strongly advocated by Charles Tilly (1995, 2000, 2001). His formulation of the problem was the most direct and, perhaps, the most demanding in what regards the necessity to develop research methods able to cope with the variability of political phenomena, with the recurrent nature of political change processes, and with the context- and path-dependent dynamics of its spatial and temporal evolutions. Moreover, as he explains, the empirical variable-based, model-invariant design needs to be replaced by a design based on mechanisms and processes, more prone to uncover the dynamics of phenomena (Tilly, 2000, p. 4). Tilly shows that the dynamic variability of the contextual processes does influence the way political processes are described.
and explained. Model-invariant explanations are often too much reductionist since they actually eliminate context. Providing as illustration an example of a village drama in Romania after the 1990s, when people demanded the restoration of their land property rights held before the communist regime came into power, Tilly requires a political process modelling which should take into account the context as it enhances the identification of regular patterns which characterize political phenomena (Goodin and Tilly, 2006: 6). A similar position has been advocated by other scholars in various areas of social and political sciences: in political science by Lars-Erik Cederman (1997, 2001, 2005), and in social science by Charles Taber (2001).

Notwithstanding such strong positions as well as the criticisms formulated by these and other scholars, the paradigmatic conservatism in political methodology once again proved its resistance to change. Compared with similar methodology revision programmes in sociology and social psychology research, the means to make a political methodological change programme operational and efficient remained poor as long as experimental political science seized the methodological resource. The nomothetic modelling paradigm in the experimental research acquired too powerful a tradition to easily make room for change in political methodology. For a long while, mathematical and empirical modelling not only dominated the methodological scene but also took over the view.

When noted, and finally agreed and accepted, political attitude computational modelling already had a rich past and was looking ahead to a richer future. Not to speak about the political culture theory, a graceful host for much of the latest approaches in political attitude modelling research (though not fully computational). Political attitude computational modelling research thus appeared much as a methodology provider whose know-how was developed outside political methodology or at the thin border between social and political research methodology. Its value cannot and has not been denied in political methodology, but it has not been praised either. As regards its contribution to the classic political methodology, it brings the conceptual and operational means as well as a rich experimental background for approaching the dynamics, recurrent nature and the context-dependent aspects of political change processes.

**First Research Programmes**

The first systematic computational modelling approach of political attitudes was initiated in the late 1950s by a Columbia sociologist, William McPhee, who had the idea of evaluating the public survey data on a computational basis. McPhee is credited as having actually discovered what a political attitude computational model in reality is, how it works and what it does: his page on the Columbia University website, carefully maintained by one of his early collaborators, Robert B. Smith,\(^1\) reminds us of a great mind and a visionary research programme leader.

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\(^1\) I hereby acknowledge and appreciate the precious advice of Dr Robert B. Smith in understanding the spirit and the technical details of the research work he developed together with William N. McPhee during the 1950s and 1960s.
At that time, both computers and public survey methodology were used for the first time in such research: the computer programming tasks required skills almost unknown in social and political research, while surveys brought such huge amounts of empirical data as to require a ‘calculation machine’ for providing the analytical results. McPhee designed a computer simulation in which a three-process system was able to associate individual voting choices with several dynamic variables describing the individual preferences, and the local social context: the dynamic variation of an individual’s internal predisposition towards one or another of the candidates in the presidential campaign was associated with the variation in the individual’s interest in political participation. This relationship was subjected to the political persuasion exerted by the electoral campaign media communication. The classic paradigm of the small worlds in which the local community survey was crucial for predicting the outcomes of the voting process, provided relevant support to the idea of modelling the role of the social context in shaping individuals’ political attitude towards voting and voting choice. As opposed to the Columbia group of sociologists, the Michigan group introduced a new paradigm which simply left the other one in the shadow. However, the computer simulation idea was kept alive in an ambitious project defined at the end of the 1950s by William McPhee and James Coleman, thus becoming the cornerstone of the fundamental research programme in social and political sciences for the years to come. They introduced the idea that computer simulations could provide appropriate support for the analytics of voting choices in the aggregate data, thus assisting the scale-up of the investigations from the individual level to mass electorates and approaching them in their real complexity (McPhee and Coleman, 1958, pp. 6–9).

Early political attitude research employed computational modelling mostly with respect to the individual level. As this area of modelling research accumulated expertise and struggled to respond to the ever-increasing demands of societal and political programmes, it changed not only the paradigms but also the target, addressing the issues of political attitude formation and change in the aggregate. Although traditionally modelled by means of empirical approaches, the micro–macro relationship was approached in political attitude computational and simulation modelling research on a complexity basis, providing the framework for the study of the emergence of structure and order at both the society and polity levels.

It took a long time until this idea was properly revived by Thomas Schelling (credited as the early founding father of the social simulation approach to the emergence and dynamics of social change under social influence) and Bibb Latané (credited as the founder of the computational and simulation modelling approach to the emergence of political attitudes under social influence) at the beginning of the 1980s. It took, however, not only time but also a profound change in the research methodology, which was stimulated by the ‘cognitive revolution’ in both social and political psychology research. The computational modelling techniques much based on the sciences of the artificial, namely artificial intelligence (AI), artificial life (ALife) and artificial autonomous agents (AAA), have proved decisive for the theoretical advances in many research domains, political attitude research included.

Modelling of political attitudes was, for a long time, a subject of empirical research in voting behaviour, electoral campaigns, public opinion dynamics and the elites’ role in influencing voting choices of individual voters. Starting in the
mid-1980s, the traditional empirical paradigm was paralleled and then gradually replaced by the computer simulation paradigm. In almost half a century, the former, while leaving the front stage, has actually achieved high recognition and scientific status as Experimental Political Science (Druckman et al., 2011). The latter remained inconspicuously expecting a true change, while benefiting enormously from the burst of computational and simulation technologies developed in this time period. In less than a decade, the computational modelling of political attitudes turned into the most relevant research endeavour in political science.

Once it accumulated a critical mass of theory and method, this area of research provided the most relevant contribution to the newly emerging Computational Political Science.

The Challenge of Political Culture

Political attitude computational modelling research witnessed a stable systematic development during the 1980s. It had, however, grown up in a scientific and political context whose sensitive dynamics exceeded by far the capacity of available research methodologies, resources and technologies to cope with. As many times before, computational and simulation modelling methodological resources in sociology and social psychology surpassed those of political science in what regards the capacity to approach highly sensitive, non-equilibrium social and political phenomena. The burst of social simulation and computational sociology domains and their associated research methodology proved once again that these social science domains acquire faster the new modelling technologies offered by the theories developed in the sciences of the artificial: AI, ALife, AAA, artificial neural networks, cellular automata (CA), multi-agent distributed systems (MAS), agent-based systems (ABS) and complex adaptive systems.

Political attitudes, as traditionally approached and modelled by social psychology research on public opinion dynamics, witnessed the painful decades-long passivity of the political methodology field in the face of technology-based advances in the modelling research methodology. What actually triggered the process of massive methodological change in political science was an old-fashioned theory, equally praised and contested during the 1960s (and ever since): political culture theory.

Though classic already, as introduced by Philip Converse (1964), political culture theory has never been approached from a computational and simulation modelling perspective, and even less in association with, as a basis for, or as a far-reaching goal of political attitude computational modelling research. This trend has nonetheless become more visible in a wide range of political attitude modelling approaches which include almost all aspects from ideology to polity dynamics. The gradual shift of research foci and paradigms from electoral and voting models to political culture models is one of the most complex evolutions induced by the development of computational modelling of political attitudes. The trend, initiated in the mid-1960s and left aside for several decades, has lately become a true cornerstone of the theories concerning political regime shift from authoritarian to democratic and participative ones.
Once revived by the abrupt political evolutions in Eastern Europe with the fall of the Berlin Wall in 1989, political culture theory seemed to offer a proper area for the applications and developments of the computational and simulation modelling of major political and social change phenomena, political attitude change phenomena included.

**The Assault**

One important impetus came during the late 1990s, when Charles Tilly harshly criticized the political methodology and political analysis domains for their inertia in using old-fashioned modelling paradigms and in their slow pace and clumsy style of adapting to the imperative complexity requirements of the study of political regime change. The political phenomena generated by the fall of the Berlin Wall shed more emphasis on his criticism, addressing the modelling research methodology in political science, stuck in the classic nomothetic paradigm.

Another impetus arrived in the 1990s, generated by an impressive number of academics from various areas of political science who initiated systematic political culture approaches to the Eastern European democratization phenomena from a modelling perspective. This revived and emphasized not only the extant bulk of political attitude modelling research but, equally relevant, the political culture theoretical approaches almost dismissed during the past several decades. This actually reinforced the political culture theory with respect to the post-communist Eastern European political change phenomena. Involved in a global research project, Ronald Inglehart constructed a huge resource of survey data (*World Values Survey*) which includes, among data on many other issues, relevant data with regard to variational phenomena in political attitudes, political beliefs, political values and the clash in the 1989 aftermath of competing normative systems.

Notwithstanding this assault of political culture theories, the enthusiastic approach to modelling the major political regime change in Eastern Europe stopped shortly afterwards due to a weak computational and simulation modelling methodology background. Also, Eastern Europe was not the only case study. The classic modelling methodology was no more able to prove enough explanatory power against the new empirical evidence concerning political regime change in various geopolitical areas all over the world, like the Arab Spring phenomenon.

It was a crucial moment for realizing the true power of political attitude research as a means to achieve political awareness. Such cases and some others, like the rejection of the European Constitution in 2005 or the Ukraine–Russia conflict in 2014, prove that the societal need for anticipative evaluations of institutional change or political conflict-prone situations is much stronger than expected. The society as well as the polity which proves predictable weaknesses is considered vulnerable. It is this type of vulnerability which actually challenges political attitude modelling research in achieving a systematic dimension. It is expected to provide for an increased level of performance in envisioning and evaluating the dynamics of highly sensitive political context-dependent scenarios in domestic politics and international relations areas.
It is this view on political awareness which has highly motivated this work. Eastern Europe is but one of the geopolitical realms which need consistent means and resources for constructing long-term institutional education and investigation programmes in political attitude modelling research.

A ‘Two-Way Ticket’ Approach

This book is about the computational modelling of political attitudes. More explicitly, it is about modelling the processes of formation and change of individual political attitudes which provide for the emergence of group and mass phenomena. To put it in more detail, the book approaches more closely the issues of computational modelling concepts, methods and instruments and their operation in virtual experimental media in order to replicate behavioural or structural aspects of real-world individual, group or mass political attitude phenomena.

The issue has already been approached within the domain of mathematical and empirical modelling. The use of computational modelling with regard to political attitude research is not new. Also, this is not the first book to introduce it. On the contrary, the book is not aimed at talking about something really new. It rather talks about something which has existed for some time already and produces only now (and perhaps for the near future) effects which matter.

The computational models of individual, group and mass political attitude phenomena have existed for some time now. Two questions should be answered here. What would be relevant to know is to what extent the specific research reported so far has provided for the emergence of new theory. Moreover, it would be worth finding out whether political attitude computational modelling research has achieved thus far a critical mass of theory and methodology to define itself as a relevant component (if not the kernel) of a new discipline, namely Computational Political Science.

At first glance (and perhaps at second glance too, for those who consider themselves beginners in this area), this research area looks like a huge puzzle of political attitude computational models developed rather lately and spread across various social and political science fields. The answers to the research questions formulated before are provided by the research area itself: one should only note the order in this puzzle. However, revealing the hidden order is not an easy task since the models themselves connect and combine theoretical and computational modelling aspects from two huge areas: social and political science theories about attitude formation and change, on the one hand, and computational modelling theories, on the other hand. Usually, approaches which aim at identifying an order in this huge collection of models inform this bilateral connection between political attitude modelling and computational modelling either one way or the other in a highly subjective preferential fashion.

This book takes on a ‘two-way’ approach. One way consists of describing political attitudes in terms of their structure, context, mechanisms and processes from the perspective of the computational modelling instruments which replicate
them or put them forth in the virtual experimental media. The dual is that of describing
the computational modelling in terms of mechanisms and processes (and eventually,
software tools and resources) as a means to obtain a particular class of political atti-
tude-based group and mass phenomena in the computational media. In other words,
the theoretical modelling aspects should be explicitly presented in computational
terms and specific elements used to replicate and/or accomplish them in the virtual
experiments. And the other way around, the computational modelling aspects should
be explicitly described in the social psychological and political terms of the
phenomena which are actually being modelled.

It is often the case that books approaching this or connected subject matters
propose either one way or the other of this ‘two-way’ path towards understanding
(and, hopefully, employing) the computational modelling research paradigm and
instruments in political attitude research. Well-known authors, like Charles Taber and
Richard Timpone (1996), explain in their book mainly the computational modelling
issues and instruments, providing the details for social scientists eventually inter-
ested in employing such tools in particular research issues or areas. This alternative
is biased in the feeling that political attitude researchers might be tempted to try new
research tools to test new ideas when the old tools might not prove able to fulfil
the expectations invested in them. However, this is a one-way ticket alternative since it
does not develop in the same detail (if at all) the typical social or political phenomena
which might be explained by employing particular computational modelling instru-
ments. Other authors approach this issue the other way around: they mostly indicate the
modelling problems and approaches in social and political sciences, while leaving the
researcher free to choose from a rather huge collection of computational modelling
instruments about which they do not know (at least, not well enough) how?, when?
and why? to use them (Mutz, Sniderman and Brodie, 1996; Dillard and Pfau, 2002).
This alternative is biased in the hope that political attitude computational modellers
have good knowledge in both areas – political attitudes and computational modell-
ing – and that they are only about to make a choice on the appropriateness of
particular modelling tools for a given class of political attitude aspects. This touches
a highly sensitive area which regards the level of interdisciplinarity modellers have
or might achieve. Farsighted, it makes a point on the quality and appropriateness of
the educational programmes and universities’ curricula in both computational
modelling and political attitude areas – again a sensitive (if not painfully true) area
of concern, since such programmes and curricula are perhaps usual in some top-level
universities, but not in as many as might be needed. For example, the universities in
the Eastern Europe, where I come from, miss almost completely such programmes.
Societal needs for such expertise are unexpectedly high, and they may exceed the
imagination, level of experience and fast reactivity of the experts who are supposed
to appropriately define such highly required areas of competence in the labour
markets. In the Eastern European high-expertise labour markets this is the case, and
perhaps in many other places in the world. At least in the east, European universities
lack such programmes and/or curricula, and often they do not even get informed
about the latest doctoral areas’ evolutions. They also lack the capacity to realize the
societal utility of prediction and forecasting studies based on political attitude mass
phenomena. In the geopolitical realm of Europe and within the European Union, the past years have offered serious warnings of which only some have become embodied in high-risk challenges. One such challenge was the rejection of the European Constitution in 2005 in a period when profound changes shook the European Union roots. Another challenge was the Greek crisis which burst long ago, but only now seems to affect the very foundation of the European Union. Not to talk about the challenge raised by the Ukraine–Russia conflict in 2014. The computational modelling of political attitudes for prediction and anticipative risk evaluation purposes is worth a much closer look from the eyes of academic research, governmental structures and civil society communities.

Criteria in Model Selection: The Addressed Modelling Aspects

Perspectives

This book provides a systematic account of the computational modelling of political attitudes. In order to mirror this development during the past eight decades, it takes into consideration two theoretical research perspectives.

The first one is the theoretical and methodological perspective offered by the political attitude research in social and political sciences, social and political psychology and political culture. There are references in various chapters to other important areas in political science, like the political methodology domain. Relevant comparisons with Experimental Political Science are meant to emphasize the centripetal tendencies of computational modelling approaches on political phenomena (i.e. attitudes, beliefs and ideology, norms, international relations, conflict, insurgence and war, political regime change, governance and polity) to aggregate into a united disciplinary framework within political science, which we call here ‘Computational Political Science’.

The second one is the perspective over both theoretical and methodological computational modelling aspects which have provided support to the political attitude models presented in the book. The references to such aspects are meant to specify the various reasons, some conceptual, others operational, which have recommended them for being considered in the definition and design of the political attitude models. Though the references to the computational aspects do not reach every technical detail, they are nevertheless meant (if present) to support a better understanding of the modelled phenomena. The computational theories, concepts and methods, as well as the computational and simulation technologies often employed in the political phenomena modelling, are provided in each chapter as a means to justify the outcomes of the various computational experiments.

The two perspectives are combined into a systematic, unitary style of presentation, which is structured for each political attitude computational model into three components: conceptual, operational and computational levels of the modelling architectural design. The computational level often has an associated simulation
modelling component, which (if present in the original model) is also presented in some (purposefully, not too boring) theoretical and technical detail.

The architecture of the book itself is thus achieved from combining several essential dimensions of presentation. These dimensions appropriately extract the major modelling goals and themes underlying the types of modelled political attitude phenomena, and the more general political phenomena with which the dynamics of political attitude phenomena could be related. The level of conceptual and operational descriptions, as well as the evaluation of computational modelling solutions, is based on mechanisms and processes which have been identified and selected from both political and computational viewpoints in the model construction. The mechanisms and processes are therefore provided by (i) social and political psychology, and various research fields in political and social sciences, for example the theories of social and political influence or the theories of democracy, and by (ii) different research fields in computer science and the sciences of the artificial, such as AI, ALife, CA, AAA, MAS, ABS, artificial society modelling (ASM) and artificial polity modelling (APM).

Though there is an impressive literature on the concepts of ‘mechanism’ and ‘process’, as well as endless debates in the philosophy of science and specific research areas on their definition, meaning and role played in modelling social and political phenomena, our book takes these concepts as the relevant level in addressing and emphasizing the explanatory power of various computational models for the addressed political attitude phenomena. However, explaining them in proper philosophical and technical detail would require another book.

**Dimensions**

There are several modelling dimensions which proved essential for our approach.

A first modelling dimension addressed in the conceptual modelling level/aspects in each chapter concerns the psychological as well as the social and political psychological mechanisms and processes which underlie the formation and/or change of political attitudes.

A second modelling dimension addressed in the operational modelling level/aspects in each chapter concerns the mathematical formalisms which provide for the replication of real-world political attitude phenomena as computational experiments. Each political attitude model thus employs either a mathematical model, which is translated into a computational model so that it can be simulated, or a generative model, which is simulated in order to produce outcomes. They are finally evaluated by comparing the obtained outcomes with real-world phenomena. On this dimension, the mechanisms and processes defined and described at the conceptual level are replicated by means of computational means able to mimic the original mechanisms and processes in real-world social systems, and to replicate the type of outcomes they produce.

Finally, a third modelling dimension addressed in the computational modelling level/aspects in each chapter concerns the proper computational and simulation means able to achieve the outcomes defined at the conceptual modelling level.
and described in operational terms at the operational level. As regards the main computational and simulation modelling paradigms, each chapter specifies this detail by also providing justifications or reasons explaining how a particular paradigm provides for (i) the replication of context constraints, (ii) social and political interaction conditions and (iii) particular outcomes. For example, the dyadic interpersonal networks described and employed in social influence and political persuasion scenarios are achieved by means of cellular automata in the Dynamic Social Impact Model (Nowak, Szamrej and Latané, 1990) and by means of an agent-based system in the Diversity Survival Model (Huckfeldt, Johnson and Sprague, 2004).

**Types**

As regards the type of modelling approach, many of the computational models of political attitudes described in this book are complexity-based modelling research approaches. The models explain the dynamics of political attitude attributes like stability or extremity, and provide for the emergence of political attitude phenomena like formation and change such that corresponding real-world phenomena can be explained. The description of this complexity-based type of modelling is facilitated by the mechanisms and process-based approach. Mechanisms and processes enhance the explanation of the emergence of the type of phenomena addressed by computational and simulation political attitude modelling. This is also a way of approaching the relations between the micro–macro levels of the social and political systems. The modelling of the micro–macro relations in what concerns social and political action and interaction is one of the fundamental research programmes in both social and political sciences. As regards the computational approach to this issue, a historical initiative, namely the research programme on the micro-to-macro phenomena in electoral phenomena (political attitudes included), defined by William McPhee and James Coleman in the late 1950s, has shaped the political attitude modelling ever since. The effects generated by this fundamental research direction in both social and political sciences have been relevant enough to justify an impressive volume of literature and research and to inform the rise of several new disciplines, such as social simulation and computational sociology as new disciplines in the area of social sciences, or computational political science as a prospected new discipline in political science.

**Themes and Paradigms**

The major theoretical themes in political attitude computational modelling research which are covered in this book concern (i) social influence, (ii) political information processing and (iii) the emergence of structure and order in social and political systems.

For each major theme, a model or class of models is described in theoretical, operational and computational terms and details. Without making these presentations too technical, they are meant to explain the appropriateness of the computational
modelling methodological choices to the conceptual and operational architecture of each political attitude modelling approach. This option aims to make it easier for the reader to understand how the conceptual and operational foundation of the model meets the particular requirements and/or constraints of the selected computational modelling methods, and the other way around; that is, how the computational modelling method is particularly suited to achieve the outcomes designed at the conceptual and operational levels of each model.

**Model Selection and Goals**

The book presents a collection of computational models of political attitude phenomena elaborated during the past half-century. By presenting this collection, the book aims to achieve several goals.

The collection is itself a construction: each of its constitutive elements, that is each of the computational (and simulation) models, illustrates a type of explanation about particular political attitude formation or change phenomena, for example the mass phenomena generated by the political persuasion during an electoral campaign when individual persons are persuaded to cast their votes for one or another of the candidates.

However, what this book aims to find is the way, rather than the terms, in which the explanation is achieved. The explanatory terms come from the particular expertise which is involved: political attitudes are often the complex outcome of a mix of sources and factors which regard both the individual and the group or society at large as well as the social and political context. The way explanation is achieved comes instead from the modelling method. It is the modelling and its various methodological forms in the particular area of political attitudes which make one true subject of this book.

First and foremost, the goal which this book has pursued was to find a strategy to perform the model selection. Selecting the models might follow several possible strategies. One strategy is to select the most relevant models only. Another one is to select all the models which are more or less addressing the same issue. The former provides for a synthesis, that is it achieves a picture of the area by identifying the models which are typical and perform best, while the latter provides for an exhaustive picture of an area which, by the way, is not predefined. On the contrary, the book is looking for a way to define it by employing a smart selection.

The selection issue is closely tied to one of the main characteristics of the image offered by this book with regard to the computational modelling of political attitudes from a methodological perspective. The various modelling aspects collected, presented and evaluated in this book are approached here as belonging to the same general framework. This unifying view is meant to bring together the separate methods and methodological designs which have been tried as independent means to achieve the goal of explanation. By employing a particular modelling method as a piece of methodology, the researcher should not overlook the whole. This view was explained and adopted by Charles Taber and Richard Timpone (1996, p. 2) in their book on computational modelling in social sciences. The same view was
adopted by Paul Johnson when he approached the issue of simulation modelling in political science (1999, p. 1510).

Though very few, the authors or the schools of thought assuming this viewpoint, share the idea that computational modelling in general, and computational modelling of political attitudes in particular, provides for a (complete) revision of the classic theories in the field by means of a methodological fresh input. Identifying the computational methods involved as being part of a more general unifying framework helps a researcher identify the way in which modelling provides for a general theoretical development with respect to an issue which is insufficiently (if at all) explained. A good example is Converse’s theory (1964) with respect to the instability of political attitudes: modelling the individual voting choice as depending on three independent variables, namely political participation, political issue and ideology. Converse noted the poor stability of political attitudes and beliefs in mass publics during and between presidential election campaigns. He used his empirical model to explain the political attitude instability by correlations with the level of education and voter sophistication. Half a century later, Milton Lodge, Charles Taber and collaborators elaborated a theory based on a computational model which explains political attitude instability by the ‘hot cognition’ hypothesis, proving that the political information processing in individuals is biased in the valence they associate with each piece of information they receive during the electoral campaign communication (Lodge et al., 1995). The instability of political attitudes is thus explained by the affect-based theories of information processing, judgement and cognition (Lodge and Taber, 2005).

The point which this example makes on the unifying perspective assumed in this book is that computational modelling has made political attitude research an area of advanced theoretical knowledge with regard to the emergence and complexity of political change phenomena at the mass level. It is this methodology that offered the means for theory building. Also, this is another true subject in this book.

Finally, the book aims to identify the existence of a critical mass of theoretical and methodological knowledge which might empower one to say that the computational modelling of political attitudes appears as a new field of theoretical and experimental investigation contributing to the emergence of a new discipline: Computational Political Science.

Criteria in Organizing the Models

This book presents a collection of models and computational modelling approaches on political attitudes. The selection of models follows a chronological order from the early 1940s until present times. The historical dimension is aimed at emphasizing the ages which have deeply marked the development of this research field.

The selection of models has also followed the criterion of relevance with regard to the political science area, the modelling paradigm and the impact on the political theory and methodology development.

This introduction addresses this type of approach by briefly describing the goals, outcomes and relevance of the computational modelling of political attitudes. From a historical perspective, several ages are identified and briefly characterized
with respect to the historical development of attitude modelling research, in general, and social and political attitude computational modelling research in particular.

Part I covers in theoretical detail and from a historical perspective the political attitude definition and attributes, which are considered to be relevant in modelling political attitude phenomena. Chapter 1 provides an overview of the definitions of social attitudes as well as the main models developed in social psychology with respect to the various sources and routes of attitude change phenomena and various paradigms of modelling the change. The social psychology modelling of attitude formation and change and the relationships between attitudes and behaviours or beliefs have inspired the computational modelling of political attitudes. Chapter 2 employs a similar approach from a different perspective, namely, a political psychology and political science perspective. It describes eight ages in the historical conceptual and experimental development of political attitude computational (and simulation) modelling. Also, it presents some general considerations and the type of approach to the model: modelling, in general, and computational modelling in particular.

Part II presents the first relevant approaches in the history of political attitude computational modelling. Chapter 3 is devoted to the Voting Choice Computer Simulation Model developed by McPhee and collaborators in the late 1950s. Chapter 4 describes another computational modelling approach which was developed at the same time: the Community Referendum Model (Abelson and Bernstein, 1963). These models are presented in technical detail so that the models in the next chapters may be better understood by comparison with these first approaches.

Part III introduces in philosophical, conceptual and computational detail an impressive computational modelling approach on political attitudes: the Social Impact Model (Latané, 1981) in both its original, mathematical version (Chapter 5) and also in its dynamic versions developed thereafter (Chapter 6). Social impact modelling is based on the social influence paradigm and initially employed a purely mathematical model. However, the computational versions developed afterwards rather surprised everybody (authors included) by their genuine self-organizing qualities and the power to generate emergent phenomena. Though initiated in a strict deterministic paradigm, the ‘Dynamic Social Impact Theory (DSIT)’ class of models also includes approaches based on the chaotic dynamics of political attitude extremity. All of this makes the social impact the only class of approaches which has tried all known modelling paradigms: mathematical, dynamic and chaotic.

Part IV includes political attitude models which address culture issues from convergent perspectives: culture and collective behaviour. One perspective is that of simulating (political) attitudes as culture attributional items and studying the dynamics of culture change. A second perspective concerns the democratic culture: it allows for the study of the survival of diversity of opinion and tolerance in democratic societies. Finally, a third perspective is concerned with collective action. It includes three chapters. Chapter 7 presents one of the most influential modelling approaches in social simulation, which represents the conceptual and experimental basis for almost all the other modelling approaches on political attitudes
and culture: the Culture Dissemination Model (Axelrod, 1997). The model defines a
new concept, the so-called thought exercise, which defines what a virtual experiment
is and how it should be employed in social and political modelling and simulation.
Chapter 8 presents the Diversity Survival Model (Huckfeldt, Johnson and Sprague,
2004), which builds on the experimental principles of the artificial society model
and revisits the former model of voting choice elaborated by McPhee. The model
approaches the issues of political attitude formation and change in a democratic
society by employing both social psychology and political science classic theories.
Chapter 9 presents a collective action model based on political attitude formation
and change computational and simulation modelling: the Political Contagion Model
(Johnson, 1999).

Part V is devoted to spatial models. Chapter 10 describes the class of models which
employ the system dynamics paradigm. Chapter 11 describes the multidimensional

Part VI is concerned with modelling approaches based on political information
processing, motivated reasoning and political cognition theories. Chapter 12 presents
the JQP Model (Kim, Taber and Lodge, 2009). Chapter 13 describes a political atti-
dude strength modelling approach: the PASS Model (Kottonau, 2002).

Part VII includes some of the most relevant computational models of ideology
formation and change. The introduction to Part VII makes a synthesis of the main
paradigms, theories and modelling approaches in political ideology modelling
research starting with Converse’s model until the complex approaches developed
more recently. It includes three modelling approaches. Chapter 14 presents a bot-
tom-up model of political influence which explains the emergence of ideological
macro phenomena: the Ideological Polarization Model (Baldassarri and Bearman,
2007). Chapter 15 presents a computational approach to evaluating the quality of
ideological computational and simulation modelling outcomes: the Ideological
Landscapes Model developed by Lorenz (2014). Chapter 16 makes an overview
of the complex integrative computational and simulation modelling approaches
to political ideology, and describes in some detail the Cognitive Affinities Model
(Homer-Dixon et al., 2013).

Part VIII is devoted to achieving a typology of polity modelling approaches. Four
approaches are analysed. Chapter 17 presents the ETH school of thought and the
classes of agent-based models of social conflict and violence, and ethnic and nation-
alistic insurgence (Cederman, 1997; Cederman and Girardin, 2007a, b). Chapter 18
presents the Japanese school of computational and simulation modelling of polity
dynamics: the Polity Reconstruction Model (Sakamoto and Endo, 2015). Chapter 19
presents the holistic school of polity computational and simulation modelling and
the classes of polity models of state crisis and state failure in different countries
experiencing civil conflict and war in various geopolitical regions of the world like
Africa and Asia (Cioffi-Revilla and Rouleau, 2010). Finally, Chapter 20 presents a
model of civil uprisings and revolutions in the Arab world known as the Arab Spring:
the Compartmental Model (Lang and De Sterck, 2012).

The models have been selected from a wide range of areas of concern in political
science, such as political persuasion and social influence, political information
processing, reasoning and cognition, affect-based components of political preferences and choices, ideology formation, spread and variation, spatial models of political attitudes and belief change and polity models. The approach on presenting the models is rather qualitative and exploratory since this is the first attempt to achieve a global ‘mapping’ of a currently emerging area: there are many approaches which, though extremely interesting, have been left aside for considerations concerning the limited space in this volume. However, trying to gather all documentation and organize information proved difficult tasks due to the unexpected richness and width of this topic and the impressive interest it has attracted in almost all relevant schools and laboratories of the world. The volume mirrors only a small part of a global scholarly endeavour which seems to be powerful enough to allow for major paradigmatic shifts and discipline emergence in political science.

The Epilogue is the concluding part of the book. However, Chapter 21 is not actually drawing conclusions, but emphasizing the disciplinary aspects of political attitude computational modelling research and the emergence of a new interdisciplinary field of research in the classic domain of political science, namely Computational Political Science.

First and foremost, the book aims to introduce a collection of computational and simulation models of political attitudes, which now allows for systematic advanced studies.

It also aims to place these quite varied areas and styles of approaches into the context of the new paradigm in political science and methodology provided by computational modelling in a huge range of domains from political attitude, belief and choice, to collective action and polity instability.

Finally, the book aims to provide researchers with a useful tool and an insightful overview of almost one century’s history of modelling thinking on the issues of social and political attitudes. The time has come, from both theoretical and methodological viewpoints, to convert a century-long research work into a new conceptual endeavour and give way to a new discipline: Computational Political Science.

References


INTRODUCTION

Part I

SOCIAL AND POLITICAL ATTITUDE MODELLING
1

Attitudes: A Brief History of the Concept

The end of the nineteenth century and the beginning of the twentieth century marked a huge interest in psychology as it was trying to become autonomous and gain full recognition among sciences, thus defying Kant’s historical challenge, initially formulated in his *Critique of Pure Reason* (Kant [1871]1998: 597). In order to build up the objectivity argument, psychology relied more on the experimental social sciences emerging at that time: experimental psychology, psychometrics and psychophysics. More than just sensation measurement experiments, these disciplines called for quite complicated concepts of measure and measurement and enhanced a quantitative-like modelling of some basic psychology issues, like behaviour. Thus, the foundations were laid for approaching a concept which, at the end of the nineteenth century, appeared attractive though confusing and contradictory, closely tied to philosophy, psychology and sociology conceptual frameworks, hard nevertheless to place among affine concepts, to define and measure: the attitude.

Over more than one century, the research interest in attitudes has known peaks and troughs. It has served most diverse scientific and applicative goals, going from propaganda to commercial and political marketing, from child socialization to smoking or drinking behaviour control. It has been supported by almost all computational, artificial intelligence, artificial life and web technologies which have been developed in the meantime.

Attitude research was born as the kernel area of social psychology. For a long time social psychology led attitude research, including the study of political attitudes as particular cases of social attitudes. Gordon W. Allport had a major influence in the development of the field of political attitudes as a distinct area of research. In the mid-1920s, Howard Lasswell laid the foundations of political psychology as a separate
discipline at the thin border between social and political sciences, deeply influenced by both social psychology and political science theories. Political psychology was meant to be a political science field of the study of political attitudes. Overwhelmed in the past by influences from sociology, social psychology, political sociology, propaganda, leadership or conflict studies, political psychology has succeeded in becoming a science about political attitudes in the true meaning of the word (Kuklinski, 2002). However, it lacks proper technology to approach political attitude modelling research in its very complexity. Political science, in general, needs to shift its focus from traditional to advanced research technologies. The computational modelling of political attitudes, as it has been developed since the mid-1940s, seems to have contributed decisively to this shift of focus by emphasizing the ways in which such technologies could and should be employed in political attitude, political culture and ideology research.

This chapter is aimed at recalling valuable concepts, theories, approaches and research experiences that represented milestones in social and political attitude modelling research.

**Attitudes in the Philosophy of Mind**

**The ‘Mind–Body’ Problem**

The nineteenth century was a time of extraordinary advances in almost all sciences. Fundamental and experimental research advances in biology, brain and neural sciences and the anatomy of motor and sensorial structures made possible the emergence of a new view on the old ‘mind–body’ problem. Started in the Leipzig Laboratory headed by Wilhelm Maximilian Wundt at the end of the nineteenth century, experimental psychology organized the first experiments proving the organic binding between body and mind (Voinea, 2012).

The notion of ‘attitude’ is mentioned in several fundamental texts as early as the second half of the nineteenth century. Authors with classic encyclopaedic formation, like Herbert Spencer, authors in the philosophy of mind, like William James, and other classic authors at the end of the nineteenth century in sociology and psychology included the notion of attitude in their considerations on the mind–body problem.

The earliest reference to the term ‘attitude’ in the literature about the individual and the society was introduced by Herbert Spencer. In his *First Principles*, Spencer associates the term with the thinking and reasoning activity underlying human judgment (Spencer, 1867: 4). Spencer makes reference to the term by emphasizing an idea from biology; his view was that it binds together the mental and sensory processes of the human being, thus making it achieve an overall integrative condition which is characteristic for the human organism only (Spencer, 1867: 326). While Spencer does not give a proper conceptual definition, he nevertheless suggests that the term could be understood in various meanings which recall (either separately or mixed) emotions and moods (Spencer, 1867: 556), opinions and beliefs (Spencer, 1867: 4), communication by means of body expression or position (Spencer, 1867: 354), but mainly as logic and moral judgment (Spencer, 1867: 3–4). Vaguely enough, Spencer’s description and scientific foundation of the notion become nonetheless a
common term for the theories of the time which address the issue of association between sensation, behaviour and self-consciousness.

As Alexander Bain further elaborates upon it during the next years, the term gains more conceptual consistency in addressing the binding between body and mind in terms of the connection between the capacity of the human body for object perception (outer world) and the capacity of the human mind for self-consciousness (inner world) (Bain, 1868: 24–25; 102; 120–121; 198).

When Dewey (1884: 278–289) introduces the concept of the new psychology, the sciences concerned in one way or another with the social aspects of man’s activity develop the notion of attitude into a fundamental concept. In the Principles of Sociology, Franklin Henry Giddings (1896) views attitude as the expression of a conscious state. As such, attitude is associated with affect, overt behaviour and kinship relations, group membership or social activity. Several other remarkable authors have elaborated on the definition of attitude as a locus of the multiple bindings between mind and body: inner and outer experience, the psychological attitude toward experience (Wundt, 1897, 1907). Of the American authors, the philosophical work of William James has combined concepts like functions of the brain, habits and emotions, bodily sensations and desires, behaviours, states of mind and consciousness into a unified conceptual picture of what ‘attitude’ might mean (James, [1890]1918: 241). His work has influenced all subsequent research work in the American philosophy of mind, experimental psychology and social psychology by making the ‘attitude’ a concept which addresses the essential principles of the social activity of humans and, moreover, the unity of human action.

Attitudes in Social Psychology

Measurement Theories

There is an initial phase in the history of attitude research which is completely devoted to measurement. It echoes a time when psychology itself, in its struggle to acquire the status of autonomy and scientific objectivity, was in search of a concept of measure and a theory of measurement which could account for the very special kind of psychological processes, objects or states. Dominated by the Freudian psychoanalytical paradigm, psychology was in need of a new paradigm able to support the evidence provided by the findings in the newly emerging biology, neural and brain sciences. Experimental psychology, psychometrics and psychophysics started their historical search for the proper ways to identify the means of connecting mind processes and body sensory responses to stimuli. All this needed a new concept of measure.

Like many other basic psychological concepts defined as abstract constructs, like belief, emotion, feeling, memories or human intelligence, attitude escaped the traditional theory of measurement which dominated the natural sciences from the ancient times of Euclid. The conceptual and experimental studies developed at the beginning of the twentieth century on this notion translated it into a relevant dimension of the psychology’s struggle for identifying a new concept of measure and a new method of measurement. Attitude measurement research covering the first half
of the twentieth century (Symonds, 1927; Thurstone, 1928; Droba, 1932; Katz, 1937) has received theoretical and methodological support from three relevant sources: it has been substantially stimulated by the comparative studies on human intelligence (Spearman, 1904a), strongly supported by the paradigmatic shift from the stimulus-response to the mental life of the individual as the explanation of human behaviour (Thurstone, 1924) and enhanced by the advances in mathematical statistics introducing multifactorial analysis (Spearman, 1904b).

Attitude was, from the very beginning, associated with the binding between mind and body. It has been conceived as the locus where the action choice is made in abstract deliberative processes able to synthesize sensorial and perceptive information and send it back to the organism’s motor and communication subsystems as an explicit command or as part of a brain message addressed to all the other parts of the body and mind. When Leon Thurstone claimed in 1928 that ‘attitudes can be measured’ (Thurstone, 1928), this was perhaps the most relevant moment in the history of attitude research: the historical promise was fulfilled. On this new background, a new science was born at the border between psychology and sociology: social psychology.

What was the attitude literature all about at that time? Remember, everything recalled here actually happened in the early days of the twentieth century. Research on individual and social attitudes looked much like a miscellanea of most diverse conceptual backgrounds from the Gestaltist tradition to the Freudian psychoanalytics. The new interdisciplinary domains, like experimental psychology, psychometrics and psychophysics, started bridging the gap between classic psychology and the experimental model in natural sciences. All of them had a fruitful time in developing experimental research and advancing theories with regard to the measurement of processes which involved connections between mental and sensorial aspects, like learning or action decision-making. A new research concern arose with regard to the measurement of abstract objects; that is, objects of mental processes. A new concept, namely the intensive measure, and a new measurement theory, namely the scales of measurement, were defined, thus completing the classic Euclidean picture of measurement based on space geometry, iterative sum (i.e. addition) and the concept of unit (Stevens, 1946).

The theoretical advances in both experimental psychology and the theory of measurement developed in the first three to four decades of the twentieth century point to a considerable support from statistics (Rice, 1928, 1930), which made possible attitude measurement research (Droba, 1932). Attitude scaling experiments and theories would not have been possible without the questionnaire concept and experiments introduced by Sir Francis Galton (1874, 1888) and exquisitely continued by his pupil, Karl Pearson ([1892]1900), who extended the correlation analysis for large bodies of empirical data. Nor would it have been possible without the contribution of sampling theory founded at the end of the nineteenth century (Kiaer, 1895–1896, 1897) and of estimation theory (Fisher, 1925). Thurstone’s (1928) scale, Likert’s (1932) scale, Thurstone’s (1931) theory of multifactorial analysis and Spearman’s (1904b) ranking theory complete the picture of a dramatic search for measure and measurement of psychological data, in general, and social attitudes, in particular.
Attitude scaling is perhaps the most important battle psychology won in its complete war against its own limitations, a war initiated as a historical response to the evaluation Immanuel Kant ([1871]1998: 597) made on the status of psychology among sciences.

A full theoretical description and explanation of attitude measurement is provided in Thurstone and Chave (1929). Scale measurement of attitude is based on the classification of empirical data collected from self-reporting answers of the respondents into classes which are appropriately associated with degrees of intensity underlying valenced evaluations of the attitudinal object, be it real or abstract. The classes thus defined correspond to units on the attitude scale.

In Search of Definition

Between the early 1920s and mid-1930s, the notion of attitude identified a fundamental research target in classic and interdisciplinary social sciences: everybody sought the proper term, the appropriate description, the adequate concept. Putting it in just one word, everybody was looking for the definition. No other notion before has been so widely approached in psychology and no other definition attempt has been so deeply assumed by so many scholars in as many diverse social classic and experimental sciences. This generalized interest, facilitated by the studies of human behaviour, memory and intelligence at that time, finally resulted in a huge amount of attitude research literature: in a very short while, it included a considerable number of papers, books and handbooks, general reviews and an impressive volume of research bibliography. The differences of conceptual perspective and the wide variations in the range of meanings and roles associated with this notion made the whole picture ambiguous through too much diversity. Mental state and consciousness, feeling and belief, moral judgment and action deliberation, motor and neural, language, gesture and body posture, almost every psychological, sociological, even physiological basic term and mechanism could be retrieved in the early original attempts to find the definition of attitude.

At some point, one has a strong feeling that, initially, the notion of attitude ‘swept’ almost everything which could be either strongly or just weakly tied to soul and reason: from a simple gesture like a frown of disapproval to a moral judgment, from a common behaviour like talking to a neighbour to action choice, everything seems naturally associated or identified with attitude. No matter if it is about facial gesture, body language, mental state or language utterance, everything is viewed, in one way or another, as a dimension or aspect of attitude.

So, the question of the age is: What actually is an attitude? Everybody involved in the philosophy of mind and social science studies asked. What is more interesting is that everybody answered. And no answer seemed less justified than another. It is amazing and, perhaps, most confusing. It nevertheless makes sense if, looking back to that age from our position today, we admit that the extreme diversity and ambiguity of the initial definitional attempts were the very effect of the assumed idea that behaviour expression and action deliberation involve almost all known and imagined processes
and structural components of the human being. And, as a generally accepted position, attitude is this very locus (in the early 1920s as well as today, nobody really knows exactly where!) somewhere inside the human being where all of this is actually getting shaped, that is, behaviour and action, judgment and feeling, spelling and intonation, gesture and body posture.

At the beginning of the 1920s, in the domain of psychology and philosophy of mind in both Europe and the USA, the specific interest and the contributions of many traditional schools of thought converged, at a certain moment, to a single point: the attitude. And each of the contributors brought their own view. This initial diversity in meanings, definitions and explanations is meant to afford much later for the incredible flexibility of the attitude concept and for its open character. The notion of attitude accumulated almost everything classic theoretical psychology and sociology put together at the birth of social psychology. Its essential diversity was the substance which provided for the seemingly never-ending process of getting defined by every newly emerging discipline about individuals and societies, politics and polities.

We should notice and keep in mind this interesting characteristic of the age because it will later prove useful in making us understand what actually happened when Gordon W. Allport finally succeeded in adjusting this enormous conceptual work into one single, unitary, profound conceptual definition. The notion’s original and, by all means, essential diversity was the substance of its almost unbounded flexibility proved much later.

Everything seemed to get shaped when, in the late 1910s, William Thomas and Florian Znaniecki defined attitude as the fundamental concept of social psychology (Thomas and Znaniecki, 1918: 27). Their definition strongly emphasized the social perspective over the new concept. They defined attitude as the variable outcome of a process of interaction between the individual and the social environment. The attitude is always toward something, thus supporting the Aristotelian concept of intentionality of mental states, exquisitely reminded later by Franz Brentano (1862). It is reflected by the individual consciousness. It is the product of social activity, and has social value (Thomas and Znaniecki, 1918: 22–23). Thomas and Znaniecki emphasized from the very beginning, in their either joint or separate studies, that social psychology and, in particular, attitude research are not meant to sustain the individual–collectivity dichotomy, but, on the contrary, to study both the individual and the social group from the perspective of their capacity for social action and interaction able to induce variation and change on each other. Analysing the background in the social action and its dynamic character, Znaniecki (1925: 63–69) described the relevant role attitudes play in social change. He underlies the fundamental aspect which the science of social psychology aims to study: social influence as effect of social interaction, at both individual and group level (Znaniecki, 1925: 57). The social influence already appears as a major research dimension and, from both theoretical and experimental perspectives, the most relevant context in which attitudes have been studied from the very beginning up to present times. Thomas and Znaniecki’s challenge provided an impetus to a considerable amount of attitude research literature which was dominated markedly for almost two decades by the search for a proper definition.
Starting with the impressive work of Florian Znaniecki and William Thomas (1918–1920) about the Polish peasant, the 1920s abounded with hundreds of valuable papers searching for the proper way to define the new concept and the new science of social psychology. Searching for a definition involved unexpectedly large domains of relationships with other basic concepts from traditional psychology and sociology. By the mid-1930s, the literature about attitudes and the authors had been repeatedly synthesized by several relevant reviews with impressive reference lists (Bain, 1930; Droba, 1934; Murphy et al., 1937), which provided the bibliographic background for our own brief review in this chapter.

As defined by Symonds (1927: 200), the seven meanings of attitude include almost everything from motivation, emotion, motor- and neural-set, to verbal responses expressing likes and dislikes. Some authors define attitude as similar to feeling or motivated by desire (Russell, 1921) or wish (Holt, 1915). Some authors approach it from a behavioural perspective (Bernard, 1926, 1931; Symonds, 1927, 1928; Bain, 1928), while others view it as a predisposition to social action (Bogardus, 1923, 1931; Faris, 1925, 1928; Young, 1925; Znaniecki, 1925). Attitude is described as a unifying capacity of both mind and body synthesized by the system comprising both neural and muscular components to prepare appropriate social behavioural response to the stimuli (Allport, 1924: 320). Thurstone defines the attitude as an overall cumulative capacity of the human affective, belief-involving and rationality-based responses to objects (Thurstone, 1928: 531). The approach which achieves more agreement and which has finally prevailed is that of viewing attitude as mainly representing a capacity of the human being to prepare for taking an action with regard to particular objects of interest (Murphy and Murphy, 1931). This preparatory capacity takes into account both the object and the subjectivity of the human actor (Droba, 1933: 447), and connects a state of the mind with object experience so that any (deliberate) action with respect to the object is the outcome of some appropriate mental-based actualization of the experience (Baldwin, 1901–1905; Murphy and Murphy, 1931; Warren, 1934). To become effective, the action-preparatory state needs to be appropriately sustained by certain cognitive and affective capacities of the individual and, at the same time, to get contextually stimulated by situations in the social environment. However, the action seems to depend to a much greater extent on the disposition than stimulus, thus marking a departure from the traditional behaviourist theory based on the stimulus–response paradigm. This particular idea was pursued by Gordon W. Allport and represents the essence of the definition he gives to attitude. His definition seems to actually dismiss Freudian interpretations and favour neuro-biologically and socially inspired views on attitudes. After almost two decades of intensive research work on both conceptual and measurement dimensions, in his 1935 remarkable definition, Gordon W. Allport succeeded in combining various perspectives into a unified concept (Allport, 1935: 798).

In his definition, Gordon W. Allport makes explicit references to authors and their definitions as involving either explicitly or implicitly the concepts of mental state (Allport, 1924; Droba, 1933; Cantril, 1934), disposition (Warren, 1934), affect-based state of readiness (Chave, 1928; Ewer, 1929), psychological stress between parts of the nervous system viewed as an organic whole (Kohler, 1970), tendency to
action as a valenced reaction or response to a social context situation (Bogardus, 1931), action‐aimed binding between individual consciousness and social value (Thomas and Znaniecki, 1918), acquired social experience which conditions and controls the individual’s activity (Krueger and Reckless, 1931) and verbalized disposition for the future (Murphy and Murphy, 1931). This definition unites conceptual aspects coming from the most relevant theories in psychology, experimental psychology, sociology or philosophy of mind (Clarke, 1911). As Gordon W. Allport himself emphasizes, his definition explicitly eliminates the mind–body dichotomy by avoiding the explicit distinction between motor and neural sets. It also explicitly excludes the innate forms of readiness, habit‐like views, rigid behaviourist schemas, and emphasizes that what we should call ‘attitude’ is concerned more with the intentionality of the action than with the environmental stimulus.

There are several powerful ideas which make the substance of this definition, which explain why it has prevailed in comparison with the previous ones, and which also justify why later attitude modelling theories have found it inspiring. One relevant idea, as the author himself explains, is the polarity of attitudes, an ancient Greek philosophy concept about contraries as the source of motion which can be found in Empedocle’s, Plato’s or Aristotle’s writings. The dynamic nature of attitude is another idea which foreshadows the future system dynamics theories, and which has permanently provided insight for both theoretical and experimental modelling approaches based on all dynamic paradigms and dynamic modelling methodologies (system dynamics, process flow, cellular automata and agent‐based systems). Finally, there is the idea about the intentionality of mental states, an Aristotelian concept packed in a new formula. The idea that the attitude is based on the individual’s response to an environmental situation has inspired both behaviourist and non‐behaviourist interpretations, going from S–R and schema theory to methodological individualism. The directionality of attitude concerns the idea that attitude is always about an object, be it a physical object (like a chair, a person or an environmental situation) or an abstract one (like an idea, a feeling, an emotion or a belief). Moreover, by means of attitudes, object appraisal is explained at both individual and social levels, from both substantial and abstract perspectives. However, the idea of directionality in attitude definition remains the subject of hot philosophic debate, as an attitude might still exist when no external object is actually involved. Perhaps, one should accept that directionality is but one conceptual dimension of attitude, although not an absolute one.

There are two fundamental aspects in Allport’s definition of attitude: one is that the attitude is organized through experience, and the other is that attitude has its own dynamics. The former addresses a fundamental characteristic of attitudes: their acquired nature. The latter addresses the temporary reorganization of knowledge as learning occurs, and in this case it points to the role memory plays in the conceptual economy of the attitude term. The dynamic view of the attitude also addresses a typical variation, fluctuation or modification of the influence attitude exerts on its actual object, and in this case it points to the timely unfolding of the processes which constitute attitude’s functions or functional roles in relation to the outer world (objects) or inner world (behaviour). For these reasons, Allport’s definition was and still is the most appreciated in social psychology (Murphy, Murphy
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and Newcomb, 1937: 889; Sherif and Cantril, 1945: 295–296). It has influenced all subsequent social attitude research for it opens up attitude research to modelling approaches and lays the foundations of several types of approaches in attitude conceptual and paradigmatic research: functional, structural and attributional.

Also relevant to our approach in this volume, attitudes were investigated and defined with respect to political opinions, parties and war (Rice, 1928; Allport, 1929; Vetter, 1930; Droba, 1934; Lasswell, 1936). We will briefly review the main attitude definitional approaches in the subsequent sections of the present chapter.

**Functional Theories**

For the decade following Allport’s remarkable synthesis, attitude research focused on the functional approach explaining attitude formation, expression and change (Katz, 1989: xii).

As Sherif and Cantril (1945) explain the rationale of this new trend, the action-preparatory capacity in Allport’s definition is itself described in a functional key: it models the subject’s preparedness as an internal state depending on the degree of activation of appropriate subsystems of the human organism (i.e. the motor and mental sets). From a functional point of view, the characteristics of attitudes in Allport’s definition are: (i) directionality; that is, attitude is always toward an object; (ii) it is not innate, but formed (acquired, learned); (iii) attitudes have affective components and therefore are sensitive to variable affective moods; (iv) attitude proves stability when it has a cognitive component at the basis of the formation process; and (v) attitudes cover a huge number of stimuli, including those which were not present during their formation process (Sherif and Cantril, 1945). Daniel Katz describes attitudes as serving individual needs mainly based on individual value expression (Katz, 1960; 1989: xi–xii). Their functions might be classified according to (i) functional capacity to adapt to the variability of the social context, (ii) object appraisal and knowledge acquisition, (iii) expressive function, covering self-realizing and value expression and (iv) ego-defence (Katz, 1960). William McGuire describes four functions attitude might have: (1) the adaptive (utilitarian) function, (2) economic or knowledge function, (3) expressive function covering self-realizing purposes and (4) ego-defensive function (McGuire, 1969).

Notwithstanding the interest in the functional paradigm in the late 1940s, it lacked the support of an appropriate research methodology for approaching the complexity of the functional modelling of the attitude formation and change processes. Research interest diminished and, moreover, shifted toward political attitudes, which passed through their first flourishing era (McGuire, 1993). There were multiple reasons for these paradigmatic shifts.

As Daniel Katz describes the decline of the functional approach, it seemed too advanced a research issue compared with the performance level of the available research methodology of the time. Functional approaches emphasized the workings of mechanisms of human personality and behaviour without the means to measure and evaluate their complex attitudinal effects.
Another reason concerns the new area of research which stimulated a shift in focus in sociology during the 1940s and late 1950s toward group dynamics theories. This shadowed for a while the research on the attitude issue.

Finally and, perhaps even more relevant, there is this reason and explanation which concerns the cognitive revolution, a time of explosive development of the cognitive theories in social sciences which completely changed the overall picture in attitude research (Katz, 1989: xii). Information-processing theories made this change complete. The effect was that the functional theories were soon replaced by theories based on social cognitive processes, which assumed almost invariably the contribution of information processing, memory and knowledge representation processes. The study of individual attitudes made room for the advanced study of the social context role in the attitude formation and change processes.

In the late 1970s, functional approaches re-emerged, but only after absorbing some of the fundamental issues emphasized by the cognitive theories (Fazio, 1990; Zanna, 1990) combining them with social psychological theories on social motivation of individual behaviour (Fazio, 1990; Zanna, 1990; Ajzen, 1991).

It would be worth noticing that, during the same period, the scientific context changes in significant ways, influencing and enhancing the predictive views on attitudes and their relationship to behaviour. During the 1950s and 1960s, in parallel with attitude research, some other issues captured the attention of the research community: dynamic system theories and their apprehension for forecasting (Forrester, 1968) had a strong impact on the dynamic orientation of attitude research.

**Structural Theories**

The functional approach to attitudes was aimed at identifying the functions of attitude and the causal explanations of its formation and role. However, causality in functional terms is a hard issue as long as attitudes are highly sensitive to context. Applying deterministic principles to a high variation of such context sensitivity would make the task of measuring and evaluating it extremely complex.

Besides, there is this view that attitudes, as latent constructs, could only be inferred from the observation of behaviours, opinions and affect and emotional phenomenology which might contribute to the formation of an attitude. This view is sustained by the cognitive approach which considers that the attitude has a structure, and the empirical research of these structural components could offer a complete definition and understanding of what an attitude actually is, how it works and, most important of all, how it exerts its directive (control) influence over behaviour.

Starting with the late 1940s, new theories like balance theory (Heider, 1946), congruity theory (Osgood and Tannenbaum, 1955) and cognitive dissonance theory (Festinger, 1957) addressed the cognitive background of the processes underlying attitude change. Though not quite immediately, but soon afterwards, the classic Freudian and behaviourist paradigms made room for the new approach. Explanations for behaviour and attitude were sought more in the area of thought processes than in stimulation, conditioning and reinforcing processes.
Attitudes have been studied ever since with an increased focus on the social context and on the processes of deliberation and evaluation. The cognitive basis in attitude research was addressed by social influence theory, developed by the preceding group dynamics research orientation in social sciences. To this classic trend, a new one added: force field theory (Lewin, 1947a,b), which provided support to a first positivist modelling approach on attitude change phenomena.

Thurstone’s (1931: 261) initial structural model included one dimension only: the affect. The bipartite model advocated by Katz and Stotland (1959) described attitude structure as including cognitive and affective components. The tripartite model, introduced by Rosenberg and Hovland’s (1960: 3) definition and also by Krech et al.’s (1962: 139) definition, included affective, behavioural and cognitive components. These structural models were developed on the background of intensive development of propaganda and communication theories. The Yale model of social influence (Rosenberg and Hovland, 1960) shaped a new research paradigm: attitude change under social persuasion.

The definitional approach initiated by Gordon W. Allport in 1935 has never been completed. Cognitive theories have provided support for the study of the directive role of attitudes in their relations to behaviours, and also for the study of their dynamic character. Also, the attitudinal object approach has been based on a cognitive basis. The definitional approach has continued, and several authors have introduced modifications to the original definition, emphasizing their latest findings. All this emphasized a strong comeback of the definitional theories, this time on a cognitive conceptual background which favoured a modelling view and enhanced the development of conceptual modelling theories. Attitude formation and change processes and phenomena have become the targets of sophisticated modelling views which have increasingly employed cognitive complexity aspects.

One might distinguish two main types of approaches: dispositional and cognitive. Ajzen and Fishbein (1980: 78) and Ajzen (1991) provided dispositional definitions which emphasized the evaluative characteristic of attitude: it is based on affective (valenced) positions and enhances the behavioural response.

Eagly and Chaiken (1993: 1) provided the definition which achieved largest agreement by assuming that the attitude has three structural components: (1) one component which concerns the attitudinal object appraisal and affect, (2) a second component which involves beliefs (cognitive) and (3) a third component which addresses the behavioural, motivational (conative) component.

McGuire (1989) distinguished two perspectives in the attitude structural conceptualization: definitional and dimensional. From the various combinations between the number of topics (or attitudinal objects) and the number of dimensions on which the topic(s) were projected, he identified three classes of approaches: (1) one-to-many, in which one relevant model is that based on information processing; (2) the many-to-one, in which one relevant model is that based on the rationality of behaviour and action deliberation; and (3) many-to-many, in which ideology models are relevant.
Constructivist Theories

The cognitive orientation of attitude research was announced in the early 1930s by the laboratory experiments developed by Frederic Charles Bartlett (1932) on the relationship between attitudes, recall and memory. Bartlett’s research emphasized a constructive orientation in explaining attitude formation and change. However, by the late 1930s these findings were arriving too early. His research seems to be at odds with the main trend represented by the attitude measurement theory and experiments led by Leon Thurstone, and attitude conceptual defining attempts, undoubtedly led by Gordon W. Allport.

Bartlett’s conclusions on the constructive nature of attitudes and on the role of memory in attitude maintenance foreshadowed the later trend on social and political cognition in social and political psychology. Later approaches (Wilson and Hodges, 1992; Wilson et al., 2000) mention Bartlett’s work as inspiring attitude change modelling by taking into account the combined effect of memory-stored information and the dynamic recall of past perceptual experience.

Inspired by the research on the role of emotional phenomenology in attitudinal spontaneous expression, another relevant approach in the constructivist paradigm emphasizes the constructive nature of attitudes by underlying the context-dependent accessibility of attitudes and attitudinal objects in the memory (Schwarz and Bohner, 2001).

Attribution-Based Theories

Strength is defined by Krosnick and Petty (1995: 3) as a structural attribute of attitude with compound effects or effects which are considered appropriate in emphasizing the dynamic evolution of attitudes in certain contexts. One such effect is the attitude’s resistance to change and its persistence in time. Another relevant effect is the impact on (political) information processing, like, for example, the selection of sources such as an individual’s issue positions and beliefs could be confirmed and eventually reinforced. Finally, there is the effect of behaviour guiding and control (Miller and Peterson, 2004: 848).

In order to be employed in empirical evaluative studies of attitude variability and change, the strength needs to be measured. Measurement of strength is based on several classes of attributes: (i) attitude’s attributes, (ii) cognitive structure underlying the memory representation, storage and accessibility of attitudes and attitudinal objects, (iii) associated and/or underlying beliefs and (iv) the type of cognitive process of attitude formation (Krosnick and Petty, 1995: 5).

