Edited by
Leroy White · Martin Kunc
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Behavioral Operational Research

A Capabilities Approach

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Foreword

Students of OR, analytics, data science, and related disciplines are traditionally taught a range of modeling approaches that assume rational and perfect decision-makers and environments. Whilst this naturally permits for a more straightforward understanding of fundamental techniques and on how to find optimal policies, little attention is typically given to the role people play in these models. Likewise, practitioners applying OR techniques may fail to consider human behaviors in distinguishing between what traditional OR models might deem 'optimal' solutions versus practical solutions and how, for example, humans react to change. Consequently, policy makers may well reflect on why the suggested solution to a problem did not play out as expected when implemented in practice.

Experiments and theory in fields such as psychology, economics, and finance increasingly recognize aspects of individual behavior such as decision-making heuristics and biases and adaptations, bounded rationality and misperceptions of feedback affecting the results from quantitative models. Additionally, attributes of human behavior both shape and are shaped by the physical and institutional systems in which they are embedded. Behavioral issues in decision-making are now more widely studied at the individual, group, and organizational levels by judgment and decision-making, cognitive psychology, organization theory, game theory, and economics. OR can certainly learn from these fields, embrace their understanding, and work collaboratively; hence the rise of interest in Behavioral Operational Research (BOR) is entirely a natural consequence and a most welcome scientific endeavor.

This book, "*Behavioral Operational Research: A Capabilities Approach*", is a timely addition which builds on the authors' previous acclaimed book "*Behavioral Operational Research: Theory, Methodology and Practice*". With this new edition, the authors continue to further develop the ideas and concepts underpinning BOR, as well as raising new opportunities such as 'human-in-the-loop' approaches given the global trend toward automated decision-making. The book promotes reflective thinking around modeling characteristics and present-day issues for OR researchers and practitioners, and continues to challenge and help reframe our approach to modeling of processes and systems.

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Preface

The opportunity to use insights from the behavioral sciences in a wide range of areas and subjects has become increasingly popular over the last few years: from public policy issues, such as smoking cessation, to facilitating the productive and happy worker show the significance and reach of some the basic ideas. Operational Research (OR) is no exception. In 2016 we sought to examine whether the underlying concept of Behavioral Operational Research (BOR) is a fad or something novel. Since its publication in 2016, our edited volume *Behavioral Operational Research: Theory, Methodology and Practice* has continued to stimulate debate as to the unique contribution of BOR and the thinking behind the nascent subject has steadily matured. Given the crescendo of interest, we have decided to compile a follow-up book comprising a collection of new articles which, we hope, would further develop the ideas and concepts underpinning BOR.

As with the first book, we argue that OR is more than modeling and/or interventions. With this new edition, we thus seek to contribute further to understanding the relationship between models and behavior. We also hope to raise new opportunities. In particular, we are even more aware of the discrepancies between model behavior and real-world actions with the rise of automation of decision making, which constitutes a fundamental problem for OR. We build on the 'simple logic' of the first book of behavior *with, in* and *beyond* models by covering this time behavior *with(in)* and *beyond* models. This slight shift in emphasis hopefully creates room for more reflective thinking around modeling characteristics and issues that are ever-present for OR analysts and researchers. We hope, with this simple logic, we will show how BOR operates at the inter-disciplinary frontiers, with chapters that integrate traditional OR with diverse contributions from a range of behavioral and OR fields. This supports the suggestions of other BOR academics that behavioral OR appears to be an increasingly inter-disciplinary field and which may well be indicative of progress toward the return to the origins of the profession with OR teams that integrate multiple types of expertise. The challenge thus arises how to orchestrate existing competences and capabilities in new ways for OR approaches and practices.

What is also new in this volume is our thinking has evolved to consider the capabilities and competences that enable OR practice and theories to provide sustained improvements to decision processes and systems taking into account the impact of individual and collective behavior. Thus, the central premise of this book is a focus on the ways in which OR practitioners as model-builders, as facilitators of modeling processes, and as users of models deal with incomplete and imprecise information, subjective boundaries, uncertainty and iterative learning processes in support of the organizational problem-solving resources and decision making practices. This focus on capabilities and competences will not only meet short-term requirements for modeling and OR but also build a solid foundation for future research and initiatives. This book will, therefore, present a range of up-to-date research and practices in BOR, focusing on competences and capabilities.

While the words competence and capability are often used interchangeably, we make some distinctions. At an individual level, competence is another word for an individual's know-how or skill, whereas capability refers to a person's opportunity and ability to generate valuable outcomes. At an organizational level, an organization's core competences include collective skills and expertise, whereas capability is a dynamic feature, faculty or process that is being developed or improved.

Capabilities, conceptualized as processes in the most general sense, thus have a key role in continuously changing the competence base. Moreover, the connection between OR processes and capabilities has not yet been adequately expressed. This book aims to address the need for conceptualization and operationalization of the different aspects of the engagement process.

Another underpinning thesis of the new book is that, from a BOR perspective, there is a great deal of conscious processing (e.g. the mathematical aspects of the subject) and that there is, perhaps, a great deal of unconscious processing in the behavioral elements that we use without necessarily realizing or giving credence to. Prior research has often, simplistically, equated unconscious processing with bias, and explicit processing with normative correctness, achieved through a capacity for abstraction. However, new perspectives in behavioral research suggest that many implicit responses appear as intelligent solutions to context-specific problems and may be more successful than those generated by the application of formal rules. Hence, implicit-intuitive thought is acquiring a more central position in interaction with explicit thought, such that much of our theorizing about human reasoning competence needs to be reconsidered. We thereby hypothesize that by acknowledging the unconscious competence or capability BOR academics and practitioners can fully exploit the subject to enable people to the best possible decisions.

The book includes contributions by researchers and practitioners interested in OR and behavior bringing to be some convergences, divergences and controversies across a range of behavioral OR issues. It illustrates that our contributors, while building on a rich history of approaches to OR, are happy to interplay with other levels of inquiry to inform much of the new discipline of BOR. Relevant contributions appear to be the advancement of decision analysis, e.g. Multi-Criteria Decision Making, with the help of growing knowledge about biases, e.g. in relation to expert elicitation processes. Moreover, design sciences and project management appear relevant for some BOR approaches in practice, advancing debates on organizational learning in uncertain times.

To provide sustained decision support, BOR practitioners and approaches need to harness the cognitive and emotional capacities of individuals and groups to blend deliberate, conscious, and effortful forms of analysis with the skilled utilization of unconscious, intuitive, implicit reasoning processes. The simultaneous demands for unconscious search/problem framing and conscious explicitly rational problem-solving create a dynamic where efficiency, selection and implementation need to be balanced with variation, experimentation and discovery. However, to date, little guidance is available to practitioners about ways to learn in, from and with practice to blend competences and capabilities for efficacious decision support.

One question remains to be addressed: what is Behavioral Operational Research? A simple definition of BOR could be that it is the *study of the effects of psychology, cultural, cognitive and emotional factors on our thinking and action with the use of (advanced) analytical methods and/or model, to solve complex problems, support perplexing decisions and improve our ever-changing organizations*.

The book is structured around four key domains of BOR drawn from holding two dimensions together, i.e. *competence-capability* and *with(in) models-beyond models*. Fig. 1 illustrates the conceptual distinction between competences (the ability, knowledge, skills, needed to do something well) and capability (person's opportunity and ability to generate outcomes).

The book is formed of four parts, each exploring one of these areas.

Part I explores *Competences With(in) Models*, i.e. the technical skills of BOR experts and the technologies that are considered relevant to support decision processes with OR approaches, including methodological advances in Multi-Criteria Decision Analysis (MCDA) and experimental BOR, such as behavioral economics and hard BOR. Chapter 1, 'Behavioral Operations and Behavioral Operational Research: Similarities and Differences in Competences and Capabilities,' offers insights into which Behavioral Operations Management (BOM) competences can benefit the BOR practitioner. The next three chapters address different technical skills associated with managing the impact of heuristics and biases on normative models. Chapter 2, 'Behavioral Implications of Demand Perception in Inventory Management' describes an experimental approach to understanding biases in the newsvendor problem. Chapter 3, 'Behavioral Operational Research in

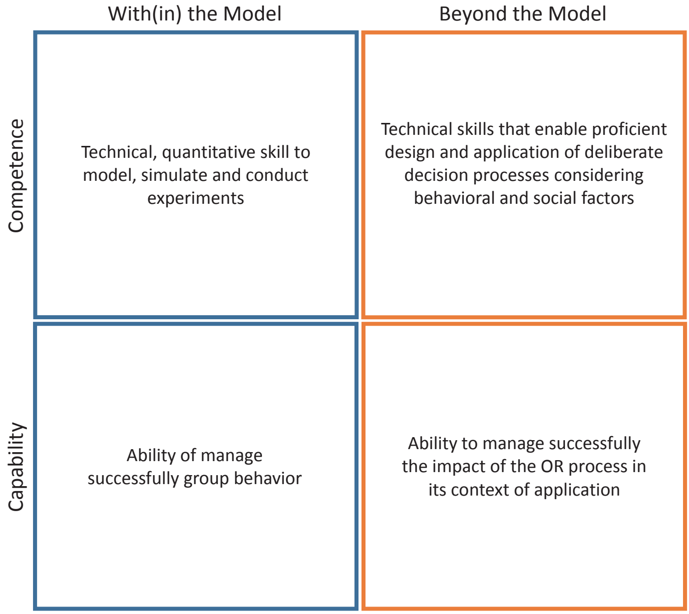

Fig. 1 Four key domains of behavioral operational research

Portfolio Selection' considers the attitudes to risk and biases of financial stakeholders and Chapter 4, 'Feedback, Information Representation and Bidder Behavior in Electronic Auctions' provides insight into how bidder behavior can be incorporated in models. This part considers the purposeful, explicit and deliberate application of technical and learnable skill, i.e. competence applied with(in) models to decision problems, ranging from experimental methods to mathematical modeling.

Part II: *Competences Beyond Models* provides five chapters looking at how expertise in specialist techniques enables the greater quality in scientific decision support, including how to overcome or incorporate knowledge of biases, ambiguity and uncertainty. The focus is on how skilled BOR experts can develop the technical competences that enable the proficient design and application of deliberate decision processes to harness and mitigate against the unconscious competence of participants. In Chapter 5, 'Probability and Beyond: Including Uncertainties in Decision

Analysis' considers how to leverage opportunities for decision aid in deep uncertainty by drawing on the creative potential of modelers. Chapter 6, 'How to Use Ambiguity in Problem Framing for Enabling Divergent Thinking: Integrating Problem Structuring Methods and Concept-Knowledge Theory' explores how to use the unconscious competence of practitioners and Chapter 7, 'Insights from an Initial Exploration of Cognitive Biases in Spatial Decisions' offers a literature review of spatial Multi-Criteria Decision Aiding to highlight the issues that modelers face when human judgment is involved. In Chapter 8, 'Modeling Human Behaviors in Project Management: Insights from the Literature Review' also presents a review of other research offering how BOR insights can help improve project managers' capabilities. The final chapter in this part, Chapter 9, 'Exploring the Machinery for Calibrating Optimism and Realism in Transformation Programs: A Practical Toolkit' provides a practitioner view on how to manage bias in transformation projects.

Part III: *Capabilities With(in) Models* addresses the skills required to understand group behavior in the modeling process. Chapter 10, 'The Importance of Human Behavior in Practice: Insights from the Modeling Cycle' considers the various behavioral factors that need to be considered throughout the modeling process and Chapter 11, 'Developing Problem Structuring Capability: A Practice-Based View' theorizes the efficacy of problem structuring interventions with the help of social practice theory. The next two chapters examine the role of stakeholders in the modeling process; Chapter 12, 'Stakeholder Behavior in Operational Research: Connecting the Why, Who, and How of Stakeholder Involvement' considers how to best manage and involve stakeholders, providing insight into different rationales for engagement. Chapter 13, 'Lessons Learned: Acquiring Insights from Non-Operational Research Perspectives', studies the contribution of prior work on Participatory Rural Analysis for OR and provides a view from an anthropological perspective into the role of local people in projects. The final chapter in this part, Chapter 14, 'The Merits of Transparent Models' argues the case for models that can be easily understood by the non-expert.

The final part of the book, *Capabilities Beyond Models*, offers a variety of chapters, including from practitioners and non-OR academics, which provide insight into the skills that BOR practitioners need in order to manage the process of an OR project. Chapter 15, 'Achieving a Balance Between Behavioral Theory and Behavioral Practice in Transformation Projects' offers a case study into how different stakeholder needs must be balanced in order to deliver successful transformation. Chapter 16, 'Conjoined Capability, Collective Behavior and Collaborative Action: What's the Connection?' also provides a case study of how to best achieve collective group behavior. In Chapter 17, 'Behavioral Aspects of the New General Data Protection Regulation: A Consumer-centric Approach to Operations,' the issues of customer behavior and the impact on the organizations collecting data are explored. Chapter 18, 'How Do We Know Anything? Philosophical Issues in the Collection and Interpretation of Operational Research Data', considers the challenges that are faced when collecting data and concludes with a rallying call for BOR practitioners to embrace the philosophical principles of behavioral science without which BOR projects will fail. Finally, Chapter 19, 'Future Directions' reflects on the learning points of the book and asks what the future holds for BOR.

We hope that this book offers relevant ideas for (B)OR practitioners and at the same time develops a collaborative research agenda, encouraging us to further develop our joint capabilities in understanding human behavior in decision practices. Our aim has been to curate a book that appeals to both academics and practitioners and that provides a useful resource for anyone coming to the subject of Behavioral Operational Research. We have deliberately kept the level of mathematical preparation to a minimum, as we also hope that the book appeals to researchers from other disciplines.

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Southampton, UK	Martin Kunc
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Any edited collection is only possible through the combined efforts of the contributors. It has been our privilege to work with an extremely exciting group of researchers and practitioners in putting together this book. We have learned a great deal from working with them and it has been our pleasure to have done so.

This book has only been possible through the continued support of our own institutions, and we are grateful to all four institutions for the support they have provided. We are also appreciative of the support that a number of other organizations have afforded us, not least the Operational Research Society, UK, for continuing to promote behavioral sciences in OR.

We are indebted to Palgrave, and the many individuals we have liaised with, for the opportunity to develop this book.

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Part I

Competences Within Models

1

Behavioral Operations and Behavioral Operational Research: Similarities and Differences in Competences and Capabilities

Martin Kunc

1.1 Introduction

The research focus in Behavioral Operational Research (BOR) is mainly related to facilitation for model building and communication of model results when Operational Research (OR) practitioners are supporting human problem solving by modeling. Research seems to be limited to and for specialists in OR modeling (mainly Soft OR models) and focused on process design and facilitation without understanding the purpose of the approaches within organizational contexts. On the other hand, Behavioral Operations Management (BOM) seems to mostly focus on the impact of behavioral factors on the solutions to problems within organizational contexts. Is there a possibility that BOM can enhance the practice of BOR? This chapter aims to explore this question.

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1.2 Behavioral Operations Management: A Short Literature Review

This section presents a brief analysis of the field of Behavioral Operations Management with some interesting insights. For more exhaustive analysis, see Bendoly et al. (2006, 2010), Bendoly and Schultz (2006), and Loch and Wu (2007). Firstly, like BOR, there are different definitions of BOM. On the one hand, Gino and Pisano (2008) define "behavioral operations as the study of attributes of human behavior and cognition that impact the design, management, and improvement of operating systems, and the study of the interaction between such attributes and operating systems and processes." They assert that BOM should employ concepts from social, which recognize the impact of groups, social norms, and systems as well as organizations on operations, and cognitive and psychology theories, which reflect how the properties of individuals impact on operations. On the other hand, Croson et al. (2013) suggest "behavioral operations as the study of potentially non hyper-rational actors in operational contexts." They consider the role of bounded rationality within operations, but they do not advocate for specific theories like Gino and Pisano (2008). However, both papers share similar constructs: the importance of the context, operations, and behavioral aspects of decision making.

In more detail, BOM and traditional Operations Management share the same goal: the design, management, and improvement of operating systems and processes. Croson et al. (2013) suggest three criteria characterize the actors in traditional Operations Management: (1) motivated by self-interest expressed in monetary terms; (2) acting consciously and in a deliberate manner; and (3) optimizing a defined objective function. On the other hand, BOM focuses on deviations from any of the three criteria through the application of behavioral theories. However, the application of behavioral theories is not aimed at getting a deeper understanding of leadership, fairness, emotions or motivation (Croson et al. 2013) or modifying cognitive and behavioral theories. The application of behavioral theory originates from the initial consideration of human behavior as a second-order effect, rather than first-order effect, in operations (Gino and Pisano 2008). For example, normative models in traditional Operations Management, such as inventory or scheduling, assume decision makers and agents in the system are rational but operating issues involve groups of people with various skills and organizational responsibilities so cognitive and behavioral aspects shape how people behave differently than hyper-rational actors.

The value of BOM lies in recognizing that almost all contexts studied within Operations Management contain people that do not behave following normative models (Croson et al. 2013). Therefore, BOM starts at a micro-level to make better recommendations of how to design and improve processes. Given the deviation from a mechanistic and rationalistic view of the organization, BOM mostly has an empirical focus testing Operations Management theory for their robustness in laboratory and real world.

However, there are researchers who suggest BOM's perspective is flawed as they use mainly one view of decision making, where heuristics are liabilities because they lead to deviations from normative models based on economic rationality (Katsikopoulos and Gigerenzer 2013). Katsikopoulos and Gigerenzer (2013) suggest there are situations where heuristics are useful for better decisions. Their program of research called *fast-and-frugal-heuristics* evaluates heuristics not according to logical norms but according to performance in the ecology of real-world decision problems.

1.2.1 The Focus of BOM Research

BOM has been usually associated with experimental research (Katok 2011) but recent research practices involve a wider set of methodologies and the identification of heterogeneity at individual level, e.g. gender and risk preferences (Croson et al. 2013). Additional methodologies are experiments using games (e.g. the Beer Distribution game in a controlled laboratory setting to evaluate impact of advance warning of disruptions; see Engin and Vetschera, Chapter 4) or decision task (e.g. systematic variations of operational tasks and scenarios involving operational decisions), modeling and simulation, surveys, archival (e.g.

service time from supermarkets), biometric research (using information from capturing body movements), psychometric research, and qualitative/conceptual studies.

Finally, there is diversity of behavioral content in terms of theoretical perspectives employed in BOM. Some of them are related to Behavioral Economics (e.g. *prospect theory*, *reference point*, heuristics and biases, and strategic behavior affecting queuing, ordering, pricing) and some perspectives associated with Organizational Behavior (e.g. social preferences, emotions, culture). The adoption of different perspectives is an important evolution in BOM compared with its beginnings where the focus was on identifying gaps between theoretical models of what should happen and what did happen in reality (Croson et al. 2013). Examples of these approaches are observed in Önkal et al., Chapter 2 of this book, as they focus on behavioral effects such as *pull-to-center* and Engin and Vetschera (Chapter 4) who observed the impact of information feedback effects.

1.2.2 The BOM Focus on Operational Contexts

The scope of BOM has been broadening in recent years (Croson et al. 2013). The original papers in BOM mostly focused on inventory, more specifically the ordering policy by relaxing newsvendor models (see Önkal et al., Chapter 2, for an example), or on supply chain settings, by using the Beer Distribution game. However, the operational issues studied in BOM have broadened together with the journals (Bendoly et al. 2006). Nowadays, applications encompass supply chain issues such as contracting or supplier relationships, product development issues such as ideation and design decisions, quality issues such as error detection (Croson et al. 2013). Other areas are forecasting (e.g. issues on how optimistic forecasts affect inventory management), production (e.g. a behavioral study of the implementation of just-in-time), service (e.g. issues such as the impact of *social loafing* on servers when they have pooled queues, the impact of the last place in queues, service selection through the use of anecdotes and other social information when consumers do not have enough information, and the effect of feedback on workers' effort allocation), risk management (e.g. learning operational risks through benchmarking rather than using probabilistic methods) in financial operations such as portfolio selection (see Momen, Chapter 3), and project management (e.g. abandonment decisions on multi-stage projects) (see Wang et al., Chapter 8).

1.3 Behavioral Operational Research: A Short Literature Review

OR is "the application of analytical methods to help make better decisions." In practice, however, the application of analytical methods is often not sufficient: a theoretically optimal solution obtained from an OR model is often not practical or becomes irrelevant by the behavior of the user of the model or the people who may be influenced by the decisions resulting from the model. The previous book on Behavioral OR compiled by these editors (Kunc et al. 2016) provided a framework, for academics and practitioners alike, to demonstrate the connection between behavior and OR modeling. A more formal definition of Behavioral OR (BOR) proposed in the current book is: "The study of the effects of psychology, cultural, cognitive, and emotional factors on our thinking and action with the use of (advanced) analytical methods and/or models to solve complex problems, support perplexing decisions and improve our ever-changing organizations" with the focus on how behavior is included in models, how people behave with models and how behavior is influenced by the model. At the core of BOR is the concept of *models* that connect the practice of OR modeling with the realm of organizational activities: problem solving and decision support systems.

The context for BOR applications is wider than the context for BOM. However, BOM has a more defined field because operations, as a set of organizational activities, has dimensions that are more discernible than problem solving or decision support systems as in the case of BOR. On the other hand, BOR shares similar appetite with BOM for the use of diverse theories such as psychology and economics to represent individual behavior. However, BOR uses these theories for uncovering how behavioral factors affect the development and use of OR models.

1.3.1 The Focus of BOR Research Practices

Franco and Hämäläinen (2016) propose a framework for organizing empirical BOR studies. In this framework, BOR research focuses on *OR actors*, such as expert modelers, decision analysts, consultants, users, etc., *OR methods*, e.g. mathematical programming, simulation, etc., and *behavior in the OR actors* during the process. In other words, BOR is closer to the work of consultants and analysts than managers and workers, as in BOM.

BOR comprises three behaviors associated with the outcome of OR processes: behavior in models, behavior with models and behavior beyond models (Kunc et al. 2016). The first area evaluates the representation of human behavior. Human behavior can be included in OR models in many different ways depending on the assumptions of the modelers (Greasly and Owen 2016). Table 1.1 presents different perspectives used to include human behavior in OR models and most common OR technique under each perspective.

The second area relates with the use of models for decision making, what information is used and how it is processed (Katsikopoulos 2016). Decision makers have different psychological capacities, do not necessarily use all available information and employ simple computations (Katsikopoulos 2016). Therefore, users may not use the model as an OR expert but there may be changes in the users' behavior still. For example, one dimension to consider is changes in cognitive functions, such as an increase in the number of options considered, occurring by using an OR model in a real setting (e.g. Kazakov and Kunc 2016) or through laboratory experiments (Arango et al. 2016). Another dimension is the impact of using a model on the behavior of a group such as affective or cognitive conflicts between members (Huh and Kunc 2016). Table 1.2 displays a summary of this position.

The final area of study in BOR is the behavior of the organization using the lens of the socially situated nature of OR practice (White 2016).

Table 1.1 OR modeling perspectives to consider when including human behavior

Approach taken to represent human behavior	Description	Representation of human behavior in the model	World view of the OR modeler	OR technique (examples)
Simplify by not including any behavior	Eliminate human behavior by omission, aggregation, and substitution	No representation or subsumed in one variable, e.g. random	Optimization	Mathematical programming
Externalize from the model	Incorporate human behavior outside the model by allowing decision makers interact with the model	Since behavior is too complex to codify, it is recorded empirically from real decisions	Gaming; Naturalistic decision making	Management flight simulators Experiments using models
Incorporate as a passive current	Model humans following similar rules without any difference	High-level variables represent average human behavior	Continuous process over long term	Continuous simulation System Dynamics Markov models
Incorporate as individual entities	Model human as a discrete entities such as machines	Discrete processes capture b variables inside the model	Discrete particles controlled by rules	Discrete Event Simulation
Incorporate through activities	Model human performance in tasks	Output variables inside the model	Actions are response to pre-defined sequence of tasks	Discrete Event Simulation
Incorporate as free individuals	Model individual human behavior with all its complexity	Micro-level variables inside the model represent states and process of change	Specific attributes of behavior are presented individually and emergent from interactions with other humans	Agent-Based Simulation

Source Adapted from Table 1. Kunc et al. (2018)

Table 1.2 The impact of OR models on decision makers' behavior

Behavioral change in:	Description	Representation of human behavior	OR technique (examples)
Heuristics	Use of heuristics under different interactions with the model	Elicitation of heuristics and their consequences	Decision analysis
Cognition	Change of mental models Better understanding of complexity	Elements of mental models (variables, causal links)	System Dynamics Cognitive mapping
State of mind	Change in the state of mind is associated with two categories of conflict: functional task-related conflict (e.g. cognitive conflict) and dysfunctional emotion-related conflict (e.g. affective conflict)	Level of conflict	Problem structuring methods

Source Adapted from Table 2, Kunc et al. (2018)

Table 1.3 The impact of using OR models on organizational behavior

Organizational behavior change expected	Description	Representation of collective behavior
Interpreting/ integrating	Interpreting is a process of explaining an insight or idea to others	Language
		Dialogue
	Integrating is a process of developing shared understanding and taking coordinated action through mutual adjustment	Storytelling
		Shared
		Observations
Institutionalizing	A process of routinization where tasks and actions are specified together with organizational mechanisms to embed the learning	Systems
		Procedures
		Structures

Source Adapted from Table 3, Kunc et al. (2018)

Since OR models do not prescribe action, differently than BOM, this area of study intends to evaluate the externalization of the inclination to act after using models (White 2016). From an organizational learning perspective, the model can help to institutionalize routines, rules, or procedures (Crossan et al. 1999). Table 1.3 provides a summary of this area.

The next section attempts to compare the competences required for BOM and BOR in terms of similarities and differences.

1.4 A Comparative Summary of BOM and BOR

The aims of the practice from both fields differ substantially as BOM is concerned with operations whereas BOR is concerned with only problem solving or supporting decision making. Therefore, the scope is more contextualized for BOM, as it involves design, implementation, and improvement of operations, compared to BOR. However, BOR focuses on qualitative (soft) and quantitative (hard) models while BOM only on quantitative models. Given the focus on practice, BOR is more eclectic on the theories employed to address behavioral aspects suitable for addressing the OR modeling process. On the other hand, BOM is limited in their theoretical sources given the strong interconnection between traditional operations management normative theories with the field of economics. In terms of methodologies, there is an overlap on experimental research methods but the experimental design diverges: BOM focuses on variations from normative models while BOR focuses on exploration of practices with behavioral lenses. However, BOM employs more research approaches to evaluate the impact of behavior because the context involves activities, resources, actors, and decision makers. BOR, with its focus on modeling, can only use research methods associated with processes, e.g. action research and case studies. Finally, the stakeholders are completely different due to the type of work evaluated. Table 1.4 presents a summary of the main aspects considered for BOM and BOR.

Table 1.4 Differences and similarities between BOM and BOR competences

Aspect considered	BOM	BOR
Aims of the practice	Detecting deviations from normative theories related to the field of operations management	Understanding and embedding behavioral aspects in the practice of Soft and Hard OR modeling related to problem solving and decision support in any organizational area
Scope	Typical activities in operations: inventory management, production management, service management, product development, quality management, procurement and strategic sourcing, and supply chain management Core area: operations	The practice of developing OR models (both soft and hard) for different organizational contexts and type of problems (strategic, tactical, and operational) with the focus on behavior in models, behavior with models and behavior beyond models Core area: models
Behavioral theories applied	Behavioral economics Organizational behavior	Bounded rationality Group dynamics Organizational behavior
Methodologies	Experimental Surveys Modeling Datasets Biometric and psychometric research	Action research experimental
Stakeholders	Managers/workers	Consultants/analysts

1.5 Comparative Examples of BOM and BOR Research Practices

This section presents two studies published in academic journals to highlights the competences employed by BOM and BOR practitioners through two examples. Table 1.5 presents a summary of the findings from the two studies.

1.5.1 BOM Competences in Practice (Moritz et al. 2013)

Research on how people make inventory decisions has provided with interesting evidence on behavioral decision making related to newsvendor decisions. People tend to follow an average response between average demand and profit-maximizing optimal quantity. Additional research has tested these average responses by influencing subjects' available information or reflecting environmental conditions such as experience, training, partial demand, etc. In this study, the authors intended to evaluate causal factors explaining the individual variations observed

Table 1.5 Similarities and differences between BOM and BOR competences in the studies discussed

Aspect considered	BOM study	BOR study
Aims of the research	Detecting deviations from the optimal decision in a newsvendor model	Understanding behavioral aspects of CEOs engagement in modeling to support their strategic decision
Scope	Only inventory management Core area: operations	The practice of developing OR models (both soft and hard) with the focus on behavior with models and behavior beyond models Core area: strategy
Behavioral theories applied	Cognitive reflection	Cognitive structures (mental models)
Methodologies	Experimental	Action research
Stakeholders	Managers/workers	CEO/consultants

in previous empirical works because they argued that previous research reported average results implying homogeneity in the subjects while subjects are heterogeneous.

The authors employed evidence from research in cognitive psychology and consumer behavior to justify the need for evaluating individual variance in newsvendor-type decisions. More specifically, they used the concept of *cognitive reflection*, as measured by the Cognitive Reflection Test (CRT), to evaluate behavior and task outcome. They employed three experimental studies varying the conditions and subjects, e.g. experienced decision makers and students. Study 1 comprised experienced supply chain managers and analysts. Study 2 with three different conditions employed students from a business school. Study 3 used another set of professionals with a different condition than in study 1.

The basic theory tested is the newsvendor model, which is dated from 1888. This model assumes that a decision maker needs to define an order quantity to satisfy stochastic demand in a single period. The decision maker has costs, price, loss for unsatisfied demand, and a salvage value for unsold inventory. There is an optimal order quantity that depends on the inverse of the cumulative distribution function for demand and a critical ratio between the costs of having too few units relative to demand (price minus costs plus loss of customer goodwill due to unsatisfied demand) and the total costs comprised by the costs of having too few and too many inventory units relative to demand (costs minus salvage value).

Empirical research indicates that people tend to over-order when the critical ratio is low and under-order when the critical ratio is high. In other words, when the cost of having too few units is low, people tend to over-stock; but when the cost of having too few units is high, people tend to under-stock. Some explanations suggest that some people use heuristics such as anchoring and adjustment using the mean demand while other people followed a demand-chasing heuristic.

The authors attempted to understand the decision making process of individuals using cognitive science instead of heuristics. They use *cognitive reflection*, which is a perspective based on dual process theories of decision making, e.g. *System 1* (intuitive, tacit, contextualized, and quick decision making processes) vs. *System 2* (reflective, analytical, and based on abstract reasoning decision making processes).

They designed experimental conditions varying the availability of information related to the newsvendor model with the expectation the decision maker is able to solve the optimal quantity. If subjects are not able to solve the optimal quantity, they may be influenced by System 1 features. Therefore, they measured the use of System 1 features using CRT. To justify the adoption of this method, they employed a set of psychology literature explaining the drivers of the values observed in CRT tests. Then they proposed a set of hypotheses associating previous observed heuristics in newsvendor's experiments with cognitive reflection conditions. For example, a hypothesis stated "when making repeated newsvendor decisions, individuals with higher cognitive reflection will exhibit less chasing of prior period demand" (p. 75).

Experiments looked at behavior, e.g. exactness versus variance, and backgrounds, e.g. engineers vs. accountants. The experiments were developed using a computer-based newsvendor experiment previously utilized in other studies and a new variation in the demand of the model. More than 300 subjects participated in the studies.

The analysis of the results involved direct (e.g. ANOVA) as well as mediation models considering the different treatments for the experiments.

In addition to the contribution to the literature, the authors offered potential implications for practitioners. For example, analysts with higher cognitive reflection tendencies perform better when demand is stochastic and stable. They are also better to employ demand-chasing heuristics in high and medium critical ratio newsvendor environments.

1.5.2 BOR Competences in Practice (Torres et al. 2017)

A central debate concerning strategy processes is related to how managers can effectively manage their organizations and strategies in dynamic environments. System Dynamics modeling, as a modeling methodology for developing strategies within dynamic environments, is a widely employed OR modeling method for strategic planning. However, most studies only report the final model and the results of using the model to test strategies under diverse scenarios. There is a gap in terms of how the modeling process affect the behavior of the decision makers and their impact on decisions made.

Moreover, there are important synergies between System Dynamics models and the field of strategy to support the development of strategy because many managerial challenges are associated with a manager's ability to understand and manage reinforcing feedback loops driven by asset stock accumulation through learning by doing, scale economies, network effects, information contagions, and complementary assets. Traditionally, System Dynamics modeling is known as a behavioral modeling method (Kunc 2016). Therefore, there are protocols to include behavior in models as well as understanding the impact of behavior with models and beyond models, as suggested in Kunc et al. (2016). More specifically, there are protocols to measure the improvement in cognition, e.g. *mental models* (Gary et al. 2008).

Their study has two contributions. Firstly, they propose a protocol for supporting strategy development via System Dynamics modeling developed in collaboration with the CEOs of a set of small organizations. Secondly, they illustrate the effectiveness of this protocol one year after the initial study.

Their study involved performing the development of strategies with five different small companies and their CEOs over a period of a month and then measuring the insights generated with the performance of the companies a year later. Similar to previous research in OR modeling, they employed case studies in real rather than experimental settings.

The authors illustrated the process using a swim lane flow chart, as shown in Fig. 1.1. The study describes each step in detail with the reactions from the decision makers through quotes. Additional evidence of the engagement of the decision makers was a selection of relevant variables, initiatives adopted in the face of uncertainties as well as decisions to be made.

The results from the study were related to changes in cognition. For example, they measured the development of cognition through the changes in the structures recognized in each iteration during the modeling process such as strategic resources, adjustment processes, drivers of adjustment processes, causal relationships, feedback structures, and

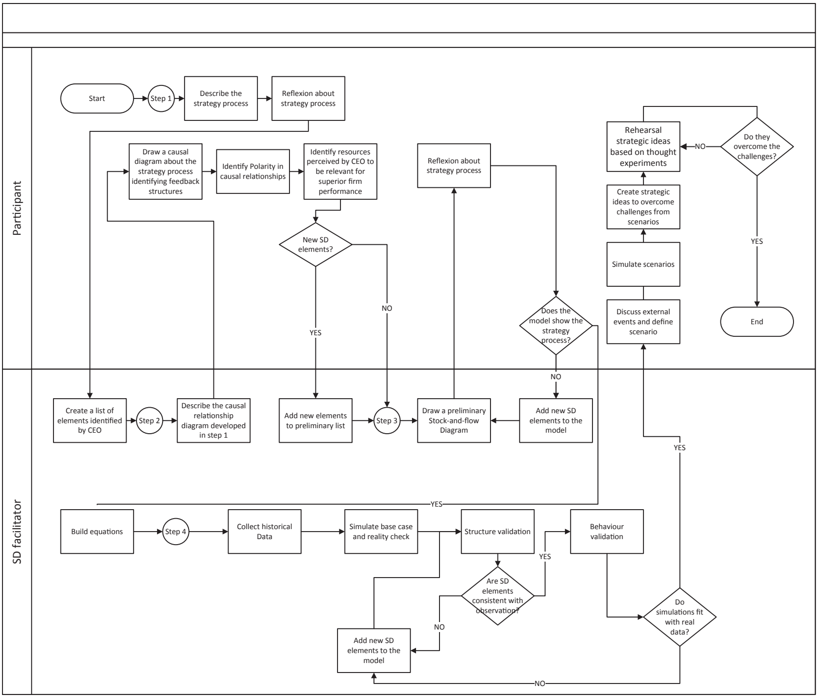

Fig. 1.1 Modeling process followed with the decision maker (*Source* Based on Fig. 1, Torres et al. 2017, p. 1084)

delays in processes (see Fig. 1.2 for an example). Another important aspect observed was the heterogeneity in individual behaviors during and after the modeling process. For example, three of the CEOs did not develop improved strategies as well as showing no changes in their mental models. The performance of their companies was poorer a year later. The rest of the CEOs generated more strategic options that were implemented over time and obtained an improvement in the performance of their businesses.

Some implications from the study were evidence of CEOs from small businesses usually running their companies based on past experiences so most strategic decisions are based on judgments emerging from mental models of their organizations and industries through trial and error. Thus, strategies employed in small organizations emerge from

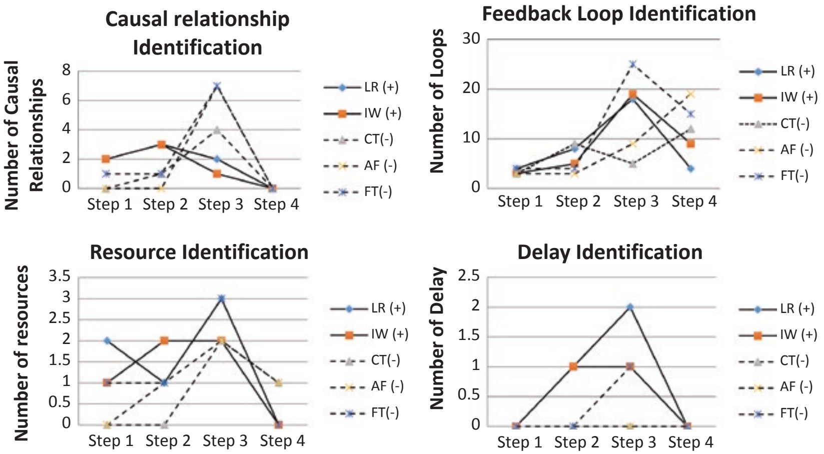

Fig. 1.2 Changes in cognition during the modeling project using a protocol based on CEO's answers in each step of the protocol. Each case study has associated the outcome of the process one year later adding (+) if it was a positive results and (–) if it was a negative outcome (*Source* Based on Fig. 7, Torres et al. 2017, p. 1092)

contingency rather than from a planning process. Consequently, System Dynamics models, in this case for strategic planning, enabled the CEOs to test and refine their strategic decisions through simulation exercises that reflect dynamic environments. Modeling helped the CEOs theorized the potential impacts that emerged from their mental models influencing the business decisions made under uncertain conditions.

1.6 Different Competences for BOR and BOM

Competences are based on how technical skills enable the proficient design and application of deliberate decision processes, taking into account behavioral factors that intervene in deliberate decision structuring. This chapter considers the purposeful and explicit application of technical skills to decision problems, ranging from decision support provided to individual decision makers (BOR example) to decisions made in a specific task environment (BOM example). From an analysis of the BOM and BOR literature and the two studies, we suggest some questions of relevance for competences pertaining to both fields: What is the subject knowledge (inventory management vs. strategic management)? What is discipline-specific skill (operations vs. strategic planning)? And what type of education/proficiency is required (operations and psychology vs. strategy and modeling)?