Notable approaches to attitude strength modelling have been developed on an empirical basis. The conceptual modelling of attitude strength has been mainly concerned with the definition and measurement of attitudes’ strength attribute. As a latent construct itself, the attribute of strength has been addressed in the structural modelling of attitude change. Some approaches view the construct of attitude strength as most appropriate in explaining resistance to change (Pomerantz et al., 1995: 409) by the resistance outcomes, like polarization. Other approaches employ strength in consistency studies of attitudes’ variability (Chaiken et al., 1995).
However, as an attribute, strength is described by means of attributes of its own, which complicates the picture quite a lot (Krosnick et al., 1993). Strength’s measures could be defined on some relevant dimensions: (i) political interest and political involvement, (ii) certainty of position toward an object and the ways in which it could be influenced by affective aspects and (iii) knowledge (Pomerantz et al., 1995: 409–410).

The empirical models of attitude strength employ a complicated mathematical formalism as they use factorial analysis (both exploratory and confirmatory) to identify the structural components of attitudes and the relationships among them (Visser et al., 2006). These approaches provide both the list of attributes and their measures. Such measures have been designed to be used in the empirical modelling of attitude formation and change.

Krosnick and Abelson (1991) indicate three main measures of attitude strength: importance, accessibility and extremity.

Fazio and Olson (2003: 143–145) describe three primary indices of attitude strength: accessibility, ambivalence and evaluative-cognitive consistency.

Krosnick and Smith (1994) define 10 attributes of attitude strength: extremity, certainty, importance, intensity, latitudes of rejection and noncommitment, interest, knowledge, accessibility, direct experience and affective-cognitive consistency.

Visser et al. (2006) and Bizer and Krosnick (2001) describe the following studies of latent structure of attitude strength-related elementary attributes: importance, knowledge, accessibility, certainty, ambivalence, structural consistency, extremity, elaboration and intensity. Each such measure is considered itself as a latent construct. In their extensive papers, the authors make reference to attitudes’ characteristic properties and processes based on studies of composite (index of) attributes defined by other authors: (a) attitude strength, defined as a composite index obtained by different authors by averaging measures of importance, certainty and intensity (Haddock et al., 1996, 1999), measures of extremity, certainty and accessibility (Bassili and Roy, 1998), measures of importance and certainty (and other measures; Holland et al., 2002); (b) embeddedness, defined as a composite index obtained by averaging measures of (mainly) importance and knowledge (Pomerantz et al., 1995) and by averaging measures of (mainly) importance and elaboration (Kokkinaki, 1998); (c) commitment by averaging extremity and certainty (Pomerantz et al., 1995) and by averaging measures of importance, certainty and personal relevance (Hodson, et al., 2001); (d) conviction as an index obtained by averaging measures of knowledge, certainty, ambivalence and extremity (Kokkinaki, 1998) and (e) ego-preoccupation, a composite index obtained by averaging measures of importance and elaboration (Abelson, 1988).

**Cognitive Modelling of Attitude Change**

Cognitive models of attitude change are addressed by all subsequent chapters, so that this section briefly introduces the models which are basic references for the political attitude computational models presented in this volume. Cognitive modelling of attitude formation and change includes several classes of conceptual models. The
models are based on the structural definition of attitude and are aimed at explaining the formation and change in structural terms.

One such class includes models in which the rationality principle prevails: the relationship between attitude and behaviour employs reasoning, planning and control components (Fishbein, 1963; Fishbein et al., 1975; Ajzen, 1985, 1991).

A second class includes the consistency-based models, which assume a basic hypothesis: attitudes are formed on the basis of consistent beliefs, values, knowledge and behaviour. Any contradiction amongst structural components of attitudes is tackled by mechanisms of identifying or restoring the balance, congruence or consistency between them (Heider, 1946; Osgood and Tannenbaum, 1955; Festinger, 1957).

The role of communication in political attitude formation and change has been emphasized by the theories concerned with the social and political persuasion mechanisms and processes. This research area has been successfully exploited by the cognitive modelling of attitude change in persuasive communication and contexts, usually electoral campaigns. This has resulted in a class of models of attitude formation, attitude spread and attitude change under persuasive communication dominated for a long time by the Yale model (Rosenberg and Hovland, 1960). The advances in the psychological and social psychological theories of information processing and their strong impact on the attitude theories (Anderson, 1981, 1982, 1991) provided the background for a class of cognitive models of attitude change which are based on cognitive mechanisms.

The constructivism in cognitive modelling of attitude change is illustrated by the class of so-called dual processes in both social psychology (Wilson and Hodges, 1992; Wilson et al., 2000) and political ideology modelling research (Duckitt et al., 2002; Duckitt and Sibley, 2010). The dual-process models are based on the hypotheses that the individual might hold contradictory beliefs and could engage in behaviours which apparently contradict their beliefs, attitudes or values, and that this is possible due to the different activation, accessibility and association of the various structural elements stored in the memory and/or acquired contingently. Combined with the theories of motivated reasoning, for example, such models have provided for approaches on political attitude formation and change which explain political attitude instability in terms of political information processing and political cognition (Lodge et al., 1995). In ideology cognitive modelling, the dual-process models introduce the idea that the ideological attitude could be defined and also formed and changed on multiple dimensions and not only on a single left–right dimension.

Finally, there is a class of models which are based on dual processes and are mainly focused on the role of affect in attitude formation and change and in the ways in which attitudes guide behaviour (Zaller, 1987, 1992, 1996; Fazio, 1990; Fazio and Olson, 2014).

Consistency-Based Models

Early models of attitude are based on psychology theories. The theory of congruity (Osgood and Tannenbaum, 1955) is an enhanced model of Heider’s (1946) theory concerning the attitudes’ cognitive organization. It works on the hypothesis that
contradictory information, knowledge or conceptual frameworks used in making judgments make people engaged in such judgments feel the pressure to choose either one or the other side of the contradictory background. Heider was the first to use a kind of psychological algebra of attitudes as a formalism of representation. The representation of the attitude change in congruity theory is rather logical and philosophical. Congruity theory does not explain why people change their minds, but only how they change their minds. The theory, nevertheless, offers a prediction model of how a third party would react when two main parties are arguing with each other. The prediction model is based on the idea of social change as an effect of social persuasion.

The theory of cognitive dissonance (Festinger, 1957) is a theory about attitude change. In Festinger’s theory, the change is determined by the inconsistent background of beliefs or cognitions with respect to an attitudinal object. Different degrees of such inconsistency, going from concept incoherence and ambiguity to contradiction between opinion and behaviour with respect to one and the same attitudinal object, is called dissonance. Cognitive dissonance theory is based on the social influence model. The theory does not use a formalism of representation for the attitude or a specific formula for the evaluation of attitude change.

Attitude change modelling based on the cognitive dissonance mechanism includes (i) semantic networks and (ii) neural networks models (Voinea, 2013).

**Expectancy–Value Models**

The consistency-based model of attitude change was soon replaced by a structural modelling approach based on the attributes of objects. The attributes of attitudinal objects are associated with subjective expectations and subjective values. The expectancy–value model (Fishbein, 1963) is based on the idea that an attitude with respect to a certain object associates a pair of components: one is the subjective expectation, and the other is the subjective value of the attribute. Fishbein and Ajzen (1975) calculate the attitude as the sum of the expected value for each of the attributes of an attitudinal object. As one examines the attributes of a certain object, one develops an expectation (i.e., measure of belief) as a probability that the particular attribute of that object makes it useful for one’s goal or desire. This expectancy–value model is an operational model in which the subjective belief and the subjective desirability with respect to certain value can be calculated with mathematical statistics formulae. This model has been further developed by the theory of reasoned action (Fishbein and Ajzen, 1975) and by the theory of planned behaviour (Ajzen, 1985, 1991).

**Information Integration Theory and Model**

Starting in the 1970s, attitude research diversified in order to aggregate research in two distant areas: (1) cognitive psychology, and neuro and brain sciences; (2) machine learning and artificial intelligence. There has proved huge interest in using the computer as a virtual medium for experimental behaviour and attitude research based on knowledge processing models.

The advances in computer theory and applications made possible the use of an information-based paradigm in modelling attitude change. In this area, the most
relevant theory is Norman Anderson’s (1981, 1982, 1991) theory of information integration (IIT), which is based on the information processing paradigm. It models the human mind’s capacity to integrate information from several sources in order to make a judgment or to form an attitude with respect to a certain object. The model assumes that the human mind looks like an information processing system, which has several functions of information processing: valuation, integration and response.

The information processing paradigm has been the most relevant paradigm in computational and simulation modelling for quite a long time, for many scientific domains, social sciences research included. In psychology and social psychology, this paradigm, notwithstanding wide scepticism and severe difficulty of gaining acceptance in quantitative research, has succeeded (even if late enough!) in gaining the attention of modelling researchers: IIT is true proof of this significant advance on the interdisciplinary orientation of social sciences modelling research.

A class of models take as their basic assumption the idea that attitudes are formed with respect to one’s beliefs about an attitudinal object. Such beliefs are then involved in the evaluation of the utility of particular attributes of the object. An overall evaluation sums up all these attributes’ evaluations and finally an attitude is formed. The models have strong mathematical support in employing the subjective probability calculations.

Attitude is formed by combining various beliefs and the results of evaluations based on such beliefs with respect to the object’s attributes.

Affect in Attitude Formation and Change

Since the early interest in explaining reactions to objects and situations, affect or affective states called dispositions have been considered as dominating such reactions (Wundt, 1897, 1902). Further developed, especially after the cognitive revolution, affect has been shown to play a relevant role in social interaction, judgment and preference formation, to get associated with pieces of information in information processing and stored in the memory structures as valence associated with attitudes and attitudinal objects. Moreover, affect could induce instant choices even before proper deliberative processes might take place (Zajonc, 1980).

The primacy of affect along with the motivated reasoning mechanisms and theories has been employed in political information processing, political judgment and in political cognition theories and models (Lodge and Taber, 2005).

The following cognitive models of attitude change are repeatedly evoked by several modelling approaches in the subsequent chapters. They are briefly presented in this chapter for both experts and non-expert readers with the aim of synthetically aggregating a huge amount of exquisite conceptual modelling research which has been developed over the past half century.

MODE Model (Fazio, 1990)

The model was elaborated by Russell Fazio in the 1990s (Fazio, 1990) and extended afterwards by Fazio and Olson (2014). The MODE model is based on dual processes (Fazio and Towles-Schwen, 1999) and addresses the processes of the mind which
mediate the relationship between attitudes and behaviours. The attitudes are shown to guide behaviours by means of two types of processes: deliberative and context dependent (Fazio, 1995). The spontaneous processes regard the automatic activation of memory structure of attitudes and attitudinal objects, which could guide behaviour even without conscious processes underlying rational inferences and choices. The deliberative processes concern the choices between alternatives on utility-based evaluations. Motivational processes depend on the resources an individual has or could employ in controlling behaviours. Behaviours could be guided by combinations of such processes (Fazio and Olson, 2003).

**RAS Model**

The model is based on the idea that attitude structure has both memory‐stored and online components which get different degrees of accessibility as they become associated with affect values (valences) and therefore impact the information processing and the individual’s response to the social and political communication messages (Zaller, 1987, 1992). From a political attitude theoretical perspective, the dual-process background and the four axioms of the model (reception, resistance, accessibility and response axioms) address the issues of political awareness and political involvement as basic requisites for the individual’s political judgment and choice (Zaller, 1996). Along with other dual-process, affect-oriented models like the impression‐driven model (Lodge et al., 1989), the RAS model provides insight into political cognition and political information processing issues.

**Persuasion Models of Attitude Change**

**Yale Model**

The Hovland–Yale model of persuasive communication (Hovland et al., 1953; Hovland et al., 1957; Hovland, 1972) is based on the ‘source–message–receiver’ scheme in modelling the individual actor (receiver), the source of messages and the political attitude formation and change in both individual voters and a large population of voters. The receiver is a potential voter in an electoral campaign or in a propaganda campaign, which receives messages from external sources, like the campaign media. Attitudes as well as beliefs are subjected to persuasion processes. Persuasion is successful, meaning that the receiver is persuaded to adopt a particular issue position or political attitude, if both the messages and the sources have their attributes of credibility, competence and authority highly-evaluated by the receiver.

**Cognitive Response Model**

Cognitive response theory and models are based on the idea that people involve cognitive efforts in information processing of the (persuasive) messages they receive. They are based instead on empirical evidence in persuasion scenarios and address attitude formation and change processes induced by persuasion situations and processes (Greenwald, 1981, 1989; Petty et al., 1981).
Elaboration Likelihood Model

In this model, the attitudes are approached as evaluative judgments (Petty and Cacioppo, 1986a). The model is based on the concept of the elaboration continuum; any point on this continuum is a characterization of the motivation and the cognitive abilities of a person to elaborate on the relevant qualities/merits of the attitudinal object (i.e. person, event, issue).

In making evaluative judgments with respect to an object, people actually evaluate the object with the goal of determining how good or bad an object is. In making evaluative judgments of the likelihood, people actually determine how likely (or unlikely) it is for the object to prove good or bad to them. In doing so, motivated people would involve an effortful evaluation judgment in which they would use the knowledge they already have (if any) and the new information they get about the object and its attributes. The elaboration continuum can thus be described as follows: at the high end, a point will describe an attitude change which has been achieved by analysing the object-relevant information and by involving personal knowledge and reasoning. This kind of attitude will be resistant to counterarguments, and will prove to be of a higher degree of stability and strength.

At the low end of the elaboration continuum, a point will describe an attitude change which has been achieved with a low effort of evaluation of the available information. Such attitudes could be achieved by processes which do not involve high cognitive abilities or resources, like classical conditioning, self-perception or heuristics.

The elaboration likelihood model postulates are as follows:

• Postulates 1 and 2 regard the (subjective) correctness of attitude.

• Postulate 3 regards the amount and direction of attitude change, which depend on variables which produce persuasion by involving one or more mechanisms.

• Postulates 4 and 5 regard the objective evaluation and biased (valenced) elaboration.

• Postulate 6 regards a trade-off between the central and peripheral processes.

• Postulate 7 concerns the attitude strength as produced by central (high strength, more resistant attitude, higher stability) or peripheral processes (low strength, unstable attitude).

Central and Peripheral Routes for Persuasion

The elaboration likelihood model describes two fundamental processes (dual processes) which underlie the attitude change in persuasive communication, and how the strength of these attitudes is modified: central and peripheral processes (Petty and Cacioppo, 1986b). The central processes are those which involve extensive cognitive effort in the information processing of messages, in evaluating the attributes of
the object or issue, whereas the peripheral processes require less cognitive effort. The two kinds of processes differ both quantitatively and qualitatively.

**Dual Processes (Wilson and Hodges, 1992)**

The idea that attitudes are constructions which vary in time and context was initially introduced by Bartlett (1932) in his experiments on memory and reminding.

Research literature on attitudes shows interest in the idea that attitudes are constructions based on the available schemas’ (Tesser, 1978) preponderant structural component, that is, cognitive, affective or behavioural components (Zanna and Rempel, 1988; Fazio, 1990).

Attitudes are constructed and not reports on the memory content. Construction is based on large databases of beliefs, behaviours and other components. Attitudes could be contradictory: they are not consistent since they use only subsets of this database (knowledge, beliefs, behaviours and other elements).

One relevant source of influence is represented by context (situational factors): accessibility of attitudes and moods. Another relevant source is represented by the thoughts involved in attitude construction about the attitudinal object, and reasons.

Attitudes vary in their (1) latitude of acceptance, (2) strength and (3) structure. Strong attitudes are more stable, whereas weak attitudes are unstable.

**Argument**

The conceptual aspects of political attitudes appeared as a modelling research issue in the early social psychology papers, which initially addressed the measurement issue. As the theories of social influence gained terrain, and the theories of computational and simulation modelling penetrated social psychology research, political attitudes attracted more and more research interest. The first computational and simulation modelling approaches on political attitudes were elaborated in social psychology research. It is in this area that political attitudes first appear as a modelling issue, and it is also this area which has provided for the further development of political attitude modelling research as a distinct area. The brief history of the attitude concept and models is, therefore, essential for the understanding of the development of the political attitudes modelling area and its impact on political science research.

Political science research has been traditionally interested in voting behaviour studies. Distinctly approached in the Columbia model, and especially in the seminal work of Philip Converse, political attitudes have been a computational and simulation modelling research issue in political science since the 1960s.

**Web Resources**

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Chapter 1 briefly introduced the conceptual backgrounds of political attitude computational modelling research in social psychology. This chapter presents the computational backgrounds and the historical development of political attitude computational modelling research in political science and political psychology.

Computational modelling of political attitudes has a solid background in social simulation research, which has requested and often imposed a certain way of approaching the issues. Nonetheless, political science research, especially in the area of electoral studies, started quite early creating a way of its own in approaching political attitudes. This has resulted in eight ages of systematic development toward including the most relevant theories about information processing and cognition, drive and affect, values and culture, norms and institutions, society and polity. Starting with the mid-1940s, we have identified eight ages in the development of computational modelling of political attitudes. There are four main ages of continuous development of computational modelling of political attitudes which roughly overlap the ages of attitude research development in social and political psychology as described by several authors (Katz, 1989; McGuire, 1989; Converse, 2006; Sullivan et al., 2009).

The first age starts with the Columbia model and the first computer simulation model developed by William McPhee in the late 1950s, while the second age focuses on the Michigan model, since each school of thought brought a conceptual
framework of its own. Starting with the 1960s, we identify four more ages characterized by specific conceptual and computational modelling paradigms:

The 1960s could be viewed as the age of political culture modelling, the 1970s appear as the systems dynamics modelling age, and the 1980s represent the age of social influence models. Starting with the 1990s, the artificial life (ALife) theories and technologies have deeply transformed political attitude computational and simulation modelling research. The 1990s cover the bottom-up modelling age, strongly dominated by artificial society models; after 2000 political cognition models are coming of age, and starting from 2010 the age of social complexity modelling witnesses advances in the artificial polity models.

Methodologies and conceptual backgrounds from both political and computer sciences have provided support to the development of political attitude modelling as a rapidly growing interdisciplinary research area. Though not a discipline in its own right, political attitude modelling research is actually building new theory upon the solid conceptual frameworks of experimental political science and social simulation research. It is thus enhancing the emergence of new computational and simulation-based disciplines within the traditional domain of political science: a desirable (and long-awaited) computational political culture, and (not at all surprising, given the parallel developments in the computational social sciences) computational political science. Free from some classical constraints and limitations which characterize experimental political science, political attitude computational and simulation modelling has succeeded in accumulating so far a critical mass of theory and method, thus shaping the contour of the emerging areas and contributing a substantial and consistent body of theoretical and experimental work.

This chapter presents the ages, the main modelling schools of thought and the likely trends for the near and far future of this research area.

Conceptual Modelling Backgrounds

Conceptual modelling in political attitude research has often been inspired by the fast and impressive developments in social psychology, starting with the early 1940s.

In its early days, political psychology was marked by personality studies, Freudian psychoanalysis and behaviourist psychology research. As the cognitive revolution won over the behaviourist thinking, a major paradigmatic change transferred the research focus from the stimulus–response to cognitive-based modelling approaches of political attitudes and their relationship to behaviour.

The computational modelling approach has found a fertile terrain in political attitude research. Moreover, computer technology and, especially the forecasting dimension of the computer simulation studies in the social dynamics area, have reinforced the tendencies toward prediction of voting behaviour, voting choice and political preference formation and variability. Thus, major projects and impressive resources have been systematically invested in political attitude research, especially after the mid-1940s. Even from those days, computational modelling appeared a proper way in which to approach the study of political attitude change. It took a while,
however, for political science research scientists to defeat a certain apprehension and get acquainted with computer technology (Johnson, 1999).

Computational modelling in social psychology has often served in political attitude research as a basis to start from. Truly computational and simulation modelling of political attitudes has always carried a social psychology heritage which undoubtedly reinforced its own creativity and the capacity to sustain research work. Soon, political science research started developing autonomous backgrounds in both conceptual and computational modelling of political attitudes. It is this subject that we approach in this chapter, in particular, and in this volume, in general: the stages of development, the main theories and paradigms, and some of the most relevant computational and simulation models of political attitudes.

This chapter introduces a chronological view of the history of the computational and simulation modelling research of political attitudes. Starting from the times of Columbia electoral studies, the ages and the main schools of thought in this area and in the closely connected areas of research are briefly introduced with the aim of identifying and explaining the background sources and influences in the construction of the main conceptual and computational modelling approaches. The concluding remarks summarize our view with regard to the trends for the near and far future in political attitude computational and simulation modelling research.

**Attitude Research in the Early Days of Social Psychology …**

The brief history in Chapter 1 presents the times and the main themes in the early days of social attitude research, describing the context of the emergence of social psychology as a new discipline having the attitude as a fundamental concept.

By the mid-1930s, Gordon W. Allport’s definition (1935) appears as a great challenge in sociological and psychological research: it introduces a new vision about the processes behind attitude formation and change. Allport speaks about dynamically organized experience of interaction between the individual and the environment, whatever the meaning of ‘environment’ could be: physical, social or abstract. He also speaks about a conjoint state – mental and neural – which is responsible for how, when and why an attitude is ever formed or changed. Nothing points to the classic behaviourist scheme and even less to the Freudian psychoanalysis. On the contrary, everything looks like a complex picture described in basic terms: action potential, control, reorganization and interaction. Notwithstanding its simplicity and elegance, the definition proves so strong a sense of complexity as to challenge new approaches almost one century afterwards.

However, one should not draw the conclusion that, as soon as it had been issued, this definition completely changed the picture in attitude studies. Unfortunately, it did not. At least, not immediately. And not even soon afterwards. What happens in the same period looks at odds with the introduction of the new concept. What Gordon Allport seems to synthesize in his theory is a strong role of social interaction and
purpose in individual action expressed in a highly context-sensitive concept of attitude as deliberation for action and dynamic organization of behavioural experience. However, reviewing the attitude research literature on political attitudes of that time, we will notice that Freud’s theories and behaviourist approaches are still in place and Gordon Allport himself could hardly escape them. He published (1929) relevant research on political attitudes in which he starts from the hypothesis that people’s political choices are dependent on the individual’s personality and ideological preferences. It was perhaps too early to impose the new idea of political ideology modelling as a complex pattern of beliefs, values, political attitudes and a sophisticated political cognitive support including both internal resources and external sources of information. Almost one century after Gordon Allport formulated it, this is still an open question.

… and Political Psychology

Political psychology addresses the political behaviour of individuals in relationship with a particular polity. As such, the political behaviour of the individual citizens is viewed in a dynamical interdependence to the social norms, political culture, institutions and leadership (Huddy et al., 2013). Early political psychology theories were based on moral approaches of political behaviour and political leadership. In this view, some authors consider the political psychology approach as rather a psychological perspective on the very domain of political science (Krosnick, 2002a). At some point on this relative positioning of political psychology with respect to political science, the political attitude research inspired a separation of conceptual positions (Krosnick, 2002b). Other authors (Lupia, 2009) define political psychology from a rational choice theory perspective, emphasizing more the rationality aspects (preferred in economy-based models) than those of personality trait, affect and emotional phenomenology (preferred by psychology-based modelling). Still others include in the history of political psychology multidisciplinary backgrounds, like the psychology of leadership, social psychology, social learning theories and the theories about the priming of affect in political information processing and political cognition (Sullivan et al., 2009). Contemporary political psychology is based on political information processing and political cognition theories and employs a considerable level of experimental and quantitative analysis (Kuklinski, 2002).

Analysing the history of political psychology from the early 1920s until the late 1990s, there are three periods which appear relevant for its development and which will be treated in more detail in what follows: there is a first interval between the 1940s and the 1950s, a second one between the 1950s and the 1970s, and a third period between the 1980s and the 1990s.

Lasswell laid the foundation of political psychology on the Freudian paradigm (Lasswell, 1930, 1931; Baran and Davis, 2014: 48–50). Often, his interpretation of attitude proves a strong behaviourist tendency (Lasswell, 1936: Chapter IX, p. 427). In his earlier studies on propaganda involving a thorough analysis of the individual personality from a Freudian (psychoanalytic) position, Howard
Lasswell (1927) draws the conclusion that political attitudes can be strongly influenced by means of ideological propaganda.

Some authors (Sullivan et al., 2009) distinguish several development stages in political psychology. During the 1940s and the 1950s it is dominated by the works of Howard Lasswell on personality. During the 1960s until the late 1970s political attitude research is dominated by the behaviouristic approach in psychology, attitude change, belief systems and voting behaviour in social psychology, and the research on political symbols in political science (Sears, 1983). A third stage starting with the 1980s until the 1990s is dominated by the political ideology and belief systems.

**Attitudes in Political Science**

The foundations laid by psychology and social psychology in attitude research have represented for quite a long time a solid background in political science. Attitude has not been defined in political science once again or differently than it has already been defined in social psychology. On the contrary, political science has started building up a whole new theory on the previously elaborated conceptual background worked out during the early 1920s and 1930s when social attitude theories penetrated political science, providing for the later development of political attitude theories in political psychology.

Political science research employed attitude definition and conceptualization mainly for the study of political behaviour. The electoral studies developed by the Columbia sociologists during the 1950s as well as those developed a decade later by the Michigan group extensively used the classic social psychology theories on attitudes. Though still dominated by personality theory and behaviourism, such electoral studies provided the conceptual foundation of influential models of political attitudes, ideology, political behaviour and political culture.

The classic approach in political science research on attitudes is the functional approach. As elaborated in social psychology, the functional approach served as reference and conceptual background for a similar approach in political behaviour studies (Campbell et al., 1960). In the functional approach, the attitude definition includes (a) object appraisal, (b) mediation of self–other relationship (social adjustment) and (c) externalization and ego-defence. For the first time, belief systems are described as organized and structured in hierarchies in which beliefs can condition other beliefs in relationships which provide meaning to the attitudes based on such structures. Campbell and collaborators introduced reference group theory and extended the presidential elections empirical basis of survey research to a national level.

During the 1970s and the 1980s, attitude theories, enriched with cognitive science support, were combined with theories on social cognition and social judgment which have provided the background for the new political information processing and political cognition models of behaviour, mainly elaborated by the Stony Brooks group. Memory-based and online models have been combined to explain the ways in
which individuals perceive and process the political information in an electoral campaign (Lodge et al., 1995; Lodge and Taber, 2005). Their theory and model of political cognition was founded on the conceptual background laid down earlier by the research developed by Petty and Cacioppo (1986b) on the central and peripheral routes to persuasion and on the Elaboration Likelihood Model (ELM) dual-path, multiple-process model of persuasion and attitude change (Petty and Cacioppo, 1986a).

The Ages

This section presents a chronology of the main theoretical and experimental trends in political attitude research starting in the first decades of the past century until the present days. Several authors have identified roughly the same stages in the development of political attitude research. However, many of these authors have synthesized a period of time which does not go further than the beginning of the 1990s. The true story of computational and simulation modelling of political attitudes was just about to begin at that time, though it had been prepared during the previous four or five decades. Starting in the 1990s, the computational and simulation technologies acquired a high capacity for creating and manipulating large populations of artificial agents in virtual space and time. Artificial Life technologies (ALife) have been intensively employed in the agent-based modelling and simulation of artificial societies and polities.

Political attitude computational modelling research has developed fast over a period of time of eight decades in continuous stages covering no more than one decade each. From a general perspective, one might say that there are two main ages: before the 1990s and after. The political attitude modelling literature is mainly concerned so far with the first age, while in this book we are more concerned with the second one. Let us take a closer look.

The early history of political attitude modelling research starts at the beginning of the twentieth century with psychological studies of voting behaviour (Visser, 1998). By the mid-1950s, political attitude modelling research was strongly dominated by the propaganda issues which provided systematic support to the development of political persuasion studies (Hovland et al., 1953; Hovland, 1957). The influence of propaganda theories would have a strong, however delayed impact on political attitude modelling research. Later in the 1970s, social influence theories based on the previous propaganda and communication studies reinforced the modelling research on political attitudes. It is this body of social influence modelling theories which, at that time, was associated with the new computer technologies and employed for approaching one of the most enduring and stimulating research questions of political attitude research: the political context. It is worth studying the ways in which political attitude research has approached this fundamental issue and, consequently, another fundamental issue: attitude change.

Daniel Katz (1989) distinguishes three stages in the emergence of attitude research: the first one, characterized as definitional research, regards the period between the
In the 1920s and the 1930s, the second stage covers the functionalist theories of attitude formation and change strongly dominated by behaviourism, and finally a third stage dominated by the cognitive consistency theories.

William J. McGuire (1989) describes and explains the history of political attitude research as a half-century history divided into three main stages: electoral studies and voting choices, structural attitude, and ideology. During the 1940s and the 1950s, attitude research was dominated by theories of personality and the Freudian psychoanalytic paradigm of attitude conceptual modelling. A second stage between the 1950s and the 1970s was dominated by voting behaviour and voting choice studies which laid the foundations for political persuasion and political attitude computational modelling. A third stage between the 1980s and the 1990s corresponds to the age of the cognitive revolution in social sciences: political attitude modelling is focused on ideology modelling research.

Philip E. Converse (2006) makes a conceptual description and explanation of these stages as he has perceived them since the days in which he contributed to the elaboration of the Michigan model. Chronologically, he identifies two major stages: the micro and the macro studies. He describes each decade since 1960 as a distinct age of development at both the conceptual and experimental levels. The initial age corresponds to the period of elaboration of the Michigan model. It is with this age that Converse’s masterpiece on mass beliefs and political attitude instability is actually associated. In the subsequent stages, his political culture model has been improved by Nie, Petrocik and Verba who have taken into account policy issues and party identification for explaining the (in)stability of political attitudes (Nie et al., 1976, 1979). Finally, Converse talks about a macro-studies age, making reference to the macro polity impressive report elaborated by Erikson et al. (2002) as a fundamental theoretical and experimental contribution to the study of political attitudes in the aggregate.

In the view presented in this book, the main ages and paradigms in political attitude modelling research have been related to social attitude research. Especially after the 1970s, the history of the political attitude modelling research area should be drastically amended for at least three reasons.

First, there is major concern within the political science domain with respect to the technology underlying the research methodology: the period starting in the late 1970s until the present day has been a time of powerful technological discoveries, appropriately echoed in the political methodology area by the clear orientation toward employing the ALife technologies in modelling research: cellular automata, agent-based systems, complex adaptive systems and, lately, the huge class of web technologies. Also, social networks research (Watts and Strogatz, 1998; Goel et al., 2010) has strongly influenced the type of modelling and experimental approach in political attitude research, in particular, and in political science, in general.

Second, the social simulation research developed after the mid-1990s has stimulated political science research to adopt the same research methodology. The examples to provide here are many. One is the social force field model introduced by Lewin (1947a, b) and extensively used in the social influence theory and its applications in political attitude change and political persuasion modelling (Nowak et al., 1990;
Another one (to name but two of the modelling approaches presented in this book) is represented by the diversity survival model (Huckfeldt et al., 2004) which adapts two social simulation models, namely the artificial society model (Epstein and Axtell, 1996) and the culture dissemination model (Axelrod, 1997) so as to tackle the idea of political attitude change modelling in the small worlds.

Finally, one should make a clear distinction between what has already been recognized as Experimental Political Science (Druckman et al., 2006, 2011), and what is currently getting shaped as the emerging Computational Political Science, a field of research within the general domain of political science which would be fundamentally based on the most advanced computational and simulation technologies. This distinction helps one comprehend the past and the present of political attitude research and to get a real picture of the future of political science research, in general. Experimental Political Science represents the elegance of the conceptual and experimental background of the past as it aggregates the most exquisite achievements of more than one century of classic political analysis and political methodology, empirical research and statistical modelling. Political attitude research represents the force of the present as it achieves an interdisciplinary synthesis of the most advanced political science theories and the latest computational and simulation technologies. It is worth studying the trend of development induced by the political attitudes computational and simulation modelling research within the global domain of political science: it shows – as this book is trying to prove – an increased overall capacity of political science research to embed a huge constellation of both specific and interdisciplinary modelling approaches which intensively employ the new computational and simulation technologies in order to cope with the complexity of political phenomena and achieve a more powerful explanatory power in what determines the dynamics of change of both societies and political regimes all over the world. Computational and simulation modelling seems to be a new type of approach in political attitudes research, while actually it is not. It appeared around the mid-1950s as a side effect of a social and political context and has been reiterated ever since every decade or two. It appeared much later after the rise of Experimental Political Science. While Experimental Political Science has repeatedly proved declining tendencies, computational and simulation modelling has proved an enduring increasing and extending tendency, much reinforced by its undeniable capacity to sustain theory building.

In our view, the ages of conceptualization and development in political attitude modelling research as defined and justified in this chapter, though distinct, are nevertheless very much interconnected and intermixed. Over long periods of time, some conceptual and methodological research issues appear as recurrent themes. Once re-appeared, their approach is designed so as to adapt to the new computational and simulation modelling technology and research methodology.

What both William McGuire (1989) and Philip Converse (2006) have identified as distinct periods of conceptual development based on clear paradigms and research questions in political attitude modelling is actually a period of about four decades between the 1950s and the 1990s. At the time, computational modelling appeared as a relevant research methodology, at least for the research area of system dynamics which was in vogue among the industrial management modelling experts (Forrester,
1958, 1968). However, at the beginning of this period, computer technology was not appropriately developed for decisively impacting research areas which had traditionally employed survey research, like electoral studies and voting behaviour modelling. It was, eventually, not (sufficiently well) known in order to be able to fulfill the expectations for performance of a research community which was more used to praising the intrinsic value of data than the time a computer needs for providing full statistical analysis outcomes. And, perhaps, not cheap enough to sustain and accomplish the methodological needs of a rather small research community like the political attitude modelling community. To resume Johnson’s thorough analysis of this matter (1999), for the political scientists eventually involved in political attitude research, computer technology was a real problem, as it was perceived by both computer science experts and the political scientists who remained for a while (quite long, as some would like to argue) in the embarrassing position of non-experts. As technologies of the artificial – like cellular automata (CA), artificial intelligence (AI), artificial life (ALife), machine learning (ML), knowledge representation (KR) and distributed multi-agent systems (MAS) – have been developed and systematically diversified with a strong orientation toward achieving the techniques of artificial autonomous agents, the old subject matters in political attitude modelling research have been approached again and new solutions have been provided to the issues of political interaction, political context and, lately, to political information processing and political cognition.

As this historical picture appears to us today, we could dissect this period of time into several distinct time intervals which are generally characterized by different computational technological backgrounds and different conceptual paradigms of political attitude formation and change. We would call these time intervals ‘ages’ as they actually mark complex paradigmatic shifts of focus from one type of conceptual modelling paradigm to another and from one type of computational modelling technology to another.

We start this analysis in the late 1940s. We will trace back all the relevant moments on two parallel dimensions of research: on the one hand, the social simulation modelling of social and political attitudes; on the other hand, the computer science modelling technologies applied to social and political attitudes. We have thus identified eight ages.

First Age, The Golden Age (From the Mid-1940s Until the Late 1950s): Columbia Model and the Role of Social Context

Between the mid-1940s and the late 1950s, political attitude fundamentals as well as modelling research flourished primarily in the area of electoral studies, especially in the US presidential elections, for which huge amounts of electoral empirical data were systematically collected both at local and federal levels by a powerful network of statistical offices specialized in the collection and analysis of these data. The classical paradigms of the early days of both social and political psychology – the Freudian and the behavioural – do not disappear, but their relevance diminishes. Research focus shifts toward political attitudes and their relationship with the
political behaviours: intensive studies are developed with concern to their structures, and their role in predicting voting behaviours and electoral outcomes.

The golden age of political attitude computational modelling starts around the mid-1940s with the Columbia model elaborated by a team of sociologists at Columbia University (USA) under the supervision of Paul Felix Lazarsfeld. The Columbia model was elaborated for evaluating the political preferences and predicting the voting choice of people in local communities in presidential elections starting with the 1940 US presidential elections. The electoral studies developed by the Columbia team were aimed at modelling the voting behaviour of the people in local communities. Such behaviour was viewed as dependent on social status, social context and internal predispositions or what we call today ‘attitudes’ (Lazarsfeld et al., 1944; Berelson et al., 1954).

The Columbia model emphasized two fundamental ideas: the importance of social context and local interactions among the citizens of a local (small) community during the period of presidential elections. The voting choice of an individual citizen is modelled as a dependent variable. The variability of the voting choice depends on the citizen’s social status. As relevant elements for the social status, the model employs sociometric measurements and takes into consideration the rural/urban residence, religion and social position of individual citizens. The model, however, is based on a body of theories which illustrate the voting choice as the outcome of political attitude formation under several social context factors. One such theory is concerned with the local interpersonal networks (dyadic networks), which are fundamental for the formation of political attitudes. A second one regards the role of elites, which are assumed to dominate the interpersonal networks of relationships of the individual citizens and influence their political attitudes. A third one is based on the homophily principle (Merton, 1948; Lazarsfeld and Merton, 1954), that is, individual persons like to discuss with peers who confirm or agree with their own opinions. The theory of the two-step flow of communication emphasizes the role of elites in the formation of an individual’s political attitude (Katz and Lazarsfeld, 1955; Katz, 1973).

For the first time, the electoral studies were simulated on a computer by a young member of the Columbia sociologists group: William McPhee. He is the author of the first computational model of political attitude formation and change, later developed together with two of his collaborators: Robert Smith and Jack Ferguson (McPhee and Smith, 1962; McPhee with Smith and Ferguson, 1963). In order to model the variability of the individual citizen’s political interest in the presidential elections and candidates, McPhee combined several relevant theories about attitudes as internal predispositions, about the role of communication in the formation of political attitudes, and about the learning theories based on the classic stimulus-response paradigm. The computational modelling technology was based on a classic algorithmic design of three processes (McPhee, 1961, 1963; McPhee and Smith, 1962; Smith, 1969, 1985) describing (a) the stimuli perception by the individual voters, (b) the update of the variables describing the individual’s political interest level and attitude attributes (i.e., direction and strength) and (c) the learning (and forgetting) of the stimuli perceived during an electoral campaign. The input stimuli were simulated by a distribution of values
based on preliminary sociometric measurements. Though strictly deterministic and with a huge but limited number of iterations (i.e. equal to the number of individual actors as they were registered in the official electoral statistics documents), the program written and tested by McPhee and his collaborators proved an elementary capacity to achieve a dynamic variation of the variables describing the political attitude values (in both direction and strength). This undoubtedly encouraged the researchers to test it later in the real presidential campaign with the explicit purpose of predicting the voting preference distribution on the voting day and at some customized intervals of time ahead of the voting day. The work was exhausting as the program was actually written, tested and run in a machine-level programming language. However, hope burst out when the results not only confirmed McPhee’s expectations, but also exceeded these expectations. As he realized the power of the computer simulation in predicting political attitudes, McPhee became very active, struggling during the next years to initiate, together with James Coleman, an impressive research programme on computer modelling and simulations of the political attitudes in mass electorates (McPhee and Coleman, 1958).

Though started on the solid background of the Columbia model, and benefitting from the visionary ideas of two impressive personalities, McPhee and Coleman, the idea of a computer simulation model of political attitude dynamics has been extant for many years after. It has been transferred to several other teams and projects, year after year. The fundamental targets initially formulated by McPhee and Coleman in 1958 are still to be reached: the study of the emergent political phenomena in large masses of electorate by means of computational simulation (McPhee and Coleman, 1958).

It was as interesting and appealing idea as it was extremely demanding. Perhaps it appeared too early: man and machines were not yet prepared for taking this challenge.

Second Age (1950s–1960s): The Michigan Model and the Role of Political Ideology

*The American Voter* (Campbell *et al*., 1960) is essentially describing a modelling approach of the formation and change of a citizen’s political attitudes and voting choices. The approach is known as the Michigan model, and it differs from its Columbia predecessor in the philosophy underlying the conceptualization of the model: while the Columbia model is based on the concepts of social context and local interpersonal communication networks, the Michigan model is based on nation-level surveys which bring a different picture over individuals’ voting choices. The model identifies different factors which are assumed to matter in shaping individuals’ electoral preferences: political interest and partisanship, policy position and ideology. The modelling approach addresses a relevant theory of the time: reference group theory.

The Michigan approach on reference group theory takes into consideration two aspects of the relationship between the individual and the reference group: one regards the relationship between the individual and the group, while the other is
concerned with the relationship between groups and politics. Campbell and his collaborators show that the more proximity between group and politics is perceived by the individual belonging to the group, the more the individual is influenced by the group in the electoral preferences (Lau, 1987: 192–193). Motivational functionalities of the attitude structure are a characteristic of the behaviourist paradigm. Campbell and his collaborators approach the political attitude issue from a functional perspective: they assume that attitude structure is based on functional relationships between two or more beliefs. Several types of functional relationships are identified, like (i) means–end and (ii) motivation-based relationships.

Attitude structures, described as hierarchies which include beliefs and their connections to basic values, enhance congruence-based inferences and judgment. The hierarchic structures may also enhance prediction about individuals’ issue positions based on knowledge about individuals’ beliefs. Campbell et al. (1960) achieved an advanced view upon (i) political attitude structures and (ii) their operationalization. Their work defined ideology in terms of attitude structures and developed the first operational models of prediction of voting behaviour from the study of clusters of attitudes at the national level. Attitude definition includes elements of object appraisal, belief structure and organization (hierarchies of beliefs), and behavioural components. Elements of personality theory are still present in Campbell et al. (1960) and also in the studies developed by McPhee and his co-workers on socialization and inheritance of an ideological preference from family (McPhee, 1963; McPhee, Smith and Ferguson, 1963).

The Michigan model is closer to the A–B–C model of attitude structure than the Columbia model and it will set the pace for the later studies developed by Philip Converse (1964).


While still in the middle of the second age, and separately from the Michigan electoral research, which endures in spite of deep modifications brought later by Nie, Verba and Petrocik (1976, 1979), Philip Converse, the youngest member of the Michigan team, published his mass belief model (1964), a remarkable paper, which actually initiated and defined the third age. It roots the individual voting choices in the individual ideological leanings and draws rather pessimistic conclusions about the common American voter. The model explains the attitude instability and the ideology confusion in individual voters by the level of education and low individual cognitive resources. Ever since its publication, Converse’s model dominated the field of ideology-based modelling in political attitude research. Moreover, it laid the foundations of the operational view of political culture theory.

Converse’s was a purely empirical model, however; the only one which was fully tested against empirical data at the federal level. Popular and stimulating, it became a standard reference for all subsequent computer simulation research. Ideology-oriented research would start to dominate the field in the late 1980s until the present days.
In the same period of time, Gabriel Almond and Sidney Verba (1963) elaborated their own political culture model. More than Converse’s, their model makes strong ideology assumptions in describing political attitude formation and change. The major contribution of these classic political culture models is the introduction of a classic operational view upon political culture (dependent variable) in terms of political attitudes, political beliefs (ideology) and values, which are defined as independent variables. Both approaches process huge amounts of public survey data and perform an exquisite political analysis in statistical terms. Both models only address empirical experiments. For a long time these two models provided the main framework for the political culture approach in electoral studies in general, and in political attitude modelling and simulation research in particular. While dominating the field for the next decades, neither of the two modelling approaches will result in a computational modelling approach. During the late 1970s, Elkins and Simeon (1979) noticed that the political culture paradigm makes strong comebacks every time societies in crisis are in search of political attitude-based explanations of their dynamics. Later, in the 1990s, the political culture approach made its latest powerful comeback as reiterated by the political change phenomena associated with the fall of the Berlin Wall in eastern Europe.

The extended and consolidated empirical basis of the classic political culture models has cast a shadow over the computational and simulation modelling of political attitudes. It has nonetheless continued penetrating the area and has followed a different path than that seemingly opened by political culture research. The alternative appeared as a distinct research programme aimed at identifying the appropriate technology for predicting political attitudes and behaviour. This endeavour employed the most advanced research approaches of that time: spatial and multidimensional models of the dynamics of political attitudes and ideology change (Woelfel and Saltiel, 1978). Its roots should be sought in the social persuasion paradigm inspired by Lewin’s idea of a social force field (Lewin, 1947a, b). The idea inspired the social influence theories and dominated the social psychology research on attitude change for the next decades until the late 1990s when it was finally challenged by the theories of complexity. As a matter of fact, it has never been truly dismissed. Its connection to Newtonian dynamics is still sustaining its explanatory power in modelling attitude change as a dynamic process.

The first to think about the motion of ideas in Newtonian dynamics terms was a German philosopher, Johann Friedrich Herbart. He defined a mechanics of ideas in which ideas’ motions are guided by mechanical laws (Boudewijnse, et al. 2001: 108). Herbart wrote about that at the beginning of the nineteenth century, but his dream of fully elaborating a mathematical psychology has never come true. However, much of his dream was revived once again during the 1970s by the Galileo Project Team.

**Fourth Age (1970s–1980s): The Social Force Field Models and the System Dynamics Paradigm**

From a theoretical perspective, this age is dominated by the revolutionary effects of two theories which had actually started being developed much earlier: the social force field theory (Lewin, 1947a, b) and the theories in cognitive psychology.
introduced by Norman Anderson in late 1950s (1959, 1964) and further developed for more than a decade (1981–2008) as the Information Integration Theory (IIT) of information processing in cognitive psychology.

The force field paradigm was inspired from physics and adapted by Kurt Lewin (1947a, b) so as to model the social influence and persuasion as forces exerted through communication between the individual actors. This paradigm successfully replaced both the Freudian and the behavioural paradigms. In a short while, attitude modelling research almost entirely sunk into an ocean of formal models in which the attitude is put in motion by the social forces of persuasion exerted by messages transmitted in the communication processes, usually electoral campaign communication.

Political propaganda models, elaborated by Carl Hovland and the sociologists in the Yale team during the 1960s (Rosenberg and Hovland, 1960), were re-modelled with a new mathematical formalism: message and attitude were defined as variables in a Newtonian mechanics scenario of ‘force’, ‘mass’, ‘motion’ and ‘acceleration’ which were easily transformed into a computer simulation program. The force was represented as the effect of transmitting a persuasive message from a Source to a Receiver. A message was characterized by a conceptual structure and by its ‘mass’, that is, the amount of information which it carries. A Source has attributes of credibility, competence and authority represented as numerical values. The range of such (normalized) values is meant to express the domain of variability of these attributes. A Receiver represents the individual actor (usually the voter) who holds an attitude toward the Source and an attitude toward the object of communication. The Receiver is subjected to persuasive message communication so that the Receiver’s initial attitude toward the attitudinal object is influenced by both her attitude toward the Source and by her attitude toward the object as persuaded by the message. As the message carries the attitude which is (tentatively) persuasively transmitted, the Receiver actor evaluates it and accepts it under the constraints induced by her own attitude toward the Source. The Source’s credibility, authority and perceived competence will control the attitude change in the Receiver from the original attitude value to that persuasively imposed through the message.

All this looks like déjà vu: apparently, the Yale model is back in place! However, there is a considerable difference from the original model. What makes it interesting is the computational modelling paradigm.

Let us take a closer look at the computational technology of that time. At a glance, the picture of the computer simulation paradigm in the 1970s is really changed with respect to that employed by McPhee and collaborators in their model. The trend of the time is represented by the social dynamics modelling paradigm developed by Jay Forrester (1968) in his studies concerning social dynamics.

The social force field and the system dynamics paradigms are employed in the computational modelling of political attitudes and ideology. Two kinds of modelling approaches are relevant. The original one has been elaborated as a mathematical model by John Hunter and collaborators (Hunter et al., 1984). It is based on the system dynamics paradigm and uses difference equations to describe attitude variation. This kind of computational model employs system dynamics for describing
the mechanisms and processes which control attitude variation and change. The applications of the model tried out several formalisms for the description of political attitude change in various paradigms:

- behaviourist paradigm, by employing the S–R mechanism,

- information processing paradigm by means of the cognitive mechanisms suggested by the IIT model, and

- cognitive consistency paradigm, by employing the attitude change mechanisms defined by Heider’s balance theory (1946) and Festinger’s cognitive dissonance theory (1957).

The original mathematical model was further developed by Ralph Levine and collaborators (Hunter et al., 1972; Levine, 1983, 2003; Levine and Doyle, 2002). In their advanced version, the difference equations are transformed into differential equations.

This age is by far dominated by the ideology multidimensional models developed under the Galileo project. Spatial models of political attitudes and beliefs provide the integrated framework for achieving a representation of ideology in the Galileo project (Danes et al., 1978; Woelfel and Saltiel, 1978). Multidimensional models assume that an ideology as well as an attitude can be represented as points in the multidimensional space of their attributes (Barnett et al., 1976).

There was, however, another theory which strongly influenced the political attitude modelling research during the fourth age and beyond: the IIT developed by Norman H. Anderson has been the dominating information processing theory in the area of social and cognitive psychology for a very long time, and it still is one of the most relevant theories which have decisively marked the emergence and further development of modern computational modelling. IIT has been elaborated and published over a long period of time, such that its influence has been dominating in both the third and the fourth ages of the development of political attitude computational modelling. IIT is a functional theory of information processing and cognition. It involves basic cognitive processes: perception, thought and response to a perceived stimulus situation (action). Integration of information is based on three basic operations: summing up, multiplying and averaging. The information integration diagram includes three operators. The first one is concerned with the psychological representation of the perceived stimuli (valuation). When there are multiple identical psychological representations (which is the usual case, as there are multiple informers), they are either summed up or multiplied (depending on the context, goal and stimuli). The second one is concerned with the integration of the psychological representations constructed by the first operator into an internal response. The third operator is the action which transforms the internal response into an overt response to the stimulus situation.

IIT was the first theory to represent the stimulus as information, and which modelled the response to the stimulus situation as information processing based on the integration of perception, thought and action. It models information
processing as a cumulative process which actually integrates small pieces of information as they are perceived and internally represented by the human mind.

In the early 1970s, IIT fuelled fierce debates on the purposiveness and capacity of information integration of human behaviour. At the time when system dynamics was gaining terrain, IIT was still fighting the enduring behaviourist mentality in political attitude modelling research. IIT has nevertheless offered a proper view upon information processing and cognition. It is this view which will support the experimental social and political science until another revolution arises in computational and simulation modelling research. Carried this time by the sciences and the technologies of the artificial, it will make it possible for the model to explain the political phenomena by their very complexity: the ‘virtual experiment’. The term has been introduced by experimental research in social psychology which defines and uses the computational simulation as a virtual space for experiments with artificial social systems.


In political attitude modelling research, the 1980s could be described as a time of major scientific discovery. On the one hand, attitude conceptual modelling was dominated by the impressive body of attitude theories in social psychology. Social and political persuasion paradigms, as well as cognitive modelling, allowed for the development of a dual-path, multi-process theory of attitude change: attitudes which are formed by more elaborative processes are more resistant to persuasion and change, while attitudes formed on superficial information and less elaborative processes are weaker and easily change, thus explaining the instability of attitudes in general, and of political attitudes in particular (Petty and Cacioppo, 1986a,b). On the other hand, none of the major computational technologies we know today was yet in place. Computational modelling methodology was dominated by information processing and artificial intelligence (AI) modelling.

On a closer look one could notice that, at the beginning of the 1980s, major changes were about to come and visionary modelling approaches, like Schelling’s segregation model and Latané’s social impact model, started dominating political attitude modelling research and inspiring further developments. It is the age which replaced causality-based with complexity-based modelling, the empirical (observational) experiment with the virtual (simulation) experiment, and the attitude representation as a numerical value (usually associated with attitude strength) was replaced with a structural representation.

From a conceptual point of view, the age is dominated by social influence theories. Persuasion is modelled in the force field paradigm. For political attitude modelling, almost all formalisms were tried out, from purely mathematical, like Latané’s first attempt to model the social impact (Latané, 1981), to the chaotic dynamics and catastrophe theory (Latane and Nowak, 1994). Apart from Thomas Schelling, who reigns in social science modelling research, Bibb Latané is perhaps the most relevant researcher of this age: he tried out all paradigms, tested all the social impact
computational models against masses of empirical data and introduced the first computational models of political attitudes. Though concerned with different issues of research, his models are the best reference of the age for at least three reasons. First, the class of social impact models includes the first true dynamical models of attitude change developed in the force field paradigm. Second, the computational simulations of the social impact prove for the first time complex attributes of self-organization and emergence. Third, Latané was the first to systematically employ computer simulation in theory building.

The dynamic social impact class of models (Nowak et al., 1990) uses relatively simple rules of persuasive impact. Well supported by a cellular-automata implementation, the model achieves self-organization qualities, and the simulations of the model make evident four types of social influence emergent phenomena: clustering, correlation, consolidation and continuing diversity. The model explains how an individual actor’s political attitude changes under the persuasive presence of others. This is relevant, as the class of social impact models includes multiple paradigms: mathematical, dynamic and chaotic. The models do not work on the contents of political attitudes, but on the formal rules that manipulate the contextual factors which facilitate (or not) attitude change.

It is worth noticing that, shortly before 1990, when the first dynamic model of social impact was elaborated (Nowak et al., 1990), the major computational modelling technologies were still missing. The classic dynamic models were using variables and the mathematical formalism of differential equations. The concept of interpersonal networks, as intensively used in the Columbia model, requested social network support, but social network theory was still nascent at that time. Moreover, AI resources seemed almost exhausted and the interest in AI techniques started to diminish. Studies in ALife provided for the advance of cellular automata technology, and for a while it was the only computational and simulation technology in place able to support dynamic computational modelling and simulation. In this context, and inspired only by Dewdney’s (1987) funny computer games, the social impact class of dynamic models appeared as a pioneering approach combining aspects and principles which later on became key concepts in social network theory, agent-based models and self-organizing artificial social system models.

After 1990, this situation changed dramatically. This is the time when computational and simulation modelling of political attitudes and their associated phenomena really starts developing and producing the most relevant approaches.

**Sixth Age (1990s–2000s): A Strong Comeback of the ‘Small Worlds’ Concept and Paradigm. ‘Bottom-Up’ Modelling**

From a theoretical perspective, the age is characterized by the domination of several modelling theories in social psychology, political science and political sociology and computer sciences.

The social psychology approach to political attitude modelling is dominated by constructivist theories, which view the attitude as a construction which is dependent on both the individual’s cognitive resources and on the context. The constructivist
theories appear as a reaction to the long-dominating consistency-based theories. The dual-process theories (Wilson and Hodges, 1992; Wilson et al., 1995; Schwarz and Bohner, 2001; Cohen and Reed, 2006) assume that an individual actor might store in her memory different data and might employ different mindsets in her attitudes toward objects. This explains attitude instability by the difference in the accessibility and/or activation of the memory-stored information about the attitudinal objects and by different thought processes involved in different contexts. As distinct from the consistency-based theories, which assume that attitudes and behaviours are (and should be) consistent, the dual-process theories assume that the attitude–behaviour relationship is not always consistent, and that consistency itself is dependent on the context and the thought processes involved, such that an individual actor might have different attitudes towards the same object in different contexts.

In the political science and political sociology approaches on computational modelling of political attitudes, there is a strong comeback of the theories on social context initially elaborated by Paul Lazarsfeld and the Columbia sociologists. These theories are reinforced by the generous technological support offered by the agent-based systems, partly inherited from the social simulation theories and experimental research. Huckfeldt and collaborators (Johnson, 1999; Huckfeldt et al., 2004) elaborate a class of dynamic models of diversity survival in democratic societies in scenarios of persuasive communication in electoral campaigns. The classic theory of social context in both its versions – the Erie study employed in ‘People’s Choice’ (Lazarsfeld et al., 1944) and the Elmira study employed in the ‘Voting’ (Berelson et al., 1954) – is re-evaluated. The new approach is now influenced by the powerful theories about friendship in interpersonal networks (Merton, 1948; Lazarsfeld and Merton, 1954) and the theory of the two-step flow of information (Katz and Lazarsfeld, 1955). In this context, McPhee’s computer simulation model, elaborated five decades ago, is revisited by means of the new computational and simulation techniques.

From a computational modelling point of view, the age is dominated by theories on the ‘would be worlds’ (Casti, 1992, 1996), social simulation (Gilbert and Troitzsch, 2005) and the experimental research based on the ALife agent-based technologies: cellular automata, agent-based systems, complex adaptive systems and social networks.

The concept of artificial society introduced by Joshua Epstein and Robert Axtell (1996) is fundamental in the computational and simulation modelling of political attitudes. Their book on how artificial societies emerge, grow, decay and disappear decisively influenced the modelling philosophy and offered an appropriate research framework for the virtual experiments with large populations, artificial social and political systems.

This emphasizes the essential role played by the computational and simulation technologies of cellular automata and agent-based simulation. The new technologies and their employment in social simulation introduce the so-called bottom-up modelling technique (Epstein and Axtell, 1996). The bottom-up models start with a simple artificial social system which consists of a set of artificial agents, a set of a few simple rules of interaction and a mechanism of interaction based on methodological individualism. As the individual agents start interacting, their interactions provide for emergent phenomena at the macro level.

There are two main themes which dominate this age in the area of political attitude research on both conceptual and computational modelling dimensions: political cognition and ideology.

Based on research work which started in the early 1990s, the models based on political information processing and political cognition dominated the first decade after the year 2000.

The Stony Brook school of thought is famous for research in this area. Milton Lodge and Charles Taber and their numerous collaborators promoted a different paradigm and a different computational model of political attitudes. Their model is based on the constructivist theories of dual processes and on the previously developed research work in the psychology of affect and its role in political attitude formation and change. The JQP model (Kim et al., 2010) combines memory-based and online components of attitude change process with the mechanisms and processes of affect primacy and hot cognition.

The other dominating research theme of the age is ideology modelling. From a conceptual perspective, the novelty of the age, closely tied to conceptual modelling of political attitudes, concerns the classic left–right spatial models of ideology and voting (Enelow and Hinich, 1984) which are replaced by the two-dimensional models inspired from the dual-process theory (Duckitt, 2001; Duckitt et al., 2002; Duckitt and Sibley, 2010). From a computational point of view, computational and simulation modelling of ideology is dominated by the approaches based on systems which integrate political beliefs and attitudes in the same framework and employ theories of mind (Anderson et al., 2004), theories of cognition (Thagard, 2006) and theories of affect and its role in political information processing and cognition (Homer-Dixon et al., 2013).

Eighth Age (Present Day): Polity Models

The rationales behind the development of polity models concern their relationship to political attitudes. So far, polity modelling has focused on the constructivist idea of achieving politics as an emergent phenomenon rooted in individual interactions at the micro level. The classic problem of social action (Parsons, 1937, 1951; Coleman, 1986) has been approached on a complexity basis in agent-based models which employ the mechanism of methodological individualism at the micro level. It is known that such models perform well in scenarios with micro-to-macro emergence, like structure emergence. However, the methodological individualism and agent-based models have poor performances in the modelling of macro-to-micro phenomena. For this reason, models of polity need a political attitude model underlying the phenomena which bind the macro-level phenomena to the behaviour of the individual agents at the micro level.

Polity modelling has been developed on two main dimensions, which resulted in two classes of approaches: (1) models of governance and policy studies; (2) models of international relations and conflict.
In the first class of approaches there are models of elections and government formation, which involve electoral studies of voting behaviour and voting choice, partisanship and political judgment. One of the most relevant polity models in this paradigm, especially concerned with political attitudes in the aggregate, is the Macro Polity Model (Erikson et al., 2002). It is an empirical model which poses and answers some of the most fundamental questions of polity modelling: How do citizens and governments interact with each other? How do individual citizens’ preferences relate to the governmental policies? How do governments influence citizens’ attitudes and behaviours? How does partisanship influence governmental policies? How does public opinion influence institution emergence and change? However, this modelling dimension has not been explicitly pursued in computational modelling owing to its severe degree of complexity. One of the computational simulation modelling attempts proved successful: the MASON RebeLand model is an artificial polity which explains polity operation as based on the ‘demand-and-supply’ principle, such that a new public policy is developed by the “Government” component as a response to any public issue which is generated by the policy positions (i.e., political attitudes) of the individual agents at the “Society” component level. (Cioffi-Revilla and Rouleau, 2010: 37). Other models (Cioffi-Revilla et al., 2007, 2008) address different types of polity in various geographical areas, periods of time and cultures.