There are important differences in the competences between both fields. Firstly, BOM uses mostly normative models with an optimal solution defined (e.g. portfolio selection problem discussed in Momen, Chapter 3) while BOR uses normative modeling methodology for problems that may not have an optimal solution. Secondly, BOM uses experiments to variate the conditions under the normative models runs to test boundary situations and try to approximate real decision making settings (see Engin and Vetschera, Chapter 4). On the other hand, BOR follows case study and action research approaches (see Wang et al., Chapter 8, for examples on project management) to evaluate behavioral aspects affecting real decision making settings. Thirdly, BOM core competences are based on behavioral economics (see Önkal et al., Chapter 2, Momen, Chapter 3, and Engin and Vetschera, Chapter 4, for examples) while BOR is grounded on cognitive science and organizational behavior (see examples in Burger, Chapter 11, and White, Chapter 16, in this book). Fourthly, BOM intends to improve the design and performance of operations considering the impact of human behavior on normative models while BOR intends to improve the modeling process that is inherently driven by human behavior.

1.7 Conclusions: Toward an Enhancement of BOR using BOM

There are some opportunities for enhancing BOR based on the competences observed in BOM. Firstly, the area of operations has been thoroughly modeled using normative models with clear optimal solutions. Scholars have not explored if there are better ways to adapt the normative models to the real settings. This is an area where BOR can help BOM, especially accounting for the impact of behavioral aspects in the process of structuring the issues faced in operations (focused on modeling rather than testing). Secondly, BOR can adopt some of the BOM competences for the area of *behavior with models* such as experiments, psychology theories and use of normative (or quasi) normative models. Thirdly, BOM core competences in the area of *behavior in models* in terms of the inclusion of the results from experiments to portray realistic behaviors in models can be used in BOR to contextualize the behavioral aspects of the models. For example, Wang et al. (Chapter 8) show how biases and heuristics are improved in project management. Fourthly, BOR and BOM have similar scope when the concern is *behavior beyond models* since they try to improve the performance by influencing behavior of the actors or decision makers (see Wang et al., Chapter 8). However, the scope of BOM also involves design and implementation of solutions, which is an area that BOR can benefit substantially.

BOR practice can definitively enhance its competences and capabilities by adopting some of the principles of BOM such as the use of similar (quasi-normative) models in different context to account for the clear impact of behavioral aspects. Another aspect is to use already well-established literature on biases and heuristics to account for behavioral issues in and with models. However, the use of biases and heuristics should consider perspectives that consider them not only liabilities but also assets in decision making, as discussed previously. Finally, a more realistic and contextualized BOR practice, which takes into account the operations, can be the most useful enhancement to be learned from BOM.

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2

Behavioral Implications of Demand Perception in Inventory Management

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2.1 Introduction

The newsvendor setting, as one of the fundamental models for inventory management, has been studied extensively in the Operational Research literature (e.g. Porteus 2002 for a review) and has a variety of practical applications carrying significant consequences. The recent crises of Kentucky Fried Chicken (KFC) in 2017 is a felicitous example where inventory management problems led the company to the closure of hundreds of its restaurants in UK due to failed supply of its main ingredient—the chicken (O'Marah 2018; Owens 2018). In another example, Raz and Porteus (2006) report that the US publisher

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of "*Harry Potter and the Half Blood Prince*" had to rush to print 2.7 million additional copies when the book became the fastest selling in history. Similarly, Schweitzer and Cachon (2000) discuss how annoyed parents had to cope with disappointed children when Burger King restaurants underestimated the demand for free Toy Story movie toys to be included with their kids meal deals in 1996. Given its widespread practical as well as theoretical significance, the newsvendor problem thus emerged as a nascent topic of study in the behavioral operational research literature, but it has been extensively studied in behavioral operations management (BOM) literature (see Kunc, Chapter 1).

Since the seminal paper of Schweitzer and Cachon (2000) examining order decisions in controlled laboratory settings, experimental work on the newsvendor problem has consistently yielded the same insight: actual decisions are biased. Decision makers fail to order the normative (i.e. expected profit-maximizing) values and their decision behavior follows a particular pattern. This so-called *pull-to-center* pattern refers to the tendency of decision makers to set order levels between the normative quantity and average demand (e.g. Bolton and Katok 2008; Bostian et al. 2008; Zhang and Siemsen 2016). For high profit products, such as books, bicycles and fashion apparel, this behavioral pattern implies orders lower than the expected profit-maximizing quantity, but higher than the average demand, while for products with low profit margins, such as computers, it leads to order values that are higher than the theoretical best, but lower than the mean demand (Schweitzer and Cachon 2000).

The *pull-to-center* effect has been shown to be robust when the basic newsvendor setting is extended to consider the impact of various factors, such as different feedback frequencies (Lurie and Swaminathan 2009), types of information (Gavirneni and Xia 2009), decision

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making in groups (Gavirneni and Isen 2010), gender differences (De Véricourt et al. 2013), and the framing of objectives (Schultz et al. 2018). Schweitzer and Cachon (2000) and Bolton and Katok (2008) argue that the *pull-to-center* effect can be explained by two special cases of the *anchoring-and-adjustment heuristic* (Kahneman et al. 1982): the tendency of decision makers to anchor on mean demand and adjust insufficiently toward the expected profit-maximizing order quantities (*mean anchoring heuristic*), and the adjustment of current order quantities in line with previous period's demand realizations (*demand chasing*). Su (2008) proposes random optimization errors as the driver of the pull-to-center effect; however, Kremer et al. (2010) show that random errors do not fully explain this pattern, and the decision bias is context dependent. Other explanations for the pull-to-center effect proposed in the literature include overconfidence (Ren and Croson 2013), psychological costs of *underage* and *overage* (Ho et al. 2010), *impulse balance equilibria* (Ockenfels and Selten 2014), *loss aversion* and *mental accounting* (Becker-Peth et al. 2013), and *prospect theory* (Long and Nasiry 2014).

In this chapter, we focus on the decision makers' perceptions of demand uncertainty in the newsvendor setting as a possible driver of the *pull-to-center* effect. In particular, we propose that decision makers deviate from normative theory (as indicated in BOM literature, see Kunc, Chapter 1) not necessarily because they lack the competence to set expected profit-maximizing order levels but because their perceptions of uncertain demand may be different from its true form; in essence, they order the 'right' amount for the 'wrong' demand. In the following, we first compare the perceived and actual properties of demand (i.e. demand size and variability) and investigate how they impact order decisions. We then examine whether the biases in the perception of uncertainty are context dependent; in particular, whether the difference between the perceived and true demand increases or decreases as the properties of the underlying distribution change. In the final section, we discuss how decision processes can be redesigned to convert these unconscious competences into capabilities to improve decision making.

2.2 Perception of Uncertainty in the Newsvendor Setting

In the traditional newsvendor setting, the decision maker determines, given the selling price and ordering cost, how many units to order of a product whose demand is uncertain. In the behavioral operational research literature, while investigating the possible drivers of the *pull-to-center* effect, Ren and Croson (2013) focus on the *variability* of the uncertain demand, and suggest that decision makers are *overprecise*, which they define, in the newsvendor setting, as 'a biased belief that the distribution of demand has variance lower than its true variance' (p. 2504). Consequently, they model the overprecise perception of the actual demand distribution D as a mean-preserving but variance-reducing transformation of the actual demand:

$$D_P = \beta D + (1 - \beta)E[D] \tag{2.1}$$

where the parameter $(1 - \beta)$ captures the decision maker's level of overprecision and $E[D]$ is the mean of the actual demand D. Newsvendors with $(1 - \beta) = 0$ are perfectly unbiased (i.e. the true and perceived demand are the same), whereas $(1 - \beta) > 0$ indicates a belief that demand is less variable than it actually is. Ren and Croson (2013) propose that, overprecise newsvendors maximize expected profits, given the perceived demand, D_P; that is, their objective can be denoted by $\max_x pE[\min(x, D_P)] - cx$, instead of the normative newsvendor objective function $\max_x pE[\min(x, D)] - cx$, where p is the selling price, c is the cost of ordering, and x is the order quantity. It is argued that this behavior leads to the *pull-to-center* pattern; decision makers order less than the normative level in high profit margin situations, and order more than the normative level in low profit margin settings (see their Proposition 1 for a formal proof).

While Ren and Croson (2013) discuss the difference between perceived and actual demand variability, we argue that a biased perception of demand size may also result in suboptimal decisions. In order to capture this behavior, we model the decision makers' perception of the actual demand D as a variance-preserving, but mean-shifting transformation (i.e. a shift in demand in the sense of first order stochastic dominance; see Shaked and Shanthikumar 2007):

$$D_P = D + \delta \tag{2.2}$$

where δ captures the direction and strength of the bias in the perception of demand size. If $\delta > 0$, then the decision maker perceives demand to be larger than it actually is, whereas if $\delta < 0$, then the perceived demand size is smaller than the true demand; newsvendors with $\delta = 0$ are unbiased. Like Ren and Croson (2013), we propose that, although decision makers may have the competence to set expected profit maximizing order levels, decisions are biased because the perceived and true demand sizes differ.

Schweitzer and Cachon (2000), among other possible utility functions and heuristics that might influence newsvendor decision making, consider *aversion to overage* (i.e. ordering more than the actual demand, and consequently, being left with unsold units) or *underage* (i.e. ordering fewer units than the actual demand, and consequently, having to turn away customers), and propose that decision makers who are averse to being left with unsold units would order less than the expected profit-maximizing quantity, whereas those averse to having to turn away customers would choose quantities higher than the normative levels. This tendency could be equally attributed to the perception of demand size being different than the true demand. In particular, decision makers who perceive the demand size to be smaller would consequently believe the probability of overage to be higher than it actually is, and order less than the profit-maximizing quantity; whereas decision makers who perceive demand to be larger than the true demand, would also believe the probability of underage to be higher, and set order quantities higher than the theoretical benchmarks.

2.3 Impact of Changes in Demand Characteristics

We argued above that although decision makers may have the competence to set normative order levels, differences in perceived versus actual properties of the demand distribution may impact their orders, hence leading to potentially biased decisions. This section examines how the observed patterns in demand perception behave when there is a change in the actual size or variability of the distribution.

Establishing that biases in demand perception are context dependent would prove beneficial for designing processes that use this unconscious competence to improve decision making. Furthermore, changes in demand are frequently encountered in practice; for example, airlines use advertising campaigns and promotions to increase demand for all fare classes (Cooper and Gupta 2006), or manufacturers face irregular orders from industrial customers responding to their own up and down demand (Davis 1993). Finally, such an analysis might provide insights about whether the deviations in perception of demand can always be equated with normative inaccuracy in the newsvendor context.

2.3.1 Changes in Demand Variability

To discuss how the perception of demand variability behaves as true variability changes, we refer to the data from Kocabıyıkoğlu et al. (2015). Although studying changes in demand was not the main focus of their study, their experimental design required participants to make newsvendor decisions under four different demand distributions with the same mean ($E[D] = 40$), but different variances (see Table 2.1 for the specific demand distributions used, and the corresponding variances). They manipulated change in demand via a within-subject design, and the participants worked with each demand distribution for 10 rounds. They considered both high profit margin ($p = 120$, $c = 30$) and low profit margin ($p = 120$, $c = 90$) settings; which was controlled with a between-subject design. 26 participants were assigned to the high profit margin condition, while there were 29 participants in the low profit margin condition. The average actual order decisions observed in Kocabıyıkoğlu et al. (2015), as well as the expected profit maximizing quantities, denoted by x and x^* respectively, are provided in Table 2.2.

Table 2.1 Demand distributions in Kocabıyıkoğlu et al.'s (2015) study

Distribution	Mean	Variance
Uniform(30, 50)	40	33.33
Uniform(20, 60)	40	133.33
Uniform(10, 70)	40	300.00
Uniform(0, 80)	40	533.33

Table 2.2 Actual and expected profit-maximizing orders in Kocabıyıkoğlu et al. (2015)

	High margin setting		Low margin setting	
	x	*x**	*x*	*x**
Uniform(30, 50)	39.40	45	38.11	35
Uniform(20, 60)	40.13	50	35.85	30
Uniform(10, 70)	40.94	55	35.83	25
Uniform(0, 80)	41.41	60	33.42	20

Consistent with the rest of the behavioral operational research literature, the *pull-to-center* effect was observed in Kocabıyıkoğlu et al.'s (2015) experiments; the observed orders were greater than the corresponding normative quantities under the low margin scenario, and smaller than the theoretical benchmarks under the high margin scenario.

By using the data from Kocabıyıkoğlu et al.'s (2015) study, current work examined the existence of overprecision by calculating the overprecision parameters, $(1 - \beta)$. Through this new analysis (see Fig. 2.1), we observed that the overprecision parameters were uniformly positive, indicating their participants perceived demand to be less variable than it actually is. This is in line with Ren and Croson's (2013) results, which suggest overprecision as one of the drivers of the pull-to-center pattern.

The parameters provided in Fig. 2.1 suggest the decision makers' degree of overprecision did not stay constant across demand sizes. Rather, the higher overprecision parameters observed at lower variability levels when the profit margin was high suggest that the decision makers' tendency to perceive a more stable demand (i.e. perceive demand to be less variable than it actually is) became weaker when demand was more variable. The opposite pattern emerged in the low margin scenario. That is, overprecision parameters were lower at lower variability levels (for example, $(1 - \beta) = 0.62$ when demand was distributed Uniform(30, 50) and $\text{Var}(D) = 33.33$, while $(1 - \beta) = 0.72$ under demand distribution Uniform(10, 70), with corresponding variance $\text{Var}(D) = 300.00$) implying that the decision makers' perception that demand is more stable (i.e. less variable than it is in reality) became stronger when demand was more variable.

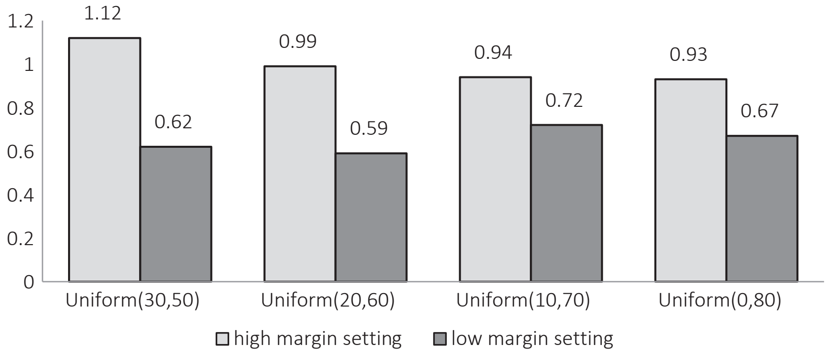

Fig. 2.1 Overprecision parameters ($1 - \beta$)

The results discussed above suggest that the strength of decision makers' tendency to perceive demand to be less variable than in reality is context dependent. Such an *induced stability bias* may have significant ramifications for demand forecasts and order decisions and needs to be taken into account when designing systems/procedures to support and enhance decision making. Furthermore, decision makers' perception of demand vis-à-vis changes in variability emerges as a pattern that should be given particular importance in both *high risk markets* that yield low margins, as well as in *low risk markets* that yield high margins, since the difference between the true and perceived demand propagates widely in such settings.

2.3.2 Changes in Demand Size

In other ongoing work, Kocabıyıkoğlu et al. (2018) investigate the impact of demand size on newsvendor decisions with a controlled laboratory study. In particular, they present an experiment which consists of 40 rounds, where every 10 rounds, the demand distribution changed in a manner that shifted the mean while preserving the variance (see Table 2.3 for the specific demand distributions used with corresponding mean values). The selling price was set as $p = 120$; 47 participants worked with $c = 30$ (i.e. the high margin setting), while 46 participants were told the ordering cost was $c = 90$ (i.e. the low margin setting).

Table 2.3 Demand distributions in Kocabıyıkoğlu et al.'s (2018) study

Distribution	Mean	Variance
Uniform(0, 80)	40	533.33
Uniform(10, 90)	50	533.33
Uniform(20, 100)	60	533.33
Uniform(30, 110)	70	533.33

Table 2.4 Actual and expected profit-maximizing orders in Kocabıyıkoğlu et al. (2018)

	High margin setting		Low margin setting	
	x	*x**	*x*	*x**
Uniform(0, 80)	50.39	60	45.04	20
Uniform(10, 90)	52.17	70	47.08	30
Uniform(20, 100)	58.24	80	55.13	40
Uniform(30, 110)	70.08	90	63.73	50

Table 2.4 provides the average actual orders observed, x, and normative quantities, x^*, under both profit margin scenarios.

Before we discuss how the perception of demand size behaves with respect to variance-preserving but mean-shifting changes in the distribution, we note from Table 2.4 that the participants in this latter study exhibited the *pull-to-center* pattern. In particular, they ordered more units than the expected profit-maximizing quantity in the low margin setting (suggesting they perceived demand to be larger than it actually is), and fewer units than the normative level in the high margin setting (suggesting they perceived demand to be smaller than its true form). To measure the strength of this bias and how it behaves with respect to changes in demand size, we calculate the demand size parameters δ for order decisions and Fig. 2.2 presents this analysis.

Figure 2.2 presents consistently negative δ values in the high margin setting, and positive δ values in the low margin setting, confirming that participant's perceived demand to be smaller than it actually is when the profit margin was high, with the opposite tendency influencing decisions in the low margin setting. Furthermore, this difference between the perceived and true demand sizes was not constant across demand distributions. In particular, in the low margin setting, the tendency to perceive demand to be larger than it actually is weakened at higher

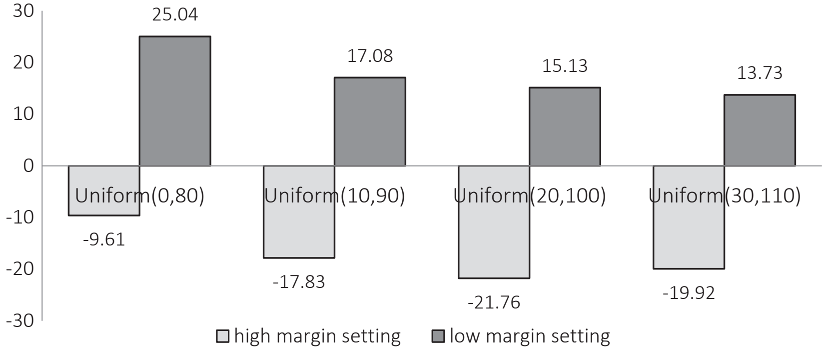

Fig. 2.2 Demand size parameters δ

mean demand levels. For example, the demand size parameter δ was 25.04 when demand was distributed *Uniform*(0, 80) and $E[D] = 40$, while it was 13.73 when demand was distributed *Uniform*(30, 110) and $E[D] = 70$. In the high margin setting, the strength of the tendency to perceive demand to be smaller than it actually is also varied across demand sizes; specifically, it became stronger at higher mean demand levels. For example, the demand size parameter was $\delta = -9.61$ when demand was distributed *Uniform*(0, 80) and $E[D] = 40$, while it was— 19.92 under *Uniform*(30, 110), with $E[D] = 70$.

The analysis above on the context-dependency of this *induced scale bias* is in line with the findings on demand variability discussed previously. Although the 'misperception' of demand size gets weaker as the market grows for low profit margin products, in high profit margin industries, this bias gets stronger, and would potentially impede building market share by leading to consistent under-ordering, and consequently, higher numbers of turned-away customers.

2.4 Aligning the Perceived and True Demand

This chapter posits that perceptions of demand uncertainty can potentially influence and bias newsvendor decision making. We argue, although decision makers may have the competence to set order quantities in line with normative benchmarks, they may not fully exploit this capability due to potential biases in perceptions of demand size and variability. Next, we discuss possible interventions in this context that may help to improve newsvendor decisions.

One of the main aims of Behavioral Operational Research studies is understanding human behavior and decision processes, and their impact on system consequences to build tools for re-designing, managing and improving them. Two intervention approaches have consequently been identified in the behavioral literature (Gino and Pisano 2008): (i) a prescriptive approach, which suggests integrating these unconscious effects into the formal models, and (ii) a descriptive approach, which highlights the relevance of being aware of and understanding individual decision processes and their shortcomings. The prescriptive approach can be used when a decision maker's biases may be corrected via feedback and training, while the descriptive approach provides guidance in cases where de-biasing is not feasible.

Unlike other factors that have been identified in the literature as affecting inventory management decisions, like the frequency of feedback (Lurie and Swaminathan 2009) or making decisions in groups (Gavirneni and Isen 2010), the uncertainty the organization is facing cannot be re-designed under most circumstances, except for indirect interventions through, for example, pricing and advertising (e.g. Petruzzi and Dada 1999), and remains primarily exogenous. Although this may suggest that descriptive interventions are more appropriate, prescriptive solutions might also be adopted, since the organization can design interventions to counteract the shortcomings in demand perceptions via internal procedures; that is, it may be possible to aid/enable the decision maker to set the 'right' order quantity, for the 'right' demand.

A possible intervention may take the form of re-designing the decision task to incorporate, for example, nudges to reduce overprecision. In the literature, Lichtenstein and Fischhoff (1980), Arkes et al. (1987), and Koriat et al. (1980) have proposed such methods, and Ren and Croson (2013) have successfully applied the SPIES tool (Haran et al. 2010), which is based on eliciting likelihoods over the entire range of possibilities rather than asking for the 90% confidence interval, to reduce overprecision and improve newsvendor decision making. Similarly, Plous (1995) found that group judgments are less overprecise than individual judgments, which suggest delegating inventory decisions to teams might reduce the bias in demand perception and improve decision making.

Another possible intervention mechanism might be providing structured feedback and decision support for inventory managers to bring their demand perceptions closer to reality. Analytics tools and simulations to help the decision makers' conceptualization of the parameters and shape of the demand distribution may be effectively employed. Along similar lines, comparisons with other managers' perceptions, combined benchmarks and/or past demand realizations could prove informative. It is worth noting that such support systems need to be monitored and frequently updated; otherwise, the bias in inventory decisions might be magnified leading to *spillover effects*. If decision makers are not promptly made aware of the changes in demand, they would still be setting orders for the now obsolete distribution, which is already perceived differently from its true form. For example, if the decision makers' strategies lag behind the market growth in a high margin industry such as fashion retail, this would lead to further under-ordering, due to inventory managers both not taking into account the actual increase in the market size, as well as perceiving demand to be smaller than it actually is.

Organizations can also influence their inventory managers' demand perceptions by providing incentives designed to align the perceived and true demand. Since incentive plans are based on various performance measures (e.g. Sarin and Winkler 1980), such a scheme could focus on order decisions and/or profits, which can be monitored by the organization, and aim to influence the decision makers' perception of demand through bringing these measures closer to their normative levels, and discouraging under- and over-ordering.

Evidence discussed so far indicates that ordering fewer units than the theoretical best is more prevalent for products with high profit margins. One way to prevent this might be introducing penalties for lost sales; however, two potential issues might render this type of scheme impractical. Firstly, although there is evidence that imposing negative incentives may lead to better performance (Goldsmith and Dhar 2013), a strong conviction that people will not respond to such plans exists (Bullock 2017), and they can potentially make managers' earnings unstable and hard to predict (Basu et al. 1985). Furthermore, because of the imperfect observability of demand (Dai and Jerath 2013; Besbes and Muharremoglu 2013), monitoring lost sales may not be feasible; "newsvendors observe sales realizations, rather than demand realizations" (Rudi and Drake 2014, p. 1335). Introducing incentive plans with sales-dependent components (e.g. Basu et al. 1985; Lal and Staelin 1986), such as piece-wise linear commissions per unit sale might potentially motivate inventory managers to increase order levels and avoid under-ordering. We note that, careful monitoring of such a system is essential, to prevent decision makers from driving up order quantities beyond the normative levels in response to such a reward structure (Kalra et al. 2003).

In low profit margin settings, on the other hand, decision makers are observed to order more units than optimal. Although measuring performance in terms of unsold units might be easier practically, imposing a penalty for overage might still prove to be complicated, because of the factors discussed above. Rewarding managers for selling fewer units would be equally impractical and counterintuitive. A quota-based system (Raju and Srinivasan 1996; Mantrala et al. 1994; Chen 2000), that sets thresholds for unsold units, and rewards decision makers as experienced unsold units falls below certain levels might be used to prevent over-ordering. The constant re-evaluation of such an incentive system, for example, tracking managers who consistently experience no unsold units, is imperative as it might motivate decision makers to drop inventory levels sharply, particularly when lost sales are difficult to monitor. It should be noted, however, that the update frequency of the system should be carefully determined, since although shorter evaluation windows increase the motivating power of the plan, they also add to administrative expenses (Churchill et al. 1993).

2.5 Conclusions

Studies of newsvendor decision making in controlled laboratory environments have established that actual order decisions deviate from theoretical benchmarks and proposed possible drivers for this pattern (e.g. Schweitzer and Cachon 2000; Bolton and Katok 2008; Kunc,

Table 2.5 Summary of results

	Perception of demand size	Perception of demand variability
High margin setting	• Smaller than true demand • Gets stronger at higher mean demand levels	• Less variable than true demand • Gets stronger at lower variability levels
Low margin setting	• Larger than true demand • Gets stronger at lower mean demand levels	• Less variable than true demand • Gets stronger at higher variability levels

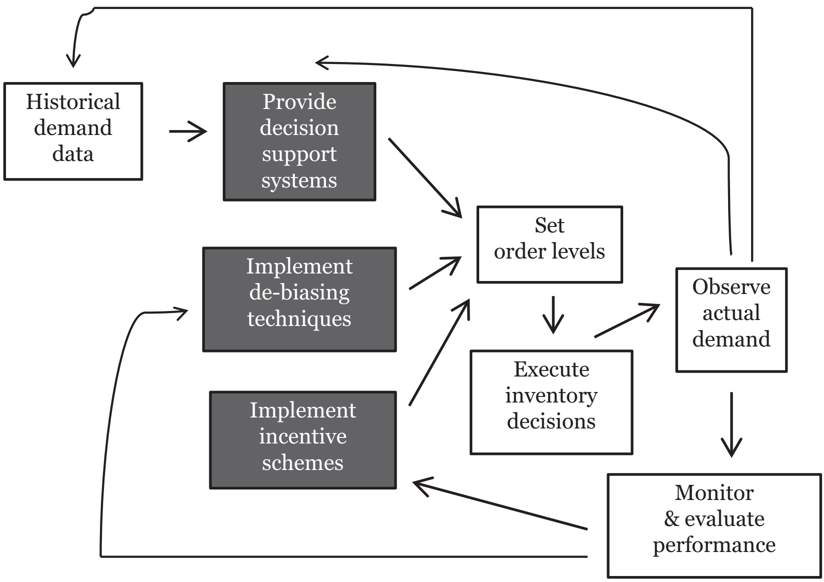

Fig. 2.3 Intervention mechanisms to align true and perceived demand

Chapter 1). In this chapter, we propose that the order decisions may be biased primarily due to distorted perceptions of demand uncertainty. We compare actual and perceived demand in terms of size and variability, and investigate how this gap behaves with respect to changes in the properties of demand. Table 2.5 provides a summary of this chapter's insights. We also discuss intervention mechanisms (summarized in

Fig. 2.3), which can be used individually or collectively, including decision support systems and incentive schemes, that acknowledge the decision makers' unconscious competences, and propose re-designing tasks to manage and improve decision making processes. While the focus was on the newsvendor domain, we believe that our findings on distorted perceptions of uncertainty may resonate across a multitude of Behavioral Operational Research platforms. Moreover, some important capabilities of BOR practice, e.g. facilitation, can help to address these issues in the newsvendor domain (see Kunc, Chapter 1).

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3

Behavioral Operational Research in Portfolio Selection

Omid Momen

3.1 Introduction

Portfolio selection is part of the finance that discusses asset choice and diversification to improve investor's wealth. Despite conventional finance, behavioral finance does not consider the investor to be completely rational. Instead, it discusses the effects of psychological factors on decision-making. Hence, Behavioral Operational Research (BOR) is the way to bridge between Operational Research and behavioral finance.

The term *portfolio selection* (optimization) first gained attention, when Markowitz (1952) proposed his famous model. In the past decades, many portfolio selection models have been developed using basic operational research ideas. However, behavioral finance scientists have criticized those models, because they do not contain human attitudes and behavioral biases. For example, some scientists such as Thaler (1999) explain the importance of mental accounting, which is a behavioral bias of investors, who have multiple parallel accounts (goals) in

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their minds. Following this idea, the term *behavioral portfolio* was first introduced by Shefrin and Statman (2000). Considering the *mental accounting* concept, Das et al. (2010) introduced the Mental Accounting model (MA), which is extended in many studies: considering derivatives and non-normal returns by Das and Statman (Das et al. 2010; Baptista 2012; Momen et al. 2016, 2019a; Alexander et al. 2017).

Most of the above studies have considered behavioral effects on portfolio selection from two different points of view: *elemental* and *structural effects*. By definition, elemental effects only influence components of portfolio models, while structural effects change the way the portfolio is designed as a whole. In the following sections, we first discuss the effects of behavior on portfolio selection, and then we present some models that have taken those effects into consideration.

3.2 Effect of Behavior on Portfolio Selection

In this section we explain elemental and structural effects of behavior on portfolio selection, respectively. We first address individual elements and how they affect portfolio selection, and then we mention different issues that influence structure of portfolio selection.

3.2.1 Elemental Effects

Over the course of past decades many elements have been introduced for portfolio selection. However, the most prominent elements include expected return of investments, risk of investments and more recently behavioral biases of investor (as indicated in BOM literature; see Kunc, Chapter 1). We address all of them in the following paragraphs.

3.2.1.1 Behavioral Biases

Sjöberg and Engelberg (2009) discuss the effect of psychological factors on investment decision-making. Moreover, researches such as Brandt and Wang (2003) and Holt and Laury (2002) open up the possibility that psychological factors may have an effect on decision-making of investors. Furthermore, studies such as (Fellner 2009; Pan and Statman 2012; Pompian 2012) discuss more specifically the impact of behavioral biases on investment decisions.

Researchers have distinguished numerous biases (e.g. Bailey et al. 2011). Some of the most influential behavioral biases are *overconfidence* (one's irrational belief in his strength of intuitive reasoning, judgment and cognitive abilities), *ambiguity aversion* (investor hesitation when probability distributions of events seem uncertain), *self-control* (investor inclination to spend now at the expense of saving for future) and *framing* (investor responds to similar situation differently due to difference in context). These behavioral biases have many unpleasant consequences for investors, such as: lower expected utility (Odean 1998), excessive trading (Barber and Odean 2001), lower returns (Bailey et al. 2011) and leaving market (Odean 1999). More importantly, they generate deviations from normative models assuming perfect economic rationality (as indicated in BOM literature; see Kunc, Chapter 1).

3.2.1.2 Risk

There are two questions in modeling risk for portfolio selection, first what risk measure should be used in modeling the risk of assets, second how the investor attitude toward risk should be addressed. In order to answer the first question, some studies use *pure risk* (Siebenmorgen and Weber 2003), and *risk premium* (Cillo and Delquié 2014), others mostly consider a form of *Value-at-Risk* (VaR) (Shefrin and Statman 2000; Berkelaar et al. 2004; Das et al. 2010; Alexander and Baptista 2011; Brunel 2011; Baptista 2012; Alexander et al. 2017).

These risk measures have the benefit of conceptual and calculation simplicity (Leavens 1945; Garbade 1986; Jorion 2007). However, none of them are proper coherent risk measures (Artzner et al. 1999). Specially, VaR as the most popular behavioral risk measure is not coherent, because it is not subadditive. This is an important drawback for a behavioral risk measure (Kalyvas et al. 1996), because behavioral portfolios are built based on the assumption that people have different mental accounts, and if a risk measure is not subadditive, it may produce mental account sub-portfolios for which the sum of risks is less than the risk of investor total holdings. This is against the idea that diversification does not increase risk.

The next drawback of these risk measures is related with the second above mentioned question, because these risk measures include investor attitude toward risk by deriving a single fixed risk aversion coefficient. There are three main issues regarding the use of risk aversion coefficients. First, they are fixed during the time, second, they are fixed in different mental accounts (goals), and third, they are fixed in encountering various levels of gain and loss. However, Pratt and Arrow in an early introduction of risk aversion came up with the hypothesis that risk aversion changes (Halek and Eisenhauer 2001), and others such as (Brunnermeier and Nagel 2008; Guiso and Paiella 2008; Sahm 2012) also confirmed this hypothesis in different ways. Moreover, there are studies that indicate people have varying attitude toward different levels of gain and loss (Kahneman and Tversky 1979; Fennema and Wakker 1997), and also risk aversion cannot be fixed throughout mental accounts (Das et al. 2010).

3.2.1.3 Expected Return

Some portfolio models use standard estimators for expected return (Shefrin and Statman 2000; Berkelaar et al. 2004; Nevins 2004; Das et al. 2010; Alexander and Baptista 2011; Brunel 2011; Baptista 2012; Alexander et al. 2017; Momen et al. 2017a), which suffer from the two following issues. First, the standard estimators are sensitive to return outliers. As Fabozzi et al. (2010) argue, sometimes even one outlier such as an extreme return affects the expected return, which is unfavorable in modeling. Second, behaviorally biased investors do not usually completely rely on statistical estimators; instead they tend to follow their own attitudes toward expected returns. Therefore, it is very appealing for them to have a model that includes their own estimates (Fabozzi et al. 2010).

3.2.2 Structural Effects

There can be many structural effects of behavior on portfolio selection; here, we present two effects that have been documented recently: prescription effect, and mental accounting effect.

3.2.2.1 Prescription Effect

Portfolio models rely on analysis of humans for inputs. It means that inputs such as expected return of assets and their covariance matrix should be estimated and inserted to the models by humans. According to Raiffa (1968) there are three types of analyses: *normative*, *descriptive* and *prescriptive*. (1) Normative analysis is concerned with the rational solution to the problem at hand. It defines an ideal that actual decisions should strive to approximate. (2) Descriptive analysis is concerned with the manner in which real people actually make decisions. (3) Prescriptive analysis is concerned with practical advice and tools that might help people achieve results more closely approximating those of normative analysis.

Based on the above definitions, the unsatisfying performance of investors due to behavioral traits can be explained as follows (Russo and Schoemaker 1992; Odean 1999): investors and their advisors incorporate different types of analyses. Advisors as rational agents perform normative analysis to achieve acceptable performance, while the instinctive behaviors of investors are in the descriptive analysis domain. Therefore, none of their views can provide a satisfying portfolio. A satisfying portfolio is based on prescriptive analysis, this is called prescription effect.

3.2.2.2 Mental Accounting Effect

Investors with mental accounting bias do not consider their portfolios as a whole. Instead, they consider their portfolios as collections of mental sub-portfolios (mental accounts) where each sub-portfolio is associated with a goal and each goal is evaluated by deviation from a threshold also known as a risk measure. According to Shefrin (2010), mental sub-portfolios are segmented in a narrow framing process, which overlooks interdependencies between mental accounting structures. Hence, the segmentation of sub-portfolios is rarely optimal. However, if an investor wants to consider mental accounting, he has to find a new structure that is able to contain several mental accounts at the same time.

3.3 Behavioral Portfolio Models

As stated in the previous section, from a BOR point of view, portfolio models can be designed by considering elemental effects and structural effects. In this section, we present models for containing these two effects.

3.3.1 Models for Elemental Effects

In Sect. 3.2.1, three elemental effects were presented. In this section, models for each of those three effects are depicted in the same order.

3.3.1.1 Models for Behavioral Biases

Pompian (2012), Pan and Statman (2012), and Nordén (2010) find behavioral biases to be among psychological factors that impact the risk attitude. On the other hand, behavioral biases are affected by past returns as stated by Chen and Kim (2007) and Statman et al. (2006). Following these results and Grable et al. (2006), varying risk attitude depends on behavioral biases and investors latest realized return from the market.

In order to represent a relationship between risk attitude (α), behavioral biases and latest realized return of investor, an obvious option is to consider multivariate linear regression (Momen et al. 2017b):

$$\alpha = \Theta \mathrm{B} + \varepsilon \tag{3.1}$$

where $\Theta = [\theta_0\,\theta_1 \cdots \theta_M]$, $\theta_i (i = 0, 1, \ldots, M)$ is the i-th regression coefficient, $\mathrm{B} = [1\, b_1 \cdots b_M]'$, $b_j (j = 1, \ldots, M)$ is the j-th behavioral bias, M is the number of behavioral biases under consideration, and ε is the error term.

Equation 3.1 can be used to derive constraints in the model that calculates risk aversion based on behavioral biases. However, the problem is that regression does not infer or present causality between variables (Scheines et al. 1998). To infer causality based on data, one should follow causation methods such as the PC algorithm (Scheines et al. 1998), which results in a network of relations between desired variables. The algorithm decides on independence of pairs of variables (e.g. behavioral biases) by using conditional independence tests (Spirtes et al. 2000). Therefore, we define $S = \left[b_1\, b_2 \cdots b \alpha r^T\right]'$ and $s_i (i = 1, \ldots, M + 2)$ as the i-th element of S, where $b_k (k = 1, \ldots, M)$ is the k-th behavioral bias, r^T is the latest realized return, α is an indicator of risk attitude (confidence level in the risk measure), and M is the number of behavioral biases under consideration. Equation (2) summarizes the output of the PC algorithm (Momen et al. 2019b):

$$\mathrm{A} \times \mathrm{S} = S_0 \tag{3.2}$$

where $\mathrm{S}_0 = \left[b_{01}\, b_{02} \cdots b_{0M}\, \alpha_0\, r_0^T\right]'$ is the vector of intercepts, A is an $(M + 2) \times (M + 2)$ matrix, the ij element $\left(a_{ij}\right)$ of which is defined as follows.

$$a_{ij} = \begin{cases} 0 & ,\ \text{No edge from } s_i \text{ to } s_j \\ 1 & ,\ i = j \\ -\text{edge coefficient from } s_i \text{ to } s_j & ,\ \text{Otherwise} \end{cases} \tag{3.3}$$

The above formulations are intended to draw a relationship between risk attitude and behavioral biases of the investor.

3.3.1.2 Models for Risk

A proper risk measure for behavioral portfolio selection should be coherent, and should contain investor attitudes. There is a category of risk measures with these qualities, which are called spectral risk measures (SRM) and defined as (Acerbi 2002):

$$M_{\phi_a} = -\int_0^1 \phi_a(p) q_p \mathrm{dp} \tag{3.4}$$

where q_p is the p payoff quantile, $\phi_a(p)$ is an investor specific weighting risk aversion function, and $p \in [0, 1]$.

SRMs relate the risk measure to the subjective risk aversion of the investor. More precisely, the SRM is a weighted mean of the quantiles of payoff distribution, where the weights are related to the investor risk aversion function (Dowd and Cotter 2007).

The most well-known spectral risk measure is the Conditional Value at Risk (CVaR) (Rockafellar and Uryasev 2000). However, CVaR leaves little space for investor views on the risk measure (Grootveld and Hallerbach 2004). Hence, Dowd et al. (2008) assess several risk measures, and argue in favor of exponential risk measures.

3.3.1.3 Models for Expected Return

Black and Litterman (1991) have proposed a method for estimating robust inputs that are able to contain investor views (Silva 2009). Asset proportions derived from such a model are less sensitive to the model input variations (Fabozzi et al. 2007). The Black-Litterman estimator of return (r_{BL}) is defined as follows:

$$r_{\mathrm{BL}} = \left[(\tau\Sigma)^{-1} + P'\Omega^{-1}P\right]^{-1}\left[(\tau\Sigma)^{-1}\Pi + P'\Omega^{-1}q\right] \tag{3.5}$$

where Π is expected excess return vector, Σ is covariance matrix of returns, τ is a small scalar ($\tau \ll 1$) in $\Pi = \mu + \epsilon_\Pi, \epsilon_\Pi \sim \mathrm{Normal}(0, \tau\Sigma)$, where μ is the unknown true expected return of assets, which is often estimated using equilibrium expected return. q is a $K \times 1$ vector of investor views, P is a $K \times N$ matrix in $q = P\mu + \epsilon_q, \epsilon_q \sim \mathrm{Normal}(0, \Omega)$ and Ω is a $K \times K$ matrix expressing the confidence in the views, N is the number of available assets, K is the number of assets that the investor has views on their expected returns. One can interpret $\tau\Sigma$ as investor confidence in the precision of his estimates for the equilibrium expected returns, and Ω as his confidence in the accuracy of his views on individual asset returns.

3.3.2 Models for Structural Effects

After presenting models for elemental effects in the previous section, in this section, we introduce models for the two structural effects that have been discussed before.

3.3.2.1 Models for Prescription Effect

When dealing with the modeling of a portfolio for a client (investor), advisors or investment advisory companies either rely on their own market perception to build a model for their client or trust the client's perception of market. In the first case, the literature shows that the relationship between advisor and client will be terminated prematurely, since clients cannot rely on advisors understanding the market for a long time. This is usually due to the client's irrational understanding of his abilities to outperform the market. However, in the second case, as clients usually have less experience and information about the market than advisors, they often end up losing their money, which again ruins their relationship with the advisor. A third option for advisors is to measure the behavioral biases of their clients and use them as proxies to balance between first two options. In this way, the model will decide whether the advisor should rely on his own perceptions or not, and if so to what extent.

As shown in Fig. 3.1, the conceptual model of Prescriptive Portfolio Selection (PPS) reveals that its parameters are trade-offs between advisor and investor, or in other words between normative and descriptive analyses. In order to estimate parameters using this model, we cannot solely rely on any of these analyses, and the best thing we can do is to compromise, which is provided by prescriptive analysis. Therefore, a proxy can be used to compromise between normative and descriptive analyses. This proxy can be a behavioral bias (or several) that distinguishes between normative and descriptive analyses. For example, Momen et al. (2017a) derive a model that balances risk and return with overconfidence bias and find out that investors have no significant preference between results of their own perceptions and the proposed model (Prescriptive Portfolio Selection).

3.3.2.2 Models for Mental Accounting Effect

In most available portfolio selection models, decision variables are defined as the proportion of assets in the portfolio. However, in order to include mental accounting effect, we define decision variables (w_{ij}) as proportion of asset_j in sub-portfolio i (SP_i). This definition helps us to model behavioral portfolio selection that usually includes more than one sub-portfolio in a collective manner; hence, the name *Collective Mental Accounting* (CMA) has been proposed (Momen et al. 2019a). CMA is defined as follows:

w_i: Vector of asset weights in sub-portfolio i ($w_i = [w_{i1}, w_{i2}, \ldots, w_{in}]$)

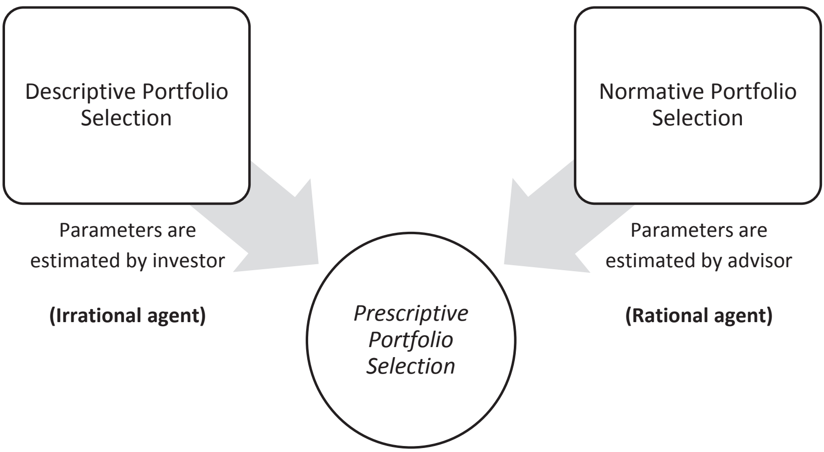

Fig. 3.1 Conceptual model for prescription effect

$\Sigma_i w_{ij}$: Proportion (weight) of asset j in the aggregated portfolio (total asset holdings)

Ω_i: Proportion (weight) of wealth allocated to sub-portfolio i, if exogenously determined

n: Number of assets

m: Number of sub-portfolios

The expected return for the portfolio is defined as $\sum_{j=1}^{n} r_j \sum_{i=1}^{m} w_{ij}$, where r_j is the expected return for asset$_j$. In CMA, there is a risk measure (as constraint) for each sub-portfolio, which is defined as $\Pr[r(\mathrm{SP}_i) \leq H_i] \leq \alpha_i$ for sub-portfolio i, where $r(x)$ is the random variable of expected return for portfolio x, and α_i is the maximum probability of not reaching the threshold for sub-portfolio i (H_i). Therefore, the basic CMA model is as follows:

$$\mathrm{Max} \sum_{j=1}^{n} r_j \sum_{i=1}^{m} w_{ij}$$

$$\Pr[r(\mathrm{SP}_i) \leq H_i] \leq \alpha_i;\ i = 1, 2, \ldots, m$$

$$\sum_{j=1}^{n} \sum_{i=1}^{m} w_{ij} = 1 \tag{3.6}$$

The above model has the capability to calculate the proportion of each sub-portfolio endogenously. In other words, there is no need to pre-specify the proportion of an investor's wealth for each mental sub-portfolio. Anyway, some researchers such as Baptista (2012) believe sub-portfolio proportions should be defined exogenously, because some experienced or confident investors may not like to rely on mathematical model outputs solely, and prefer to define their sub-portfolio weights themselves. Therefore, in CMA, one can pre-specify sub-portfolio proportions by including them in a simple mathematical constraint such as $\sum_{j=1}^{n} w_{ij} = \Omega_i;\ i = 1, 2, \ldots, m$, where Ω_i is the exogenously defined proportion for sub-portfolio i. One can rewrite $\Pr[r(\mathrm{SP}_i) \leq H_i] \leq \alpha_i$, as:

$$rw_i^T - k(\alpha_i)\sqrt{w_i \Gamma w_i^T} \geq H_i \tag{3.7}$$

where r represents the vector of expected returns, w_i is vector of asset weights in sub-portfolio i (i.e. $w_i = [w_{i1}, w_{i2}, \ldots, w_{in}]$), Γ denotes covariance matrix, and X^T is the transpose of X. Therefore, the CMA model can be rewritten as:

$$\text{Max} \sum_{j=1}^{n} r_j \sum_{i=1}^{m} w_{ij}$$

$$rw_i^T - k(\alpha_i)\sqrt{w_i \Gamma w_i^T} \geq H_i;\ i = 1,\ 2,\ \ldots,\ m \tag{3.8}$$

Now we introduce the semi-definite programming (SDP) representation of the CMA model, thus it can be solved by methods such as the interior-points or spectral-bundle, efficiently. The derivation and proof of the followings are available in Momen et al. (2019a). We define all VaR constraints in a semi-definite matrix S as follows:

$$S := \begin{bmatrix} S_1 & 0 & \ldots & 0 \\ 0 & S_2 & 0 & \vdots \\ \vdots & 0 & \ddots & 0 \\ 0 & \ldots & 0 & S_m \end{bmatrix} \succcurlyeq 0 \tag{3.9}$$

where $S_i;\ i = 1,\ 2,\ \ldots,\ m$ is a semi-definite representation for the *i-th* VaR constraint, and is proven to be as follows:

$$S_i := \begin{bmatrix} \left(\frac{rw_i^T - H_i}{k(\alpha_i)}\right) I_n & Q w_i^T \\ w_i Q^T & \left(\frac{rw_i^T - H_i}{k(\alpha_i)}\right) \end{bmatrix} \succcurlyeq 0;\ i = 1, 2, \ldots, m \tag{3.10}$$

where I_n is the identity matrix of size n, $Q^T Q = \Gamma$. Therefore, the SDP representation for the CMA model is as the following:

$$\text{Max} \sum_{j=1}^{n} r_j \sum_{i=1}^{m} w_{ij}$$

$$S \succcurlyeq 0 \tag{3.11}$$

where e_n is a vector of n elements all equal to 1, and X, Y is a natural inner product between X and Y matrices.

There are many applications for the CMA model. Some studies such as Statman (2004) argue that in behavioral portfolios people are risk averse in one layer of portfolio pyramid and they are risk seeker in another layer. This means that models should be able to accommodate various types of risk measures in one model for behavioral portfolio selection. Since CMA includes all sub-portfolios in one model, it is possible to consider different measures of risk for each sub-portfolio.

There are many cases that an investor wants to impose upper or lower bounds on his portfolio such as $f(w_1) + f(w_2) + f(w_3) \leq \beta$, these are only possible in a standalone model such as CMA. It allows investors to be conservative in some sub-portfolios, and speculative in other ones, without changing the model entirely. For example, it is possible to use a very conservative risk measure such as the worst-case VaR for one sub-portfolio and conventional VaR for another sub-portfolio.

With the above logic, it is also possible for investors to impose various other arbitrary constraints on different sub-portfolios. For instance, an investor can ban short selling in one sub-portfolio ($w_{1j} \geq 0, j = 1, 2, \ldots, n$) while permitting it in other ones (w_{ij} free in sign, $j = 1, 2, \ldots, n;\ i = 2, \ldots, m$).

3.3.3 Concluding Remarks

We discussed the role of BOR in portfolio selection in two steps: first we introduced effects of behavior, then we presented at least one BOR remedy for each of the presented effects. We classified effects in two categories: elemental and structural.

In elemental effects, we revealed the effects of behavioral biases, risk, and expected return on portfolio selection. More specifically, we mentioned the effects of behavioral biases on investment performance, and presented multiple regression and causation methods to include them in the BOR modeling. We also revealed the issues that exist regarding the modeling of risk in portfolio selection, and introduced spectral risk measures as a broad way of including investor attitudes toward risk while keeping the risk measure coherent. Moreover, we brought up the issue of robustness in expected returns along with the need for investor ideas to be included in estimating the expected returns. In order to resolve these issues, we proposed the use of Black-Litterman robust estimators instead of standard estimators.

As structural effects, we presented the prescription and mental accounting effects. Prescription effect is addressed by showing the usefulness of a prescriptive portfolio selection that makes a balance between views of investors and their advisors. Mental accounting effect is derived from behavioral finance and psychology which conclude that investors have several simultaneous mental accounts (investment goals), instead of just one. We presented Collective Mental Accounting model with a semi-definite programming representation to contain all mental accounts.

In summary, here we tried to emphasize the importance of considering behavioral aspects in modeling portfolio selection. We showed that in modeling portfolio selection, the modeler should be aware of two distinct types of behavioral effects, which could be dealt with by BOR. The goal was to provide a helicopter view on the modeling process along with some issues and remedies to complete the picture. Based on this chapter, one can see the future behavioral improvements of portfolio models either in structure of models or in the details of elements. With this concept in mind, we can expect future contributions to be more converged toward the goal of better models that capture behavioral issues and account for limitations of normative models integrating BOR practice (as indicated in Kunc, Chapter 1).

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4

Feedback, Information Representation and Bidder Behavior in Electronic Auctions

Ayşegül Engin and Rudolf Vetschera

4.1 Introduction

Electronic Reverse Auctions (ERAs) have gained considerable importance as a resource-saving procurement process (Sehwail et al. 2008; Ganesan et al. 2009; Wooten et al. 2017). They enable firms to contact suppliers world-wide in real time and also suppliers to participate in procurement processes of many potential customers. However, they also create a demanding decision environment for participants, who have to make bids in a very dynamic setting, based on very limited information. In such an environment, decision-makers tend to rely on heuristics and act in a way that deviates from normative models of rational decision-making (Hämäläinen et al. 2013). This is usually the focus of

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BOM practice (see Kunc, Chapter 1). The extent to which decisions are influenced by such biases depends on, among other factors, their priming and the way in which information is presented to decision-makers during the process. Feedback information provided by the system to bidders is therefore of crucial importance in these decisions. We thus consider ERA platforms an important area of application of Behavioral OR methods, which study the effects of such conditions as uncertainty, time pressure and information presentation on decision-making behavior. Behavioral OR studies not only generate insights into the factors that affect decision-maker behavior in such environments, but also provide advice to system users and designers on approaches how to avoid biases and ultimately achieve more rational decisions.

Given the impact that the amount and the format of information provided to bidders might have on their behavior, we present an empirical study on such information effects in this chapter. We see this empirical study as an example how rigorously designed behavioral experiments can lead to results that are useful to support designers and users of systems that support (collective) decision-making that gets closer to normative models (see Kunc, Chapter 1). Within this chapter, we first give a brief overview of ERAs. The second part continues with different types of feedback that a decision-maker can receive from the ERA platform, and their possible reactions. We present an experiment on the effects of different feedback types. The final section discusses the results. Most of this chapter is based on results published in Engin and Vetschera (2017, 2019) and Engin (2019).

4.2 Electronic Reverse Auctions (ERAs)

In an ERA, the buyer of a service or goods is the auctioneer, who initiates the process by providing a detailed description of the service or good that he or she wants to acquire. The suppliers of the requested service or good are the bidders, who submit their bids specifying the price at which they offer to fulfill the request. Auctioneer and bidders communicate exclusively via an electronic platform. This restricted form of communication, together with the complexity of the environment

(Charki et al. 2011), can cause problems, in particular for the bidders. This has led to major criticisms against ERA usage (Pham et al. 2015). We argue that the issues the suppliers are facing partly originate from the necessity to decide based on the limited feedback that the platform provides. This restricted information, and the particular way in which it is presented, can trigger behavioral biases in the suppliers' decision processes, leading to suboptimal behavior. For this reason, it is important to study the effects of different feedback types on the decision-making behavior of the individual bidders.

4.3 Feedback Types

In the ERA platform, decision-makers (bidders) need to submit their bids based on the information and on the feedback provided by the platform. Platforms are set up by auctioneers and developed by programmers, the bidders have no influence on the amount or format of the information they receive. Here we study several properties of this information that might influence bidder behavior:

1. The amount of feedback (i.e. more or less detailed information about the market)
2. The context of feedback
3. The framing of feedback (i.e. win/lose framing with hypothetical payoff information versus only historical bid table).

4.3.1 The Amount of Feedback

Normative decision theory typically argues that more information prior to decision-making leads to better results (e.g. Sterman 1989; Cantor and Macdonald 2009). However, literature provides some opposing empirical evidence (e.g. Van Knippenberg et al. 2015; Crook et al. 2016; Mengel and Rivas 2017). In an ERA platform, the only possibility of obtaining information is the feedback provided by the platform. Providing additional feedback, e.g. about bids made by other bidders, can therefore influence bidder behavior positively or negatively, depending on how they process that information.

Prior literature on different information levels in ERA platforms has studied the relationship between cost distribution and bidding behavior (Maskin and Riley 2000), differences between high versus low cost type bidders (Saini and Suter 2015; Aloysius et al. 2016), behavior of bidders whose cost functions are drawn from different distributions (Güth et al. 2005), or behavior of the bidders, when they are provided with rank feedback about the other market participants (Elmaghraby et al. 2012). Our research question is concerned with the impact of different amounts of feedback in the ERA platforms on individual decision-maker behavior, considering their individual characteristics in information processing.

In an ERA, bidders are faced with a complex decision environment, with only limited information. Bidders have to interpret the received information in order to maximize their own utility. However, if the information is too complex for the decision-makers to process, their cognitive resources decrease, leading to suboptimal decision-making.

We conduct an experiment to analyze whether providing more information leads to a bidding behavior that benefits the decision-maker. Experimental literature uses two types of feedback treatments in auctions. One treatment provides only information about the auction result as 'winning' or 'losing' the auction. The other treatment provides information about other market participants' historical bidding behavior (Neugebauer and Selten 2006). In our experimental study, we use these two treatments to examine the effect of additional information on behavior. In the *minimum information* condition, bidders only receive information about the auction outcome and if there will be a subsequent auction. The other feedback type, which we label as *maximum information*, adds a historical bid table about all market participants.

4.3.2 The Context of Feedback

Another important aspect that we take into consideration is the context of feedback. The objective usefulness of additional information, as well as the subjective willingness of bidders to accept and process such information, depend on the particular environment in which the auction takes place. The environment can contain a different number of players, who behave in a more or less rational way, and who have different amounts of information. We operationalize these concepts in three different market settings. The first market setting contains computerized opponents that are playing according to a preset rule (i.e. truthful bidding) and one human player, whose behavior we study. In the second market setting, every participant receives the same feedback treatment (i.e. all market participants have either minimum or maximum information treatment). Here all of the market participants are humans.

In the third market setting, the markets also consist of human participants, but they receive different amounts of information. Half of the market participants receive the minimum information treatment, the other half the maximum information treatment. Previous literature focused on only one aspect (e.g. Shogren et al. 2001; Dorsey and Razzolini 2003; Lusk and Fox 2003; Ockenfels and Selten 2005; Neugebauer and Selten 2006; Engelbrecht-Wiggans et al. 2007; Filiz-Ozbay and Ozbay 2007). By combining information levels and environmental characteristics, we are able to study the effects of additional information in different environments.

4.3.3 The Framing of Feedback

As already mentioned, a minimum information treatment is often communicated to participants as 'winning' or 'losing' the auction (Neugebauer and Selten 2006). However, this framing can trigger a psychological effect, which can significantly alter the decision-makers' behavior. Being the 'winner' has a well-documented psychological effect on behavior (Lopez and Fuxjager 2012), and in the auction context the existence of this phenomenon is extensively documented (e.g. Adam et al. 2011, 2012, 2015; Astor et al. 2013). So far, this effect was not considered in previous studies on different levels of feedback.

In an ERA, decision-makers have two objectives. One is winning the auction, and the second is to maximize the individual profit, if the auction is won. In a reverse auction, the first objective is improved by bidding a low value, the second by bidding a high value. Information compatibility theory argues that individuals consider an objective that is more salient as more important than other, less salient objectives (Lichtenstein and Slovic 1971). Different forms of feedback can focus the decision-maker's attention on different objectives. Specifically, we argue that using the words 'win' and 'lose' in the feedback can lead to priority shifts toward the objective of winning the auction. We study in our experiment whether such behavioral effects of different wording in the feedback occur and if these effects can be mitigated by using different wording.

4.4 Research Model of the Experiment

The experiment is concerned with the first three aspects of the feedback (i.e. the amount, context, and framing of the feedback), taking into account individual characteristics of the decision-makers. This experimental study, conducted in computerized format, consists of two separate experiments.

For examining the amount of feedback, we define maximum and minimum information treatments. We expect that the participants, who receive a detailed feedback and therefore are better informed about the market (i.e. the maximum information treatment) are also better able to bid optimally. As participants should avoid to make deliberate losses, providing the participants with their bid rank relative to the other market participants will lead them to adjust their profit margin better and bid less aggressively. Therefore hypothesis 1 argues that:

H1: Participants who receive maximum information feedback make bids that lead to higher profit margins.

The second feedback aspect, which is investigated in the experiment, is the context of the feedback. As already explained, we use three market settings, one with (fully informed and rational) computer bidders, one with human bidders receiving the same type of information, and one with human bidders receiving different types of information. We assume that participants avoid to take high risks in the more complex settings, and therefore formulate the following hypotheses about informativeness of feedback:

H2a: In homogeneous markets, participants bid less aggressively when they are bidding against human opponents in comparison to computerized opponents.

H2b: The effect described in H2a is larger in markets with heterogeneous information structure.

The third feedback aspect we consider in the experiment is the 'win/lose' framing. In order to shed some light on this issue, we maintain the maximum and minimum information feedback treatments and add slightly modified versions of these treatments. The original maximum and minimum information feedback treatments both explicitly use the words 'win' or 'lose'. The first added treatment adds the hypothetical winning bid to the maximum information feedback treatment. This information provides the decision-maker with the profit margin that would have been obtained if winning the auction. We expect that this hypothetical bid information will mitigate the *winner's curse effect* despite the usage of 'win/lose' framing by shifting attention to the goal of maximizing profit and clearly showing that winning the auction might actually lead to a net loss. The second additional treatment shows the participants only the historical bid table, but does not explicitly indicate whether the auction was 'won' or 'lost'. The participant has to extract this information from the table. We expect that participants engage in less aggressive bidding behavior, if they are explicitly shown the consequences of offering the winning bid. Therefore, the third hypothesis is formulated as:

H3: If maximum information feedback with the historical bid information is presented to the participant, they show less aggressive bidding behavior.

As we have already argued, decision-makers differ in the way they process (additional) information. We therefore also control for decision-maker characteristics. In particular, we consider the rationality/emotionality score and the reflectiveness/impulsiveness of the participants. High rationality of a decision-maker is expected to lead to less aggressive bidding behavior, because these individuals are characterized by fully processing the received information. Thus, the feedback does not invoke emotional responses, which might lead to suboptimal bidding behavior. Concerning reflectivity vs. impulsiveness, impulsive decision-makers tend to react before they can extensively asses the provided information. Therefore, they are expected to be more prone to exhibit suboptimal bidding behavior. We formulate hypotheses 4 and 5 as:

H4: Less aggressive bidding behavior is observed in more rational decision makers.

H5: Less aggressive bidding behavior is observed in more reflective decision makers.

The experiment was conducted in two lab-controlled studies. Both studies were executed in a similar manner in order to guarantee the comparability of the results. In all sessions, participants completed an ERA and psychometric tasks in a computer laboratory. The auction part of the study consisted of an ERA with multiple rounds. The participants were informed that they had the role of a manager of a construction company that is bidding for realizing a construction project. The auctioneer (i.e. the buyer of the construction project) decides after each round, whether he wants to continue the auction or accept the last round of the auction as the deciding round. For comparability, all auctions had the same number of rounds. This was not revealed to participants to avoid end-round effects. Participants were recruited among business administration students. They were presented with experimental instructions in the laboratory, completed the tasks and were incentivized for their contribution.

4.4.1 Study A

Study A has a 2×3 factorial design. One dimension consisted of the minimum and maximum information treatments, the other dimension contained homogeneous and heterogeneous markets with human or computerized opponents.

4.4.2 Study B

Study B has a 1×2 factorial design. In this experiment, only the homogeneous market structure was used. Furthermore, the feedback treatments were the hypothetical winning bid and the historical bid table without 'win/lose' wording.

4.4.3 Results

In total 384 participants volunteered for the experiment. For hypothesis 1, results comparing the minimum and maximum information treatments show that more information leads to more aggressive bidding behavior in the sample. Comparing the hypothetical bid treatment and historical bid table treatments, results show that participants, who received feedback without the 'win/lose' framing, exhibited significantly less aggressive bidding behavior. Also, aggressive bidding behavior was lower for participants who have high rationality scores and are characterized as reflective decision-makers. With respect to hypotheses 2a and 2b, there are no significant results in this sample.

We can conclude from our results that providing the decision-makers with more detailed information about the market has indeed an effect on their bidding behavior, regardless of the opponent or information structure in the market. However, using 'win/lose' framing seems to direct the focus of bidders toward the objective of winning the auction and leads them to disregard other important objectives (i.e. avoiding a bid that leads to a negative profit margin). Furthermore, it is important to keep in mind that characteristics of the individual decision-makers have a significant effect on how the feedback is perceived.

4.5 Discussion

In this chapter, we investigate effects of feedback in ERAs, as various information aspects can alter the decision-making behavior of the individuals in a dynamic decision-making context (Hämäläinen et al. 2013; Franco and Hämäläinen 2016). As decisions can only be based on the information that is communicated through the platform, how the information is perceived by the individual can alter his or her decisions. In order to investigate this topic, we conducted two laboratory experiments focusing on the amount, context, framing and its effects on bidders with different characteristics such as decision-making styles. Our studies show that the straightforward argument that providing participants with more feedback information improves performance does not necessarily hold. Depending on the personal characteristics, more detailed feedback leads some participants to bid more aggressively, which then results in the majority of the cases in lower payoffs in total due to serious underbidding. Therefore, auction platforms that provide exactly the same amount of information in exactly the same format to all participants are not necessarily 'fair', but in fact favor some type of bidders to the disadvantage of others.

This insight might have direct consequences for the design of auction platforms. Apart from these direct results, we also consider some methodological aspects of our study worth mentioning. The aim of behavioral OR studies is to ultimately generate relevant insights for the practice of OR. As we have already mentioned in the introduction of this chapter, many behavioral effects are dependent on the context in which decision-makers act (Hämäläinen et al. 2013). Many experiments in behavioral economics and also in behavioral decision-making are deliberately performed in a 'sterile' laboratory setting that provides as little context as possible. Such experiments were clearly useful to identify systematic deviations from rational decision-making and have led to an impressive catalog of biases (Montibeller and von Winterfeldt 2015). However, complex interactions between bidders in an auction require to study behavioral phenomena in a more realistic setting. This does not mean that it is not necessary to design and conduct experiments in a rigorous way, strictly controlling the relevant (contextual) factors and taking into account additional factors such as individual decision-making styles of subjects. We think that such rich, but controlled experiments are necessary to generate insights into behavior useful for actual applications.

In that sense, our results are in line with the goals of the behavioral OR literature and its results (Hämäläinen et al. 2013). Individual differences of actors in their decision-making characteristics, abilities and proneness to decision-making biases interact in a complex way with environmental factors and systems. This is usually the focus of BOM practice (see Kunc, Chapter 1). If platforms that the decision-makers use are tailored to their needs, decision performance will improve. Providing more flexibility in the amount and format of information that ERA platforms provide to bidders thus might help to overcome resistance to using such systems.

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Part II

Competences Beyond Models

5

Probability and Beyond: Including Uncertainties in Decision Analysis

Ian N. Durbach and Theodor J. Stewart

5.1 Introduction

The formal modeling of risks and uncertainties in multi-criteria decision analysis (MCDA) involves treating uncertainties both in the formulation and modeling of the decision problem (often referred to as *internal* uncertainty), and uncertainties arising from exogenous factors (*external* uncertainty). In this chapter we focus on the latter, a typical example being an outcome of a course of action that is to some degree unknown, perhaps because it is contingent of future events.

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Many approaches have been developed for uncertain decision problems, and these are reviewed in Stewart (2005), Durbach and Stewart (2012), and Stewart and Durbach (2016). This chapter takes a more explicitly behavioral view of the subject of uncertainty modeling in MCDA. Given the space limitations, we focus our attention on the use of probabilities and scenarios, both because these involve important behavioral issues, and because together they cover a broad range of uncertainties that analysts are likely to encounter in practice.

Probabilities are by some margin the most common way of modeling uncertain outcomes, both in decision analysis and more generally. We do not attempt to review probability-based decision models, or indeed to refer to any one model, but rather discuss general limitations to the use of probabilities in decision analysis that will apply to any decision model that employs probability. The first half of the chapter describes these limitations as well as interventions that attempt to reduce or eliminate them.

When uncertainties are of such complexity and magnitude that it becomes difficult or impossible to quantify them with probabilities in an operationally meaningful way, it can be preferable to model the uncertainty with scenarios—narrative descriptions of possible futures—rather than forcing the decision-maker into giving quantitative assessments of probability that he or she finds difficult or impossible to make sense of, and which may be a poor reflection of their beliefs as a result. The second half of the chapter discusses behavioral issues around the use of scenarios and the integration of scenario planning and decision analysis. Again, we describe the issues in general terms; they apply equally to any scenario-based decision model.

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5.2 Behavioral Limitations in Probability Assessment and Use in Decision Aiding

In the context of facilitated decision support a 'good' probability assessment is one that accurately represents a decision-maker's opinion about a quantity of interest, regardless of how accurately that opinion reflects reality (Garthwaite et al. 2005). Ideally a decision-maker's judgments should be well-calibrated against, or at least take into account, available data; but ultimately if a decision-maker chooses to hold a minority opinion then that is their choice, and one that must be respected by decision support. It has long been recognized that it is difficult to obtain good probability assessments in decision analysis (Spetzler and Stael von Holstein 1975; von Winterfeldt and Edwards 1986). The real question is whether these difficulties can be reduced or eliminated, and whether alternative non-probabilistic approaches do any better.

A core finding in psychological research over the past fifty years is that many kinds of judgments are subject to systematic distortions. This is the *heuristics and biases* research program brought to prominence by Tversky and Kahneman (1974), and reviewed in Gilovich et al. (2002) and Kahneman and Egan (2011). Many of the original heuristics (availability, representativeness, anchoring and adjustment) relate to probability assessment, and these have been substantially added to over the years. Montibeller and von Winterfeldt (2015b) provide a recent, comprehensive summary of biases as they relate to decision and risk analysis, grouping them into *cognitive* and *motivational* groups of biases.

Cognitive biases arise when a mental calculation leads to an assessment of probability that is systematically different from accepted normative standards. An 'easy' example is one that violates the conjunction rule; but assessments that are insensitive to changing base rates would also be considered cognitively biased. Among other effects, cognitive biases can induce decision-makers to allocate similar probabilities to all events (*equalizing bias*), to focus on a much-reduced set of futures states (*myopia*), to be sensitive to scaling, to ignore base rates, to inadequately update judgments in light of new information (*conservatism*), and to judge the sum of mutually exclusive events to be different to the probability of the union of those events (*sub/super-additivity*).

Motivational biases arise when an assessment of the probability of an event is influenced by how desirable or undesirable it is. Reported examples of motivational biases include inflating the estimated probability of a desirable outcome (*optimism bias*), but also using the cautionary principle to inflate the estimated probability of undesirable outcomes, particularly when these are poorly understood or occur far into the future, or to estimate probabilities in such a way that favors a particular alternative over others (see Montibeller and von Winterfeldt 2015b, for further discussion and references).

These effects are not unique to probability assessment, nor are they unique to decision analysis. Biases in probability assessment are relevant to any area that uses subjective probability as an input, while the same biases that affect probability judgments can also affect the assessment of other parts of the decision model, such as attribute evaluations and weights. Yet when thinking about the use of probabilities in decision analysis in particular, another important behavioral question arises: is probability the best way for decision-makers to think about uncertainty?

There are many kinds of uncertainty (e.g. French 1995; Zimmerman 2000), and subjective probability is a broad concept with which it is possible to model a great variety of these. However, for some kinds of uncertainty other tools may be more appropriate, particularly from the perspective of behavioral goals like ease-of-use and transparency. For example, in some cases decision-makers may be more comfortable expressing their uncertainty linguistically or in the form of decision rules; fuzzy and rough sets have been developed for this purpose, respectively (Zimmerman 1987; Greco et al. 2001). In other cases decision-makers may wish to explicitly model their ignorance. This is not possible in a standard probabilistic framework, but ignorance is accommodated by Dempster-Shafer *degrees of belief*, one implementation of which for decision aid is the evidential reasoning approach (Yang 2001). In cases of 'deep' uncertainty—uncertainties that are by definition too large to be amenable to numerical analysis—qualitative descriptions of potential future scenarios may be preferred (Stewart et al. 2013; see also later in this chapter).

5.3 Partial Compensation in a Conventional Framework

Although not straightforward, many biases in probability assessment can be reduced or avoided by using debiasing tools and procedures, allowing the analyst and decision-maker to remain in a conventional probability-based framework. This section briefly reviews developments in this area. The main messages emerging from this literature are that (a) biases, while persistent, can often be reduced; (b) tools are primarily either cognitive strategies designed to help the decision-maker to confront his or her biases, or visual aids facilitating understanding and interpretation of probability concepts; (c) prescriptive decision analysis has in fact done quite well with respect to bias reduction, with many debiasing tools constituting, in our view, accepted best practice in MCDA.

The success of the heuristics and biases program means that its main message of flawed human judgment has garnered a great deal of attention, rebuttals much less so (e.g. Johnson and Bruce 2001; Kynn 2008). Since these are relevant to behavioral OR, we summarize them here. The most important message is that biases are often found using framings deliberately chosen to induce them, and that more-or-less simple changes have been found to reduce the severity of these biases. These include using frequencies rather than probabilities, using negative framings, providing base rates, and making nested probabilistic structures explicit. Environments favorable to good assessment are summarized in Johnson and Bruce (2001) and Shanteau (1992): they include those aided by expertise, training and relevant feedback, motivation, a naturalistic rather than experimental setting, and prediction tasks rather than memory retrieval tasks. All of these are either common features of decision problems (e.g. naturalistic settings, prediction tasks) or would generally be considered good problem structuring practice (e.g. feedback, training, inclusion of relevant stakeholders representing experts and interest groups).

These findings also point more-or-less directly to potential ways of debiasing probability judgments. There is no ‘silver bullet’ when it comes to debiasing, and most approaches are pragmatic, common-sense tools that encourage the decision-maker to think more deeply about the problem at hand, and to reconsider including their own preferences and perceptions (Arkes 1991; O'Hagan et al. 2006; Larrick 2007; Montibeller and von Winterfeldt 2015a). A large number of potential debiasing approaches are reported in the reviews in Montibeller and von Winterfeldt (2015a) and Ludolph and Schulz (2018), while a useful categorization is, following Larrick (2007), one that groups cognitive, motivational, and technological debiasing approaches. Specific debiasing strategies include, for example, asking the decision-maker to consider counterfactual information, using visual aids that facilitate probabilistic reasoning, alternate elicitation procedures that avoid framings most susceptible to biases, tools that incentivize or otherwise increase a decision-maker's interest and motivation, and explicitly making the decision-maker aware of potential biases (e.g. Spetzler and Stael von Holstein 1975; Johnson and Bruce 2001; Garthwaite et al. 2005; Larrick 2007; Montibeller and von Winterfeldt 2015a). A recent review found the first two of these accounted for the majority of debiasing applications in health-related judgments (Ludolph and Schulz 2018).

Evidence on the effectiveness of debiasing approaches is mixed, and the reviews above contain several examples both of successful and unsuccessful debiasing interventions. Ludolph and Schulz (2018) report a success rate of around 70% which, given the bias toward publishing positive results, seems a fair reflection of the mixed effectiveness of debiasing attempts.

5.4 Non-quantitative Scenario Planning Responses and Absorption into OR

The heuristics and biases described in the previous section arise even in well-defined sampling frameworks. Strategic decisions typically face uncertainties that are complex and interrelated, and for which precise mathematical measures such as probabilities become operationally difficult for decision-makers to comprehend, and for facilitators to validate. Scenario planning (e.g. Van der Heijden 1996; Bradfield et al. 2005) is an alternative approach based on constructing a small number of narratives describing plausible ways in which the future might unfold. These can be used for strategic decision-making, to better understand causal processes, or to challenge conventional thinking within organizations (Wright et al. 2013).

Behaviorally oriented research has played an important role in the core scenario planning literature (e.g. Bryson et al. 2016). Avoiding 'business as usual' thinking was an early motivation that continues to be actively researched (Nemeth et al. 2018). The scenario construction process is informed by findings on, for example, the influence of facilitator and group properties (Ackerman and Eden 2012), stakeholder ownership in and control over the scenario planning process (Soste et al. 2015; Cairns et al. 2016), and heuristics and biases arising during scenario construction (Bryson et al. 2016). Recent studies raise the possibility of a variety of causal relationships that might serve different organizational purposes, and might require different kinds of scenarios (Maier et al. 2016; Derbyshire and Wright 2017).

Although scenario planning need not always be undertaken to arrive at a decision, in cases where there is little consensus on best practice. Informed but informal judgment is common (e.g. Cairns et al. 2004), but new proposals appear regularly, ranging from qualitative (Schwartz et al. 2019) to quantitative (Favato and Vecchiato 2017) and mixed approaches (Lehr et al. 2017).

It is here that decision analysis would appear to offer fruitful opportunities for integration with scenario planning, particularly from the perspective of providing theoretical foundations that are often claimed to be lacking in scenario planning (Spaniol and Rowland 2018). Attempts were made fairly early on to co-opt scenarios into decision analysis (Goodwin and Wright 2009), with the integration of scenario planning and MCDA described in Stewart et al. (2013) and specific variants[1] proposed in Montibeller et al. (2006), Ram et al. (2010), and Durbach (2014), but this work has not found its way back into the mainstream scenario planning literature (e.g. Amer et al. 2013). Two

[1]Note that these approaches do not employ probability concepts, although they do include other quantitative features which we outline in the next two sections.

key factors implicated in the lack of take-up are differences in opinion about if and how assessments should be aggregated over scenarios, and to what extent this aggregation should reflect a desire for ‘robust’ performance over scenarios. These questions are both closely related to the goal of the decision-making process itself, and thus involve a substantial behavioral component that we take up in the remainder of the chapter.

5.5 Robustness to Scenarios and *Antifragility*

Many discussions refer to the need for scenarios to be diverse but ‘plausible’. As an aid to decision-making, scenarios should also capture significant potential impacts (gains or losses), as discussed for example by Derbyshire and Wright (2014) and Derbyshire (2017), for purposes of more formal decision analysis.