In the second class of approaches there are models of conflict which study the emergence of national, regional and macro-regional political and social phenomena (state failure or massive immigration due to open military conflicts). Models of states as single agents involved in international relations scenarios have been developed since the 1990s. The first computational model is the Tribute Model (Axelrod, 1995). Agent-based models of social conflict, nationalism and insurgence have provided the means to study how the neighbouring state agents could engage in conflict scenarios and what consequences such conflicts might have (Cederman, 1995; Cederman and Girardin, 2007).

The Japanese school of polity modelling has developed a similar class of polity models, based on the artificial society and culture modelling (Yamakage and Mitsutsuji, 2006; Yamakage, 2009; Sakamoto and Endo, 2015). This class of models is more oriented toward the complexity of state reconstruction after state failure than to conflict management and conflict emergence.

About the ‘Model’ in Philosophy, Logic and Science

A model is an interpretation of a theory. Inspired from mathematical logic, this classic definition has been refined and adapted so as to mirror a specific idea about theory building and theory testing.

A brief presentation of the concept of a ‘model’ and its definitions offers the opportunity to describe the various ways in which ‘modelling’ is relevant in building up new theory.
**Modelling in Philosophy of Science Terms**

In the philosophy of science, ‘model’ definition as inspired by mathematical logic has been refined by an additional dimension: the analogy (Hesse, 1970). Instead of defining it as a formal interpretation of an abstract theory, a ‘model’ is thus conceived as an analogy-based interpretation of a theory with reference to an object in the real world. Hesse (1970: 19) considers models as being fundamental for theories for three reasons: their functional design, their explanatory power and their predictive capacity.

This approach has been further developed in the philosophy of science by Mario Bunge, so as to allow the foundation of the relationship between the model and the theory on a new principle. Bunge (1967) advanced the idea that modelling should be based on two conceptual pillars: a general background theory and a description of a specific object.\(^1\)

Bunge’s approach on ‘models’ and ‘modelling’ is a functional one. The reference to an object as well as the requirement that a model should be achieved by analogy with that object has transformed modelling into a procedure of ‘mimicking’ the object addressed in the theory. Besides the attributes deriving from an analogy-based abstract construction, this kind of approach endorsed a model with provisional characteristics. This has transformed it into a tool used to obtain provisional descriptions of the same or other objects in the same or in different settings.

Bunge’s functional theory has been considered a basic reference by the schools of thought founded in both sociology and political science modelling research. His later works on the definition and meaning of computer models, simulations (Bunge, 1967, 1969) and mechanism (Bunge, 2004) have provided support to a trend in the philosophy of science which has relevance for the approach in this book.

The conceptual disputes in the philosophy of science concerning the definition of a model, its role in theory construction, the truth of a modelling approach and the realism of its outcomes are issues which go beyond the scope of this book. However, we will mention but one of these issues which concerns the very subject of this book: the mechanisms. Traced back to Bunge, whose works represent a starting point in the development of a scientific trend in social and political science modelling, this concept has been (and still is) the central point of the theories on the explanatory power of complexity-based models.

**Computational Modelling in Its Own Terms**

In computational modelling, the concept of a ‘model’ is defined as a construction or as a representation.

In the development of political attitude computational modelling research there are several works of reference with regard to the notion of ‘computational model’ and the way it could be used for theory testing and theory building in the political science area. One such work has been elaborated by Taber and Timpone (1996). The authors define a ‘model’ as a representation of a theory describing a real-world object or phenomenon.

\(^1\)Bunge’s theory was inspired mostly from physics, like several other modelling theories of that time; see Hartmann (1996) and Niehans (1990) for more references on model definition and modelling in the positive sciences, economy and social sciences.
(Taber and Timpone, 1996: 2). It represents the usual conceptual frame in which the terms of ‘model’ and ‘modelling’ are employed in a classic computational approach.

What is specific about computational models is that they transfer the formal description of a theory into a computer description. They use a programming language, computational rules and computer resources. The transfer from a mathematical description to a computational one requires the ‘translation’ of the theoretical terms in computational terms. It also requires a particular way of making the model produce an outcome; that is, by simulating it. A simulation means to run a model, by ‘model’ denoting a (set of) computer program(s) which produce(s) a computational outcome (i.e. numerical data or graphical shapes expressing numerical data resulting from specific computations). It is this outcome which is evaluated with analytic instruments or with any other evaluative computational or non-computational tool. Once this outcome is obtained, the model itself can be evaluated for its relevance, effectiveness and validity of the results it has produced and for the achieved performances.

A computational model could be used in multiple ways: (i) as a replication of the structure of a system or object of interest, or (ii) as a behaviour of that system/object. What is essential in constructing a computational model is the way in which the model achieves similar (analogous) behaviour to a real-world system. Another case could be the study of the ‘states’ in which the model is at certain moments of time and in certain conditions, providing that the states are achieved as a function of the model structure. To these ends, the model construction includes rules, components or constitutive elements/subsystems, relationships between its subsystems, such that the overall behaviour of the model is achieved from the interconnection and interaction of these subsystems (top-down architectural design). Another possibility is provided by bottom-up designs, in which the components and rules of their interactions (mechanisms and processes) are available (predefined) in the model and it is only the contextual workings of the model which provide for the emergence of specific behaviours of the model. The research issues here are the mechanisms employed by the model. These mechanisms are computational, but their design might address two classes of aspects: (i) a proper computational aspect or (ii) an aspect which is specific to the modelled issue (object, system, situation, phenomenon, etc.), which has to be expressed in computational terms too. For example, a computational model of political attitude change might include a time mechanism in order to control the execution of the programs, and it might also include a computational mechanism of cognitive dissonance, which is employed by the political attitude change phenomenon in specific individual or social settings. It is the computational form of the cognitive dissonance mechanism which represents an issue of research in constructing the computational model of political attitude change.

A real problem in making a computational model work is the simulation of the model. Simulation is a basic concept in computational modelling. It is also an issue in the philosophy of science and has been studied for its profound implications with regard to the meaning, realism or validity of models. We will not approach these terms on a philosophy of science basis, though they are implicitly targeted by any research approach. We will address the concept of model and modelling in loose terms, aiming
rather at aggregating various examples of such models before generalizing their meaning and eventually achieving a more abstract image.

Having briefly overviewed this basic description and justification of terms, a classification of research issues and questions is now possible.

One issue is that of the explanatory power of the computational approaches of political attitude phenomena. Explanatory power has been quantified differently with respect to the type of research:

- statistical explanation is based on pattern identification in the aggregate data;
- explanatory power of experimental research resides in the intrinsic causality model revealed by the relationship between variables;
- explanatory power of generative research resides in the mechanisms employed in achieving model behaviour as close as possible to the behaviour of the object which is being modelled.

Computational modelling of political attitudes has provided for all these types of explanation.

Another issue is the computational design of the political attitude mechanisms. The modelling of political attitude phenomena is based on sociological, psychological and social psychological mechanisms. Such mechanisms could be modelled by means of computational mechanisms. There are two techniques of achieving a political attitude mechanism in a computational medium: either by replicating it or by mimicking it. In both cases a computer program or a set of programs will be used. The difference resides in the way the model achieves the desired (expected) kind of behaviour: either by design or by emergence. The major concern of computational modelling of political attitudes or of any other political phenomena is that of achieving behaviour as close as possible to the real-world behaviour.

Finally, there is one more issue revealed by this area of research: emergence of structure and emergence of order. Both types of emergence phenomena are generated by the dynamics of the micro–macro relationship in a polity system. The particular issue in this case is how the emergence of order could occur such that individual behaviours at the micro level are influenced by the emergent structures and phenomena at the macro level (institutions, political powers, etc.).

The approach in this book has identified and included models which explicitly or implicitly suggest a solution to this research question. Generative methodologies like the agent-based systems (ABS) or cellular automata (CA), multi-agent systems (MAS), complex adaptive systems (CAS) and network media provide the proper environment for the study of such phenomena.

**Computational Modelling Approach in Social and Political Sciences**

As an interpretation, the model needs a definition of the concept of ‘truth’. This kind of definition provided for a model-theoretic framework in the early logic-based computational modelling research. Patrick Suppes (1960) extended the concept to
psychology research, with a special focus on S–R learning modelling, making reference to the definition of truth in the semantic theory of Alfred Tarski (1944).

For classic modelling research in political science, like, for example, spatial modelling of the voting system (Hinich and Munger, 1997), the notion of ‘model’ has been defined from an analytical perspective. A model is viewed as a substitute for a theory; it is used when the theory itself could not be proved due to intractability or other conditions resulting from the complexity of the modelled object or system which makes it highly difficult or impossible.

A ‘model’ could be defined in mathematical or statistical terms. However, it must be a construction based on logical consistency of its assumptions. A model has a fundamental predictive dimension. It is used to answer a research question of the type ‘what if …?’, allowing the researcher to elaborate and investigate possible scenarios by manipulating the variables describing the object and context and also the parameters which control the relationship between variables.

Bunge’s approach to the concept of ‘model’ is based on a functional perspective; he considers that a model is constructed on a general theory and makes reference to a system or object. His approach is inspired from the notion of a model in physics and suggests a static description of models. However, his point of view, that the model makes reference to an object in a certain context, has placed him among the philosophers promoting, along with the analogy dimension of a model, its context dependency. The methodological effects of this theory address the issue of mechanism, considered to be the basic element in theory construction. Models could be used for testing a theory or probing it in various empirical (experimental) settings. The notion of simulation becomes important because the simulation is evaluated as a method of model testing.

Charles Tilly extends this idea, developing a theory of context-dependent model construction based on mechanisms and processes and a dynamic view (McAdam et al., 2001; Tilly, 2001; Goodin and Tilly, 2006).

The diachronic view of models (Hartmann, 1996) involves the issue of theory construction (new theory). Hartmann describes three types of models, of which we will describe the first class only: models as a substitute for theory.

**Type of Explanation Achieved**

Experimental political science has been founded on the causal and statistic models of explanations.

Computational modelling of political attitudes achieves explanatory power from a different paradigm: a mechanism-based explanation. The research suggests a dimension of constructivist type of explanation in which the explanation is achieved by employing mechanisms whose outcomes and/or behaviour would mimic the effect and/or behaviour in the real-world system or phenomenon. The mechanism-based explanation is advocated by Peter Hedström in his research on analytical sociology (Hedström and Svedberg, 1998; Hedström and Bearman, 2009), but mostly by Charles Tilly (2001).
Near and Far Future Trends in Political Attitude Modelling Research

The near future obviously belongs to political cognition research which involves content-based modelling of mechanisms and processes of political attitude formation and change. Thus, it might explain how beliefs, attitudes and values could be altogether modelled in complex social and political contexts.

The far future belongs to political culture, which needs massive technological support in order to combine societal and political levels of attitude formation, dissemination and change. The political culture concept as it has been induced by Converse’s model is perhaps most inspiring but insufficient for the modelling of political attitudes. As Mishler and Pollack (2003) suggest, a continuum of political culture will most probably achieve the proper framework for the study of political attitudes and their emergent phenomena.

As far as computational modelling technology is concerned, the near and the far future will most probably employ web technologies. I shall have more about that in the Epilogue.

References


Part II

SOCIAL AND POLITICAL INFLUENCE MODELS OF ATTITUDE CHANGE

Some of the most relevant authors in the literature on agent-based systems and social simulation (Troitzsch et al., 1996; Troitzsch, 2013) associate early research in computer simulation of political phenomena with Orcutt (1957), and also with Abelson and Bernstein, well known for their community referendum model (1963).

Other authors (McKuen and Brown, 1987; Johnson, 1989, 1999; Visser, 1996; Huckfeldt et al., 2004: 128) consider that modelling attempts based on computer simulations of electoral campaigns and voting behaviour were elaborated much earlier. Modelling and simulation research on electoral campaigns and voting choice, especially focused on political persuasion, can be traced back to the late 1940s, when the sociologists of the Columbia School developed a very ambitious project on voting behaviour modelling. Among them we distinguish William McPhee, a young member of Lazarsfeld’s team. He elaborated the first computational and simulation model of voting choice which addressed the issue of political attitude formation and change.
Voting Choice Computer Simulation Model

The *Computer Simulation Model of Voting Choice* (McPhee, 1961, 1963) was inspired by the research underlying the Columbia electoral studies of the 1940 US presidential campaign published in the famous book *The People’s Choice* (Lazarsfeld et al., 1944). On the basis of the empirical findings reported and analysed in the volume authored together with Bernard Berelson and Paul Lazarsfeld (Berelson et al., 1954), William McPhee developed a computer simulation modelling approach and elaborated its theoretical and methodological aspects. Starting in 1958, more experimental research work with this model was developed together with his research assistant Robert B. Smith, who designed and performed the simulation runs on an IBM 650 computer, and Jack Ferguson, who joined their team a year later.1 The model was tested in the 1960 primary elections in Wisconsin (USA), and the theoretical and experimental results and conclusions were published starting in 1961, though much of this research remained unpublished or unknown. When retrieved much later, it was re-evaluated for its precious contribution to the simulation modelling of political attitudes based on their content and on the culture of community political participation (Huckfeldt et al., 2004: 13).

The electoral studies developed by the Columbia group are mainly concerned with individual citizens’ electoral behaviour in presidential campaigns. As theory, they are characterized by a fundamental tenet: the social context is essential for the formation and change of the individual’s voting preferences and choices.

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1Details provided by Dr Robert B. Smith in a personal letter transmitted to the author by e-mail on 4 October 2014, concerning the history of the computer simulation voting choice model elaborated together with William McPhee. Helpful details, precious support and encouragement from Dr Robert B. Smith are hereby gratefully acknowledged.

Companion website: www.wiley.com/go/Voinea/political
McPhee’s Voting Choice Computer Simulation Model includes theoretical and experimental elements concerning the formation and change of political attitudes toward candidates and parties during and across electoral campaigns. The model proves the main hypotheses of the Columbia electoral studies: the electoral media and campaigns have only ‘minimal effects’ on individuals’ voting behaviour. Instead, individual voting choices are shaped by the social context represented by the interpersonal networks of relations (dyadic networks) within which individuals interact in face-to-face discussions about political issues. Though dependent on the social and individual attributes, the voting choice is modelled as a behavioural response to social interaction stimuli coming mainly from the interpersonal networks of relations.

However, McPhee goes beyond the classic limits of the behaviourist paradigm. He works on a learning assumption which endows each individual with the ability to learn from the political influence exercised by peers in interactive discussions within the dyadic networks. The model thus achieves specific dynamics: individual voting dispositions, preferences and choices change over repeated persuasive political campaign stimulation such that perceived electoral stimuli (political messages) are reinforced (or, on the contrary, forgotten) by means of a learning mechanism. Thus, in the aggregate, overall voting choice patterns emerge from the dynamics of the individual political disposition change. Variability of the individual political predisposition, in turn, depends on convergent effects of perceived campaign stimuli and the political influence experienced from individual interactions.

Conceptual Model

McPhee’s theoretical and experimental research represented pioneering work in the computer modelling and simulation of electoral behaviour. At the conceptual level, the Voting Choice Computer Simulation Model combines principles from psychology, sociology and social psychology with voting behaviour and mass communication theories. The model combines the psychology of attitude formation under social and political pressure with an instrumental utility-based modelling approach of the voting choice as dynamically balancing the costs and benefits of individual interactions within the ambit of interpersonal networks.

Columbia electoral studies offer empirical support to the behaviourist ‘stimulus–response’ paradigm in modelling citizens’ voting behaviour. In this paradigm, formation and change of individual political attitude toward the electoral issue as well as individual voting choice are viewed as being determined by a combination of external social stimuli and internal predispositions. Regarding this simulation model, the first in the short history of political attitude computational modelling research, there are two essential aspects of major interest for the purpose of our study: the modelling principles and the dynamics of the political attitudes as generated by the simulation model.

The computational modelling of political influence and the simulation of political attitude change are based on the fundamental idea that political preferences are shaped by the social characteristics of the voters and by their social interaction experience.
The main assumption of McPhee’s model is that the political attitudes of the citizens (i.e. their issue positions with respect to the electoral candidates and parties in the presidential elections) are not determined by individual attributes and predispositions only. Their political attitudes are influenced by the social environment and the individual interactions with peers, which allow for social pressures to propagate through networks of interpersonal relations. Citizens get the news from the media, but have discussions about it with their acquaintances, close ties or influential others in their networks of personal contacts. These dyadic interactions are considered to be essential for the formation and change of political attitudes within the interpersonal networks, especially during electoral campaigns, when political interest is highly stimulated (Berelson et al., 1954; Huckfeldt et al., 2004: 39).

Social Process Model

The original model is strongly influenced by Paul Lazarsfeld, who in the early 1930s developed research on consumer behaviour, in particular on the psychological aspects of deliberation and action concerning purchase behaviour (Lazarsfeld, 1934). Lazarsfeld defined consumer behavioural tendencies. To formally describe them, he used variables representing the consumer’s internal predispositions and socio-economic status, the characteristics of the products to be purchased and the influences from the external social environment and interpersonal networks of contacts. He further described consumer behaviour with a three-process scheme including stimulation, consultation (i.e. influence) and deliberation. Reconsidered later in the Columbia group, headed by Lazarsfeld, this scheme has been inspiring for the modelling of the voting behaviour of the individual citizen as subject to social context influence.

The computer simulation voting model is based on three causally chained processes: stimulation, influence and learning. The processes are linked in a loop which feeds back the political influence onto the predispositions and the perception of new campaign stimuli. The system thus achieves a dynamic behaviour. In this system, the learning process provides for a self-regulatory function, making possible the adjustment of individual agents’ predispositions and perceptions of the social stimuli as a consequence of social network influence.

The model describes presidential elections. In the elections, a community of $n$ citizens is involved. The real community of citizens is described as a set of $n$ individual (artificial) actors with three relevant characteristics: political interest (utility), political preferences and political predispositions. The actors interact among them within networks of interpersonal ties. The actors are the target of the campaign messages, which are defined and described as political stimuli. The outcome of a simulation run is a ‘map’ of distributed voting choices, which provides for a dynamic picture of political choices (votes).

The computer simulation run of the model has three steps.

The first simulation step consists of the political stimulation process. An individual agent is characterized by previously determined predispositions with attributes of direction and intensity. These predispositions are expressed as probabilities or levels of preparation for social action (i.e. voting) and levels of political interest.
The second simulation step consists of the political influence process: the individual actor $i$ encounters another actor $j$ from a set of previously determined actors (sociometric method). The actor $i$ compares its political interest value with the value of the contact actor; if their utility value is the same, they both get rewarded by an increase in their intention to vote. If their intention to vote is thus reinforced, they will make the final vote decision. Otherwise, their intention level will decrease, which will force the actors to wait for another stimulation stage in order to become more interested in voting.

The third step consists of the learning process. The learning mechanism updates the political predispositions and feeds them back to the inputs of the stimulation process. Thus, the updated predispositions are subjected again to the influence of the campaign media. The aggregated variation results in a dynamic process in which variation is generated by the interactions within the network of personal connections and reinforced by the persuasive campaign messages.

McPhee adopts this social process model in his voting choice simulation model and makes it operationally effective by including several computational simulation techniques.2

**Dyadic Networks**

With regard to the political persuasion issue, the Columbia School introduced a new conceptual paradigm on the formation and change of political attitudes: the network of interpersonal relations, which is a concept that defines the individual’s connections with close ties, acquaintances and influential persons (i.e. opinion leaders) with whom they discuss the political issues of the day and whom they trust for their authority and expertise.

Columbia empirical studies showed that exposure to electoral campaign messages and communication does not have a major impact on changing the individuals’ voting preferences unless mediated by personal relations (opinion leaders, influencers and close ties) in face-to-face personal discussions. Even if change-effective, the mass media messages (and the overall campaign media news coverage) result in the reinforcement of existing political attitudes, since individuals selectively seek and accept information, discussants and media news which would rather confirm and/or sustain their own preferences, trying to avoid cognitive dissonance and sometimes the discomfort of conflicting situations based on disagreement (Festinger, 1950, 1957).

**Two-Step Flow of Communication**

In their book on interpersonal influence, Elihu Katz and Paul Lazarsfeld (1955) address the issue of political attitude formation and change in the context of a presidential election campaign. During elections, public and private mass media channels compete for influencing citizens’ opinions, attitudes and behaviours via campaign messages. The authors show that the networks of interpersonal relations

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2 See Figure 1 in McPhee (1963: 171).
actually operate as intermediate filters for the mass media messages: individual citizens’ predispositions are influenced by their networks of close ties in evaluating and understanding the campaign messages, and in shaping their final voting choices.

The concept of dyadic networks is employed in the theory of the two-step flow of communication (Katz and Lazarsfeld, 1955) about opinion leaders and their impact on individual political preference formation and change. It is also employed in the political persuasion theoretical approaches concerning both communication and political participation and partisanship issues (Berelson et al., 1954).

**Homophily Principle: ‘Likes Attract’**

The experiments based on the Voting Choice Computer Simulation Model use socio-metric measurements. The empirical studies in the Erie County study showed that the selection process is dependent on mainly two factors: social status (socio-economic level, religion and residence) and similarity.

Studying the similarity factor, Paul Lazarsfeld and Robert Merton introduced the concept of homophily (Merton, 1948; Lazarsfeld and Merton, 1954) for describing a principle of connecting people in local social networks: ‘likes attract’. The explanation for the similarity factor is the general tendency of individuals to avoid conflicting situations, which makes them choose persons on the basis of shared beliefs, similarity of preferences and attitude agreement. These concepts and theories provided the basis for Lazarsfeld and his associates to introduce the concept of the network of relationships for replacing the traditional sociological concept of ‘group’. The concept allowed the study of interdependent patterns of communication and influence in interpersonal networks (Huckfeldt et al., 2004: 26).

Individuals have a tendency to select like-minded people to discuss political issues on which they share attitudes or preferences. This tendency is self-reinforcing, as an individual would always select like-minded people to share issue positions. One advantage for the dyadic networks is that agreement is reached by consensus, easily achieved when individuals select each other for interaction on the basis of the homophily principle. One disadvantage is that such networks would invariably end up in a universal agreement if the increase in agreement were to depend linearly on an increase in the number of peers sharing the same political attitude toward an electoral issue. In this case, the study of diversity survival appears as a challenging research problem. McPhee was the first to approach it in a simulation model of political attitude change (McPhee, 1963: 81). His approach represents, in many ways, a fundamental reference for the one developed much later by Huckfeldt and his collaborators (2004).

**Operational Model**

From a simulation experimental perspective, McPhee’s Voting Choice Computer Simulation Model is basically working within the classic theories of social dynamics. What makes the model so interesting is the design of the political influence
mechanisms and processes. With a strong algorithmic flavour owing much to the programming framework of classic computer science of the early 1940s, the simulation model achieves a particularly interesting process dynamics from a strictly deterministic programming paradigm (see Figure 3.1).

Much of the operational view underlying the voting choice simulation model is based on the classic theories of dynamics. Such theories use variables and processes to account for a causal chain explanation of change in the model system: change of each variable is causally connected to changes in other variable(s). Processes of change iteratively update the variables, providing for the variability of the system as a whole. System overall dynamics emerge as a global pattern as the system variables are updated by these processes.

The model is based on the idea that the social environment during electoral campaigns can be described as a stochastic environment. Along with a rational view of the individual citizen, and with the stochastic characteristics of the social environmental stimuli, the model employs the new ideas following from the empirical (survey and panel) studies underlying the Columbia theories of political behaviour. Two ideas will become influential for all the subsequent research in simulation modelling of social and political phenomena. One concerns the introduction of influence processes which involve, for each individual actor, repeated discussions with the relations within interpersonal networks until consensus is reached and a
voting choice is made. The second idea is based on the *homophily* concept (‘likes attract’), introduced by Lazarsfeld and Merton (1954), that people selectively accept both media messages and others’ opinions if they reinforce and/or confirm the individual’s own beliefs and issue positions (attitudes).

At the operational level, McPhee’s *Voting Choice Simulation Model* introduces several computational and simulation modelling techniques.

The model consists of a computational system representing a community with \( n \) individual citizens involved in a presidential election campaign. System dynamics model the development in time of the aggregate political preferences of \( n \) individual actors preparing to make their final voting choices. It is a process-based model which addresses issues of social dynamics theory and uses classic computational modelling concepts. Given a set of \( n \) individual actors, the model simulates the aggregation of citizens’ voting preferences as their predispositions change during repeated persuasive campaign stimulations and political influences exercised by peers in the dyadic networks.

First, McPhee adopts a technique of computational simulation based on probability distributions of perceived stimuli (McPhee, 1963: 170–179; McPhee, Smith and Ferguson, 1963: 77–78). This technique involves several concepts used for the first time in political attitude simulation modelling. One concerns the scaling of the perceived stimuli, a concept inspired from Lazarsfeld’s (1950a,b, 1959) two-class model and extended so as to include several classes like in the Guttman scale measurement method: the technique of scaling the individual perceptions of social stimuli, rating them into several classes from ‘weak’ to ‘strong’ and using this in the stimuli sampling. The other one is the Monte Carlo method of random sampling, a method which has been used in numerical simulations for achieving probability distributions of a certain item, in this case the probability distributions of the political attitudes during and across electoral campaigns.

Second, McPhee accommodates in his model the idea of social influence forces and the concept of social reality as defined by Lewin (1947a, b). McPhee’s idea that the social empirical evidence has to remain a reference level in testing the validity of simulation experiments is rooted in the Lewinian concept of social reality. As invoked by McPhee, and as one of the long-debated and systematically questioned elements of simulation experiments’ validation theories, it still represents a key dimension of the validity requirements, which actually are the most sensitive and challenging aspects in social and political agent-based simulation modelling research.

Third, he introduces the idea that repeated individual interactions within dyadic networks allow individuals to exercise political influence on each other by means of face-to-face discussions. This political persuasion can be remembered. As persuasion effects accumulate, learning allows for remembering them, or at least part of them. Modified predispositions are then subjected again to perceived stimuli. The individual actor can thus achieve different impressions from different stimulations and from modified predispositions. This process works on the basis of a cumulative learning mechanism which provides for a dynamic change process and allows the study of aggregated dynamics.
Electoral Campaign Appeals

A *stimulus situation* is modelled as a set of inputs denoted as ‘appeals’. The ‘appeals’ are relevant stimuli defined as political messages sampled by the individual actors themselves on a rational choice basis (McPhee and Ferguson, 1962; McPhee and Smith, 1962; McPhee, 1963). The stimulus situation is modelled as a probability distribution and becomes a vector of political influence. It takes as inputs the media news and coverage as well as messages in the interpersonal networks (McPhee, 1963: 173).

The model formalizes the empirical findings in the election studies and explains the macro-level aggregate patterns of voting preferences. The model uses these macro-level patterns to predict political attitude change phenomena across elections (Smith, 1985: 63).

What people usually do is selectively ‘sample’ the news themselves: individual preferences, and tendencies make each person understand the news from different perspectives, with different backgrounds and with different cognitive abilities. This difference is due to both internal and external factors, but what interests here is the external factor, particularly the role played by the social network as a ‘filter’ for the individual perception. Real stimuli, therefore, become perceived stimuli; that is, representations of sampled biased information from a stochastic communication environment. For a large number of individuals used to computationally represent and simulate a community of citizens in an election scenario, modelling the social stimuli and the stimulus situation is not an easy task. The complexity of social stimuli is modelled so as to retain the operational aspects manageable in a computer simulation.

Probability Distributions of Appeals

The model defines and represents the electoral stimuli (McPhee, 1963: 170) as a distribution of probabilities. The concept is inspired from a survey technique of converting a proportion (i.e. the proportion of people perceiving various degrees of strength of electoral appeals) into a probability measure. A stimulus distribution thus appears as the formal representation of the distribution of people’s ‘impressions’ acquired from sampling the real stimuli provided by the electoral campaign environment. Aggregated, these patterns of perceptions of sampled stimuli distributions describe the variability of people’s political (party) preferences. If repeatedly exposed to electoral campaign stimuli, this variability specifies a functional dependence between perceived strength degrees of social stimuli and changes in the individuals’ predispositions. This function can be instrumentally employed in controlling political preferences by varying the stimulus in order to change the behavioural response (McPhee, 1963: 173). The conditional response is then analysed to evaluate the influence of the social networks in the formation and change of individual political behaviours and attitudes. The model, therefore, provides a conceptual and practical view on how political influence actually works in electoral campaigns and what are the practical means to simulate it with a computer program.

These initial distributions of probabilities expressing stimuli and attitudes towards election (party or candidate) are meant to express the dependence of the individual’s
voting intention formation and voting decision-making on the social context. The initial distributions express a certain relationship between social structures (like social status, social role), predispositions, which are subjected to influences from personal interconnections, mass media messages and so on, and social action (voting).

**Variables**

The model uses variables to represent the individual citizen (voter) and its relevant attributes: predispositions (i.e. political attitudes toward candidates and parties), political interest (utility) and political preference. Variables representing the individual’s predispositions can have three values: ‘Democratic’, ‘Republican’, ‘No Voting’. There are two directions (Democrat and Republican), and seven degrees of intensity defined in ‘The index of political predisposition in the 1948 election’ (Janowitz and Miller, 1952: 715).

**Individual Actor**

The individual citizen is modelled with the help of a set of variables which extract the most relevant attributes of a real citizen (see Figure 3.2): predispositions (political attitudes), political interest and political action (i.e. voting choice). Besides these attributes, the model includes data concerning the individuals’ socio-economic status, religion and residence attributes, collected from empirical studies.3

Individual actors modify their predispositions under the influence of social networks: they interact with each other within interpersonal networks of relations. For each individual actor, the collection of personal relations is identified in preliminary empirical studies by sociometric measurements.

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3 Surveys fully described in the appendix sections of both Lazarsfeld *et al.* (1944) and Lazarsfeld and Merton (1954).
POLITICAL ATTITUDES

The view of an individual citizen whose political attitudes (predispositions), political interest and political participation are modified by social networks (group membership) is characteristic for the Columbia School. It is the view of small worlds in which individual actors depend on each other in networks of close relations (family, friends, co-workers). The influential others (opinion leaders) in their networks help them adjust their understanding of the media news and form or change their political attitudes.

Figure 3.3 Variables, mechanisms and processes involved in the modelling of political influence. Variables are used to represent (a) individual attributes and (b) stimuli from the social environment. Mechanisms controlling the political influence processes: (a) a threshold mechanism controlling the value of the political interest (i.e. subjective utility); and (b) a cumulative mechanism for predispositions update during the learning process. Processes: (a) grey arrows indicate stimulation processes; (b) black arrows indicate influence processes.

Political Attitude

In the early literature on attitude’s definition and measurement, it is associated with a behavioural predisposition to the stimulus (object or situation) which elicits attitude activation (Bogardus, 1931: 62; Allport, 1935: 810; Campbell, 1963).

From an operational perspective, in the voting choice simulation model the predispositions are defined as issue positions of the citizen with respect to the election campaign issues. Such issue positions (i.e., political attitudes) have an internal structure which is socially determined (Smith, 1985: 61).4

4 The technical details in this section are mainly based on: Smith, R.B. (1985) Aspects of the perspective and method. In R. B. Smith (ed.), A Handbook of Social Science Methods, Volume 3, Quantitative Methods, Focused Survey Research and Causal Modeling. Praeger, New York; Chapter 1, pp. 59–79. I gratefully acknowledge the support offered to me by Dr Robert B. Smith and his precious guidance.
Predispositions are characterized by two attributes: direction and intensity. The attribute of direction takes two values (for example, ‘left’ and ‘right’), while the attribute of intensity could take several values (usually, a real number between 0 and 1) describing the level of activation/interest in a stimulus situation. For the 1948 presidential elections modelling, two directions were defined (‘Democrat’ and ‘Republican’) and seven degrees of intensity in ‘The index of political predisposition in the 1948 election’ (Janowitz and Miller, 1952: 715).

Political action (voting choice) is determined by both internal and external forces. On the one hand, the social structural attributes (status, religion and residence) play a relevant role as well as the individual’s predispositions. On the other hand, the perceived social stimuli are as relevant as the internal factors. The political stimuli are represented by the campaign messages and interpersonal influences.

Mechanisms

Several mechanisms are involved in making effective the political influence from either stimuli arriving from the campaign media or from the network of interpersonal relations.

The model uses a social psychological mechanism of political persuasion which combines external sources of influence (social structure, political messages, interpersonal relations) and internal predispositions in modifying the individual preference (Smith, 1985: 62).

Stimulus and predisposition make a threshold mechanism which controls the level of political interest (i.e. individual utility). It determines the participation and also the direction of participation: left or right, Democrat or Republican Party.

Each citizen is supposed to interact with others within networks of personal relations, acquaintances and close ties. Though interaction is necessary for political influence to operate effectively, it is allowed only under strictly defined circumstances: any two individual agents start discussing only if their average utility value is over a specific threshold. Since utility values are compared against a predetermined threshold, only higher values of political interest will result in political predisposition (attitude) change in favour of voting. This process is self-reinforcing, so that the strength of a previously settled predisposition might increase.

If the comparison of two individual actors shows that their political interests are similar, then political attitude is reinforced by an increase in the level of political interest of each actor, which can trigger an increase in their partisanship and, consequently, in their political participation.

As emphasized in his earlier work with Berelson and Lazarsfeld (Berelson et al. 1954: 25–27), McPhee’s idea behind the mechanisms of controlling the political interest variable is that, for any two individual citizens, political participation (voting) is enhanced by the social structure (high social status and relevant social role) and by the level of political interest. Each discussion in the dyadic network results in rewarding both actors if they have similar voting intentions (political preferences for the same party), or punishing them if their preferences differ: similarity of political interest (i.e. the same utilities) increases their participation, and each individual gets rewarded by an increase of its utility value, whereas dissimilarity in political interest
results in weakening partisanship of each, such that both agents are punished by a
decrease in their utility value. Reward and punishment help in implementing the
homophily principle of selective interactions in the interpersonal networks; they are
instrumentally employed in achieving either homogeneity (convergence to agreement
by an actor’s compliance in his interpersonal network of relations) or polarization
phenomena. The idea of using reward and punishment in achieving convergence is a
strong argument in favour of homophily as the principle for describing political
influence propagation in social networks. McPhee’s Voting Choice Simulation Model
is the only one to use a control framework of the convergence to homogeneity phe­
nomena. All the other subsequent approaches to the universal agreement phenomena
are concerned with the problem of diminishing the convergence tendencies in social
simulation and achieving methods which conserve disagreement and diversity
without affecting the democratic type of the model society (Johnson, 1999; Huckfeldt
et al., 2004).

Finally, the learning mechanism actually completes the operation of the political
influence process. It allows for the final levels of political interest to be used for
updating the predisposition of each individual agent: the modified predispositions
are backpropagated and subjected once more to campaign stimulation. If exposed
again to political messages, the updated predisposition, inducing the individual’s
voting behaviour, becomes associated with particular stimuli. The idea, inspired by
early behaviourist theories of stimulus–response learning (Estes, 1950) and one-trial
learning (Guthrie, 1946), explains how stimulus constitutive elements and predispo­
sition structural attribute values (e.g. direction) are associated with specific behav­
ioual responses.

Though considered a classical example of ‘stimulus–response’ behavioural
learning and often criticized for too much social determinism (Visser, 1996), McPhee’s
model goes beyond these paradigmatic limits. He describes the political persuasion
process within the dyadic network as a Polya process (Polya, [1957]1973) and sug­
gests that particular values of the predisposition’s attributes (i.e. direction) appear
repeatedly as the individual agent shows preference for discussing the issue with like­
minded people (McPhee et al., 1963: 79). These appearances, shared by like-minded
persons in the dyadic network, will actually reinforce a particular voting preference.
The process describing this tendency is a self-developing process. As a particular
voting preference appears more often, this facilitates the tendency toward achieving
agreement, making the individuals discuss and increase the level of their political par­
ticipation. In the aggregate, the effect of these self-developing, self-reinforcing
processes becomes evident in the emergence of clusters of voting preferences. The
macro-level phenomena are emphasized in the Wisconsin Primaries case study.5

The 1960 Wisconsin Primary election computer simulation experiment was
meant to show how mass media messages and the networks of interpersonal relations
influence the individuals’ initial predispositions and shape their final voting choices.
The case study of the presidential elections in Wisconsin, USA, 1960, with two
presidential candidates, Nixon and Humphrey, shows how the simulated changes in

the campaign ‘appeal’ result in changes in the vote distributions. The case study proves how the voting preferences depend on the social context and on the campaign stimulation. The variations in the voting preferences of two types of target population, namely farmers and town middle-class in northwestern Wisconsin, are studied as being dependent on the dynamics of their predispositions. The predispositions change process plays an important role in the dynamics of the relationship between the dispersion of the ‘appeals’ (stimuli) and the form of response (vote choice): depending on the subjective ‘interpretation’ of the appeal, the individual’s behaviour depends on the social-status characteristics (Protestants/Catholics, rural/urban), on the level of individual’s disposition and on the appealing power of the stimuli (the so-called ‘farm’ appeal). The dynamics of change in the individual predispositions provide for the emergence of voting preference polarization phenomena.

**Model’s Relevance**

McPhee’s *Voting Choice Simulation Model* has been forgotten for a long time, most probably because of its explicit background in behaviourist theory. The model is based on the stimulus–response paradigm, and this made its critics see it as working on social determinism principles which could be accepted as a rough explanation of the associations between stimuli and voting preferences during the electoral campaigns, but which could not explain more than that. For example, it could not explain the voting choices and the polarization of voting preferences unless a free-choice dimension was introduced in the process of individual predisposition change. McPhee was aware of these critics and addressed the subject in one of his papers (McPhee, 1961), trying to explain how, how much and to what purpose was his approach going beyond the principles and constraints imposed by the classic stimulus–response model of behaviour. His modelling approach includes a dynamics of voting preferences aggregation which could not have been achieved by the stimulus–response model only. Moreover, his model exceeds the limits of the social process model by introducing some mechanisms – learning, in particular – which made the processes acquire a certain dynamics. In explaining this design choice and its meaning, McPhee included at least two aspects which are essential for our understanding of the particular dimensions on which computational and simulation modelling of political attitudes have developed ever since. McPhee’s model puts a special emphasis on the dynamics of individual interactions within the networks of personal ties. It is these dynamics which, as observed empirically in his experiments, had inspired him to develop research on two dimensions. One belongs to political methodology and addresses an issue which somehow was in vogue at the time: ‘plausible scenarios’. During the 1950s and at the beginning of the 1960s, the idea of social forecasting, originally developed in the area of military studies by Herman Kahn (1962), was gaining support in social studies. McPhee was the first to introduce a new paradigmatic approach in political attitude simulation modelling: he speaks about his simulation experiments as ‘what could be’ and ‘what might have been’ types of experiments, thus inducing the idea that a computer simulation works on possible scenarios and develops each of them in the ultimate detail, so that aggregate
phenomena could be virtually observed and virtually experimented. In the political science of the 1950s, this means to break up the tabu of empirical research. Such a speculative exercise demands a reference system in which the truth requirement could be anchored, so that he calls on Lewin’s concept of social reality (Lewin, 1947a, b). This view of plausible scenarios which can be virtually generated by computer simulation runs and studied as an alternative reality addresses a notion which will be established and recognized much later as the ‘would-be worlds’ concept introduced by John Casti (1997) in his theory on computer simulation modelling. Making reference to a ‘thought experiment’, a concept introduced earlier by Daniel Dennet (1994), Robert Axelrod (1997) suggested a culture dissemination model which is based on a thought exercise, understood as a ‘what if…’ scenario generated with agent-based modelling techniques.

McPhee used this concept to address the fundamental characteristic of a computer simulation model to provide a view of the potential developments of a process or set of processes which depend on individual interactions. It is precisely this aspect of the potential developments which McPhee addressed in describing the aggregate patterns and dynamics of political attitude change in his simulation model. McPhee foreshadowed a concept established much later in computational and simulation modelling, which is specific to the generative approaches of political and social phenomena (Axelrod, 1997; Cederman, 2005). The ability to experimentally investigate so early (perhaps too early for the limited capacity of the computers of that time) the concept of ‘thought exercise’ makes Bill McPhee and his co-workers, Bob Smith and Jack Ferguson, the forerunners of a simulation modelling concept which will later on be employed by Robert Axelrod (1997) in his culture dissemination model.

The second essential aspect in McPhee’s justification addresses one of the fundamental goals of social science theory: explaining the link between the micro and macro levels of a social system in computational and simulation modelling terms. McPhee was the first to develop a political attitude computer simulation model which describes virtual experiments able to provide believable clues on how the micro-level individual interactions might evolve in the aggregate.

By the end of the 1950s, the experience McPhee had already gained from the electoral studies and computer simulation modelling, turned into a new research project. The issue proved to be so highly relevant as to foster McPhee’s engagement in a new fundamental research programme on computer simulation modelling of mass dynamics defined and explained together with James Coleman (McPhee and Coleman, 1958). The programme aimed to study the electoral phenomena in large populations of individual voters (McPhee and Coleman, 1958: 6). The issue of interest was the aggregate phenomena as the outcome of the individual interactions developing at the micro level of a social system (McPhee and Coleman, 1958: 7). The approach addressed the problem of studying the aggregate electoral dynamics with the help of computers and specific computational instruments able to translate the discrete observations describing the individuals and their interactions into artificial complex social systems describing the emergence of macro-level phenomena (McPhee and Coleman, 1958: 9). Though never fully accomplished by its authors, this programme nevertheless laid the theoretical foundations of a new approach on social action in the
study of social systems: the emergence of macro-level social and political phenomena from the individual interactions at the micro level.

As a matter of fact, this subject has become a research issue as the ‘small world’ research has slowly grown since the early 1950s. It emphasized new directions of research in social systems involving computational support for modelling and simulations. Two famous research groups have systematically pursued this orientation of research: while William McPhee was developing his voting choice computer simulation model, another important research group was developing a separate project on a computer simulation model of the presidential elections of 1960 and 1964. Though developed separately (McPhee, 1963: 169), the approach of Ithiel de Sola Pool, Robert Abelson and Samuel Popkin (1965) addressed mainly the same issue: the persuasive influence of the campaign communication and the role played by the networks of interpersonal relations on individuals’ voting predisposition, choice and behaviour. Other projects, like the Simulmatics project (de Sola Pool and Abelson, 1961) and Community Referendum (Abelson and Bernstein, 1963), emphasized and deepened the differences from McPhee’s type of approach and identified new dimensions of research on the political attitude phenomena.

Abelson and Bernstein (1963) developed a computer simulation model on similar issues, namely the attitude change of individuals in a small community under the influence of (a) campaign media communication and (b) individual interactions. Though concerned with the same research questions regarding the individual interactions and their effects in the aggregate, their model focused more on the interactions’ characteristics, like the rules which should govern the communication with the citizens, and the behavioural response of each citizen to the influence exercised by means of campaign messages. The study of these rules finally resulted in a heavy simulation model which has never been tested against empirical data due to its overwhelming, sophisticated structure.

McPhee and collaborators modelled the aggregate phenomena of the changes induced in the individuals’ political preferences and choices by the campaign media and the networks of close ties. This modelling approach is based more on the contents of the political predispositions, and not on formal aspects of the individuals’ social actions, like the number of individuals or their interactions’ characteristics.

This approach has inspired further development of two areas of research: one is concerned with the methods and techniques of modelling and simulating the social systems as complex collections of individual agents, which has increased the interest in agent-based modelling of social phenomena. The other one is mainly concerned with the micro-level individual interactions and the macro-level phenomena they might generate.

Much later, Axelrod (1997) developed a simulation model of culture dissemination which builds upon the idea that attitudes (as culture elements) change due to individual interactions, which are viewed as a generative engine: the emergence of macro-level phenomena is explained by the micro-level individual interactions (methodological individualism).

Both Abelson and Bernstein’s model and Axelrod’s model are extensively investigating the idea of generative individual interactions at the social micro level. Their
models are rather interaction models and accomplish, in many ways, the claims of the early programme of McPhee and Coleman (1958) on the study of mass behaviour and social action. Their model is briefly introduced in the subsequent chapter in order to describe its main characteristics and performances.

**Philosophy of Computational Modelling and Simulation**

McPhee’s voting choice model was the first computer simulation model of voting behaviour in the history of computational approaches in political science.

It could be that this model arrived too soon in a research community which was not yet prepared for the intricate claims of a ‘simulation program’. Computers were still too big and too slow, whereas the political science research of the 1940s had been almost ‘swept’ by research on military issues and war propaganda. Columbia’s well-known studies were meant to bring about the behavioural revolution in political science. In the underground of this tardy revolution, however, the computer simulation era started almost unnoticed, as a silent companion. William McPhee was remarkably ingenious and subtle. And so is his Voting Choice Simulation Model.

**References**


Community Referendum Model

The Community Referendum Model (Abelson and Bernstein, 1963) simulates how citizens’ attitudes change as a result of the communication in a community referendum campaign: the individuals change their attitudes as a consequence of their exposure to the mass media campaign messages, and also as an effect of the discussions with peers in the networks of interpersonal relations. The model is as general as to cover a large class of both non-political (community referenda on social issues) and political processes (electoral campaigns) (Abelson and Bernstein, 1963: 93–94).

Computational and simulation modelling has some theoretical similarities with McPhee’s model (1963): the model is a computational construction of the political campaign on a particular issue in a social community. This artificial construction consists of a ‘miniature’ dynamic system which is implemented as a symbolic replication of a real campaign. While a single simulation run takes a few minutes on a computer (IBM 7090), it represents a real time of 1 week. Several runs thus cover as many weeks, simulating the campaign time. The outcomes of the simulations are interpreted as group phenomena, showing how the polarization of attitude positions on the referendum issue depends on the individual’s political interest and on that of their friends.

The simulation model consists of a set of artificial individual agents representing 500 citizens (Abelson and Bernstein, 1963: 94), a set of rules which the agents use for assertion, evaluation, and for the campaign message processing, and a set of rules for attitude change.
Conceptual Aspects: The Individual Agent

The individual citizen is represented in the model as a complex computational entity (individual agent) with an internal sophisticated structure with several attributes (see Figure 4.1): (i) social status and other relevant characteristics of each individual; (ii) initial settings of the individual interest, issue position and evidence of previous voting and experience with referendum campaign issues, like knowledge and attitudes toward such issues as acceptance/rejection positions (pro and con); (iii) exposure to the news channels supporting the referendum campaign and frequency of exposure to each such channel; (iv) individual attitude toward campaign key persons (i.e. influencers).

The agents are subjected to two sources of influence: mass media public communication channels and personal interconnections. Each agent is characterized by issue positions, political interest for the referendum issue and the capacity to process the information provided by both public channel and the citizens in the network of interpersonal connections.

The message consists of an assertion about the referendum issue with which an agent could agree or disagree. The agreement/disagreement is subject to a set of rules which are initiated according to the type of assertion and its source.

Political Influence and Political Attitude Change

The individual agent is able to evaluate incoming assertions on the referendum issue: the agent has an attitude with respect to each assertion which has been evaluated (pro and con). This issue position is changing as the agent receives more messages from the media. A major role is played by the persons in the network of interpersonal

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**Figure 4.1** Individual agent's internal representations of the electoral campaign.
relations, that is, citizens in the community that are considered pivotal for the referendum campaign (Abelson and Bernstein, 1963: 95). The individual agent has a position toward such influencers, and her position is changing as more discussions are engaged in with peers in the different networks – for example, at home or at the work place. The agent is characterized by a specific degree of interest in the referendum issue. This interest is also changing as the individual is exposed to the news media messages in the campaign and to the different issues of the influencers. The model is aimed at providing predictions for group phenomena.

An attitude (issue position) is changed if the source is liked, if there is content consistency, if there is consistency with the individual’s value system and previous experience with campaign issues or voting preferences. Individual agent interactions are simulated discussions and consist of assertion communication. Once communicated, an assertion is evaluated on the basis of the appropriate rule set.

**Operational Model**

The simulation model has a modular architecture which consists of mainly two modules (see Figure 4.2): the computational agents (population) and the computational structures, which consist of a pool of simulation variables and data structures, mechanisms and processes aimed at enhancing the individual interactions in a large population of individual agents.

**Figure 4.2** Community referendum simulation model: structure and processes.

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The individual agent has a very sophisticated description. This includes both social structure (demographic characteristics, sociometric data) and attributes like political interest and attitude position toward the referendum issue, and a considerable number of measures of the agent’s capacity to interact, goal of interaction, internal predispositions, consistency of beliefs, extremity of issue positions and values associated with her interest toward the campaign messages and the conversations with peers in the networks of interpersonal relations.

Each individual agent is subjected to a classic sequence of phases: stimulation phase (achieved through campaign messages), influence phase (by assertions accepting/rejecting assertions) and learning phase (by assertions memorizing/forgetting). However, this classic scheme is employed in a specific way: corresponding mechanisms and processes in each phase are triggered by rules describing nearly each possible situation which an individual agent could encounter during simulation runs.

**Stimulation Phase**

The stimulation process is based on communication channels. At the operational level, the influence exerted on the individuals by means of communication channels and discussions with peers is controlled by the levels of resistance to influence, which define the attitude extremity levels. The campaign influence is successful when an individual agent has a mild position toward campaign issue(s) and her degree of interest in such issue(s) is sufficiently high as to make the agent sensitive to campaign stimulation (messages). The model covers situations in which almost all individual agents are influenced to some degree (Abelson and Bernstein, 1963: p. 98).

**Influence Phase**

**Rules**

The individual agent is able to change her attitude toward the referendum issue as the effect of the influences exerted by the sources in the communication channels and the peers in the interpersonal networks. The change processes are triggered by rules which are based on probability updates.

In each simulation run, the main variables – interest, issue position and experience – are updated in a cycle: during the first half of this cycle (A), the individual agents activate the rules which guide the evaluation of exposure to a source internal to a communication channel (A-rules), while the evaluation of their exposure to the discussions in the dyadic networks is performed during the second half of the cycle (B) by the activation of another set of rules (B-rules).

There are three sets of rules (Abelson and Bernstein, 1963: 98–112) involved in the appropriate processes which converge toward the changes in political interest, political attitude and vote choice.

There are 22 A-rules (A1–A22) for evaluating the probability of individual exposure to different sources of campaign messages. The model defines various direct and reverse measures of exposure, like (1) attractiveness of a communication
channel and attraction toward a particular issue, (2) receptivity to a particular source, (3) credibility of a certain source, a concept inspired by the work of Hovland and collaborators (Hovland, Janis and Kelley, 1953) and (4) attitude change factors, like the degree of change and direction of change. The model also includes the coupling of variables whose relationship and variability provide the means to evaluate additional factors like, for example, the ‘attention value’ (i.e. ‘low’ or ‘high’), ‘assertion match’ (i.e. ‘positive’ in case of agreement, ‘negative’ in case of disagreement), individual interest as a function of assertion match, individual satisfaction as a function of the degree of consistency between assertion and individual predispositions toward particular campaign issues (Abelson and Bernstein, 1963: 101).

There are 27 B-rules (B1–B27) for evaluating the probability of individual exposure to conversations with peers in the dyadic networks of interpersonal relations. These rules are parallel to several A-rules as their role is to transfer what has been defined in terms of exposure to campaign messages into terms of exposure to conversational interactions with peers. The B-rules work on conditionals defined by concepts like:

- receptivity of an individual agent to another agent as a function of the extremity of attitude position of the latter;

- assertion match, which describes how much the assertions accepted by one agent are also accepted by the conversation partner;

- number of exposures to conversational interactions – the higher this number, the more the attitude position will change;

- interest in the campaign issue increases with the increase of the number of exposures to both conversations and communication through campaign channels;

- degree of forgetting (also used by McPhee in the learning process) – applies only to inconsistent assertions, and is used to keep within realistic limits the assertions involved by any individual agent at a given moment of time during the conversation with another agent.

The rules evaluating the probability of exposure to the conversations with peers in the dyadic networks are operating under the fundamental principle of homophily (as formulated in B27), which induces, in the long run, the effect of general consensus generated by the selection criteria of the peers from the network of interpersonal contacts. The authors make explicit that the attitude change occurs as the result of selective exposure to conversations with peers, and not as an effect of the experience-based reactions to the messages transmitted by the sources in the campaign communication channels (Abelson and Bernstein, 1963: 94). The issue is especially relevant to the political persuasion within networks of interpersonal relations, an area addressed by McPhee with his collaborators (McPhee, 1961; McPhee and Smith, 1962), and which will be further ‘inherited’ by the approaches developed almost half
a century later, two of them comprised here: Latané and collaborators (Nowak \textit{et al.}, 1990) and Huckfeldt \textit{et al.} (2004).

This issue is particularly relevant since it concerns the problem of universal agreement in modelling democratic societies. It was developed by Abelson in a subsequent paper (Abelson, 1964), and especially by Robert Huckfeldt and collaborators in their diversity survival model. In his exquisite mathematical modelling theories in social psychology, Abelson (1967) developed a differential equation-based mathematical model of the processes of individual interactions in small worlds. He succeeded in emphasizing in a particular formal way that the modelling of political attitude change as the outcome of the individual interactions in dyadic networks should be approached from the perspective of dynamic processes: it is only by considering the dynamics of individual interactions that the issue of diversity survival can be simulated in a believable way, that is, replicated by simulation models which do not reach universal agreement. Believable simulation models would remain stable in spite of new attitude positions which might be introduced by means of dyadic conversations and compete in the social space of an interpersonal network. The idea will strongly influence the modelling approaches developed much later by Bibb Latané and collaborators (Nowak \textit{et al.}, 1990), Robert Axelrod (1997) and by Robert Huckfeldt and his collaborators (Huckfeldt \textit{et al.}, 2004).

**Variables**

The \textit{interest}, \textit{issue position (attitude)} and the \textit{assertion-acceptance} variables are coupled so that their correlation can be evaluated during the simulations.

**Mechanisms**

The individual agent uses an \textit{assertion-acceptance} mechanism which allows for the evaluation of the influencer’s credibility, where the influencer could represent both the sources internal to the communication channels and discussion partners. This mechanism is useful in evaluating the degree of inconsistency between an individual’s issue position and the acceptance of an incoming assertion; if there is consistency, then the individual agent will accept the assertion, otherwise the agent will support increased pressure toward attitude change. Moreover, the spread of the degrees of acceptance/rejection of a particular assertion can thus be traced in the networks of interpersonal relations of each individual agent.

The model has never been tested against empirical data at the parameters described in the theoretical model, which is based on a population of 500 individual agents and a huge number of detailed descriptions for each agent, channel, source, rules and interpersonal networks. The richness of the model is sometimes overwhelming, and Abelson and Bernstein (1963: 115) admitted that the test simulations were performed with a very simplified set of manufactured data for only a set of 50 individual agents and a reduced set of assertions, channels, sources and conversational partners.
Philosophy of Simulation

The Community Referendum Model uses computer simulation with the explicit goal of unifying the theories of individual and group behaviour (Abelson and Bernstein, 1963: 93). Simulation modeling allows for the explanation of group behaviour by the interactions among individuals. One of the justifications provided by Abelson and Bernstein concerns the reduced capacity of statistical modeling to cover the individual attitude change and group behaviour issues. The static characteristic of statistical models based on variables and linear relationships among them has only limited ability to describe and explain the processes of behaviour and attitude change at both individual and group level. In order to overcome such limitations, they employ the computer simulation technique in constructing a dynamic model able to describe and explain the political processes which develop in a community during electoral or social campaigns. Such a simulation model consists of complex sets of variables (Abelson and Bernstein, 1963: 94) and computer programs which are meant to mimic the real structure and the dynamics of the community’s voting preferences by symbolically reproducing the dynamics of change in the individual agents’ attitudes and voting choices as they are exposed to a communication campaign.

Abelson and Bernstein published their model after a previous major experience in studies of electoral behaviour. At that time, the issue was one of the (if not the most) relevant subjects in political science. Their approach was not the only one: other than the computer simulation model developed by William McPhee and his collaborators (McPhee, 1963; McPhee and Smith, 1962), the issue was previously approached by Ithiel de Sola Pool and Robert Abelson (1961) in the Simulmatics project. It was also approached from a psychological perspective involving the psychology of personality as well as the psychology of voting (Lipset et al., 1954). Along with these social psychological and political science approaches, some of the most advanced approaches of that time in the area of artificial intelligence (AI) and problem-solving models were developed, aimed at replicating the thought processes in humans by means of computer programs (Newell et al., 1958) which further inspired Robert Abelson and Alex Bernstein.

Trying to assess the philosophical idea behind the computer simulations, Abelson and Bernstein make a technical distinction between two types of simulations which are used by the various approaches of the time: one is a simulation type aimed at predicting ('prognostic simulation') the final outcomes of a computer simulation model (for example, predicting the winner in the presidential elections1) and the other type is concerned with the simulation of the processes involved in a situation at hand ('process simulation') aimed at studying and tracing the detailed characteristics of the processes involved. The first type should be based on a detailed description of the agents involved in the scenarios. For example, de Sola Pool and Abelson identified 480 types of voters by cross-classifying demographic characteristics and survey data. This was further oriented toward defining classes of agents and their types of attributes. The study of the individual agent thus becomes a fundamental

1 See more details in the book by de Sola Pool et al. (1965).
dimension of research. The second type of simulation should be based on the detailed description of the processes: mechanism involved, variable descriptions, relationships between variables and coupled variables, and so on. This orientation has finally resulted in a second fundamental dimension of research which is that of process simulation. Prognostic simulation is based on large amounts of empirical data and achieves a description of future possible situations (outcomes) like, for example, the polarization of voting preferences.

When such large amounts of empirical data are not available, survey data could support and enhance the study of processes by detailed descriptions of the variables involved and their continuous transformations (Abelson and Bernstein, 1963: 120–121). This dimension of research will later on inspire Latané and collaborators in the design of the dynamic social impact model. It will also inspire Huckfeldt and collaborators in their agent-based approach of the diversity survival model (Huckfeldt et al., 2004).

**Conclusions**

The two computer simulation models were developed almost in parallel, they nevertheless show some basic difference in their conceptual backgrounds: McPhee’s model (McPhee, 1961; McPhee and Smith, 1962; McPhee, Smith and Ferguson, 1963) is strongly influenced by Lewin’s concept of social forces (Lewin, 1952, 1959), while Abelson and Bernstein’s model is more oriented toward achieving aggregate mass behaviour from rule-based interactions at the micro level.

McPhee’s approach is fundamentally oriented toward the achievement of a computer simulation system which could appropriately represent predispositions’ content and their relevant attributes, and mimic the predispositions’ change, a process which he describes as basically depending on political campaign stimulation and dyadic network persuasion.

Abelson and Bernstein’s approach is much more oriented toward the achievement of a computer simulation system which could appropriately represent and mimic the interactions among a large number of individual actors.

Though both models have to cope with the problem of universal agreement in dyadic interaction networks in which the selection of discussants is driven by the *homophily* principle (‘likes attract’) (Lazarsfeld and Merton, 1954), McPhee’s model addresses the aspects of content-based roots of agreement, while Abelson and Bernstein model the individual interactions as the engine of reaching agreement.

Abelson and Bernstein’s Community Referendum Model often constitutes a basic reference in the history of simulation modelling and agent-based models (Troitzsch et al., 1996; Uhrmacher and Weyns, 2009: 57; Troitzsch, 2013). Agent-based systems and models are extensively used in social simulation (Gilbert and Troitzsch, 2005) and computational sociology (Squazzoni, 2012) to create artificial societies (Epstein and Axtell, 1996) and simulate complex, self-organizing social processes (Edmonds and Meyer, 2013).
References


Part III

THE ROLE OF PHYSICAL SPACE IN POLITICAL ATTITUDE MODELLING

The Dynamic Theory of Social Impact, DSIT, (Nowak et al., 1990) is a computer simulation model providing a dynamic version of the early Social Impact Theory, SIT (Latané, 1981). Together with the segregation model (Schelling, 1971), they are considered the first social influence computational and simulation models of attitudes and behaviours. Their authors are considered the pioneers of the social simulation area of research.