The earliest attempts to integrate scenario planning with MCDA (Goodwin and Wright 2009) in effect carry out a formal deterministic MCDA (multi-attribute value function model) analysis within each scenario, resulting in an overall evaluation of the consequences of each policy action in terms of an aggregate value under the scenario. Goodwin and Wright (2009) do not clearly discuss resolving conflicts which may still arise when comparisons are made of alternatives across scenarios, although the tenor of the discussion hints at a desire for some form of robustness. A clearly robust solution would be one which has maximum aggregate value (or nearly so) under all scenarios, and such a solution may actively be sought, but may seldom be achievable.

Montibeller and co-workers (e.g. Montibeller et al. 2006; Ram et al. 2010) formalize robustness in a similar context to Goodwin and Wright by applying a max–min approach, i.e. by selecting the policy or course of action, which maximizes the minimum aggregate value (across scenarios). The use of max–min concepts as a ‘worst-case’ analysis is quite widely spread across the literature, but apart from a reference to two-person zero-sum games, which is more of an analogy than a realistic model of most decision-making situations, does not have a fundamental theoretical basis (cf. French et al. 2009, p. 345), and must be viewed at best as a heuristic. Its use must be viewed with some caution as, for example, if the max–min solution is only slightly better on the minimum aggregate value but much worse under other scenarios, the approach may be very difficult to justify.

On the other hand, Derbyshire and Wright (2014) point out that the common process of constructing scenarios often follows some form of causal chain which they term *intuitive logic*, which can itself introduce cognitive biases such as overconfidence and a form of conjunction fallacy that they term a *simulation heuristic*. These may lead decision-makers to underestimate the effects of worst-case extremes. In fact, the entire concept of *plausibility* would be subject to many of the cognitive biases described in Sect. 5.2. Taking a lead from the concept of *antifragility* (Taleb 2012), Derbyshire and Wright (2014) suggest that such problems may be ameliorated by actions such as a *backwards logic method* for designing scenarios (starting from a broader range of extreme outcomes and actively exploring possible routes to their occurrence), and designing actions to be flexible across all extreme outcomes.

Clearly, however, the operational practicalities of robustness or antifragility for practical decision analysis are still elusive. But the approaches described above do not fully consider the multicriteria aspects of the problem under conditions of uncertainty, as aggregation across criteria is performed as a preliminary step prior to consideration of effects across scenarios, and certainly robustness (or antifragility) is not examined at the level of individual criteria. Nevertheless, robustness in terms of, for example, environmental impacts may under some situations be more critical than that of financial impacts, and vice versa. Thus, in the next section, we discuss an approach for retaining consideration of the original criteria and scenarios in a more unified framework, based on the concepts set out by Stewart et al. (2013).

5.6 Scenarios as a Dimension of Preference

The decision analyst does seek some more quantification of the concepts discussed in the previous section, and we here present more formal links between scenario planning and MCDA, with an emphasis on value function modeling.

To this end, let us denote by $v_{ik}(a)$ the performance on an appropriate additive value measurement scale (to be elicited in conjunction with the decision-maker, DM) of action or policy a in terms of criterion $i(= 1, 2, \ldots, m)$, assessed under conditions of scenario $k(= 1, 2, \ldots, s)$. Under the assumptions of additive value theory (Keeney and Raiffa 1993; Belton and Stewart 2002), the DM's preference orders can be represented under conditions of a specified scenario k, in terms of an additive value function $\sum_{i=1}^{m} w_i v_{ik}(a)$, and this assumption has been invoked in the approaches of Goodwin and Wright (2009) and Montibeller et al. (2006) discussed in the previous section. However, the assumption of additivity cannot directly be assumed to apply to aggregation across scenarios. For example, even if a proper probability space can be defined across scenarios, it does not follow that preferences aggregate additively under an expectation operator (cf. the axiomatic development of multi-attribute utility theory by Keeney and Raiffa 1993).

The situation is aggravated by the fact that a set of scenarios cannot, in general, be viewed as a proper probability space or even a random sample from such a space, so that additive probability theory is generally not applicable, as has been stressed by many authors e.g. Derbyshire (2017). Scenarios are coherent 'stories' that may typically incorporate different characteristics of potential futures and different ranges of potential point-wise outcomes. It is not usually even intended that all possible futures are to be captured by the set of scenarios. Furthermore, one scenario may describe political developments in great detail but pay scant attention to economic consequences; a second scenario may do the exact opposite. Questions like 'does political event x occur in this scenario?' will be much easier to answer in the first scenario, and may not be answerable at all in the second. This raises theoretical and practical problems when asking the DM to assess the relative likelihoods of scenarios. Essentially the DM is being asked to 'fill in the details' required to place these scenarios on the same multidimensional probability space, but we have no idea of how they are doing this or what biases they may fall prey to in the process. Thus references one does find in the OR literature to probabilities on scenarios, and use thereof in analysis, are largely invalid.

Elsewhere, we have outlined an alternative structure for evaluating multicriteria decision-making problems under different scenarios representing deep uncertainties, most recently in Stewart et al. (2013). Each scenario is viewed as a dimension of concern that needs to be taken into account by decision-makers, i.e. a dimension of robustness, or *anti-fragility*, to unexpected futures that may not be represented in terms of statistical sample spaces. The extent or importance of this concern to the decision-maker may be influenced by a sense of the 'likelihood' or plausibility of the occurrence of the scenario, but may even more be influenced by concerns such as ease of recovery from disastrous events however 'unlikely' they may be (and as we have stressed, probabilities are at best debatable for deep uncertainties). Within this context, we should also recognize that one particular scenario may be 'disastrous' in terms of some criteria, but be tolerable for others, and vice versa for another scenario.

With these thoughts in mind, Stewart et al. (2013) argued that preferences of a decision-maker within a specified scenario, and for a specified criterion conditional on a scenario outcome, have all the features defining a criterion for evaluation of alternatives. In effect, there are $m \times s$ criteria according to this viewpoint, which we termed metacriteria. For any one metacriterion, say $(i,\ k)$, it is assumed that there would be a preference ordering of alternatives. Note that there is no presumption that the ordering for one particular original criterion i is the same under different scenarios say k and l, so that ordering of alternatives according to i may well be, or may commonly be expected to be, scenario-dependent. Provided that the metacriteria are preferentially independent in the sense defined by Keeney and Raiffa (1993), recalling that conditional on scenarios the model is deterministic, a valid representation of decision-maker preferences can be structured in additive form $\sum_{k=1}^{s} \sum_{i=1}^{m} w_{ik} v_{ik}(a)$. It would not, in general, be true that the w_{ik} terms would be factorizable in the form $w_{ik} = w_i^1 w_k^2$, where w_i^1 and w_k^2 refer to criterion and scenario weights, respectively, and in fact from our discussion above, such a factorization would be highly unexpected (and a flag for doubtful structuring).

The process would then follow standard (deterministic) value function methods for multicriteria decision-making with $m \times s$ criteria.

Typically the number of scenarios used in strategic planning is not large (3 or 4 is often recommended), so that the number of metacriteria will remain manageable. The guidance given by analysts to decision-makers does nevertheless require care with the two forms of elicitation:

- In comparing alternatives for elicitation of the partial values $v_{ik}(a)$, the decision-maker should be directed to think in terms of impacts in terms of the criterion i under conditions of scenario k, with particular emphasis placed on preference intervals (gaps) at the lower (undesirable) end of the scale;
- In eliciting the weights w_{ik}, a form of swing weighting (as described in Belton and Stewart 2002, section 5.4) may be preferable. In comparing swings for two metacriteria, the consideration would be the relative importance of the metacriterion, including the fundamental importance of the underlying criterion, its sensitivity (fragility) under conditions of the scenario, and the intrinsic plausibility of the scenario. It would probably be convenient to structure the comparisons in one of two ways (for details, see Stewart et al. 2013):
    - For each scenario in turn compare all criteria, followed by comparing all scenarios for one selected criterion;
    - Or vice versa.

An issue that is in need of further research is the extension of the above framework into conditions under which each scenario contains secondary random elements more fully describable by standard probability distributions.

5.7 Conclusions

Probability-based models constitute the majority of approaches dealing with uncertainty in multicriteria decision problems. Probability judgments are subject to biases, but to a large extent these are known, as are possible ways to minimize them and when these do and do not work.

MCDA best practice incorporates much of this knowledge, and guidelines are readily available (e.g. Belton and Stewart 2002; Montibeller and von Winterfeldt 2015a).

Probabilities become less useful when uncertainty reaches a level at which probabilities become difficult to comprehend and quantify, even with existing cognitive aids and careful problem structuring. This is a gray area—there is no single point at which uncertainties become unmanageable using probability—but at some stage it may be more natural to model uncertainty using scenarios. Methods integrating scenarios with decision analysis exist for this purpose.

Scenarios can also be influenced by heuristics and be subject to bias. A growing body of work documents these biases as well as suggested best practice (e.g. Bryson et al. 2016). These include thinking carefully about group composition and facilitator involvement, as well as combatting more traditional biases like overconfidence and availability. These should be standard practice in any scenario planning process.

For the decision analyst who wishes to provide scenario-based decision support, we emphasized the view that scenarios are inextricably linked to the overall goal of the decision process, specifically to the kind of robustness that the scenario planning process has been set up to achieve. In this view, each scenario is a dimension of concern to be taken into account by decision-makers. Scenarios should emphasize different aspects of the future that the decision-makers want to be robust to, and decision-makers should be allowed to express preferences for some kinds of robustness over others. This leads naturally to a formulation of scenarios, within the MCDA model, as attributes, rather than as more-or-less externally given states over which we and others have argued aggregation by expectation is neither appropriate nor desirable.

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6

How to Use Ambiguity in Problem Framing for Enabling Divergent Thinking: Integrating Problem Structuring Methods and Concept-Knowledge Theory

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6.1 Introduction

Understanding the relationship between actors' knowledge, behavior and action is a key challenge for modeling approaches (White 2016a). Participatory activities are expanding modeling beyond prediction in order to include processes co-designed with stakeholders and inclusive of multiple knowledge forms (Brugnach and Ingram 2012). As White (2016a) discussed, originally OR focused on the objectivity of the scientific method, and the adopted models assumed a singular version

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of rationality (Jackson 2006; Keys 1997; Mingers 2000) independent from different perceptions (Ackoff 1962, 1978; Lesoume 1990; Mingers and Rosenhead 2004; Raitt 1979). However, soft modeling approaches investigated the possibility of using qualitative methods, including subjective values to support decision-making (Checkland and Holwell 2004; Davis et al. 2010; Eden and Ackermann 2006; Mingers 2011; White and Bourne 2007; Yearworth and White 2013). Capturing differences in problems frames, through models of viewpoints, enhance an understanding of a problematic situation and to help support its resolution (Eden 1992; Giordano et al. 2017a; White 2016b).

In doing so the presence of *ambiguity* in the perception of the problem to be addressed, between model developers and model users, and among different users, is challenging the effectiveness of participatory modeling approaches (e.g. Brugnach et al. 2007; Janssen et al. 2009; Wood et al. 2012). Ambiguity is a type of uncertainty that indicates the confusion that exists among actors in a group regarding what the concerning issues, problems or solutions are (Weick 1995). It reflects the multiplicity of interpretations and meanings different actors bring to a modeling exercise. Ambiguity can be both a source of creativity and a source of conflict (Giordano et al. 2017a). While it is commonly overlooked during modeling, how ambiguity is resolved and embraced is determinant for the quality of the participatory process supported by the modeling exercise, influencing what is being modeled and the outcomes generated (e.g. Brugnach and Ingram 2012; Leskens et al. 2014). This is particularly true in participatory modeling activities for the design of environmental policies, where a plethora of different decision-actors, with different, and potentially conflicting, goals and values

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need to be involved. Furthermore, considering behavior in participatory modeling activities should strengthen the relationship between *representing* and *intervening* focusing on the mediating role of the model and its social practice (White 2016b).

Within this context, what is the most suitable approach for representing different values, goals and knowledge when engaging stakeholders in a participatory modeling process? Providing answer to this research question is the main scope of this work.

On the one hand, representing the different contributions could produce several benefits in the modeling exercise. Firstly, integrating different pieces of knowledge allows one to develop a model capable of supporting policy- and decision-makers in accounting for the different issues related to the problem. Secondly, it could have a positive effect on the stakeholders' long-term engagement in the participatory activity. Evidences show that if the participants are capable of recognizing their contributions in the developed model, then they will develop a sense of ownership toward the model itself that could guarantee the long-term engagement (Giordano and Liersch 2012).

On the other hand, integrating different perspectives in the modeling process raises several issues. Firstly, dealing with conflicting problem understandings requires efforts from the modelers to achieve a consensus among the participants. Secondly, power issues need to be accounted for. That is, are the collected pieces of knowledge equally important or different weights have to be assigned according to the expertise of the stakeholders (Krueger et al. 2012; Giordano and Liersch 2012)?

Addressing the abovementioned issues is of utmost importance in order to facilitate the participatory modeling process and to make the obtained model suitable for supporting the decision-making process.

This work describes an innovative approach based on the integration between problem structuring methods (PSM) (e.g. Checkland 2000; Rosenhead 2006), and specifically Fuzzy Cognitive Mapping (FCM) (Kosko 1986), and Concept-Knowledge (C-K) theory (Hatchuel and Weil 2003; Agogué et al. 2014b; Le Masson et al. 2017) as a means to transform ambiguity from barrier to enabling factor of divergent thinking in participatory modeling. The activities described in this work demonstrate the suitability of the integrated approach to avoid the polarization of viewpoints, conditions that can greatly interfere with the development of participatory models for collective actions. To this aim, as suggested by some authors (e.g. Brugnach et al. 2011; Giordano et al. 2017a; Pluchinotta et al. 2019a), we assumed that divergent frames can still yield organized collective actions when different problem frames are sufficiently aligned and a *shared concern* among the stakeholders is built, avoiding the formation of wrong assumptions about the others' problem frames.

The proposed approach was experimentally implemented in two case studies aiming to design environmental policies for water management and groundwater protection, namely Kokkinochoria area (Republic of Cyprus) and Apulia Region (South-East of Italy). The obtained results demonstrate the potentialities of FCM and C-K theory integration in supporting divergent thinking.

This chapter is structured as follow, after the present introduction, Sect. 6.2 describes the integrated approach and discusses the case studies, while concluding remarks and the lesson learned are reported in Sect. 6.3.

6.2 Integrating Problem Structuring Methods and Concept-Knowledge Theory

In order to provide answer to the research questions, an innovative approach based on the integration between PSM and C-K theory, was designed and implemented in two case studies described further in the text.

This developed multi-methodology is meant to facilitate the alignment of different problem frames and available knowledge and to enable the creative process for innovative policy design and consensual participatory modeling exercises.

On the one side, C-K theory supports the innovation management within a design generative process. It is based on the distinction between two expandable spaces: a space of Concepts (C-space), and a space of Knowledge (K-space). The co-evolution of the C- and

K- spaces represents the generative process (Hatchuel and Weil 2003). In this work, the K-space expansion phase is supported by making the decision-makers aware of the main reasons of ambiguity, while the C-space expansion is realized accounting for the policy alternatives that could be implemented to overcome the main differences in problem framing.

On the other side, FCM allows one to elicit and structure individual problem frames, and help to identify and analyze the main elements of ambiguity and those elements that can alter the modeling outcomes. Thereafter, the results of the ambiguity analysis are used as elements of the K-space, supporting the creativity process within a C-K theory framework.

The following phases were identified in the proposed methodology:

1. PSM, and specifically Fuzzy Cognitive Mapping activities are used to elicit and structure stakeholders' individual problem understanding, and to detect the most important elements in their mental models;
2. Ambiguity analysis is implemented to detect and analyze similarities and differences in problem frames. To this aim, two elements were accounted for, i.e. the most central elements in the FCM and the expected dynamic evolution according to the FCM simulation.

Starting from the results of the previous phases, a C-K theory-based tool, namely P-KCP, designed and implemented in the domain of policy design, was applied in order to facilitate the alignment of the problem frames and the creation of the shared concern as starting point for the generation of policy alternatives (Pluchinotta et al. 2019a for details). Therefore:

3. Phase K aims to gather missing information and building a comprehensive summary of current knowledge about the issue under consideration. It combines the outputs of the ambiguity analysis with scientific literature studies, available data, emerging technologies, best practices, etc. This phase supports the building of the overall K-space combining and aligning the individual stakeholders' K-spaces, in

order to reach a shared concern and a common knowledge between each viewpoint.
4. Phase C allows for the development and expansion of the C-space supported by the creation of a shared base of knowledge. Phase C consists of one-day generative workshop in which stakeholders collectively evaluate and discuss the elements representing the dominant design (i.e. traditional policy alternatives) and suggest expansions of the C-tree. The tree-like structure of the C-space illustrates various policy alternatives as concepts connected to the initial design task under consideration.
5. An integrated model is developed referring to the aligned problem frame defined during the phase K. The model is capable to simulate policy scenarios designed during phase C, and to support the further expansions of the K-space by introducing the elements concerning the potential impacts of the selected policy alternatives.

The proposed multi-methodology was implemented in two case studies aiming to design environmental policies for groundwater protection in Kokkinochoria area (Republic of Cyprus) and Apulia Region (South-East of Italy). For the sake of brevity, the case studies' activities are used in this work for describing the different steps of the adopted approach.

6.2.1 Case Studies Description

The purpose of this section is to briefly present the insights from the applications of the integrated methodology combining FCM and C-K framework for supporting the co-design of environmental policies for groundwater (GW) protection in two case studies, namely Kokkinochoria area (Republic of Cyprus) and Apulia Region (South-East of Italy).

Generally, Mediterranean regions are heavily dependent on GW for socio-economic development (e.g. Zikos et al. 2015). Both areas under analysis are characterized by seawater intrusion caused by intensive agricultural activities in coastal areas, which rely on both surface water and GW (e.g. Pluchinotta et al. 2018; Zikos and Roggero 2012). This situation is resulting in an increasing imbalance between withdrawn water and the GW recharge, causing an impoverishment in GW quantity and quality (Pereira et al. 2009). Furthermore, both challenging contexts are characterized by the presence of several decision-makers with conflictual objectives and different problem formulations (e.g. Ferretti et al. 2019).

Indeed, most of the policies implemented in the Mediterranean basin aim to improve the efficiency of GW use through innovative irrigation techniques or to restrict the GW use through tight control of farmers activities (Giordano et al. 2015). Nevertheless, evidence suggests that many times those policies largely failed to achieve a sustainable use of GW, due to an oversimplification of the ambiguity in problem frames associated (Giordano et al. 2017a). Table 6.1 summarizes the key elements of the case studies.

Table 6.1 Key policy elements of the case studies

	Kokkinochoria area (Republic of Cyprus)	Apulia Region (South-East of Italy)
	(Zikos and Roggero 2012; Zikos et al. 2015)	(Giordano et al. 2017a; Pluchinotta et al. 2018; Ferretti et al. 2019)
Policy goals	1. Provide sufficient water in both quantitative and qualitative terms for domestic and agricultural use 2. Protect the GW quantity and quality in Kokkinochoria aquifer	1. Provide sufficient water for agricultural use 2. Protect GW quality and quantity keeping high level productivity of the agricultural sector
Policy means	1. Water transfer via the South Conveyor 2. Halt excessive water abstraction by: (i) registering boreholes, (ii) installing water meters (iii) stop issuing new licenses	1. Pricing strategy for water volume reduction 2. Direct control of water volume used by farmers
Time framing	Several years	Several years
Stakeholders	Water Development Department (National and Regional), Regional Agricultural Department, Ministry of Agriculture, Farmers, Farmers' associations	Apulia Region Authority, Surface Water Management Authority (Irrigation Consortium), Farmers, Farmers' associations

6.2.2 Fuzzy Cognitive Maps

FCM aim to elicit and structure the different stakeholders' problem frames. The basic assumption is that, to make ambiguity a source of creativity in policies co-development, decision-makers need to be aware of the existence of different, and equally valid, problem understandings. The first issue to be addressed concerned the selection of the experts to be involved in this. In order to minimize the selection bias and the stakeholders marginalization (Reed et al. 2009) a top-down stakeholder identification practice, namely *snowballing* or *referral sampling*, was implemented (Harrison and Qureshi 2000; Prell et al. 2008). The preliminary interviews carried out resulted in the widening of the set of stakeholders involved (Giordano et al. 2017b).

The individual FCM were developed through semi-structured interviews, collecting the stakeholders' perceptions about the cause–effects chains affecting the GW management and protection in the two study areas. Then, the interviewees described causes, direct and indirect impacts of GW mismanagement. The interviews were analyzed to detect the keywords in the stakeholders' argumentation (the variables in the FCM) and the causal connections among them (the links in the FCM). Figure 6.1 shows how the stakeholders' narratives, collected during the interviews, were translated into FCM variables and relationships. Figures 6.2 and 6.3 shows two examples of the stakeholders'

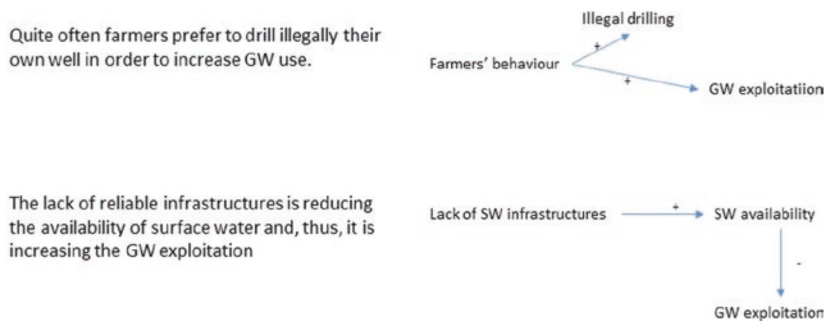

Fig. 6.1 Translating quotes from stakeholders' interviews into FCM variables and relationships

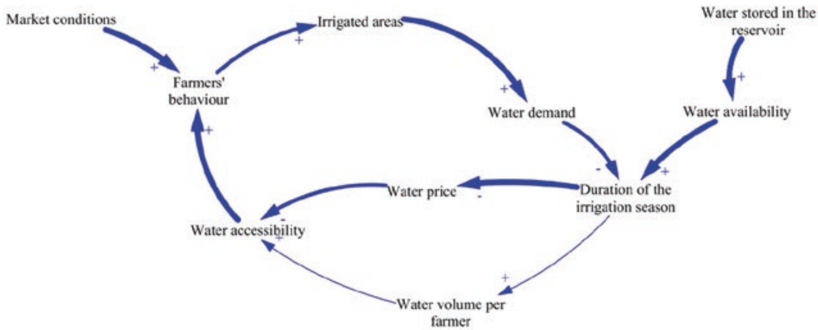

Fig. 6.2 Example of stakeholder's FCM developed for the Apulia case study (*Source* Adapted from Giordano et al. 2017a)

Fig. 6.3 Example of stakeholder's FCM developed for the Kokkinochoria area case study

FCMs developed in the case studies, respectively, Apulia region and Kokkinochoria area.

The link/relationship of a FCM can be either positive or negative. The existence of a positive relationship between "A" and "B" means that if A increases then B increases. If the link is negative, then an increase in A implies a decrease in B. Once all the concepts and links were identified, the analysts were required to define the strength of the links accounting for the stakeholders' problem frames. The strength of a link between two concepts (in the interval [−1; 1]) indicates the intensity of the relationship between them, thus how strong is the influence of one concept over the other. The relationships between variables can be represented through an adjacency matrix (e.g. Pluchinotta et al. 2019b). In the FCM, this matrix allows the overall effects of an action on the elements in the map to be inferred qualitatively, as described below.

6.2.3 Ambiguity Analysis

This phase aimed to detect and analyze the main differences and similarities among the different stakeholders' problem understandings, through two sequential analyses. Firstly, the FCM were examined to detect the most central elements in the stakeholders' problem understanding, the so-called "nub of the issue" (Eden 2004). Secondly, the FCM capability to simulate qualitative scenarios (e.g. Borri et al. 2015) was used to describe the expected evolution of the variables' states according to the stakeholders' problem understandings.

Concerning the first analysis, FCM centrality degree was assessed: the higher the centrality degree of a variable, the more central is the variable and the more important is the concept in the stakeholder's perception. Santoro et al. (2019) describe the methodology for assessing the centrality degree. The second analysis aimed at comparing the way the involved stakeholders perceived the evolution of the system through the change of state of the FCM variables. To this aim, the FCM capability to simulate qualitative scenarios was adopted (Kok 2009). Two different scenarios were simulated and compared, i.e. the Business-As-Usual (BAU) scenario and the GW overexploitation scenario. The comparison allowed us to identify the variables that, according to the stakeholders' mental model, will be affected in case of a reduction of GW quality due to overuse for irrigation purposes. Figure 6.4 shows the comparison between the two scenarios for the Water Development District (WDD) in Cyprus.

The graph shows that, according to the WDD's mental model, the overuse of GW for irrigation purposes will lead to a decrease of the water quality, and an increase of the seawater intrusion with a consequent reduction of the agricultural production, due to the decrease of the GW quality. These are the most affected variables in the WDD's mental model. Thus, the higher the impacts of GW overuse on the variables in

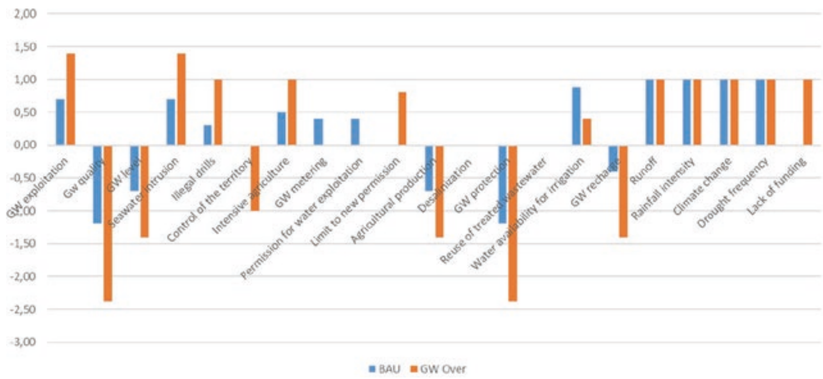

Fig. 6.4 Comparison between BAU and GW overexploitation scenario according to the Cyprus WDD's mental model

the stakeholder's mental model, the more central these issues are in the stakeholders' problem understanding.

The most important elements were, hence, detected by aggregating the FCM centrality degree and the impact degree, as shown in Table 6.2. These elements represent the most important goals to be achieved through the implementation of a GW protection policy, according to the stakeholders' problem frames.

Table 6.2 shows how different stakeholders perceive the same problem differently. Some of the stakeholders used different elements to characterize the GW management problem. In other cases, stakeholders considered as central the same elements, but they perceived different evolutions of the variables' states, e.g. the agricultural productivity was considered important by most of the stakeholders, but only the farmers consider this element as improving due to the increase of GW use.

A similar analysis was carried out for the Capitanata case study. The ambiguity analysis allowed us to analyze why and where stakeholders' problem understandings differ each other's. The results of this analysis were used to support the creation of a shared concern and the gather of knowledge on the issue under consideration, i.e. phase K.

Table 6.2 Identification of the most important elements in the stakeholders' problem understanding for the Cyprus case study

Decision actor	Variable	Centrality degree (index)	Impacts degree	Importance degree
Water Development Department	Infrastructure effectiveness	High	Weakly negative	Medium
	Reuse of treated wastewater	Medium	Negative	High
	Farmers' behavior	Medium	Negative	High
	GW quality	High	Highly negative	High
	Territory control	Medium	Weakly negative	Medium
Farmers' association	Agricultural productivity	High	Negative	High
	GW quality	High	Negative	High
	Energy costs for GW use	Medium	Negative	High
	Farmers' behavior	Medium	Weakly positive	Medium
	Infrastructure effectiveness	Low	Positive	Medium
Regional Agricultural Department	Regional livelihood	High	Negative	High
	Agricultural productivity	High	Negative	High
	Salinization process	Medium	Negative	High
	Infrastructure effectiveness	Medium	Weakly negative	Medium
Ministry of Agriculture	Agricultural productivity	High	Negative	High
	Optimization of water distribution	Medium	Negative	High
	Social sustainability	Medium	Negative	High
	Innovation adoption in irrigation	Low	Negative	Medium
	Territory control	Medium	Weakly negative	Medium

(continued)

Table 6.2 (continued)

Decision actor	Variable	Centrality degree (index)	Impacts degree	Importance degree
Farmers	Farmers income	High	Positive	High
	Agricultural productivity	High	Weakly positive	Medium
	Energy costs for irrigation	Medium	Weakly negative	Medium
	Irrigation infrastructure eff.	Medium	Weakly positive	Medium
	Innovation adoption in irrigation	Medium	Weakly positive	Medium
Regional Branch of the WDD	Seawater intrusion	High	Negative	High
	Illegal drills	High	Negative	High
	Agricultural productivity	Medium	Weakly negative	Medium
	Territory control	Medium	Weakly negative	Medium

6.2.4 C-K Theory and the Shared Concern

A C-K theory-based tool has been designed and tested in the domain of policy design (Pluchinotta et al. 2019a for details). This participatory policy design tool (P-KCP) has been applied in both case studies for a methodological support to the K- and C-spaces expansions.

Specifically, within the policy design process decision-makers operate under conditions of uncertainty, due to limited information about policy outcomes, which can undermine policy effectiveness and complicate policy development (e.g. de Marchi et al. 2016; Nair and Howlett 2016; Tsoukias et al. 2013). It has been recognized that novelty in the alternatives' design phase of a decision aiding process, can come through the expansion of the solutions space (Colorni and Tsoukiàs 2018). The expansion of the solutions space can be obtained through the evolution of problem formulations, due to revision or update (Ferretti et al. 2019) and to the alignment of ambiguous problem frames (Giordano et al. 2017a). Within this context, design theory describes design processes through a formal methodology, supporting the capacity to be innovative in generation of policy alternatives (Pluchinotta et al. 2019a).

Briefly, modern design theories focus on generating objects that are partially unknown and will be progressively discovered during the design process itself (Hatchuel and Weil 2007; Agogué and Kazakçi 2014a). Thus, C-K theory is based on the distinction between two expandable spaces (Hatchuel and Weil 2002). The K-space represents all the knowledge available to a designer at a given time and its elements are propositions whose logical values are known (i.e. the Designer can define them as true or false), whereas the C-space is a set of propositions whose logical status are unknown, (i.e. it cannot be determined with respect to a given K-space) (Hatchuel and Weil 2002; Agogué et al. 2014b). The design process is thus defined as the co-evolution of C- and K-spaces: Concepts are elaborated by using Knowledge and new Knowledge is gained through the elaboration of Concepts (Fig. 6.5) (Le Masson et al. 2017).

Phase K aims to build a shared base of knowledge supporting the subsequent generative C phase thanks to its expansions. The K phase

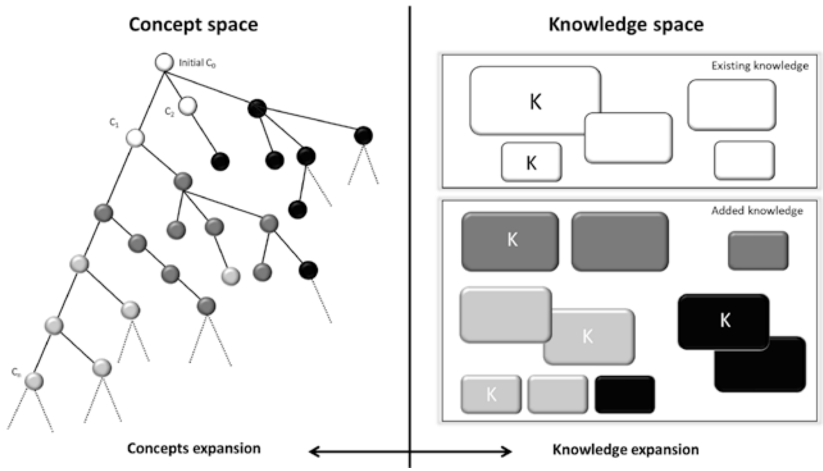

Fig. 6.5 The C-K approach

uses the FCM and ambiguity analysis outcomes to support a participatory group activity where different stakeholders' problem frames are presented and discussed. It detects and analyzes potential conflicts among stakeholders leading to the definition of common knowledge and a shared concern on the GW protection problem. The shared concern, namely a common problem formulation among the involved stakeholders, represents the starting point for the generation of policy alternatives.

Afterward, a stakeholder generative workshop for the C-space building and expansion was carried out for the design of policy alternatives in both case studies.

During the one-day generative workshop, the process of designing policy alternatives was supported and managed accordingly to the C-K principles of innovation management. In the C phase, stakeholders evaluate the dominant design (traditional policies) and propose innovative policy alternatives through the expansion of the C-space. The C-space illustrates various alternatives as concepts connected to the *initial design task* thanks to the tree-like structure (Agogué et al. 2014b). It represents the map of all possibilities, highlighting the dominant design and improving the search of new alternatives. Figure 6.6

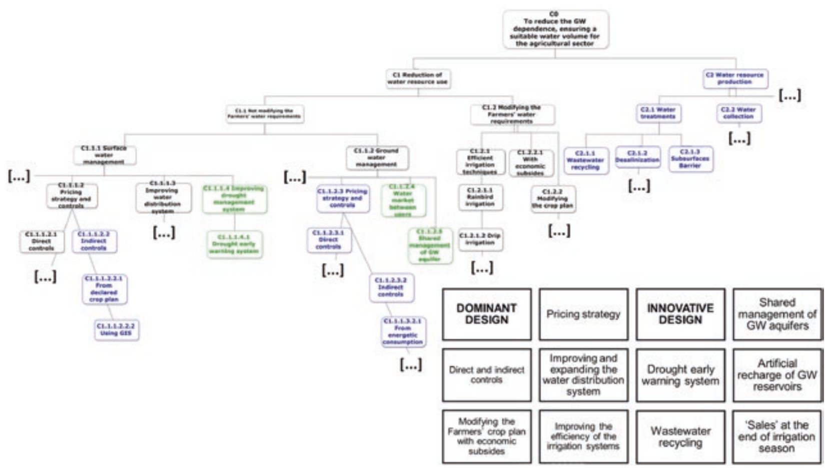

Fig. 6.6 The C-space showing all the policy alternatives generated (*Source* Adapted from Pluchinotta et al. 2019a)

shows the C-tree produced for the Apulia case study, where the initial design task was the design of GW protection policy for the agricultural sector. In both case studies, the discussions in the C phase led to a portfolio of preferred policy alternatives shared with all the stakeholders and to the introduction of a few innovative policy alternatives. For instance, for the Apulia case study, the alternative 'shared management of GW aquifers' has been recognized as a promising long-term strategy, enhancing the innovative management of GW through a collective decision-making process. A shared GW governance could empower the farmer community through reward regulations for virtuous GW use, overcoming the traditional *command and control* policy. The starting points for this C-space expansion were: (i) a specific piece of knowledge in the shared K-space brought by one stakeholder on common-pool resources management, according to Ostrom's (1990) works, that introduced the awareness of the attributes defining the GW resource (i.e. the K-space expansion); (ii) the outcomes of the ambiguity analysis that identified the pivotal role of the 'illegal pumping' variable in different stakeholders' mental models (Pluchinotta et al. 2019a). Figure 6.6 uses a color code: (i) the branches describing known policy alternatives are colored in dark black, (ii) the ones in black indicate attainable policy alternatives using existing knowledge or a combination of K-space subsets and (iii) the paths in grey represent innovative policy alternatives, requiring the expansion of the K-space in order to enlarge the C-space.

6.2.5 Integrated Model Development

As described previously, the results of the ambiguity analysis were used to support the discussion among stakeholders aiming to align individual problem frames and to support the development of the shared K-space. As a result, an integrated model was developed based on the shared K-space in both case studies. Specifically, a Social FCM was defined in the Kokkinochoria case, whereas a System Dynamics model was developed for supporting the policy design in the Apulia case. Both models are based on the integration among the different stakeholders' mental models. In the Apulia case study, the availability of the ambiguity analysis results contributed to enlarge the K-space, making stakeholders aware of the others' problem frames. At the end of this phase, the involved decision-actors partly adapted their frames. Particularly, the irrigation consortium became aware of the importance of providing information to farmers in time to actually influence their decision-making process. It also became aware of the illegal pumping activities, which requires a better understanding of the impact of the water price policy. Finally, the regional authority introduced the irrigation consortium's role in influencing the farmers' behavior. These new elements were introduced in the adapted versions of the individual FCM. Then, by aggregating the individual FCM (Ozesmi and Ozesmi 2004), the following Social FCM was developed. The development of this model is described in Giordano et al. (2017a).

As further development, a System Dynamics model was developed based on the Social FCM, as described in Pluchinotta et al. (2018) (Fig. 6.7). The model was used to simulate the impacts of the

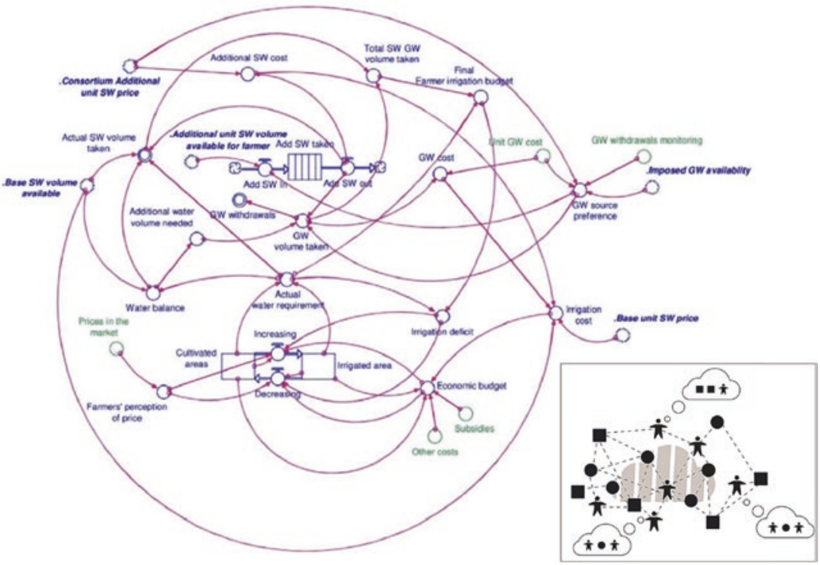

Fig. 6.7 System Dynamics model describing the farmers' behavior in the Apulia case study (*Source* Adapted from Pluchinotta et al. 2018)

alternatives defined during the C-space creation phase and, in doing so, to contribute to further enlargement of the K-space.

Similarly, in the Kokkinochoria the results of the discussion during the K-space development were used to align the stakeholders' mental models and to enable the development of an integrated model. It is worth noting that in this case the misalignment that was hampering the development of the integrated modes was not provoked by the lack of common elements among the mental models. The misalignment was mainly due to differences in the perceived polarity of the causal connections and, thus, of the expected evolution of the state of the variables. In order to overcome the ambiguity as a barrier, participants were required to discuss the expected evolution of the system variables. A consensus was achieved for the interested variables. Figure 6.8 shows the aggregated FCM to be used for further discussing the effectiveness of the proposed alternatives with the stakeholders.

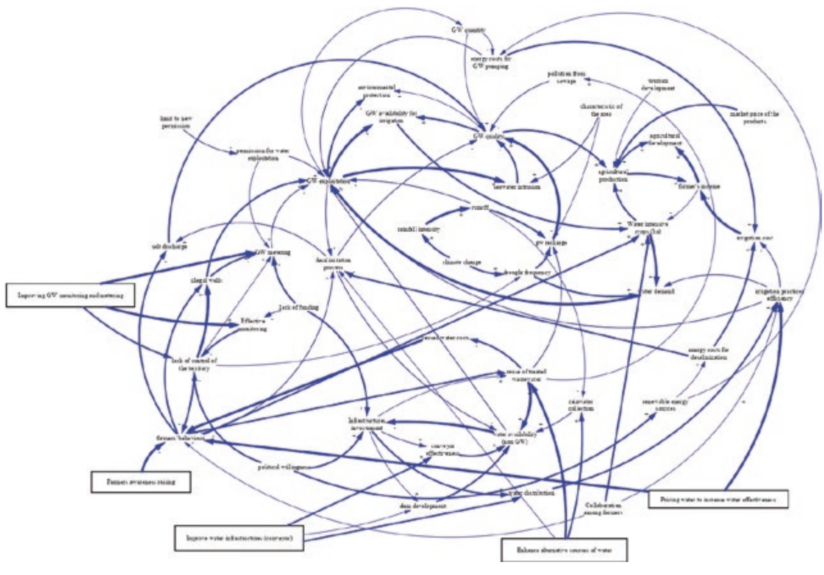

Fig. 6.8 Aggregated FCM developed during the stakeholders' WS in the Cyprus case study

6.3 Discussion and Conclusion

The results collected in the two abovementioned case studies allow us to draw some conclusions concerning the suitability of the PSM and C-K integrated approach to support analysts and modelers in dealing with ambiguity in problem framings during participatory modeling exercise for designing innovative policy alternatives. The PSM, and specifically the FCM, demonstrates their capability to structure the complex cause–effect chains affecting the stakeholder's problem understanding. The ambiguity analysis—based on the FCM modeling approach—allowed us to detect divergences and, in some cases, potential sources of conflicts in GW management. These elements were at the basis of the convergent thinking phase. Making the different stakeholders aware of the differences and similarities forced them to critically analyze their own problem framing, to identify the assumption they usually made concerning the behavior of the other actors and to challenge those assumptions. In many cases, the discussion based on the results of the ambiguity analysis helped to change the individual problem frames and to achieve a satisfactory alignment, and to co-define the shared K-space capable of generating the policy alternatives for GW protection in the two case studies. Thus, evidences collected during the experience in the case studies demonstrate that making the decision-actors aware of the existence of ambiguous problem framings is the key to enable creative and collaborative decision-making processes.

The analysis of the results obtained in the two case studies detected potential limits of the adopted approach. Firstly, it requires time and resources in the analysis phase—i.e. FCM development and ambiguity analysis. Nevertheless, the results showed that making the participants aware of the existing differences greatly facilitate the discussion. Therefore, it is possible to state that the time consuming first part of the process allowed a fast and effective convergent thinking phase.

Secondly, the adopted method requires the long-term engagement of the stakeholders. Since the divergent thinking phase is based on the elicitation and analysis of the individual perceptions of the problem frame, having the same stakeholders participating in all the different phases is a key for the reach of the collective behavior and the success of the whole process. Participants are sources of information and their opinions may also be compared against available data, contributing to further refinement of the model (Rouwette 2017). To this aim, efforts were carried out after the early phases of the method implementation in order to meet the actual needs and concerns of the different stakeholders. The results of the individual FCM analysis concerning the main goals to be achieved were used to enhance the communication between the analysts and the participants and, thus, guarantee the stakeholders' involvement in the different phases of the process.

Lastly, the stakeholders expressed the need to have quantitative assessment of the effectiveness of the selected measures in protecting GW. To this aim, the models developed during the interaction with the stakeholders in the two case studies are used for providing further information to the involved stakeholders.

From a behavioral research perspective, as argued by several scholars (e.g. Hämäläinen et al. 2013) there is now a growth in need to incorporate different perceptions into modeling interventions (White 2016a). In this sense, the proposed study offered interesting insights for the understanding of the collective behavior, proposing an integrated method to address behavioral concerns and to avoid the use of behavioral *objectivistic* assumptions in participatory models.

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7

Insights from an Initial Exploration of Cognitive Biases in Spatial Decisions

Valentina Ferretti

7.1 Introduction

Behavioral decision research has demonstrated that judgments and decisions of ordinary people and experts are subject to numerous biases, from both the cognitive and motivational points of view (Tversky and Kahneman 1974; von Winterfeldt and Edwards 1986). This line of research stimulated the study of behavioral issues and their implications across many disciplines, recently reaching the domain of Operational Research (Kunc et al. 2016).

Within the broad field of Operational Research, the domain of spatial multi-criteria decision analysis, i.e. the integration of geographic information systems (GIS) with multi-criteria decision analysis (MCDA) techniques, has been attracting increasing interest in the last two decades, from

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both the research and application points of view (e.g. Malczewski 2006; Ferretti 2013), especially in the environmental decision-making field (e.g. Huang et al. 2011).

Several reasons may explain this growing trend. First, recent technological developments in spatial analysis have allowed to upscale GIS capabilities leading to the embedding of GIS and MCDA within the same software packages (Malczewski 2006). Second, the increased awareness about the important role of the spatial dimension (it has indeed been estimated that 80% of data collected and managed across all sectors of society include geographic references; Williams 1987, p. 151) has led to more integrated decision-making processes (e.g. Ferretti and Gandino 2018). Indeed, combining information on location or geographical extent with structured expert judgment elicitation processes helps analysts fuse disparate data sets into new and valuable information, thus gaining important insights on the decision problems under analysis.

While the attention toward possible biases has already permeated the non-spatial MCDA field (e.g. Morton and Fasolo 2009), the presence of both traditional and possibly new biases has not yet been explored in the growing domain of spatial MCDA. Given how the World Wide Web has profoundly reshaped the public perception and usage of maps making them an ordinary tool across all domains, the time seems ripe to investigate the maps' role as mediators leading to possible behavioral implications for human judgment in spatial decision-making processes.

The objective of this research is thus to initiate the exploration as well as a preliminary discussion of behavioral aspects in both the design of spatial MCDA models and in the interpretation of their results. To detect modelers' behavior trends and patterns, this chapter proposes a review of the recent literature on spatial MCDA processes according to multiple dimensions of interest (field of application, decision problem type, choice of the MCDA method to use in combination with GIS and corresponding justification for its choice, degree of balance of the decision models and type of classification used in the final maps' legend for the interpretation of the spatial results).

The contribution of this study is twofold. First, this chapter will initiate a discussion about the implications of the observed behaviors in GIS-MCDA applications. Second, it will propose preliminary guidelines on how to design spatial decision processes able to convert unconscious effects into beneficial competences.

The remainder of the chapter is organized as follows: Sect. 7.2 illustrates the literature survey method and the study research questions, Sect. 7.3 presents the preliminary results of the review and classification of the literature and, finally, Sect. 7.4 concludes the chapter by discussing implications of the findings and initial guidelines.

7.2 Literature Survey Method and Research Questions

This study is the first one to explore the presence and implications of behavioral aspects in spatial decision-making processes. As a consequence, a research based on keywords linked to the fields of behavioral science and spatial decision-making processes is unable to provide relevant results. Authors, spatial decision support systems' designers and modelers are indeed not yet aware of the presence of behavioral aspects (i.e. cognitive and motivational biases) in map-mediated judgments and therefore do not mention them in their scientific papers. This study has thus performed a literature search using the SCOPUS scientific database and the list of keywords from Table 7.1 with the aim of identifying all applications of spatial decision analysis starting from the environmental decision-making domain. The reason for a preliminary focus on the environmental domain is its intrinsic need for the integration between geographical information science and decision science, which results in this field being the most active one in the development of applications of spatial decision analysis (Malczewski and Rinner 2015). Indeed, in environmental decision-making processes all key components of the decision have a spatial nature: from the alternatives under analysis that have a spatial localization, to the geographic distribution of their impact, to the spatially non-homogeneous values of the decision-makers and stakeholders' preferences (e.g. value functions and weights; Simon et al. 2014).

To be able to identify key and recent behavior's trends and patterns associated to the design and use of spatial decision support systems, this study reviewed in detail and classified the literature published between

Table 7.1 Keywords used for the literature search on the SCOPUS scientific database

Date of the search	List of keywords	Number of resulting papers published between 1 January 1990 and 31 December 2015
May 2016	TITLE-ABS-KEY ([“MCDA” OR “MCA” OR “MCDM” OR “Multi Criteria Decision Analysis” OR “Multicriteria Decision Analysis” OR “Multi Criteria Analysis” OR “Multicriteria Analysis” OR “Multi Criteria Decision Making” OR “Multicriteria Decision Making” OR “Spatial Multi Criteria Evaluation” OR “Spatial Multicriteria Evaluation” OR “SMCE”] AND [“GIS” OR “Geographic Information Systems” OR “Spatial Decision Support Systems”]) AND (LIMIT-TO [SUBJECTAREA, “ENVI”])	539

1 January 2013 and 31 December 2015, i.e. 229 papers, which represent 42% of the whole body of literature published on the topic. After removing duplicates, papers written in a language different than English and papers not including an application, 149 articles were left for a full review.

The following three research questions underpin the exploration of the novel field of research of behavioral spatial decision science:

1. How do modelers in spatial environmental decision-making choose the MCDA method to be integrated with GIS?
2. Are decision models in GIS-MCDA studies balanced or unbalanced in terms of criteria structures and what are the associated implications for human judgment?
3. How are the final maps resulting from the spatial decision-making process presented with reference to the class break choice (e.g. equally sized sub-ranges versus use of different cut-off points) and what are the associated implications for human judgment?

The answers to the above questions will be illustrated and discussed in Sect. 7.3.1.

7.3 Meta-Analysis of the Literature

The last two decades have experienced a constant and rapid increase in the yearly number of publications dealing with the integration of MCDA and GIS to address decision problems in various domains (e.g. Malczewski 2006; Ferretti 2013).

Table 7.2 shows how the 149 reviewed studies have been classified according to the field of application and the decision problem.

Most decision problems concerned land suitability analyses (49.66%), followed by site selection problems (16.78%), with applications mostly in the water resources/hydrology and environment/ecology domains (22.15% and 20.13%, respectively). These findings confirm the trend highlighted in previous reviews by Malczewski (2006) and Ferretti (2013).

Table 7.2 Classification of the studies according to the field of application and the decision problem

	Decision problem						Miscellaneous	Total	%
	Land suitability analyses	Site selection problems	Risk assessment	Vulnerability assessments	Plan/ scenario evaluations	Impact assessments			
Water resource/ hydrology	23	6	1	2	0	0	1	33	22.15
Environment/ecology	11	6	1	1	4	3	4	30	20.13
Natural hazard	0	1	10	10	0	0	2	23	15.44
Urban/regional planning	11	1	1	1	0	0	2	16	10.74
Waste management	6	6	0	0	0	0	1	13	8.72
Agriculture	10	0	0	0	0	0	0	10	6.71
Energy	6	3	0	0	0	0	0	9	6.04
Forestry	2	1	0	0	0	0	3	6	4.03
Recreation/tourism	3	0	0	0	1	0	0	4	2.68
Geology/ geomorphology	1	0	1	0	0	0	1	3	2.01
Miscellaneous	2	0	0	0	0	0	0	2	1.35
Total	75	24	14	14	5	3	14	149	100.00
%	50.34	16.78	9.40	9.40	3.35	2.01	9.40	100.00	

The term land suitability analysis includes site search problems, with the definitions of land suitability analyses, site search problems and site selection problems being those by Cova and Church (2000, pp. 402–403) and Malczewski (2004, pp. 4–5). Hence, a site selection problem is present, if all relevant characteristics of the candidate sites are known and sites are ranked to find the best one for a certain activity. When a set of alternative sites is not available, a site search problem is present. In this case, the boundaries of the best site are defined within the problem-solving process.

The following paragraphs will illustrate and discuss the answers to the research questions introduced in Sect. 7.2.

7.3.1 How Do Modelers in Spatial Environmental Decision-Making Choose the MCDA Method to Be Integrated with GIS?

As highlighted by Hämäläinen (2015, p. 246), there is the danger in environmental decision-making that modelers who only know one modeling technique interpret every problem as solvable with it. Therefore, when faced with the decision problem of a client, they choose the MCDA method they know, even though another method might be more appropriate to provide meaningful recommendations. Focusing on integrated GIS-MCDA approaches, the choice of which MCDA method to combine with GIS has indeed recently been highlighted as one of the key meta-choices for spatial decision support systems designers (Ferretti and Montibeller 2016). The 149 articles resulting from the literature search proposed in this study have thus been reviewed with the aim of identifying which MCDA methods have been integrated with GIS across the many available applications and of highlighting whether a justification for the choice of the particular MCDA method was provided.

Table 7.3 illustrates the results of the literature review from the point of view of the MCDA method being used, while Table 7.4 highlights how many studies provided indeed a justification for the selection of the MCDA approach.

Table 7.3 MCDA methods used in the reviewed studies

MCDA method	Frequency	%
Analytic hierarchy process	91	61.07
Weighted linear aggregation	20	13.42
Fuzzy analytic hierarchy process	7	4.70
Analytic network process	7	4.70
ELECTRE	4	2.68
Ordered weighted average	4	2.68
Compromise programming	3	2.01
Fuzzy overlay	2	1.34
Boolean overlay	1	0.67
Choquet integral	1	0.67
Compound value method	1	0.67
Point allocation method	1	0.67
Ideal point method	1	0.67
Rapid impact assessment matrix method	1	0.67
Not defined	14	9.40

Table 7.4 Number of studies providing a justification for the selection of the MCDA approach

MCDA method choice justified	Number of studies	%
Yes	80	53.69
No	69	46.31

Some articles used more than one MCDA method, thus leading to a frequency column in Table 7.3 with 158 total cases (from 149 reviewed papers).

Consistently with previous reviews (e.g., Malczewski 2006; Ferretti 2013; Huang et al. 2011), the vast majority of the studies selected the Analytic Hierarchy Process (AHP) (Saaty 1980) as the MCDA approach to be integrated with GIS in spatial decision-making processes (61.07% of the studies). The present literature review tries to look beyond the above descriptive statistics by checking first if a justification for the selection of the specific MCDA method is indeed provided in the reviewed paper and, if yes, by analyzing the type of the provided justification. Table 7.4 summarizes the trends in the 149 reviewed papers with reference to the presence or absence of a justification for the selection of the MCDA approach.

In 46% of the studies in which the applied MCDA method was defined, modelers do not justify their MCDA method selection (e.g. Bagdanavičiute and Valiunas 2013). This may be considered an indicator for the presence of the *hammer and nail bias*, i.e. the tendency for modelers who know only one modeling technique to interpret every problem as solvable with it, which has been highlighted as a key danger in environmental decision-making (Hämäläinen 2015). The hypothesis of the author is that modelers not influenced by the hammer and nail bias would justify the selection of the MCDA method to be integrated with GIS by stating, for instance, its advantages over other MCDA methods (e.g. Dragićević et al. 2014; Malekmohammadi and Rahimi Blouchi 2014).

Moreover, among the 69 studies (46%) which do not provide a justification for the selection of the MCDA method, there is none that uses more than one MCDA approach. Hence, modelers in these studies may just know one MCDA technique and perceive every decision problem as solvable with it.

Zooming into those studies that used the AHP approach (i.e. 61.07% of the total), Table 7.5 shows the frequency of the papers providing a justification for the selection of the method.

As 41% of the studies employing the AHP approach do not provide a justification for its selection (e.g. Gdoura et al. 2015), this trend may suggest the presence of the hammer and nail bias.

After analyzing the arguments provided by the modelers to justify the selection of their modeling approach, it is worth highlighting that among 54 studies which provide a justification for the selection of the AHP, 26 of them (48%) referred only to the popularity of this approach (e.g. Bagheri et al. 2013) and 21 of them (38%) referred to its use in other similar studies (e.g. Esquivel et al. 2015). This trend may also show the presence of a *groupthink bias*, resulting in modelers and

Table 7.5 Number of studies providing a justification for the selection of the AHP approach

AHP method choice justified	Number of studies	%
Yes	54	59.34
No	37	40.66

context experts applying popular modeling techniques without questioning them (Hämäläinen 2015, p. 247).

7.3.2 Are Decision Models in GIS-MCDA Studies Balanced or Unbalanced in Terms of Criteria Structures and What Are the Associated Implications on Human Judgment?

Recently, Marttunen et al. (2018) highlighted the importance of objectives hierarchy related biases by reviewing the literature on real world applications of MCDA. Key findings from this study show that the hierarchy structure and content can substantially influence weight distributions. For example, hierarchical weighting seems to be sensitive to the *asymmetry bias*, which can occur when a hierarchy has branches that differ in the number of sub-objectives. These results have triggered research question 2 in this chapter with the aim of studying whether the same trends can be highlighted also for spatial applications of MCDA.

To this end, the 149 papers have been reviewed by checking the size and structure of the decision model structures (i.e. value trees, objectives' hierarchies and networks of clusters of objectives). If model structures were only described verbally, they were reproduced based on the provided descriptions.

A GIS-MCDA structure of criteria was considered balanced if it fulfilled two requirements. Firstly, the level of each lowest-level sub-objective should be the same for all sub-objectives. Secondly, the difference in the number of lowest-level sub-objectives between the objective with the most sub-objectives and the objective with the least sub-objectives should not be more than two (see Figs. 7.1 and 7.2 for the visualization of the differences between a balanced and an unbalanced structure of criteria).

Constraints criteria were not considered within the analysis of the GIS-MCDA structure of criteria, as they are typically not evaluated by decision-makers and only used in the screening phase to identify relevant alternatives. For criteria structures different than the hierarchical one

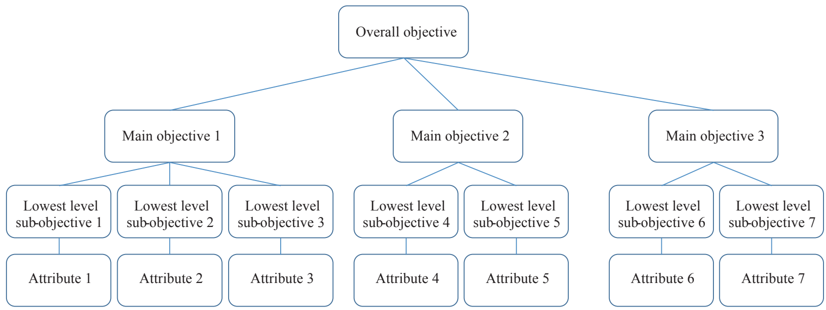

Fig. 7.1 Example of a balanced value tree

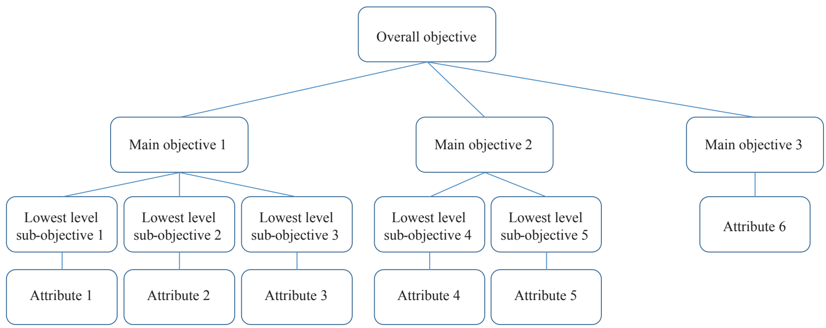

Fig. 7.2 Example of an unbalanced value tree

(e.g. in the Analytic Network Process models), the number of criteria in each cluster was counted and it was checked whether the difference between the cluster with more elements and the one with less elements was bigger than two.

Table 7.6 summarizes the trends in the 143 papers with reproducible criteria structures with reference to their level of balance.

The results of the review show that 32.17% of the models in GIS-MCDA applications may be considered as based on unbalanced criteria structures (e.g. Yal and Akgün 2013). When criteria structures are not balanced, those objectives which are decomposed into several sub-objectives and are thus defined in more detail, are more likely to receive a higher total weight. This judgment distortion effect is known as the *splitting bias* (Jacobi and Hobbs 2007; Hämäläinen and Alaja 2008).

Table 7.6 Classification of the reviewed papers according to the structure of the decision criteria

Criteria structure	Number of studies	%
Balanced	97	67.83
Non-balanced	46	32.17
Total	143	100.00

Table 7.7 Classification of the studies according to the number of criteria included in the decision structure

Number of criteria in the decision structure	Number of studies	%
>7	90	62.94
<7	53	37.06

Table 7.8 Justification for criteria selection

Justification for criteria selection	Frequency	%
Literature	81	54.36
Expert judgment	28	18.79
Data availability/data driven approach	28	18.79
Legislation/institutional recommendations	13	8.72
No justification	11	7.38

When analyzing the trees, Miller's (1956) 7 ± 2 rule was also considered. According to this rule, the limit for receiving, remembering and transmitting information on different elements is in the range of 7 ± 2 elements. Saaty and Ozdemir (2003) highlighted that the rule is also valid when developing pairwise comparisons and argue that considering more than seven elements in pairwise comparisons leads to inconsistent judgments and hence flawed weights, for instance, within the AHP process. Therefore, the literature review presented in this paper also analyzed the number of criteria included at the same level or within the same cluster in the decision structures, as too large decision structures might lead again to judgment distortion and flawed weights (Table 7.7).

As in 62.94% of the studies the number of criteria on the same level was bigger than seven, there is an additional danger of inconsistent weight judgments in GIS-MCDA studies in environmental decision-making because of too large decision structures.

To explore possible reasons explaining large and unbalanced decision structures, the arguments used by the authors to justify their criteria selection were analyzed. Table 7.8 lists the five most frequent justifications. As authors of some studies used multiple arguments to justify their criteria choice, the total number of studies in the frequency column is bigger than 149.

Interestingly, the "Data availability/data driven approach" category is the second most frequently used justifications for criteria selection. Studies categorized as data driven highlight, for example, that within the process of criteria selection, data availability and quality was an important argument (e.g. Mighty 2015). This may indicate that in GIS-MCDA applications in the environmental decision-making domain a special form of the *availability bias*, i.e. the human tendency to think that examples of things that come readily to mind are more representative than is actually the case, may occur. Indeed, the decision to include or exclude an evaluation criterion when structuring a spatial decision model may be influenced by the easiness with which an evaluation criterion map can be created. Hence, researchers might consider a criterion in their analysis because the evaluation criterion map already exists or is easy to construct, even though the evaluation criterion map indicates spatial homogeneity, or the criterion is not relevant, i.e., it is not referring to a fundamental objective for the decision.

7.3.3 How Are the Final Maps Resulting from the Spatial Decision-Making Process Presented with Reference to the Class Break Choice and What Are the Associated Implications for Human Judgment?

In GIS-MCDA applications, modelers usually have to describe the final spatial distribution of the multi attribute aspect under study (e.g. risk index, vulnerability index, suitability index, etc.) by means of a geographical output map (Malczewski and Rinner 2015). For this purpose, common mapping techniques allow them to color areas proportionally to the represented variable by means of classification methods. However, Monmonier (1991) has highlighted that the applied classification method can have effects on the pattern of a map. Therefore, even though different versions of the map provide the same information, decision-makers' judgment about risk/vulnerability/suitability and their associated decisions may be different depending on which classification method is used.

For example, the study by Jung et al. (2013) provides two different final output maps of fire risk in the Kolli Hills in India obtained through a GIS-MCDA approach. Both maps are based on the same final scores, but apply different classification methods. The visual comparison of the two maps shows that when the equal interval method is employed (i.e. the modeler uses the lowest and highest value of the relevant distribution and then divides this range into equally sized subranges; Monmonier 1993), most values fall in the interval belonging to the "high risk" category. When, instead, the map uses the natural breaks method (i.e. the variance within classes is minimized and the variance between classes maximized; Jiang 2013), most areas are categorized as "very high risk" areas.

Imagining a decision-maker who has to allocate a budget for forest fire protection, he/she may perceive the overall risk as higher when visualizing the map obtained using the natural breaks method, as more areas are classified as having a very high fire risk. Therefore, he/she may be willing to invest more in forest fire protection when making a decision based on the latter map, compared to one based on the map where the equal interval method was employed, even though the two maps were generated from the same final data.

To explore GIS-MCDA applications' trends with reference to the map classification approach, this paper reviews the type of legend used in the final output maps of the 149 papers under consideration. When the study used classification methods and provided linguistic labels for the different classes in the legend, the study was categorized as using qualitative output maps (e.g. unsuitable areas, suitable areas, etc.; Akin et al. 2013). When the authors reclassified scores on a numerical scale indicating different levels of intensity, the study was categorized as using quantitative output maps (e.g. Hamzeh et al. 2015). Both qualitative and quantitative maps are based on classification procedures. When the authors used continuous color scales in the final output map to indicate

Table 7.9 Trends in GIS-MCDA applications with reference to the type of output map

Type of legend	Frequency	%
Qualitative legend	89	59.73
Continuous color scale	19	12.75
Quantitative legend	16	10.74
Different maps with different legends	5	3.36
Other	20	13.42
Total	149	100.00

the range between the minimum and maximum values (e.g. Wanderer and Herle 2015), studies were categorized as using maps based on a *continuous color scale*. Table 7.9 summarizes the trends in the reviewed papers with reference to the type of output map being generated.

The "Different maps with different legends" category refers to studies in which different final output maps with different types of legends were used (e.g. Romano et al. 2015). At least one of the maps presented in these studies used a classification method.

Considering categories "Different maps with different legends", "Qualitative legend" and "Quantitative legend", 73.38% of the studies applied classification methods when creating the final output map. Thus, in the majority of the GIS-MCDA applications reviewed, class break choice can influence human judgment in the interpretation of the output map. Zooming into those studies that used a classification method to present the final output map, 22 of them (20.18%) used the equal interval method, 46 (42.21%) used a classification method different from the equal interval one and 41 of the studies (37.61%) did not state which classification approach was used. This may suggest poor practice, as not all relevant information to replicate the results of the studies are adequately presented.

7.4 Conclusions: Preliminary Guidelines

This section builds on the answers to the three research questions presented in Sect. 7.3 with the aim of suggesting preliminary guidelines for the improvement of judgments and decisions in spatial modeling processes.

Starting from research question 1, key findings highlight that in almost half the applications a justification for the selection of which MCDA approach to integrate with GIS was missing, thus suggesting that a *hammer and nail bias* may exist. When a justification was instead provided, it often referred to the popularity of the method, thus opening the possibility for a groupthink bias. Choosing the right MCDA approach is indeed one of the key meta-choices for spatial decision support systems designers, as recently highlighted by Ferretti and Montibeller (2016). A solution for debiasing the *hammer and nail bias* and *groupthink* might be for modelers to use a set of guiding questions when deciding which MCDA method to combine with GIS (Ferretti and Montibeller 2016). For example, the first guiding question could be "what type of results would you need to obtain?" The possible choices available for this question are land suitability maps (choice problem), or comparison among existing alternatives (ranking problem), or clustering alternatives into predefined categories (classification problem). The second guiding question for the selection of the most appropriate MCDA method to be integrated with GIS could refer to the type of elicitation protocol to be used to gather information from experts/stakeholders. The available choices with reference to this question refer to the use of qualitative elicitation protocols or quantitative elicitation protocols. Another important guiding question for the selection of the MCDA approach in spatial applications considers the relevant characteristics of the problem in terms of compensability, uncertainty and interaction. Indeed, depending on the level of compensation accepted by the decision-maker, the level of uncertainty characterizing the inputs to the model and the level of interaction among the decision criteria, different methods could and should be selected. The interested reader can refer to Ferretti and Montibeller (2016) for a more detailed discussion of the guiding questions and associated meta-choices available for GIS-MCDA designers.

The author believes that this set of guiding questions may help GIS-MCDA modelers to question the MCDA method they know or those approaches that are very popular in their field of research and therefore select the most appropriate one given the characteristics of the decision context under analysis.

With reference to research question 2, 32% of the analyzed spatial models proposed unbalanced criteria structures, which may lead to the splitting bias and important implications on both the elicited weights and on the final results. Possible guidelines to tackle this issue consist in: (i) building concise objectives' hierarchies and considering opportunities to simplify the hierarchy, (ii) carefully considering if asymmetric hierarchies are appropriate and in that case use either weighting procedures which are insensitive to the hierarchy structure or consistency check questions across branches, and (iii) avoiding deep hierarchies as they are more prone to behavioral and procedural biases than flatter hierarchies (Marttunen et al. 2018).

Finally, with reference to research question 3, over 59% of the studies used qualitative legends with ambiguous labels and incomplete information when creating final output maps, which indicates bad practice and may lead to judgment distortion in the interpretation of the results. It is indeed known in the behavioral decision science domain that different people associate different meanings to the same qualitative label (e.g. high risk or medium risk or low risk of a certain event happening) when a clear definition is not agreed, thus resulting in the need to avoid ambiguity as one of the key properties of a good set of attributes (Keeney and Gregory 2005).

A possible recommendation in this case is to always develop a spatial sensitivity analysis over different classification methods, which will allow to detect (i) the presence of significant differences in final output maps when varying the classification approach and (ii) the possibility of consequently different interpretations from the decision-makers.

The following two limitations of the present literature review should be highlighted. First, the search in the SCOPUS scientific database has been limited to the environmental science field of research, but it is not possible to guarantee that all relevant studies were classified as environmental science studies by the database. Second, due to missing information about the evaluation criteria maps in the sample, the analysis of the classification methods was limited to output maps. Yet, different classification methods can also influence the pattern of criteria maps.

In conclusion, the findings from this review and classification of the recent literature on GIS-MCDA in the environmental decision-making field show that spatial multicriteria decision-making processes represent a new and interesting domain of research for behavioral sciences. Indeed, the answers to the research questions explored in this paper have highlighted several biases affecting judgments in GIS-MCDA processes. First, the hammer and nail syndrome and groupthink may be relevant biases playing a role in the design phase of the models. Second, the splitting bias and the availability bias may be relevant biases playing a role in the structuring phase of the models. Finally, ambiguity in the final output maps could be a relevant issue playing a role in the interpretation phase of the model results and in the subsequent recommendation stage. Preliminary debiasing solutions have been suggested for each identified bias in spatial decision-making processes and future developments of this innovative field of research will focus on testing and comparing the efficacy of the proposed debiasing approaches.

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8

Modeling Human Behaviors in Project Management: Insights from the Literature Review

Lin Wang, Jianping Li and Chao Li

8.1 Introduction

The last decade has witnessed a movement of project management toward the 'human side'. Both the practice and research recognize that project management is not all about providing normative guidance, but subject to cognitive biases, emotions, social preferences, cultural norms, etc. (Loch 2016; Stingl and Geraldi 2017). These behavioral aspects deviate the project decisions from being rational, and may further influence the project implementation performance (Wang et al. 2017). While traditional project planning and controlling methods (e.g. PERT, CPM and earned

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value management) have long been adopted for discussing the best practice, Behavioral Operational Research (BOR) offers new opportunities to support project problem-solving by applying Operational Research (OR) methods to model the behaviors involved (Kunc et al. 2018).

Previous literature has already provided foundations for understanding BOR theory and methods. For example, Hämäläinen et al. (2016) interpret BOR studies as two main streams and proposes an integrative framework with the key interrelated concepts of *OR methods, OR actors and OR praxis*. Kunc et al. (2016) construct the BOR theory into three main research areas including *behavior with models, behavior in models* and *behavior beyond models*. More discussions are on the application of specific OR methods, e.g. problem structuring methods (Davis et al. 2010), in tackling behavioral issues. However, in the project management domain, there still lacks a comprehensive overview on how BOR improves project managers' capabilities to make decisions.

Under these circumstances, this chapter aims to answer the following three research questions (RQ):

RQ(1) What are the key behavioral issues for project decision-making?
RQ(2) How BOR has been applied in tackling these issues?
RQ(3) What are the future directions for applying BOR to project management?

The next section will present the review methodology. Then the qualitative insights are discussed in Sect. 8.3, which concludes the biased behaviors and the principal BOR methods applied. Section 8.4 will propose the avenues for future research, followed by the conclusions in Sect. 8.5.

8.2 Review Methodology

8.2.1 Review Stages

We performed a literature review using the academic electronic database *Web of Science* to synthesize the research. This review followed three stages:

Stage 1 (Key words searching): We firstly conduct a survey with the keywords 'behavio* OR soft' AND 'decision*' appearing in the title, abstract or keywords, and 'project' appearing in the title. This search produced a broad scope of literature on behavioral decision-making with high relevance to project management. Then the topics of 'Behavioral sciences', 'Business economics', 'Computer sciences', 'Engineering' and 'Operations research management science' are selected, resulting in 367 papers.

Stage 2 (Refining): The abstracts and keywords of the selected articles were reviewed carefully, eliminating the publications related to general behaviors, normative decision theory and other irrelevant disciplines, resulting in 87 papers.

Stage 3 (Snowballing sampling): As some articles outside of the scope of our survey might also be relevant, the snowballing approach is conducted (Stingl and Geraldi 2017). 30 additional articles are added, thereby the total article in the review was 117.

8.2.2 Data Analysis

We firstly classified the sample articles by the actors involved and the number of projects to provide a holistic view of their distribution. Figure 8.1 demonstrates that most studies have their focus on the behavioral aspects of individuals in single project management, while those of multiple stakeholders and in multi-project management are limited.

Considering the methods applied, while numerous case studies and laboratory experiments emerge and seek for explanations of the behavioral issues, only a limited number of articles (23 articles, 19.7%) employ OR methods to facilitate behavioral decision-making. As presented in Fig. 8.2, problem structuring methods (PSM) and System Dynamics (SD) are two leading techniques, with other complements such as Real Options and Neural Network Analysis, which will be discussed in Sect. 8.3.2 in greater detail.

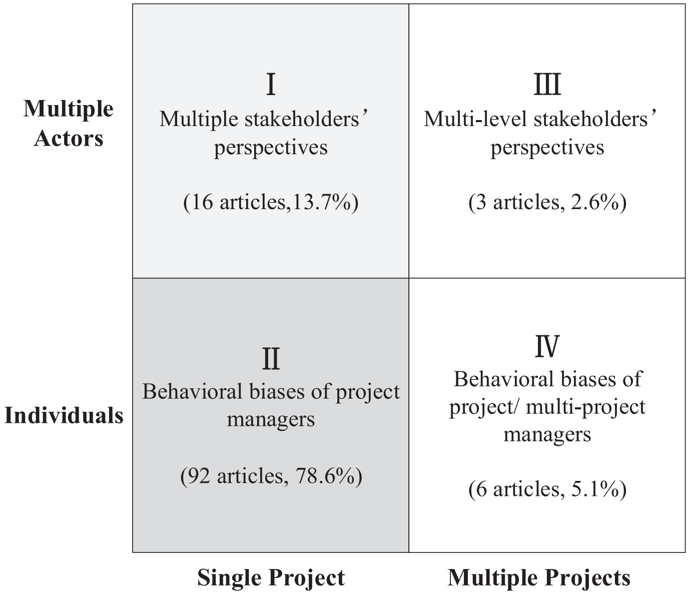

Fig. 8.1 Pre-analysis of the sample article distribution

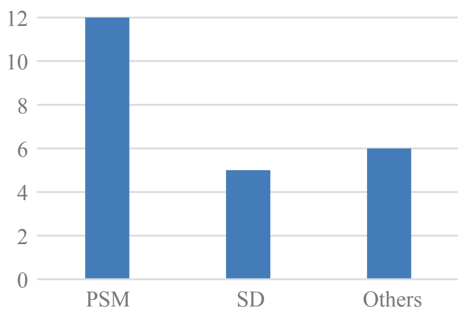

Fig. 8.2 Distribution of the sample articles regarding OR methods applied

8.3 Qualitative Insights

The specific insights from the literature review are presented in two parts. Firstly, an in-depth discussion about the behavioral issues is made to well-locate the multitude of heuristics and biases, as well as providing the context and research focus in which BOR can potentially be applied. The second part investigates how human behaviors have been modeled using OR methods. The state-of-the-art applications of the leading methods are discussed to connect the concepts of behavioral aspects and the BOR methods.

8.3.1 What to Model: The Behavioral Issues and Their Psychological Determinants

8.3.1.1 Individual's Behavioral Biases During Project Implementation

By further analyzing the research topics, three main themes are observed: *Escalation of commitment* (54 articles, 46.2%)*, Biased forecasts and planning* (19 articles, 16.2%) and *Reluctance to blow the whistle* (17 articles, 14.5%). All the three influence individual decision-making and are fit for the project implementation processes (i.e. initiating and planning, reporting, and monitoring and control) (Wang et al. 2017).

Biased forecasts and planning has long been observed regarding the inaccuracy of project estimates (Flyvbjerg et al. 2002). Its psychological and political-economic explanations include *optimism bias, strategic misrepresentation*, *anchoring*, etc. (Flyvbjerg et al. 2002; Lovallo and Kahneman 2003). For the de-biasing purpose, Flyvbjerg (2013) takes an outside view using quality control and due diligence.

Reluctance to blow the whistle indicates the unwillingness to transmit bad news during project implementation. Keil and Robey (2001) argues that the unfaithful reporting prevents decision-makers from perceiving the true status of projects. *Mum effect* and *deaf effect* are suggested constructing this phenomenon, and several factors (e.g. behavioral immorality, face-saving and credibility) have been tested to explain each effect (Park et al. 2008; Cuellar et al. 2006).