The Dynamic Theory of Social Impact uses a computer program to model and simulate the political attitude change in social persuasion scenarios as a class of emergent social impact phenomena which are dependent on the number of individuals, their physical location and the strength of their (political) attitudes. A typical social persuasion scenario consists of the interaction between the individual and the groups of supportive and opposing others. The effects of social persuasion at the micro level are modelled as emergent attitude change macro-level phenomena. The model has been tested against huge amounts of empirical data in various experimental settings. It is perhaps the only model which started in the traditional mathematical modelling paradigm and has gone through almost all modelling paradigms: the model-invariant paradigm with intensive testing against huge empirical data collections, inter-personal connection networks with their social deterministic structure (featuring social networks, a nascent theoretical area at that time), cellular automata with their self-organizing characteristics, and catastrophic modelling with chaotic processes. Its impressive robustness and flexibility, as well as its capacity to generate emergent phenomena which illustrate the basic social self-organizing processes, made it one of the most influential and inspiring modelling approaches for what we know today as agent-based social simulation modelling. What this model shares with the others in our presentation is the idea of explaining macro-level political change phenomena by the individual interactions at the micro level of
society. What makes it distinct from the other models is the idea that physical location, number of individuals and strength of their attitudes are enough for generating the dynamics of attitude change as the effect of social persuasion. While this design works very well as a generative engine for small, compact groups scattered in a limited physical space, it has its own limitations: while preserving diversity, it nevertheless fails to explain it by the chosen parameters only. Extremity of attitude is therefore studied in a catastrophic model for explaining political attitude change (Latané and Nowak, 1994). Moreover, both Social Impact Theory (Latané, 1981) and Dynamic Social Impact Theory (Nowak et al., 1990) take political attitudes as but one example of attitudes without going on to define what makes their change distinct amongst social attitude change in general. It is this detail which made us contrast it with models which are true political attitude models.
Political attitude change is as much an issue in social psychology research as it is in political science. It is often studied as an effect of persuasion in areas like voting behaviour, electoral studies and political psychology. It is also studied in group dynamics and in political culture. One fundamental research question is concerned with the source of political attitude change: *Where is the change in political attitudes coming from?* Another one looks at *how* the change is spreading out, and *what* are the conditions of its unfolding: *How does this changing unfold?*

By the beginning of the 1960s, the former was the issue in vogue. It was the time when Bibb Latané had started his research on the bystander effect. While many of the relevant answers to the *where from?* question had been provided in less than two decades, Latané had been preparing the answer to the second. It is his answer to this question which makes the subject of this chapter.

*Social Impact Theory* (Latané, 1981) is a social psychology approach on political attitude change which has been developed within the conceptual framework of public opinion change. It aims to prove that the social impact is the result of the combined effect of the factors acting on three dimensions of the social system: the geometry of the social space (spatiality factor), the number of the others (population size) and the strength of the attitude held by each individual (attitude value). The theory applies a force field model to a social influence typical scenario of the persuasive presence of the group on an individual. It defines the *social impact* as a concept which describes the *factors* moderating the social influence processes and the magnitude of the combined effect of their influence on the operation of group persuasive processes. The effect can be briefly stated as the greater the group social impact on the individual, the more significant the change in the individual’s opinions, beliefs, attitudes or
behaviours. For one example, this effect becomes particularly interesting when studied in connection with electoral behaviour and political participation (Harkins and Latané, 1998).

**Physical Space and Social Influence Modelling**

By the end of the 1970s, in attitude research in general, and in political attitude research in particular, social influence modelling approaches were mainly addressing the cognitive aspects and the information-processing abilities of the individual (Petty and Cacioppo, 1981), the information sources and the access to information (Anderson, 1971).

One issue, as Bibb Latané observed (Latané et al., 1995: 796), remained to be investigated: *How and how relevant is the physical space in political attitude formation and change phenomena?*

Starting with the 1940s, the impact of the physical space in persuasion research had somehow been neglected with the advent of the new TV media communication technology, which actually made spatial distance not matter anymore. Media were not considered essential in influencing the individuals’ attitudes, whose formation and change was moderated by small groups of opinion leaders (elites) able to comprehend the electoral media information (Lazarsfeld et al., 1944; Katz and Lazarsfeld, 1955; Katz, 1973).

What Latané observed and finally pursued with a remarkable insistence was the role ‘physical space’ in terms of ‘distance’, ‘closeness’, ‘neighbourhood’, ‘adjacency’, ‘borders’ and ‘contiguity’ (in spatial and geographical terms) could play in assessing complex social and political phenomena, like cultural diversity, the survival of opinion diversity or the emergence of extreme political attitudes.

Trying to approach this issue was a good chance for starting thinking about individual interaction in terms which included physical distance along with the cognitive issues, which made the dominant view at that time. Surprising as it seems, it represented one of the pioneering approaches on modelling and simulation of individual interactions in large social settings. By the end of the twentieth century, this issue provided one of the most dynamic research areas: social simulation. Also concerned with individual interactions, it has developed within the paradigm of methodological individualism. Bibb Latané is considered one of the forerunners of this modelling approach in social simulation and computational sociology (Gilbert and Troitzsch, 2005: 148; Squazzoni, 2012: 104–105).

**Modelling Social Pressure as a Force Field**

Latané’s social impact theory was inspired by a classical impact model in physics: the force field model. The attempt to use theories from physics in sociology and social psychology was, however, not new. The idea had been introduced and used by other sociologists starting in the late 1940s, like Kurt Lewin (1951), whose theory of force field analysis applies for a large number of social situations, in particular
for the management of change. His theoretical ideas were further developed by John French (French and Raven, 1959), who described power as the source of social influence. Models of the spatial interaction of individual human agents have found inspiration in gravity models described in the early paper of Carrothers (1956) on social distance in large groups. What makes Latané’s social impact theory really special to our study is its applicability to the study of political attitude change phenomena. The original theory has its own limitations, but its contributions to the simulation and modelling of political attitude change are, nevertheless, remarkable. Latané constructed a mathematical model of a social influence force field much like the mechanical model of the force field, taking the social influence, in particular persuasion, as a ‘force’ exerted by a group on an individual. This analogy is thus aiming to explain how to assimilate the presence of the others with a force of social pressure (Jackson, 1987).

The essential difference from other social influence modelling attempts resides in defining the effect obtained by applying the ‘social force’ of a group on an individual. The effect is dependent on both the physical distance from the source and the magnitude of the force impact. This makes it necessary to define ‘physical distance’ and ‘magnitude’ of the impact in social influence terms. While the notion of spatial distance between any two individual actors is addressed in terms of statistical mechanics (Lewenstein et al., 1992), the notion of magnitude includes both the group size issue (approached by the group dynamics theories in sociology and social psychology) and the issue of attitude strength (approached by the cognitive theories in social psychology).

Even after making explicit this essential difference, there is still one more, no less important, difference. Social impact theory, in Latané’s view, aims at modelling the operation of social influence processes: it makes explicit how social influence actually takes place and how much the context enhances it or not. Latané’s approach is thus a meta-theoretical approach providing for an explanatory model of the relationship between the micro-level social influence factors and the macro-level political attitude change phenomena, rather than the psychological and social psychological mechanisms which are responsible for it.

Social Impact Theory (1981)

Defining the Social Impact

Early psychology and social psychology studies of the connection between social influence and attitude change were mainly concerned with the individual attitude. The first to approach the issue of the influence of the presence of others on an individual’s performance was Triplett (1898). His experimental work inspired later social facilitation theories (Zajonc, 1968).

In Kelman’s theory, the relationship between social influence and individual attitude change is modelled by means of three processes of influence: compliance, identification and internalization (Kelman, 1958: 53). As Kelman defines them, these processes prove that the influence which the individual accepts from the (direct or
mediated) interaction with others may operate at different levels: motivational, cognitive or normative. Any attitudinal change assumes at least two individual agents (dyadic interconnections): an influencer and a recipient agent. Changes in the individual attitudes are identified and evaluated as patterns of attitude structural components – beliefs, feelings, cognitions – and are essentially determined by three main factors, whose functionality is the same no matter what the particular attitudinal object is: (i) the relevance of the individual’s expectations with regard to the effect of the accepted influence, (ii) the kind of power of the influencer and (iii) the way in which the influence is induced in the recipient agent. Social influence, therefore, is modelled as a particular connection between mechanisms of individual means-ends control, motivational mechanisms and mechanisms of reputation and credibility (Kelman, 1958: 54). Kelman’s theory puts the emphasis on the psychological characteristics of the individual personality and its behaviour in dyadic relations.

Gordon W. Allport (1968: 3) defines the social influence as the overall effect of the others’ presence, extending the notion of ‘presence’ so as to cover general situations in which the others are actually or only virtually present, that is, present in one’s mind by virtue of rational thinking and/or memory representations. In this case, what matters in describing and explaining attitude change is the size of the group as the number of the individual agents simultaneously involved in interactions with the others, exerting influence on, and being influenced by the others. This factor, introduced in the early social psychology theories, like cognitive dissonance (Festinger, 1957), and information integration theory (Anderson, 1981), has been particularly difficult to operationalize since the classical attitude definition does not explicitly introduce structural descriptors of individual networking aspects. The operation and the effects of these kinds of social interactions are as difficult to predict as they are complex. Though implicitly considered or incompletely specified, the social space appears as a potential parameter of the social interactions in the work of Festinger and collaborators (Festinger et al., 1950). Persuasion and involvement have been studied for their role in attitude formation and change (Petty and Cacioppo, 1980, [1986]2011; Petty et al., 1981, 1983) as fundamental dimensions of social influence mainly involving the cognitive features of the individuals, and the cognitive aspects of the processes of interaction between individuals.

Latané took on this impressive cognitive tradition. Moreover, he aimed at integrating this traditional cognitive view on social influence and impact into a more general view.

Summarizing Latané’s various types of laboratory and experimental case studies research, the term referring to the presence of others addresses mainly the situations in which an individual is influenced by several other persons either closely or remotely situated in the spatial environment underlying the social space. It also addresses the situation of a mediated communication between an individual and other persons, whom an individual might watch on TV or listen to radio broadcasting. The theory defines in mathematical terms the role the presence of others plays in bringing about change in the socially determined attributes of an individual, like opinions, beliefs, behaviours and attitudes (Latané and Darley, 1970; Keating and Latané, 1976; Latané and Nida, 1980; Latané and Bourgeois, 2001a: 62).
Social impact is defined as the overall result of the combined effect of three factors: immediacy (in terms of the physical distance between the source and the target of social influence), number (as the number of sources of social influence) and strength (as the strength of the attitudes held by the others).

The immediacy \((I)\) factor models a basic notion in space representation: the distance. The mathematical as well as the operational definition of the physical distance is based on the classical Euclidean distance. However, Latané’s later research revealed several other formalisms employed in describing and explaining the social impact not only in physical distance terms, but also in terms of the social networking of an individual (Lewenstein et al., 1992). The presence of others is made effective by evaluating and comparing their distance with respect to an individual target. Their spatial distribution becomes, therefore, relevant for the magnitude of the social impact. For an individual’s political attitudes, the ‘closeness’ of others in terms of physical distance has a strong social impact: the closer persuasive others are, the more influence they have on the individual’s attitudes.

Number \((N)\) models a basic notion in group dynamics: the group size. The presence of others is made effective by both their number and their spatial distribution with respect to the individual target. However, the relationship between the number of others and their social impact on the individual is not as straightforward as it might appear at first glance: increasing the number of others definitely has a social impact on the individual, but a stronger degree of their impact is not always directly proportional with their increasing number.

The third factor in social impact theory, the attitude’s strength \((S)\), models the cognitive attributes of the others (in terms of ‘authority’ or ‘power of persuasion’), which become relevant for inducing a change in an individual’s attitudes.

### Mathematical Model

The mathematical model states that the social impact \((\hat{I})\) is a function of the strength \((S)\) of the influence the others have on the individual agent, the number \((N)\) of the others, and immediacy \((I)\) as their close or remote spatial location with respect to an individual actor:

\[
\hat{i} = f(SIN)
\]  

(5.1)

where \(f\) is a multiplicative function (Latané, 1981) aimed at properly describing the simultaneous effect of the three factors. Latané works with a power function, which best covers the marginal decreasing effect of many additional others.

The initial empirical studies and experiments provided for a particular version of the social impact formula which takes the number factor as variable while the other two factors are constant values. The social impact is dependent on the variable number of the sources of influence as follows:

\[
\hat{i} = kN^n
\]  

(5.2)
where $\hat{i}$ is the value of the social impact, $k$ is a constant describing the specific characteristics of the experimental studies and $n$ is a power coefficient (Latané, 1981: 346–347).

This rather descriptive than predictive formula (Jackson, 1987: 112–113) represents the initial expression in social impact theory, which does not give any more technical details about the $n$ exponent, except the recommendations extracted from the experiments: its value has been hypothetically assumed to be less than 1, and evaluated on an average of 0.5 as recommended by the empirical findings, and $N$ is the number of sources (Latané and Nida, 1980; Latané, 1981).

The original version of the theory takes into consideration the situation in which the social impact value is calculated (a) for an individual as the persuaded ($influenced$) and (b) for an individual as the persuader ($influencer$) of a group.

The many-to-one situation, called the multiplicative force field (Wolf and Latané, 1985: 203), is characterized by a single target and multiple sources of influence, corresponding to the scenario of the social influence exerted by the group on an individual member.

The social impact value calculated for an individual in the presence of $N$ sources of social influence (multiplicative effect) is given by the formula:

$$\hat{i}_{\text{current}_{\text{individual}_{\text{agent}}}} = k\sqrt{N} \quad (5.3)$$

where the individual ($influenced$) is the target of the social influence exerted by $N$ others.

The one-to-many scenario, called the distributive force field in scenarios of majority–minority influence (Wolf and Latané, 1985: 211), describes the situation in which a single source of influence (individual) is persuading $N$ others (group), so that the influence is divided among $N$ targets.

In the case where the individual is the source of influence ($influencer$), the social impact value calculated for an individual agent, who is persuading $N$ others (distributive effect), is given by the formula:

$$\hat{i}_{\text{current}_{\text{individual}_{\text{agent}}}} = \frac{1}{k\sqrt{N}} \quad (5.4)$$

where the individual agent is the source of social influence (the $influencer$) and $N$ is the number of others (the $influenced$).

**Still Relevant, in Spite of Hard Critics**

Social impact theory has several critical aspects, both theoretical and methodological.

One of the most criticized aspects regards the descriptive character of social impact theory and of its mathematical model, which pays too much attention to the sources of influence (able to explain how the influence occurs) at the cost of paying too little attention to the intra- and interpersonal psychological processes
(able to explain why the social influence occurs) (Maass and Clark, 1984: 440). Also criticized was the modelling of the number factor effect with a power function without taking into consideration probabilities of change (Barr and Passerini, 1998). Another criticized aspect concerns both a theoretical and a methodological characteristic of the social impact theory namely the single process approach, which takes a dual-type process like, for example, the majority and minority influence as a single-type process on the basis that they both can be described by the same set of variables (Wolf and Latané, 1985: 215; Martin and Hewstone, 2003a: 355–356). Still another most criticized aspect is that of the force field model invoked by Latané as a source of inspiration for the social influence force field. While some have questioned the appropriateness of a force field for modelling social influence (Troitzsch, 2009: 36-39), others (Doms and van Avermaet, 1985; Wolf, 1987) have argued that the social influence on a large audience might have a diffusion effect of social impact rather than a division effect as suggested by Latané.

Beyond the hard criticism formulated by relevant authors in the domain, and the critical view assumed by Latané himself, social impact theory remains relevant for several reasons. Let us briefly evaluate some of them.

**Social Impact Theory as a Data-Driven Theory**

Empirical sources and an experimental testbed were essential for the social impact theoretical construction. The robustness of both theoretical achievements and experimental outcomes resulted from repeated testing against large volumes of empirical and analysis data. For this approach, social impact theory is what we call a *data-driven theory*.

**Social Impact Theory as a Metatheory**

Social impact theory is a metatheory. It is concerned with the factors moderating the operation of the social influence processes, and not with explaining the operation of social influence processes (Latané, 1981: 343). As such, social impact theory is a relevant modelling exercise for providing meaningful descriptions and formal explanations of the relations between individual interactions at the micro level of a social system, and their effects at the macro level.

**Social Impact Theory as a Model-Invariant Explanation of Political Attitude Change**

Social impact theory is a mathematical model of the social impact of a group on an individual. It provides for a model-invariant explanatory approach to political attitude change. The three factors taken into consideration in the modelling of the social impact provide for a general law model, able to explain the operation of any kind of social influence process. This modelling paradigm is called *model invariant*
since the model must work in the same way across empirical situations, regardless of their specific type: conformity, helping others, diffusion of responsibility, majority and minority influence, obedience, stage fright or political attitude change.

Notwithstanding its explanatory power, a model-invariant approach is based on a reductionist perspective on social influence and several strong assumptions with regard to social impact. As Latané himself admits (Nowak et al., 1990: 364), social impact theory is a static theory: it assumes that the individual is a passive receptor of the group influence. The theory further assumes that the social influence is uniformly distributed around the individual: the others are at equal distance from the target (see Figure 5.1).

The factors which affect the operation of the social impact process are formal factors (space and time) and do not identify in any way the qualitative content of the individual’s attitude.

Social Impact Theory as a Rational Choice Model

Social impact theory assumes a rational view of political attitude change, which occurs whenever the forces ‘pushing’ the individual to adopt the others’ attitude prevail over the forces which make the individual resistant to change. The direction in which the individual is finally ‘pushed’ by the competing social forces is decided by how great one force effect is in comparison with the effects of other forces acting in the same force field, much like physical objects subjected to physical force field effects (Pachur et al., 2013: 289–291). The philosophy of this kind of approach allows for evaluating the social impact under the requirements of the rational choice theory, where the social impact could be defined as the final outcome of a social force comparison framework in which the magnitude of the social force should be maximized in order to become decisive in influencing an individual. From this point of view, Latané’s social impact theory is based on a simple rule of ‘majority rule’, which has been detailed later in the dynamic version.
Characteristics of Social Impact Theory

As regards its subject matter, *social impact theory* is not concerned with the nature of persuasion, and even less with the nature of political attitudes. It is concerned with the contextual objective, rather than subjective, factors which enhance (or not) the operation of social influence processes. Identifying these factors, and the way they constrain the operation of social influence processes, represents the central theoretical issue.

The theory develops a social space model which is defined in the classical paradigm of causality. As inspired by the force field from physics, the model seems to be confined within the mechanical paradigm of ‘force’ (as the cause) and ‘impact’ (as the effect), thus making a parallel between a ‘social impact’ and a ‘physical impact’. Somehow, the theory also maintains a traditional view in regard to the interpersonal (dyadic) relations in defining the social impact by taking into account the physical distance between two points. Thus, the social impact is calculated for each individual on the basis of the Euclidean distance to each of its neighbours.

Nevertheless, *social impact theory* succeeds in introducing a different perspective on attitude change by considering the social impact as the measurable effect of the influences perceived by an individual from both close and remote neighbours. This global perspective modifies the classical picture of attitude change: the view in which the influence is conveyed between two persons on the basis of an interpersonal (dyadic) relation is replaced by a global view over the influences to which an individual is socially exposed. This seriously weakens our classical understanding of attitude change as a causal phenomenon. Attitude change becomes a macro-level phenomenon, whose justification requires a different modelling of the micro–macro link in a social system.

This helps us in emphasizing a second differentiating aspect of *social impact theory*: the research method. Latané started with a mathematical model and replaced it later with a computer simulation model. The explanation of this choice comes from Latané (1996a,b) himself.

If *social impact theory* was meant (and limited!) to identify a universal law concerning the social impact of the group persuasive influence on the individual, then its formula succeeded in finding it. However, if *social impact theory* was meant to identify the relevant contextual factors and how much these factors facilitate (or constrain) the operation of the social influence processes, then its formula identified something more than just a general law. In this case, the phenomenon identified by the social impact formula is different from a covering law, which is supposed to apply regardless of the particularities of the context. This phenomenon goes far beyond an invariant of the model. While covering the invariant aspects of the phenomena considered as effects of the persuasive presence of the others on an individual, social impact theory seems to uncover a more complex relation between social impact and the factors influencing the operation of social influence processes. As a metatheory, *social impact theory* builds upon the potential power of a principle, and not just on the contingent outcome (possibly distorted) of a rule.

The point here is the complexity of the context, not the simplicity of the rule. Putting it in other words, the main research issue here concerns the generality of the
operational context-dependent particularity of the social influence processes, not the context-independent generality of the rule describing this influence. The phenomenon identified by the social impact theory formula is a complex one. It is about the dynamics of the relation between the individual and the group when (i) the group is quite large, so that it can be generalized to a social system, (ii) the group members interact with each other, so that each individual is both a target of the others’ influence and also a source of influence for the others and (iii) the interactions between the many individual members of the group are reiterated for a long time.

While the mathematical model underlying social impact theory assumes a static scenario in which the individual is the passive target of the social influence from the others, the phenomenon identified by the social impact theory formula is essentially a dynamic one: the exercise of influence at the level of individual interactions is reciprocal. The mathematical model limits itself to identifying the invariants and a dual effect: a multiplicative and a divisive formula. The true effect is a multifaceted one, meaning that, while being one, it looks differently every time it appears. It is called ‘emergence’ and appears in self-organizing forms. Even in social forms. This is what Latané himself observed and appropriately developed in dynamic social impact theory.

References


Dynamic Social Impact Theory and Model

*Dynamic Social Impact Theory* (DSIT) (Nowak *et al.*, 1990) was initially meant to extend the original *static impact theory* to the general case in which all three factors – *strength*, *immediacy* and *number* – would be allowed to vary simultaneously, scaling up the mathematical model to a population of individuals being influenced and influencing each other in a fully reciprocal persuasion scenario. This scenario is much closer to the reality of political attitude change phenomena and more helpful for making plausible predictions about political preferences and variations in public opinion. However, adapting the original social impact mathematical model to more variability in the combined effect of the three factors brings forth a requirement which the original model fails to cope with: the nonlinear dynamics of political attitude change.

While the original social impact theory relies on a causal model-invariant explanatory law of how the three factors would affect the individual’s response to group persuasive influence, the new model, adapted to include more variability, would need to go far beyond the traditional deterministic frame in order to scale up to a large population of interactive individuals. Since initially only the *number* factor was varied as the other two factors were kept constant, introducing full factor variability increases the complexity of the original mathematical model up to a certain limit where both conceptual and methodological approaches need to be changed: a nonlinear dynamic approach and the reductive simulation paradigm have replaced the initial model-invariant causal approach and the mathematical modelling paradigm (Nowak *et al.*, 1990: 362–364).

And this is just the tip of the iceberg.

The original social impact theory took the author almost two decades of intensive empirical research. Though it took one more decade to work out the new...
dynamic model, things went far from what, originally, had been expected: the original mathematical model actually turned into a computational simulation model with self-organizing forms, which fascinated both the social psychology and the political science communities. It succeeded in changing paradigms, astonishing the audience, updating the history of mathematical modelling of political attitude change, and breaking up a tabu! Continuing diversity, as it had been modelled by Latané and his collaborators, finally succeeded in breaking up the universal agreement tabu, while several other authors couldn’t escape it,

And things did not stop here, either. The model was further modified so as to include a catastrophic theory approach on political attitudes’ extremity: the cusp. Nonlinearity of social impact in political attitude extremity proved once again that the model is able to identify the thin shape of dynamic attitude change. No other model of political attitude change has ever gone as far as Latané’s did. What did it need to turn the static social impact theory into the dynamic one? What it needed was actually a huge paradigm change.

It would be worth taking a close look at this notable and most fascinating experience in the computational modelling and simulation of political attitude change phenomena.

**What Does It Take To Change a Static Theory Into a Dynamic One?**

*Social impact theory* models the individual’s response to the persuasive presence of others (group persuasion) as depending on the simultaneous effect of three moderating factors: the strength of the attitudes held by the others (‘authority’ in social psychological terms), their immediacy (‘closeness’ in terms of physical space) and their number (group size). Characterized as one of the relevant ‘main-effects’ models (Martin and Hewstone, 2003: 318) in the theoretical research on the majority–minority influence, it uses a single equation to specify a functional dependency between the social impact and the multiplicative effect of three variables representing contextual objective and subjective factors.

In its original version (Latané, 1981), *social impact theory* provides empirical evaluations of the dependence of the social impact’s magnitude on the number variable only. It identifies a power function as best describing the increase in the social impact with an increasing number of others as well as the decreasing marginal effect of many additional others. The other two factors, the strength and the immediacy, were introduced in the model as constant values. As the individual is considered the passive receiver of the social influence without the capability to interact and become a source of influence for the others, the original version of social impact theory has been considered a static theory (Nowak et al., 1990: 364).

Generalizing it to a social setting with many individuals, each individual holding a different political attitude and withstanding the persuasive presence of others, became for Latané and his collaborators a most challenging endeavour. The solution to the many difficult problems, however, required a computer simulation model instead of the mathematical one used before.
While preserving a strong explanatory power like its predecessor, the DSIT model differs in the explanation construction paradigm. The computer simulation model offers an explanation of the political change phenomena in other terms than social impact theory does. Both the static and dynamic models rely on the same fundamental mathematical equation of the social impact, but the difference between the static and the dynamic versions is that the former calculates numerical values of a power function describing the outcome of the abstract system in numerical terms, while the latter lets the system self-organize during the reiterated simulation runs and reach stable or dynamic equilibrium configurations, which are graphically observable, and which make the emergent phenomena observable.

However, this paradigm shift from a model-invariant explanatory approach to a context-dependent dynamic one, although not surprising, was not an obvious paradigm choice given that some of the simulation methodologies were still in their infancy when the original social impact theory was published, and even much later when the DSIT showed its first, nevertheless impressive results.

Let us take a brief look at the history, as it will depict the scientific context of this issue.

**Historical Context of Nonlinear Models in Social Psychology**

In developing the DSIT, Latané and co-workers make reference to two relevant attitude research paradigms in social psychology.

One of them assumes the cognitive dimension of attitudes and concerns the study of attitude change from the perspective of the relationships between an attitude’s structural internal components. Persuasion and involvement have been studied for their role in attitude formation and change (Petty and Cacioppo, 1980; Petty et al., 1981, 1983) as fundamental dimensions of social influence. One of the most notable approaches on attitude change belongs to Petty and Cacioppo ([1986]2011), who developed the model of the two routes of persuasion: central and peripheral. If an individual does not have a position with respect to some particular issue and, moreover, they are not involved or the issue does not have a particular relevance to them, then the peripheral route of persuasion combines with the hypothesis of the persuasive presence of the others. The individual response to the group persuasion is more sensitive to the social environmental persuasive influence. In this case, the individual could easily be persuaded by the media and/or by close others. Internalized or not, the wish to comply with the others is at work, and it works even better when the others are numerous, are in the individual’s proximity and their attitude’s strength is high.

DSIT does not argue on this. Moreover, it reinforces the idea that the persuasive influence of the others on the individual works much easier on the peripheral route, especially if this influence has the arguments of number, spatial proximity and

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1 See Kelman (1958: 53) for an exquisite theoretical presentation.
strength of attitude (Nowak et al., 1990: 364). The common belief justified in the social psychology literature is that, unless deviant, and under increasing persuasive pressure from the others, the individual’s attitude change goes in the direction of more compliance with the others. And this compliance tendency might go on until uniformity of attitude prevailed. The most notable social psychology approaches on explaining uniformity are those of Moscovici (1976, 1985), Moscovici and Zavalloni (1969) and Isenberg (1986), who analysed attitude change in the relationship between majority–minority and drew the conclusion that attitude change goes toward compliance with the majority reaching, therefore, a final state of universal agreement. One main characteristic of the social psychology research in this period of time was the focus on the ‘milieu’ of interpersonal relations of the individual, which provides the means for communication and persuasion. The same focus on the individual’s interpersonal relations is characteristic of the political science research on the role of persuasion in political attitude formation and change (Lazarsfeld et al., 1944; Katz and Lazarsfeld, 1955).

The other attitude research paradigm concerns the study of attitude change from the perspective of the relationships between attitudes in some external context, thus dominating the area of mass beliefs (Converse, 1964). Converse’s idea that the political attitudes in a large population prove low consistency, lack of structure and instability was very influential (Zaller, 1992) until very late. Converse’s model represents the only individual-based political attitude formation and change empirical model which has been extensively tested against a huge volume of empirical data. The social psychological research on social attitudes (ideology) has been dominated by structure and measurement models. It has been oriented towards the role played by personality traits and habitual opinions, values and social role, moral and pragmatic beliefs in the structural aggregation of attitudes (Eysenck, 1954; Kerlinger, 1972; Wilson, 1973; Middendorp, 1978).

Though different from both of them, Latané’s approach on dynamic social impact could be considered to belong to the second paradigm, insofar as it is a meta-theory concerned with the social influence in the attitudinal change phenomena in a large population, and not with the structural components of single attitudes. It might be considered to belong to the second paradigm as far as the DSIT is concerned with the factors involved in the operation of the political attitude change processes and in the emergent phenomena associated with this. However, we should also notice that the DSIT explicitly relies on the former paradigm to assume the cognitive background of the strength factors. As regards the latter paradigm, the simulation models based on the DSIT reach quite opposite conclusions than most other previous modelling approaches.

In the argument presentation, the authors of the DSIT make reference to several mathematical linear models of attitude change using spatial functions. Social attitudes have been modelled in the Asch paradigm by Cohen’s (1963) static model of social influence, using a Markov model with four states to describe the influences of the social environment on the single individual. Hägerstrand (1965) modelled innovation diffusion as conditioned by the probability that target individuals come into contact with innovation sources. Abelson and Bernstein (1963) created a simulation
model able to predict opinion change in a community referendum. The conclusion drawn by Abelson (1968), supported by his previous research on mathematical models in psychology (Abelson, 1964), was that mathematical linear models always end up in uniformity of agreement as they usually study a functional linear relationship between the amount of change and the degree of social pressure: as the latter increases, the former increases too.

One of the questions DSIT aimed to answer regards, therefore, the aspect of the end state in the vast majority of the social influence models of attitude change among the individuals exposed to group persuasion. Taking as argument the diversity of human society in general, and the opinion diversity of a democratic society in particular, the DSIT contradicts these models and provides a possible answer for modelling the ways of preserving real-life continuing diversity: spatial contextuality.

It is at this point that Latané was supposed to make a research paradigmatic choice. One reason to leave the traditional longstanding assumptions of classical deterministic modelling was the need to afford an argument against the almost unanimous belief that, under the compliance condition, social influence makes political attitudes finally converge toward universal agreement.

Before Latané, Abelson and Bernstein (1963) identified a solution to the problem of uniformity of agreement in their microsimulation model of community referendum results. They noticed that, in social influence processes, the conditions for maintaining extremity of attitudes would prevent the system from reaching uniformity (Abelson and Bernstein, 1963: 106).

After obtaining encouraging empirical results of his own, Bibb Latané and collaborators must have taken Bernstein’s conclusion as a guideline (Nowak et al., 1990: 371). There was a long way to go, but this is how they made the paradigmatic choice by adopting a nonlinear dynamic political attitude change model. It is this choice that requested the DSIT rely on a computer simulation model in order to study the complex dynamics of political attitude change. While the original social impact theory is a theory about the individual’s response to the persuasive influence of the group, DSIT is a theory about the response to social persuasive influence of the individuals interacting in a complex social setting, which has three basic characteristics: individual interactions, reciprocity of persuasive influence, and recurrence of persuasive processes.

Modelling this kind of social setting in a social influence scenario under the psychosocial law defined by social impact theory requires different concepts of ‘social system’, ‘physical space structure’, ‘individual interaction’, ‘strength’ and ‘immediacy’.

**Conceptual Model**

DSIT starts from the hypothesis of a social setting in which many individuals interact with each other. The social setting includes an abstract social space and an associated finite physical space. In this social setting, each individual is assumed to hold a political attitude with respect to some public issue, such that the population can be characterized by a distribution of the individual attitudes toward this issue. It is also
assumed that each individual might change their attitude with time as a result of the persuasive presence of the others in the social space.

The origins of change reside in both the individual’s interpersonal network of relations, which works as a means of communication, and also in the interactive nature of the relations between individuals. As each individual is embedded in a global ‘milieu’ representing the entire network of interpersonal relations, each individual is exposed to the persuasive presence of the others: each individual may be influenced by the others and may influence the others. As persuasive influence may be exerted in this social setting by any individual on any other, multiple parallel persuasion processes would simultaneously unfold. Moreover, at the operational level, these processes would interact with one another. In a certain period of time, as persuasive interactions among individuals will be reiterated, we can imagine multiple recurrent persuasion processes interacting with one another as the individuals interact with each other.

From this short description, the social setting already proves to have several of the relevant characteristics of a complex social system.

First, there is a physical space and, as the interpersonal network suggests, a spatial unfolding of the individual interactions. Second, there is a considerable number of individuals, possibly a large population, which makes this scenario quite complicated. Besides the spatial unfolding of the individual interactions, the time unfolding of the recursive persuasive influence processes makes a dynamic picture. Both spatial and time unfolding of the social influence processes involve the idea of bidirectional causality in a dynamic social system made up of many interactive individuals.

The individuals are assumed fixed in the physical space underlying the social space. They communicate through their interpersonal relations network. It is further assumed that each individual exercises their persuasive power with the explicit goal of modifying the attitude of the other. The dynamic outcome of this social system at a particular moment of time would look like a (graphical) ‘map’ of the individual attitudes in the population.

The aspects which make this social setting work as a dynamic social system with self-organizing characteristics are (1) the bidirectional causality, (2) the representation of political attitude value and the attitude change rule, (3) the distinction between two different types of persuasive influence and (4) the physical space geometry and structure.

The problem of social impact, originally formulated in social impact theory, changes into: How do the individuals’ attitudes change under the persuasive influence of the others in the social settings described above?

What would the answer look like? Two of the above-mentioned aspects are presented in the following sections: the first concerns bidirectional causality, and the second concerns the political attitude value and the attitude change rule.

**Individual Interactions and Bidirectional Causality**

Groups have been described in the sociologic and social psychology literature as complex social systems with specific dynamics and self-organizing capabilities (McGrath et al., 2000: 95–99), which are manifest in the emergence of group-level
phenomena and in their causal power over individuals (Sawyer, 2005). Groups have often been used to model the dynamics of larger and more complicated social systems, by making it easier to pursue distinction between the level of the individual actions and goal-directed behaviours (micro level) and the behaviour at the group level (macro level) (Coleman, 1986: 1312).

**Bidirectional causality** is a term denoting the causal power attributed by the researchers to individual-level and system-level behaviours to determine each other. It concerns both the ways in which individual goal-directed actions and behaviour bring about system-level behaviour, and the ways in which the group behaviour has consequences on the individual behaviours. This reciprocity of action and behaviour between the actors at different group levels is described as a complex effect following from the reciprocal interactivity among the individuals in the group (Sherif, 1936; Hackman, 1992). Sometimes, an equivalent and even older syntagm is used to describe the relations between the individual actions and behaviours, and the system behaviour: the dual terms *downward causation* and *upward causation* are often used in the psychological and social–psychological emergentist literature to describe the macro-to-micro and the micro-to-macro phenomenology respectively (Sawyer, 2005).

Bidirectional causality in small groups has been associated with *number* (Simmel, 1902) as an essential explanatory factor. Combined with the spatial distribution of the individuals in the social space and taking into consideration the persuasive influence exerted by virtually any individual on the others, the social system concept in DSIT defines a complex social system with a self-organizing capability concerning the clustering of similar attitudes. In the conceptual model of the dynamic social impact, bidirectional causality would refer to an (abstract) complex social system and to the nonlinear dynamics of the attitude change in this system.

The unidirectional causality model based on social impact theory, where a single individual’s attitude changed as an effect of the persuasive and numerous presence of the others, is now replaced with a model based on complexity of social interactions and emergence of attitude change macro-level phenomena. Bidirectional causality would, therefore, denote the complicated dynamics of the political attitude change in a social system in which all individuals influence each other and are exposed to the persuasive presence of others, and this influence is dependent on the physical closeness of the others: the closer they are, the greater their influence.

**Political Attitude Values and Rule of Change**

With regard to the political attitude value, the theory works with political attitudes represented as binary-valued elements: any individual can hold one of two exclusive positions with regard to a specific issue (‘like/dislike’, ‘accept/reject’). The representation of political attitude as a variable with binary values might seem too reductionist a hypothesis. It might also appear as inconsistent with the theories of attitude measurement, which assume a gradual variation of the attitude value on a bipolar scale. However, the assumption that (political) attitude is a dichotomous variable does not contradict the representation of attitude values as continuous, as the attitude measurement scales suggest. In the limit, even measured on such a scale, the attitude
is finally perceived in binary terms, since it is meant to express the preference for a certain object (Nowak et al., 1990: 365).

In order to achieve dynamics of change, the attitudes are defined as being recursively updated after each step of social impact (Lewenstein et al., 1992: 765):

\[ \text{att}_{i}^{\text{new}} = -\text{sign} \left( \text{att}_{i}^{\text{old}} \right) \]  \hspace{1cm} (6.1)

where \( \text{att}_{i} \) is the attitude value for the individual \( i \) at two consecutive moments of time and \( \hat{I}_{i} \) is the social impact for the same individual \( i \). The ‘sign’ function helps to make it obvious if there is an attitude change from one moment of time to the next during the simulation run.

**Supportive and Opposing Persuasive Influence**

The third is the distinction the theory makes between two types of persuasive influence. As the social impact can be ultimately viewed as a sensitive indicator of the overall change induced by the group influence on each individual’s political attitude, this change has been defined by comparing persuasive opposing and persuasive supporting social impact on the basis of the psychosocial law described in social impact theory.

While social impact theory specifies a unique strength factor, DSIT introduces two strength factors, thus dividing the influencers (the others) into two groups (dichotomous preference space): those who hold an opposite attitude than the individual, and those who share the individual’s attitude. Persuasiveness is a concept which models the persuasion for inducing attitude change in the individual. It measures the strength of social pressure for change when an individual subject is surrounded by others who do not hold the same attitude. Persuasiveness describes the persuasive power of the source to make the individual change their attitude. This type of strength factor is evaluated with a specific type of social impact, called persuasive impact and denoted by \( \hat{i}_{p} \).

The other type of strength, supportiveness, describes the solidarity of the others with an individual with whom they share the same attitude and whom they help resisting the persuasion of those with opposite attitudes. The second type of strength factor is evaluated with a specific type of social impact, called supportive impact and denoted by \( \hat{i}_{s} \). Supportiveness is a concept which models the solidarity of those who hold the same attitude with an individual and make them resist the social influence coming from those who hold an opposite attitude.

Together, the persuasive \( \hat{i}_{p} \) and the supportive \( \hat{i}_{s} \) social impact provide for the total social impact to which an individual is subjected:

\[ \hat{i} = \hat{i}_{p} + \hat{i}_{s} \]  \hspace{1cm} (6.2)

A self-organizing characteristic is introduced in this system by allowing a non-linear dynamic attitude change process. It actually compares two different types of persuasive influence: the supportive and the opposing one (see Figure 6.1). The attitude value at each moment of time depends on the previous attitude value and on the social
impact value. As the value of persuasive influence opposing the attitude of the individual exceeds the value of the supportive influence of the others, the attitude will change.

Both strength and immediacy factors are dependent on the geometry and structure of the physical space. Modelling the social impact as dependent on the physical proximity modifies the original social impact equation.

### Dynamic Social Impact

The physical space and the geometry of the social space are determinant for the immediacy factor, which expresses the notion of ‘closeness’ to the source of influence in terms of the physical location of an individual in the social space. The social space has been designed following several geometric configurations so as to allow for the study of the variability of social impact as dependent on the type of the physical space: (a) fully connected model, based on homogeneous (equal) distances between individuals; (b) hierarchical geometry model, based on hierarchy of groups in which the distances between individuals are dependent on the hierarchical levels in the group to which the individuals belong; (c) strong diluted model, based on a random connectedness between an individual and the others; and (d) the Euclidean two-dimensional space (Lewenstein et al., 1992: 764).

Though all these alternatives have been investigated and their performances compared (Lewenstein et al., 1992), the mathematical model underlying DSIT will be presented here in the Euclidean geometry version for calculating the immediacy for each individual.

Inspired by the gravity model in physics, the immediacy factor models the inverse proportionality of the social impact with the square of distance for each pair of individuals. As both strength factors, the supportiveness $s_i$ and the persuasiveness $p_i$, vary with the inverse of the squared distance between a source $i$ and an individual target, a mean degree of social influence is calculated for each.

![Figure 6.1 The dynamic model of social impact. There are two types of social persuasive forces: supportive and persuasive.](image-url)
The persuasive impact of the group on a single individual is modelled as the mean effect of a persuasive force exerted by multiple sources (group) on a single individual. The mean persuasive impact $\hat{i}_p$ is defined for each source $i$ by cumulating the persuasiveness of each source $i$ and then dividing the sum total by the number of persuasive sources in the group $N_0$:

$$\hat{i}_p = \frac{\sum_{i=1}^{N_0} \left( \frac{p_i}{d_i^2} \right)}{N_0}$$  \hspace{1cm} (6.3)

where $d$ is the distance between the source $i$ and an individual target.

The social impact of the persuasive opposition exerted by $N_0$ sources on a single individual $\hat{I}_p$ is given by

$$\hat{I}_p = \sqrt{N_0} \left[ \frac{\sum_{i=1}^{N_0} \left( \frac{p_i}{d_i^2} \right)}{N_0} \right] = \sqrt{N_0} \hat{i}_p$$  \hspace{1cm} (6.4)

where $\hat{I}_p$, $p_i$, $d$ and $N_0$ are as previously described.

Similarly, the supportive impact of a group who share the same attitude as an individual is modelled as the mean effect of the forces exerted by multiple sources (group) on a single individual. The supportive impact $\hat{i}_s$ is defined by cumulating the supportiveness of each source $i$ and then dividing the sum total by the number of supportive sources in the group $N_s$:

$$\hat{i}_s = \frac{\sum_{i=1}^{N_s} \left( \frac{s_i}{d_i^2} \right)}{N_s}$$  \hspace{1cm} (6.5)

where $d$ is the distance between the source $i$ and an individual target.

The supportive effect diminishes as the supporters are farther from the subject and many in number. The social supportive impact exerted by $N_s$ sources on a single individual $\hat{I}_s$ is given by

$$\hat{I}_s = \sqrt{N_s} \left[ \frac{\sum_{i=1}^{N_s} \left( \frac{s_i}{d_i^2} \right)}{N_s} \right] = \sqrt{N_s} \hat{i}_s$$  \hspace{1cm} (6.6)

where $\hat{I}_s$, $s_i$, $d$ and $N_s$ are as previously described.

The total social impact cumulates the supportive and the opposing impact so that the result will produce (or not) an attitude change: if the persuasive opposition impact is greater than the supportive one, $\hat{I}_p > \hat{I}_s$, then an attitude change occurs for the individual.
Computer Simulation Model

In political attitude formation and change modelling research, Latané’s experimental research on social impact was pioneering work, for it used a new philosophy of experimental modelling: the computer simulation.

The philosophy of the DSIT computer simulation was characteristic of a wave of revived interest in the computer simulations of the late 1960s which dominated the 1990s decade, along with the advances in dynamic systems and complexity theory (Latané, 1996b). We should keep in mind that social impact theory was developed and reported long before social networks or cellular automata theories reached the simulation power they got soon after the mid-1990s. Only by situating it in the right historical context can one appreciate the real value of Latané’s endeavour and its excellent potential of application and further development.

By the mid-1960s, when Latané began his early research work on the bystander effect and political attitude change modelling (Latané and Darley, 1968; Latané and Harkins, 1976), experimental research in social psychology, widely open to the model-invariant paradigm and mathematical modelling, was still fighting the prejudices against computer simulations. Political methodology was even less penetrated by the new modelling paradigm and, undoubtedly, more resistant to change; some, otherwise very few, scholars in this experimental research area were complaining about the old-fashioned model-invariant paradigm (Tilly, 1995).

In social psychology, at least, computer models and simulations were developed on two main paradigmatic dimensions: (a) the explanative, and (b) the generative paradigm.

In the explanative paradigm, the computer model is used to perform the operations and get the outcomes predicted by a preliminary mathematical model (Coleman, 1964: 528–529). This view has been promoted mainly (Troitzsch, 2013: 13–16) by the early microsimulation model of election outcomes in a referendum campaign developed by Abelson and Bernstein (1963) in the Simulmatics project (de Sola Pool and Abelson, 1961).

This kind of approach has evolved towards the idea of using computer simulation modelling in theory construction. It was this view which later provided the basis for the generative paradigm (Troitzsch, 2013: 16).

This new paradigm in experimental social psychology started to be systematically introduced during the 1960s, by authors like Robert Abelson (1968). This first decade of early approaches on computer simulations in social psychology is summarized in the seminal work of Oström (1988), who succeeds in disentangling the meaning of the new paradigm (Oström, 1988: 383–384). Identifying the computer simulation’s huge potential in tackling the dynamical complexities of social behaviour – namely, (1) intrinsic variability of the latent variables, (2) qualitative cognitive structure of attitudinal processes, (3) modelling the interdependence relationships between the latent variable and the observable variables, (4) multiple interdependencies among structural processes and (5) time – Oström describes the general research tendencies of the time, making a strong prediction...
about the capacity of the new paradigm to provide solutions to most complex phenomena studied in social psychology. In less than one decade his prediction had been fulfilled by the incredible advance in computer simulation theories, modelling methodologies and their performance typologies.

Latané’s view of computer simulation seems to fit in the former paradigm, as the reductive simulation procedure (Nowak et al., 1990: 362) has been essentially used in DSIT for proving the outcomes defined and predicted in the social impact mathematical model. Though it has been associated with advances in the cellular automata and compared with Schelling’s (1971) seminal work on segregation, DSIT makes reference to more popular approaches, the so-called ‘computer recreations’ explained in technical detail by Dewdney (1987) in his articles and books.

The DSIT model has been compared with a two-dimensional cellular automaton model and with a social network (Fink, 1996), but also with a neural network model (Eagley and Chaiken, 1993).

The cellular automata theory has its origins in one of von Neumann’s (1951) works on system replication inspired from biology, and has been developed mostly after John Conway elaborated his Game of Life (Gardner, 1970). By the end of the 1960s, the most relevant experimental research work is Schelling’s (1971) segregation model, intensively promoted at the time. The model was usually called ‘checkerboard’ instead of ‘cellular automaton’, and has similarities with another simulation paradigm, what we know today as an agent-based simulation model. At the beginning of the 1990s, John Casti (1992) turned it into a new appealing theory of complexity, and Wolfram advanced it to what we know today (Wolfram, 1983, 1986, 2002).

The cellular automaton is a finite automaton, which is defined as an abstract computational device with finite input alphabet, a finite number of predefined states and a state-transition function which provides for the next state by defining and describing it as a function of the actual state and input (Casti, 1992: 189). Usually, it is a one- or two-dimensional\(^2\) grid of fixed cells in which each cell is identified with an individual agent, which interacts locally only with the direct neighbours. The local area of interaction could be, therefore, a four-neighbour area, the so-called von Neumann neighbourhood, or an eight-neighbour area, called a Moore neighbourhood. The simulation consists of applying to this grid a simple rule of interaction between cells, such that cells’ states are updated simultaneously at each iteration. The complexity of cellular automata does not reside in their structure or rules, which are quite simple, but in the iterative application of a few simple interaction rules to a large population of individual agents (cells). In this case, the state transitions prove emergent properties. Such emergent phenomena show, for example, how the micro-to-macro link works in a self-organizing social system. Groups have often been considered and studied as small social systems with specific dynamics and self-organizing properties.

\(^2\) A multidimensional implementation is also possible; see Wolfram (1986).
The type of simulation model used in DSIT has many similarities with a cellular automaton; however, it has some relevant dissimilarities too. Like a cellular automaton, a grid representation is used in the computer simulation, so that each individual has a spatial location (cell) and neighbours, and a simple rule guides the attitude change. Each cell has initially assigned an attitude value (binary value) and a state transition function. The group influence on the individual is simulated by the interactions between cells (Fink, 1996: 8). The individuals are kept immobile but, unlike the classic cellular automata, each individual can be influenced by distant others, and not only by the direct neighbours.

From this latter point of view, DSIT has some similarities with social networks. Though no reference is made in the text, Latané’s simulation model bears similarities with Schelling’s model of segregation, at least in the philosophy of approach. Like Schelling, Latané proves interest in the emergent phenomena connected to the relationships between the individual and the group (persuasion, conformity, minority influence). Unlike Schelling, Latané makes a strong point in bringing forth the relevance of personal interconnections, making everything resemble more closely social networks.

A social network consists of actors (nodes) and links (relationships or social structures) between actors. What makes the DSIT computer simulation model similar to a social network is the group modelling as a social network. The computer simulation model takes as the basic level of interaction the dyad and focuses on the micro-level interactions in the physical space. The agents are interconnected by links which represent physical distances between individuals. In a social network, the nodes represent individual actors, and the connections represent communication links. Each individual (node) communicates with virtually all the others in the network: the connections (i.e. distances between two individuals), the nodes (i.e. the individuals) and the strength of individual attitudes are identified by well-defined variables. Unlike Schelling’s model of social influence based on segregation, and similar to a social network, in the DSIT simulation model the attitudes are ‘moving’ in the social space, looking for a convenient attribute context, and not the individuals, which are fixed. Besides structural and interaction similarities, complexity similarities can be identified in the convergence of attitudes and in the emergence of majority–minority group patterns (Fink, 1996: 9).

The similarities with neural networks are also relevant: the input and the output of the network are predefined, the nodes (i.e. individual attitudes) are interconnected, their number and their associated values (e.g. attitude values, strength values, immediacy values) are specified, as is the function of transfer (i.e. the social impact, which describes the aggregation of others’ influence for each individual) and of node activation (i.e. attitude change). Also similar to a neural network is the idea of using several levels of persuasive influence processing, which in DSIT correspond to the persuasive and supportive social impact, and which aggregate the influence to the output node, working much like the hidden nodes in a neural network (Eagley and Chaiken, 1993: 101–103, 142–143). Unlike neural networks, the DSIT computer simulation model is not a learning system. Its behaviour is not trained, but emerging on a context-dependence principle.
Simulation Modelling

The fundamental components of the computer simulation model in DSIT are social space, individual (agent), social impact factors and political attitude change rule.

The fundamental assumptions are twofold: conceptual and operational.

From a conceptual perspective, the computer simulation model is used to implement Latané’s psychosocial law of social impact. Social impact is the combined effect of three factors: group size, physical locations of individuals in the group and the distribution of their attitudes with respect to a public issue. Social influence works mainly on the peripheral route (persuasion and non-involvement at personal level) and binary attitude values (pro and con).

From an operational perspective, the computer simulation model is used to identify the macro-level (group-level) consequences of the iterative application of the simple rules of social impact and political attitude change at the micro level (individual level). Four kinds of emergent phenomena are visualized and analysed: consolidation, clustering, correlation and continuing diversity.

Social Space

The simulated social space is modelled as a collection of social agents which interact with each other in a finite (abstract) physical space. This makes ‘spatiality’ a dimension of the social interaction, since each agent has a sense of physical space associated with the social space, although not equivalent to it.

The representation of this social space is a grid with $n \times n$ cells (Figure 6.2), each cell representing a social agent. The agents are fixed and they interact with their neighbours. The neighbours may be closer (direct neighbours) or distant: virtually, each individual is assumed to perceive the persuasive presence of all the other individual neighbours. To limit the number of distant neighbours whose presence is persuasively relevant, the system takes into consideration all neighbours within a specified radius around the current individual.

Though the agents do not move from one cell to another, the model assumes that they know the attitudes of each other. The model assumes that, either by their simple

![Figure 6.2 The social space is a squared grid of $n \times n$ cells, each cell representing an individual.](image)
presence or by means of media communication, all individuals know about the attitudes of all the others and that they exercise their persuasive influence (either supportive or opposing) on each other.

Euclidean geometry is assumed. For each pair of individuals, a Euclidean distance is calculated. The individual locations in the physical space make the model predictive with regard to the spatial configuration of subgroup aggregation in the social space. The individuals are distributed in the physical space such that supportive and opposing aggregations of individuals may emerge as distinct spatial configurations.

**Individual Agent**

The individual agent is represented as a string of four parameter values: attitude value (binary), two types of attitude strength identifying either a supportive or an opposing attitude value, and the immediacy value (Figure 6.3).

The *attitude value* is a binary value; it can take one of two values, ‘1’ (pro) or ‘0’ (con), representing a ‘like/dislike’ position toward a public issue (attitudinal object). Each attitude is described as a two-state variable which takes either the *pro* or the *con* value, with graphical signs associated, respectively ‘I’ for ‘pro’ and ‘–’ for ‘con’.

The *persuasiveness* $p_i$ is a random number between 0 and 100, as is the *supportiveness* value $s_i$. The values of persuasive impact and supportive impact are calculated iteratively for each individual during a simulation run.

The *immediacy* factor should prove that the social impact (either supportive or opposing) decreases as the others (supportive or opposing others respectively) have a more distant location in the physical space with respect to the individual target. The ratio between the supportiveness $s_i$ of the source $i$ and the Euclidean distance $d_i$ between the source $i$ and an individual target provides for a formula of immediacy which shows that the supportive impact decreases as the squared distance increases. And this is the same for the persuasive opposing impact $p_i$ and its corresponding immediacy formula. As the social impact rule is a multiplicative formula of three factors, parallel processing is required. Synchronous processing of the persuasive

![Figure 6.3](image.png) **Figure 6.3** The individual agent.
influence is achieved by simulating a parallel updating of the grid cells on a serial computer; the computer simulation model works with two matrices which are updated at two consecutive discrete time steps during a simulation run, such that all cell updates are done simultaneously.

*Number, attitude strength* and *immediacy* are defined as global variables; their dynamic variability is modelled as the generative mechanism for attitude self-organization and emergence of attitude change phenomena. The complexity of the system and its self-organizing features reside in the differentiated representation of persuasive influence as *supportiveness* and *persuasiveness* variables, and in the set of simple update rules for (a) attitude change and (b) social impact as either supportive or persuasive impact.

The *attitude change rule* is a decision rule, which compares the supportive and the opposing persuasive impact for each individual. Whenever the persuasive influence for changing an attitude is greater than the support for keeping it, an attitude change occurs; the attitude value is updated and the other attribute values are changed as well (i.e. the persuasiveness and supportiveness values are updated). The following attitude change procedure summarizes the main steps for simultaneously updating all grid cells at each run.³

**Attitude Change Procedure**

repeat for all cells

**Initialization:**
Selection of values from random distributions:
- attitude strength $\text{att}$ is assigned a random value from distribution of values between 0 and 1;
- supportiveness $s$ is assigned a random value from distribution of values between (0 and 100);
- persuasiveness $p$ is assigned a random value from distribution of values between (0 and 100);

**Communication session:**
communicate attribute values: load current values in the old values matrix;

**main loop**

- cell $i$:
- calculate social impact:
  \[ \hat{\text{I}} = \hat{\text{I}}_p + \hat{\text{I}}_s; \]
- apply political attitude change rule:
  if $(\hat{\text{I}}_p > \hat{\text{I}}_s)$
  then
  mark cell $i$ in the grid;
  update attitude value:
  \[ (\text{new_att}_i) \leftarrow \text{sign} (\text{old_att}_i \cdot \hat{\text{I}}); \]
  update $s$ and $p$ for the marked cells;
  load values in the new values matrix;
  communicate new attribute values;

³ See Latané and Nowak (1997: 49, Table 2.1).
The procedure continues until no more attitude changes occur. At this moment the simulation run stops. Statistics are calculated and (numerical and graphical) results are displayed.

**Emergent Phenomena**

The most interesting and appealing part of the DSIT is represented by the emergent phenomena observed as outcomes of the simulation runs.

There are four types of emergent phenomena: **consolidation**, **clustering**, **correlation** and **continuing diversity**. Definition, measurement and interpretation of these self-organizing social forms are at the heart of DSIT, which aims to explain their meanings in political attitude change phenomena emerging in large dynamic social settings. They are not derived as a result of calculating the solutions of the equations in the mathematical model of social impact theory, but are observable as visual dynamic outcomes of the repeated application of the simple rule of social impact to individual interactions in large social settings over a long period of time. They show that the social impact rule has a strong dependence on the context, on the initial conditions and on the spatiality and group size factors. The DSIT, while developed within the social psychologic cognitive paradigm, succeeds in shifting the focus from internal factors characterizing the cognitive abilities of the individual to the number (size) and immediacy (closeness in terms of physical location and spatial geometry and geography of a social space) factors describing political attitude change phenomena. These four emergent phenomena represent robust results of DSIT: they have been obtained from both empirical experimental settings (laboratory and field experiments) and as computer simulation program outcomes.

**Clustering**

*Clustering* emerges from the attribute spatial self-organization (Figure 6.4). It is the macro-level effect of large, repeated individual interactions at the micro level: neighbouring individuals tend to share similar opinions, behaviours and attitudes. Clusters as islands of people sharing the same attributes (i.e. attitude value, spatial neighbourhood) offer protection against the persuasive influence of opposing others. Inside clusters, therefore, other phenomena might emerge; namely, consolidation and correlation.

**Correlation**

*Correlation* is an effect of the social persuasive influence of the others on the individual; it consists of the attributes of neighbouring individuals becoming increasingly related after repeatedly exercised persuasive influence than they were before. Latané’s understanding of the issue in DSIT makes reference to a typical social influence situation in which individuals belonging to a particular dynamically evolving cluster (subgroup) have their membership conditioned by their increasing willingness to become similar to their co-members. As members of a cluster they are eventually (unless the cluster lies at the border of the group) surrounded by like-minded others and therefore less or not at all exposed to the counter-persuation of
Figure 6.4  Clustering phenomena in the simulations performed with SITSIM. (SITSIM is a software program on the Modeling Social Dynamics website. It has been developed by James Kitts, Michael Macy and Martina Morris under NSF Grant SES-0433086. http://socdynamics.org/index.html (See Web Resources).)
the opposing others. Consequently, they start behaving like members of their subgroup, and not as independent individuals within the group. This results in increasing correlation between subgroup members’ identical or similar attributes.

Though not further developed beyond statistical correlation coefficients used to emphasize the emergent spatial clustering effects, the idea that ideologies could arise from spatial correlation only has been questioned. However, asking this question could be, at least, a sign of misunderstanding, if not a malicious reading of the text itself, since Latané is suggesting how ideology formation is facilitated by spatial factors influencing the self-organizing social forms, and not generated by them only. But, sometimes, questions betray the malicious more than answers do.

Spatial correlation of attitudes has been studied as an issue of ideology formation in sociology, social psychology and political science. However, we should briefly emphasize the difference in the approaches on correlation of attitudes as ideology in social psychology and in political science research. In Converse’s model of mass beliefs, political attitudes are characterized by instability, lack of correlation and lack of structure. In order to explain (lack of) correlation, Converse starts from theoretical assumptions and characterization criteria based on the level of cognitive abilities of the individuals and the role their mass beliefs play in their political choices. His approach answers a why? question on the (lack) of correlation in political attitudes. Latané’s approach answers a how? question on the emergence of correlation. It is a meta-theoretical approach to a complex social setting in which spatiality and physical location play an important role in the operation of the social influence processes; namely, in the spatial clustering of individual attributes. Spatial clustering of attributes fosters correlation of initially unrelated attributes, a phenomenon studied in geography, culture and in political science as spatial auto-correlation.

**Consolidation**

*Consolidation* concerns a tendency inside the minority groups toward reducing diversity (Huguet et al., 1998: 832) by strengthening the similarity within the group. The reason is that minorities are subjected to the adverse persuasive pressure of the majority. As a consequence, minority members have a tendency to reinforce their similarity within the group in order to withstand the majority influence. On the other hand, while being exposed to an increasing persuasive influence of the majority, minority members might be convinced to accept the majority attitude. The majority increases its influence, therefore, by increasing its size (Harton and Bullock, 2007: 527). As minorities (factions) are diminishing in size, they are often ‘absorbed’ by the majority. However, this does not always happen. If their size does not diminish more than 30% of the group size, then they have good survival chances. Nevertheless, this is not the only condition of minority (faction) survival.