Escalation of commitment (EoC), also called 'Project Escalation', refers to the tendency of keeping investing in the failing projects. EoC is not only considered as a biased behavior, but also evaluated as the status of project runaways (Melinda and Morris 2009). Most studies focus on its

Table 8.1 Behavioral issues and their psychological determinants/constructs

Project implementation process	Behavioral issues	Psychological determinants/ constructs	Explanations	References
Initiating and Planning	*Biased forecasts* and *planning*	*Optimism bias*	The cognitive bias that induces an overly optimistic belief in expecting the positive events	Lovallo and Kahneman (2003) and Son and Rojas (2011)
		Strategic misrepresentation	The deception of using false or misleading information for pursuing the personal or group's interests	Flyvbjerg et al. (2002) and Winch (2013)
		Anchoring	The tendency to make estimates by adjusting the initial values	Lovallo and Kahneman (2003) and Son and Rojas (2011)
		Confirmation Bias	The tendency to accept supportive evidence and ignore negative evidence when making decisions with uncertainty	Son and Rojas (2011) and Loch (2016)
Reporting	*Reluctance to blow the whistle*	*Mum effect*	The reluctance to report negative news when projects go wrong	Keil and Robey (2001) and Park et al. (2008)
		Deaf effect	The reluctance to accept negative news about the troubled situations	Keil and Robey (2001) and Cuellar et al. (2006)

(continued)

Table 8.1 (continued)

Project implementation process	Behavioral issues	Psychological determinants/ constructs	Explanations	References
Monitoring and Control	*Escalation of commitment*	*Sunk cost effect*	The tendency to escalate the commitment because of the resources that have already been invested	Keil et al. (2000) and Denison (2009)
		Optimism bias	The cognitive bias that induces an overly optimistic belief in expecting the positive events	Son and Rojas (2011) and Winch (2013)
		Completion effect	The tendency to escalate the commitment because the projects are approaching completion	Keil et al. (2000) and Buxton and Rivers (2014)
		Goal incongruence	The goals of the project participants and the organization are different	Keil et al. (2000) and Buxton and Rivers (2014)

psychological determinants (e.g. *sunk cost effect* and *optimism bias*) (Keil et al. 2000), while prior decisions (e.g. *strategic misrepresentation* and *deaf effect*) are also considered as triggers for project escalation (Cuellar et al. 2006; Winch 2013).

Table 8.1 summarizes the behavioral issues and their relevant psychological determinants. Note that we illustrate the main constructs instead of the determinants in *Reluctance to blow the whistle* because the dichotomy of mum effect and deaf effect is more obvious in the sample literature.

8.3.1.2 Multiple Stakeholders' Perspectives

For most of the case, project decisions are not made by individuals, but involve a collection of stakeholders who hold different perceptions, interest bases, goals, etc. These differences, on the one hand, may induce cognitive conflicts. On the other hand, may act as information sources that enrich the group's framing of plausible futures (Ackerman et al. 2014). While each stakeholder may have their own perspective, the modeling interventions help them to communicate and learn from others' mental models, change their behaviors, and reach the consensus, which may avoid the future resilience (Kunc et al. 2016). Problem structuring methods have been widely applied in this field which will be discussed in Sect. 8.3.2.1.

In our review, the multiple stakeholders' perspectives have been incorporated in various research topics, serving the main purposes of accommodating the conflicts and providing rich pictures to counter individual biases. (Note that these two purposes are not strictly disparate but may both function in some studies.) Liu and Leung (2002) develop a value management model from the behavioral paradigm, postulating that goal specificity and conflict moderation can increase participant commitment and satisfaction. Joham et al. (2009) suggest that at the conceptualization stage, especially when there are multiple powerful stakeholders in ill-defined context, the engagement of multiple perspectives can help to deal with the inevitable conflicts. Crawford et al. (2003) argue that faced with ill-structured and problematic situations, it is necessary to engage people to continuously develop and redefine their perspectives. Ackerman et al. (2014) propose that the process of engaging a range of stakeholders can help managers to develop a comprehensive understanding of the risks and the interactions among them. It is also suggested as a learning process.

8.3.1.3 Behavioral Aspects in Multiple Projects

A further extension concerns the multi-project management context. Several research studies have addressed the bounded rationality and conflicting interests in portfolio selection decisions. For instance, Loch (2000) identifies the existence of 'pet projects', i.e. the projects that are pursued as personal favorites rather than selected in the formal processes. Schiffels et al. (2018) experiment with four heuristics to investigate the influence of cognitive biases on portfolio selection process. In the context of innovation process, Loch (2016) overviews the key behavioral issues from the individual decision biases, the interactions in small groups and those in large groups.

During portfolio implementation, Ekrot et al. (2016) look into the antecedents of project managers' voice behavior. The results reveal that idea encouragement, career perspectives, qualification opportunities and peer collaboration are positively related to the voice behavior, with the moderating effects of organization-based self-esteem and affective organizational commitment. Concerning the failing course of actions, termination decisions are critical to free up resources and to create room for new opportunities. E.g. Lechler and Thomas (2015) demonstrate that the dysfunctional executive advocacy (i.e. high incidence of 'pet projects') can negatively influence the project termination decision quality.

8.3.2 How Behaviors Are Modeled: The Application of BOR in Project Management

8.3.2.1 Problem Structuring Methods

Problem structuring methods (PSM) refers to a family of action-oriented methodologies that aim to tackle problematic situations characterized by multiple perspectives, conflicting interests, and high uncertainties (Davis et al. 2010). The commonly applied PSM include

Soft Systems Methodologies (SSM), Causal Mapping, Strategic Options Development and Analysis (SODA), etc.

At the front-end of the project, when the objectives are often unclear and different stakeholders hold divergent perceptions, a shared understanding about the project and the context should be obtained to avoid further rework and conflicts (Winter 2006). Joham et al. (2009) combine the Alexander's 'Synthesis' and Checkland's 'CATWOE' for project conceptualization. Davis et al. (2010) further emphasize the importance of uncertainty in problem structuring and introduce Hierarchical Process Modeling methodology to engage multiple stakeholders. For the estimation and planning purpose, Doloi (2011) employs SSM to identify the main cost influencing factors by considering the perceptions from stakeholders over the project life cycle. Walker and Steinfort (2013) apply SSM to project situational analysis, which acts as the precursor to effective project planning and implementation by providing rich pictures for visualizing the messy context.

Considering the dynamism and complexities embedded into the environment, *PSM* are also applied to engage multiple perceptions in risk analysis and implementation activities. Ackermann et al. (2014) adopt causal maps to elicit the multiple perspectives of stakeholders, captures the causal relationships between risks and identifies the risk priorities based on stakeholders' preferences. Yeo and Tiong (2000) construct a soft negotiation model to reduce the risks in build-operate-transfer (BOT) concession projects. PSM have also been applied for forensic post mortem analysis, e.g. Ackermann and Eden (2005).

8.3.2.2 System Dynamics Modeling

System Dynamics modeling (SD) has supported project management in numerous ways (e.g. resource allocation, risk evaluation, litigation, etc.), with its advantages in considering non-linearity and feedback mechanisms (Lyneis and Ford 2007). Various human behaviors have been incorporated in SD models for better representing the nature of project management systems, such as morale, pressure and fatigue (Eden et al. 2000).

When considering the behavioral biases, several research studies examine their impacts on project performance. Ford and Sterman

(2003) investigate how the behavior of hiding the rework requirements from managers and colleagues can exaggerate the schedule failure of '90% syndrome'. Son and Rojas (2011) evaluate the impact of optimism bias on the deviation between forecasted productivity and perceived productivity in project control. Considering both strategic and tactical uncertainties, Wang et al. (2017) indicate that over-reacting behavior, influenced by biases and reporting errors, can generate project escalation. Van Oorschot et al. (2013) use SD modeling to analyze how *information filters* blur the decision-makers' perception of the real situation, and further influence the project performance.

SD is also suggested as an effective de-biasing tool. For example, Pala et al. (2015) claim that causal loop diagrams (CLDs), the qualitative analysis of SD, is an effective tool to cope with project escalation by facilitating the decision-makers to better understand the decision situation, generate the failure reasons and identify the alternatives.

8.3.2.3 Other Methods

Among other OR models for dealing with human behaviors, Real Options has been applied to distinguish between warranted and unwarranted escalation of commitment (Keil and Flatto 1999). Considering the flexibility to alter decisions with projects implementing, Real Options takes the advantage of future opportunities, based on which the escalation behavior can be rational with the economic benefits that may favor continuation (Keil and Flatto 1999). Moreover, Huang et al. (2014) incorporate the effect of overconfidence into a real options decision-making model. The results demonstrate that with the overconfidence degree increasing, the underestimation of the trigger value becomes more serious. Furthermore, Denison (2009) conducts an experiment that confirms the role of Real Options in mitigating the tendency to keep investing after bad news.

Other simulation models have also been applied. Bhandari and Hassanein (2012) proposes an agent-based framework that can integrate behavioral biases and appropriate de-biasing strategies to support investment decision-making. Based on Multi-agent simulation, Leitner et al.

(2017) claim that overconfidence can detect the systematic forecasting errors regarding the over- or underestimations of the predicted indicators in distributed investment decisions. Likewise, Zhang et al. (2003) introduce Artificial Neural Network to construct an early-warning system for predicting the project escalation tendency.

Table 8.2 provides an overview of the literature with regards to the application of BOR.

Table 8.2 Overview of the literature employing BOR

No	Reference	Methods	Research focus	Behavioral aspects
1	Yeo and Tiong (2000)	PSM	Achieve convergence of multiple stakeholders' perceptions and expectations to reduce risks in BOT projects	Negotiation and conflict accommodation
2	Liu and Leung (2002)	PSM	Build value management model in construction projects that illustrates the relationship of goal specificity, conflict moderation, participant commitment and satisfaction	Negotiation and conflict accommodation
3	Crawford et al. (2003)	PSM	Engage people to continuously develop and redefine their perspectives for ill-structured situations	Negotiation and conflict accommodation
4	Ackermann and Eden (2005)	PSM	Elicit a comprehensive understanding of failures in complex projects by integrating multiple perspectives	Framing of rich pictures from multiple mental models
5	Sharif and Irani (2006)	PSM	Support IS evaluation by encapsulating multiple human and organizational benefits	Negotiation and conflict accommodation
6	Winter (2006)	PSM	Negotiation and renegotiation of perceptions for ill-defined problems	Negotiation and conflict accommodation

(continued)

Table 8.2 (continued)

No	Reference	Methods	Research focus	Behavioral aspects
7	Joham et al. (2009)	PSM	Engage people to accommodate conflicts among multiple stakeholders in 'messy' situations	Negotiation and conflict accommodation
8	Sankaran et al. (2009)	PSM	Use questioning and reflections to promote collaboration among stakeholders to address ill- structured problems	Negotiation and conflict accommodation
9	Davis et al. (2010)	PSM	Engage participants to yield new insights and handle uncertainty in the front-end of complex projects	Framing of rich pictures from multiple mental models
10	Doloi (2011)	PSM	Integrate the broad stakeholders' perceptions to provide rich pictures for cost estimation	Framing of rich pictures from multiple mental models
11	Walker and Steinfort (2013)	PSM	Provide rich pictures for visualizing the messy problems of disaster recovery projects	Framing of rich pictures from multiple mental models
12	Ackermann et al. (2014)	PSM	Engage multiple stakeholders to provide a comprehensive understanding of the risks and the interactions between risks	Framing of rich pictures from multiple mental models
13	Ford and Sterman (2003)	SD	The impact of rework concealing on '90% syndrome'	Reluctance to Whistle-blowing
14	Son and Rojas (2011)	SD	The impact of optimism bias on project planning and control	Biased forecasts and planning, and Escalation of commitment
15	Van Oorschot et al. (2013)	SD	The impact of information filters on the 'decision trap' that stretches current project stages	Reluctance to Whistle-blowing
16	Pala et al. (2015)	SD	The support of causal loop diagrams to project de-escalation	Escalation of commitment

(continued)

Table 8.2 (continued)

No	Reference	Methods	Research focus	Behavioral aspects
17	Wang et al. (2017)	SD	The selection of remedial actions in project implementation under a behavioral paradigm	Escalation of commitment
18	Keil and Flatto (1999)	Real Options	Distinguish between warranted and unwarranted escalation	Escalation of commitment
19	Denison (2009)	Real Options	The support of Real Options to project de-escalation	Escalation of commitment
20	Huang et al. (2014)	Real Options	Incorporate overconfidence to Real Options for mineral resource mining project evaluation	Overconfidence behavior
21	Bhandari and Hassanein (2012)	Agent-based framework	Construct an agent-based de-biasing framework for project investment decision-making	Cognitive biases, Affective biases, and Conative biases
22	Leitner et al. (2017)	Multi-agent simulation	The impact of forecasting errors on coordinating the distributed investment decisions	Overconfidence behavior
23	Zhang et al. (2003)	Neural network	Predict the escalation tendency	Escalation of commitment

8.4 Discussion

8.4.1 Diversity vs. Integration Regarding the Research Themes

Considering the key behavioral issues for project decision-making, a significant imbalance of their distribution toward the *Individuals/Single Project quadrant* (92 articles, 78.6%) is discovered, and mainly on the *Escalation of Commitment (EoC)* theme (54 articles, 46.2%). This high aggregation leaves the gap of exploring more diverse research themes to draw a comprehensive map of human behaviors in project management, especially concerning the multi-stakeholder, and multi-project context. Meanwhile, for understanding each behavioral issue, integration frameworks should also be underscored. For instance, the studies on EoC vary from the cognitive science side of analyzing the psychological roots to the OR side of proposing the de-biasing decision support systems. The wide range of theories and methods describe this phenomenon from multiple facets and each of them acts as a small piece of the 'EoC jigsaw'. Thus, to benefit from the pluralism and provide a common language for researchers to well-locate their studies, there is a necessity to bridge different disciplines.

8.4.2 Evolution of Both BOR and Project Management Methods

Regarding the methodologies employed, although BOR models are not as popular as case studies and surveys in our sample literature, they have verified their effectiveness in supporting learning and de-biasing decision-making (e.g. Pala et al. 2015). It is a nice finding that BOR is driving the evolution of behavioral studies in project management by complementing the factor models with rich structures and quantitative evidence to incorporate behaviors. Besides, the development of BOR also provides new avenues for the use of OR methods in project management. For example, SD has long been employed to incorporate behavioral factors in projects, yet directly modeling the biased behaviors to analyze their impacts (e.g. Son and Rojas 2011; Wang et al. 2017) is an attempt that needs further development. In this respect, the contextualization of biases in normative project management models is closely aligned with Behavioral Operations Management (BOM) rather than BOR (as described in Kunc, Chapter 1). Future studies can extend the application of BOR by adopting multiple methods and exploring evidence from different cases.

8.4.3 Development of Behavioral Decision-Making Capabilities

Behavioral decision-making capabilities are beneficial for tackling behavioral issues throughout the project lifetime. These capabilities can be divided into categories following the processes of recognizing the behavioral issues, analyzing their impacts and taking actions to mitigate the negative effects such as indicated in Kunc (Chapter 1). Project managers should firstly be sensitive to the existence or possible occurrence of biased behaviors. Learning the classical behavioral theories (e.g. *prospect theory* and *sunk cost effects*) or summarizing lists of cognitive biases during project implementation (e.g. Table 8.1) can help project managers to reflect on themselves when checking the project status in order to perform as the normative models suggest. Moreover, as the behavioral factors may have delayed impacts or leave side effects on other project components, the long-term and systematic understanding of the overall project is also essential for analyzing the impacts and taking corresponding actions. BOR models can facilitate the capability development by visualizing the interrelationships between project components, observing the consequences of behavioral factors and rehearsing the managerial actions taken to mitigate the effects. As Kunc et al. (2016) discuss, concentrating on the cognitive and behavioral factors would eventually become part and parcel of our work. Applying BOR models would also be the complementary skills for project managers accordingly leading to more integration of BOM and BOR practice (see Kunc, Chapter 1).

8.5 Conclusion

This chapter contributes to both the project management and the OR communities by proposing a systematic review for understanding the behavioral issues, presenting the state-of-the-art application of BOR in the project decision-making, and proposing avenues for further connecting BOR with behavioral studies in project management. It not only outlines the biased behaviors that project managers should reflect on themselves, but also helps to develop well-suited models for capturing realistic behaviors in the project management domain. Following are several suggestions for project managers based on this review:

- Be aware of the behavioral styles of both themselves and the team members.
- Update the knowledge base of the classic behavioral theories (e.g. prospect theory and sunk cost effects) and possible behavioral issues at different project implementation stages.

- Hold a systematic and long-term perspective to analyze behavioral issues.
- Be skilled in BOR approaches for understanding and rehearsing the behavioral actions.
- Install structures and processes for team members to sense, recognize and react to behavioral issues.

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9

Exploring the Machinery for Calibrating Optimism and Realism in Transformation Programs: A Practical Toolkit

Leasil Burrow

9.1 Introduction

Optimism can provide catalytic momentum, without which, many transformation projects would never leave the drawing board. The human need for optimism is strong, contagious and will prevail (Sharot et al. 2007), suggesting that optimism is the essential launchpad for all transformation programs and the morale-making magic that provides momentum throughout.

Sadly, wild optimism has consequences. Left unchecked, it creates an environment where delusion and deception propel the actors into surprise failure. It is essential that leaders of transformation programs develop a mechanism for calibrating optimism throughout the program lifecycle.

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The phenomenon known as the *planning fallacy* (Lovallo and Kahneman 2003) is avoided when optimism is calibrated by realism, where previous mistakes are acknowledged and learned from (Russo and Schoemaker 2002; for a review, see also Buehler et al. [2010]). By developing a transformation toolkit for acknowledging and learning from past successes and failures, the organization can develop routinized unconscious competences to underpin transformational success.

This chapter examines the unconscious effect of optimism in transformation programs and offers a practical calibration toolkit.

9.2 The Trouble with Optimism

In the 40 years since the Monty Python team urged us to "always look on the bright side of life" (song from the film "*The Life of Brian*", lyrics by Eric Idle, 1979), leaders seem to have wholeheartedly embraced their advice. We are so keen to look on the bright side, we can become blinded by our own biases, heuristics and confidence. Yet, without this optimism we may become so paralyzed by imagining the plethora of budgets blown, milestones missed, and benefits left untapped that few transformation programs would even begin.

Optimism bias is the positive belief of success that clouds the possibility of failure. Setting out the principle of the *hiding hand*, Albert O. Hirschman (1967) postulated that once the audacious project is underway, creativity will prevail, and obstacles will be overcome. Sadly, the woeful track record of large-scale programs casts doubt over Hirschman's hopeful ideal suggesting that biases and behavioral issues continue to hamper programs and projects (see Wang et al., Chapter 8).

Even when it is widely acknowledged that the program is off-track, the leaders' natural action-orientation can cause them to fall back on simplistic solutions or set-piece interventions. This is especially prevalent and dangerous when a leader's identity has become 'bound' with the success of the program (Staw and Ross 1987) or where there are multiple strong stakeholders (see Malpass and Cassidy, Chapter 15). Solutions generated become less rational and the compulsion to be in control (Bochman and Kroth 2010) leads to hasty action. In short, unfettered optimism can lead to late identification of problems and adoption of ineffective solutions.

9.3 Calibrating Optimism and Realism

Perceiving realism and optimism as sworn enemies is too simplistic. Rather, they coexist in a delicate balance. Careful calibration is required if we seek to maximize the benefits of participatory planning (see Giordano et al., Chapter 6) while avoiding the pitfalls. Unchecked optimism will sleepwalk us into failure, yet we must not allow realism to squash ambition or nothing would ever change.

So, what is the solution? Knowledge of past failure alone is not enough. Planning fallacy (Fig. 9.1) is so robust and persuasive (Winch and Maytorena 2011) that it is difficult to overcome (Buehler et al. 1994) and not even experts are immune (Englich et al. 2006).

Delusion and deception can be minimized by sturdy governance and reinforcement mechanisms. Yet, we must consider that the learning itself could be a carrier of biases because they endure even once the person is aware (Tversky and Kahneman 1974). For more sustainable results, leaders must go beyond learning alone.

To ensure that the triumvirate of governance, learning and reinforcement is truly embedded in a transformation, they must become automatic while balancing the internal stability with the ability to adapt. Put simply, it should work like a self-correcting machine. This metaphor is rooted in organizational cybernetics and draws upon viable system models, cultural agency theory and autonomous agency theory (Beer 1972; Schwarz 1997; Gua et al. 2016) to examine the coexistence of the system of transformation and the meta-system of governance and control.

Fig. 9.1 Three ingredients of planning fallacy

9.4 Organizational Transformation as Machinery

For learning to occur, the past must be acknowledged. In direct challenge to the concept of *project amnesia* (Schindler and Eppler 2003), we should consider that the issue is not that people forget but rather they re-imagine the past or become conveniently blind to inconvenient truths. Without first developing a de-biased view of past performance, any attempt at 'learning' will merely reinforce previous habits. A shift toward collective consciousness is an essential prelude to developing autonomous or semi-autonomous habits and norms. The goal is to ensure that continuous improvement based on realistic insight becomes automatic, leaving the actors free to focus their attention on delivering benefit.

Leaders must actively listen to the people they seek to influence; they must ask the questions previously unimagined. To affect this shift toward organizational capability there must also be an element of motivation and continuous reinforcement to avoid the transformation being seen as a transient leadership whim.

In sum, learning is just part of the story; the foundation of vision, listening and curiosity, is reinforced by motivating rituals and metaphors. The following toolkit is organized around these five components or *machines* and draws upon behavioral sciences, major program management theory and real-world strategies.

9.5 A Practical Toolkit: Building the Machinery of Transformation

9.5.1 Build a Vision Machine

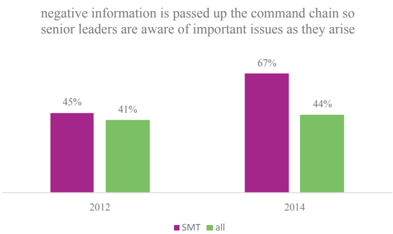
We live in the data epoch. We have more data at our disposal than ever before and the volume continues to double every three years (Henke et al. 2016). Yet, even data intended to convey the truth can make matters worse if they are open to interpretation depending on the viewer's perspective or motive (Cox et al. 2003). Often the only way we cope with this cognition overload is to stay within the familiar territory of our own discipline. By staying with the familiar, we cease to notice; "focusing is good, but sometimes you need to take a look around" (Bazeman 2014).

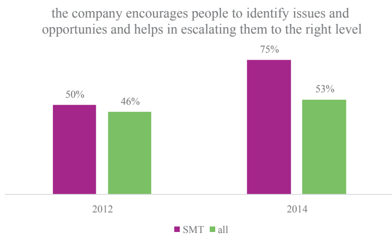
Collectively the multi-disciplinary leadership team must be challenged (or challenge itself) to see the bigger picture. In doing so, their differing viewpoints become a strength and can neutralize the disproportional influence of a powerful leader (Brower and Gilbert 2007). It is critical that each leader offer their unique perspective rather than reinforcing commonly held views; *common information* effect (Stasser and Titus 1987) and *confirmation bias* (Watson 1960).

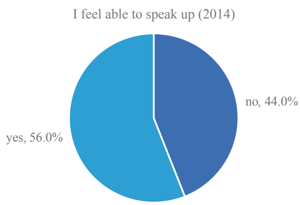
> **Real world example**: a well-known consultancy commissioned to quantify long-term prospects of a large multi-national organization, invited leaders to a 'data bath'. Organizational insight from a plethora of usually separate disciplines were collated and turned into visual artifacts, schema and diagrams. Leaders spent several hours interacting with the data. This elevated the absorption of insight to an experience, enabling the leaders to see rather than glimpse.

Individually, artifacts of insight can provide illusionary comfort (Fenton-O'Creevy et al. 2003; Langer 1975) to leaders in the grip of self-belief (Royer 2003) who regard them as *panopticons of truth*. In a 2015 study by the author (Burrow 2015) in which the post implementation review (PIR) documents of 100 international ICT projects were examined, 73% of project leaders claimed that project failures are always/often process-related, i.e. attributed to others. This supports (Buehler et al. 1994) findings that people are more confident in self than others; a delusion. The pseudoscientific form of many of these objects, e.g. PIRs, create a danger of *platonisity* (Taleb 2010), i.e. a focus on the neatly ordered at the expense of something far messier and unpredictable. By combining and interpreting the insight then using each element to offer contextual insight for the others, i.e. complementarity (Green et al. 1989; Bryman 2006), the leaders' vision widens. Rigorous interrogation of existing insight is essential. Further, it is crucial to consider the longitudinal comparison. Failure to do so leaves the leaders in the land of snapshot rather than panorama.

Real world example: An ICT organization collected data on the employees' opinions using two separate survey mechanisms. The output of each survey could be viewed through two 'lenses'; seniority and comparison to previous year. By combining two questions from one survey with one question from another, data from the perspective of the leaders and the staff, over time, brought some valuable insight into focus.







While whatever was not being disclosed by the staff remained invisible and inaudible, the increasing delusion of the senior leaders became evident. The inconvenient truth emerged; staff were not willing to speak truth to power and it was getting worse.

Leaders are urged to cross-reference multiple data sources to allow the truth to emerge. Yet even with this panopticon of insight, leaders may remain in the grip of their own biases. To move beyond the cursory, leaders must combine the insight with something more 'on the pulse'. The true story that sits behind the metrics is easy to miss but invaluable if captured. It requires the willingness and ability to listen.

Vision Machine Recap:

Step 1: ensure the leadership team is cross-functional and operating as a team
Step 2: routinely immerse the leaders in multiple sources of data
Step 3: combine and interpret data for contextual insight and rigorously challenge it
Step 4: adopt various 'lenses' when interpreting the data to develop wider insight

9.5.2 Build a Listening Machine

Transformation programs can avoid perpetuating underperformance by "careful analysis of what went right, what went wrong and make recommendations that might help future project managers avoid ending up in a similar position" (Nelson 2007). But how can we de-bias our interpretation of what actually *did* go right and wrong? Further, how can we be assured that we are not in the grip of confirmation bias? Leaders must be willing to challenge the artifacts of success (e.g. green status in Red-Amber-Green scorecards) and move beyond the visual into more multi-sensory feedback on the current status. They must be open to the idea that the existing insight may be occluding the real story. The easiest method of finding out is simply to ask; to open a dialogue with key actors.

Encouragement of bottom-up change is nothing new (Van Dyne and LePine 1998) yet, for this to stick, the leaders must truly listen. They must embrace the resulting constructive ideas without considering them to be threats or distractions (Grant et al. 2011). To caricature dominance complementarity theory (Carson 1969; Kiesler 1983); when one party speaks, the other should be listening. If both are speaking, no one is hearing. Leaders should create space for others to be heard.

To suggest a universal solution to this dissonance issue would be naïve and unhelpful. In practice, a blend of methods is needed to form the *Listening Machine*. The pros of one can compensate for the cons of another. Consider the use of *day-in-the-life-of* (DILO) studies (Gouillart and Sturdivant 1994), such immersive experience can fast-track the understanding of the current state, yet if it takes on the tone of a 'royal visit' it will be prone to the Hawthorne Effect (Mayo 1933; Landsberger 1958) and will reinforce existing views. Interviews with key actors could be prone to similar vulnerabilities unless undertaken by a skillful and neutral interviewer. Leaders could consider commissioning a targeted anonymous questionnaire to ask the pointed questions that would be difficult/impossible in a face-to-face context.

Real-world example: In a study by the author (Burrow 2015) leaders were asked if business cases were ever deliberately made more positive to secure funding and if they personally misrepresented the truth in this way.

		Others lie	
		yes	no
I lie	no	40%	4%
	yes	56%	0%

This suggests that lying was the norm. This insight was then tested in interviews with key actors who then offered further context. This insight could not have been gained through interviews or visits alone.

It is important that leaders are exposed to a realistic narrative from supporters to skeptics, all areas of the operating model and all strata of seniority. While it is tempting for leaders to rely on the usual factory, shop, team or group from which to garner their insight, they must stretch themselves to go beyond the familiar to get a realistic sense of 'the mood music'. Leaders willing to tap into the *new power* (Heimans and Timms 2014), i.e. willingness to channel the participative momentum of the staff, stand to deliver lasting transformation; where staff shift from being consumers of change to co-owners.

Listening Machine Recap:

Step 5: develop a suite of interventions which give leaders access to actors who are willing and able to offer realistic views of progress
Step 6: eliminate the chance of leader-influence by using a neutral intermediary
Step 7: ensure that the actors selected to participate in the research are representative of the organization
Step 8: use social media to provide contextual perspective

9.5.3 Build a Curiosity Machine

Leaders must be bold to absorb the insight that becomes knowable and bolder still to build a machine that will provide answers to questions they have yet to think of.

By integrating quantitative and qualitative insight, leaders can elaborate and clarify results from one method to another (Green et al. 1989). Similarly, the combination of readily available organizational insight with bespoke research brings the truth closer to the surface. The idea of the *Curiosity Machine* is that truth is surfaced (or delusion diminished) when a broad range of data is combined and interrogated with open curiosity. The curiosity must not be driven by confirmation bias but rather driven by a collective will to learn and succeed.

This essentially turbo-charges the management technique of *triangulation* (Denzin 2006) allowing research techniques are used iteratively to "derive a more complete understanding" (Rossman and Wilson 1985) and maximize internal validity (Creswell and Plano Clark 2011).

Such multi-dimensional insight will lead to an inevitable departure from the myopic collusion of collective confirmation bias.

Real-world example: In 2016 an ICT company identified a correlation between field engineers' perception of their own authority and their stated levels of pride in their work with consumer net advocacy. This was then actively used to drive customer advocacy. No one asked the specific question "does engineer engagement impact on customer satisfaction?" Insight emerged because of curiosity without agenda or silo-boundary.

Leaders must create space for curiosity to flourish. One way is to build a trusted insight team that will revel in interrogating the data, looking for patterns and connections (potentially augmented by artificial intelligence). This team must be independent and curious and given free reign to develop and test hypotheses. They must have regular access to the leadership team. Learning from insight cannot be a one-off activity, it should be a regular agenda item at all decision-making forums thus becoming a de-biasing ritual. By doing so, leaders can look beyond the surface data and explore something more meaningful upon which to develop their learning.

> Curiosity Machine Recap:
>
> Step 9: combine existing data, bespoke research (qualitative and quantitative)
> Step 10: appoint an independent insight team to identify patterns, develop and test hypotheses
> Step 11: develop the routine of bringing the insight into decision-making processes

9.5.4 Build a Learning Machine

Learning machines (Burchell et al. 1980) act as a temporal bridge from one project/phase to the next, turning this liminal space into learning space.

Before examining the mechanism for bridging, we must first determine the phases being bridged. Leaders can choose to look beyond the recent past and the perimeter of their organization to learn from similar transformations elsewhere. They can also consider lessons learned from early phases to enhance the efficacy of subsequent phases. New and ongoing insight is essential. By adopting a phased roll-out approach, each phase can be constructed as a series of small experiments, leading to orthopraxis.

When designing a phased roll-out, it is tempting for leaders to choose familiar areas of the organization led by trusted allies who smooth out errors, fix issues and provide positive feedback. This clouds the truth and prevents learning. Consider creating trials under the purview of engaged skeptics, i.e. those willing enough to be involved but not so invested as they artificially skew the insight.

Each experiment provides insight that can then be used to 'bridge' to the next phase. When building the 'bridge', the trick is to create meaningful *boundary objects* (Star and Griesemer 1989) to assimilate and codify knowledge. This must be something more 'alive' than turgid PIR reports. Whatever object is chosen to convey the learning it must distill the complex and nuanced learning into reusable content thus becoming a *memory object* (Cacciatori 2008) as well as a boundary object. The aim is to develop a usable suite of boundary/memory objects, to share knowledge across temporal boundaries from one phase to the next, thus creating transparency. For this to be successful, the leader or teams in subsequent phases must want to consume the learning. The more engaging and fun the boundary object, the more likely it is to be consumed.

A human is the ultimate boundary object. If veterans of early phases transfer temporarily into the new phase, they collaborate with new actors to solve problems based on experience *and* context. Actors make the transformation their own rather than something that is done unto them. By working together, veteran and actor can operate as *choice architects* (Thaler and Sunstein 2008) removing obstacles to the desired outcome.

Real-world example: The International Olympic Committee facilitates the transfer of knowledge between Organizing Committees of Olympic Games (OCOGs). Knowledge transfer is not limited to written procedures and reports, it is a personal experience. Staff from future games are seconded to current games to gain immersive experience. Debriefing from one games is hosted in the city of the next and networks of veteran advisors are made available to current OCOGs throughout the lifecycle. "These personal perspectives, visual guides and technical images often better represent the inner workings of an Olympic Games than any report could ever do." (International Olympic Committee 2011)

Learning Machine Recap:

Step 12: test design principles by creating small experiments under the purview of committed skeptics
Step 13: create engaging and relevant objects to take lessons-learned into subsequent phases
Step 14: involve key actors from previous phases in the implementation of subsequent phases

9.5.5 Build a Motivating Machine

Actual learning is vulnerable to time constraints and further inhibited when the over-emphasis on control leads to "low and ceremonial performance" (Kapsali 2001). If this becomes the norm all learning from previous programs or phases can be overlooked, ignored and omitted even if it is highly relevant to the new context (Swan et al. 2010; Prusak 1997). A lesson is not learned until something changes as a result (Milton 2011). There needs to be a shift from the cursory or ceremonial to something altogether 'stickier'.

The new regime must be 'woven into the fabric' of the culture (Shefrin 2008). Learning and transparency will only improve performance where there is motivation to do so and reinforcement mechanisms are used to underpin the desired culture (Keller and Price 2011). Therefore, a culture of learning (and transparent governance) must be underpinned by appropriate objects, rituals and metaphor. The people aspects of the transformation must then be encapsulated in a crisp people strategy.

For people to embrace change, they must understand what is changing and why. The wider the message needs to spread, the simpler the message must be. If the *what* and the *why* cannot be distilled into an 'in-a-nutshell summary', it is not going to stick. The object must be simple and engaging. It should feel fresh and authentic; sparkling with the language of the new culture.

Before launching the people strategy, it must be robustly tested through various 'lenses'; especially, how this change will impact actors at all levels throughout the system. Ideally, involve the actors or their proxy. Looking at the change throughout a variety of lenses provides clarity about the problem the transformation seeks to solve. It also helps paint the picture of 'when we get this right…' This in turn helps leaders construct the narrative in the language of the actors rather than the leaders.

It is critical that these core narratives are agreed prior to launching the transformation and/or people strategy. If leaders fail to pre-determine their narrative they risk encountering a 'ready, fire, aim!' scenario from which it is difficult, if not impossible to recover.

For truth and transparency (as a prelude to learning) to prevail it is critical that a compelling metaphor permeates throughout all communications. Metaphor creates and conveys meaning and underpins organizational culture by developing heuristics of decision-making and behavior (Ruth 2014; Cornelissen et al. 2005). The tone is as important as the message, e.g. paternalistic language will simply jar with any transformation that claims to be people-led.

Metaphor can in turn influence the creation of objects and rituals, i.e. ceremonial events (Trice and Beyer 1984). For example, transformations that adopt a metaphor of speed and agility, the governance framework must allow for swift resolution of presenting issues.

It is within this *Motivation Machine* that we start to feel the value of optimism. Stories of progress and achievement create belief in future success and builds optimism. Yet calibration occurs by leaders being clear and realistic about success and slippage. To promote pragmatism and to counter the illusion that all is knowable, leaders must be prepared to say, "We've evolved our thinking." Only this will provide the controlled drift the program to a mutually beneficial outcome.

Motivation is of course intrinsic and personal. One cannot bestow motivation on another, it comes from within. To motivate people within a transformation make it for them and about them. There is a human need to know where we fit. In a transformation everyone needs to understand how they will be affected and how they can contribute to success. All must be able to readily answer the question, "what is my contribution?"

Real-world example: During the launch of a people strategy, the leadership team (in a large ICT company) hosted a roadshow of interactive workshops during which every employee determined their personal contribution to the strategy. They completed a pledge card and took a selfie, with their pledge clearly visible. As the roadshow progressed, these selfies were built into a 'wall' (collage). Each location displayed their own 'selfie-wall' alongside those of other locations. The roadshow concluded with a TV-style broadcast with live links to teams across four continents. This built excitement, momentum and commitment. It fostered the feeling of team endeavor and individual contribution; turning the strategy into a live and lived experience.

Motivation Machine Recap:

Step 15: develop a robust people strategy that underpins the transformational change and test it through various lenses
Step 16: identify and eradicate any counter-productive language or metaphor, replace it with a motivating narrative
Step 17: develop engaging rituals that include actors at all levels to ensure that truth surfaces to the decision-makers
Step 18: make the transformation personal to make the change stick

9.6 Summary

This machinery of transformation change seeks to develop a system of orthopraxis. Under bold leadership, programs should course-correct throughout by maintaining realistic deliverables that can manage expectations of stakeholders, shareholders, and actors (the transformers and those to be transformed).

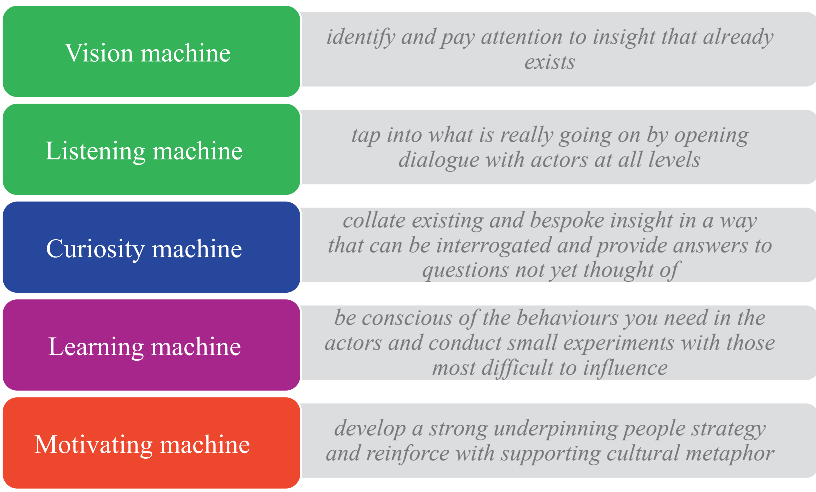


Fig. 9.2 Transformational machinery

Bold leaders are those who can acknowledge that goals can change throughout multi-year delivery (Cooke-Davies 2002) and stakeholders and users may not even know what they want/need until they see it (Sommerville and Sawyer 1997). More sophisticated leaders aim for a controlled drift (Pinto and Slevin 1988) to a mutually satisfactory set of outcomes. Success is maintaining grip without strangulation.

In sum, the combined machinery (Fig. 9.2) to calibrate optimism and realism in corporate transformation adopts a corporeal metaphor where an organization learns to see, hear, question, act/learn and motivate.

It is tempting to think this system of machines is a one-off linear construct where successful transformational change pops out the end. However, to truly embed continuous learning, this must be a continuum where the organization researches, discovers, acts, reinforces and then researches some more. At any given stage in a multi-phase transformation all four of these elements should be at work simultaneously as well as operating as a simple feedback loop, or *circularity of action* (Ashby 1958, p. 53) (Fig. 9.3).

Providing all machines are included in the toolkit, the precise design of the components can be context-specific and be in keeping with the company 'vibe'. The choice of interventions within each 'machine' is not infinite but rather limited by the boundaries of our collective imagination.

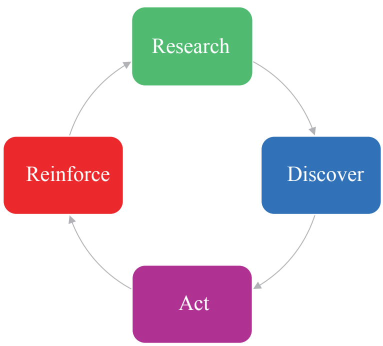


Fig. 9.3 The nature of continuous learning

9.7 Conclusions and Cautionary Tales

It is noted that "the lying game has long historical roots and is deeply engrained in professional and institutional practices. It would be naïve to think it is easily toppled" (Flyvbjerg 2005). Yet it is worthy of consideration that ease of lying or self-deluding is inversely proportional to the transparency within the system. We must attempt to free ourselves of intrinsic delusions and safeguard against extrinsic deceptions. Old rituals of collective confirmation bias must be identified and eradicated.

Leaders must be especially attuned to the fragility of transformation programs that are being implemented by those who will be impacted first or the most. For example, transformations linked to reward structures are often seen as a loss of status. When HR professionals are expected to implement such change, know that they too are impacted, they must overcome the powerful instinct for self-protection. By adopting the lenses approach, leaders can develop empathy for their position and design the roll-out accordingly.

The creation and adoption of a practical toolkit for transformational change may not comprehensively eradicate delusion and deception from the system but the potentially catastrophic effects can be contained. The resulting realism will go some way toward calibrating delusional/deceptive optimism, yet the helpful and catalytic optimism will survive.

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Part III

Capabilities Within Models

10

The Importance of Human Behavior in Practice: Insights from the Modeling Cycle

Sean Manzi

10.1 Introduction—The Importance of Understanding Behavior

Many systems involve a human component making behavior an important concept in Operational Research (OR) (Franco and Hämäläinen 2016). As discussed in the previous volume by these editors (Kunc et al. 2016), there are many ways in which behavior can be considered in relation to a model, ranging from it being consciously not included in the model (simplification) to explicit modeling of decision processes (Greasley and Owen 2016). The role of the OR practitioner however, extends beyond just creating a model. The modeler must also facilitate the project itself (Kahn 1994), determine if and how behavior might be relevant, collect data about behavior, incorporate that behavior in the model and support decision making about appropriate changes to

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behavior. This involves undertaking a project in collaboration with the problem owners; the stakeholders. Working with project stakeholders to undertake an OR project that leads to a change in practice requires the OR practitioner to have an understanding of how stakeholders perceive, think about and interact with the modeling process.

In considering how behavior can be incorporated in models in such a way that it leads to a successful change in practice, this chapter will discuss considerations for the OR practitioner throughout the modeling process regarding; how they involve stakeholders, consider behavior, incorporate that behavior in a model and support stakeholder decision making through to implementation of a change in practice. It is structured based on the modeling cycle outlined in Fig. 10.1 (Landry et al. 1983) and four transitional aims between the stages of the modeling cycle (creating shared understanding, translation, interpretation and implementation). The chapter is based on both the existing literature and the authors own experience as an academic and OR practitioner. Experiences from five key projects outlined in Table 10.1 have informed this chapter and where appropriate are referenced in the text using numbers in braces, e.g. {1}. Reference is made in Table 10.1 to the 'Method name' as described in the framework for representing human behavior by Greasley and Owen (2016).

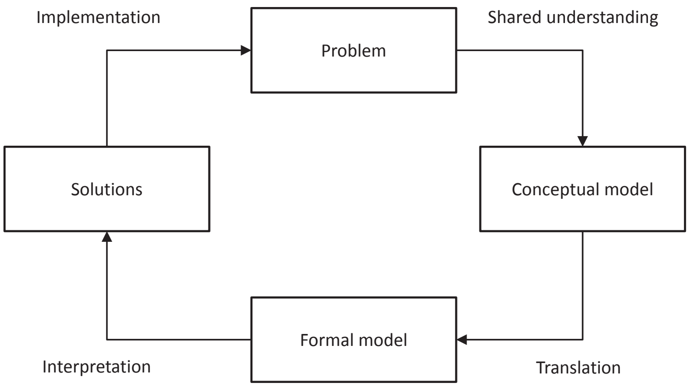

Fig. 10.1 The modeling cycle and intermediary stages adapted from Landry et al. (1983)

Table 10.1 Descriptions of the applied OR projects used to inform the chapter

Number in text	Title	Summary	Method name	Simulation approach
{1}	Mental health system modeling workshops	Stakeholder analysis, process mapping of whole system and causal loop mapping of issues which highlighted many behavioral issues in the system including an unwillingness to discharge patients and perceived inequalities in workloads	NA	Problem structuring
{2}	Modeling acute psychiatric care pathways in the South West of England	Models of acute psychiatric care pathways were created with the aim of determining capacity requirements to avoid out of area placements. The behavior of the bed management team responsible for allocating patients to beds was captured during process mapping as a series of decisions to prioritize patients	Entity	Discrete Event Simulation
{3}	Impact of a triage support system for memory clinic referrals	The aim of this project was to model the change in waiting times for memory clinic services if a triage support system was introduced to screen out those people most likely to be inappropriate referrals. The model was simplified to remove human behavior such as ignoring the triage advice. It was decided to study the issue of advice acceptance separately	Externalize	Discrete Event Simulation

(continued)

Table 10.1 (continued)

Number in text	Title	Summary	Method name	Simulation approach
{4}	Identifying service use patterns of severe and complex mental health patients	A network-based approach was used to identify and analyze the service use patterns of mental health patients within an area of the South West of England. This approach involved modeling the service use behavior of the patient cohort, identifying communities of patients with similar patterns of service use and predicting future service use based on these patterns	Individual	Network modeling / Agent-Based Simulation
{5}	Integration of sequential sampling models in realist informed agent-based simulations of informal decision making	A pilot study was undertaken to determine the feasibility of integrating experimentally informed sequential sampling models of decision making within an agent-based simulation	Individual	Agent-Based Simulation

10.2 The Problem Situation—Determining if and How Behavior Might Be Relevant {1, 2}

An important question for the OR practitioner to ask themselves at the start of a project is "where might behavior be important in the client's system?" The client/project stakeholders will identify the problem situation of interest but it is down to the OR practitioner to identify questions that can be asked of a system model to provide solutions to the problem (De Gooyert et al. 2017). At this early stage the OR practitioner can begin to determine how relevant behavior is to the problem and system being studied.

Many problems faced by OR practitioners can be described as complex, messy or *wicked problems*. This is often an indication that human behavior is present within the system of interest. Problem structuring methods provide a way for the OR practitioner to refine the problem situation using stakeholder input to determine what the core problems are and the importance of the human element of the system. The importance of behavior in the problem situation can be assessed by: Identifying those people who directly and indirectly interact with the system, determining how people interact within the system and with the system and whether the behavior of one or more stakeholder groups might be responsible for an issue with the system {1}.

Stakeholder analysis (Reed et al. 2009) is a good place to start understanding whose behavior may be important in influencing system function as it aids the OR practitioner in identifying the stakeholder groups associated with the problem situation. Process mapping can then be used to determine what the different stakeholder groups do within the system and how they interact with each other. Root cause analysis (Rooney and Heuvel 2004), cognitive mapping (Eden 1994) and qualitative System Dynamics approaches such as causal loop mapping (Mingers and Rosenhead 2004), are useful for finding out what different stakeholder groups think are the issues within the system and what might be responsible for causing them {1}. Conducting root cause analysis etc. with multiple stakeholder groups enables the OR practitioner to see where there is consensus between stakeholders regarding the issues in the system.

10.3 Conceptual Modeling

10.3.1 Generating Shared Understanding {1, 2, 3}

During the conceptual modeling phase the OR practitioner aims to elicit from the stakeholders their subjective representations of the system being studied. Central to this process is the representation of the stakeholder's view of the system in a way that is relatable to them. The stakeholders must be able to recognize their behavior within the conceptual model. The ability of the stakeholders to understand and relate to the conceptual model of the system is linked to their ability to engage with the modeling process, recognize the potential for change and explore possible improvements to the system (Elf et al. 2016; Van Nistelrooij et al. 2015) {2, 3}.

Representing the system of interest externally to the mind of the individual as a conceptual model provides the opportunity to gain new insights into the functioning of the system from the stakeholders. The stakeholders are the experts regarding their behavior in relation to the functioning of the system, but their understanding is limited to the elements of the system of which they have direct experience. A well created conceptual model that all stakeholder groups reach consensus on and can relate to, provides a neutral starting point from which to critically appraise the functioning of the system (Zimmerman et al. 2016). The role of the OR practitioner is to support the project stakeholders in understanding where the system may be inefficient and reach a consensus on where that inefficiency lies.

Ensuring shared understanding is of high importance where behavioral components of systems are concerned. The behavioral rules of a system are often informal so they can deviate from official guidance or have no documented procedure at all {2}. Various stakeholder groups sometimes perceive a system to function in different ways or may act on the system in different ways, this can even occur within stakeholder groups (Tako and Kotiadis, 2015) {1}. It may be that these differences in stakeholder behavior are responsible for the problem in the system. In such an instance it is necessary to record in detail the variation and continuity in behavior between stakeholders so that it can be replicated in the model.

It is difficult to get people to talk openly and honestly about their actual behavior rather than their ‘idealized’ behavior because they are often concerned about the ramifications of deviating from what are considered ‘normal’ processes and behavior {1}. However, it is essential that the OR practitioner be able to elicit information about the actual processes and behaviors that stakeholders perform within a system so they are accurately represented in the model. Ensuring that stakeholders feel they can honestly relate their actual system relevant behavior can be difficult when there are power differences between different stakeholder groups (Walker and Haslett 2001).

The OR practitioner needs to enable all relevant stakeholder groups to input into the project on equal terms. In some instances there might be differences of opinion, concerns about judgment or perceived differences in authority. Within organizations power and authority is determined in part by an organizational hierarchy and the seniority of individuals (Cialdini and Goldstein 2004). There is a tendency for people in a lower position of authority to defer to those in a higher position of authority. Where there might be a lack of cohesion and/or locomotion (i.e. motivation for change) (Edmondson 1999) it might be necessary to begin by meeting with different stakeholder groups separately to mediate issues of perceived (or actual) judgment and authority.

This approach becomes important when eliciting multiple perspectives of a problem or system where there is no written formal process or the actual process has deviated considerably from the formalized process. It is rare for any one person to have complete knowledge about the structure and operation of a system. Multiple stakeholder perspectives are required when the system or problem situation being studied is socially constructed or could be perceived differently by different people. Eliciting multiple viewpoints allows the OR practitioner to triangulate the differing points of view to find where they complement and conflict with each other (Simmons and Lovegrove 2005). Where complementing points of view are found one can be more certain of their accuracy, where conflicting points of view occur questions can be asked about why people’s perceptions of the problem or situation differ.

10.3.2 Translation—From Real World to In-Silico

Simulation modeling is as much an art as it is a science. The translation of a qualitative conceptual model into a quantitative formal model requires the OR practitioner to interpret the conceptual model in relation to the problem and the data available to parameterize the formal model. This is a more difficult proposition for behavioral models due to the complexity of behavior itself and a lack of routinely collected data. The model must remain relatable to the stakeholders while being of a sufficient level of complexity that the model has credibility with the stakeholders. It must also be sufficiently transparent and understandable so as to engender trust in the model and its outputs.

Models of social systems where the functioning of the system is determined by the behavior of the individual are particularly difficult to communicate to stakeholders. Most models can be conceptually represented using process diagrams but representing complex decision rules is more difficult in this format. One technique for conceptually communicating complex decision rules is to formulate them as 'If-Then-Else' statements as used in computer programming. The structure of 'If-Then-Else' statements can be defined as human-readable meaning that their functioning is literal and easy for people to understand. In a simulation model such statements might be hidden behind an animated front end or within the back end code of the model. For communication to stakeholders with little or no experience of modeling techniques or computer programming, 'If-Then-Else' provides a way to explicitly state different outcomes based on particular actions or choices and related to particular components of a model.

Agent-Based Modeling (ABM) is becoming more commonly used where a model is studying the behavior of individuals within a system (Siebers et al. 2010) but it is also a rather abstract and complex modeling approach. The use of process diagrams such as the one presented in Fig. 10.2 can be useful to communicate the behavior of individual agents within the system {5}. The process diagram can be used to represent the decision processes of an agent on each time increment within the simulation and the changes in the state of agents that occur as a result. Communicating the complexity of a models structure in a simple

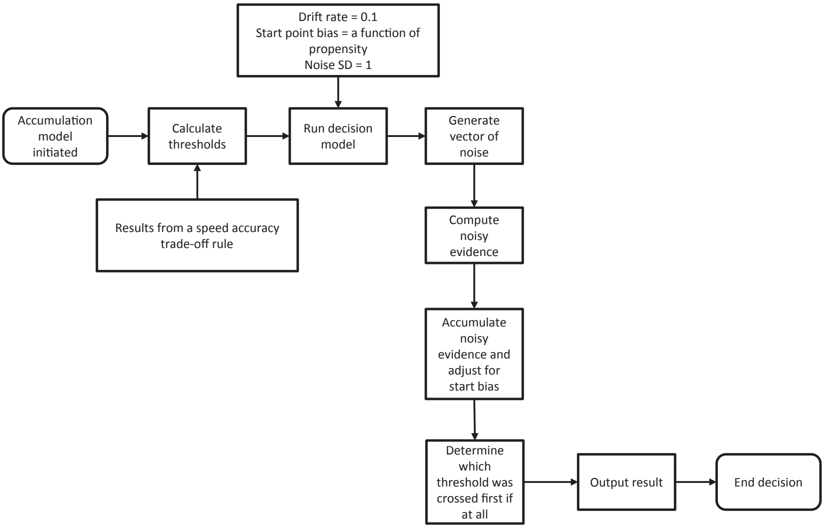

Fig. 10.2 An example flow diagram describing the computational processes of a sequential sampling model as embedded in an agent-based model

way is essential to ensuring stakeholder understanding, generating trust in the model and giving the model creditability (Small and Wainwright 2018) {4, 5}.

Gaining credibility and trust in a model is a difficult trade-off for the OR practitioner as it requires them to ensure stakeholders understand how the model works, a central concept in the group model building approach (Zimmerman et al. 2016). Engaging stakeholders in the translation and model building process is one way to increase their understanding of how the model works but it is difficult due to the technical complexities of building a simulation model. Some of the complexity of the model arises from the need of the OR practitioner to create a model that stands up to peer review and academic scrutiny {2}. Such considerations are often of no concern to stakeholders who only want a solution to their problem. Robinson et al. (2014) have suggested that simpler less rigorous models can be built together with stakeholders to produce information that prioritizes satisfying the needs of the client organization. Achieving greater involvement of stakeholders in the creation of the formal model has been associated with greater stakeholder understanding of the model and developing more useful insights from the model (Heaton et al. 2015).

10.3.3 The Formal Model—Incorporating Behavior in Models {5}

The framework for representing behavior in models as outlined by Greasley and Owen (2016) discusses a range of levels at which behavior can be incorporated into a model. For the flow, entity and task-based levels of behavioral modeling, data that represents behavior is often operational in nature and the behavior is implicit within the data. In the individual level behavioral model more explicit data is required regarding decision making and variations in behavior. Representing highly complex behavioral interactions and decision making of individuals within a model is a more challenging proposition. This section outlines an approach for determining and modeling decision dynamics. Using sequential sampling models of simple decision making informed by realist-based descriptions of behavior, agent-based models of complex human behavioral processes can be constructed {5}. This approach has the potential for creating models to test complex behavior change interventions in-silico to support the intervention development process.

The realist approach describes decision making in terms of the context of the situation influencing the decision making mechanism of the individual to produce an outcome (De Souza 2013). The context mechanism outcome (CMO) format of describing behavior can be used to describe informal human decision making (Manzi et al. 2016). CMO descriptions of decision making and behavior can be mathematically represented using sequential sampling models and these can be embedded within an agent-based model (ABM) to study the complex interaction of individual-level decision making {5}.

Sequential sampling models (SSMs) are a type of threshold model used to model decision making. They are based on neuronal action potentials and are a well-studied model of human decision making

(Forstmann et al. 2016). From second to second, people are faced with a multitude of decisions some of which are consciously considered, some can be described as unconsciously considered or autonomic (e.g. to move one's hand away from something hot) and heuristics or stereotyped responses (e.g. stopping at a red light). Consciously considered decisions occur after sufficient information is accrued so as to inform a decision to perform an action or not (Adolphs 2003).

When a person is faced with a decision to act or not act, they will consider the evidence that is (and has been previously) available to them (Forstmann et al. 2016). For example, the decision to eat or not eat might be predicated physiologically on how hungry a person is, environmentally on the availability of food and the appropriateness of eating in their current situation and attitudinally on their adherence to a routine of eating and willingness to eat the available food. These are but a few factors that will influence an individual's willingness to eat but they can also be represented within a simulation model. Patterns of physiological hunger based on metabolic rate, size of a person and when they last ate can be created at an individual level. This information could be used as a starting point for the accrual of evidence for eating; the environmental and attitudinal information then provides the remaining evidence.

The data used to parameterize a sequential sampling model is normally collected through controlled laboratory decision experiments where pay-off preference and decision time is measured under a variety of circumstances, e.g. amount and type of food available, cost of food, environmental setting. Differences in the reaction times across different scenarios can be converted into rates for the accrual of evidence. The differences between individuals' response times produce uncertainty (noise) within the model. While some data will be available from the scientific literature to parameterize an SSM, this approach does require data to be collected through laboratory experiments increasing the time and resources needed. The additional data requirements are a limitation of this approach. Future research needs to compare the accuracy of stochastic SSM's against deterministic probability models.

10.4 Solution Generation

10.4.1 Interpreting Model Outputs {2, 3}

Using the formal model, the OR practitioner will conduct a number of experiments to present a range of solutions to the problem situation defined by the project stakeholders. The model outputs must then be communicated to the client and stakeholders in such a way that they can usefully inform decision making. In addition to graphs, tables and text, an animated representation of the dynamics arising in the model can help people to understand the project findings {2, 3, 4}. Many simulation software packages use a graphical user interface (GUI) that animates the model providing a dynamic representation of the system. From the experience of demonstrating such models to stakeholders, it is often best to have a specific demonstration model of an idealized example that is representative of the results being communicated. Separating demonstration models and the models used to run experiments, releases the OR practitioner from the need to make the more complex experimental model aesthetically pleasing and it can be constructed for multiple runs and trials {2}. The demonstration model can be made more visually relatable for the stakeholders, be designed for single runs and with functionality such as sliders and manual inputs to demonstrate specific change scenarios.

Van Nistelrooij et al. (2015) have found that involving stakeholders in the model validation process provides them with a better understanding of the system function and the modeling results. This finding is linked to the generation of shared understanding. The involvement of stakeholders in the model validation process is thought to more actively encourage them to revise their mental models of the system being studied and its function (Van Nistelrooij et al. 2015). Such changes in thinking are necessary for the adoption of solutions not previously considered by stakeholders and the understanding of how to implement a suggested change in practice (Vandenbosch and Higgins 1996).

A benefit of stakeholders more completely understanding the results produced by a model is that they can determine which changes to behavior and the system would be practical to make (De Gooyert et al. 2017; Heaton et al. 2015). Many changes have financial implications; changes to operating capacity and resource availability require investment in infrastructure which might not be immediately possible for many organizations. Changes to behavior are often less financially expensive for an organization but can be practically more difficult to achieve. Changing behavior works well when there is stakeholder consensus about the change that needs to be made, a clear rationale for the change, demonstrable benefit and communication of the change to be made.

The idea of satisficing solutions is an important concept for the OR practitioner to understand as it informs the model build from the outset (Robinson et al. 2014). There is a tendency to want to create a 'perfect' model that is more complex than is required to produce a solution that satisfies the client's needs. Understanding the client's needs at the beginning of a project enables the OR practitioner to build a model that is complex enough to capture the important dynamics of the system being studied while keeping the model simple enough to minimize the data required to parameterize the model and ensuring it can be communicated to and understood by the project stakeholders (Elf et al. 2016; Van Nistelrooij et al. 2015).

Enabling the stakeholders to find a solution that they can all reach a consensus on is of more practical use than finding the perfect solution (Van Nistelrooij et al. 2015). The outputs of a model should support the decision making of the stakeholders not replace the decision making process. This is especially important for models that study social systems or individual behavior. A model is unlikely to describe how to change behavior, but the interaction of behavioral dynamics within the model can indicate which behavior could be changed to achieve the desired state.

When interpreting the results of a model, it is the role of the OR practitioner to facilitate stakeholder discussion about how the desired change in behavior can be achieved. Presenting a range of solutions to the stakeholders enables them to determine a solution that satisfies the organization's needs. Evidence from a recent unpublished pilot survey of Emergency Medical Service planners in Germany found that decision makers preferred an average of three solutions from multi-objective combinatorial optimization models (Manzi et al. 2018). This finding indicates that decision makers like to be able to choose between multiple solutions, but only want a limited number of alternatives to choose between.

10.5 Implementation—Helping Decision Makers Change Behavior {2, 4}

Throughout this chapter, the argument has been made that including behavior usefully in models to inform a change in practice requires the OR practitioner to engage stakeholders in the modeling process. It has been stated in the OR literature that greater stakeholder involvement in the modeling process increases the likelihood that a model derived solution will be implemented in practice (Franco and Montibeller 2010). Increased stakeholder involvement has been associated with a variety of factors that mediate the likelihood of stakeholder acceptance of the model derived solution. These factors have been examined throughout this chapter and can be summarized as:

- Ensuring organization and cultural relevance of the model and its solutions (Zimmerman et al. 2016)
- That the model and its solutions are based on evidence (Zimmerman et al. 2016)
- The ability of stakeholders to relate to the model (Elf et al. 2016)
- Stakeholder understanding of the model inputs and outputs (Van Nistelrooij et al. 2015)
- The level of stakeholder consensus (Van Nistelrooij et al. 2015)
- The level of stakeholder representation (Heaton et al. 2015)
- Perceived equitability of stakeholder representation (Heaton et al. 2015; Walker and Haslett 2001)
- Stakeholder trust in the model and other stakeholders (Walker and Haslett 2001).

Table 10.2 provides an overview of aims for involving stakeholders at each stage of a modeling project and advice for involving stakeholders to elicit useful information for the building of a model that includes

Table 10.2 Steps for involving stakeholders to include behavior in models

Project stage	Aim	Advice
Problem structuring	Work with stakeholders to understand the relevance of behavior to the system	• Use stakeholder analysis to identify who is involved • Use process mapping to determine if and where people are involved • Use root cause analysis, cognitive mapping, causal loop diagrams to find out how people are involved and if there are behavior-based issues with the system
Conceptual modeling	Develop the conceptual model in collaboration with stakeholders	• Include all stakeholder groups in an equal and fair way
	Translate behavioral processes with stakeholders to ensure the valid representation of the behavior	• Elicit accurate information about actual behaviors by developing trust and understanding the organizational hierarchy
Formal modeling	Ensure that the modeling approach is appropriate for the type of behavior you want to model and the data you have available	• See Greasley and Owen (2016)
	Ensure that stakeholders can understand the internal dynamics of the system	• Use demonstration models to complement graphs, tables and text with animations to visualize behaviors and complex system dynamics • Involve stakeholders in model validation helping to changing mental models through understanding the dynamics of the system
Generating solutions	Use the model and its representation of behavioral dynamics to produce a change in behavior that improves system function	• Present a range of solutions, but not too many • Create satisficing solutions that are achievable for the client to implement • Engaging with stakeholders to model behavior as described should improve your chances of successfully informing change

behavior. Engagement with stakeholders throughout the modeling process can be used to both inform the creation of a model that includes behavior, and improve the likelihood that the outputs of the model will translate into successful changes to practice. Considering both behaviors in the model and around the model are intrinsically linked concepts that should be considered together within an OR project.

10.6 Conclusion

This chapter serves as a starting point for understanding how the inclusion of behavior in models and considering stakeholder behavior around the modeling processes are linked concepts. The majority of studies in this area report on group model building (GMB) projects undertaken using a System Dynamics approach. However, the evaluation of the role of stakeholder engagement in relation to implementation as a general concept for OR projects is limited and the role of stakeholder engagement for models that include behavior is even more limited. Therefore, a priority area for further research should be to understand how stakeholder engagement through the modeling cycle can be used to better inform models that include behavior. Monks (2015) argues that the interdisciplinary field of implementation science is a counterpart to OR for research into creating effective change. To further this suggestion, implementation science offers a perspective from which to study how effective stakeholder engagement can be used to inform models of behavior to achieve changes in practice.

For the OR practitioner there is much to consider regarding if and how behavior should be included in a model, and how to work with stakeholders to best facilitate the model building process to change practice (see Malpass and Cassidy, Chapter 15). The concepts for stakeholder engagement presented in this chapter and summarized in Table 10.2, are mostly related to the need for good communication between the OR practitioner and the project stakeholders. As experienced OR practitioners will anecdotally know, considering how one engages with stakeholders throughout the modeling process is essential to a successful project. Traditionally, project stakeholders have been viewed as the 'enemy'

(De Gooyert et al. 2017). For those new to the practice of OR, building relationships with stakeholders and using them as a resource will result in a better project and a more useful model. This is especially true where stakeholder behavior is a component of the model.

By emphasizing competencies for engaging stakeholders for practice change, this chapter sets the scene for further reflection on and approaches to participatory modeling, ownership of change as well as political perspectives on such activity. In the following chapters, Burger (Chapter 11) proposes Social Practice Theory to help us reflect on the embeddedness of collective change efforts, and De Gooyert (Chapter 12) emphasizes the multiple rationalities for stakeholder engagement. The capabilities for participatory and developmental BOR practice are further elaborated upon in the subsequent chapter by Korzilius and Van Arensbergen (Chapter 13). Jointly, these contributions provide further insight into how competences in facilitated participatory modeling may lead to a change in practice.

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11

Developing Problem Structuring Capability: A Practice-Based View

Katharina Burger

11.1 Introduction

For a while, OR practitioners have been using problem structuring in facilitated group engagements to aid stakeholders to identify actions to change the status quo (Rosenhead 1989). However, particularly the complex situational interplay of individual and collective behaviors in problem structuring interventions (PSIs) is still not well understood (Sandberg et al. 2017). This ongoing efficacy puzzle is at the heart of much of the new behavioral OR (White 2009, 2016). New theoretical perspectives are needed that bridge the gap between participants, interventions, and the broader organizational context (Franco and Hämäläinen 2016). The question is: how might a PSI modify the participants' capability to change the status quo?

Practice-based theorizing (Nicolini 2017) has emerged as an integrative approach to studying Soft OR interventions in a way that considers

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the socialized individual in context (White et al. 2016; Burger et al. 2019). Practice theories constitute a palette of approaches; indeed, "there is no unified practice approach" (Schatzki et al. 2001, p. 2). However, many practice theories have in common that they offer a middle path between an emphasis on structure and individual agency in explaining human social activity (e.g. Bourdieu 1977; Schatzki et al. 2001; Nicolini 2012). As such, they offer novel ways to explore how the individual and collective dimensions of decision making in PSIs may be understood. To proceed, we have to choose among the possible theoretical perspectives, each of which offers a partial view of the phenomenon under study.

Here, we adopt Social Practice Theory (SPT) (e.g. Shove and Pantzar 2005; Shove et al. 2012; Pantzar and Shove 2006, 2010), as it has been shown to be particularly useful in informing interventions that are aimed at advancing behavior change in practice (Hargreaves 2011; Spotswood et al. 2015; Spurling et al. 2013). SPT may, therefore, provide us with insights about the behavioral efficacy of both the process and content of PSIs. Using the concept of a *practice*, rather than the term *behavior* as a unit of analysis, practice-based theorizing decenters the individual as a rational choice maker. The observable behavior of individuals is seen as just the tip of the iceberg, and attention is drawn to material infrastructures, shared social meanings, and embodied competences in decision processes (Walker 2014).

We proceed as follows: first, we investigate how SPT conceptualizes change and how this relates to PSIs in theory. Second, we review an empirical case study of a PSI through the lens of SPT. Third, we consider how the behavioral efficacy of PSIs may be studied with the help of practice-based theorizing, and how PSIs may contribute to enabling new collective capabilities.

11.2 Background to Practice-Based Theorizing

Practice-based theorizing emphasizes the socio-material, culturally-embedded processes of capability development (Røpke 2009) which are expressed in habitual ways of doing and being. Both values and norms and external institutional and governance arrangements shape the embodied and entrenched dispositions of agents to act in certain ways, i.e. to act in recognizable practices (Warde 2005). To study practices systematically, SPT provides a conceptual repertoire to distinguish between materials, competences, and meanings as the elements of practice (Shove et al. 2012) (Table 11.1).

These elements, when jointly enacted, are recognizable as a practice, e.g. car driving. While competence is a core element of a practice, it is the combination of the three elements that creates the capability for its purposeful application. The dynamic entangling of these elements by practitioners in repeated and regular performances allows an empirically helpful understanding of practice (Hargreaves 2011). The notion of capability, in this perspective, can be related to "the 'putting together,' or integration work, of social practice" (Walker 2014, p. 51). Capabilities in practice emerge, persist, shift, and disappear when new connections between elements are made. It is possible to speak of a proto-practice when the links have not yet been made, a practice when the elements are linked, and these links are sustained by a circuit of reproduction and finally, an ex-practice when the links have been broken (Pantzar and Shove 2010).

Changes in practices are achieved through the re-configuration and innovation of new constellations of materials, which may include technology but also people, the meaning given to an activity, and the process competence in implementing related actions (Reid and Ellsworth-Krebs 2019). This may well require the 'breaking' of old constellations that have persisted over time and which may now be accountable for a problematic status quo (Potthoff et al. 2017; Shove 2012). Such 'breaking' of established practices is catalyzed, firstly, by social differentiation and processes of distinction (Warde 2005), i.e.

Table 11.1 Elements of practices (cf. Shove et al. 2012)

Element of practice	Description
Materials	Objects, items, technology, physical entities, tangible stuff
Competence	Skills, know-how, and technique
Meanings	Symbolic meanings, ideas, and aspirations

different groups performing practices differently and thereby creating the ingredients for struggles for legitimization. In PSIs this is supported by inviting a wide range of stakeholders who may have different ways of seeing their activity in a system and engage in processes of boundary critique to broaden their understandings (Franco and Hämäläinen 2016). Second, change may occur through "improvisation and innovation by enthusiasts who challenge the orthodoxy of a given practice" (Geels et al. 2015, p. 7). In PSIs, this is encouraged through the processes of problematization and encouraging experimentation with ideas through the group modeling processes. As such, we can suggest a relationship between characteristic PSI elements and their corresponding mechanisms for catalyzing practice change (Table 11.2).

An SPT perspective on PSIs thus foregrounds how PSIs encourage the social interaction of stakeholders with different worldviews to advance learning processes through joint experimentation (Reed et al. 2010) (Table 11.2). However, practice change tends to be gradual, involving learning through networks of both individuals and their communities of practice (Brugnach 2010; Brugnach et al. 2008; Giordano et al. 2017; Reed et al. 2010). An SPT perspective, as such, also calls upon us to interpret in situ behaviors with reference to their wider context. The behavioral efficacy of a PSI needs to be seen as being interwoven within the longer-term system transitions that form the object(ive) of the specific intervention. For example, sustainability challenges demand innovative and experimental ways of linking scientific experts, policy makers, and diverse practitioners for more than a PSI event. In such a policy context, PSIs exemplify one way among many

Table 11.2 Practice change efficacy of PSIs

Practice element	PSI process element	SPT change process
Competence	Multi-stakeholder participation	Using the potential for creative and innovative responses arising from stakeholders with differentiated practices
Meaning	Boundary critique	Encourage legitimization struggles
Materials	Group model building	Experimental 'putting together' of practice elements, improvising and innovating

other policy instruments to support the coming together of diverse knowledges to generate adaptive responses (Geels 2005; Shaw and Kristjanson 2014).

In the following section, we consider a case study through the lens of SPT with a view to identifying how practice changes may be related to the in situ performances.

11.3 Case Study: Development of Problem Structuring Capability

Our case study is informed by two subsequent research projects that focused on sustainable urban redevelopment with the same local authority, maintaining the same core stakeholders. In the initial problem structuring workshops, participatory modeling was undertaken to develop new capabilities for sustainable urban transformations (Davis et al. 2010; White et al. 2016; STEEP 2014). We consider here a PSI workshop that took place during the first project through the lens of SPT and situate it in the wider context of the transition projects.

11.3.1 Modeling with Differentiated Multi-stakeholder Competences

At the workshop, stakeholders represented engineering firms, the local council, smaller not-for-profit organizations, different universities, and consultancies. This diversified competence base led stakeholders to identify four key problem areas associated with a low carbon transition in the specific locality: decision-making, infrastructure development, commercial and technological feasibility, and transport (Fig. 11.1).

During the workshop, participants discussed the needs of residential and business customers and different usage types and heat demands (customer segments). Questions about ways to connect customers to renewable and low carbon energy systems, contractually and technologically, were debated (channels), as was the need for early

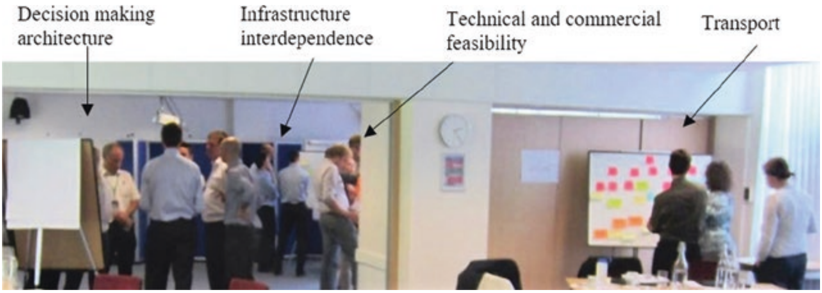

Fig. 11.1 The problem structuring workshop

developer engagement (relationships). On the supply side, key partners were—generically—identified (infrastructure providers, developers).

Key activities and resources (energy generation and supply options) and the need to understand the commercial viability (cost structure) were mentioned. The models developed in the workshop included suggestions for practices of engagement through formalized alliances, agreements about funding and financing and consideration of the management and administration of expended effort, and appropriate reimbursement of costs. Considering the terminology used and the processes that the participants considered, business models appear to represent "the way things are done around here." Business models are, indeed, multifaceted systems models that consider multiple connections between materials, meanings and competences in their description of how value is created (Lambert and Davidson 2013; Zott et al. 2010; Hindle et al. 2015).

11.3.2 Modeling for Shared Meanings with Boundary Critique and Legitimacy Struggles

The group modeling allowed participants to seek out opportunities for exploration, interaction, and manipulation of the different meanings that they assign to the practices associated with low carbon development (Easterby-Smith and Cunliffe 2017; Gherardi and Nicolini 2001; Gherardi et al. 2007). Participants described processes of gaining a shared understanding ("we think that we've come up with a much clearer idea of what this actually meant") and dialogic processes mediated by the physical tools provided (flipchart, post its, marker pens) ("we were switching things around right until the last minute, so it's not really finalized I think in terms of group consensus"). While thus maintaining some degree of difference, the modeling process appears to have served to reconcile the different individual views, by allowing multiple participants to jointly modify the shared material (Franco 2013; White et al. 2016). Such deliberation is constitutive of a program for purposeful action which arises in the mangle of unconscious and conscious articulation (Boothroyd 2013). As Fig. 11.1 illustrates, by visualizing the concepts and their relationships on the flipcharts and whiteboards, assumed relationships are made 'public' and 'productive' as participants jointly engage in discovery processes (Rae and Carswell 2001). Evaluative statements about the perceived efficacy of the processes for making participants aware of their previously scripted interpretations (Bohm 2004) were made ("So that's quite an important insight in how we're doing it"). In situ processes where individual viewpoints can challenge 'official' narratives have special relevance for change and transformation of ideas into actions (Leinaweaver 2015; Miller 2012). In practice-based theorizing, such struggles for the legitimization of meanings are seen as one of the mechanisms that can initialize behavior change (Warde 2005; Geels et al. 2015).

11.3.3 Modeling to Experiment, Innovate and Creatively Develop New Socio-Material Constellations

In our case study, group model building appears to have supported deliberation by bringing the perspectives of different participants into relations (Ewenstein and Whyte 2009). By surfacing held beliefs about shared practices (business model logics), it becomes possible to challenge the legitimacy of such traditional practice bundles (e.g. materials, competences and meanings associated with centralized fossil-fuel based energy systems) and jointly model innovative constellations of materials, meanings and competences (e.g. more sustainable, low carbon energy-as-a-service system). This development of new constellations is aided by the materials which, even though low-tech, allow for creativity, experimentation, and reconfiguration of ideas on the flipchart. In this way, they are suitable to aid with improvisation and innovation of new systems models. For example, the business model canvas for the city of Bristol, UK, which was further developed in the follow-up project, considers the development of community solar photovoltaics (PV) (materials), along with the engagement of users of solar PV (competences) and meaning (reduced emissions, better utilization of renewable energies and general energy awareness from users) (REPLICATE 2017) .