**Continuing Diversity**

*Continuing diversity* is a hard challenge, withstanding the sword for almost a century. It was initially formulated in political attitude terms by Robert Abelson (1963), but has been approached with equal interest in various research areas, from biology to
culture, from economy to sociology, from ecology to political science and, last but not least, to computer science and the sciences of the artificial, computational simulation included. The end of the 1990s witnessed a revived interest in continuing diversity approaches in culture emergence and dissemination (Axelrod, 1997) as well as in political science (Huckfeldt et al., 1998). The complex social systems theory and the availability of computational and simulation modelling methodologies and software enabled this revived interest to become quite high. It soon exceeded expectations, and the field got revolutionarily extended. New disciplines emerged, social simulation and computational political science being but two of them. New paradigms appeared, like agent-based ones. This is the reason why we have included all political science aspects at the beginning of this chapter. Before the boom in artificial societies, Latané had quietly prepared us for the shock of change: his impressive research work is just an elegant and rich preamble, and he is a forerunner of all this social science deep paradigmatic changes.

Latané suggests three types of approaches to this issue: one is a social psychology approach based on social influence and the role of spatial proximity in persuasion; the second one is a physics-inspired approach based on the force field model and Euclidean space; and the third one is a computational simulation approach based on the nonlinear dynamics of both the change rule and of the spatially self-organizing social forms.

From a social psychology perspective, continuing diversity in scenarios of social persuasion concerns the survival of a minority’s attitudes in spite of the persuasive pressure of an opposing majority. Clustering, consolidation and even correlation might converge in making a small-size minority survive within a large majority. On the one hand, the small size is a disadvantage if compared with the majority size. However, spatial clustering shields the (small) minority from the majority pressure, since minority members are more influenced by like-minded others inside their subgroup and, therefore, less or not at all exposed to the opposing persuasive influence of the majority. (The problem still remains at the borders, where members have to resist higher pressure, and sometimes they do not.) For the minority kernel, however, the pressure to stay (minority exerted) is likely to be higher than the pressure to change (majority exerted); hence, the rate in attitude change decreases and the minority survives, making the whole group achieve continuing diversity. It is more reinforced and secured, Latané noticed, when personalities with high attitude strength anchor the borders and secure the members inside by making them resist the change (Latané, 1996a: 23).

From a mathematical and computational perspective, continuing diversity is a matter of nonlinearity and complex social systems. As Abelson demonstrated, linear models which exploit the linear proportional relation between increasing social influence and attitude strength decreasing end up in ubiquitous agreement, which sets these models rather apart from real-life situations. Instead, nonlinear models which exploit an attitude change rule based on the relation between supportive and opposing social impact succeed in preserving diversity in spite of the presence of noise. If, moreover, nonlinear rule change (at the operational level) combines with nonlinear variability in the individual resistance to change (at the individual attribute level), then the social systems achieve dynamic equilibria in which majority and minority coexist for longer.
Generations of Computer Simulations

There have been several generations of computer simulation programs which have been developed by Latané and his collaborators: SITSIM (Nowak and Latané, 1994), GROUPSIM (Rockloff and Latané, 1996) and CAPSIM (Latané and Bourgeois, 2001a).

The fundamental characteristic of these computer simulation models is that their outcomes (either numerical or graphical) have been permanently compared with empirical experiment outcomes (i.e. empirical data and results).

SITSIM

SITSIM (Nowak and Latané, 1994) was the first computer model developed for the simulation of DSIT. SITSIM has an \( n \times n \) grid representing the social space of the experiment, and each cell in the grid represents an individual agent. It is used in iterative simulations and tested against empirical data for validation and confirmation of the results (Latané and Nowak, 1997: 53).

Social space: a grid of \( n \times n \) cells is used to represent a physical space for a group of individual agents. Each agent corresponds to one cell; the space is characterized by the Euclidean distance between any two agents (Lewenstein et al., 1992).

Individual agent: the agent does not move in the grid space. An agent is characterized by a set of four attributes: attitude value (binary), two strength parameters (supportiveness and persuasiveness) and immediacy value.

Attitude change rule: an agent will change their attitude toward a specific issue if the pressure from opposing others is greater than the support from the individuals sharing the same attitude.

Emergent macro-level phenomena: consolidation, clustering, correlation, continuing diversity (Figure 6.5).

Several series of simulations have been performed with SITSIM. The purpose of the extensive testing was the necessity to check whether the outcomes of the simulations indeed represent the properties of the system under the social impact rules. SITSIM allowed for the factorial combination of 20 variables (Latané, 1996a: 20) designed to affect certain dynamic characteristics of the system under group social influence so that their role and effect could be observed and quantified. To this aim, a set of test variables was chosen, including (a) the methods to simulate the parallel processing of the factors’ influence on the operation of social influence processes, (b) population size (number of sources), (c) initial minority–majority proportions in the population and their distribution, (d) strength, (e) using borders to the physical space, or let the space wrap around, and several other parameters. Results proved to be extremely robust and easily identified in the empirical data.

SITSIM simulations show that consolidation emerges only when minorities have a critical mass (30%). For lower proportions, the minority groups are overwhelmed by the majority.

SITSIM defines specific measures for evaluating and comparing self-organizing social forms and their characteristics (Latané and Nowak, 1997: 51–53).
Figure 6.5  Simulations performed with the NetLogo SITSIM model. The configurations obtained show (a) emergence and (b) polarization phenomena. NetLogo implementation of the SITSIM model follows the original model (Nowak et al., 1990). The NetLogo SITSIM model has been implemented by Nigel Gilbert and can be found in the public domain at http://ccl.northwestern.edu/netlogo/models/community/Sitsim (see Web Resources).
Self-Organizing Social Forms: Measurement Indexes

*Clustering measurement* uses a numerical index based on the probability that closer others are less influenced by individuals holding opposing attitudes and, therefore, have less chances to change their own attitudes under the persuasive influence of the others. The individuals most exposed to persuasive influence would be those at the borders of the physical space, since they are not surrounded by people sharing the same views. *Consolidation measurement* uses a numerical degree of consolidation which is calculated for two cases: (a) if majority prevails; (b) if minority prevails. *Continuing diversity measurement* uses an index of the dynamic quality of the social interaction.

GROUPSIM

GROUPSIM (Rockloff and Latané, 1996) is a computer simulation program which further extends the capabilities of the SITSIM program to predict the post-discussion individuals’ choices, and the degrees of consolidation and clustering. The difference from SITSIM is that the agents are constrained to have a reduced number of direct interconnections (four interconnections) and a single interconnection with an individual outside the current ‘family’ subgroup. GROUPSIM has been tested empirically in 24 discussion sessions in which individuals answered questions before and after discussing the topics with the other members of the subgroup.

During the simulations, the number of supporters/oppositions is varied so as to make evident the dependence of the emergence phenomena on the number of others.

*Social space:* each agent can communicate with a four-person subgroup (von Neumann neighbours). *Borders:* wrapping around is allowed, so that the physical space becomes a torus (no borders).

*Individual agent:* does not move in the physical space.

*Attitude change rule:* the number of others will decide if the individual agent will change their attitude. GROUPSIM is able to predict individuals’ choices on changing their attitudes as influenced by the number of persons holding a specific attitude in the subgroup.

*Emergence phenomena:* GROUPSIM is able to predict the emergence of consolidation (reduction in diversity), clustering, correlation and continuing diversity, and to predict the extent (degree) of consolidation and clustering. Attributes of the individuals in the same subgroups tend to become more similar and more representative as they are repeatedly discussing a specific topic. Attributes are spatially self-organizing as a result of the persuasive presence of others. And this self-organization takes individuals’ adjacency as a criterion.

CAPSIM

CAPSIM (Latané and Bourgeois, 2001a) is a computer simulation program which advances the features of GROUPSIM by introducing different change rules dependent on the topics discussed by the individual agents. The model includes *attitude change probabilities*, which moderate the individual’s choice for changing the attitude,
depending on the number of others. CAPSIM’s outcomes are probabilistic simulations in comparison with SITSIM’s, which are considered deterministic.

CAPSIM predicts three different levels of self-organization in dependence on (1) the different types of discussion topics, (2) different topics of discussion among individuals within a subgroup and (3) for different groups.

**Social space**: has an underlying physical space as a grid with \( n \times n \) cells; von Neumann neighbour; no borders (torus).

**Individual agent**: each agent is characterized by a set of attributes; a probability of change is assigned to each discussion topic. The simulation modelling was tested against empirical experimental evidence for self-organizing forms of social influence. To this end, the authors developed an experimental framework called **Computer Administered Panel Study** (CAPS) which recruited and managed participants in 10 groups of 24 persons each (Latané and Bourgeois, 2001a: 65–66).

**Attitude change rules**: change probabilities – a probability of attitude change is assigned to each discussion topic. Three scenarios were simulated: (1) conformity game, (2) deviation game and (3) attitude toward a political issue. For each scenario, a different attitude change rule was introduced in the simulation program. Numerical measures (degrees) of self-organization forms for consolidation, clustering and continuing diversity were defined so that empirically obtained and simulated results could be compared.

**Consolidation score** is represented as a measure of the reduction in size of minority as a consequence of social influence (Latané and Bourgeois, 2001a: 70). **Clustering score** is a clustering index represented as a measure of the increasing similarity of neighbouring individuals as a consequence of social influence. **Continuing diversity index** (numerical index) is calculated as a percentage of the groups which maintain diversity in spite of social influence (Latané and Bourgeois, 2001a: 70–71).

### The Relevance of Social Impact Theories for Political Attitude Modelling

Social impact theories, in both static and dynamic versions, are relevant for their implications in the study of political attitudes, political culture and polity.

Many authors, however, including Latané himself, explain the relevance of social impact concept and theory by taking as argument the implications of their results from a sociologic perspective. Both concept and theory have a strong social psychological ‘flavour’, guiding the interpretation of results toward the culture emergence and culture dissemination domains.

While the orientation toward social representations and culture dynamic phenomena is identified by many analysts, critics and authors, including Bibb Latané (1996a) himself, what actually matters, with regard to the subject of this book, is rather the consideration that social impact theory is one of the first studies on the political mechanisms and processes underlying the structure of a polity.

To further explain this, we should, before anything else, recall two essential aspects concerning social impact theories.
The first is the classification of the social impact theories as meta-theories. They are mainly studying how certain factors affect the operation of social influence processes, not defining what social influence is and why it works. The second is the view that the successive generations of computer simulation models (which have been constructed for testing the reliability and validity of the theories) are purposefully constructed as virtual experimental settings for the study of the operation of social influence processes in large social settings characterized by generalized interactive features at the micro level.

Remembering these fundamental characteristics of the social impact theories helps us realize their equally fundamental contribution to the study of social self-organizing forms emerging from the unfolding of social influence processes.

There are two dimensions, at least, on which their contribution is deeply relevant: (a) self-organizing forms reveal the micro-to-macro and macro-to-micro mechanisms which support the relation between the individual, on the one hand, and the social system (society) and political system (polity), on the other hand; (b) the philosophy of simulation: how could a computer simulation model support theory construction?

**Mechanisms Connecting the Micro and Macro Levels of a Social System**

There is this explanatory dimension of any model, which counts in the first place. In our case, the simulation model underlying the social impact theory has an explanatory relevance for political mechanisms and processes which has to be taken into account; it is one of the first simulation models which explains the mechanisms of downward and upward causation in the case of emergent macro-level phenomena generated by the operation of recurrent persuasive processes at the micro level of a social system over a period of time. The simulation model applies to as wide a domain as possible, from attitudes, behaviours and beliefs to public opinion. All four self-organizing forms appear almost constantly in the simulations; namely, consolidation, clustering, correlation and continuing diversity represent themselves or embed as many mechanisms of either top-down or bottom-up generation of attitude formation and change phenomena. Few of the current political attitudes simulation modelling methods allow for the construction of downward causation mechanisms: cellular automata, agent-based modelling and even complex adaptive systems do not solve this problem or could hardly cope with it, making their solutions appear either too expensive in terms of computational resources or too rational and often at odds with the real world. This is the case with the artificial societies, which could be grown up quite easily, but do not include mechanisms which might support the concept of downward causation. Latané instead describes such mechanisms in his dynamic theory of social impact, suggesting several paradigms for which they could be extremely relevant. One of them is the evolutionary paradigm. It might allow for developing mechanisms of top-down causation in value formation and selection in simulation modelling of political attitude formation and change emergent phenomena: attitudes appear as agents in search of a favourable ‘niche’, where, as
soon as they arrive, they start struggling for the opponents’ removal (Rockloff and Latané, 1996: 363–364). The idea of a minority group as a favourable ‘niche’, accommodating sets of attributes and reinforcing their similarities so that, as time passes, they become correlated, gives rise to the idea that spatiality plays a role in consolidation of similarity and enhancing minority survival. The other one is the culture emergence paradigm. Latané (1996a) and others (Harton and Bullock, 2007) wrote extensively about it, identifying a connection between patterns of regional differences and patterns of attitude clustering. Latané’s simulation results on correlation also suggest that ideologies might arise from attribute spatial correlations within and across cultures (Latané and Bourgeois, 2001a: 64). Sustained by empirical and simulated results, the emergence of ideologies as spatial correlation of attributes needs to be further elaborated. Research on political conflict and insurgency (Laitin, 1991; Tilly, 1995; Fearon and Laitin, 2003; Cederman and Girardin, 2006) shows that regional geographical patterns might give rise to ideological positions and conflicts between central and local political power on the background of ethnical regional geographical patterns (upward causation). Moreover, research on political geography shows how political ideologies can affect individual voting behaviour by simply revising geographical borders of electoral field units (downward causation). Since both mechanisms address spatiality-based political mechanisms, the question on ideology arising from spatial correlation within and across cultures remains an open and challenging issue.

Philosophy of Simulation

The philosophy of simulation underlying Latané’s huge experimental research on social impact combines, on the one hand, the longstanding tradition of providing robust empirical evidence in support of theory construction and demonstration, and, on the other hand, the chance to inform theory construction and validation by means of simulation results. Undoubtedly, the computer simulation model is viewed much as a ‘derivation machine’, or anyway as something which, in Coleman’s tradition, could never have been accepted as a basic means to state a theory. However, Latané used it in this latter sense and, moreover, gave it a high credit in theory construction, and justified it so as to convince even the hard-believers in the social psychology community. And this is no easy thing.

Static impact theory’s idea is to use mathematical equations in order to discover universal laws which guide attitude change in social influence scenarios. This model-invariant approach is then used as an explanation of the change phenomena in terms of the variables and their values (see Figure 6.6).

DSIT’s philosophy about the use of simulation in the dynamic social impact research is briefly exposed in the so-called reductive simulation procedure (Nowak et al., 1990: 362), which is used for (1) discovering the macro-level effects of the individual interaction rules implemented on the micro level, and (2) cross-validation of empirical data and simulation results so that incompleteness or internal contradictions could be detected during theory testing (Nowak et al., 1990: 374). While the validation of simulation results against empirical data belongs to the classic model-invariant tradition, when models were both constructed and validated on an empirical
basis, the use of computer simulation (Latané and Bourgeois, 2001a,b) for achieving emergence phenomena at the macro level by means of reiteration of update rules at the micro level is a new paradigm introduced as the research on complexity and self-organization got theoretical support by the end of the 1980s (see Figure 6.7).
SITSIM illustrates a conception about how computer simulations and empirical data could stimulate and enforce each other’s performances (Latané and Bourgeois, 2001a: 62). Simple update rules at the micro level of individual influence may provide for the emergence of macro-level phenomena which are observable by means of simulation only.

Later on, as new generations of computer simulation models were developed for testing DSIT, Bibb Latané (Latané et al., 1994; Nowak and Latané, 1994; Latané, 1996a; Latané and Nowak, 1997; Latané and Morio, 2000) enlarged his view on the use of computer simulation by emphasizing more the complex, self-organizing nature of social systems, the relevance of social simulation and the need for an enhanced view on the role social simulation plays in our understanding of complex societal dynamics.

Web Resources

Modelling Social Dynamics Website
Site developed by James Kitts, Michael Macy and Martina Morris, under NSF Grant SES-0433086, at http://socdynamics.org/index.html.

NetLogo Website

References


Part IV

POLITICAL ATTITUDE APPROACHES BASED ON SOCIAL INFLUENCE, CULTURE CHANGE AND COLLECTIVE ACTION MODELLING

Rich as a class of models, and equally prolific as a modelling philosophy, the numerous approaches which make up the class of dynamic social impact models emphasize a deep paradigmatic shift toward modelling political attitude change as a dynamic, context-sensitive, path-dependent process. In conceptual terms, all this makes more and more obvious a shift of focus from empirical toward generative scenarios of attitude change able to provide for the typical experimental settings achieved by means of artificial life technologies. At the beginning of the 1990s, political attitude research ran around the clock to keep pace with the amazing advances in cellular automata, social networks and agent-based systems modelling methodologies which were coming of age. Modelling research seemed fundamentally attracted by the idea of generating scenarios of change which were much richer than the empirical experimental settings and at the same time much more complex. ‘Would-Be Worlds’, the concept defined by John Casti (1997) introduced a modelling paradigm able to provide for the evaluation of the potential developments of an artificial system (model) by generating and examining simulation scenarios able to reproduce in the model the dynamics of real-world change phenomena. Casti’s work reveals a philosophy about simulation modelling which emphasizes the generative characteristic of a model as a means to achieve in virtual experimental media (e.g., simulation runs of a computational model) path-dependent outcomes. Such modelling techniques were soon afterwards created with other artificial life technologies as well, like multi-agent distributed systems (MAS) and agent-based
systems (ABS). This philosophy of simulation replaced the classic computer simulation idea of testing a model against (empirically provided) data by a constructivist idea of achieving model dynamics and complexity by employing a generative computational architecture denoted ever since as the ‘bottom-up’ architecture. Bottom-up artificial systems are designed to evolve as the multiple artificial agents inside them repeatedly interact with each other. Based on the methodological individualism idea that individual initiative is the true engine of social development, such systems achieve ‘upward causation’ (macro-level emergence) by introducing an interaction rule at the micro level. The bottom-up paradigm has been intensively employed in artificial society simulations (Epstein and Axtell, 1996), and in the study of the dynamics of culture dissemination and change (Axelrod, 1997). These two modelling approaches have fundamentally revolutionized modelling research as they have decisively influenced the subsequent orientation of political attitude modelling research in both North American and European schools of thought. The agent-based systems provide the appropriate framework for revising the computational and simulation models developed earlier by McPhee, Latané, Abelson and their collaborators. It is this technology which makes possible the revision of the social persuasion scenarios of political attitude change in networks of interpersonal relationships and dyadic interactions. The new models elaborated by Robert Huckfeldt, Paul Johnson, John Sprague and their numerous young collaborators bring to the front old conceptual and technical problems: universal agreement and the survival of diversity in democratic societies, the dissemination of culture and the dynamics of culture change in homogeneous/heterogenous societies of artificial agents, and the collective action and the role of elites/activists in enhancing political protests.

Part IV introduces the main modelling approaches which dominated political attitude research during the 1990s. They focused on the revision of the classic theories about the social context, the role of interpersonal relationships in social and political persuasion and the complexity-based modelling of self-organizing social systems (artificial societies). These modelling approaches include: Chapter 7 briefly describes Axelrod’s Culture Dissemination Model (1997). The subsequent chapters present agent-based models which either revise or extend Axelrod’s ‘thought exercise’ about culture change in self-organizing social systems. Chapter 8 introduces the Diversity Survival Model (Huckfeldt et al., 2004) and Chapter 9 presents two collective action modelling approaches concerned with political attitude formation and change: the Political Contagion Model (Johnson, 1999) and the Cooperative Social Action Model (Johnson and Brichoux, 2002). The selected models bring forth in various ways the issue of social persuasion by emphasizing that agent-based as well as social network technologies help revisit interpersonal networks and dyadic interactions as the basic context of individual interactions. The Diversity Survival Model (Huckfeldt et al., 2004) thus reminds the reader about the classic opposition between the typical Columbia modelling approach based on dyadic interactions as a means of preserving the contextual dynamics of social influence processes in the small worlds, on the one hand, and on the other hand, the type of modelling approach, mainly advocated by the Michigan group, which emphasizes the atomization of political opinion and attitude once the individual is considered an autonomous decision-maker among many others at the national level (Huckfeldt, 2014).
This model represents a classic reference in social and political sciences. From a philosophy of science perspective, Axelrod (1997: 206) described computational and simulation modelling as a speculative experimental scenario called ever since a virtual experiment. It is based on the classic idea of constructing possible, believable scenarios of the future developments of a dynamic system introduced by Jay Forrester in the early 1950s as a forecasting model-based simulation technique. Beyond the heritage of this classical tradition in employing computational technology in social studies, Axelrod’s computational and simulation modelling approach brought, nevertheless, something new: its main relevance and the power of his arguments reside in the chosen domain (attitude change, social influence and culture dissemination), the technology (agent-based modelling), the constructivism of the modelling approach (bottom-up) and the principle of social interaction (methodological individualism).

Axelrod aims at identifying the theoretical and experimental support for developing an experimental version of both social and political sciences; his approaches are well known and famous for their simplicity and for promoting the concepts long expected to change the spirit of theory development in these sciences: replace empirical tradition with the generative alternative. Again, his attempt is not unique: the late 1990s witnessed a boost in new research approaches; take that of Epstein and Axtell (1996) as perhaps the best example, which proved that the idea of experimental social and political science has long gained new background and tools from the sciences of the artificial – AI, ALife and artificial agents – which have massively and decisively penetrated the traditional empirical background and changed minds, means and aims.¹

¹For a comprehensive view on bottom-up approaches of social systems, self-organizing social systems and agent-based models of society, see the classic works of Joshua Epstein and Robert Axtell (1996) and Gilbert and Troitzsch (2005).
Axelrod’s Model of Culture Dissemination (ACM) is relevant to our approach for at least one reason: it opens up the door for experimental research in areas which have long kept distant and resistant to the new technologies, like culture modelling in general and political attitudes in particular. For this would lead us to understand the different ways in which the ACM modelling concept has influenced the area we target in this volume. Its underlying philosophy unites complexity and self-organizing social system concepts and theories with the principles of experimental research, the constructivist philosophy of modelling and simulation, and with the new technologies of the artificial, thus becoming the turning point of profound paradigmatic changes in the computational and simulation research in social science in general and in particular in political science. It has been inspiring and offered a reference for future complex developments in several areas: dynamics of culture and cultural drift, dynamics of public opinion and last but not least, political attitudes.

For the purpose of our study, there are several aspects which need to be emphasized and briefly explained with regard to ACM: the principle of social action at the micro level and how it generates culture dissemination and change phenomena at the macro level. In order to understand all this, we will briefly present in the following subsections (i) the individual agent, (ii) the social influence mechanism and (iii) the emergence of macro-level phenomena.

Modelling Principles

Axelrod suggests a methodological individualism approach inspired by Boudon (1986): individuals who interact with one another constitute the source of social and political motion. Another principle is that people look for like-minded others to communicate with (homophily, as introduced by Homans (1950) and Rogers (1983)). A third principle is that culture dissemination could be viewed as an abstract form of communication, as communication suffices for exchanges between individuals which enhance social influence.

Conceptual Model: A Computational and Simulation Model of Culture Change

ACM works with an artificial social environment, which is defined as a geographical space with finite borders (Figure 7.1). The individual agents in this environment represent villages characterized by different cultures (Figure 7.2).

Axelrod’s model defines a culture in the most abstract way: a culture is defined as a set of features. Each feature has a set of traits, and each trait can have a specific value, and may differ from one individual agent to another.

The model is based on cellular automata. The environment is represented as a square grid of 10×10 cells, where each cell is occupied by an individual agent (i.e. a village). The individual agents are able to interact only with their von Neumann neighbours, so that an individual agent will communicate with its direct neighbouring agents placed at northern, southern, eastern and western positions.
Each feature can have up to 10 traits, and a trait can have a value which is a continuous value between 0 and 1. At the beginning of a simulation run, the traits are initialized from a normal distribution of values.

The individual agents are able to interact with their neighbours following a single rule: similarity. The similarity is viewed as a number of features/traits shared by any two individual agents. For a higher number of shared traits, the chances of individual agents getting in contact and communicating increase, so that the first thing an

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**Figure 7.1** The environment is represented as a grid of $10 \times 10$ cells. Agents are represented as cells on a square grid. Agents are ‘villages’; they are geographically situated in this environment such that in each cell there is an individual agent. Each agent has four neighbours (von Neumann neighbours). Agents interact with each other following simple rules which define their behaviour: (1) selection and (2) cultural change.

**Figure 7.2** Culture representation.

Each feature can have up to 10 traits, and a trait can have a value which is a continuous value between 0 and 1. At the beginning of a simulation run, the traits are initialized from a normal distribution of values.

The individual agents are able to interact with their neighbours following a single rule: similarity. The similarity is viewed as a number of features/traits shared by any two individual agents. For a higher number of shared traits, the chances of individual agents getting in contact and communicating increase, so that the first thing an
individual agent will do is to look for other agents with which it has at least one trait in common. The number of shared traits shows the degree of similarity. The similarity-based interaction models the interaction based on the *homophily* principle that likes attract. An individual agent will therefore look for like-minded others to contact and communicate with, thus justifying some other basic mechanisms, like the need to avoid conflicts and to expect from the other agent confirmation of its own values, preferences, choices or attitudes. The similarity-based mechanism is the only mechanism involved in the communication between individual agents.

Culture change is made effective by means of a copy mechanism (i.e. convergence mechanism): the more often they interact, the faster the convergence of their cultures.

**Operational Model**

The model operates in two phases: a phase which concerns the selection of an individual agent for further interaction, and a phase in which culture change occurs.

**Selection Phase**

The selection mechanism makes each agent select another agent to interact with. The selecting process is based on the evaluation of agents’ degree of similarity: similar agents have more chances to interact as interaction takes place only if two agents share features. An interaction occurs with a probability which is equal to the degree of similarity between two agents, that is, the number of shared features from the total features.

Cultural change is based on a convergence mechanism which operates by feature transmission from one agent to another.

An interaction always results in a culture change by letting the agent who initiates an interaction copy a feature (at random) from another agent. A feature is selected from those features which differ between the two agents and its trait is copied by the agent who initiated interaction. Thus, their similarity increases the chances to interact, and the more they interact, the more similar they become.

While enhancing the dynamic, nonlinear nature of the interactions among individual agents, the similarity-based interactions prove fast convergence toward either monoculture emergence or toward deep polarization.

**Change Phase**

The dynamics of the culture dissemination model are formally described as follows.

Let \( C \) be a culture, and \( v_i, v_j \) be agents \( i, j = (1, 2, …, n) \) (see Figure 7.3) and let \( \alpha \) be a feature in culture \( C \) on which the two agents have different traits:

\[
C\big(\alpha\big( i \big) \big) \neq C\big(\alpha\big( j \big) \big)
\]  

(7.1)

As the two agents \( v_i \) and \( v_j \) have a similar feature \( \phi \)

\[
C\big(v_i, \phi\big) = C\big(v_j, \phi\big)
\]

(7.2)
their interaction results in agent $v_i$ selecting either $\alpha$ or any other feature $\beta$ of the agent $v_j$ on which they have different traits:

$$C\left(\beta(t^v_i)\right) \neq C\left(\beta(t^v_j)\right)$$

(7.3)

and copying the trait from agent $v_j$:

$$C\left(\beta(t^v_i)\right) \leftarrow C\left(\beta(t^v_j)\right)$$

(7.4)

where ‘$\leftarrow$’ denotes a ‘copy’ operation and $t^v_k$ denotes the $k$th trait on feature $\beta$ for agent $v_i$ in culture $C$ ($k = 1, 2, \ldots, m$, with $m$ the total number of traits a feature has in culture $C$), as specified in Step 2 in the formal statement of the model dynamics (Axelrod, 1997: 208).

**Simulation Results**

The emergence of culture regions is differently associated with three factors: culture complexity, territorial size and the patterns of local convergence and global polarization which emerge from the model dynamics.

- Culture complexity in terms of the number of features and traits per feature: fast polarization is enhanced by a small number of different features and traits.

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**Figure 7.3** Two agents have a similar feature and a different feature. An interaction might occur with a probability which is equal to the degree of similarity (i.e. proportion of similar features). In the case that the interaction finally occurs, the agent that initiates the interaction (agent A) selects (at random) another feature from agent B on which they differ and copies it.
As the number of different features increases, the convergence is slower and the diversity is preserved for longer.

- The territory size is an unexpected result of the simulations: the larger the territory, the more chances that diversity is preserved.
- The model dynamics consist of patterns of convergence and patterns of polarization (see demo in Figure 7.4).

**Web Resources**

**NetLogo User Community Models**

Dissemination of culture by Iain Weaver at http://ccl.northwestern.edu/netlogo/models/community/Dissemination%20of%20Culture.

**References**


Robert Huckfeldt and his collaborators got back to the political attitude modelling ideas promoted in the 1950s by William McPhee. Their evaluation of McPhee’s work and ideas was synthesized by Paul Johnson (1999) who succeeded in providing an excellent comparative analysis between McPhee’s computer simulation and the new simulation methodologies. This explains their choice for a new modelling methodology: agent-based systems. Their option is justified by the enduring ideas promoted by the Columbia School and by McPhee’s pioneering modelling approach on the role played by the social context in political persuasion and political attitude change.

Huckfedt and collaborators offer us the chance to understand how much the research design and simulation technologies have changed in the areas of political influence: their model is based on agent-based simulations and implements a constructivist (bottom-up) approach which employs methodological individualism (Boudon, 1986) for achieving a mechanism of individual interactions, and through it perform political persuasion in networks of interpersonal relations. In spite of the huge performance gap between old and new modelling theories and technologies, the conclusions drawn from their simulations are roughly the same as several decades ago, and therefore quite discouraging: computational and simulation modelling cannot fully replicate and thus explain the survival of diversity in human society regardless of the political regime and the constraints deriving from it in what regards the public expression of this diversity. And this should be taken as perhaps the most challenging conclusion drawn from the study of the modelling approaches on political attitude change and the survival of diversity issue in political science.
The challenge resides in achieving the proper theoretical and technological backgrounds for replicating the conditions of democracy in computational systems able to simulate in believable and productive ways the issue itself, since democracy cannot survive without diversity of opinions and attitudes, without open debates and without the spirit of tolerance. In order to study democracy one has to replicate it virtually and then simulate the dynamics of a democratic society as a complex system.

This challenge resides in the philosophy of computational and simulation modelling as well: models get explanatory power from the theories underlying their performances. Political attitude computational and simulation modelling needs improved theoretical backgrounds in order to achieve better performances.

**Conceptual Model**

With their *Model of the Survival of Diversity*, Huckfeldt and his collaborators modified the ACM so as to study the survival of political diversity in situations which extend Axelrod’s original model (Huckfeldt et al., 2004). Some of these modifications are substantial and regard (i) the individual agent, (ii) the interpersonal (dyadic) networks, (iii) the description of political attitudes and (iv) the principles and mechanisms for discussants’ selection and for political attitude change.

**Individual Agent**

First of all, this model is different from Axelrod’s original model by employing agent-based systems instead of cellular automata, like ACM (Axelrod, 1997) and the class of dynamic social impact models before (Nowak et al., 1990). Huckfeldt et al. (2004) modified the type of computational individual agent from a static to a moving agent able to interact with any other individual agent and not only with its direct neighbouring agents. This allows for simulations based on agents which have richer repertoires of action and cognitive and deliberative abilities.

The artificial agents represent autonomous individuals (Huckfeldt et al., 2004: 127). Computationally, they are described as autonomous agents and their implementation is based on swarm technologies, including object-oriented programming and agent-based systems. Such individual agents are independent from a central and/or pre-specified structure of control; they are endowed with capabilities of behaviour, interaction and adaptation to their environment (Johnson, 1996, 2002). In particular, the individual agents are capable of looking for other individual agents, gathering and offering information from/to other individual agents, learning from their interaction experience, and adapting to the political attitudes of other agents in their network (Huckfeldt et al., 2004: 127–128).

The individual agents are endowed with repertoires of competences, like gathering information, memorizing and managing information and data structures (i.e. lists pointing to other agents with which they have already interacted or with which they share features). They are also endowed with repertoires of executive, control and management abilities, which they employ in the construction, update and management of internal data structures, like the lists of agents and the lists of
shared features with other agents (Johnson and Huckfeldt, 2001, 2005; Huckfeldt et al., 2004: 127–129).

In the social environment represented by the network of interpersonal relations (dyadic network), an individual agent is fully characterized with a set of features and traits (see Figure 8.1).

A feature may be considered to represent a political attitude toward a particular issue (issue position). A set of features may thus be used to identify an agent. For example, in an electoral campaign, an individual agent may have political attitudes toward different campaign issues, like electoral candidates, political parties, public policies and so on. A set of features would look like \{F_1, F_2, \ldots, F_n\}, where ‘F’ stands for feature (see Figure 8.2).

Each feature takes numerical values, which are called traits. For example, for each feature a trait can take one of the four possible values: \{0, 1, 2, 3\}. A full description of the agent in terms of features and traits would finally look like that shown in Figure 8.2.

To the numerical description of political attitudes, inspired by the tradition of public opinion research, information processing and opinion dynamics, Huckfeldt and collaborators associate data structures (i.e. lists) which are generated during the individual interactions and further allow for the simulation of the structural components of attitudes, like beliefs and knowledge. An individual agent is able to construct and manage several data structures which hold evidence of the history of the interactions. These data structures memorize the experience of interaction, and also the perceptions, beliefs and expectations each agent gets from interacting with other agents.

Figure 8.1  The individual agent has an internal modular structure. The individual agent’s structural design includes four main modules: (a) features, (b) communication and interaction, (c) memory of interaction experience and (d) influence mechanism.
Another type of difference from the previous approaches and from ACM itself concerns the consideration of the network density and heterogeneity. These two notions bring to the front Granovetter’s (1973) concept of weak ties, which gives support to the idea that loosely connected networks enhance the survival of disagreement and political heterogeneity in networks of political communication (Huckfeldt et al., 2004: 17–23). As an essential difference from the high-density networks in which more (if not all!) the people are connected to one another, low-density network configurations allow for particular opinions or attitudes to penetrate the interpersonal network of an individual agent and thus maintain political diversity. Diffusion of a particular political attitude in low-density networks is dependent on the frequency of contact between two loosely connected persons: (a) in high-density networks\(^1\) in which a minority disagrees on a certain issue position, the social compliance mechanism would quickly reduce disagreement and result in global homogeneity; (b) in fully connected networks\(^2\) a community might get polarized on a certain political attitude and the network’s homogeneity reinforces it, such that persons from one group will never get in contact with persons holding different attitudes; (c) in low-density networks\(^3\) the configuration best supporting the change process, the weak ties favour the infusion of new political attitudes which, due to network heterogeneity, might enhance political attitude change for those who get under this source of persuasion.

These theoretical considerations provide the proper framework for constructing the experimental setup. In order to get these kinds of networks and political attitude diffusion stereotypes, Robert Huckfeldt, Paul Johnson and John Sprague (2004)

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\(^1\) See Huckfeldt et al. (2002: Figure 1a, 21).
\(^2\) See Huckfeldt et al. (2002: Figure 1b, 21).
\(^3\) See Huckfeldt et al. (2002: Figure 1c, 21).
adapted the ACM original setup and processes (see Diagram 8.1 for details). Thus, both the agent selection process and the political attitude change process are modified so as to experimentally achieve the characteristics of political persuasion in low-density heterogeneous networks of interpersonal connections (dyadic networks).

**Selection Process**

The modifications concern (i) an increased number of individual agents in a single cell and (ii) an increased number of different networks of interpersonal relations to which an individual agent actually belongs, an idea about conflicting attitudes previously introduced as the concept of ‘cross-pressures’ by Lazarsfeld and co-workers (Lazarsfeld et al., 1948; Berelson, et al., 1954) and later on by Campbell and his collaborators, who also make reference to a related concept: ‘politically heterogeneous membership’ (Campbell et al., [1960]1980: 80). The original grid model is extended to a neighbourhood/workplace model analysed previously by Abelson and Bernstein (1963: 114) in which the individual agent is simultaneously influenced by multiple networks of interpersonal relations like the direct neighbourhood, the workplace and the place of worship (see Figure 8.3).

These modifications are accompanied by several new concepts and new measures which are introduced in order to evaluate diversity and its survival in the context of individual interactions.

The model introduces (i) agent-level diversity measures that are based on indicators summarizing the interaction experience (encounters and acquaintances) of an individual agent and (ii) the aggregate level diversity measure of entropy as a function of the number of issues and of the number of issue positions held by the

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![Diagram 8.3](image)

**Figure 8.3** An individual agent is simultaneously influenced by multiple types of networks of interpersonal relations: (1) the place where they live (residence or neighbourhood), (2) the place where they go to work (workplace) or (3) the place where they go for religious services (churches etc.).
population of agents. The measures of diversity help evaluate the number of encounters and the number of connections which are based on similarity (acquaintance, harmony) and identicality (identical).

The encounter-type experience is associated with the notion of neighbourhood: two individual agents that belong to the same neighbourhood have more chances to interact. They can also interact if they have the same workplace, or if they meet at the place of worship. The probability of this type of interaction is based on proximity and availability.

The ‘acquaintance’ indicator describes the types of interactions which occur between individual agents sharing at least one feature (similarity indicator). As a random interaction takes place, an individual agent checks whether there is any shared issue position (attitude) with a randomly encountered agent, building up expectations on an eventual agreement with the other agent. The existence of a shared attitude and of a similarity-based agreement provides the preconditions for acquaintanceship. The individual agent keeps the evidence of its acquaintances in a list which is updated as the agent accumulates experience. This data structure is then used in describing expectations (i.e. beliefs concerning the possibility of reaching an agreement with another agent) and in the construction of the harmony and identicality indicators.

The ‘harmony’ indicator describes the proportion of opinions across all issues (Huckfeldt et al., 2004: 153–156) shared by any two acquaintances, and the ‘identicality’ indicator describes the proportion of the shared opinions from all opinions held by each agent.

These measures and the data structures on which they operate provide a much more detailed analysis of the types of interactions in the networks of interpersonal relations. They also provide the basis for understanding how the individual agents accept opinions of other agents, how they are influenced by the attitudes of the others. This is a distinct capability of the model in comparison with the original model, in which one agent simply copies a feature from another agent on an elementary similarity-based criterion.

The heterogeneity of the networks as well as the various cognitive abilities of the individual agents (political information processing, belief and attitude change) require a different persuasion mechanism underlying the political attitude change process.

**Persuasion Process: Political Attitude Change**

As a difference from the original model, the Model of Diversity Survival modifies the modelling strategy of the persuasion process: while ACM works out the influence mechanism as a simple copy mechanism triggered by the degree of similarity between the interacting agents, this model is based on an autoregressive mechanism triggered by any new political opinion or attitude introduced in a dyadic network (see Diagram 8.1). Any new attitude which penetrates the dyad induces a process of attitude adjustment in the individual agent, which triggers a polling mechanism reaching the network beyond the dyad in search of confirmation (rejection) of the new attitude.
Given:

- \(n\): total number of individual agents in the model system;
- agent \(i\): \(\text{att}_i\) is the current political attitude of agent \(i, i = 1,2,\ldots,n;\)
- acquaintance of agent \(i\): \(\text{acq}^i_k, i = 1,2,\ldots,n,\) is the number of agents, and \(k = 1,2,\ldots,K,\) where \(K \leq n\) is the number of acquaintances of agent \(i;\)
- interpersonal network of acquaintances of agent \(i\): \(N(\text{acq}^i_k)\)
- \(k\): size of the interpersonal communication network of an agent (i.e. number of acquaintances);
- list of \(k\) acquaintances with which agent \(i\) reached agreement on issue positions in the past or with which opinions are shared: \(L(\text{acq}^i_k),\) where \(i\) and \(k\) as before;
- \(P\): number of shared political attitudes in the interpersonal network of agent \(i;\)
- list of \(p\) currently shared political attitudes, \(L(\text{att}^i_k), p = 1,2,\ldots,P;\)

repeat Steps 1–5 for each agent \(i, i = 1,2,\ldots,n: \)

**Step 1:** encounter agent \(j, j = 1,2,\ldots\)

**Step 2:** for each encounter with another agent \(j:

create new_acquaintance:

\[\text{acq}^i_{k+1}\]

include new_acquaintance in the interpersonal network of the agent \(i:\)

\[N(\text{acq}^i_{k+1}) \leftarrow N(\text{acq}^i_k, \text{acq}^i_{k+1})\]

**Step 3:** for each acquaintance \(k(k = 1,2,\ldots,K,\) with \(K \leq n\)) in the interpersonal communication network of the agent \(i:\)

if acquaintance \(\text{acq}^i_k\) issues a new political attitude, \(\text{new}_\text{att}^i_k\) then

**Step 4:** poll the network, \(N(\text{att}^i_k),\) with regard to the new political attitude, and get the number of acquaintances \(k\) with which has reached agreement on more than half of the shared issue positions \(p:\)

if

\[k > \frac{n}{2} \text{ and } p > \frac{P}{2}\]

then

**Step 5:** change, i.e. new political attitude becomes current political attitude of agent \(i:\)

\[\text{att}^i_k \leftarrow \text{new}_\text{att}^i_k\]
from the other agents (acquaintances) in its interpersonal network. Each time an agent initiates an interaction, it occurs with a probability equal to the proportion of shared opinions (Step 2 and Step 3 in Diagram 8.1). Each time one of the agent’s acquaintances shows an attitude or offers an opinion on a randomly chosen issue, the agent requests acknowledgement or rejection of this opinion from all the other acquaintances with which agreement has been reached in the past on more than half of the opinions held (Johnson and Huckfeldt, 2001; Huckfeldt et al., 2004; Huckfeldt and Johnson, 2010) (Step 4 in Diagram 8.1). The individual agent which generates the polling mechanism will not let itself be persuaded by a new attitude which is introduced in the dyad by the discussion partner but which is not held by a relevant proportion of the agent’s acquaintances in the remainder of the network (Huckfeldt et al., 2004). A new political attitude would therefore get relevance and persuasive power in the interpersonal network of an individual agent only if it gained the support of a significant number of others (i.e. more than half of the agent’s acquaintances) on a significant number of issues (i.e. more than half of the issues on which they agreed in the past). This makes the acceptance (rejection) of a new opinion a slower process than in the ACM model (Step 5 in Diagram 8.1).

Another difference from the ACM is provided by the cognitive abilities of the individual agents, and the aspects of memory-based modelling of political persuasion (Lodge et al., 1995). The individual agent is endowed with cognitive and reasoning capabilities: each agent remembers the interactions and the other agents as well as their attitudes. Each agent accumulates experience of interaction by: (1) maintaining lists of previous encounters with other agents, and lists of acquaintances; (2) maintaining evidence on how many opinions have been shared with each other agent in past interactions.

Model Dynamics

The dynamics of the political attitude change model are dependent on the network distribution, the asymmetry of relationships and the open type of the interpersonal network, a concept inspired by Granovetter’s (1973) concept of weak ties.

The experimental settings and the goal of the simulation experiments is to achieve diversity as an emergent outcome of the individual interactions in the model system (Huckfeldt et al., 2004: 153–155) and across a wide range of initial conditions. As a self-organizing social system, the model system achieves local equilibria and becomes relatively stable.

The model strategy is different from the class of dynamic models of social impact (Nowak et al., 1990; Latané et al., 1994), from the model of bounded confidence (Hegselman and Kraus, 2002) and from the model proposed by Shibanai et al. (2001). The model is based on an agent-based system in which individual agents interact and, by interacting, self-organize in endogenous networks of acquaintances.

The model explains the change in political opinion and attitude. The agents acquire experience from their individual interactions and aggregate in networks of interpersonal connections in which several agents share the same opinion on a set of issues. When new political opinions/attitudes penetrate dyads, the agents do not change their previous opinions/attitudes unless they identify sufficient evidence that
a relevant proportion of their peers accept the opinion. This influence becomes
decisive if the individual agents share a previous experience in which they agreed on
a relevant proportion of the opinions on various issues. This way, the opinion/attitude
change in the autoregressive approach is dependent on the distribution of preferences
and acquaintances in the network. This is also important because it means that not all
the communicated information (messages) become influential in the network. Thus,
the majority is always rewarded, while the minority is always punished.

The simulations have been run for different settings: 1‐cell home grid,
10‐cells × 10‐cells home grids, and so on. A simulation run starts from a random dis-
tribution of opinions/attitudes and consistently achieves a stable level of diversity.
The model preserves diversity in a higher degree than ACM does, and with different
mechanisms: while ACM is based on implicit mechanisms of cognitive dissonance
reduction, conflict avoidance and social compliance which foster convergence and
enhance the tendency toward homogeneity, the Model of Diversity Survival is based
on the autoregressive mechanism which achieves political attitude change depending
on the preference and attitude distributions in the entire network (Huckfeldt et al.,
2004: 160–167). This reveals a substantial difference from Axelrod’s model, by
introducing in the bottom‐up, methodological individualism‐based approach a strong
argument towards consideration of structural (relational) characteristics of the
political communication and persuasion in interpersonal networks. Though essen-
tially an agent‐based model, this approach addresses a fundamental issue in the
debates concerning the social action theories on the macro‐level effects of micro‐
level individual interactions: the model combines methodological individualism
with structural modelling, which is more specific to the area of social networks than
to the agent‐based systems. The issue is of fundamental importance for the compu-
tational and simulation agent‐based modelling of social action, as proved by other
authors and research works (Hedström and Swedberg, 1998; McAdam et al., 2001;
Mayntz, 2003; Hedström, 2005; Hedström and Bearman, 2009). However, it has a
special relevance to our study as it reveals that political attitude change research
advances toward modelling theories which combine individualistic and structural
modelling strategies in order to explain the macro‐level emergence political phe-
nomena by the micro‐level interactions of the individual agents. Rooted in the early
work of McPhee and collaborators (McPhee et al., 1963), the basic idea of the model
of diversity survival is that agents’ interdependence in communication (interper-
sonal) networks enhances the contextualization of a new political attitude by com-
paring it against the attitudes of the other agents in the network (Huckfeldt et al.,

Huckfeldt and collaborators revive the old idea of social context, but this time the
political persuasion model employs a different body of methodology and technology of
evaluating how individual agents change their political attitudes toward various issues
during their discussions with peers in their interpersonal networks. This persuasion
model in dyadic political discussion networks has notable differences from both the
SITSIM model (Nowak et al., 1990) and Axelrod’s culture dissemination model.

It combines interaction‐based models of social action and social influence
(Epstein and Axtell, 1996; Axelrod, 1997) with structural (relational) issues inspired
by both social networks research (Watts, 1999; Watts and Strogatz, 1998) and
political methodology research (McAdam et al., 2001). It also addresses political attitude change issues as approached in both memory-based models and online models of candidate evaluation (Lodge et al., 1995) by combining elements of agents’ cognitive abilities with how individual agents use their memory during their interactions (Zaller, 1992), theories which address the structure of attitudes and, last but not least, theories concerning the spread of information as depending on the density of interpersonal communication networks (Granovetter, 1973, 1985).

This mix of ideas makes the Model of Diversity Survival the most relevant for both the theories of political communication and persuasion in a democratic society and for the area of computational and simulation modelling of political attitude change. Its relevance resides not only in the mix of ideas which have never been combined all in a single model ever before; its relevance also comes from the attempt to explain both the emergence (upward causation) of political attitude change phenomena (macro-level) and the influence of macro-level phenomena on the individual agents at the micro-level (downward causation). Though the subject of a long-lasting theoretical debate, the macro–micro link has a special relevance for political attitude computational and simulation modelling research, for it targets the capacity of current computational and simulation models to generate and sustain a body of theory which has not been completed as yet: the role played by the political culture as the fundamental regulator of the relation between macro-level phenomena and the individual interactions in the context of political interdependence as described by the model of diversity survival.

Web Resources

As explicitly mentioned by Professor Paul E. Johnson, the code and experimental settings and simulation results obtained from the swarm simulation of the Diversity Survival model are extensively described on the website: http://pj.freefaculty.org/Swarm/MySwarmCode/OpinionFormation/

References


Political Contagion Model

The Political Contagion Model (Johnson, 1999) employs an agent-based system, that is, an ALife technology used to build up artificial social systems and artificial societies. As the author mentions in his explanation, the model reveals major problems induced by the use of agent-based systems in simulating the role of social context and the interdependence of peers in interpersonal communication networks.

One is the problem of data involved in the simulation and regards (i) the empirical versus generated data and (ii) the expected versus obtained relationship between the inputs and the outputs of simulation runs: which one explains the other? and what is explained? The model does not actually use empirical data, nor does it generate output data which are aimed at confirming preliminary empirical observations. Therefore, the questions are essentially concerned with the methodology of the model’s input/output descriptions and explanations, and with the validation of the outputs in computational and simulation modelling of political attitude change phenomena.

A second problem concerns a theoretical research question about the micro–macro link in political models: is the model able to explain the macro-level phenomena (i.e. political attitude change) by means of the individual interactions at the micro level?

One explanation concerns upward causation: the emergence of macro-level phenomena (i.e. political attitude change) from individual interactions (i.e. discussions in the dyadic networks).

The other explanation concerns downward causation: the influence (i.e. formation and change) exerted on the individual political attitudes by the aggregate structures and phenomena.

Johnson’s model of political contagion is the only one in the history of political attitude computational and simulation models which addresses this fundamental
issue of political science: it employs a modified version of the agent-based model originally developed by Axelrod’s *Culture Dissemination Model* to study (i) attitude change emergence as generated by the individual interactions in the dyadic networks (micro-to-macro) and (ii) the influence exerted by such phenomena at the macro level onto the individual interactions (macro-to-micro).

While the effect of the micro-to-macro link is synthesized as the emergence of social order, the effect of the macro-to-micro link can be synthesized as the influence exerted by the aggregate structures and phenomena on the individual agents’ behaviours and attitudes. The former framework is intensively studied in social simulation and computational sociology, where agent-based systems and models offer the appropriate technology and methodology of research. The latter, however, needs a different approach than the *bottom-up* one adopted by the former, as agent-based systems in the methodological individualism paradigm could hardly approach, and even less explain, downward causation.

In Coleman’s classical terms, if approached in the downward causation paradigm, ‘political protest’, ‘authority’ or ‘institution’ could be modelled as aggregate structures which exert influence on the political attitudes of individuals. Johnson chooses to model ‘political protest’ as a macro-level emergent structure which exerts its influence back to the micro-level individual behaviours which have generated it in the first place. Thus, the author employs an agent-based model, which have long been exercised to achieve stable global activity of individual agents at the micro level for studying situations in which emerging (temporarily aggregated) structures (i.e. groups of protesting agents) exert attraction on more individual agents for participating in the protest (i.e. contagion). Political contagion is thus described and explained as a downward causation process.

**Conceptual Model**

The *Political Contagion Model* (Johnson, 1999) is an application of an early model of *Diversity Survival* in democratic societies (Huckfeldt et al., 1995), and it is the first (if not the only!) to formulate the micro–macro problem in political methodology terms of complex systems and also in terms of computational and simulation modelling methodology.

The model deals mainly with political opinion formation and draws on the classic issue of political protest as approached in the political theory literature. It compares two earlier models, Granovetter (1978) and Lohmann (1994), and works out an alternative which includes many of their principles in a more constraint-relaxed, agent-based model on a methodological individualism-based explanation of the emergent outcomes.

Granovetter’s (1978) threshold computational model of protest explains the emergence of social protest as depending on a critical mass of individuals involved in critical evaluations of the government: as the number of these individuals exceeds a certain threshold, the social group of protest emerges. Lohmann’s (1994) game-theoretical model is based on a similar idea of protest, but in a different theoretical approach which works with the concepts of rationality and political information processing abilities of the individual actor: the rational actor observes the actions of all the other
individual actors in the model system. If at time $t - 1$ a critical mass of actors $X_{t-1}$ are providing observable signals that they question the desirability of the government, then the individual agent makes the decision to question it itself, thus joining the protest.

Johnson’s model relaxes the requirements on an agent’s rationality and enhances an information processing ability, otherwise present in the former approaches too. His model assumes that the individual agent is a bounded rational agent who takes his personal social condition as a reference and also as a criterion for evaluating the government’s performances. Evaluating its personal condition as unsatisfactory makes the agent acquire a belief about the non-desirability of the government. This belief further induces an unfavourable attitude toward the government. If the agent’s belief gets reinforced by similar attitudes of agents who protest against the government in the immediate neighbourhoods of the individual agent, then the agent might get influenced and could himself adopt a negative attitude towards the government, thus joining the protest.

Johnson’s model defines political contagion as a political influence generated and sustained by an attitude toward an object (i.e. the government) which is held by many agents. As an individual agent becomes aware of this attitude in the aggregate, it appears like being subjected to political influence while observing the social aggregate. The individual agent observes a political protest against the government as a social aggregate in which a certain political attitude toward the government prevails. These observations are modelled as macro-level stimuli exerting a political influence on the individual agent. When the individual’s beliefs about the government as the source of discomfort in the agent’s personal condition are congruent with a negative attitude toward the government spread in the aggregate, this congruity reinforces the individual belief concerning the government desirability and makes the individual agent strengthen its beliefs and finally join the protest. The dynamics of the political contagion describe, therefore, a complex social aggregate which appears as the macro-level output which emerges from the individual decision-making, beliefs update and conjoint actions of an increasing number of individual agents. The journey from the macro-level stimuli to the macro-level output is nevertheless complicated, since the individual beliefs, attitudes, action decision-making and internal status need to be described and updated in each individual agent.

**Operational Model**

Political contagion is modelled as collective action with an agent-based model. The cells in the grid representing the spatial environment of the model system are randomly initialized with a normal distribution of individual agents.

Each agent is characterized by a number of variables describing the ‘personal condition’ with numerical continuous values in the interval $(0; 1)$, such that lower values are associated with low personal condition, and high values are associated with a high personal condition. The higher the values that personal condition takes, the lower is the possibility that the agent is not satisfied with the government. Another variable is the discomfort threshold, which takes continuous values in the interval $[0.5; 1]$. The individual thresholds are initialized with a normal distribution. As a
moving agent, the individual agent is characterized by spatial coordinates which identify its location in the environment such that the individual agent is aware in each moment whether it is close or far from the other agents which protest against the government. These coordinates are then used by the individual agent to either run away from the political protest or to get closer to the political protest and finally join it.

A simulation run develops on a sequence of discrete time steps; at each time step each individual agent takes the same actions: belief update as observing the aggregate, evaluating the conditions for joining (or not) the protest, and choosing a spatial location as close/distant as possible to the protest.

Belief update is accomplished by observing the Moore neighbourhood at each local position with a certain radius: if \( r = 1 \), then the individual agent is able to observe 1-cell area of Moore neighbours (eight neighbours) in all directions around its own cell; if \( r = 2 \), then the individual agent can observe the Moore neighbours in 2-cell areas in all directions.

The model succeeds in getting a map of political contagion for a simple scenario in which an individual agent is trying to get spatially closer to other agents with a high level of discomfort associated with low values of personal condition. In this map, the colours indicate how close to the protest area and how strong is the belief of an individual agent that the government is ‘bad’: dark colours indicate distant-from-protest cells and low belief strength, while a red colour indicates close-to-protest cells and high belief strength.

**Collective Action Model of Political Protests**

An advanced modelling approach on political protest and political regime change was developed as a collective action model (Johnson and Brichoux, 2002). This approach models the power of commitment in cooperative social action. It achieves various scenarios of emergence and spread of political protests in situations in which activists are (or are not) stimulating the common people to engage in political protests against political leadership. The model is based on theories about individual success motivation. It also builds upon Olson’s theory of collective action (Olson, 1965), and in particular on the theory of critical mass elaborated by Oliver and Marwell (1988) and collaborators (Oliver, Marwell and Teixeira, 1985). As support for the former, the authors employ Kuran’s threshold model of preference revelation (Kuran, 1989, 1995). The model explains the emergence of political protests by running an agent-based system in which the agents are heterogenous: they represent two types of political actors, common people and political activists. The agents communicate among themselves and are also able to observe other agents and get acknowledged for their beliefs and behaviour.

**Closing Remarks**

The best aspect of these models is that they succeed in finding a believable construction of political attitude formation and change as a collective action process: the individual agents consider the protesting agents (i.e. what the author
denotes the ‘aggregate’) as sources of observable signals. These observations are modelled as macro-level stimuli which are used as feedback, thus succeeding in re-orienting the individuals in updating their beliefs and in their action decision-making at the micro level.

Web Resources

Paul E. Johnson’s research papers page: http://pj.freefaculty.org/ResearchPapers/

References

Part V

MULTIDIMENSIONAL SPATIAL MODELS

System dynamics, as introduced by Jay Forrester during the late 1960s (Forrester, 1968), is a modelling paradigm which allows for the representation of the dynamics of systems’ behaviours in terms of variables, processes and mechanisms. Forrester was a pioneer in the computational and simulation modelling of social systems: he employed system dynamics to model the dynamics of change processes in large social structures. Taking advantage of the rise of computer technology and advances in computer simulation, Forrester (1961, 1969, 1973) employed it in forecasting the behaviour of both industrial and social systems.

His works fundamentally changed the modelling perspective over social and political modelling. Moreover, his views challenged experimental psychology as well as social and cognitive psychology to use the system dynamics paradigm for the modelling of behaviours, beliefs and attitudes. For almost two decades during the 1950s until the late 1960s, attitude modelling research in social and political psychology was dominated by behaviourist modelling. The system dynamics paradigm provided perhaps the most powerful reinforcement to the idea that behaviours can be controlled from outside by messages with a certain frequency and conceptual configuration. However, system dynamics offered much more than this, competing with the behaviourist paradigm until weakening its position in modelling research: it provided a way to model the behaviours of the system by taking into consideration both internal and external stimuli as well as the system structure. This attracted the attention of social and political psychologists, who found this view appropriate for attitude modelling. The system dynamics view on behaviour and attitude change was influential in the first computer simulation model developed by McPhee and collaborators in the late 1950s and the beginning of the 1960s for modelling aggregate tendencies in the voting choice of the electorate in presidential elections.

The idea of combining system dynamics and computer simulation was reinforced by the contribution of another area of intensive research during the 1950s, namely the
propaganda studies and persuasive communication research developed by Carl Hovland and his team at Yale University. One of the most relevant studies during the 1950s is the Yale model (Hovland et al., 1953), which assumes that, in political propaganda, persuasion is achieved by the ‘source–message–receiver’ scheme, in which both the message and some attributes of the source, like its credibility, authority and competence, are essential for the quality and effectiveness of persuasive communication. The influence of this model in political attitude research has been tremendous: at that time, no modelling approach would have escaped it. On the contrary, both social psychology and political psychology have intensively employed it in explaining political attitude formation and change. Its influence diminished only after cognitive theories had substantially penetrated social and political psychology research.

One last detail would appropriately complement this already complicated picture: computational modelling and simulation at the time was in a period of rapid growth, and strong enough and quite promising so as to attract the eyes of electoral strategists for electoral campaign and electoral media communication designs. Pioneered by William McPhee, computer simulations seemed very attractive, though unfortunately extremely expensive. And the most prohibitive costs were not those for acquiring computer machines, but those for computer programming and modelling expertise. The history of the rise and growth of experimental political science would tell much about the times of this painful experience. Computers and computer simulation advances were in constant development starting in the 1950s. System dynamics was the first computer simulation paradigm and has been employed in political decision-making, electoral studies and political behaviour research.

System dynamics was originally designed for modelling economic processes, in which the dynamic behaviour of a variable is studied by computer simulations. A computer simulation was used as a means to implement the model by varying both internal (state) and external variables (stimuli).

The behaviourist paradigm models a system as a black box and a system’s behaviour as solely determined by external stimuli, which could either reinforce or punish certain types of behavioural variations. The main characteristic which made the systems dynamics paradigm so appealing for social and political psychology research concerned its ability to model the behavioural change: the system’s behaviour is viewed as influenced by both internal processes (attitude change, belief change) and external stimuli (messages) such that the model includes one or multiple feedback loops which contribute to the causal explanation of the behavioural change.

In systems theory, a system is characterized by a dynamic state. It could vary as a function of factors defining both internal and contingent sources of variation. The dynamics of a system are described by a rule which always identifies the next state following from the current state under certain classes of external and internal stimuli. The system dynamics paradigm provides for a causal view upon the structure and behaviour of a system. As a difference from the behaviourist paradigm, which achieves a system’s behaviour in open-loop representation, the system dynamics paradigm achieves a system behaviour in a closed-loop representation. Behaviourist modelling is based exclusively on external control of the behaviour, whereas in
system dynamics the system’s behaviour is modelled as a dynamic feedback loop in which both external and internal structures are involved (Levine, 1983: 326–327).

A system dynamics model is represented as a causal loop, which is often described as a ‘stock and flow’ model: a ‘stock’ is always a variable whose quantitative value could dynamically increase or decrease, while a ‘flow’ is a rate of change process, which could also dynamically increase or decrease. Their variations are described by differential equations which represent the rules describing the state change. The system dynamics model could be simulated on a computer such that the dynamic transfer from one state to another (i.e. the system’s trajectory in time) could be registered and further studied with quantitative analysis methods.

**Attitude Change Modelling**

In individual and social psychology, as well as in political psychology, the attitudes and beliefs are the variables which cover relevant aspects of internal sources of change.

The Hovland–Yale model of persuasive communication inspired a ‘source–message–receiver’ modelling of attitude and belief change. Attitudes and beliefs are subjected to persuasion processes in which messages with a particular conceptual configuration are received from external sources, either individuals or groups or media campaign communications. Approached in the system dynamics paradigm, attitude and belief change has been modelled as a dynamic variation and described with the help of differential equations.

The system dynamics approach to attitude and belief change modelling as well as the inspirations coming from other disciplines, like communication, cognitive psychology or information processing, has succeeded in shaping a class of modelling theories able to answer the demands and expectations formulated in social and political psychology research with concern to several relevant issues: decision-making and preference aggregation in mass publics. This class of modelling theories has opened the door for the development of computational and simulation modelling of political attitudes. Though not actually a movement, this research area comprised famous scholars and groups known by their topics of interest and the solutions they have provided to major research questions.

One of these groups was conducted by John E. Hunter, who laid the basis of system dynamics modelling of attitude change. John E. Hunter and collaborators founded a basic trend in attitude change research as they developed a class of mathematical models for simulating the dynamics of attitude change in the most important paradigms: behavioural, information processing, cognitive dissonance (Levine, 2003). In these models, attitude change is modelled as an effect of persuasive communication, and influenced by both message and source.

Hunter’s work was further developed in two main (otherwise, closely tied) research areas of attitude and belief change modelling: (i) spatial-linkage models, which include several classes of multidimensional attitude–belief change models, like variable mass models, spring models, discontinuous models and hierarchical models; (ii) multidimensional ideology formation and change models.
The class of attitude change models based on the system dynamics paradigm further inspired Joseph Woelfel and his collaborators to extend Hunter’s issue of dynamic attitude change to the study of spatial modelling of attitude and belief change. They developed the *Galileo Model*, a theory which provides support to several classes of spatial-linkage models. These classes of models address the problem of measurement of attitude change in multidimensional cognitive spaces. Though actually a measurement model, *Galileo* is based on a cognitive theory about attitude formation and change inspired by the early research on the semantic space (Osgood and Tannenbaum, 1955), balance theory (Heider, 1946) and cognitive dissonance theory (Festinger, 1957).

Some of the research issues initially developed by John Hunter and collaborators, like the hierarchical models of attitude–belief change, were further developed by Edward Fink and his team: hierarchical models of inter-attitudinal change address the issues of dynamically changing cognitive systems and structures (Dinauer and Fink, 2005).

Also initiated by Hunter, the issue of ideology change was further developed by George Barnett, Kim Serota and others into modelling approaches to ideology as both influencing and being influenced by political communication in large masses (Barnett, 1974; Serota *et al.*, 1975).
The system dynamics paradigm employed by John Hunter in explaining the attitude change process facilitated its description as a process whose dynamics depends on both the process’s history and on the context in which it develops. John Hunter got famous for his attitude change model. It is the first model which is based on differential equations. It employs the system dynamics paradigm for explaining the attitude change as depending on external (contextual stimuli, messages, influence), and internal (initial attitude, attitude’s strength) factors. The conceptual and operational aspects of this model are explained and further develop by Hunter’s collaborator, Ralph Levine.

Conceptual Aspects

In the system dynamics paradigm, the attitude is defined as a dynamic variable with attributes of magnitude, direction and structure. The system dynamics model takes as variables the receiver’s attitude toward the object (message) and the receiver’s attitude toward the source. Attitude variability is bounded, and it depends on other factors too, like persuasibility, that is the capacity of being persuaded of the person who receives the persuasive message(s).

In a behaviourist model, the attitude change would depend on the message and on the capacity of the person receiving the message to be persuaded, the so-called persuasibility factor. Using a differential equation and our variable notation, the
rule of attitude change reproduces the original model as follows (Levine, 1983: 23/336):

\[
\frac{d(\text{att})}{dt} = pm
\]  \hspace{1cm} (10.1)

where \( (\text{att}) \) is the attitude, \( p \) is the persuasibility factor, \( m \) is the message and \( d(\text{att})/dt \) is the first derivative of the attitude variable with respect to time, that is, the attitude’s rate of change.

As initially defined by John Hunter and further refined by his disciple, Ralph Levine (1983), a system dynamics model achieves the attitude change by evaluating a differential equation in which the rate of attitude change is a function of the attitude itself, the message and the persuasibility factor. Adapting the notation used by Levine in defining this equation (Levine, 1983: 24/336), we get the following differential equation:

\[
\frac{d(\text{att})}{dt} = p(m - \text{att})
\]  \hspace{1cm} (10.2)

where \( p \) is a persuasibility factor which characterizes the receiver of the message, \( (\text{att}) \) is the attitude of the receiver toward a particular object, \( d(\text{att})/dt \) is the rate of attitude change (i.e. the first derivative of the attitude) and \( m \) is the intensity of the message as expressed in attitude units.

Equation 10.1 models attitude change from a behaviourist point of view, emphasizing that attitude is a dynamic process which could be controlled from outside only by sending appropriate messages to the receiver. Equation 10.2 models attitude change by means of the system dynamics paradigm such that the initial attitude held by a person toward a particular object could be changed by sending the person persuasive messages, but the rate of change will depend not only on the message and on the person’s persuasibility, but also on the initial attitude and its strength. In this paradigm, the attitude change is defined as a dynamic recursive process which models both internal and external sources of change and influence factors.

The outcome of this conceptual model should depict the dynamic trajectory of the attitude change process during a given time interval. In order to obtain the results, an operational model is necessary. It transforms the concepts which describe the nature of change in operational terms. The operational model provides for the implementation of a computer simulation version of the conceptual model. System dynamics models have often been used in structural equation modelling such that the advantages of this modelling paradigm have been transferred to the statistical analyses of the results which facilitates the causal modelling (Levine, 1983: 20/334).

Hunter et al. (1984) developed a class of mathematical models for simulating the dynamics of attitude change in the most important paradigms: behavioural, information processing and cognitive dissonance.
Operational Aspects

A system dynamics model is represented as a diagram in which the processes (flows) and variables (stocks) are represented together with their variations (arrows). A negative loop is a feedback loop, in which time is the essential dimension of change. Attitudes are measured on attitude scales in attitude value units. Messages are represented as quantities on the same scales.

A difference between a current value of the attitude toward an object and its value at a subsequent moment of time is described by a differential equation, which quantifies the change in attitude in terms of the dynamics of the rate of change.

Equation 10.2 is a linear differential equation which has a recursive form, such that the rate of attitude change depends on the attitude itself, on the message and on the characteristics of the person who receives the message. As Levine (1983: 24/336) describes it, such a system dynamics model of attitude change includes a feedback loop. The feedback mechanism consists of the difference (denoted as the degree of dissimilarity) between the position advocated by the message and the receiver’s attitude toward a particular object. It is this degree of dissimilarity (measured in attitude units) which determines the change in attitude and its dynamics. The mechanism of evaluating the dissimilarity between a person’s position and the position advocated by a (persuasive) message toward a particular object inspired the Galileo model, which was developed for the measurement of attitude change in multidimensional cognitive spaces.

The dissimilarity-based mechanism of attitude change in persuasive communication processes at both the individual level and in large populations and the system dynamics modelling paradigm has been addressed by several mathematical models aimed at providing the means to operationalize attitude change. In what follows, three such models are presented. They have been selected for the influential role played in the development of computational and simulation models of attitude change by the teams involved in relevant research projects targeting the modelling of the effects persuasive campaigns might induce in the voting choices of large electorate masses. The models presented in the following sections summarize a long period of social and political attitude modelling research based on the system dynamics paradigm as a distinct research orientation from the orientations based on social influence theories. These latter orientations were reinforced during the late 1980s. They achieved a different computational expression only after the mid-1990s when the new technologies based on artificial intelligence (AI) and artificial life theories (ALife) took the lead in almost all social and political modelling research areas.

Proportional Change Model

Equation 10.1 could be written to describe a belief change as well. It defines the rule of change in a belief change system dynamics model. The model concerns the belief change which could be observable (measurable) for a person who already has a belief with respect to an object and who accepts a change to this initial belief as recommended by incoming message(s). As such, it is an expression of the Proportional
Change Model (Danes et al., 1978: 243), initially formulated by French (1956) and reformulated by Anderson and Hovland (1957) in a recursive form by Equation 10.3:

\[
\text{new\_belief} \leftarrow \text{old\_belief} + \alpha [(\text{belief\_advocated\_by\_message}) - (\text{old\_belief})]
\]

(10.3)

where the rate of belief change from the old to the new belief depends on the dissimilarity between the positions advocated by the message and the receiver, respectively, and a factor of the receiver’s persuasibility \(\alpha\).

The difference between the new belief and the old one, as reformulated by Equation 10.4,

\[
(\text{new\_belief}) - (\text{old\_belief}) \leftarrow \alpha [(\text{belief\_advocated\_by\_message}) - (\text{old\_belief})]
\]

(10.4)

is defined as directly proportional to the difference between the belief advocated by the message and the initial belief held by the person who receives the message, with \(\alpha\) a factor of proportionality.

The model has been very popular ever since Hunter formulated his mathematical model in a fashion which suggested similarities with Newtonian dynamics so as to emphasize its potential application to the dynamics of cognitive objects. The idea was not new, as it had also been inspired by the earlier theories of Kurt Lewin on the issue of force field theory applied to social influence (Lewin, 1952). As emphasized by John Hunter, Jeffrey Danes and Joseph Woelfel in their joint research paper (Danes et al., 1978), linear as well as nonlinear versions of this model have been employed in belief and attitude modelling research in social judgment (Sherif et al., 1965), cognitive dissonance (Aronson et al., 1963) and attitude–behaviour relationship (Fishbein and Ajzen, 1975).

Belief Certainty Model

The degree of certainty with which a person holds a belief about a particular object or an attitude toward it, called the polarity of the belief/attitude, was initially formulated by Osgood and Tannenbaum (1955) in their congruity theory.

The Belief Certainty Model, as initially formulated by John Hunter and S. Cohen\(^1\) and reformulated by Danes et al. (1978), is a mathematical model of the polarity principle which has been used for the operationalization of the change in beliefs/attitudes. It states that the change in belief (attitude) is directly proportional to the degree of dissimilarity between a message and a person’s advocated belief (attitude) toward

\(^1\) As their book remained unpublished, our references to it are always indirect, as provided by the authors who have edited Hunter’s works and who have worked directly with John Hunter as disciples and collaborators, like Ralph Levine and Jeffrey Danes.
an object, and is inversely proportional to the degree of certainty with which the person holds the initial belief (attitude):

\[(\text{new} \_ \text{belief}) - (\text{old} \_ \text{belief}) \leftarrow \frac{\alpha[(\text{belief} \_ \text{advocated} \_ \text{by} \_ \text{message}) - (\text{old} \_ \text{belief})]}{1 - \text{degree} \_ \text{of} \_ \text{certainty} \_ \text{old} \_ \text{belief}} \]

This model has been the subject of long theoretical debates (Danes et al., 1984: 204) on the polarity of attitudes and beliefs and the relationship between polarity and resistance to change in persuasive communication: some authors consider that the polarity of belief and its resistance to change are directly proportional (the so-called ‘polarity effect’), advocating the idea that extreme beliefs change with great difficulty (if at all) (Sherif and Cantril, 1946). Other authors (Anderson and Hovland, 1957; Hovland, 1972) advocate a different idea, that a belief’s resistance to change is supported by an increased level of information (i.e. a greater amount of information is hypothesized to mean a higher quality of information also, a point of view which, in my opinion, might not get support anymore from one who watches television nowadays, especially during electoral campaigns).

**Accumulated Information Model**

The *Proportional Change Model* assumes that the proportionality factor $\alpha$ is constant. Its value could be set up during the model application design for cases in which the message guarantees the truth of the claimed belief and/or attitude toward an object, and the factor $\alpha$ is used for the control of the belief and/or attitude change trajectory. Initially, the model was employed in research on belief and attitude change in persuasive communication scenarios in which old beliefs are held with high degrees of certainty and are, therefore, hard to change (Janis and Hovland, 1959).

If, however, the factor of proportionality $\alpha$ is assumed to vary itself as a function of the person’s accumulated information about a particular object, then the accumulated information model could be formulated so as to account for this hypothesis. The hypothesis, initially formulated by Norman Anderson (1959, 1965) and also by Rosenberg (1968), has been mathematically formulated by Saltiel and Woelfel (1975). In their formulation, the $\alpha$ factor decreases as the number of incoming messages increases significantly:

\[\alpha = \frac{1}{\text{number} \_ \text{of} \_ \text{messages}} \]

There are two possible interpretations the authors give to this formula. One interpretation would adjust the belief of the receiver after $n$ messages to the average of the belief values conveyed by these messages. However, this interpretation assumes that the number of prior messages is known (or irrelevant). Otherwise, another interpretation would be more appropriate: the receivers make content (value) comparisons
each time they receive a new message and assess, among other things, the degree of
information they have about the object or the claimed belief or position in each mes-
sage. If no prior information is found, the receiver accepts the belief or attitude
advocated by a new message as no arguments can be found against it.

These ideas were further studied by Woelfel and collaborators in the Galileo
Model, which elaborates on the relationship between the mass of attitude and its
change trajectory. These theories assume that the message can be viewed as a ‘force’
which ‘moves’ the belief or attitude along one or more dimensions of change in the
cognitive space. The intensity of such ‘force’ would depend on the number and con-
cept configuration of the incoming messages.

Advantages and Disadvantages of the System Dynamics
Modelling Paradigm

Attitude change is a dynamic process which, in this modelling paradigm, received for
the first time a dynamic description and evaluation in terms of system theory. Many
of the concepts underlying this modelling paradigm are rooted in Newtonian
dynamics. What it has provided for, along with Lewin’s theory about force fields and
its applicability to social systems, is an operational description of the attitude and/or
belief change trajectory. Evaluating attitude change in persuasion scenarios necessi-
tated an appropriate formalism, which was initially inspired by Forrester’s theory on
social dynamics.

However, attitude is very much context sensitive, and its sensitivity requires
much more dynamic detail. System dynamics made room for other methodology and
technology alternatives in attitude change modelling. The sciences of the artificial
soon became relevant in this direction.

However, the orientation Hunter founded has been continued and adapted into a
new paradigm: the spatial models of attitude change.

Hierarchical Models

Hierarchical models are a class of spatial models of attitude change. They explain
and predict political attitude and belief change in terms of inter-attitudinal and belief
structure theories (Dinauer and Fink, 2005). They are based on the fundamental
assumption that attitudes are stored in the memory as part of larger cognitive
structures.

Attitude change is approached in many classic attitude theories in terms of the
variations of the relationships between structural attitude components: beliefs, affect,
cognition and behaviour.

Balance theory (Heider, 1946) describes the attitude structure as a dyad or a triad
of cognitive components, namely attitudes and beliefs. Attitude change is associated
with a non-balanced relationship between the components of a dyad/triad, which
means conflicting attitudes and/or beliefs. As people prefer balanced relationships
within these dyads/triads, the conflict is reduced or eliminated by modifying the
attitudes/beliefs. Cognitive dissonance theory (Festinger, 1957) assumes that the structural elements which are in a dissonant relation, like attitudes and beliefs, induce an internal pressure for dissonance reduction. In order to reduce the dissonance, the individual person who experiences it modifies the content and/or relevance of these elements.

Spatial models of attitude change are rooted in the early mathematical models of attitude change developed by John Hunter and collaborators. These approaches are based on Newtonian physics and model the attitudes and their structure with the help of basic physical notions like ‘acceleration’, ‘force’ and ‘mass’, addressing the dynamics issues of an object’s motion in the physical space. These approaches concern attitude change as induced by message communication, and are based on the Hovland–Yale modelling paradigm: ‘source–message–receiver’.

In hierarchical models, inter-attitudinal change has been approached in terms of hierarchical structures of concepts (Dinauer and Fink, 2005; Dinauer, 2009). In conceptual hierarchies, the connections between concepts (conceptual structure) support the connections between conceptually related attitudes (inter-attitude structure) and explain how the attitudes change in relation to one another.

Hierarchical models prove that attitude change is constrained by the hierarchy itself (superordinate–subordinate levels), whereas spatial models prove that the change occurs for all linked objects regardless of their hierarchical relationships.

References


The spatial models presented in this chapter include several classes of models: Multidimensional Attitude Change Models, Spring Models, Variable Mass Models, Spatial-linkage Models and Hierarchical Models. All these models have been developed within the extended Galileo research framework for measurement of change in cognitive and cultural processes. What is specific to Galileo modelling is the approach to change in both cognitive and cultural processes in terms of the relationships among cognitive and cultural concepts viewed as ‘objects’ (Woelfel and Fink, 1980: preface, 10). Anything could be an ‘object’ in a cognitive space: attitude, belief, behaviour.

Attitude change is modelled as a cognitive process. Conclusions drawn from the multidimensional measurement of change in cognitive objects, like attitudes held by individuals or collectives (i.e., groups or society at large), have been generalized so as to give an account on the measurement of change in cultural objects (Woelfel and Fink, 1980: 32–37).

Galileo was originally conceived as a measurement model, and it is based on mathematical modelling. The computational dimension appears inherent due to complex mathematical calculations requested for the modelling of continuum and multidimensional aspects. As time passed and its complexity increased, the computational modelling character of the Galileo approach became more and more emphasized.

Measurement of attitude change in the Galileo modelling framework starts from the assumption that experience has a representation, and this representation should be based on objects and their relationships. From this point of view, Galileo is a model of relative representation (Woelfel, [n.d.]2009: 2) since each object is represented by means of all the rest of the objects which constitute the system being represented; that is, a cognitive system or a culture. As a difference from the Aristotelian
categorical representation, the *Galileo Model* addresses the multidimensional representation: the representation space has as many dimensions as objects. An object in such a space could be an attitude, a belief, value or emotion, or any cultural object.

The *Galileo Model* was conceived and has been used for change measurement in attitude and cultural processes.

**Conceptual Background**

These classes of approaches are inspired by several classic modelling theories with concern to attitudes, communication and cognitive processes.

One source of inspiration is represented by Osgood’s concept of *semantic space* (Osgood, 1964: 171). He used connotative meanings of the objects in a semantic space to derive the attitudes toward particular objects. Inspired by this idea and by George Herbert Mead’s (1934) works on mind and self, Joseph Woelfel developed multidimensional models of attitude change which (a) define each concept by its *dissimilarity* (also called semantic ‘separation’ or ‘discrepancy’) to all the other concepts in the semantic space (Woelfel, 1980) and (b) evaluate this ‘dissimilarity’ in order to measure the attitude change (Woelfel, 1980: 99; [n.d.]2009: 2). The Galileo model is a relativistic model as its fundamental assumption is that an object (concept) gets a meaning only from relating it to other objects in a cognitive space (Woelfel and Fink, 1980: 145). The *self* is also considered an object in this space. The model approaches the issue of representation of cognitive and cultural experience.

Another conceptual background is provided by the Yale model (Hovland et al., 1953) on persuasive communication. Inspired by this model, the multidimensional attitude change model works with two types of variables: (a) the messages $x_i$, viewed as ‘forces’ which make the attitude ‘move’ along the dimensions described by the other concepts (objects, attributes) with which they are linked; (b) the ‘difference’ or ‘dissimilarity’ (also called ‘separation’, ‘discrepancy’ or ‘distance’) between the recipient’s attitude and the concepts (i.e. stimuli) provided by the incoming (persuasive) message(s) in a communication process.

The notion of ‘discrepancy’ (‘dissimilarity’ or ‘separation’) in a semantic space is considered equivalent to the notion of ‘distance’ in a metric space. The semantic space could be considered a multidimensional space: each concept (object) introduces a new dimension along which the attitude change could develop. This change is determined by the most relevant concepts in the semantic space, namely, by the concepts which are closer to the ‘self’ or within a neighbourhood which defines the ‘self’.

As regards the ‘self’ issue, the authors of the *Galileo Model* found inspiration in Mead’s theory on mind and self (1934) as well as in Heider’s theory of balance (1958) and in Festinger’s theory of cognitive dissonance (1957). However, the model departs from its inspiring sources by considering that the ‘self’ is an information structure constructed dynamically in the so-called ‘self-process’. In the *Galileo Model*, the ‘self’ is defined as a set of relationships with all the other objects in a cognitive space. These relationships are modelled as distances between the ‘self’ and all the other objects. As an information structure, the ‘self’ is dynamically changing.
as a result of the changes induced in the cognitive space from processing the new information provided by the incoming messages. The change could also be induced from internal information processing (Woelfel and Fink, 1980: 145).

A third source of inspiration is represented by Newtonian mechanics. Each message is modelled as a ‘force’ whose effect on the actor’s attitude is to modify its location in the cognitive space and, therefore, its discrepancies from all the other concepts within the space. Each object in the attitude space has a location and a mass. The motion of an attitude in a multidimensional space is evaluated on the methodological background of the metric multidimensional scaling measurement methods (Young and Householder, 1938; Torgersen, 1958).

**Formal Models Based on the Galileo Model**

Stan Kaplowitz and Edward Fink (1982: 373–378) provided a review of the models developed on the Galileo theoretical and methodological background. Variable-mass (VM) impulse models (Saltiel and Woelfel, 1975) include VM.1 models (Woelfel and Saltiel, 1978; Woelfel et al., 1980) and VM.2 models (Danes et al., 1978). These models are designed to show how the message’s force can influence the attitude trajectory. A change in attitude can be predicted by the mass of messages, that is, the configuration and amount of information (number of messages and content) necessary to move any object (concept) toward the person’s so-called ‘self’ neighbourhood. Messages which identify two objects (concepts) or identify the similarity of two objects (concepts) are likely to be highly effective in making the receiver resistant to other (persuasive) incoming messages with a different content. Information of this type increases the concept’s mass and makes it resistant to high acceleration.

*Fixed-mass spring* models assume that the information in the message works like a ‘spring’, in that it serves as the connection between two concepts identified by the message: the more information received about an object (concept), the stronger anchored the concept and, therefore, the more difficult it is to be moved (changed). More complex spring models assume that messages both create springs and add mass to the concepts. This may induce variability in a concept’s capacity to resist change (Kaplowitz and Fink, 1982).

Another model based on the Galileo approach is the *Hierarchical model* (Dinauer, 2003; Dinauer and Fink, 2005), which is designed for the measurement of inter-attitudinal change.

**Galileo Model**

**The Conceptual Model**

*The Galileo Model* (Woelfel and Saltiel, 1978) provides for the cognitive theory underlying the multidimensional attitude change measurement model.

As a difference from the Aristotelian way of defining the experience based on the concept of ‘category’, the *Galileo Model* is concerned with the cognitive experience, which is modelled as a mathematical continuum. The *Galileo Model* works with the
notions of ‘objects’ and their relationships in order to represent experience and to measure the change in attitudes. An ‘object’ is defined as a representation of experience (Woelfel, 1980: 2; Woelfel and Fink, 1980: 145). The cognitive space of a set of representations corresponding to the attitude domain is considered a multidimensional space. Since the cognitive space is viewed as a representation of experience, the attitude is a cognitive structure which could include (or not) an affective component, avoiding the idea of developing a measurement model based on affective dichotomies usually employed by the classic scale measurement models.

Attitude change is viewed as a cognitive process in this multidimensional cognitive space. As such, an attitude change is defined with respect to the concepts of ‘self’ and ‘object’. From a conceptual point of view, it is based on the notion of similarity/dissimilarity, which in operational terms is defined as ‘difference’ or ‘distance’.

The notion of ‘self’ is defined in the same paradigm: it is defined, like any other object in the attitude domain, in terms of its relationships with all the other objects in the cognitive space (Woelfel, 1980: 99). As it is defined by its dissimilarities with respect to all the other objects in this space, these pairwise separations are conceived as beliefs (Woelfel, 1980: 99).

Attitudes are defined as beliefs; that is, measured dissimilarities between the ‘self’ and any of the other objects in the cognitive space (Woelfel, 1980: 92).

The ways in which attitude change could be associated with a particular behaviour are derived from preliminary research concerning the predictive role of the socially relevant others who know and influence an individual actor’s behaviour (see the notion of ‘significant others’ in Haller and Woelfel (1972)).

Attitude change modelling has been addressed in the Hovland–Yale model of persuasive communication (Hovland et al., 1953; Anderson and Hovland, 1957), which assumes that the essential factors are the message, the source of the message and the recipient (audience) of the message. The model further assumes that four main elements which should be taken into consideration for the evaluation of an attitude change are: (i) the attitude of the source (i.e. as perceived by the receiver) with respect to the attitudinal object, (ii) the attitude advocated by the message, (iii) the initial and (iv) final attitudes of the receiver (i.e. as modified by the message). In unidimensional models, the values taken by these concepts always lie on a single axis, and their variation range is described by values which go from one end to the other of this axis. Classic measurement procedures, like the Likert scales, are based on this measurement principle.

An alternative to this unidimensional attitude change modelling approach is the multidimensional one. It is rooted in the idea introduced by Osgood et al. (1957) that variables describing attitude change can be measured with multidimensional methods. This was further extended by Joseph Woelfel et al. (1980: 153) in their modelling approach: attitudes can change on multiple dimensions, each dimension being associated with an object (concept) in the attitude domain.

Other theoretical roots of this approach can be found in the works of George Herbert Mead (1934). Mead’s view of the continuous interaction between the individual actor and the social environment was adapted and used by Woelfel and
collaborators to develop a theory about the measurement of the dynamics of attitude change in social communication processes. Attitudes are defined by means of their global set of relationships to the concepts in the cognitive structure of the attitude domain (Woelfel, 1980: 92). Attitude change is therefore associated with the overall change in this global conceptual structure.

Woelfel describes it (Woelfel and Saltiel, 1978; Woelfel, 1980: 94) with an equation which models attitude change as depending on three main factors: (1) the number of old messages which contributed to the original attitude formation, (2) the number of new messages which contribute to the change of attitude and (3) the amount of discrepancy between the new and the old attitude (i.e. an averaged position between the positions advocated by each of the new persuasive messages).

The linear force aggregation theory – see Woelfel (1980: 94, equation 1) – is an attitude change measurement model. Attitude change is considered to be a cognitive process which can be described as a motion in a multidimensional space. The dimensions are the attributes of the object and the motion is defined with the Newtonian expression of relationship between force, mass and acceleration.

Attitude change is described as the outcome of the weighted sum of the ‘forces’ exerted by each message on the existing attitude towards a particular object such that a new attitude is issued after an interval of time (measurement time).

Adapting the original equation – see Woelfel and Saltiel (1978: equation 5), the model describes attitude change as a consequence of receiving new messages (new information) about the attitude:

\[
\text{new}_\text{att}(t_1) \leftarrow \text{old}_\text{att}(t_0) \left[ \frac{m_0}{m_0 - m_1} \right] + I \left[ \frac{m_0}{m_0 - m_1} \right] 
\]

(11.1)

where \([t_1 - t_0]\) is the interval of time, \(\text{new}_\text{att}\) is the new attitude measured at time \(t_1\), \(\text{old}_\text{att}\) is the original attitude at time \(t_0\), \(m_0\) is the number of messages out of which the old attitude has been formed, \(m_1\) is the number of new messages received during the interval of time \([t_1 - t_0]\) and \(I\) is the amount of other messages received over the specified interval of time.

The force aggregation theory shows that the stability of attitudes increases in direct proportionality with the amount of information contained in all received messages (Woelfel, [n.d.]2009: 94).

The Operational Model

The Galileo Model operationalizes the definitions of attitude and belief so as to allow for an operationalization of their motion in the multidimensional space of objects and attributes. The operationalization of the attitude definition consists of replacing the classic association between an attitude object and an expression of affect (like/dislike) with the association between two points in the cognitive space of a set of representations: one point should be the ‘self’ point, while the other point could be any of the other ‘objects’ points in the attitude domain. The association between the two points is defined as the distance between these points.
The operationalized definition of a belief is the distance between any two concept points (with the exception of the “self” point) in the cognitive space of a set of representations such that one point is an attribute point.

At the operational level, the Galileo Model defines the cognitive change processes (attitude change) and cultural change processes (culture change) as changes in spatial locations within the cognitive or cultural space, respectively. The change in spatial location is assimilated with a ‘motion’ in the multidimensional space of a set of representations (Woelfel and Fink, 1980: 39). An attitude change, described as a cognitive process suffered by an object (i.e. attitude) in the cognitive space, is modelled as a motion of an object relative to the other objects in a physical space. The Galileo Model defines attitude change as a cognitive process which updates the relationships between all concepts in the cognitive space as new (persuasive) messages are received by an individual actor. These relationships are measured by pair comparison methods, and the dissimilarities are expressed as matrices which are evaluated by metric multidimensional scaling procedures. The typical outcome of such procedures is the representation of the cognitive objects (concepts or cultures) as points in a multidimensional space (Riemann space).

Once a cognitive space is defined for a set of objects (concepts or cultural objects), the laws of Newtonian physics could be addressed as laws of motion for all concepts within the space (Woelfel, [n.d.]2009).

As initially described by Woelfel and Fink (1980) (see also Kaplowitz et al., 1983: 234–235), the set of assumptions which allow for modelling the cognitive space and objects on a Newtonian mechanics basis are: (i) the concepts within a cognitive system have location and mass characteristics; (ii) attitude and belief change with regard to a particular object in the cognitive system is expressed as a motion in that space under Newtonian laws of physical motion; (iii) any incoming message received by a recipient is viewed as exerting a force which influences the current state of the cognitive system (as inspired from McGuire’s (1968: 257) idea); (iv) modelling the motion of a concept as a physical motion, the Galileo model assumes that the acceleration of the concept in the cognitive space is calculated by dividing the force induced by the message by the mass of the concept; (v) the mass of a concept is assumed to be represented as the cumulated amount of information received through the incoming messages.

The notion of reference frame is associated with the study of an object of perception by comparison with other objects in some experience. A reference frame is defined as a set of objects which are taken together to serve as a standard of reference in measuring the identity or activity of some (set of) object(s) (Woelfel and Fink, 1980: 53). There are several types of reference frames: (1) accidental (natural); (2) contrived (laboratory); and (3) the mathematical reference frame.

When the reference frame for experimental research differs across observers and/or time, a transformation is needed (objectivization principle). If the rules of transformation are not known, then the outcomes cannot avoid errors of interpretation affecting the validity of the experimental research. In order to avoid such problems, a mathematical reference frame is usually defined and constructed. It allows for the transformation of observations in one reference frame to another one in a general,
abstract manner (Woelfel and Fink, 1980: 55). A reference frame, once established, (Woelfel, 1980: 108) provides for a description of the cognitive processes. The definition of a concept is given by its location (position vector) within the reference frame. Changes in the meaning of any concept are modelled as changes in the location or position vector.

The operationalization of a multidimensional attitude change process comprises two phases:

- In the first phase, a reference frame is constructed. The aim of this phase is that of transforming the raw data by following the metric multidimensional scaling procedures.

- The second phase is based on the measurement of change as a motion in a multidimensional space. The ‘force’ paradigm is applied since the force aggregation theory has a formal similarity to Newtonian mechanics. The attitude domain comprises multiple objects (beliefs, attitudes). Any object is viewed like a physical object in a physical space: they have location and mass attributes.

The metric multidimensional scaling procedure for establishing the coordinate reference frame on a set of objects consists of the following steps (Woelfel and Fink, 1980: 66):

1. Identify the set of reference objects.
2. Set up the standard separation (standard measure), that is, the separation between the two elements of an arbitrary chosen pair of objects in the set.
3. Separation estimations for all pairs of the remaining objects; separations are estimated as ratios of the standard separation.
4. A matrix of distances is obtained and converted into a deviation matrix with origin at the centroid of all the points (Torgersen’s method) or at an arbitrary point (Young and Householder’s method).
5. The deviation matrix is converted into a matrix of scalar products.
6. The scalar products matrix is transformed into the matrix $R$ in which any concept $P$ is represented by a position vector $R_{p}^{\mu}$, where $\mu = 1,2,\ldots,r$ is a set of $r$ orthonormal vectors.

The cross-observer transformations (Woelfel, 1980: 105) consist of applying this procedure for obtaining the $R$ matrix. The transformations over time consist of applying rotations and translations for the comparison of time-ordered individual or aggregate coordinate frames (Woelfel, 1980: 106).

For a number $n$ of observers, the $R$ matrix ($n \times r$ matrix) will be obtained representing a non-Euclidean system of coordinates (Riemann manifold). As multidimensional attitude change is modelled as the overall outcome of the external forces exerted by the incoming messages, this procedure provides for the description of
their effect such that it can be measured (Woelfel and Fink, 1980: 155). Messages are represented as vectors in this space (Woelfel and Fink, 1980: 150). Concepts are represented as position vectors. Under the equal mass condition, each concept will converge on the centre of mass of the distribution of concepts. This means that the attitudes and beliefs of an individual actor are predicted by the average beliefs and attitudes indicated by the persons who are closer to that individual (i.e. these close persons are called ‘significant others’). An experiment focused on the measurement of political attitudes of elementary and high school actors showed that they were accurately predicted by the average political attitudes of the significant others (Woelfel and Fink, 1980: 153).

**Implementation**

*Galileo* is a complex commercial software platform which provides a multiple components package specialized in the measurement of cognitive processes and systems. It includes several generators of questionnaire patterns (automated and electronic questionnaire makers), a program for providing data entries and programs for text analysis.

*Galileo* includes neural network components for text analysis (CAPTAC).

For political attitude change measurements, *Galileo* includes programs used in electoral campaigns for generating electoral campaign strategies or for estimations of the vote percentages likely to be obtained by candidates (BALLOT).

**Web Resources**

*Galileo*

www.galileoco.com. Commercial site: includes a literature database, a technical documentation database and packages of software programs.

**References**


Part VI

POLITICAL COGNITION MODELLING

Information Processing, Affect and Cognition

For quite a long period of time during its century-long history, political attitude modelling research was dominated by the social influence paradigm. It was the Columbia group that, for the first time, introduced a modelling framework based on the concept of social influence which explained individual political attitudes toward the voting choice. Less than a decade later, the Michigan group (Campbell et al., 1960) and Converse’s work in political culture (1964) introduced new variables and a new model design. Social context and the interpersonal dyadic networks, heavily exploited by the Columbia model, were left aside in favour of other factors which might explain political judgment and behaviour, like political involvement and partisanship, policy position and ideological preferences. However, lacking the proper means to model the way people obtain and use political information in order to inform their voting choice, the issue of political judgment itself remained to be explained. Under pressure of strong criticism and also as a reaction to disappointing results, a model revision started in the mid-1960s. By the end of the 1980s, this turned into a whole paradigm revision enhanced by the new cognitive theoretical research in the areas of political preference, judgment and decision-making.

General Picture and Cognitive Background

With regard to political attitude modelling, we should note that Converse’s seminal work on beliefs in mass publics raised a historical challenge: How can political attitude instability be explained? It took more than half a century to find a proper answer to this question. It nevertheless remains an open question.

Two possible answers were provided by Achen (1975) and Zaller (1992). Each author found a different interpretation and elaborated a different model as an alternative to Converse’s. Achen’s model assumed political attitude stability. Zaller’s
model reinforced the idea that political attitudes are highly unstable and variable from one person to another. However, the explanations provided by each of them were contradictory and expressed, first and foremost, a paradigmatic difference. Achen’s explanation of the perceived political attitude instability was based on his view on attitudes measurement, while Zaller’s was based on a theory of cognition with a social-psychological background.

What came afterwards was a huge paradigmatic shift in the whole of political science experimental and analytical research from modelling based on social influence theories rooted in the social psychology of behaviour and persuasion, to modelling based on social and psychological theories of cognition.

As strongly involved in facing Converse’s historical challenge, interdisciplinary approaches in political and computer sciences joined a common research framework following a pattern already working in the social sciences at that time. Thus, political psychology, political cognition and political sociology, on the one hand, and computational modelling, artificial intelligence (AI), machine learning (ML) and artificial life (ALife), on the other hand, joined a common project on explaining the nature and sources of political attitude instability as had been observed by Converse (1964) in the survey data.

One of the points of hot debate was the instability of beliefs and political attitudes explained by Philip Converse as a direct effect of individual weak belief structure and as a side effect of low individual cognitive and educational resources (Converse, 1964: 47, 51). Looking from this perspective, the issue of political attitude instability represents the cornerstone of political attitude modelling research.

There have been two main cognitive approaches developed in political attitude modelling: (i) the Bayesian approach and (ii) the affect-based approach on motivated reasoning.

The Bayesian models (Achen, 1992; Gerber and Green, 1998) consider that individuals are sensitive and responsive to new information, but that each piece of information is added in the same way (i.e. objective way) to the memory of the individual. Thus, individual political attitude changes as a consequence of political information processing. Information is provided by media exposure processes such as the electoral campaign and/or interpersonal communication.

Stony Brook is one of the most remarkable schools which has fundamentally influenced the computational modelling of political attitudes by systematically constructing a political cognition theory and simulation models using various AI-based methodologies, like semantic networks, social networks, information processing and agent-based systems. The models elaborated by Milton Lodge and Charles Taber are based on motivated reasoning (Lodge and Taber, 2005) and assume that affect influences the processing of each new piece of information in ways (i.e., subjective ways) which modify political attitudes and beliefs or the social perceptions of candidates.

Other authors, like David Redlawsk and Richard Lau (Redlawsk, 2002, 2004; Redlawsk and Lau, 2005) developed a simulation model for hot cognition. The simulation platform, called Dynamic Process Tracing Environment (DPTE), is meant to emphasize and trace the dynamics of the processes underlying affect-based vote choice.
Other authors have approached information processing, affect and cognition in attributional models. The PASS Model (Kottonau and Pahl-Wostl, 2004) is a computational simulation system based on an agent-based information processing design which simulates the dynamics of political attitude strength as influenced by political psychological factors associated to electoral media exposure, electoral campaign activities of the political parties and interpersonal communication.

Political Attitude: The ‘Hot Potato’ of the 1960s

Whilst achieving the highest recognition during the 1960s, the attitude formation and voting behaviour model developed by Angus Campbell et al. (1960) in The American Voter as well as the mass beliefs model elaborated soon afterwards by Philip Converse (1964) faced a major challenge in explaining the serious ‘gap’ between theoretical design, assumptions and expectations with regard to the voting behaviour at individual and aggregate levels, on the one hand, and the real picture as seen through the lens of survey data, on the other hand.

As revealed by Converse’s (1964) conclusions drawn from survey and panel data, the picture of how the common American people justify their own voting choices was rather disappointing. Moreover, it proved troublesome. His conclusions focused on the apparent instability of common people’s political attitudes, their low cognitive capacities and poor ideological knowledge which they seemed to employ in making their voting choices. As Converse understood it, what was actually expected to be an informed voting choice proved to be quite an uninformed one. Moreover, all this appeared as a systematic feature of how voters react or justify their own choices in presidential campaigns: the correlations between the patterns of political involvement in the empirical data and the level and type of education were the only relevant ones (though not fully convincing) provided in the theoretical foundations of the model. Several key factors, like the low level of education, political involvement and the amount of political information finally converge to the idea that common people’s political beliefs lack structure, that is, a high level of political sophistication or conceptualization. The conclusions drawn from the analysis of empirical data revealed a large segment of the electorate missing coherent political attitudes and ideologically consistent political preferences and voting choices.

The first element of the model to be questioned was, of course, the variable selection. All this stimulated the revision of the model. The revision, provided almost two decades later by Nie et al. (1976, 1979) in The Changing American Voter, improved the variable selection, but the problem remained. Almost half a century later, Philip Converse himself remembered the moments of the rise and fall of their modelling paradigm, the hope and despair, the happiness and sadness experienced by the members of the famous Michigan team (Converse, 2006: 607).

One of the main questions of revision was that with regard to the survey design. Variable selection and measurement methodology have often been questioned by the authors themselves and by others, then and after. As a fundamental difference from
the earlier Columbia model based on social context and interpersonal dyadic communication, Campbell and co-workers introduced new variables which modelled political involvement and party identification, policy positions and ideological preferences of the individual citizens. While these variables model better the voting behaviour and explain the voting choices more adequately in the aggregate, they need themselves to be explained. After a thorough analysis of the survey data, Converse got an overall picture in which people’s attitude instability, weak beliefs and poor ideological backgrounds contrasted sharply with people’s ability to evaluate candidates, parties and policies and to be responsive to political messages during the campaign media communication: when asked, many voters did not remember relevant details about candidates or policies, and were unable to justify their ideological orientations. It was this particular dimension of the empirical findings which raised the issue of political judgment.

Another questioned issue was the unidimensionality of the model based on the left–right distribution of ideological preferences: both the model elaborated by Campbell et al. (1960) and the model elaborated by Converse (1964) held basically the idea of ‘one true’ ideological preference which might be identified as a point on a liberal–conservative continuum representation. The attitude constraint argument has long been subjected to critiques (Zaller, 1992). The attitude constraint view was based on the idea that political involvement and party identification expressed by the vote choice are associated with a unique ideological preference. Identifying the individual political attitude and/or belief as a point on the unidimensional ideological preference space (axis) meant actually identifying the individual attitude toward the candidate or party and, finally, their potential vote choice. Much later, new orientations in social and political psychology provided good reasons for abandoning the attitude constraint argument in favour of structural arguments concerning political attitudes and the ways in which they influence political behaviour. However, at that time, attitude constraint theory added more disturbing elements to the already complicated picture of the type of political judgment supposed to underlie the mass voting behaviour in Converse’s model. It fostered an orientation toward the theories of cognition expected to give the long-awaited answers on how people obtain and use political information, and how they use it in order to inform their voting choices.

Starting with Converse’s model, the issue of political attitude instability became a major concern. Achen (1992) suggested that political attitudes are more stable than presumed and their apparent instability is a measurement error whose roots should be searched for in the theory underlying the survey design. Later on, Zaller’s (1992) model gave the issue a completely new appeal by its association with the cognitive issues systematically approached in social psychology after the ‘cognitive revolution’: information processing, cognition and affect. Political psychology approaches embedded them in the new theories of political information processing, political judgment and political cognition. Rooted in the systematic critiques of rational choice-based approaches of political behaviour, the new theories built their background on considering affect at least as relevant (if not more!) as the rationality assumed to guide political behaviour. Modelling approaches on attitude instability seriously shook the social influence explanatory backgrounds of political attitude change, and determined
a major paradigmatic shift toward cognitive and affective factors. While social cognition theories appeared earlier and got increasing attention, interest and recognition, political cognition theories followed a much slower pace toward recognition (Sullivan et al., 2009). The most difficult aspect of this deep transformation was rather in accepting the evidence that affect actually plays a role in the construction of political judgment. It was hard to accept it against the two-millennia-old ancient Greek philosophical idea of rationality primacy in explaining the reasoning underlying human judgment.

Political Information Processing

We could say without exaggerating that, in modelling research, the issue of political attitude and belief instability represents a cornerstone. The modern and postmodern approaches to political attitude computational modelling and simulation actually start with the instability model of mass beliefs elaborated by Converse (1964). Equally praised and criticized during the past half century, this model has provided the most relevant research questions of the era:

- Do emotions influence our political thinking?
- What is the source of instability in political beliefs and attitudes?

Instability of political beliefs, as formulated by Philip Converse in his 1964 seminal work, has appeared from the very beginning more as a matter of individual cognitive and information processing capacities than a matter of social influence since it depends on the ways people acquire, retrieve, remember and use information to base their political judgment, behaviour and choices on. First formulated in Converse’s ‘black-and-white’ model of belief systems and political culture, both socialization (Campbell et al., 1960) and the attitude constraint (Converse, 1964) hypotheses started to ‘lose terrain’ when confronted with the request for explanatory power. With time, the latter prevailed, and the two theories made room for a strong revisionist trend.

Political socialization theory, intensively developed during the early 1950s and the 1960s, focused on the transmission of political preferences directly from parents to children and/or to other teenaged members of the family. The party preferences induced in the years of youth by family discussions and behaviour proved quite stable and resistant to change during adulthood. Their inertia, as well as their poor responsiveness to campaign communication, actually contradicted the idea that political attitudes have a genuine instability or that they prove sensitivity to social interaction and communication. Almost dead during the 1970s (Niemi and Hepburn, 1995), political socialization was revived during the 1990s along with the studies on the role emotions play in political learning (Nadeau et al., 1995).

The attitude constraint theory introduced by Converse (1964) experienced a similar fate. Dismissed by the New Look movement in cognitive psychology, and replaced by structural theories induced by the ‘cognitive revolution’, it could not make a comeback. Born within the view on ideology as an unstructured belief system proving instability due to internal structural and consistency weaknesses, attitude
constraint became old fashioned as soon as schema theory brought to the field different ideas with regard to the way attitudes are structured and the context in which they may gain stability.

In political attitude modelling research, the paradigmatic shift from social influence and rational choice theories toward cognitive ones was facilitated by the boost in social cognition theories, which dominated the 1970s. By the mid-1980s, a new trend had been generated in social attitude change research and sustained by social cognition orientation: dual-process theory won the ‘battle’ with the earlier structural counterpart in explaining attitude construction and change under persuasive pressure (Petty and Cacioppo, 1986). In regard to political science in general and political attitude modelling research in particular, affect studies actually flooded the social and political psychology scene and, after the 1990s, became the dominant paradigm in explaining political judgment and voting choice. Affect-based explanatory theories were preferred to rationality-based ones when modelling individual political behaviour. As Forgas and Eich (2012: 61) noted, affect-based explanations of attitude instability have been considered more often and more convincing than explanations which exclude affect.

The trend was heavily dependent on studies of information processing capacities and heuristics. This trend benefited from the artificial intelligence theories’ (AI) heritage. During the 1990s, the computational modelling of political information processing, political cognition and, in particular, political attitudes was considerably enhanced by the earlier research in artificial intelligence (AI), machine learning (ML) and knowledge representation (KR), not to mention the remarkable contributions to human cognition modelling, search heuristics and decision-making theory of some famous authors like Allen Newell and Herbert Simon (Newell, 1982, 1990; Simon, 1985). From this point of view, the Stony Brook School as the first school of computational modelling and first promoter of the idea of ‘computational political science’ has been the most noteworthy in exploiting this heritage in the development of computational modelling (Taber and Timpone, 1996).

Motivated Reasoning

Information processing was by far the subject which dominated computer science for more than a century. Starting with the 1970s, it has dominated cognitive orientation in social science research, and almost two decades later in political science as well (Redlawsk, 2004).

Much of the political attitude research in social psychology has been developed in the persuasion conceptual framework. However, social influence alone cannot explain the instability of political attitudes and beliefs. The processes of individual deliberation, political thinking and choice making are based on cognitive mechanisms and processes. Social or political persuasion phenomena depend heavily on how people acquire new information, how they combine old and new knowledge and how they use it in order to make judgments and choices. Moreover, thinking, judgment and choice are often influenced by emotional phenomena, like feelings, moods
or desires. Identifying their connections is not an easy task. However, these connections cannot be ignored as these phenomena influence each other in ways which could hardly be predicted. The ways in which their influence is exerted concern both cognition and memory processes. The processing of information could acquire certain affective valences depending on the emotional states of the individual. Information retrieval processes might be influenced by such affective contexts, which could facilitate (or not) the accessibility of memory-stored information.

The classic area for research into the roles cognition and affect play in information processing is cognitive dissonance theory (Festinger, 1957). The mechanism of cognitive dissonance is activated when the individual perceives or realizes that there is a difference between belief and reality. Dissonance reduction is aimed at diminishing this discomfort so the individual modifies a particular belief.

Research in social cognition and the psychology of cognition revealed that people are influenced in their judgment by affect, mood and feelings. The motivated reasoning paradigm is based on the hypothesis that human thinking is influenced by affect. Motivated reasoning involves several mechanisms and processes concerning memory, cognition and attitude construction and change.

Cognitive orientation in political attitude research has been dominated by the psychological and social psychological views that attitude change takes both central and peripheral routes of persuasion (Petty and Cacioppo, 1986), and attitude formation processes have a constructivist nature (Wilson and Hodges, 1992). Some models address the issues of memory-based processing (Zaller, 1992; Zaller and Feldman, 1992), while others address the affective priming effect (Fazio, 2001), and cognition modelling (Anderson, 1983, 1993; Anderson et al. 2004). In political psychology, the studies of affect in relation to political information processing included several areas like political decision-making and symbolic predispositions in political attitude formation (Sears, 1983: 83), candidate evaluation (Lavine et al., 1998), the importance of political attitude (Krosnick, 1990) and judgment formation (Lodge et al., 1989). Motivations could influence reasoning and modify the outcome of information processing by employing strategies of constructing, accessing and updating individual positions with respect to political issues. Motivated reasoning (Kunda, 1990) is a paradigm of acquiring positions on a set of biased cognitive processes which enhance the yield desired instead of objective conclusions in given situations or towards particular objects (ideas or persons).

The role of affect in political attitude formation and change has been studied systematically at Stony Brook. Their remarkable contribution came in the 1990s and concerned the modelling of online political information processing (Lodge et al., 1995). Later on, it was integrated with a memory-based model inspired by the ‘Adaptive Control of Thought – Rational’ (ACT-R) model (Anderson et al., 2004) and has been applied to scenarios of presidential elections (Kim et al., 2009, 2010). The John Q. Public (JQP) model uses the motivated reasoning paradigm to prove that political attitudes are persistent, responsive to electoral communication and could get an increasing degree of polarization due to emotional influence. This research combines theories of political cognition, political judgment and decision-making (i.e. voting choice) with political information processing.
As regards the modelling of political information processing, from a computational modelling point of view, the *JQP Model* is based on semantic associative networks and includes knowledge structures, as well as the mechanisms and processes for knowledge storage, retrieval and update. *JQP Model* combine online (Lodge *et al*., 1995) and memory-based information processing models and theories (Zaller, 1992; Zaller and Feldman, 1992; Tourangeau *et al*., 2000).

As regards the mechanisms and processes of political cognition, from a political psychology theoretical point of view, the *JQP Model* is based on the dual-process modelling framework (Petty and Cacioppo, 1986; Wilson and Hodges, 1992). It approaches political attitude formation and change and political judgment in the motivated reasoning paradigm by including the conceptual and operational premises for working with several cognitive mechanisms, like memory modularity, spread of activation, affect priming, attitude accessibility, affective congruence and hot cognition.

Following the early model of motivated reasoning (Kunda, 1990) and the models of political judgment and vote choice (Redlawsk, 2002, 2004; Redlawsk and Lau, 2005) with complex backgrounds in both cognitive and emotional-biased processes of judgment, Lodge and Taber used the concept of *hot cognition* in modelling political cognition, judgment and information processing (Lodge and Taber, 2007: 35). The model introduced by Lodge and Taber is a good example of what McGuire (1993) foresaw in the emotion-based approach to political attitude modelling.
12

The JQP Model

Political Cognition and Political Judgment in Political Attitude Change

Much of the 1960s’ classical approach on political attitude change was based on memory-use psychological theories and on political culture theories, which explain the voting behaviour of common people by their poor cognitive capacities. This approach has been challenged by new memory-use models, the structural models of attitude change and the influence of mass media and communication theories on political attitude change.

The prevalence of memory-based modelling in political attitude change research has long been supported by theories which model the memory as a ‘library’ where information is stored and retrieved.

The rational voter is a model of full information, full access to memory and information, and full knowledge of context, goals and choice alternatives. Classical models of political behaviour are memory-based models (Price and Zaller, 1993). Political knowledge of the democratic citizen is often described by memory-stored knowledge (Berelson, 1952; Berelson, et al., 1954).

Following the seminal work of Herbert Simon (1972) on bounded rationality, the rational voter model has been replaced with the bounded rational voter who is able to recall only a limited volume of knowledge. This kind of voter is influenced by the mass media news, is not able to remember everything and his knowledge is not error free.

Early research on the issue of remembering (Bartlett, 1932), memory store and recall of information, and its impact on opinion change in persuasion scenarios.
(Watts and McGuire, 1964) revealed that people forget the content of a (persuasive) message, but recollect the affective impression which induced their opinion change.

Kelley and Mirer (1974) developed a model of the dynamics of political attitude change which is based on the idea that people make their voting choices on likes and dislikes in the candidate evaluations.

Graber reports on experimental and theoretical research on the impact of presidential campaigns on political attitude change: he shows that the information base might be forgotten, while the person remembers only the conclusions, especially if they have a strong affective component (Graber, 1984: 73). As Graber explains, these theories advance the idea that the relationship between political information (i.e. campaign message) and political judgment and choice (i.e. voting) is not based on the classical memory-based model of information processing (i.e. recall), but on the online model of information processing – an idea rooted in the earlier theories developed by Anderson’s IIT model (Hastie and Park, 1986; Hastie and Pennington, 1989; Anderson, 1991) and theories of political information processing (Lodge et al., 1989).

The JQP model is a formal model of individual behaviour which explains the relatively easy changes in political attitudes. The JQP model has been compared with Bayesian learning models of political thinking and belief revision (Achen, 1992, 2002; Gerber and Green, 1998; Steenbergen, 2002; Tetlock, 2005). The mathematical modelling approaches of political attitude formation and change which are based on Bayesian models of processing (learning) of new information take into consideration the party identification of each citizen actor. Party identification influences the evaluation of candidates as the citizen actor is exposed to new information. Achen (1992) and Gerber and Green (1998) are models based on Bayesian learning of political attitudes: political attitudes are updated as new information is processed. The citizen actor is considered a rational actor. The models can explain persistence and responsiveness of political attitudes, but cannot give an account of the polarization of learned political attitudes.

**Conceptual Model**

JQP is a computational model of political attitudes and belief formation and change which includes political communication, political information processing and political cognition. The model explains political attitude instability, polarization and change phenomena by several mechanisms which make emotions play a relevant role in the processing of political information, and in the formation and change of political attitudes.

The JQP model is inspired (Kim et al., 2010) by John Anderson’s cognitive theory and the cognitive architecture known as the ACT-R model of cognition (Anderson, 1983, 1993). Rooted in the AI classic works of Allen Newell (1982, 1990), the cognitive model elaborated by Anderson is based on the cognitive mechanism of motivated reasoning and the role affect plays in attitude and belief formation, information processing and learning.
In their JQP model, Milton Lodge and Charles Taber introduced a dual-process model underlying political reasoning, cognition and deliberation. The key postulates of the model are the *automaticity, hot cognition, primacy of affect* and *online processing* (Lodge and Taber, 2007: 3–9). On this cognitive basis, the JQP model introduces cognitive and affect-based evaluation mechanisms which are employed in political information processing. JQP includes political judgment modelling and explains political attitude change in terms of *responsiveness, persistence* and *polarization* phenomena in candidate evaluations (Kim, 2009: 118).

The theoretical background of the model includes both memory-based and constructivist theories of information processing.

**Knowledge Structure and Political Attitude Representation**

The JQP modelling approach assumes the four ACT-R axioms (Anderson et al., 2004): (A1) the human cognitive system is modular, (A2) the human cognitive mechanism is adaptive and efficient, (A3) information processing combines parallel and serial processes and (A4) human long-term memory can be modelled as an associative network.

However, axioms A5, A6 and A7 make the JQP model particularly relevant for the role affect plays in candidate evaluation. The A5 axiom states that all objects represented in the memory are affectively charged (‘hot cognition’), and their positive and negative charges (‘likes’ and ‘dislikes’) play the effective role in retrieval mechanisms and processes. This concept was initially defined by Abelson (1963) and redefined by Lodge and Taber (2005) in their ‘primacy of affect’ hypothesis underlying the conceptual model of political attitude formation and change in the candidate evaluation process.

The axiom of the primacy of affect (A6) is inspired by earlier research on the role of affect in cognitive processes (Zajonc, 1980) as a characteristic of social interaction processes. The idea was emphasized even earlier by Heider (1958), who theorized that social interaction processes were dominated by affect.

The axiom of affective congruency (A7) states that the congruency between objects which are already stored in the memory and the processed information increases the accessibility of the memory-stored items.

**Political Information Processing**

The JQP model assumes that the voter agent processes political information by means of two memory modules: the long-term memory (LTM) and the short-term memory (working memory, WM), which is used as a temporary buffer for the recalled items from the LTM. The memory modules have different structures and are operated by different mechanisms: the LTM is an associative network which connects knowledge and attitudes, while the WM contains LTM-retrieved (accessible) entities.

Political attitudes have a constructive nature: they are constructed by means of memory retrieval mechanisms and processes. Political attitudes are continuously updated under informational input by cognitive association mechanisms.
The associative network consists of a set of nodes (objects) linked by connections of various strength. In a detailed example concerning George W. Bush as one of the electoral candidates in the 2004 US presidential campaign (Kim, 2009: 106, Figure 1), the candidate is represented as a ‘node’ (object) in an associative network in which it is connected with other nodes (objects) representing a candidate’s relevant attributes, like political ideology, party membership or party preference, personal features like personal charisma, moral attributes, type of public speech and type of rhetoric, positions toward relevant political issues, like tax cuts, gun control, death penalty or abortion rights, and other characteristics which might prove relevant in a candidate evaluation in a certain electoral campaign. Each object in this associative network representation has an operational structure in which the values of each structural element are calculated as depending on their accessibility, their connections to other nodes and input information (i.e. political messages of the candidate, media communications with respect to each candidate in the presidential race, etc.).

Accessibility of objects in the LTM is the key concept for understanding how JQP works: the accessibility of the objects in the LTM is functionally dependent on the criteria comprised mainly by axioms A1–A4. These criteria mainly regard (a) the frequency of retrieval requests, (b) the connectedness of the objects, (c) the spread of activation between the objects during information processing, (d) the affective congruency between stored and processed information and (e) forgetting effects. The most relevant for JQP is the affective congruency axiom, which is further associated with the axiom of the ‘primacy of affect’, making the congruence between stored knowledge and currently processed information a condition for the degree of accessibility to the memory. This emphasizes the role played by the affect primacy and affective congruency in retrieving objects which elicit the same affective responses in both previous and current experience and information processing. This also explains the persistence of attitudes and their polarization, which is enhanced by affective charges.

Mechanisms

The theories which provided for the modelling of affect in political information processing concern the priming and accessibility mechanisms and processes.

The priming effect has been used for its implications in the spreading of activation. Attitude accessibility is a cognitive mechanism which influences the retrieval of certain pieces of information/knowledge which have been previously stored in memory. The information is associated with affective valences which facilitate retrieval.

Attitude Accessibility

The memory activation mechanism enables the model to determine the level of accessibility of the concepts in the LTM as well as the items in the WM. This mechanism has been defined in the cognitive architecture of the ACT-R model and used in
the JQP model as a means to make effective the access to memory-stored objects represented as nodes of an associative network. The JQP model thus employs a classic mechanism of spread of activation, which explains how nodes are activated in an associative network. As a difference from the ACT-R cognitive architecture, which is founded on the rationality principle, the JQP model includes an affective dimension in the accessibility mechanism design. It therefore combines the mechanisms of node activation and the spread of activation in an associative network with a new mechanism: affective congruence. Affective congruence and the primacy of affect as formulated in axioms A6 and A7 (Kim, 2009: 107) are two basic mechanisms which make effective the role of affect in activating and accessing memory-stored objects and the decisive role played by the degree of congruence between a node and the new (incoming) information. Affective congruence provides the basic means for achieving an evaluative process in which affect, prior to conscious rational criteria, guides access to the memory objects (nodes). Accessibility is defined as being dependent on three components: (i) the basic activation, which cumulates the effect of frequency of past accesses to an object $i$, (ii) the influence exerted by the nodes connected to object $i$, which is propagated by the spread of activation from the connected nodes to the node $I$, and (iii) the influence of incoming (new) information, whose degree of affective congruence is evaluated with respect to the information already associated with the object $i$. This concerns a classic principle which says that people are prone to accept new information as it comes to confirm their former attitudes toward an object and reject it if it is contradicting their previously held attitudes. As a consequence, people attach a particular valence (‘like’/‘dislike’) to an object, which is updated as they receive and accept new information.

The activation mechanism models the process of human recall: it relates the accessibility of the (constructed) attitude toward object $i$ to both rational aspects, like past activation and spread of activation, and emotional aspects, evaluated by means of the affective congruency mechanism.

The accessibility of any object in the memory depends on the object representation in the memory, which facilitates an operational description based on three cumulative processes: node activation, connection strength updating and valence association (Figure 12.1).

The first process describes the level of basic activation of the node $i$, which cumulates effects of frequency of past access and forgetting. The second process describes the spread of activation between node $i$ and any other node $j$ and the effect on the strength of the connection between nodes $i$ and $j$. Finally, a process of evaluating the degree of affective congruency between one object (node $i$) and any other object in the memory (node $j$) or between an object $i$ and input information.

**Political Attitude Construction**

The affective mechanisms enable JQP to represent and make the motivated reasoning effective. They provide for the persistence and responsiveness of political attitudes in the political online information processing and political cognition processes. JQP introduces one new axiom to account for this situation.
Axiom A8 concerns attitude construction and states that political attitudes are constructed by integrating affectively charged summary evaluations with memory-based object representation. The construction process averages the weighted accessibility-based evaluations of the attitude object provided by each evaluative link (Kim, 2009: 109–110).

Attitude construction is operationally achieved by cumulating effects of object in the memory and effects of online affectively charged evaluations based on input information with regard to a particular object. At a given moment of time, attitude construction depends, therefore, on the object accessibility information as provided by the LTM. It also depends on the influence of input information on the previous values of the attitude construct. This influence results in modifications of the valence associated with objects, described as an affectively online evaluation process (Figure 12.2).

**Online Model of Political Attitude Formation and Change**

Axiom A9 (Kim, 2009: 110) concerns the online model of political cognition (Lodge and Stroh, 1993; Lodge et al., 1995), which gives an account of the way in which attitude construction depends on the affective evaluation of input information. The online model of political cognition states that the evaluations of objects are continuously updated by incoming information and are influenced by the accessibility of objects in the LTM.
Summary evaluations (running tally) of the attitude object depend on the old evaluations, the previous value of constructed attitude and the accessibility of node $i$ (Figure 12.3).

The online (ol) model of the responsive voter (Lodge and Stroh, 1993; Lodge et al., 1995) starts from the basic idea that the common voter acts as a bounded rationalist, simplifying the political judgment by drawing only the relevant elements from the campaign information (see Figure 12.4).
The mechanism, called the ‘affect integrator’ (Lodge et al., 1995: 311), can be described as follows:

- **Step 1** *(summary construction)*: extracts the affective value and associates it with each candidate in a summary evaluation called the ‘running tally’ (Lodge et al., 1995: 310); the affective value of the candidate information is memorandumized as a summary of campaign information.

- **Step 2** *(memory-stored affective value association mechanism)*: the affective value is memorized, while the justification of the affective value-based relationship is (usually) forgotten, so that the voter recalls only their affective impression about the candidate and not the justification of this impression.

- **Step 3** *(integrating the affective value of political information in the object evaluation)*: when the voter is performing a political judgment or makes a voting choice which consists of selecting a candidate based on previous campaign information, they will only remember the summary information; the affective value of the political information is integrated into the candidate evaluation and it is used as support for the voting choice.

The computational model elaborated by Kim et al. (2010) is a political cognition model based on cognitive and affective mechanisms for describing how the voter reacts to political information, how it processes political information and how it is influenced by the exposure to media. It includes both online and memory-based modelling principles.
Operational Model and Simulation

The set of cognitive mechanisms described at the conceptual level of the JQP model triggers and guides the model’s dynamic processes described at the operational level. The dynamic processes concern (i) the accessibility of an object in the associative network representing the LTM, (ii) the construction of attitude toward an object and (iii) the online construction and updating of the object’s affect-based evaluation and the integration of the new attitude value with the prior one.

The simulations are performed with a set of parameters which are systematically varied so that political attitude formation and change phenomena can be observed. The parameters involved (Kim, 2009: 111) are: $\gamma$, the parameter which controls the degree of relevance of the affective congruence in the accessibility evaluation and update; $\delta$, a control parameter of the influence over the evaluative tag (valence) associated with a given object $i$ exerted by the information provided by the spreading of activation from the objects linked to a given object $i$; and $\rho$, the control parameter over the relevance of the incoming information compared with that of the prior information.

The online processing model ensures that no prior memory-based information counts in the constructed attitude: $\gamma > 0$ (affective priming is effective; affective congruence matters); $\delta = 0$ (attitude depends solely on valence); $\rho > 0$ (online evaluation only; attitude is updated online only).

The memory-based processing model ensures that only memory-based information counts in the constructed attitude: $\gamma = 0$ (no affective priming; affective congruence does not matter); $\delta = 1$ (attitude depends solely on memory-stored information); also $\delta > 0$ (the more recent the accessed/newly arrived information, the more it counts).

The JQP actually addresses the case of hybrid models in which both memory-based and online processing of information are relevant. For this class of models, the values of the parameters are those within the shaded area in Figure 12.5.

Figure 12.5 Parameter values for memory-based, online and hybrid processing models.
Simulation experiments prove that political judgment and voter choice are influenced by motivated reasoning mechanisms. The empirical data concern the 2000 US presidential elections as provided by the National Annenberg Election Survey. The experiments included several phases.

In the first phase, five ideological groups were designed using a set of relevant characteristics: conservative and strong-conservatives, moderates, liberals and strong-liberals (Figure 12.6).

In the second phase, campaign information about candidates was presented to a set of agents in each ideological group (Figure 12.7). Both the content and order of presentation were taken as relevant parameters of the experiments. Each agent constructed evaluations of each candidate. These evaluations defined the agent’s political attitude toward a candidate. The knowledge representation for each agent included an LTM (associative network of objects representing candidates and their

Figure 12.6 Ideological groups.

Figure 12.7 Campaign information about two candidates is presented to a set of agents belonging to different ideological groups.
attributes) and a WM, which facilitated the study of the online processing of campaign information.

The simulations concerned three types of experiments: memory-based models only, online models only and hybrid models. With regard to the hybrid processing models, the JQP performances prove that political attitude formation and change processes are influenced by both rational choice and affective processes.

The simulation results concerned the dynamics of the evaluations performed by the agents in each ideological group as informed by each type of influence exerted by the campaign information under various parameter combinations (Kim, 2009: 116).

The simulation results were compared with the empirical survey results, which revealed that the simulation results emphasize the role played by the mechanisms of affect priming and motivated reasoning in political attitude construction: agents’ constructed attitudes include affect-based elements (valences) which, once memorized, controlled the subsequent candidate evaluations.

Web Resources


National Annenberg Election Survey (Annenberg Public Policy Center at the University of Pennsylvania): http://www.annenbergpublicpolicycenter.org/political-communication/naes/

References


Political Attitude Strength Simulation Modelling

Attribute-Based Modelling of Political Attitudes

The attributes of attitude have been used to explain and predict behaviour. Two main attributes have been studied: strength and stability. Both the attribute of strength and that of stability are studied as latent constructs; as their measurement is not directly possible, they are evaluated by means of their own observable (measurable) attributes.

Attitude formation, dissemination and change have been modelled in various paradigms as explicit or implicit expressions of opinions, preferences or issue positions: social and political attitude change (Nowak et al., 1990; Latané et al., 1994; Huckfeldt et al., 2004), political attitude change (Kim et al., 2010), opinion formation and dynamics (Hegselmann et al., 1996, 2000), preference formation and change (Regenwetter et al., 1999), the emergence of social attributes in the self-structure (Nowak et al., 2000), the spread of opinions and attitudes in large populations of agents (Jager and Amblard, 2004) or simulation models of social influence (Mosler and Brucks, 2001).

Some of these computational and simulation models approach the attributes of attitudes, like extremity (Latané et al., 1994), strength and direction (Huckfeldt et al., 2004; Kim et al., 2010). As one of the first attempts to model the emergent phenomena characterizing attitudes’ extreme sensitivity to social influence, Latané’s approach based on catastrophe theory has, ever since, kept the door open for further developments of attitude change chaos-based modelling. While still widely open, this door has not been knocked on by many. The reasons are mainly concerned with the kind of conceptual and operational definition used for describing an attitude change and its power to formally express the social influence as felt by a single
individual from the interactions with other individuals, or as (simultaneously) felt by multiple individuals interacting amongst them. The chaotic model of attitude extremity takes into consideration as a main variable the personal involvement of the individual subject with respect to the object of attitude. Social impact is therefore combined with qualitative aspects of the individual attitude change. A distinctive characteristic of this model is the nonlinearity of the process of attitude change. The cusp model helps identify how sensitive the individual response is to both space and time factors, and to the personal involvement factor.

Other models approach the attributes of attitudes, like strength and direction (Huckfeldt et al., 2004; Kim et al., 2010), as rather a type of attitude representation or codification necessary to simplify the structural modelling of attitude change. Many of the aforementioned models approach the formal aspects of structural attitude change in social influence processes and interaction networks. In these models, the contents of attitudes are not actually manipulated, but formally approximated by distributions of attitude attributes’ numerical values.

There are also models which provide for an attributional approach to political attitude change and explain the attitude’s overall dynamics by addressing attitudes’ content (Van Harreveld and Van der Pligt, 2004; Van Harreveld et al., 2004). One such model addresses attitudes’ attributes, like extremity, and explains them by means of the relationship between political attitude and two other factors enhancing high attitude variability and fast change, namely information processing and political involvement (Latané and Nowak, 1994; Latané et al., 1994; Liu and Latané, 1998).

The PASS Model

The Political Attitude Strength Simulation (PASS) model (Kottonau, 2002; Kottonau and Pahl-Wostl, 2004) is unique: it is the only model which approaches political attitude change during an electoral campaign by modelling the attitude’s strength in terms of the variability and change dynamics of strength’s attributes. It is also unique in trying to model the micro–macro link in terms of the relationship between social and individual aspects in attitude change phenomena. One of the first models to approach this issue was the Abelson and Bernstein model (1963). The model combines an impersonal dimension of attitude formation and change (by campaign media communication) and an interpersonal dimension (by means of individual interactions in social networks).

The PASS Model is based on the political attitude strength construct which is employed in explanation and prediction of political behaviour of citizens during electoral campaigns and on voting day. It is a computational model which has a strong simulation component aimed at reproducing, in a believable way, an electoral campaign in which the agents – namely, parties, candidates, media agents and citizens – communicate and interact in social networks. As new political evidence becomes effective for the individual agents, it modifies their attitudes’ strength and, eventually, changes their attitudes and behaviours.

Strength, as well as the attitude itself, is a latent construct. Strength’s definition is based on those attributes which can be measured and for which a measure is or can be defined.
In the **PASS Model**, political attitude strength is (indirectly) defined in terms of (i) measurable components and (ii) consequences.

The **PASS Model** provides for the definition of attitude’s strength in attributional terms. Such terms need to be measurable and play a relevant role in emphasizing (i) the sources of attitude change, (ii) the mental structures and the cognitive mechanisms and processes which underlie the formation and change of attitude strength’s attributes and (iii) the consequences of change which could be considered as predictors of attitude change, and also as predictors of the dynamics of the attitude–behaviour relationship.

The **PASS Model** defines and models the strength of attitude in terms of strength’s attributes: **extremity**, **consistency** and **importance**. The values these measurable components could take are different for various degrees (values) of strength, thus making quantitatively evident how ‘strength’ models the overall variability of attitudes. The range of strength’s degrees goes between ‘strong’ and ‘weak’. Consequently, political attitudes have extremity values which go from ‘high’ to ‘low’, and can be evaluated on a scale of **intensity** values. An attitude’s strength has the attribute of **consistency**, and can thus be evaluated on a scale of **ambivalence** values. A political attitude might have both a positive and a negative valence or, to put it in other words, agents might say that they both like and dislike something with regard to a candidate, party or political message. On such an ambivalence scale, low ambivalence would mean high consistency of a political attitude. Finally, strong political attitudes are assumed to be important to the agent, where the **importance** attribute is defined in degrees of political involvement. Weak political attitudes have low extremity value and low consistency, that is, they are ambivalent, and are not important for the agent, meaning that the agent is not politically involved in a particular political issue and/or candidate, party or in some political activity which is characteristic of an electoral campaign.

A computational simulation model is built up in order to describe the processes of political attitude strength formation and change, which is further used in achieving a dynamic description of political attitude change, and also a prediction on the number of voters/non-voters and certain/uncertain citizens (Kottonau, 2002: 58).

**Conceptual Aspects**

The model has two main levels: social and cognitive. At the social level, the model defines the agents and the social processes. At the cognitive level, the model defines and operates the processes which induce a political attitude change in an individual agent.

**Social Level of the PASS Model**

The social level is characterized by three types of agents: (i) the agents which are in charge of a particular party’s electoral campaign strategies, (ii) the agents which represent the mass media (media groups, etc.), and (iii) the citizens. There are two types of communication processes: in the electoral campaign communication process, the citizen agents receive messages transmitted by the party electoral
campaign strategists and also by the mass media, which represent external sources of persuasive political messages. The citizen agents can also communicate in their interpersonal social networks, which represent inter-agent sources of persuasive political messages. The electoral campaign is represented as a virtual political scene on which the electoral campaign agents (i.e. parties’ electoral campaign strategists and the mass media agents) compete to persuade citizens to vote for one political party or another, or for one candidate or another. Two political parties are described as competing to change the political attitudes of the citizens.

Basic assumptions regard (i) the citizens, who are supposed to have a minimal degree of political involvement, (ii) the number of competing political parties, assumed to be limited to two, (iii) the electoral campaign strategists, who are supposed to be independent of their competitor strategists and (iv) the resources (budget and baseline campaign activities), which are supposed to be identical for each political party participating in the electoral campaign.

The general experimental setup consists of a competition process between the electoral campaign strategists of each political party: each campaign strategy team makes decisions with regard to the amount of accumulated resources in a particular period of time before the voting day so that their party wins the elections. Electoral campaign strategists, regardless of their political team or mass media group membership, issue persuasive campaign messages which are perceived by the citizen agents (message perception processes). The competition concerns the message perception capacity of the persuaded citizen agents, which depends on the number of perceived mass media messages as well as on the spread of political attitudes in the interpersonal networks by individual interaction (discussions). The model explains how the citizen agents may be persuaded to cast their vote, and also how the political parties should manage their campaign resources and the duration of campaign activities so as to ensure a win on voting day.

Communication processes are (i) message perception and (ii) citizens’ communication.

Voting behaviour depends on the strength with which an individual citizen agent holds a political attitude. The strength is evaluated by quantitative measures of the agent’s degree of political involvement (importance), the political attitude’s level of consistency (ambivalence) and the degree of extremity (intensity).

Cognitive Level of the PASS Agent

The citizen agent is defined as a bounded rational agent. The bounded rationality (Simon, 1972) of the individual citizen agent is achieved from two constraints on their cognitive capacity. The citizen agent is only partly knowledgeable of the electoral campaign information. In addition, political information processing is assumed to be biased in various ways: limited memory availability of political attitude and attitudinal objects’ knowledge due to forgetting factors, selectivity in the interpersonal communications due to homophilic tendencies in the individual interactions and to the homogeneity factor in the social networks (Kottonau, 2002: 45; Kottonau and Pahl-Wostl, 2004).
Cognitive Mechanisms and Processes

The design of the cognitive level, including cognitive mechanisms and processes, is inspired from two major models, the RAS model (Zaller, 1992) and the JQP model (Lodge and Taber, 2005; Kim et al., 2009; Kim et al., 2010), as well as from dual-process modelling (Tourangeau, 1992; Wilson and Hodges, 1992) and mental accounting research (Henderson and Peterson, 1992). To this cognitive model architecture a new component is added for the complex evaluation of the strength of an individual political attitude.

The conceptual basis of the message perception at the individual agent cognitive level is the idea of separate mindsets for an individual agent’s involvement during the electoral campaign (motivated cognition), and the organization of an agent’s memory into judgmental separate accounts (positive and negative) of the target political party. The political attitude is thus divided into separate accounts for each competitor party. During political information processing, new evidence is associated by the individual agent with one of these accounts depending on the valence the agent associates with each of them. The individual agent perceives more of the mass media messages and eventually increases their interactions with other agents in the interpersonal networks, thus sharing with the other agents attitudinal structural elements which could reinforce or weaken a particular attitude by strengthening or weakening its strength attributes (importance, ambivalence and extremity).

At the individual agent’s perceptive level, the PASS Model works with original perceived messages. From the entire persuasive message, the individual agent actually extracts a relevant part, called the persuasive message extract, PME (Kottonau, 2002: 49). An individual citizen agent is supposed to evaluate a message using two keys: the affective tag of the original message and the credibility of the source. The PME is supposed to combine these two attributes for each perceived message. If persuasion is successful, then the PME’s evaluation finally results in a political attitude change at the individual citizen level.

The procedure (Kottonau, 2002: 51–59) is performed in several steps, each step employing a separate formalism for describing the integration of the PME information into the agent’s memory and the strength’s attribute which is evaluated.

The first step consists of updating the PME accessibility in the individual agent’s memory. The accessibility depends on the agent’s degree of political involvement and also on the quality of its memory: the accessibility increases with an increased involvement of the agent in a particular political issue. However, this step aims at operationalizing the theoretical situation of information availability and accessibility at both the conscious and subconscious levels.

The second step is concerned with the updating of PME credibility, a process which addresses the confirmation bias of new information processing. The credibility of any new message may increase or decrease, depending on the affective tag which is attached to any new message. This affective tag could be similar (or not) or identical (or not) to the valence of the political attitude acquired in previous information processing steps.

The third step consists of the updating of the individual agent’s level of involvement, which depends on the number and frequency of perceived messages.
The fourth step revises accordingly the attitude valence and the political attitude extremity by updating the individual agent’s response intensity and valence.

The fifth step revises the political attitude’s ambivalence, which is essential for a political attitude change. The ambivalence is re-evaluated on a response intensity basis as recommended in Thompson and Zana’s (1995) approach on the role of ambivalence in evaluating social attitude strength.

Once all its attributes and their operational measures have been updated during political information processing, the sixth step revises the attitude strength itself in the light of newly acquired evidence. The value of the attitude strength is calculated as the product of three factors: degree of involvement, attitude consistency and attitude extremity, as calculated in the previous steps.

The final step is aimed at testing the attitude certainty, which is sensitive to the time factor and provides useful insight with regard to the proportion of decided and undecided agents (voters) in the population of individual citizen agents.

Simulation Aspects

The PASS Model operates a social network with 100 agents representing citizens who are the targets of an electoral campaign. The simulation (Kottonau and Pahl-Wostl, 2004) achieves interesting and believable dynamics of each attribute involved in the evaluation of attitude strength and finally in attitude change. The degree of complexity of this approach is quite remarkable as it works with 100 individual citizen agents in both a social setting (communication processes in the electoral campaign) and a cognitive internal setting (mindsets, associativity and accessibility of memory attitudinal elements and objects, online information processing, comparison and update of various factors, like affective tags, attitude valences, etc.). This sophistication makes the model get blocked when it includes a high number of individual agents, which might indicate that a new technology of agent-based modelling is needed.

Applicability

The simulation model proves useful in two main research directions. It is among the few models which are based on an attitude’s attribution descriptions and the dynamics of their interrelationships. Its complexity, though difficult to tackle with the current simulation modelling technologies, could stimulate and reinforce the theoretical approaches of both political cognition and technology of cognitive processes simulation in large heterogeneous populations of agents.

The other research direction is the design, analysis and optimization of advertising strategies in political campaigns, which really needs a reinforcing approach.

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Cambridge.
Political Attitude and Other Approaches on Ideology: A Brief Review

Computational and simulation modelling research on political ideologies has evolved from measurement concerns to cognitive and complexity-oriented approaches. While the former were rooted in the debate on stability of political attitudes and beliefs in mass electorates as initially formulated by Converse (1964) and further argued by Achen (1975) and Zaller (1992), the latter were rooted in the debates on the role of ideology in social and political change. It is this latter orientation of research which interests our presentation of computational modelling of ideologies. Though it is based on political attitudes, it has induced two types of complexity-based modelling approaches: (a) those targeting phenomena of social structure emergence and (b) those targeting phenomena of political order emergence; combinations of these two approaches are often targeted. The modelling approaches in the former class of phenomena have been generated by the definitional and theoretical approaches of ideologies as complex combinations of attitudes toward social and political major issues. The models in the latter class have been generated by the dynamic modelling approaches on ideology change.

This part presents some of the most relevant ideology computational and simulation modelling approaches which are based on political attitudes. Ideology computational modelling employs methods for approaching complex phenomena like emergence of structure and/or order, and self-organization processes like clustering of political attitudes and polarization of ideology.
Ideology has been defined and modelled as a cluster of attitudes (Campbell et al., 1960), belief systems (Converse, 1964: 2–3), systems of attitudes viewed as structures organized on multiple dimensions (McGuire, 1989: 49) and organized attitudes, beliefs and values (Rokeach, 1968, 1973). These conceptual backgrounds have induced a development of ideology modelling approaches based on structures of political attitudes and beliefs and their variation in electoral communication campaigns. This type of modelling approach has often assumed a political culture perspective over ideology.

On the other hand, ideology has been defined and modelled as belief systems about social and political order (Parsons, 1951; Campbell et al., 1960; Kerlinger, 1984; Erikson and Tedin, 2003; Jost et al., 2009a), institutional aspects included (Denzau and North, 1994). In their comprehensive review of literature on the ideology theory and ideology formation and change modelling, Jost et al. (2009a) provided a synthesis of the traditional definitional and conceptual frameworks as well as the new trends emphasized by the qualitative models in this area. Their approach is relevant from a theoretical perspective, which succeeds in covering the major problems and orientations in the ideology theory on political, psychological and social science backgrounds. The major developments they identified at the theoretical level are relevant for modelling theory as well, explaining the main type of approaches in this respect.

A similar approach, but from a different perspective, was elaborated by Homer-Dixon et al. (2013), who made a synthesis of the modelling paradigms and trends in ideology research which cover more or less the same time interval. Their approach is mainly methodological and emphasizes the modelling approaches which have employed computational and simulation technologies in their conceptual and methodological modelling designs. They identify a spread of focus on multiple, though narrow, aspects of ideology modelling based on computational and simulation technologies, thus providing arguments toward their own strategy of developing an integrative modelling approach on ideology. As computational and simulation technologies have advanced incredibly fast during the past three to four decades, the conclusion they draw regarding the cleavages induced by these technological developments fully justify their approach. Two reasons may have induced a trend toward the specialization in ‘niche’ issues within modelling theory and methodology research:

• On the one hand, as Homer-Dixon et al. (2013) described it from a methodological perspective, ideology modelling research has emphasized two major types of cleavages: spatial versus non-spatial, and individual versus social.

• On the other hand, following the cleavages which have deepened at the modelling theoretical level, modelling research methodology has itself been divided into several classes of approaches. Moreover, the lack of computational instruments for the study of complex issues, like ideologies, has induced an increase in the number of approaches in almost all paradigms of computational and simulation modelling: spatial, cognitive, social networks, agent-based models, artificial societies and complex adaptive systems.
Definitional Frameworks in Ideology Modelling

By employing different concepts and basic assumptions, the definitional approaches to ideology have induced in the ideology modelling research choices for various types of paradigms revealing the social, cognitive or psychological dimensions and perspectives of analysis. Schematically, a brief dichotomy-based description would best describe the ideology modelling typologies from a paradigmatic point of view. Ideology modelling research has been founded on the classic conceptual dichotomies which have marked its various definitional approaches: left versus right, individual versus group and cognitive versus social.

The left–right model of ideology has inspired not only the spatial modelling approaches, but also various other models which view ideology as combining social, cognitive and psychological dimensions as well as economic and political conservatism: Jost (2009: 134–135) elaborates a motivated social cognition model of ideology by taking into analysis relevant dichotomies, like the opposition between the need for stability and the desire for change (Jost, 2009: 129).

The spatial modelling paradigm has been employed in the development of ideology formation and change models, like the unidimensional left–right spatial models (Enelow and Hinich, 1984, 1994; Enelow, Hinich and Mendell, 1986; Hinich and Munger, 1996). In this type of paradigmatic approach, typically developed within the rational choice conceptual framework, the notion of utility is employed so as to define a construct of ideology in which socio-economic and socio-political principles combine in providing an explanation of human action choice as determined and/or accompanied by ideology arguments. A second type of spatial modelling paradigm provided for bidimensional models, which have typically involved value theory (Braithwaite, 1997), psychological and sociological theories on political attitudes (Eysenck, [1954]1999) and political culture theories (Inglehart, 1997). A third class of spatial modelling paradigms has provided for the multidimensional models inspired from culture theories (Geertz, 1964). Multidimensional spatial models have emphasized a strong holistic character due to their approach on ideology as a phenomenon involving multiple topics and multidimensional attribute or cognitive spaces. Tendencies toward holistic modelling approaches which take into consideration the ‘whole’ of the factors which provide for ideology formation and change and for its measurement were claimed during the early 1970s (Barnett, 1974; Serota et al., 1975, 1976; Barnett et al., 1976). Later on, the tendency toward integrative models claimed by Homer-Dixon et al. (2013) developed towards cognitive and complexity-based paradigms.

Another classic dichotomy employed in ideology modelling is individual versus group. Jost and collaborators (Jost et al., 2009a,b) classified ideology conceptual modelling approaches into top-down (specific to political science approach) and bottom-up (specific to psychological approach).

The dual-process model of ideologies (Duckitt, 2001) is based on political attitudes and their organization on single or multiple cognitive dimensions of preference and judgment (Jost et al., 2009a). The model starts from the hypothesis that attitudes toward social and economic issues are distinct and they could predict ideological
patterns of preferences. Individuals’ social dominance orientations are based on a power-struggle view of the world and predict economic conservatism as prevalent in comparison with social conservatism, while individuals’ right-wing authoritarianism orientations are based on a view of the world as threatening and predict social conservatism as prevalent with respect to economic conservatism. The individual orientations provide indicators to the functional structure of ideologies so that they are analysed as good predictors of the intergroup ideological positions (Duckitt et al., 2002; Duckitt and Sibley, 2010). The dual-process model thus combines top-down with bottom-up modelling. As a methodological approach, dual-process modelling has so far employed structural equations – see Duckitt et al. (2002) and Weber and Federico (2007).

The theoretical models of ideology have inspired or have been based on numerous empirical modelling approaches, many of them addressing the political attitude issues. Notwithstanding conceptual richness, theoretical broadness and effervescence of search for empirical support, very few political attitude-based computational models have been developed on these quite impressive backgrounds. The proper explanation to this situation resides in the need for an appropriate computational modelling technology able to cope with the complexity of the ideology issue, as well as in the need for an integrative paradigmatic approach able to overcome the cleavage-prone tendency and also the tendency to spread the focus in ideology theoretical and empirical modelling.

This part selects some of the ideology computational and simulation models which are relevant as political attitude-based models. Regardless of the historical age to which they belong, each of these models represented a breakthrough in its time for identifying a proper methodological and technological modelling solution for an important theoretical problem. Other computational models of ideology, which are not necessarily based on political attitudes, have been developed in areas like electoral studies, opinion dynamics, voting behaviour, political parties and partisanship. Though not included in the area covered by this book, and also for reasons concerning the space available in this part, some of these latter models are mentioned briefly as they are more or less connected with the issue of ideology modelling.

Early Ideology Empirical and Computer Models

The classic definition of political ideology which provided initial support to ideology computational modelling is based on political attitudes toward objects like parties, candidates and policies.

During the 1950s, the Columbia model introduced a social influence paradigm in modelling ideology change. The Columbia studies, elaborated by Paul Lazarsfeld and collaborators (Lazarsfeld et al., [1944]1968, 1948; Berelson et al., [1954]1986), focused on the social context of political (voting) preference formation, taking into consideration variables describing social status, residence and religious preferences. The Michigan model developed by Angus Campbell and his team (Campbell et al., 1960) approached ideology formation from the point of view of the interest in
political participation (voting), policy issues (governmental action) and political loyalties (party identification).

The 1960s were dominated by the political culture approach to ideology. Converse’s is an empirical model based on the study of several variables used as the predictors of ideology orientation of an individual voter. In the same period, Gabriel Almond and Sidney Verba (1963) introduced a political culture theory of ideology formation.

Converse defined the concept of ideology as an organized structure of attitudes and beliefs, and provided the first conceptualization (constraint theory) and operationalization (correlation) of a belief system related to political attitudes and values. The constraint theory has been the subject of debate, as Converse’s model has been criticized for his unidimensional approach based on the consistency between attitude (issue position) and ideas which make up a belief system.

Campbell et al. (1960: 189–190) approached ideology as a ‘cluster’, in which attitudes are organized on a functional criterion illustrating a ‘means-and-ends’ view (Campbell et al., 1960: 189). The functional approach has further served for identifying a class of models which are based on ideology as a response to individual needs. As such, this suggests an opposed perspective to the models based on institutions or power modelling. The political culture modelling approach to ideology, as a modelling tradition initiated by Converse (1964) and Almond and Verba (1963), focuses on political attitudes and belief structures, defining their functionalities on a rationality basis.

These models represent the theoretical and empirical foundation and inspired ideology computational modelling approaches developed a decade later, as soon as the computer technologies offered solutions and computer expertise had diffused among sociologists and political scientists.

Two main modelling paradigms are addressed in the following section: spatial and cognitive. Developed in the 1970s, the political information processing theories as well as the cognitive theories in ideology research inspired ideology cognitive modelling, which includes political reasoning, political judgment as well as political cognition issues. It is only lately that the integrative spirit has gained ground and proved more powerful as the technologies of ALife have provided ways to unite these and other computational paradigmatic approaches into complex, more believable ones.

**Spatial Paradigm**

**Multidimensional Spatial Models of Ideology Change**

In the early 1970s, scale-based attitude measurement was facing a challenge which made it appear a rather poor and slight means to measure the complex structures of political attitudes and beliefs viewed as ideology patterns. An attitude scale was meant to organize individual self-reporting ideological positions of the respondents so that preferences and their intensity could be measured in a population. However, extending the attitude scale-based measurement to ideology might have proved a very difficult task as political ideology is defined as a structure of political attitudes and beliefs. Ideology measurement would thus have to approach complex ideological patterns that include attitudes, beliefs and values altogether as structural attributes.
Holistic conceptualizations of ideology measurement became salient as value theory research provided a different approach on the issue of ideology and its structure by defining it as organized structures of attitudes and beliefs (Rokeach, 1968). Though this conceptual perspective has allowed for substantial advances in the study of ideology as more complex than a multicriteria evaluation of attitudes toward objects with ideological significance, it has nevertheless revealed a major weakness of attitude scale-based measurement: data provided by attitude surveys do not reveal whether the selected attitudes are relevant enough to correctly identify the attributes and the structure of an ideology (Serota et al., 1976). In order to obtain the set of relationships among relevant attributes of an ideology, an entire population should be investigated with respect to a predefined list of concepts which are supposed to characterize an ideology as a whole.

A first attempt to solve this requirement aimed at providing a holistic empirical modelling approach on ideology was that of considering the ideology as a culture pattern: Scott’s (1959) idea was to describe ideology as a cluster of interrelated culture items which could be described on a correlation basis, such that, for several groups, the differences between items revealed the ideological difference between groups. Geertz’s (1964) idea was to define an ideology as culture and to view it as a spatial representation (i.e. a map) such that each object (i.e. culture item) would have a location and a relative distance to other objects on the map.

Serota et al. (1976) follow both ideas and define an ideology as a culture with a multidimensional spatial representation achieved with the multidimensional scaling method. This approach measures an ideology by evaluating discrepancies between concepts as distances in the spatial representation.

**Political Ideology as a ‘Map’**

This type of model defines a political ideology as a structure of culture items following a spatial representation inspired by a spatial analogy with a ‘map’, an idea introduced in the earlier modelling approach developed by Geertz (1964).

Ideology is modelled as a set of concepts. By means of the multidimensional scaling technique, the concepts are transformed into points represented in a multidimensional space such that each point could be projected on each dimension (axis) of this space. This representation is used for defining and evaluating the differences between objects in this space as distances. The notion of ‘distance’ is employed as a means of operationalizing the judgments concerning the dissimilarities (discrepancies) between concepts. Evaluating the dissimilarity (discrepancy) between any two concepts allows for the construction of a matrix of distances between concepts. The multidimensional scaling method allows the transformation of this matrix into a spatial configuration of the concepts and their relationship in the ideology structure.

The experimental procedure combines two steps:

- The first step consists of selecting a collection of relevant ideology concepts from a sample of individuals. The concepts are selected from a survey based on a questionnaire in which the questions concern concepts describing a particular
issue, like, for example, social change and social structure. The respondents provide as many concepts as they need to answer the questions properly (open-ended questions). The salient concepts in each answer are selected such that an aggregated set is collected. This aggregated set of concepts is meant to reliably represent a group’s ideology. This aggregated set is introduced in the second step of the procedure.

- The second step consists of the measurement of the relationships between the concepts defining the ideology. The ideology measurement is performed as perceived by two separate groups of individuals.

Ideology structure is achieved as a configuration of objects (relevant concepts) in a multidimensional (cognitive) space. The model is based on the method of multidimensional scaling used in spatial modelling of political attitude change. The model has been used (Serota et al., 1976) in measuring the ideological differences between two specific groups defined as ‘upper class’ and ‘lower class’. The model has also been employed in measuring the effects of interpersonal and media communication on ideology in empirical longitudinal studies on several groups of individuals (Barnett et al., 1976). Measurements of the communication impact on the political attitudes and ideology change in several groups have been reported with respect to the 1974 US congressional elections. The measurement of discrepancies between concepts as an effect of interpersonal/media communications revealed homophily-induced modifications of the distances between concepts.

The evaluation of the impact of the concepts in the political messages (stimuli) on the ideology structure has been used in the design of message strategies during the electoral campaign: messages which transmit information about a relationship between two concepts would result in making the concepts ‘move’ in the space to closer positions (i.e. their distance on given dimensions in the multidimensional space will diminish). The model predicts group behaviour with respect to political candidates and parties by measuring the discrepancies between groups’ political attitudes and parties’ or candidates’ ideology.

**Cognitive Paradigm**

Classic political science modelling approaches, starting with the Yale model elaborated during the 1950s until lately, have been focused more on the mechanisms and processes of attitude formation and change which are based on media and political communication during electoral campaigns and also by the communication and political persuasion in the networks of interpersonal relations. Starting in the 1980s, this latter topic was intensively investigated with regard to the polity macro-level effects of the individual interactions at the micro level. The complexity of the political attitude phenomena has often represented a difficult aspect in modelling research approaches. The various mechanisms of interaction between individual agents as voters need further investigation with respect to the processes they control and the emergent phenomena they generate. Designs of models have only lately
involved complexity-based studies of the systemic effects of ideology-based interactions among individual agents in networks of interpersonal relations.

The list of political ideology models thus includes various topics and types of approaches, like political discourse (Leifeld, 2014), language and thought (Dirven et al., 2003), ideology formation and ideological polarization (Baldassarri and Bearman, 2007; Lorenz, 2014), dynamic parties and coalitions (Fowler and Smirnov, 2005), political insurgence, uprisings and revolutions (Lang and De Sterck, 2012), oligarchs, ideologic preferences and voting behaviour (Wright and Sengupta, 2015), political belief systems (Homer-Dixon et al., 2013) and ideology diffusion in social networks (Brzozowski et al., 2008), to name but a few topics.
Ideological Polarization Model

The Ideological Polarization Model (Baldassarri and Bearman, 2007) is a bottom-up model of political influence which studies the macro-level effects of the individual interaction mechanism in a simulated social environment consisting of multiple individual agents and their interpersonal relations. The dyadic interactions are described as discussions in the network and facilitate the political ideological influence process. The outcome of this process becomes observable by means of simulations in the emergence of dynamic configurations of the interpersonal relations network proving various polarization degrees on different issues from the issues considered initially.

The model approaches old issues with advanced computational and simulation tools and suggests new perspectives. The model aims to explain ideology polarization by studying the emergent effects of the interaction mechanism. Two dimensions of study indicate that the authors are approaching an old issue – homophily and heterophily (Merton and Lazarsfeld, 1954; Barnett, 1974) in local interpersonal networks – with advanced computational and simulation methods; namely an agent-based system.

The model investigates the outcomes of processes of dyadic discussions characterized by the homophily–heterophily dynamics and aims to provide answers to two research issues: ideological and social polarization.

The Dynamics of Ideological Distance: Conceptual Aspects

The Dynamic Ideological Polarization Model (Baldassarri and Bearman, 2007) is a model of interpersonal influence which provides insight into the emergence of ideological polarization phenomena.
Ideological influence is modelled as an attitude change process. The social and political influence paradigm has also been employed by the culture dissemination model (Axelrod, 1997) and the diversity survival model (Huckfeldt et al., 2004) in approaching the issue of diversity in networks of interpersonal interactions. The differences from these models reside in (a) the view over the process of interpersonal influence, which is modelled as a political influence process in which the similarity criterion concerns an ideological affinity (Baldassarri and Bearman, 2007), and in (b) the ideological knowledge update process, which computes an ideological distance each time two individual agents interact and updates the memory of their interaction history so that the dynamics of this knowledge guide further interactions and modify the agent interaction context.

The mathematical component of the model consists of the formal description of the conditions in which discussant selection and political influence processes take place.

### Multidimensional Interaction Space

The interaction space is defined as a multidimensional ideological space. The model has a set of issues which is established in advance such that the agent’s attitude toward each of these issues represents the ideological position of the agent. The number of dimensions is fixed in the model design. These ideological positions are further used for similarity evaluation in the selection process.

As usual in the models based on this paradigm of selection for interaction in an agent-based system, the values of each attitude for each agent are initialized with a normal distribution of values.

### Selection Process

The selection process is controlled by two mechanisms: social selection and information processing.

Selection of the discussion partner depends on the degree of similarity (homophily) of the interacting agents in two ways: by direct evaluation of the potential discussion partners and by means of the interaction history, which remembers the interactions and the discussants, increasing the homophily in the interaction context. Individual agents select their discussion partners from the other agents by evaluating their similarity with regard to ideological preferences. Homophily is achieved by taking into consideration ideological affinities between any two agents. History and knowledge of interactions are used by each agent to guide further interactions. As the agents are always looking for likes as discussion partners, the degree of homophily increases with interaction.

The selection process is controlled by two mutually reinforcing mechanisms, the attitude involvement and attitude extremity mechanisms, which have a dual action, each reinforcing the outcome of the other. Attitude involvement provides for biased information searching (i.e. information about a candidate discussant); that is, discussants are first identified for having similar ideological opinions. Consequently, biased
information search reinforces homophily in an agent’s search for like discussants. As a direct effect, individual attitudes become more extreme as the interactions with likes increase in number.

The information processing mechanism controls the history of interactions and the knowledge update in each agent, which is aware of the agents with which it has interacted, their characteristics and the neighbourhood of similar agents.

The model has a generative character induced by several essential aspects of the model design. First and foremost, the generative type of the model resides in the capacity of the individual agent to choose the discussant so as to comply with personal requirements and not as a constraint based on the group composition (choice homophily). Second, the interpersonal network is generated as agents make their discussion choices. The dynamics of the network configuration depend on the complexity of the agents’ environment, political issues and ideological similarity patterns.

Nevertheless, the model has a strong rational choice dimension as the agents make choices which are meant to maximize/minimize dimensions of the interaction space and outcomes. Rational choice aspects reside in the criteria used by the individual agents in adjusting their interactions with other agents in order to avoid conflicts and maximize the exposure to similar agents.

**Ideological Influence Process**

The agents interact and influence each other, so that ideological change works in both directions. Ideological change, modelled as attitude change, is characterized by direction and intensity. Direction is determined by the relative positions of the agents toward the same issue, and may reinforce or weaken an agent’s position. Intensity is determined by the difference in the level of interest of each agent.

Directionality of attitude change depends on agents’ relative positions with respect to the same reference issue. As an effect of their dyadic interactions (i.e. discussions), the direction of change in each agent’s ideological positions evolves along a continuum between ‘conflict’ and ‘compromise’. A situation of ‘conflict’ is generated when the agents have completely different ideological positions on all n issues which define their interaction space, while a situation of ‘compromise’ is dependent on how many issues the agents have different attitudes on. The solution of compromise is managed with a mechanism based on the reduction of cognitive dissonance. Usually, if the issue selected for a discussion (central issue) is the issue on which the agents’ attitudes diverge – or otherwise have similar attitudes on the remaining (n –1) issues – then the agents adopt a ‘compromise’ solution by diminishing their commitment on the central issue, thus reducing the dissonance and, by the compromise effect, their perceived ideological distance.

Intensity of attitude change concerns both agents in an interaction; it is a very sensitive parameter which decreases with the increase of agents’ interest. The magnitude of ideological change varies as the individual level of commitment of each agent is different: as agents hold stronger ideological positions, they are less susceptible to getting influenced during discussions with other agents.
Cognitive mechanisms are employed to control the interpersonal influence processes. The mechanisms of persuasive arguments and repeated attitude expression (Baldassarri and Bearman, 2007: 792) provide an explanation for the increases in attitude extremity when discussions with likes make an agent share with its discussion partner more issues which are in favour of its own position. Therefore, interaction with likes increases an agent’s attitude extremity and reinforces the search for other likes as discussion partners, thus making the agent’s interpersonal network more homophilous.

Another mechanism makes reference to social comparison and works through the effect of the interactions history, which updates an agent’s knowledge and makes it aware of the dimension of the group which shares its own positions with respect to the set of discussion issues. As the awareness of group membership increases, a tendency of group polarization gets emphasized.

**Ideological Polarization**

The model is aimed at explaining the situations in which polarization of public discourse phenomena occur in a network of interpersonal relations. Though it addresses US polity, the results of the tests prove generalizable and effective for applications concerning identity formation and change and collective action.

Two types of polarization phenomena are investigated: ideological and structural polarization. Ideological polarization concerns the attitude polarization of the agents with respect to an issue of public concern and discussion. Structural polarization concerns the configuration of the network of interpersonal relations of the agents.

The conclusions regard the political and social background for the emergence of ideological and structural polarization. The issues have been addressed in both the *Culture Dissemination Model* (Axelrod, 1997) and the *Diversity Survival Model* (Huckfeldt et al., 2004); both models draw the conclusion that homophily increases the group homogeneity, which increases polarization and reduces the communication between polarized groups. In their model on the dynamics of ideological polarization, the authors explain that the ideological polarization on salient single issues could involve structural polarization phenomena in groups which achieve high homogeneity, while the same groups could maintain heterogeneity on other issues. This explains the results achieved in the previous research as a matter of perception which depends (i) on the type of people who observe the polity (e.g. elites or laypeople) and (ii) on the local or global perspective these people have over the polity.

**Computational and Simulation Model**

The computational model provides for the design of the individual agents, individual interactions and the interpersonal network. It also provides for the design of the collection of generated data and analytical data processing.

The unit of interaction is the individual agent. The agent evolves in an abstract multidimensional space which is defined by its multiple dimensions, where
‘dimension’ means an issue of public discourse. The agents have an internal representation of the environment: they have internal memory and knowledge about the environment and about the ideological opinions of the other agents.

The operational model defines the computational agents, the mechanisms and processes.

The discussant selection criterion is made operational by defining the ideological distance (real and perceived). The relevant aspect in the model is the ideology as dimension of evaluation of agents’ similarity. Each agent calculates its ‘ideological distance’ to each potential discussant before deciding to select it as a discussion partner. The real ideological distance is the difference between their attitudes toward the same issue. The perceived ideological distance is the current value of this difference as modified during the history of the agents’ interactions. The ideological distance is defined as a normalized Euclidean distance; at a given moment of time, for any two agents, their ideological distance is the sum of all Euclidean distances with respect to each of the dimensions of the interaction space at a given moment of time:

\[
\text{ideo}\_\text{dist}(\text{agent } i; \text{agent } j)_t = \sqrt{\sum_{k=1}^{n} \left(\text{attitude}^i_{\text{agent }, k; \text{issue }, k} - \text{attitude}^j_{\text{agent }, k; \text{issue }, k}\right)^2},
\]

(14.1)

where: ideodist is the ideological distance between any two agents \(i\) and \(j\), \(d\) is the distance calculated as the Euclidean distance between the attitude of each agent toward an issue \(k\) \((k = 1, 2)\), \(n\) is the number of issues (i.e. dimensions of the interaction space) and \(t\) is the current moment of time. The Euclidean distance for a pair of agents, denoted \(i\) and \(j\), is given by

\[
d(a^i_k; a^j_k)_t = \sqrt{\sum_{k=1}^{n} (a^i_k - a^j_k)^2},
\]

(14.2)

where \(a^i_k\) is the value of the attitude of the agent \(i\) toward issue \(k\) \((k = 1, \ldots, n)\) at time \(t\).

The model works with a normalized ideological distance which is obtained by dividing the sum of the distances for each pair of agents by the maximum of these distances.

The selection process first evaluates a probability of interaction as directly proportional to the level of interest of each agent in a pair of agents, and inversely proportional to the perceived ideological distance between the two agents. Some agents never interact, so that their ideological distance remains the same as in the initialization phase. Some agents do interact, and still others interact more often so that their history of interaction updates their memory of interaction such that the agent remembers the agent(s) with which it has interacted and also the perceived ideological distance. The history and the knowledge of past interactions guide further interaction for each agent.
When selected for discussion, the discussion issue \( k \) is selected as the issue with the highest cumulated relevance among the absolute values of each agent’s attitude toward that issue:

\[
\max_{k=1, \ldots, n} \left( |a'_{ik}| + |a'_{jk}| \right)
\]  

(14.3)

where \( a'_{ik} \), \( i, j, k \) and \( a'_{jk} \) are defined as before.

The simulations focus on a series of case studies in which ideological and structural polarization are associated with the salience of some issue as a central issue of discussion (so-called ‘takeoff’) for some interval of time.

The index of polarization is defined as a combination of two analytical measures (dispersion and bimodality) so that it is inversely proportional to the level of polarization of certain issues of discussion. The dynamics of attitude or ideological polarization are different for takeoff and non-takeoff issues. The simulations support the case that a polarized public discourse emerges from a polarized ideological (attitude) on a specific issue (Baldassarri and Bearman, 2007: 802). As the authors prove in their simulation analysis, this case concerns situations in which takeoff outcomes are disproportionate with respect to the non-takeoff issues and are associated with a combination of highly polarized structures with high levels of ideological polarization. In such cases, polarization of the public discourse on a single salient issue (takeoff) is associated with the emergence of both structural (segregation) and ideological polarization. However, on the other issues, the discourse is not polarized and the system is characterized by heterogeneity on the other issues, which provides support to the conclusion that, overall, the system (group, society, polity) is not polarized. This explains why real societies preserve diversity in spite of highly homogeneous (polarized and/or segregated) groups, since the groups themselves could polarize on one issue at a time, but not on all, as well as polities which could include a polarized group but which rarely polarizes completely. The introduction of the ideological distance as a criterion of both selection and history of interactions updates makes this model draw conclusions which go against the sad conclusions drawn by the Culture Dissemination Model (Axelrod, 1997), which warns on the potential complete polarization of societies with a high degree of homophily. It also modifies some of the conclusions of the Diversity Survival Model (Huckfeldt et al., 2004), which explains the survival of diversity in highly homophilous societies by means of simultaneous membership in multiple neighbourhoods, selective preferences and different levels of information processing and update of agents’ internal representations of the environment.

The simulation results concern (i) the structure and configuration of the interpersonal relations network in the agent system and (ii) the ideological polarization phenomena.

Structural polarization is a side effect of the dynamics of the network configuration of connections between the individual agents in the system. Ideological polarization is achieved via attitude polarization in the agent system. The dynamic
factors are (1) the level of interest and/or commitment of the individual agents, (2) the perceived ideological distance and (3) information processing.

References


Ideological Landscapes Model

Generated Versus Empirical Ideological Landscapes

In the Ideological Landscapes Model (Lorenz, 2014), individual agents are assumed to ‘live’ in neighbourhoods where they interact with other agents more or less similar in their ideological opinions with respect to political objects/issues. Ideological opinions are defined as subjective summarizing expressions of structures of attitudes, beliefs, values and emotions about political objects. They are communicated to other agents, thus inducing processes of opinion change. The mechanisms of interaction between agents trigger processes of ideological position change. These changes provide for the emergence of macro phenomena.

The model aims to provide a means to investigate the evolution of ideological landscapes as a result of interactions between individual agents and also as a result of their homophile adaptation.

The model is based on the theoretical and computational background provided by other well-known models of bounded confidence continuous opinion dynamics (Deffuant et al., 2000; Krause, 2000; Weisbuch et al., 2001; Hegselmann and Krause, 2002). The difference from the bounded confidence opinion dynamics models resides in the study of ideological landscapes’ dynamic evolution as an effect of interaction and adaptation mechanisms which operate at the individual level.

Operational Model

An artificial society is defined as a set of $N$ individual agents which are characterized by personal opinions or attitudes or beliefs (ideological positions) with respect to political issue $x_i$. 

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The most important aspect is that agents change their ideological positions as they interact with other agents. The interaction process could result in ideology change by means of (i) homophile adaptation of the individual agents and (ii) random reconsiderations of an agent’s ideological issue position.

An ideological distance is defined as the distance between the ideological issue positions of any two agents, $i$ and $j$, such that their ideological distance is lower than the bound of confidence$^1$ $\varepsilon$:

\[
(x_i - x_j) < \varepsilon
\]  

(15.1)

If interacting agents have close ideology issue positions, then the ideology change by homophile adaptation is modelled as a change in the ideology position of agent $i$, for example, to the mean value of the two ideological positions. Otherwise, the position remains unchanged.

If an individual agent reconsiders its ideology position at some moment of time, it chooses a random position value within $[0, 1]$ with a probability $p$.

The ideology position of each agent is initialized with a value within the interval $[0, 1]$. The simulation runs provide for the generated data. The model then compares the ideology landscapes obtained from the European Social Survey and the landscapes obtained from the simulation of the model. The comparison criteria include aspects concerning (i) distributions, (ii) number, location and dimension(s) of peaks and (iii) landscapes’ global shapes.

The conclusion drawn from the analysis of the data patterns in generative model architectures is that the generated data do not achieve full characteristics of the empirical patterns. This has strong implications for the debates about the epistemological value of computational and simulation modelling based on generative technologies.

The model shows that the mechanisms and processes generate different types of agents and polities than the real ones. One reason could be that the agent-based systems are often biased in the generative processes by the initialization of their agents’ internal structures with normal distributions of attitude values, probabilities and so on. Empirical data such as the ideological landscapes are rarely (if ever) normally distributed.

Another source of bias in agent-based models identified in the experiments based on the model of bounded confidence opinion dynamics is the reductionist approach of representing attitudes as opinions, and the opinions as variables with numerical values. Ideology as a structure of attitudes and the attitude change in multidimensional spaces is a more enhanced representation which has already proved its own limitations.

The model has the virtues of a model-to-model analysis, a computational modelling tradition in agent-based systems (see a classic approach in: Axtell et al., 1996) and continued by several authors, especially in agent-based system modelling (ABS), which require a standardized system of evaluation of their design and performances.

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$^1$See the definition of ‘bound of confidence’ in Hegselmann and Krause (2002).
(see a technical report on this issue in: Cioffi-Revilla (2011). Models are compared on a set of criteria so that performances and validity can be evaluated on a standard basis.

Web Resources


References


The idea of modelling the individual mind as an artificial complex cognitive system is not new. However, it has taken shape only lately, when integrative frameworks have been developed as artificial complex systems including cognitive, emotional and rational factors. Such modelling approaches aim to construct artificial systems which can simulate the human mind (Anderson, 1983, 1993; Anderson et al., 2004). Late approaches employ methods and technologies of neural engineering to construct artificial brain systems (Eliasmith and Thagard, 2001; Eliasmith and Anderson, 2003; Eliasmith, 2013). The Cognitive Affinities Model (Homer-Dixon et al., 2013) is inspired by the cognitive theories of cognition (Thagard, 2006) which combine emotion and rationality, affect and judgment. The model has been employed in the study of the ideology impact on political cognition.

**Cognitive Affinities Model**

Ideology, as assumed in the conceptual framework of the Cognitive Affinities Model, is a complex emergent phenomenon rooted in interactive cognitive, emotional and social factors (Homer-Dixon et al., 2013: 343). The model views ideology as a complex system interconnecting networks on two levels:

- At the individual level, the ideas, beliefs, attitudes and values are interactive and interconnected in a network of concepts, which model the individual’s cognitive capacities and control the individual’s behaviour.
- At the social level, networks of individual minds communicate with each other, creating and manipulating the public discourse, exercising or only reacting to political power.
The combination of these two levels of networking gives an integrative solution to the interaction between multiple sources of human emotions, thinking processes, action decision-making and communicating abilities. This combination is able to give an account on both the self and the social identity of individuals from an ideology perspective.

The aim of the model is to explain how ideological change and social change influence each other in dynamic ways (Homer-Dixon et al., 2013: 344).

**Computational and Simulation Modelling**

The model is based on Thagard’s theory (Thagard, 2006) and method (Thagard, 2014) to represent the individual mind as a complex cognitive system: the cognitive–affective method provides the means to achieve a complex cognitive system (Thagard, 2006). The model provides for the description of the interactions between the two levels – individual and group – so that emergent social patterns describe and explain the ideology’s phenomenology. Thagard’s (2006) cognitive theory of emotional coherence is a connectionist theory which views emotions as integral to human cognition. Ideologies are particularly emotionally embedded in the identity of the individuals. The individual’s ideology is represented as a network in which all nodes (i.e. beliefs, values, etc.) have an emotional dimension: each node has associated valence, potency or arousal factors which influence the cognitive process. As emotions are assumed to play a role which is as important as that of reasoning, the cognitive processes are defined as ‘hot’ cognitive processes.

**Ideology Structure**

The conceptual structure of an ideology is represented and displayed on a computer screen by the Empathica software.¹ The cognitive–affective maps (CAMS) are representations of the emotional values associated with a set of interconnected concepts in the cognitive space of an individual actor. They are designed and displayed during a user interactive session: the user is requested to identify the concepts which are relevant for the ideology under study and also their emotional valence by selecting the type of geometrical icons and their relationships.²

In the theory, the individual mind is represented as a neural network in which the nodes are concepts. The node diagram defines the types of the nodes, indicating a class of basic attributes and relationships between concepts: emotional (positive, negative or neutral) elements (ovals, hexagons and rectangles respectively), ambivalent elements (overlapped oval and hexagon), links or interconnections between elements (straight lines of variable thickness), relations between compatible and mutually causal elements (solid links) and relations between incompatible elements

¹ Empathica is a software simulation platform, originally created by Paul Thagard. Available in the public domain at http://cogsci.uwaterloo.ca/empathica.html.
² Empathica displays multimodal CAMs; that is, diagrams with nodes which could include written text and also images, as in Thagard (2014: Figures 10 and 11).
(dashed links). The method is used for modelling the emotional bias in the individual’s interpretation of political events, messages, symbols and so on (Schröder and Thagard, 2013).

The nodes in a CAM have associated valences and activations, which allow for the evaluation of the dynamics of the emotional coherence of a set of concepts describing an ideological instance:³

\[
\text{valence} \left( n_i \right) = \sum_{\text{all } n_j} A(n_j) \cdot \text{valence} \left( n_j \right) \cdot w(n_i, n_j)
\]

(16.1)

where \( n_i \) and \( n_j \) are two interconnected nodes, \( A(n_j) \) is the activation of node \( n_j \) and \( w(n_i, n_j) \) is the weight of the connection between the two nodes (Thagard, 2014).

**Mechanisms of Ideology Adoption in Individuals, Groups and Masses**

The mechanisms employed are psychological and social.

Emotional coherence is a psychological cognitive mechanism. It represents the affective support for the motivated inference mechanism, which explains why and how individuals adopt ideologies. The social mechanisms include emotional contagion and homophily. It is a dimensional model of ideology which is based on the evaluative–potency–activity dimensionality of emotion (Homer-Dixon et al., 2013).

³As specified by Thagard (2014), the proper evaluation is performed by a computational model HOTCO, which represents the early implementation of Thagard’s theory of hot cognition. More details on HOTCO can be found in Thagard and Aubie (2008) and Thagard (2010).

**Web Resources**


**References**


Polity modelling appeared as a typical Cold War research prospective approach aimed at evaluating polity’s structure, its stability and resilience to stress factors, like economic and political crises, civil conflicts and war. The Cold War era drew the attention of the research community with respect to the considerable potential of the newly appeared computational modelling and simulation techniques, especially system dynamics, to provide for a provisional study of state crisis and state failure. High interest in research on propaganda studies, persuasive communication and political attitudes in mass electorates was paralleled by increasing interest in the roots and dynamics of civil conflicts, insurgency and warfare. While the former trend drove social and political influence studies to political attitudes and belief systems (ideology) computational and simulation modelling research, the latter provided for a constant orientation toward polity modelling research. After the fall of the Berlin Wall, the degree of interest in polity models kept constantly at high levels. Polity modelling did not change its perspective; on the contrary, it remained anchored in the interest for prospective evaluations of state crisis-inducing factors. Moreover, it increasingly specialized with respect to such factors in both domestic politics and international relations.

Polity Modelling: The Old and the New Look

The Old Look: A View Dominated by Conflict

Fast advances in computational modelling and simulation technologies during the 1990s favoured a speculative trend centred on polity modelling with a special focus on topics like (i) emergence, growth and decline of states, (ii) state failure, (iii) state expansion and state conquest and (iv) state dynamics in various situations of conflict.
The New Look: A View Dominated by Reconstruction and New Media

While the system dynamics modelling paradigm and game theory had long dominated polity computational modelling research and had driven the preference for an international relations approach, the end of the 1990s witnessed the rise of new computational and simulation modelling theories supported by a strong comeback of the Simmelian theory of social forms (Simmel, [1908]1955, [1908]1971; Cederman, 1997) on the one hand, and the rise of the artificial society modelling philosophy on the other hand (Epstein and Axtell, 1996). Agent-based systems and complex adaptive systems, as well as artificial society models, enhanced a new look on polity. A new polity conceptual framework provided support to a new approach to polity issues in social and political sciences: the bottom-up modelling approach. In this new conceptual frame, ‘polity’ appears as a complex entity with self-organizing capabilities, which disintegrates under combined social, economic and political stress, and is capable of post-confrontation/post-failure reintegration/reconstruction (Sakamoto and Endo, 2015).

Taking a look at polity modelling research during the past three decades, a methodological cleavage apparently deepens between polity and political attitude modelling research areas. Political culture theory has repeatedly failed to keep pace with the computational modelling advances in political attitude research. The economic type of approach is currently dominating the theoretical and computational polity modelling area, thus diminishing the impact of those based on political attitudes (Kollman et al., 2003; Kollman and Page, 2006). On the other hand, political attitude theories are still ambiguous with regard to the order emergence in political attitude change phenomena generated by economic or political crises. In spite of the undeniable empirical evidence of political attitudes playing a decisive role in polity dynamics (Voinea, 2012, 2014), the mechanisms which generate and enhance this role are still unclear (Mishler and Pollack, 2003; Pollack et al., 2003; Pickel, 2006). The latest studies concerning the impact of social media on polity dynamics have considerably increased the complexity of polity sensitivity to sharp processes of political attitude formation and change, like the major upheavals in dictatorial political regimes in the 1989 Eastern European anti-communism revolutions.

The theoretical foundations of polity modelling have not included so far the issue of political attitudes other than as a side effect of social and political behaviour of the individual agents in specific scenarios, or, eventually, as an element to which the conflict theories may occasionally point (Hirose et al., 2014). Our choice in this part, therefore, was not based on existing approaches on political attitudes as endogenous to polity models, but rather stimulated by the prospects with respect to the programmatic research developments on this issue. A good reason for adopting a systematic research development programme would be sustained by the expectations which have built up so far on their potential explanatory power and capacity to uncover potential challenges in the computational and simulation modelling of polity change phenomenology. Political unrest, insurgence, violence, terrorism and separatism or political regime change (with or without violence) are cases which have
appeared during the past decade in various geopolitical areas. They have raised a question of major concern to political analysts as well as to the researchers in political science: What is the role played by political attitudes in the emergence of social structure and political order in scenarios of polity instability?

More striking than ever before, the relationship between social media or new media and processes of political attitude emergence (Howard et al., 2011; Lynch et al., 2011; Lynch, 2012) has introduced in the polity conceptual modelling framework a new source of polity instability. Political regime changes, for example those known as the Arab Spring, and electoral campaigns and winners coming from large basins of virtual electorates, like Podemos in Spain for another example, show that the rebels, the insurgents or the warriors today take their political attitudes as ‘swords’ and prefer to fight their wars as political culture wars in the ‘battlefields’ of the Internet social networks. This novel reality has turned the theories about polity instability upside down. And it does so with its computational and simulation models as well. The idea of people empowerment (Nisbet and Meyers, 2010; Shirky, 2011) and the role social media and social networks actually play in the dynamics of political participation induces a new approach to political attitude emergence and change phenomena. The new media require a new paradigm in political partisanship, political socialization, political participation and political attitude modelling research (Hoff, Horrock and Tops, 2000; Van de Donk, 2000; Tascón and Quintana, 2012; Dahlgren, 2013). All these could not stay separate from polity modelling research too long, even if now they might appear as quite distant research areas.

Polity Models and Open Research Questions

This part starts with a detailed presentation of several polity models which have been selected for their particular views upon the relationship between polity instability and political change phenomena. These models emphasize phenomena of polity instability as generated by political issues like the political exclusion of ethnic groups, political ideology-rooted social conflict and the emergence of revolutions in dictatorial regimes, state failure and territorial disintegration, and the emergence of political insurgency as generated by government incapacity to issue public policies for the management of social and political grievances. More indirectly than directly, these polity models point to the issue of political attitudes in, at least, three kinds of approaches: (i) ideology-based uprisings and civil conflict, (ii) collective action and (iii) polity resilience to stress factors.

The models which have been selected as relevant for this part are as follows:

The polity model elaborated by Lars-Erik Cederman and Luc Girardin (2007a), the Ethnic and Nationalist Insurgency Model, is a computational and simulation agent-based model of polity instability generated by the emergence of ethnic and nationalist insurgency. The model belongs to an impressive collection of polity models, namely GeoSim, GeoContest and GROWLAB (in chronological order), elaborated by Lars-Erik Cederman and the team at the Swiss Federal Institute of Technology (ETH), Zurich, International Conflict Research Centre. The models, lately informed
by geographical information system (GIS) data, are based on scenarios of polity instability under the stress generated by the emergence of ethnic and nationalist conflicts (Cederman et al., 2010).

Sakamoto and Endo’s (2015) Polity Reconstruction Model is a polity model which addresses the issues of state disintegration and reintegration/reconstruction after state failure. It approaches the post-confrontation and post-failure polity behaviour which models the polity behaviour of the African countries Somalia, Sudan, Eritrea, Ethiopia and Kenya. These countries have repeatedly experienced civil and military conflicts and state failure during the past half century. The model is based on an agent-based system and has been developed on an artificial society research platform, called ‘artisoc’.

The third model, MASON RebeLand (Cioffi-Revilla and Rouleau, 2010), is a holistic approach to polity modelling based on a combined political and economic approach concerning the emergence of public policy as a government’s response to societal concerns formulated as public issues. The model has been used to evaluate polity’s resilience to socio-political stress and emergence of insurgency. RebeLand is but one of the research projects developed in another impressive collection of complex social simulation models developed by Claudio Cioffi-Revilla and the team at the Center for Social Complexity, Krasnow Institute for Advanced Study, George Mason University (USA). As a difference from the previous single-polity modelling projects focusing on single countries, like the IRUBA Model (Doran, 2005) and Bennett’s (2008) polity models, Cioffi-Revilla’s models concern complex spatial computational and simulation agent-based models of both single country and groups of countries in large geopolitical regions. The models employ cultural and environmental dynamics to explain polity instability due to the emergence of civil conflicts. They include monadic models of polity (single-country model, like the MASON RebeLand model), and multi-country models, like the MASON AfriLand project, which models polities in eastern Africa (Sudan, Ethiopia, Somalia, Djibouti, Eritrea, Rwanda, Burundi, Kenya, Tanzania and Uganda), and the MASON Inner Asia project, which includes models of large regions, including Mongolia and the surrounding territories of northern China, southern Siberia, eastern Kazakhstan and western Manchuria (Cioffi-Revilla et al., 2007, 2008; Cioffi-Revilla and Rouleau, 2009).

The Compartmental Model (Lang and De Sterck, 2012) is a mathematical model about the emergence of Arab Spring revolutions. Unlike the previous models, which define polity as a geographically situated entity, here it is defined in non-territorial terms. The model aims to explain how polity instability generated by the emergence of Arab Spring revolutions.

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1 The research platform called artisoc (from artificial society) is a general-purpose simulator developed by Kozo Keikaku Engineering Inc. The copyright of artisoc belongs to both Professor Susumu Yamakage (University of Tokyo, Japan) and Kozo Keikaku Engineering Inc., Japan. The artisoc official website, called ‘MAS Community’, is at http://mas.kke.co.jp/. For a comprehensive introduction to artisoc, see Yamakage (2009). For more details, see the Web Resources section in Chapter 18.
of civil conflicts evolves on other dimensions, like the relationship between the coercive power of the government and mass access to communication systems. Though defined in the same logic of polity reactivity to the stress generated by the emergent insurgence phenomena, the model is relevant for the way it captures polity instability. The model defines the authoritarian regime in terms of restricted mass access to social media. As soon as the restriction is eliminated and the mass dimensions of the phenomenon overwhelm the government’s coercive and punitive capacity, polity instability is thus induced: the sudden unrestricted mass access to social media and the capacity to exchange incentive messages which stimulated the emergence of uprisings made the territorial dimension of the polity become irrelevant.

Finally, some open questions and concluding remarks are presented with concern to polity modelling in particular and political attitudes in general.

**Ages in Polity Computational and Simulation Modelling**

Starting in the late 1940s, we might identify three ages in the development of polity computational and simulation modelling research.

The first age, mostly overlapping with the Cold War era, is a period oriented toward polity models in scenarios of civil and international conflict. Such models were developed in terms of international relations in world politics. As a computational modelling paradigm, this age is by far dominated by system dynamics (Choucri et al., 2006). Choucri and team developed research on state stability modelling, where the concept of state stability is defined in terms of the state system resilience to exogenously generated pressure. In this conceptual framework, the state dynamics are studied in civil insurgence scenarios and state resilience to stress factors generated by civil conflicts. This type of model was developed toward achieving predictive analysis of the factors which could introduce major disruptions in the state dynamics and even state failure.

The second age was dominated by the interest in polity modelling as a state actor in the international relations field. Initiated by Axelrod’s (1995) famous *Tribute Model*, polity modelling almost exclusively focused on the dynamics of states’ inter-relationships. Cederman’s (1997) model of a state as an emergent agent in a population of state agents for the first time considered the state agent as a geographically situated interactive agent for which the territorial attribute is fundamental. Both are bottom-up models based on the principle of methodological individualism in achieving a model of individual interactions. The differences reside in the definition of the state as an individual agent: while Axelrod’s *Tribute Model* defines an abstract state agent interacting on a simple rule in an agent-based system, Cederman’s *Model of Emergent Actors* defines a state agent as a territory-based agent able to interact with neighbouring state agents in both agent-based and adaptive complex systems. The paradigm was further employed in approaching not only state agents, but also state conquest strategies in geopolitical competitions among states with the GeoContest model (Weidmann and Cederman, 2009), and empires and confederations and international state systems with the GSSM Model (Mitsutsuji and Yamakage, 2006).
The paradigm became very popular for the way it achieves emergence phenomena at the level of international politics, where all states are abstractly defined as individual agents competing with each other for resources and power.

The third age witnessed an explosive development of modelling research on polity as a structured geographically situated agent capable of interactions with other state agents and non-state agents. Its main structural components – society and government – received a detailed approach in agent-based system terms. Polity models have increasingly included endogenous (structural) and exogenous (environmental) elements, from territory and borders to weather systems, neighbouring relationships and terrain configuration, which control its very existence and inform its dynamics (Cioffi-Revilla and Rouleau, 2010). Traditionally, the approaches focus on conflict issues. However, new issues appeared as the complexity of a real polity could be appropriately approached in computational terms: stability and instability, weakness and resilience, disintegration and self-organization are but a few of these new issues.

A Typology of Polity Computational and Simulation Models

There are several criteria for classifying the existing polity modelling approaches. During the past decade the research in this area has been based on agent-based systems and artificial society simulators. Lately, computational and simulation models of polity have been informed by masses of georeferenced (GIS) data, which require specific computational modelling so as to be easily embedded in polity models which define the polity as a geographically situated agent. Models could also be classified with respect to the single-country approach, like the RebeLand Model developed by Cioffi-Revilla and Rouleau (2010), or the multicountry approach, like the Ethnic and Nationalist Insurgency Model developed by Cederman and Girardin (2007a).

The other criterion is the structure of the polity; usually, polity is defined in territorial terms. However, besides territory, the polity structure could explicitly or implicitly include other components: namely, the government and society. These models are known as structural models. The most usual is the hierarchical model, which defines a polity as a hierarchy of levels concerning the capacity of coordination or the capacity of government reaction to civil violence in conflict-based approaches.

Hierarchical models of polity based on conflict-prone societies (Cederman and Girardin, 2007b) start from the hypothesis that ethnic civil conflicts in multi-ethnic societies are rooted in ethnic group exclusion from power. As a difference from the Fearon and Laitin’s theory (2003), which is based on the idea that the roots of civil conflict are to be found in the territorial configuration of a polity and in its low control capacity over its own territory, Cederman builds upon theories (Gellner, 1983; Gurr, 1993; Weidmann, 2009; Cederman et al., 2011; Weidmann and Salehyan, 2013) which introduce hypotheses on ethnicity, nationalism and culture-based roots of civil conflicts. The polity model which is described in the ethnic insurgenge scenario is a two-layer hierarchical structure which largely characterizes a multi-ethnic society: one ethnic group is in power, while other ethnic groups are excluded from power. Exclusion from power makes them conflict-prone and the competition for power may result in ethnic conflicts.
Polity models have usually been developed in order to approach a problem of major concern but often much too complex: namely, polity instability associated with various types of political violence scenarios which drive or enhance state damage or failure. To a large extent, polity models have focused so far on explanations of the sources of instability and their effects on state dynamics.

Depending on how polity stability is defined, various models approach the issue of conflict emergence in structured polities. Some models focus more on the type of conflict, customizing the polity modelling to the issues of endogenous conflict generation modelling and predictions of outcomes (Cederman and Girardin, 2007b; Cederman et al., 2010). Conflict-based agent-based modelling research of polity dynamics addresses the polity’s stability and resilience to various types of stress in terms of system theory (Cioffi-Revilla and Rouleau, 2010), usually to the stress generated by ethnic and political conflict with or without forms of violence on both endogenous and exogenous factors’ influence.

The latest approaches introduce the Internet (i.e. social media and social networks) as a factor facilitating revolutions by (i) disseminating information, (ii) propagating ideology and ideological incentives which stimulate upheaval of coercive regimes, (iii) stimulating collective action and overt partisanship behaviour, (iv) dismantling the governmental coercive force by reducing its structural response to stress (especially in dictatorial regimes, where access to information is censored) and (v) introducing disrupting effects on the polity’s dynamics (Lang and De Sterck, 2012).

The holistic polity modelling approaches focus more on the polity itself, aiming to study its dynamics with concern to the state’s capacity to answer the needs of a society, formulated as public issues by providing the governmental administration with the means to manage and fulfil the social and political expectations by issuing public policies (Cioffi-Revilla and Rouleau, 2010) as defined by the classic theories of polity modelling (Almond et al., 2006). Other holistic approaches on the dynamics of the polity focus more on processes of post-failure polity reconstruction, where the term ‘reconstruction’ addresses the issues of polity self-organization under economic and cultural factors (Sakamoto and Endo, 2015). While the former type of approach has been preferred by analysts of conflict in both domestic politics and international relations, the latter has been preferred by analysts interested in studying the dynamics of polity change in complex socio-political change phenomena which include political forms of violence but are not exclusively based on it. A particular branch of polity studies in this respect is that concerned with the modelling of autocratic and democratic polities and the various forms of transition processes from one form to the other (Voinea, 2014): the new democracies in Eastern Europe after the fall of the Berlin Wall represent an issue of discussion at the end of this part.
Polity Instability Models Featuring Ethnic and Nationalist Insurgence

Starting in the late 1990s, Lars-Erik Cederman conceptualized the bottom-up approach to political insurgence phenomena. Several simulation platforms, GeoSim\(^1\) and the advanced versions GeoContest\(^2\) and GROWLab,\(^3\) were developed for modelling purposes. GeoSim defines states as agents, with no internal structure. Further developed simulation platforms approach the polity as a structured agent or as an artificial society. The models developed in this late paradigm are characterized by a geographically situated approach to polity modelling, in which territory is represented as a spatial grid allowing the simulation of territorial fractionalizing processes.

A typical approach is the two-level hierarchical polity – that is, centre and subordinated periphery groups – in which the main criteria of differentiation between the individual agents and between groups is ethnicity. Polity’s geographical position, terrain, borders and neighbouring states are addressed as dynamic features and/or factors of the model.

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\(^1\)GeoSim is a modelling framework (see details at http://www.icr.ethz.ch/research/geosim/) originally created and introduced by Lars-Erik Cederman (1997). See also Cederman and Girardin (2007b) and the Web Resources section in this chapter.

\(^2\)GeoContest is an advanced version of GeoSim elaborated by Lars-Erik Cederman. For a detailed presentation of GeoContest, see: Weidmann and Cederman (2009). GeoContest is available for download simulations within the GROWLab platform at http://www.icr.ethz.ch/research/geocontest.

\(^3\)GROWLab is the current software toolbox platform for the development of modelling simulations available on the ETHZ website at http://www.icr.ethz.ch/research/growlab. See the Web Resources section in this chapter.
Geopolitical Strategic Competition, GeoSim

The state is defined as a territorial agent, which interacts with other individual and group agents. The competition for power amongst the state agents in an agent-based system is described by means of individual interactions governed by simple rules. Owing to the complexity of an agent-based system with multiple interactive state agents, the dynamic evolution of these interactions features a process of balance of power with multiple local and global equilibria, but with high sensitivity to the relationship between the leading state agent (central) and all the other agents (periphery or group agents) competing for power. The description of interaction between states as individual agents in an agent-based system was inspired by the early model of geopolitical competition developed by Bremer and Mihalka (1977) and by Axelrod (1995).

GeoSim (Cederman, 2003) models the war amongst several state agents in a multicountry geopolitical region, where the ‘country’ agent is viewed as a state agent. GeoSim features a system with the states as individual agents which have only local interactions (i.e. with adjacent neighbour states only) (see Figure 17.1).

Figure 17.1 GeoSim (Cederman, 1997) and GeoContest (Weidmann and Cederman, 2009). (a, b) GeoSim Model and (c, d) GeoContest demo simulations of the interactions between neighbourhood states. Both models could be employed for geopolitical strategy design. The snapshots were obtained by running demo simulations, which were performed with the GROWLab platform, GROWLab v. 0.9.4 for Windows (56 MB); GeoSim and GeoContest are available for download as options within the GROWLab platform: http://www.icr.ethz.ch/research/growlab/box_feeder/download. GeoSim and GeoContest accessed, downloaded and run: 24 July 2015. See the Web Resources section for this chapter.
For each state agent the power game is to take other states as subordinates, thus increasing power with an increase in the number of subordinated states until equilibrium of power is reached. As soon as the equilibrium is lost (and it is quite often as the system is highly sensitive to variations in the centre–subordinate relationships), the power contest between state agents starts again.

Nationalist Insurgency Model

The GeoSim model was adapted to another type of hierarchical state and to another type of power contest process: a state agent is defined as a unitary system comprising a unique centre of power (located in the capital city) and multiple provincial agents who are subordinated to the state agent. The centre–periphery structure allows for (a) an empire state–national states hierarchy approach and (b) a state–provinces hierarchy approach. Both polity structures allow for the study of increasingly emphasized nationalist tendencies of the national states which are trying to balance the power of the centre state. Both structures are based on the same logic of potential conflict in which a subordinated state (in the first alternative) or a province (in the second alternative) rebels against the centre state. This version of the GeoSim model, called the Nationalist Insurgency Model, NIM (Cederman and Girardin, 2007a,b), has been used in exploring ethnic nationalist insurgency cases.

Conceptual Basis of Conflict Modelling

As hypothesized by Fearon and Laitin (2003), rebellions and nationalist insurgency are characteristic of weak states which cannot exercise control over their territory and thus provinces or subordinated states might become conflict generative. Their theory emphasizes the role of a territorial control mechanism in generating conflict between top and lower levels of a state hierarchy (centre–periphery).

The NIM model was meant to prove an alternative to their classic insurgence theory: Cederman (2008) showed that the same results could be obtained in a centre–periphery hierarchical structured state with a different mechanism, namely, ethnicity and nationalism. NIM simulations (Cederman and Girardin, 2007a, b) show that a hierarchically structured state is conflict prone if it fails (a) in the nationalist mobilization of its periphery toward common societal goals and (b) in generating collective actions based on a shared cultural (national) identity. In a state organized as a centre–periphery hierarchy with a multi-ethnic demographic composition and ethnic distribution of the access to power, the mechanism of ethnicity and nationalism will always function by providing support to the nationalist ethnic coalitions of the provinces against the centre of power.

In order to model the configurations of ethnic political groups and their relationships with the phenomena of civil violence (i.e. from uprisings to civil war), the modelling starts from a few hypotheses which synthesize the modelling conceptual framework.
• **H1 (state ownership):** The main hypothesis is that ethnicity and nationalism acquire a political significance when they are directly related to state and power, an idea inspired by the fundamental theories with regard to insurgence and nationalism (Geertz, 1963; Tilly, 1996). This hypothesis allows for taking the first dimension of modelling: civil conflict arises from competition for the state power and resources.

• **H2 (political exclusion of ethnic groups):** When demographically significant ethnic groups (ethnic minorities) are excluded from state power, they become conflict prone and are more likely to generate civil violence. If ethnic groups are defined on a collective identity criterion, then the exclusion of ethnic groups from state power might degenerate into civil conflict. This tendency to generate conflict might drive state failure, like in the case of ex-Yugoslavia, where the multi-ethnic group composition competing for state power and resources resulted in state failure (state disintegration).

• **H3 (mobilization):** A state which fails in mobilizing all ethnic groups on a common identity dimension fails as well in preventing and/or avoiding civil conflict. Mobilization is based on three essential factors in the model which reinforce polity resilience to stress sources like the struggle for power between (ethnic) groups: (1) collective identities, (2) collective actions and (3) shared motivations. As a complex entity, the polity stability depends on the balance of power between the structural groups involved in the power competition (Tilly, 1978). As collective actions succeed in aggregating these groups, their mobilization provides for a balance of forces competing for power such that the polity avoids instability.

These hypotheses involve, in a rather qualitative way, the issue of political attitudes, beliefs and values which might provide for an enhanced definition of both collective identities and collective action. Though the authors do not address these issues, this does not mean that they are not involved in the qualitative aspects of the simulation outcomes.

**Computational and Simulation Modeling of Spatial Conflict Emergence**

The NIM model provides for nationalist insurgency outcomes by means of three characteristic features:

First, a terrain model is introduced, so that the type of the terrain becomes a dynamic factor which controls the relationship between centre and periphery.

Second, there is a multidimensional culture dissemination map, similar to that defined in Axelrod’s (1997) Culture Dissemination Model. This feature is meant to support the idea that the cultural groups are distributed in a cultural landscape in which the groups may be identified by their national identities.

A representation of the cultural identity as a dynamic feature providing for the clustering of individuals in ethnic–nationalist groups based on their common national identities is different from the classic idea that computational and simulation modelling of culture (identity and traits) is about fixed properties influencing the
social and political behaviour of the individual agents (Axelrod, 1997; Epstein, 2002). This allows for a political approach to both identities and the dynamics of the groups with common ethnic nationalist identities which describe a cultural space.

Third, the conventional indices of ethnicity (ethno-linguistic fractionalization) are replaced by the Expert Survey of Ethnic Groups, ESEG\textsuperscript{4} index of ethno-nationalist exclusiveness which associates ethnic configurations with political violence. As a model of ethno-nationalist civil war, the N* index consists of an ethno-political configuration (C*) and a mechanism (M*). The model identifies the ‘star’ ethnic configuration and the opportunity-based mechanism which provides for collective actions as the means to mobilization across ethnic identities (see Figure 17.2). The ESEG index\textsuperscript{5} has been constructed so that the simulation runs are based on empirical data which mirror the degree of exclusion of ethnic groups from power in all states of the world (the index has been constructed on a questionnaire basis and used in the computational modelling of dyadic relationships with empirical data\textsuperscript{6}).

**GROWLab: Advances in the Computational and Simulation Modelling of Spatial Conflict Emergence**

The GROWLab Geographic Research on War Laboratory, GROWLab (Weidmann and Girardin, 2006; Cederman and Girardin, 2007b), is a new generation of geopolitical simulation platforms which includes modules for modelling, simulation, analysis and validation of social processes with a special focus on civil unrest and civil and regional wars. The simulation platform is based on the concepts of *configurations* as generative terms (Cederman, 2005).

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\textsuperscript{4}Index elaboration was part of the datasets obtained in research projects concerning ethnic power relations (EPR) developed at ETH and presented in detail in Vogt (2011).

\textsuperscript{5}See Ethnic Groups in Power (EGiP) index in: Cederman and Girardin (2007a), Appendix. The initial EGiP index elaborated by Cederman and Girardin (2007a) has been replaced by the ESEG index, which provides data on dyadic level of analysis of conflicts.

\textsuperscript{6}More details about ESEG in Cederman *et al.* (2006).
The GROWLab design of computational model defines three basic operational concepts for the computational description and simulation of polity, polity structure, territory, topology, neighbourhoods and the interactions and relationships between agents: layer, topology and configuration (Figure 17.3).

The layer is the basic type of description. It defines the individual agent. A layer contains all agents of a given type. It represents, therefore, a collection of identical agents. In a layer, the same functionalities and abilities are defined for all agents. The layer represents the design of an individual agent. It comprises the internal representations of an individual agent, its capacities of processing information, communication and learning, and it generates data as it performs its tasks. A mapping is the layer which maps agents and spatial locations. It helps in constructing the space as a set of spatial locations. A space could be defined as a grid (a bounded space based on a matrix of cells) or as a torus (circular space).

Each layer (class of agents) has a topology, which defines and describes the neighbours, the spatial location of an agent, the spatial distance between any two spatial locations in the territory and the repertoire of relationships between the individual agents. A topology is a way of associating an individual agent with a spatial location and with any other agent temporarily in any other spatial location of the polity’s territory. A topology provides for the calculation of any distance given two agents of interest for the user.

The configuration is a class of procedures which allows for creating hierarchies of agents regardless of the layer to which they actually belong. A configuration is a procedure which works across agents and topology types and could connect any two agents in any layer. A configuration is used for building up the model structure.

A polity (‘state’ or ‘country’) is therefore represented as a territory (space) with sharp boundaries (borders), with a number of individual agents (homogeneously or heterogeneously defined).

The simulations consist of constructing the GROWLab model of an abstract polity making use of its concepts and specifying the hierarchical structure, the functions of each entity in the model (agents, territory, etc.), their relationships and so on. Each simulation run employs the empirical data (ESEG index data, GIS data). The simulations generate other data which are stored and processed separately and also visualized with separate components.
Cederman’s approach on the agent-based modelling of geopolitical conflicts is theoretically based on the Simmelian concept of ‘social forms’ which underlies the generative paradigm employed in the bottom-up models of social complexity (Simmel, [1908]1955, [1908]1971; Cederman, 2005). The basic concept in the Simmelian-inspired generative approach to social and political complexity is the configuration, meant to replace the traditional concept of system. The configuration is an emergent structure whose dynamic behaviour is dependent on context and history. The GROWLab philosophy includes three basic concepts which define the types of configurations used in the model design. The layer is a local-level, interactive type of structure that defines individual agents of the same type. The topology is a relational configuration that defines the spatial relations, which could be defined in a fixed-territory population polity. It evaluates any spatial distance between any two agents. Finally, the configuration defines the structure of a polity. The configuration of a model is a structure constructed from local types of layers.

Web Resources

ETH Swiss Federal Institute of Technology Zurich, International Conflict Research


References


The approaches focused on the polity dynamics before and during the outbreak of civil conflict or civil war usually model the spatial and temporary distribution of events and people as spatial configurations of conflict-prone regions or groups (Weidmann and Ward, 2010). The post-conflict modelling studies often emphasize phenomena like the emergence of new state entities. A good example is Kosovo, which emerged as a new state entity after the military confrontations in the Kosovo war during 1998–1999.1 There are also cases of reintegration or reconstruction of the old state entity/entities into new one(s), either the same or different state entities. African polity cases are relevant examples, usually resulting from the violent civil conflicts and civil wars during the past half century.

The study of polity dynamics in civil and military conflict scenarios could reveal important details about polity’s behaviour during the conflict phenomena and after their completion. Moreover, prolonged conflicts have often resulted in repeated state-failure scenarios, especially in northern Africa, where the cases of Somalia, Ethiopia, Sudan, Eritrea and Kenya illustrate repeated processes of state disintegration and reintegration after violent civil and military conflicts.

The model elaborated by Takuto Sakamoto and Mitsugi Endo (2015) is concerned with polity reconstruction after violent confrontations in armed conflict (from now}

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1 Though the Kosovo case has long been debated in terms of whether it qualifies or not as a state as defined and allowed by international law, our view here is not concerned with the law aspects, but only with the modelling aspects of how a new state entity emerges by the reconstruction and/or self-organization of the old entity which generated it in the first place.
on called ‘Polity Reconstruction Model’). The model is based on the conflict analysis in virtual states (CNVS) model (Sakamoto, 2013b) and on a GIS data model which enhanced the representation of conflict evolutions (Sakamoto, 2013a).

Model Definition

The virtual polity is an agent-based model (Sakamoto, 2013a) of a state entity with territory, society, government and resources. The model replicates the political and military conflicts between the government and the insurgent groups for territory hegemony. As the conflicts have ethnic and/or religious roots, both the government and the insurgent groups are characterized by attributes which exclusively describe these characteristics of the individual inhabitants.

The model polity resembles the states in northern Africa, among which Somalia has been approached as a case study, in which the population is multi-ethnic and civil conflicts emerge as the struggle for power and resources between the government and conflict-prone groups.

The definition of the model concerns the structure of the polity, the types of agents and their goals and roles. The reconstruction of the polity in the same state entity or in several such entities is modelled as a macro-emergent phenomenon based on the interactions (conflicts) unfolding at the micro level of the artificial polity.

The territory is modelled as a two-dimensional grid of cells whose boundaries’ geometry closely resembles those of the African states studied. Each cell represents the spatial unit of territory representation.

There are two types of agents defined in the model: the population type (Population) and the ruler type (Ruler). Each type of agent is characterized by a set of socio-cultural attributes (invariant) called traits, and a set of goals and roles is defined as operational procedures for each type of agent.

The Population type of agent is modelled as an individual agent characterized by three classes of socio-cultural traits: ethnicity, religion and region. The ‘ethnicity’ class includes traits like ‘ethnicity’, ‘nation’, ‘nationality’ and ‘tribe’. The ‘religion’ class includes ‘traditional’ (i.e. systems of faith which are specific to various ethnic groups) and ‘universal’ (i.e. Christianity, Islam) religions. The ‘region’ class regards the regional administrative divides. These traits are considered invariant in the model. The individual agents inhabit a territory or a region. Each cell in the territory description is characterized by a number of individual agents and a certain amount of resources.

The Ruler type is a class representation of the groups which dispute the supremacy over a region/territory. The goals of a Ruler agent are to gain, extend and maintain control over the state by excluding all other competitor Ruler agents. The Ruler type of agent has two characteristics: traits and mobilization factors. The Ruler’s traits are considered invariant and indicate whether there is some political alignment between the Ruler and the agents or whether the Ruler shows indifference with regard to the

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2 As reported by Dr Sakamoto, the model has been informed with georeferenced GIS data provided or based on local linguistics distribution maps and various encyclopaedias elaborated by other authors.
Population agents’ traits (i.e. this could be the case when the Ruler gains control over a new region). The mobilization factors are considered variable and concern the human and material resources from both inside and outside the state which are acquired by the Ruler; the more resources it mobilizes, the more powerful it is.

The polity dynamics are traced at the level of the interactions of Population and Ruler agents. The simulations use the georeferenced GIS data acquired from the real state history (e.g. Somalia). The simulations generate at each run the population which inhabits each cell of the territory. Traits and resources are initialized with distributions of values which are afterwards updated by the interactions (conflicts) between insurgent groups. The initial Ruler faces challenges from other rulers/groups. As the conflict emerges, resource mobilization is performed by each competitor until one ruler gains (temporary) control over the territory. Population-type agents prove loyalty or betray their rulers, thus modifying the dynamics of the conflicts and conditioning their outcomes. The conflicts usually result in territorial division until the state disintegrates and the initial government disappears. Each Ruler sooner or later faces the same fate. The analysis of the simulation results is based on a measure of state disintegration (disintegration index, DI) such that the system could keep track of the degree of territorial division as the effect of conflicts.

Post-Confrontation Polity Reconstruction Modelling

The model suggests a dimension of modelling which has not been pursued in the literature concerning computational and simulation modelling and artificial polity. The reconstruction dimension suggests that the development of speculative scenarios would allow the evaluation of potential outcomes which cannot be tested in reality and which, moreover, cannot be validated unless tested in the long run. Reconstruction provides a viable alternative to test possible situations and to evaluate the source of polity instability.

The model constructs various alternative scenarios to the original polity instability by systematic variation of several classes of parameters which were initially kept invariant: external resources, traits and even the territory. This allows the study of the long-term territorial condition in two kinds of scenarios: the analysis of consequences by the replication of real phenomena and the prediction of the conditions which would favour or facilitate polity territorial stability in the long run. Each study concerns the results of 20 runs with appropriate variation in the parameters’ values. The simulated experiments revealed several kinds of polity stability and instability phenomena, where both ‘stability’ and ‘instability’ are defined in terms of territorial fragmentation.

The replication-oriented simulated experiments developed two case studies. In one case, the degree of territory disintegration is associated with the changing amount of external resources presumably received by the Ruler (i.e. government). The simulations revealed a persistent instability in terms of territorial fragmentation regardless of sustained ‘infusions’ of external resources. As the author notes, the model explains a prevailing tendency toward territorial fragmentation in the conditions of genuine clan-based polity organization, a hypothesis supported by other studies as well.
In the other case, the degree of territorial disintegration is associated with values of gross national income (GNI) per capita. In these studies, several major phases could be conceived in the process of long-term territorial fragmentation: at moderate levels of local resources, there is a tendency in the long run toward stability in the territorial structure, without excluding territorial fragmentation but making it develop at a slow pace. At increased levels of GNI per capita, there emerges a stable polity with no more territorial fragmentation even in the absence of external resources. The model thus identifies as sources of polity instability the level of resources (i.e. low in real polity) and the groups’ distribution over the territory (i.e. sparse in real polity).

The prediction-oriented simulations introduced two main differences from the original model settings: the traits as well as the territory itself were systematically varied. The alternative based on variation of traits results in the emergence of a significantly increased unity achieved by government re-orientation in ethnic and religious matters. However, reconstruction based on increased unity achieved in the socio-cultural traits proved that this alternative cannot compensate the low resources problem and in the long run territorial fragmentation cannot be avoided.

The reconstruction modelling thus proves useful in generating and analysing various scenarios which otherwise would be hard to investigate.

**Conflict Analysis in Virtual States Model**

The *Conflict Analysis in Virtual States Model*, CNVS (Sakamoto, 2013a), represents a geographically situated polity with territory, population and resources. It combines an artificial society model with an agent-based model of individual interactions at the micro level of the artificial society and also with a GIS for simulating the emergence of civil conflicts and their outcomes. Case studies address state failure in African countries like Sudan (Sakamoto, 2013a).

The state reconstruction model is based on an African case study, Somalia (Sakamoto, 2013b), where the state is viewed as a self-organizing entity. Sakamoto and Endo’s polity model has three dimensions: territory, resources and traits.

Computational and simulation modelling of polity is concerned with territorial integration/disintegration caused by conflict and the use of traits and symbols in the polity modelling.

**Web Resources**

**artisoc KK-MAS (early version of artisoc)**

Yamakage Virtual Lab – Exploring Artificial Societies  Professor Susumu Yamakage (University of Tokyo, Japan). The research platform called artisoc (from ‘artificial society’) is a general-purpose simulator developed by Kozo Keikaku Engineering Inc. The copyright of artisoc belongs to both Professor Susumu Yamakage (University of Tokyo, Japan) and Kozo Keikaku Engineering Inc., Japan. The artisoc official website, called MAS Community, is at
http://mas.kke.co.jp/. artisoc is not open-source software. The software is sold by Kozo Keikaku Engineering Inc. Free rental is available for research use in a college/university. Inquiries should be addressed to the Innovative Information Technology Department of KKE, contact address at mas-support@kke.co.jp.

References


MASON RebeLand is an agent-based modelling approach defining the polity as a territory-based structured entity whose dynamics are dependent on both exogenous (environmental) and endogenous factors (internal components and their relationships). The conceptual relevance of the polity model for political attitude modelling research resides in the idea of explaining the polity dynamics by means of public issue positions which are generated at the micro level of the society by individual interactions.

The model is particularly relevant for approaching polity phenomena and conflict emergence in four scenarios: (a) polity stability, (b) polity instability and the emergence of insurgence, (c) state failure and (d) recovery after state failure. Though not explicitly modelling the political attitudes of the population toward governmental policies, RebeLand generates the overall polity dynamics by means of complex mechanisms (described by simulation loops) which involve individual agents’ perceptions, affect, action choices and issue positions toward the policy development and management (Cioffi-Revilla and Rouleau, 2010: 47).

Similar polity modelling approaches aimed at explaining the emergence of civil insurgence are mainly focused on the study of social conflict as an emergent macro phenomenon (Cederman, 2003, 2008; Cederman and Girardin, 2007a, b). Though aimed at explaining the emergence of social conflict and civil insurgence in a single-country polity model, RebeLand achieves much more relevance from explicitly
modelling the structure of a typical polity and the dynamics of the relationships among basic polity institutions and individual agents. From this point of view, RebeLand is relevant to our approach in this book for providing for the first time an operational model of a polity in political culture terms: a minimal set of values, affect, beliefs and individual agents’ issue position (i.e., attitudes) toward public policies. A public issue is defined in terms of the level of ‘satisfaction’ of an individual agent with respect to its income and its power to purchase necessary and/or wanted things, like food and security. Though at the conceptual level the model is based on rational choice and economic principles, it nevertheless expresses it in a political culture paradigm. The model describes the economic principle of supply-and-demand in terms of the individual perceptions, affective evaluations and attitudes as provided by the dynamics of the relationships between the individual and the society, on the one hand, and between the individual and the state, on the other hand.

**Conceptual Model**

RebeLand models the polity as an autonomous isolated agent representing a country in the natural environment. The model has a modular architecture. Each module represents one of the structural components of a polity.

From a general (external) perspective, the polity model consists of (1) a state as a geographically situated entity with social, political and administrative systems, with no geographical neighbours and (2) its natural environment: territory (terrain and borders) and climate. From a detailed (internal) perspective, the polity model consists of several inter-connected and inter-dependent modules: society and the population of individual agents (societal level), the governance system and its organizational (administrative) structure (governmental level), the state with its political institutional leadership and the political regime (polity level) (Figure 19.1).

Such a modelling perspective offers a background for defining the polity as a coupled socio-natural system (Cioffi-Revilla and Rouleau, 2010: 48). The operation of such a system is achieved by means of two types of structural couplings: (i) between

![Figure 19.1 General structural concepts in the RebeLand Model.](image-url)
the internal components of the polity and (ii) between the polity and its environment. The model defines and implements the polity’s operational couplings by means of different types of mechanisms and processes described by simulation loops.

Model Structure

The environmental component represents the geography of the polity, its territory, bordering and neighbouring issue, whether a system with climate dynamics, and natural resources.

The political component has two major specific sub-systems: a society component and a government component. The society consists of a population of individual agents interacting with each other as well as with the environment. The governmental component consists of governmental agents (which tax the general population, collect the revenue and distribute revenue to the population on a policy programme), and governmental coercive agents (army, police) which are supposed to prevent the emergence of domestic insurgence and to attack insurgents in case of civil unrest and civil uprisings.

The political component is based on a structure of cities with a central city, roads which connect cities (i.e., roads are designed with algorithms of minimal distance) and a distribution of population in cities.

The architecture of the model is based on a functional scheme: each agent performs a specific task and also tasks which are included in its behavioural repertoire as reactions to interactions with other agents and with the environment. The principle which defines the classes of functionalities in the model is an economic principle based on ‘producers’ and ‘consumers’. The sources of stress and the stress conditions include: agents get incomes for their work, receive a specific level of security and have a certain degree of satisfaction. If the degree of satisfaction with income, food or security decreases below predefined thresholds, the public issues generate stress and this enacts the government to issue policies to tackle the public issues.

Model’s Generative Architecture

There are four basic internal structural modules of the polity: State, Government, Society and Population. Each module is associated with a specific type of agent: state-agent, city (governmental) agent, general population agent.

The economic principle of demand-and-supply is employed in defining the way in which public issues and public policies are generated. At a conceptual level, this induces the employment of the rational choice principle in action decision making at the governmental level.

The model generates a public issue from the individual assessments of the level of satisfaction with regard to three variables, namely ‘income’, ‘food’ and ‘security’: the individual expressions of the social, economic and/or environmental stress, like individual perceptions, affect and issue positions, are transformed into a unified expression of utility which, in the model, is defined as ‘satisfaction’. Below
some predefined threshold, the level of satisfaction provides the reason for which an individual agent might develop a hostile behaviour toward political and/or administrative leadership and management: individual agents might get dissatisfied with respect to the level of income (welfare), quantity/availability of food or the security level. In a complex social setting, such behaviours could generate civil unrest, civil uprisings and civil insurgence. As a direct consequence, the individual agents express their demands as a public issue (Figure 19.2).

When the dissatisfaction of multiple individual agents emerges as a social (public) issue, it requires a governmental response: the government is expected to take action in response to the public issue and consequently develop a policy. The governmental action is defined as the public policy which is developed in response to the emergence of a public issue.

The RebeLand Model is based on the principles of open polity (Almond et al., 2006) which explain governmental action (i.e., delivery of public policy) as rational action decision-making aimed at removing the source/cause of social stress by approaching the problem which generated grievances. The public policy represents a governmental solution to a public issue. The solution (i.e., the public policy) circulates at the social level until stress is eliminated. Otherwise either a new public policy is delivered or the government is unable to administrate a public issue (Cioffi-Revilla and Rouleau, 2010: p.47), where the issues could be generated either endogenously, by means of diminishing, for example, individual incomes, or exogenously, by means of an environmental problem which affects the polity and introduces a source of dissatisfaction at the individual level. Though designed as a standard democratic polity, the model is, however, a semi-democratic polity, as some basic democratic constraints are not satisfied, like a constitutional framework and an institutional design (p. 47).

Figure 19.2 Emergence of a public issue: the various forms of stress generate a public issue.
Operational Model

RebeLand Model achieves the polity dynamics in a bottom-up architecture which is characteristic of agent-based models. This type of architecture provides for the emergence of order at the macro level (polity) from the multiple simultaneous individual interactions at the micro level (society).

RebeLand works with several simultaneous simulation loops which are associated with each type of agent in the model. The main simulation loops provide for the mechanisms which activate and operate the types of agents: general population agents, city agents and state agents.

The operation of the model is context dependent and is dynamically evolving as public issues emerge. There are three basic mechanisms employed in the RebeLand operation: they are described by three main simulation loops which contain entries for each situation which directly generate or converge to the generation of a public issue (Figure 19.3).

Normal day-to-day activity of the individual agents is achieved in the main simulation loop (Figure 19.4). It describes the basic tasks and the threshold for each variable which decisively impacts the generative context of a public issue. The satisfaction is updated for each individual agent in the general population. Satisfaction results in positive issue positions and Government assessment. Dissatisfaction results in hostile behaviours and increased support for rebel groups.

The governmental agent responds to the public issue by generating a public policy: as it does not succeed in increasing the level of satisfaction at the social level, rebel agents emerge and take action against the governmental agent. As a reaction to the former, coercive action is taken by the governmental agent and military units are prepared to face civil uprisings (Figure 19.5).

Figure 19.3  RebeLand operational model: generative mechanisms (implemented as simulation loops) describing each type of agent, its specific tasks and entry points to the other simulation loops.
Redistribution of welfare at the societal level is achieved in a simulation loop describing the state agent tasks and dynamics (Figure 19.6). As the state is not able to redistribute welfare so as to increase or keep stable the satisfaction level in each individual agent, the polity becomes unstable.

The generative paradigm is combined with a stochastic modelling of rational choices of the governmental actions. The model has been tested in three types of situations: stable, contentious and unstable polity.
From a computational point of view, the model achieves its dynamics through bottom-up emergence of issues. Both conflict-prone and conflict-free situations are managed by means of the individual interactions among the various types of agents.

**Relevance of the Model**

*RebeLand* is perhaps the only computational simulation model developed so far which employs political attitudes in polity modelling. Though rather reductionist in the formalism which achieves a computational expression of a political attitude, it nonetheless achieves a polity model with strong features of complexity and easily scalable to more elaborate types of polities. First and foremost, the model combines social, political and environmental dimensions in both the structure and in the dynamics of the artificial polity. This further enhances the occurrence of relevant dynamic polity phenomena, like stability, instability, failure and recovery after failure as emergent phenomena. Finally, the simulation outcomes prove that the model could describe the dynamics of a semi-democracy, which would recommend it for the study of the Eastern European democracies after the fall of the iron curtain. The subject has often been approached from a modelling perspective, but it has been limited so far to qualitative aspects only. Though necessary, political culture modelling research has failed repeatedly in developing a political culture operational model, and even less a computational and simulation model.

The model does not employ advanced cognitive architecture for individual agents. However, this could be developed so as to uncover the generative mechanisms of the polity instability, failure and recovery after state failure which represent much-debated issues in the area of political culture modelling research.
Web Resources

MASON RebeLand

Presentation of MASON on its web page at url: https://cs.gmu.edu/~eclab/projects/mason/

MASON is a joint research project concerning the elaboration of a multi-agent software library for simulations of polity and society. To its elaboration have contributed the George Mason University (Laboratory for Evolutionary Computation) and the GMU Center for Social Complexity. The library has been designed and developed by: Sean Luke, Gabriel Catalin Balan, Keith Sullivan and Liviu Panait, with help from Claudio Cioffi-Revilla, Sean Paus, Daniel Kuebrich, Joey Harrison and Ankur Desai.

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The Compartmental Model (Lang and De Sterck, 2012) is a mathematical model which explains the emergence and unfolding of a revolution in an authoritarian political regime. The model is relevant for the type of polity modelling based on a structured representation of polity other than territorial (geographically situated). It models the issue of social media as a fundamental dimension of polity instability development.

Conceptual Aspects

The model defines a polity in terms which do not include a territory concept. In order to capture the essence of a dictatorial regime, the model suggests two of its fundamental characteristics: excessive coercion and abusive closure (i.e. interdictions of basic human rights). The definition is based on a minimal structure: government and society (Figure 20.1). The government component is meant to define a dictatorial regime in two characteristic terms: coercive force, which makes reference to the punitive capacity, and communications censorship, which makes reference to the interdiction of mass access to social media and communication technology, a fundamental characteristic of authoritarian regimes.

The model works on several simplifying hypotheses:

- (H1) the population is assumed to be homogeneous;
- (H2) the entire population desires regime upheaval;
(H3) growth and decay are modelled by step functions with fixed-valued thresholds and relationships; and

(H4) external influences have not been taken into consideration as dynamic factors.

The polity model, therefore, works with one main variable, the number of participants to the civil uprisings, and its associated dynamic variation process.

The process describes the dynamics of the participation rate to the insurgent wave: it is generated by the time variation of the variable $r(t)$ describing the fraction of the entire population, in number of participants.

The process actually describes the dynamics of the balance between the number of participants and the entire population, on the one hand, and between the number of participants and the number of governmental (punitive) forces, on the other hand. This balance is therefore highly sensitive to two coupled processes: growth and decay (Figure 20.2).
The process of balancing the increasing tendency toward insurgence of some (variable) part of the population by counteractions of the governmental forces reaches local and global equilibria points depending on the number of individual agents who are mobilized by protesters and governmental structure (police) respectively. The initial situation describes a polity as stable when the number of protesters is small such that their visibility is low (Figure 20.3). In this case the governmental forces control any insurgent action. Coercive control is mainly achieved by the number of punitive troops and interdictions of mass access to communication (social media and the like).

Increasing mass access to social media and the fast dissemination of insurgent ideas and incentive messages (Howard et al., 2011) stimulate the visibility of the insurgents (protesters) and stimulate the emergence of a stress phenomenon which weakens the polity resilience to insurgent tendencies: as the police forces become small compared with the number of insurgents (protesters), the governmental components defect such that it is impossible to exercise their function. As a major consequence, the polity becomes unstable (Figure 20.4).

The computational modelling version targeted a number of particular polity cases: Tunisian and Egyptian revolutions, and the polity instability under insurgence stress in Iran, China and Somalia.

The outcomes of the computational modelling describe the theoretical stereotype cases of polity stability/instability describing the degree of polity resilience to sources of increasing stress. Mathematical analysis of the outcomes reveals four main theoretical situations of particular relevance, which have been confronted with country case studies, as mentioned below:

- a stable police state is characterized by total state control over the insurgence phenomena (Syria case study);
- a metastable police state is characterized by global equilibrium of civil conflict such that the government still has state control and civil unrest is controlled by the insurgent forces (China case study);
• a pre-revolutionary state is characterized by local equilibria and could evolve in a particular range of possibilities between metastable, unstable and failed state situations (Tunisia and Egypt case studies);

• a failed state is characterized by the total loss of both state and civil conflict control (Somalia case study).

The model presents a detailed mathematical analysis of the computational outcomes of running the model for various values of the growth and decay parameters. Moreover, the results are tested against empirical evidence provided by other research, especially analyses in Howard et al. (2011) of social media use during the uprisings unfolding in Egypt and Tunisia. Testing them against strong empirical evidence collected by many authors and interpreted from various perspectives not only contributes to model validation and increases its reliability, but also suggests directions for further modelling, some of them being made explicit by John Lang and Hans De Sterck themselves. In spite of strong reductionism assumed by the authors, these results are interesting per se and consolidate the perception that any further polity modelling cannot avoid making reference to it.

The model answers several research questions which address general issues of major interest emphasized by the literature on Arab Spring and on the conflicts involving polity crises and state failure in many other geopolitical areas.

The first question concerns the relationship between the considerable size of the political change phenomenon known as the Arab Spring, triggered by a relatively
small part of the population which used social media as a means to get involved in the uprising. The model shows that a dictatorial regime which has full control through censorship of mass access to information and communication, and has customized its coercive capacity to high thresholds of visibility of civil uprisings, is likely to prove highly sensitive to shocks of relatively low strength. Such shocks could enhance the emergence of political change phenomena on a large scale (e.g. national, cross-national, cross-regional). Putting it in other words, social media influence in dictatorial regimes subjected to a high degree of stress in terms of civil conflicts may prove decisive in regime upheaval scenarios. In the Arab Spring case, for example, social media were used as a means to disseminate politically sensitive information, to enhance fast and efficient coordination of protesters and to support and stimulate the leaderless type of collective action (Beckett, 2012).

Another question addresses the issue of networked political change which involves social media and the new approach it emphasizes on empowering people. Though mathematical and computational polity modelling has illuminated some of the mechanisms of polity instability, the nature and role of these mechanisms are still unclear for general situations regarding the polity and not necessarily those involving conflict.

Open Questions and Closing Remarks

One open question, of course, concerns the political attitude phenomena. The others are relatively connected to this one but also involve fundamental research methodology issues derived from both political methodology debates and from the debates in the area of philosophy of science which are addressing the concepts of ‘mechanisms’, ‘process’ and ‘generative’ change paradigms involved in both social and political change phenomena modelling.

To a large extent, all the polity models presented in this chapter, with the exception of the *Compartmental Model*, are agent-based models. As already stressed in the emergentist literature about mechanisms and processes underlying social emergent phenomena (Sawyer, 2002, 2004a, 2004b, 2005), the methodological individualism paradigm and the bottom-up models are prone to approach the upward unfolding of structure emergence in political change phenomena, while the downward path remains largely not investigated or, at least, not properly investigated. The same happens to polity modelling, which suffers from the bias and limitations induced by agent-based modelling theories.

Political attitudes, by means of their structure and the mechanisms which are assumed to generate them, involve much of the generative basis of polity (in) stability: collective action, social networks and information processing are but a few of the aspects involved in polity dynamics which are fundamentally involving, presuming, generating (or being generated by) political attitudes. Briefly, political attitude computational and simulation modelling research will penetrate (if it has not done so already) polity modelling and simulation assisted by complex GIS data and models. Many of the cultural and environmental theories underlying the
generative mechanisms of civil conflicts as well as the mechanisms actually involved in the post-conflict sustainable polity (re-)construction which have been briefly discussed in this chapter are more indirectly than directly addressing the issue of political attitude formation and change. The new media and networking research have also revealed clues to new approaches on collective action studies (Barabási, 2013; Ghoshal et al., 2013).

Though not formalized as yet, this direction is apparently unavoidable as far as human action is presumed essential to each and every aspect of society’s and polity’s dynamics. This chapter, perhaps more than the others (but as much as the book itself), is meant to emphasize the essential roles that political attitude computational and simulation modelling play or should play in society and polity studies.

One role concerns the reinforcement of a paradigmatic shift in polity modelling toward political attitudes’ complex phenomena. Besides economic aspects, which undoubtedly play a major role in polity dynamics, polity modelling needs to take into consideration the political culture basis of emergent major political and social change phenomena: it is the political culture – that is, the complex milieu of political beliefs, attitudes and values – which could be employed in explaining, for example, political regime changes or transitions from autocratic to democratic regimes in Eastern Europe (Voinea, 2014). While advocated by some authors (Mishler and Pollack, 2003), political culture is as necessary in polity modelling as it is complex and difficult to model in a unitary complexity-based approach. It actually lacks a computational modelling approach, and this problem could be step-by-step covered by the ongoing research on political attitudes’ computational modelling.

The other one regards the contribution of the computational and simulation modelling of political attitudes to the reformation of political research methodology by facilitating the virtual experimental bases of the research on the dynamics of political change phenomena; that is, the study of democratic societies, the empowerment of people and the settlement of true participative democracies wherever they are supported and enhanced by life and societal standards.

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Part IX

EPILOGUE
Shaping New Science

The political attitude computational and simulation modelling research presented in this book provides a clue on the currently emerging discipline of Computational Political Science viewed already as the computational counterpart of Experimental Political Science inside the domain of political science. It is also viewed as the political science field of research equivalent to Computational Sociology in social sciences, or to Computational Economics in economic sciences.

Computational Political Science is provisionally defined as a political science complexity field of research. One of the goals of this book is to reveal the level of aggregation of a critical mass of conceptual and methodological knowledge and expertise in this field.

Why Would Political Attitude Computational Modelling Be Important?

Computational modelling of political attitudes might play a particularly relevant role in the aggregation and foundation of a computational political science domain. The reasons concern political attitudes’ powerful recurrent and recursive characteristics. The hypothesized relationship between recurrent political phenomena and the micro–macro dynamics of a polity setting is of major importance; such phenomena are complex enough to provide for both the emergence of structure and the emergence of order. This enables them to play a decisive part in the theory building of the currently emerging computational political science.
While *Experimental Political Science* has successfully tasted a century of monopoly over the analytical tools and methodologies, its computational counterpart is still in need of defining and configuring its specific impact over the political science domain, and also of acquiring a body of concepts, theories, methods, techniques, results and performances. These issues are currently open to debate.

As one general goal, political attitude computational and simulation modelling aims to explain political change phenomena in their very complexity. Political attitude change modelling brings forth some fundamental issues, like the modelling of context-dependent dynamic change in behaviours, beliefs, values, preferences and choices.

The conceptual basis combines concepts and theories from various areas of psychology, social psychology and political science (i.e. political psychology, electoral campaigns, candidate evaluation, voting behaviour, political information processing, political communication, political reasoning, judgment, thinking and cognition) with the concepts and theories in modelling and computer science and in the sciences of the artificial (i.e. artificial intelligence, artificial life, artificial agent systems and artificial societies and polities).

There is a double paradigmatic coverage, which includes almost everything from behaviourist to cognitive modelling paradigms, and from linear to nonlinear and chaotic mathematical and computational modelling paradigms. The methodology includes, in the first place, a wide variety of mechanisms and processes described in psychology, social and political psychology. This scaffolding finds operational support and expression in the various classes of mechanisms and processes used in computational modelling. During its historical development, the computational modelling of political attitudes has employed various modelling technologies, mostly the technologies of the artificial. Many of them are based on AI theories and methods, like knowledge representation, learning and memory use or information processing. Many others are based on ALife theories and technologies, like cellular automata, agent-based systems, artificial societies and artificial polities. Both types of technologies are used in computational model building and simulation. However, the model’s performance has always been dependent on the technology choice, and this is the reason why particular modelling goals demanded appropriate technologies for achieving outcomes described by the social–psychological theoretical or experimental settings.

The philosophy behind the modelling approaches and the interpretation of the outcomes obtained have themselves come a long way from the early ideas of testing the modelling results against empirical data in order to improve the model (theory improvement) toward the latest ideas of generating data in order to obtain modelling results which converge to new theory (theory building). While early modelling research was essentially based on empirical data and actually ‘translated’ an empirical model into mathematical formalism, the latest models build upon powerful simulation components to achieve believable replication of the political attitudes emerging or changing in particular social settings. This mapping could not have been as valuable as it is without approaching political attitude modelling against a political culture background. Though rational choice theory as well as the affect-based theories have provided for relevant support to most advances in political attitude computational modelling research, the picture would not be complete without the
fundamental aspects introduced by adopting the political culture theoretical perspective. Formation and change of political attitudes could hardly be modelled without taking into consideration their deep connections to political beliefs and ideology, values and norms, behaviours and interactions. Before going any further with our presentation, we should take a brief look at this, too.

By accumulating a critical mass of modelling expertise, instruments and experimental results, the computational models of political attitudes proved useful in bringing forth relevant issues, orientations and paradigms of research. As distinct from the rational choice modelling approaches, political attitude computational modelling introduced a slight but constant complexity perspective over the dynamics of polity and society: it includes systematically methodological, experimental and theoretical concerns with regard to its associated elements of political culture, like political beliefs, values, norms and behaviours. Emergence and self-organization outputs of computational and simulation models prove that political attitudes are perhaps a consistent start toward achieving integrated models of political culture items (i.e. ideologies, values, norms, behaviours), which could be expected to provide for more believable, though a lot more complex, explanations of political and societal dynamic variability phenomena.

Experimental Versus Computational Political Science

There is a short but rich history of political attitude computational modelling research: the elaboration of the computational models spans the second half of the twentieth century, while the beginning of the twenty-first century has been dominated by the simulation type of approach. The issue has been gradually absorbed into a wider and a much more sophisticated perspective that includes beliefs, values, norms, symbols, images and rituals, and other political culture aspects (ideology, preferences, choices) which have produced altogether a ‘hard-to-define’ blend.

The differences between experimental and computational political science are many, and not all of them have been analysed in a systematic way.

The first difference, of course, arises from their separate histories: while Experimental Political Science was born at the beginning of the twentieth century, its computational counterpart is of later reference. The pioneers of this paradigm introduced it around the mid-1950s. It has, ever since, grown up as a heterogeneous collection of modelling approaches. Its genuine heterogeneity has lately faced a strong structural challenge, which mirrors research systematic tendencies or sustained scientific investigation dimensions. Its conversion toward a new scientific field within the ambit of political science is nonetheless in its infancy, and the best argument we have so far to sustain this affirmation is its lacking a unanimously agreed definition and a clear delimitation of its theoretical and/or experimental area of concern.

The second difference concerns their aims: both are aimed at explaining political phenomena. However, Experimental Political Science has characterized itself as being fundamentally concerned with the causality-based explanation, while the (presumptive) Computational Political Science, in spite of lacking a description of its domain and goal, is rather concerned with a complexity view upon explanation.
The third difference concerns their research methodologies; that is, *Experimental Political Science* is based on empirical data and analytical instruments, while *Computational Political Science* includes several methodological dimensions: One is the classic mathematical model which is further transformed into a computer program and tested against huge amounts of experimental data and employs highly specialized computations. The other one is the simulation-based modelling, which reproduces the target (real) phenomenon in the virtual media by means of virtual mechanisms and processes able to “mimic” or to achieve a believable version of the real phenomenon.

The transfer of political attitude expertise and focus from electoral to political culture studies has transformed this body of research into a truly promising way to contribute (and, hopefully, properly define and achieve) a *Computational Political Science* as the complexity counterpart to the already classic, by now, *Experimental Political Science*.

Political attitude computational modelling bears the signs of a true component of a new discipline as it carries a set of basic concepts, specific methodology and convincing results.

**Diversity and Convergence: Current Research Trends**

Quite often during the past decade, the term ‘computational political science’ has been used to denote various kinds of computational modelling approaches of the different issues in politics and political science areas covering almost every field from political behaviour to political cognition. Particular conceptual and methodological developments in areas of computational modelling research, like the computational modelling of political attitudes, prove strong ties to the computational modelling of political information processing, political cognition or political ideology. This seems to offer support to one of the background ideas of this book that all these ‘niche’ research topics might converge toward some covering domain and could finally coagulate, along with several connected areas, as ‘Computational Political Science’.

However, the diversity of modelling approaches requires at least their classification if not an explanation of this fast-developing phenomenon. We thus discover that content-based analysis of political discourse, sentiment analysis of voting preferences and choices, or political attitude change are viewed as virtually belonging to the same class of methods used for employing computational-based and simulation-based computer and ALife or AI technologies in the development and testing of modelling studies. Other connected areas include the following:

The computational modelling of influence in political online public conversations is approached by Philip Resnick (2014) as a dimension of computational political science. It concerns political debates in electoral campaigns. Another dimension of research in his view might concern real-time polling and the computational modelling of sentiments.

Computational modelling based on web technologies allows for content-based analysis and content-based reconstruction of political attitude dynamics employing
both sentiment analysis and graphic and video analysis of the public discourse (Voinea and Schatten, 2015; Schatten, Ševa and Okreša-Đurić, 2015).

Computational politics (Tufekci, 2014) is another kind of approach, addressing the use of digital technologies in the design of media and methods of massive latent big data collection. If combined with computational modelling technologies, this approach offers support to persuasion campaigns and political engineering by influencing or manipulating attitudes of large publics in political situations or with regard to parties, candidates and electoral campaigns.

Still another type of approach is represented by political engineering of parties and party systems (Reilly, 2003, 2006) and electoral engineering in conflict-prone societies (Reilly, 2001).

Each such issue deserves separate, extensive approach.

As far as politics and political science is concerned, all these issues, though very diverse, seem to converge toward a common area of study: they target the behaviours in mass publics by computational modelling their ideologies, attitudes, beliefs, values and norms. Or, to put it in a nutshell, their political culture. Computational modelling of political attitudes is just a part of the endeavour of studying all these issues in a united framework. Though its complexity is overwhelming, it cannot be avoided.

This is why extant political attitude computational modelling research is important: it dares to identify paradigms, to aggregate modelling approaches and to build up integrative frameworks. It thus shows the way ahead.

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