The different elements contained within the canvas (Timeus et al. 2017) indicate that local policymakers need to modulate different knowledges (e.g. designers, energy planners, council officials, academics, citizens/future occupants) for collective capability to develop in this urban transition context, as none of the actors possesses the capability to bring about large scale behavior change alone. Linking the group-level insights developed in situ to collective behavior change, the PSI case appears to be an instance of participatory capacity building in the wider governance practice of sustainable transitions. As such, the models' content may be indicative of the joint insight into problem-specific infrastructures, skills, and knowledge that needs to be developed further post situ so that ultimately more individuals can participate in sustainable low carbon practices (Walker 2014).

11.4 Discussion: The Behavioral Efficacy of PSIs

An SPT-perspective draws attention to the social endeavor of transforming, in a more or less intentional manner, a problematic status quo. The main implication of practice-based theorizing for PSIs is that behavior change is seen as being accomplished through the development of practice elements toward more desirable constellations. In part, PSIs may enable the surfacing of norms and values and potentially facilitate their renegotiation (Bell and Morse 2013) by creating struggles for legitimation in which a change in meanings is triggered (Warde 2005). During the characteristic modeling processes of PSIs, the capacity for "learning to learn" may be triggered as participants become aware of "how things are done here," i.e. of their unconsciously held meanings and beliefs which are then entered into a struggle about legitimacy when diverse experiences and system interpretations are expressed by the participants.

To understand the behavioral efficacy of PSIs we need to pay attention to the participants' active engagement in processes of modeling and deliberation during which the material, meaning and competence-related aspects of the problematic status are considered (Olsson and Lloyd 2017; Rosenhead 1989). Realizing that meanings are negotiable allows participants to engage in social bargaining of the structure of the problem that is to be addressed and encourages the negotiation of shared goals among the participants. Through this participation in the modeling processes, new shared meanings may emerge, which can no longer be attributed to individual viewpoints. In this way, the experimentation with constellations of practice elements during the group modeling processes may help participants to develop innovative future-oriented constellations of new practices. By modeling to re-arrange the components that make up the status quo, participants build on their knowledge of what is possible and create new constellations, both in terms of the sticky notes on the flipcharts and with the stakeholders in the room. Indeed, such collaboration-enhancing features of shared visualization processes are now well established (Eppler and Bresciani 2013; Bresciani et al. 2011).

Reflecting on the case study, the modeling process appears to have connected the individual to the collective level of action particularly when participants struggled to agree on the joint use of the shared flipchart space, experimenting upon it in a group and potentially resolving legitimacy struggles through unorthodox and innovative re-configurations of materials, meanings and competences in the resultant model. An SPT perspective then suggests that these processes during a PSI may be one way of aiding the development of longer-term innovative and locally supported constellations of practice elements, including the participants in situ. Specifically, PSIs may be efficacious as they encourage collaborative approaches to identify opportunities for purposeful action by reconfiguring materials, developing competence, and shaping meanings for new actionable configurations. Importantly, however, participatory workshops such as our case study PSI, are just one approach among many others in the governance of sustainability transitions (Geels 2005).

11.5 Conclusion

How might a PSI influence its participants' capability to change their status quo? This chapter has considered the behavioral efficacy of problem structuring interventions (PSIs) through the lens of social practice theory (SPT). We have traced how participants in a PSI develop innovative constellations of practice elements to address a problematic status quo. In our case study, the interventions helped participants to develop a business model narrative for a low carbon energy system. The PSI thus appears to have encouraged the participatory development of a new understanding of what to do, when and how to do it and why it is done.

In this way, the behavioral efficacy of PSIs for collective action may be leveraged by mobilizing the capability to challenge the orthodoxy of a given practice (Geels et al. 2015) and thereby to adapt to evolving environments dynamically (Chia 2019; Gherardi et al. 2007). This may be achieved, in part, by jointly experimenting with models to develop sustainable constellations of materials, competences, and meanings in relation to a given (bundle of) practices during the group model building processes. Post situ, the behavioral efficacy of a PSI will likely depend on the perceptual sensitivity of participants to further resources and on their competence to leverage them in the complex web of relationships and the meanings given to activities by other people who are involved in the problem situation. In this way, an SPT perspective, while allowing for a micro-analysis of in situ processes, also encourages the zooming out of the intervention and, in our case study, seeing the PSI as one way of initializing change in networks which are governing sustainable transitions.

As this chapter has highlighted, we need to consider in detail how stakeholders contribute to the capability of acting in a problematic situation. The challenge of understanding the human impact on OR processes is further elaborated upon by de Gooyert (Chapter 12), who connects the why, who, and how of stakeholder involvement in Operational Research.

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12

Stakeholder Behavior in Operational Research: Connecting the Why, Who, and How of Stakeholder Involvement

Vincent de Gooyert

12.1 Introduction

The aim of Behavioral Operational Research (BOR) is to acknowledge and incorporate behavioral effects: effects that "relate to the group interaction and communication when facilitating with OR models" (Hämäläinen et al. 2013). The BOR research agenda revolves around questions as "what are the consequences of humans being involved in OR," and "what is the human impact on the OR process" (Hämäläinen et al. 2013)? Behavioral mechanisms have important implications for the process, models, and outcomes of OR efforts (White 2016). In addition, behavioral mechanisms are one of the elements of the problems that OR projects aim to study (e.g. de Gooyert et al. 2016).

Earlier studies discussed the relevance of stakeholders in operational research (Ackerman and Eden 2011; Bryson 2004). This is especially true in the realm of problem structuring methods, which try to

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deal with *wicked problems* where different stakeholders adopt different views on what the nature of the problem to be dealt with is (Franco and Montibeller 2010), and where there can be considerable tensions between stakeholders (Malpass and Cassidy, Chapter 15). However, what the relevance of stakeholders is exactly and what the implications are for operational research is often dealt with superficially (Müller et al. 2012) and implicitly (de Gooyert et al. 2017). Earlier studies come with recommendations and tools on how to deal with stakeholders in OR (Ackerman and Eden 2011; Bryson 2004), and who to involve (Müller et al. 2012). However, such recommendations are often generic of nature. In this chapter, we aim to make the now often unconscious capability of involving stakeholders in OR more explicit, by distinguishing between different reasons for involving stakeholders, and their implications for how to involve which stakeholders.

12.2 Motives for Involving Stakeholders

In this section, we draw on stakeholder theory, Operational Research, as well as on our own experiences in practicing, supervising, and teaching stakeholder involvement in operational research, to describe four different motives for involving stakeholders. The motives are (1) improving decision quality, (2) building consensus, (3) improving relationships, and (4) the intrinsic value of involving stakeholders. In practice, operational research studies may combine motives, and the motives to involve stakeholders may change during the course of a project. Together, these motives provide answers to the question on *why* to involve stakeholders in operational research.

12.2.1 Improving Decision Quality

Operational Research applies mathematics, or modeling more broadly, to support solving real-world problems. The outcome of Operational Research can be understood as decision support: the aim is to provide information that helps making a better decision compared with the situation in which there would be no Operational Research study. One motivation to involve stakeholders is that this may lead to a better outcome of an Operational Research study in terms of decision quality compared, because it fosters *learning*. When stakeholders are involved in an Operational Research study, this allows exchange of information, confronting each other with data (Rouwette et al. 2016, p. 64), and debating the validity of competing beliefs about the problematic situation and potential solutions. Some (Soft) Operational Research methods explicitly mention learning as an important outcome of applying such methods (e.g. Vennix 1996).

The assumption behind improving decision quality as the motivation for stakeholder involvement is that the decision maker and the operational researchers themselves do not possess all knowledge relevant for addressing the problem. This assumption does not have to be true, especially for well-defined problems, for which *expert mode* problem solving would suffice (Franco and Montibeller 2010, p. 489). For more ill-structured problems, the data necessary to achieve a rich understanding of the problem commonly is spread out over many individuals (e.g. Camillus 2008). Involving stakeholders can result in covering more data, but also in improved *sensemaking*: translating the data into information that supports solving a problem (Daft and Weick 1984; Weick 1995). In addition, some information on the problem can be "difficult to examine, describe, and use" (Ford and Sterman 1998, p. 309). Involving stakeholders in operational research is one way of bringing together information, allowing to draw on tacit knowledge that would otherwise remain implicit and out of scope.

12.2.2 Building Consensus

Another motivation to involve stakeholders can be the aim to reach consensus on the nature of the problem, and related, the potential of various solutions to solve the problem. One way in which OR can help in this respect is by using models as boundary objects (Malpass and Cassidy, Chapter 15). Building consensus is a different motive compared to improving decision quality through sharing information/

learning, because even with the same information available to all parties, there might be disagreement on which solution to pursue. Consensus in that sense has more to do with the *values* that problem owners and stakeholders hold on to. Differences in values lead to differences in opinions on the desirability of implementing certain solutions. The aim of involving stakeholders can then be to reach a compromise, "increasing commitment" toward the agreed upon solutions (de Gooyert et al. 2016, p. 136).

The relevance of reaching consensus is acknowledged in the literature. Consensus in itself is not always deemed desirable or appropriate, as it might be a signal of groupthink (Janis 1972). This is also called *premature consensus* (Hines and House 2001) and can be a signal that not enough information has been gathered, that more divergent steps are required. However, although consensus is not a sufficient condition for a successful operational research project, it is seen by some as a necessary condition. Based on a study of over 400 decisions, Nutt (2004) argues that involving stakeholders is required to address the concerns and considerations of those stakeholders. Overlooking these concerns can have as a consequence that these stakeholders resist the implementation of the decision, delaying the implementation, and decreasing the chances of successful implementation altogether (Nutt 2002, 2004, 2008).

Resistance can be caused by not incorporating the values of stakeholders, but also by the procedure leading up to a decision being perceived as unfair by stakeholders (Cropanzano et al. 2007). If stakeholders are of the opinion that they should have been involved in a decision-making process where they were not, this perceived injustice may lead them to oppose the implementation of solutions. Stakeholders may even agree to support the implementation of solutions that they deem undesirable themselves, because they perceive the procedure leading up to the decision as being fair (Korsgaard et al. 1995). Having an open dialogue is an important antecedent of the perceived fairness of a decision-making process (Kim and Mauborgne 1995) and involving stakeholders in Operational Research allows for having such an open dialogue.

12.2.3 Improving Relationships

Many relationships between problem owners and stakeholders are repetitive of nature. Building consensus may help to avoid resistance in the context of a certain problem, but the same parties are likely to meet each other again in other situations in the future. The consensus to implement a solution for a specific problem, does not mean that the same parties will automatically agree on the solutions for other problems as well. Therefore, another motivation to involve stakeholders in operational research, is to invest in a stakeholder relationship more generally. This can be seen as an investment in the relationship with stakeholders, without necessarily knowing on beforehand what the exact return on that investment will be. The parties find themselves in a network characterized by repetitive interdependencies and investing in stakeholder relationships without clear immediate returns makes sense from this network perspective, while the same investments would not make sense from a project-based perspective (de Bruijn and ten Heuvelhof 2018). Investing in stakeholder relationships has shown to lead to several hard to measure effects as increased trust (Franco 2008), more favorable attitudes toward the problem owner, improved cooperation (Bosse et al. 2009; Choi and Wang 2009) and avoided conflicts (Hillman and Keim 2001).

12.2.4 The Intrinsic Value of Involving Stakeholders

A fourth motive sees involving stakeholders in Operational Research not as a means to an end, but as an end in itself. The argument is that involving stakeholders has an intrinsic value on its own. Several underlying arguments can be found in the stakeholder theory supporting this view. These arguments together form the *normative cores* of stakeholder theory (Donaldson and Preston 1995).

A first example is Freeman and Evan's (1990) extension of the transaction costs approach as described by Williamson (1984), which they use to argue that stakeholder theory is in line with the transaction costs approach. While Jones (1995) makes this into an economic argument of lowering transaction costs, Freeman and Evan (1990) make this into a moral argument. Their firm-as-contract analysis argues that all stakeholders, especially those with asset-specific stakes, have a right to bargain and deserve a "fair contract" (Freeman and Evan 1990, p. 352). More specifically, they state that "managers administer contracts among employees, owners, suppliers, customers, and the community. Since each of these groups can invest in asset-specific transactions which affect the other groups, methods of conflict resolution, or safeguards must be found" (Freeman and Evan 1990, p. 352).

Property rights form another foundation that is both used as an economic (Asher et al. 2005) as well as a moral argument. Donaldson and Preston use what they call a pluralistic theory of property rights to argue that stakeholder theory is normatively justified by the need, ability, effort, and mutual agreement between an organization and its stakeholders (Donaldson and Preston 1995, pp. 81–84). They show that property rights are always embedded in human rights. Property rights are never unlimited, as the interest of other stakeholders will always impose restrictions included in those property rights.

Another basis for a moral argument is the principle of stakeholder fairness. Phillips (1997) argues that an obligation of fairness arises whenever an organization accepts the benefits of a mutually beneficial scheme of co-operation requiring sacrifice or contribution on the parts of the participants and there exists the possibility of free-riding (Phillips 1997, p. 57). The degree of the obligation to fairness is in proportion to the benefits accepted. Besides property rights and the principle of fairness mentioned above, other foundations for moral stakeholder arguments are: common good, feminist ethics, risk, integrative social contracts theory, Kantianism and doctrine of fair contracts (Phillips et al. 2003, p. 481).

12.3 Which Stakeholders to Involve?

A widely used definition of stakeholders is "groups and individuals who can affect, or are affected by, the achievement of an organization's mission" (Freeman 1984, p. 52). Since the origin of stakeholder theory, many answers have been given to the question which stakeholders should be taken into account. Mitchell et al. (1997) contribute to answering this question by making a distinction between three characteristics that stakeholders may possess: power, legitimacy and urgency. *Power* is defined as "the ability of those who possess power to bring about the outcomes they desire" (Salancik and Pfeffer 1977). *Legitimacy* is defined as "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions" (Suchman 1995, p. 574, in Mitchell et al. 1997, p. 866). *Urgency* is defined as "the degree to which stakeholder claims call for immediate attention", based on "the following two attributes: (1) time sensitivity—the degree to which managerial delay in attending to the claim or relationship is unacceptable to the stakeholder, and (2) criticality—the importance of the claim or the relationship to the stakeholder" (based on Jones 1991, in Mitchell et al. 1997, p. 867). Using these three characteristics, they define eight types of stakeholders that differ in their amount of *salience*: "the degree to which managers give priority to competing stakeholder claims" (Mitchell et al. 1997, p. 854).

Depending on the motive to involve stakeholders in operational research, it makes more sense to involve certain types of stakeholders and not others. Therefore, we discuss for each motive below which stakeholders play a more prominent role compared to others.

12.3.1 Improving Decision Quality

When the aim is to involve stakeholders in operational research to improve decision quality through learning, the selection of stakeholders depends on the knowledge they can bring to the table. Often used stakeholder selection techniques such as the power interest grid (Ackerman and Eden 2011; Bryson 2004; Freeman 1984) and the Mitchell et al. framework (1997) put a lot of emphasis on the power of a stakeholder. However, if decision quality is the primary focus, power plays not a prominent role at all. Stakeholders should be selected on the basis of their expertise on a problem, or the access that they have to relevant data (e.g. Ford and Sterman 1998). In terms of the power interest grid, it is likely that those stakeholders that score high on "interest" should be involved, as these stakeholders are more likely to also have knowledge on a problem, given their interest.

It could be a deliberate strategy to also involve stakeholders that have only a weak relationship to the problem whatsoever. These *fringe stakeholders* (Hart and Sharma 2004) might bring a fresh perspective to the table because these stakeholders have a different perception of the problem compared to the usual suspects. Discussing a problem which such stakeholders opens new perspectives on the problem that was beyond imagination without them (Hart and Sharma 2004; Pina e Cunha and Chia 2007). These fringe stakeholders score low on both power and interest, and therefore would have not been identified using traditional stakeholder identification techniques.

12.3.2 Building Consensus

Building consensus is an important way of increasing the likelihood of successful implementation of a solution, through increasing commitment from those stakeholders that might otherwise resist implementation. Therefore, when the aim is to build consensus, the focus lies on stakeholders that have the power to resist implementation. In principle, the interest of stakeholders is of less relevance, although those stakeholders that score high on interest are more likely to have a desire to use their power, because they care more about whether a certain solution gets implemented or not. In terms of Freeman's definition of stakeholders, those "able to affect" the problem play a more important role in the context of the motive of building consensus than those "that are affected" (Freeman 1984, p. 52).

Perceived unfairness of a decision-making process is a potential source of resistance to implementation (Cropanzano et al. 2007; Korsgaard et al. 1995) and from this perspective it follows that those stakeholders need to be involved that are of the opinion that they should be involved. In terms of Mitchell et al. (1997) these are the stakeholders that score high on urgency. Nutt (2002) stresses that failing to uncover the concerns of such stakeholders may result in a decision debacle.

12.3.3 Improving Relationships

When the aim is to improve the relationship with stakeholders more generally, the selection of stakeholders depends on the likelihood of encountering the same stakeholder again in future situations. Especially in the context of unstructured, or *wicked problems* (Camillus 2008), problems typically are not 'solved' after finishing a project aimed at that specific problem. Rather, the policies implemented to manage the problematic situation are likely to have their own unintended consequences on the longer term, leading to new, related problematic situations (Camillus 2008). In such complex settings, relationships between stakeholders are likely to be multilateral and asymmetrical (de Bruijn and ten Heuvelhof 2018). A problem owner typically depends on more than one stakeholder and while in one situation the problem owner depends on a certain stakeholder, the dependency could as well be reversed in a next situation. Identifying stakeholders in this context comes down to identifying those stakeholders that the problem owner is likely to encounter in future situations. These could very well be stakeholders that have low interest in the specific problem under study. The stakeholders will probably score high on power, as this makes it more likely that these stakeholders are able to 'return the favor' of the investment in the stakeholder relationship by the problem owner. However, this is a more general conception of power of a stakeholder than the typical problem-specific power used in stakeholder identification techniques.

12.3.4 The Intrinsic Value of Involving Stakeholders

Some stakeholders are involved because of the intrinsic value of involving those stakeholders. One argument can be the moral obligation that is felt to involve certain stakeholders. This typically concerns stakeholders that score low on power and high on interest. After all, stakeholders that score high on power can defend their own interest, they do not need a problem owner to empower them. Stakeholders that score low on interest on the other hand, care less whether they are involved or not. In terms of Freeman's definition of stakeholders, those "that are affected" by the problem owner play a more important here than those "able to affect" (Freeman 1984, p. 52), the opposite of the stakeholders in the context of building consensus. In terms of Mitchell et al. (1997) legitimacy is the determining characteristic here. Stakeholders become important when this is considered appropriate based on value, beliefs, and definitions (Mitchell et al. 1997, p. 866). Some (soft) operational research methods are specifically aimed at giving a voice to stakeholders that would otherwise remain marginal, such as community operational research (Midgley et al. 2018) and community-based system dynamics (Hovmand 2014).

12.4 How to Involve Stakeholders in Behavioral Operational Research?

Stakeholder theory provides methods that can help managers to improve their thought process about stakeholders. Freeman suggests drawing a stakeholder map (1984, p. 54 and further): managers should identify the stakes that different stakeholders have to support balancing conflicting and competing roles. Furthermore, he suggests drawing a stakeholder grid based on two dimensions, namely the amount of power and the size of the stake that stakeholders have in a certain issue, the widely used power-interest grid (Freeman 1984, p. 62). These techniques are aimed at improving managers' ability to take the perspective of stakeholders. By trying to conceive how stakeholders would react to different decisions, managers thus try to keep stakeholder reactions in the back of their minds when making decisions.

A second way of taking stakeholders into account is by actively approaching them. If managers do nothing more than standing in the stakeholders' shoes, it may well be that these stakeholders never find out that they are taken into account. Therefore, organizations can use communication techniques like presenting the way that they came to their decisions to show stakeholders that they are accounted for (Freeman 1984, p. 78).

A third way of taking stakeholders into account is by actually involving them in the decision-making process. Freeman mentions two techniques that fall in this category, namely negotiation and making voluntary agreements (1984, p. 78). Freeman stresses that involving stakeholders is the only way to cope with what he calls the congruence problem, which is the problem that the perception that an organization has concerning its stakeholders, is not necessarily in line with reality. “The congruence problem is a real one in most companies for there are few organizational processes to check the assumptions that managers make every day about their stakeholder” (Freeman 1984, p. 64). We conclude that three main ways of taking stakeholders into account can be distinguished: standing in the shoes of stakeholders, communicating with stakeholders and involving stakeholders in the decision-making process. Depending on the motive to involve stakeholders in operational research, it makes more sense to adopt certain types of stakeholder involvement and not others. Therefore, we discuss for each motive below which type of stakeholder involvement plays a more prominent role compared to others.

12.4.1 Improving Decision Quality

When the aim is to improve decision quality, stakeholder involvement can be selective. Assuming that the problem owner and the operational researchers have enough information to include the perspective of stakeholders without involving them, it can be enough to have the OR team stand in the shoes of the stakeholders. Or, assuming that the problem owner and the operational researchers have enough information if they identify which parts of expertise are lacking, stakeholders could be involved just to provide those missing pieces of information, in a later phase of the modeling cycle (Manzi, Chapter 10).

12.4.2 Building Consensus

While standing in the shoes of stakeholders may suffice to improve decision quality, this type of taking stakeholders into account in behavioral operational research is not enough when the aim is to build consensus. Building consensus requires debating opposing views on a problem (Amason 1996). Besides, not involving stakeholders or involving them superficially can be problematic because if stakeholders get the impression that involvement is only symbolic, it may do more harm than good (Korsgaard et al. 1995).

12.4.3 Improving Relationships

Improving relationships is about reciprocity: a problem owner invests in stakeholder relationships without knowing exactly what the return on this investment is going to be. If that is the case, stakeholder involvement may vary from selective participation to deep involvement. The logic of reciprocity then suggests that the problem owner should expect low returns on small investments, and high returns on large investments.

12.4.4 The Intrinsic Value of Involving Stakeholders

When stakeholder involvement is an end in itself, rather than a means to another end, stakeholder involvement is likely to be extensive. Practices as community operational research and community-based system dynamics rely on deep participation to empower marginal stakeholders (Hovmand 2014; Midgley et al. 2018). Stakeholder involvement will likely commence early on in the modeling cycle (Manzi, Chapter 10).

12.5 Conclusion

Behavioral OR deals with questions as "what are the consequences of humans being involved in OR?", and "what is the human impact on the OR process?" (Hämäläinen et al. 2013). Many OR studies involve

Table 12.1 Connecting the why, who, and how of stakeholder involvement

Why involve stakeholders in behavioral operational research?			
Improving decision quality	Building consensus	Improving relationships	Intrinsic value of stakeholders
Who to involve in behavioral operational research?			
Based on expertise. High interest, low or high power	Based on potential resistance. High interest, high power	Based on network structure. Low/high interest, high power	Based on legitimacy. High interest, low power
How to involve stakeholders in behavioral operational research?			
Selective participation to add specific knowledge or perspectives	Deep involvement to uncover hidden concerns and to avoid cynicism	Different levels of reciprocity, on the long term return follows investment	Deep involvement to give voice to marginal stakeholders

not just the problem owner and the OR researchers, but also other stakeholders. However, the implications of these stakeholders are often dealt with superficially (Müller et al. 2012) and implicitly (de Gooyert et al. 2017). This is problematic, as there are very different reasons to involve stakeholders with implications for which stakeholders to involve and how to involve them. In this chapter, we distinguished between four different motives to involve stakeholders in OR: improving decision quality, building consensus, improving relationships, and because of the intrinsic value of involving stakeholders. Table 12.1 summarizes the implications of these motives for the selection of stakeholders and adjusting the design of an OR study in terms of how the stakeholders are involved. We hope this chapter helps turning the now often unconscious capability of involving stakeholders in OR into one that is more conscious.

In this way, this chapter encourages practitioners to reflect on the different practices of engagement in OR and how *meanings* (why) and *skills* (how) are coupled with the embodied and material resources for *collective action* (who). Considering stakeholder engagement through the lens of social practice theory (see Burger, Chapter 11) may allow us to extend our understanding of competences and capabilities in different contexts. A specific area of focus may be understanding better the abilities of stakeholders to implement changes, as the following chapter by Korzilius and van Arensbergen (Chapter 13) suggest.

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13

Lessons Learned: Acquiring Insights from Non-Operational Research Perspectives

Hubert Korzilius and Pleun van Arensbergen

13.1 Introduction

Hämäläinen et al. (2013) set the topics of a research agenda in Behavioral Operations Research (BOR), among which: model building, comparative analysis of procedures and best practices, and non-expert use of OR methods. In an effort to include laypeople, Hovmand (2014, p. 12) shows the importance of community modeling and states “that modeling can happen multiple times on different topics within the same community – is overlooked in the group model building (GMB) literature.” Community-based modeling with multiple meetings over

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time and with different groups might impact community engagement, problem identification, capacity building, model building, and implementation. In addition, groups should be viewed as distinct entities as they have their own goals, norms, and dynamics. Recognition of these specificities, including endorsing values of openness, diversity, and inclusion, might impact the preparation, process, and outcomes of GMB which might differ from common approaches in OR. In this chapter, we focus on an approach developed in the fields of anthropology and rural development, specifically geared toward incorporating values, knowledge, and experiences of local communities and enabling them to analyze their own reality, called Participatory Rural Appraisal (PRA) (Chambers 1994a). In particular, based on a content analysis of the literature we provide an overview of PRA tools and methods enabling non-expert participation and suited to elicit in-depth knowledge of local people such as village mapping, transect walks, and timelines. Our aim is to advance the OR research agenda by providing insights of best practices of non-experts' involvement from other fields of research.

13.2 Theoretical Background

In the tradition of the development of Soft OR methods, problem structuring methods, process consultation and facilitated modeling (e.g. Franco and Montibeller 2010; Mingers 2011; Schein 1999; Vennix 1996) our theoretical point of departure is constructivism. In mapping or modeling processes of complex problems, it is vital to (Mingers 2011, pp. 731–732): "encourage the active participation of stakeholders in the modeling process often through facilitated workshops of those affected by the problem. In order to encourage participation, models should be transparent to participants." […] This to "help understand how different people involved in a situation made sense of it, or understood it, for themselves." Franco and Montibeller state that (2010, p. 490) "Problems are socially constructed, thus the operational researcher has to help a management team drawn from the client organization in negotiating a problem definition that can accommodate their different perspectives." So, in order to give participants an active role in the research process and to fully capture the meaning of their social reality, research methods should be geared toward these ambitions (Boeije 2010). As stated, within the OR tradition there are several well-established facilitated mapping and modeling techniques such as GMB, Cognitive Mapping, and Strategic Options Development and Analysis (for an overview see Franco and Montibeller, p. 496, Table 4). Characteristic for OR in this area is the focus on strategic decision making and stakeholders often being managers, employers, and shareholders of companies, primarily in Western countries. As such, there is room for including other groups of stakeholders that might be affected by such strategic decisions, like customers, citizens, and larger communities. In general, people who are further away from board rooms, less familiar with the jargon and details of strategic issues probably have other educational and socioeconomic backgrounds. As many strategic problems have implications for them, it makes sense to let them actively participate. Eden and Ackerman (2001) underscore the role of adequate participation in strategy making as a requirement for procedural justice: the concern for fairness of procedures in arriving at decisions which is connected "to involvement in issue formulation, being listened to, and having a voice" (p. 126). However, involving all relevant stakeholders in strategic decision making may require using other modeling and mapping methods than are currently available in OR, as of potential differences in backgrounds of stakeholders. Inspired by the intriguing title of Mingers (2011), *"Soft OR comes of age—but not everywhere!"* we looked elsewhere to fill this gap. As Mingers title reminds us of Margaret Mead's famous work from 1928 "*Coming of age in Samoa*," and its approach to study people from indigenous cultures with differing norms and values from an emic perspective, we focus on the fields of anthropology and rural development research.

There is a longstanding tradition of data collection methods for studying people and communities in anthropology. Among other things, it contains comparative methods, participant observations, and ethnography. To align with existing Soft OR methods, we focused on a well-known alternative from the fields of anthropology and rural development, called Participatory Rural Appraisal (PRA). From the 1980s PRA evolved as a reaction to development experts who were dissatisfied with the reductionist and top-down approaches used in rural development. Chambers (1994a, p. 953), a key exponent of PRA, defines it as a set "of approaches and methods to enable local people to share, enhance and analyze their knowledge of life and conditions, to plan and to act. PRA has sources in activist participatory research, agroecosystem analysis, and applied anthropology." It aligns with yet is distinct from common OR practice as PRA takes place in rural areas in which communities of local people participate, and indigenous knowledge and methods are used for problem analysis and problem-solving. PRA uses a variety of tools and methods that are carried out by local people like village mapping and modeling, transect walks and timelines.

To our knowledge, Soft OR methods and PRA have only scarcely been combined in research. An exception is the study by White and Taket (1997) that provides a framework which combines elements of PRA with various OR systems methods and illustrates this in a case. The authors stress that a flexible mix of approaches, rather than a rigid style, promotes sharing of experiences and knowledge of local participants. Another exception is work by Hovmand and colleagues. Hovmand et al. (2010) discuss methodological issues in combining GMB and PRA in an effort to include marginalized communities in decision making. In particular, they consider the need for adequate problem framing and recognizing that stakeholder participation is a process rather than a matter of yes or no. They also stress that bringing the two methods together means going through a series of consecutive steps: problem scoping, team planning, and the actual model building. Yadama et al. (2010) used PRA in combination with GMB in order to identify a dynamic problem related to forest resource dependence, including feedback mechanisms between socioeconomic and ecological systems. They conclude (p. 21) "that involving people embedded in the dilemma" provides a better understanding of the dynamic problem and also "significantly improves our ability to gather longitudinal data to build dynamic models of the problem at hand over time." In his book Hovmand (2014) illustrates the mentioned methodological issues, shows the importance of engaging communities and states that community-based system dynamics uses PRA methods among other things for designing effective collaborations with communities when teams have little or no experience with GMB.

Considering the scarcity and potential of PRA in OR, we provide an inventory of PRA literature to see how participation is organized and what kind of tools are being used, including their potential advantages and disadvantages. We aim to highlight how OR might profit of non-expert method usage. We have formulated the following research questions (RQ) guiding the content analysis of the literature:

RQ(1) What types of participation are characteristic for PRA?
RQ(2) What types of data collection methods are employed in PRA?
RQ(3) What tools are used in PRA?
RQ(4) What are the reported strengths and weaknesses of PRA?

13.3 Method

We conducted a content analysis (Duriau et al. 2007) on empirical community-based research according to the PRA approach using modeling, to relate to methods used in OR. In Web of Science we searched in Topic fields with the terms: (1) "participatory rural appraisal" AND (2) community* AND (3) "model OR map*." The topic field searches in title, abstract, and key words of papers. This led to 41 papers in a period ranging from 1997 to October 2018. Five papers were deleted: one paper just referred to PRA, and four papers were non-empirical studies, which resulted in a final sample of 36 papers. In the qualitative coding procedure (Boeije 2010), we followed a similar approach as Rouwette et al. (2002). We registered the authors, title, journal, publication year (see Appendix A). Furthermore, we listed the location, participation characteristics (respondent, informant and/or participant), data collection tools, what model, mapping or other PRA tools were being used, and the reported strengths and weakness of the approach (see Table 13.1). To complete the database, the authors divided the 36 papers. In case of doubt, the authors discussed the issue and reached consensus. The publications were read, and information was entered in the database. Next, the database information was condensed and summarized (see Table 13.1) to enable answering the research questions.

Table 13.1 Methodological aspects of academic papers on community-based PRA research

#	Location	Participation	Data collection methods	PRA tools (incl. maps/models)	Strengths/weaknesses PRA
1	India	75 rural area households (men and women) as respondents and participants	Household surveys; interviews; PRA	Village resource mapping; transect walks; problem ranking; seasonality diagrams; daily time-use patterns	(S) Critical exercise for effective rural governance; provides contextual data, which is often missing in national census database
2	Mexico	Residents from indigenous communities as participants; professionals from the same communities facilitated the FGD	FGD	Maps of region, natural resources, actors; sociogram; problem tree analysis; community action plan	(S) Overcoming language barriers and illiteracy, generating trust, enabling the community to master the educational process intervention; participating in own language enables to autonomously manage the rescue, systematization and reworking of collective knowledge; stimulates feeling proud and giving voice
3	China	230 households as respondents	Questionnaire and PRA		
4	Nepal	95 households as respondents and participants	Survey, key informant interview, FGD and PRA	Seasonal calendars; livelihood seasonal monitoring calendars; transect walks	
5	India	21 tribal community health volunteers as participants	Participatory needs assessment using PRA	Drawing cobweb; fish bone technique; Venn diagram	(S) Ensuring active participation of trainees, promoting group learning and enabling trainees to help frame need-oriented training and providing concrete ideas on required plan of action for community

(continued)

Table 13.1 (continued)

#	Location	Participation	Data collection methods	PRA tools (incl. maps/models)	Strengths/weaknesses PRA
6	Iran	Villagers, goat herders, forest owners, village council members, government officials as respondents and participants	PRA; village-level survey; interviews; FGDs; secondary sources		
7	Romania	Community leaders and vulnerable groups (e.g. unemployed, elderly, social welfare recipients, persons with disabilities) as respondents and participants	Surveys; interviews; FGD		(S) Powerful when part of triangulation
8	China	135 herders families as respondents	Household questionnaires; interviews		
9	China	Farmers, herders from 478 households as respondents	PRA, via open-structured questionnaires, and Physical Monitoring		(S) Reliable results
10	Pakistan	120–200 women with various backgrounds as participants	PRA	Transect walk; social map; body map; illness matrix; listing health inequities; daily routine timeline; Venn diagram	(S) Customizable learning instrument; complete freedom to change direction of discussion and processes; promoting in-depth understanding of power relations and contextual factors impacting women's health/well-being and empowerment
11	Namibia	40 villagers as respondents, 3 elderly villagers as informants and participants	Key-informant interviews; PRA	Transect walks; memory mapping	(S) Participatory community conservation models are the real alternatives for managing national parks

(continued)

Table 13.1 (continued)

#	Location	Participation	Data collection methods	PRA tools (incl. maps/models)	Strengths/weaknesses PRA
12	Vietnam	Specialists as informants; various types of natural resource users as respondents and participants	Literature survey; key informant interviews; group interview	Cognitive mapping; timeline	(S) Increasing involvement of marginalized peoples in decision-making over their own lives. Mapping and visualization facilitates adoption of exploratory mode and ongoing verification of interpretation of interviewee's statements (W) Having a simplistic notion of community, represented as homogeneous, static, and harmonious conceals power relations within the community and masks biases in interests and needs based on age, class, caste, ethnicity, religion, and gender
13	Lao PDR	Local people and groups of local stakeholders as respondents and participants	PRA; household interviews; key informant interviews; field visits; systematic point sampling	Historical profile	(S) Useful for appraisal, but not for in-depth analysis (W) Results sensitive to selection of key informants
14	South Africa	Livestock owners and community members as respondents and participants	Participant observation; PRA; interviews	Village maps; transect walks; seasonal calendars; problems and solutions matrix	(S) great deal of interest created for local people (W) Unfamiliarity and difficulty with method, and workshops led by external facilitator created not much action; more time and experience required to train locals as facilitator

(continued)

Table 13.1 (continued)

#	Location	Participation	Data collection methods	PRA tools (incl. maps/models)	Strengths/weaknesses PRA
15	Zambia	Variety of stakeholders as participants	PRA	Conflict prevention techniques; stakeholder analysis; community assessment	(S) Tendency to internalize the appraisal of problems and opportunities within the participating community or group, which undermines local sustainability
16	Bangladesh	504 households as respondents; interested community members as participants	Questionnaire; PRA surveying in FGD's	Social and resource maps; transect walks; vulnerability and dream maps; mobility maps; Venn diagrams; pair-wise ranking; strengths, weaknesses, opportunities, and threats (SWOT) analysis	(S) Identification of significant indicators beneficial for setting priorities for action for community; more indigenous knowledge and cultural perceptions incorporated by improved accuracy; results validated
17	Nepal	Community disaster management committees members; community members; social mobilizers; NGO staff as participants	Participatory vulnerability and capacity Assessments (VCA); FGD;	Transect walks; community resource maps; social maps; risk map (both remote and digital mapping techniques)	(S) Capturing people's valuable, spatial knowledge, complementing authoritative sources of information communities; improving stakeholders' human and social capital (W) Technological barrier, map ownership, and empowerment potential
18	Bhutan	District level authorities (11); community members from diverse socioeconomic backgrounds (24); local community; household heads (174) as participants	PRA: informant discussions, FGDs; household survey;	Community resources maps	(S) Taking locally perceived values into consideration in decision-making processes can support sustainability of ecosystem management interventions

(continued)

Table 13.1 (continued)

#	Location	Participation	Data collection methods	PRA tools (incl. maps/ models)	Strengths/weaknesses PRA
19	Uganda, Tanzania	Farmers as respondents (42) and participants (73)	PRA; RRA; interviews; key informant interviews	Resource maps; climate calendars; historical calendars; cropping calendars; organization maps; pairwise ranking; transect walks	(S) Combination of PRA and RRA tools capturing relevant indicators; providing opportunities for implementation of different stakeholder groups across different levels
20	Brazil	Farmers, traders, landowners and environmental agencies (83) as respondents and participants	Interviews; PRA	Seasonal calendars; transect walks; participatory maps	(S) Inclusion of local knowledge highly valued; collaborative adaptive management of produce as viable alternative for achieving sustainability
21	India	People from three tribes as respondents and participants	PRA; survey; FGD; interviews	Village resource maps	
22	Pakistan	17 groups of villagers as participants	PRA; interviews; FGDs	Social maps; transect walks	
23	Namibia	Local people (200 per region) as participants	PRA	Village resource maps; root analysis	
24	Tanzania	Regional secretariat, agricultural officials as informants; villagers, leaders, elderly people, 122 households as respondents and participants	PRA, FGDs, key informant interviews, direct field observations and survey	Physical resource base; land use maps	(S) Combination of methods enhances reliability of collected data and enables triangulation
25	India	Migrant employees as participants	PRA	Social maps	(S) Effective participatory learning tool; inexpensive method to gain knowledge about community; teaches the researcher community participation (W) Method does not provide complete, elaborate or accurate details; subject to variation; less participant involvement if made on paper; durability and long-term effects are questionable (suggestion to use computers)

(continued)

Table 13.1 (continued)

#	Location	Participation	Data collection methods	PRA tools (incl. maps/models)	Strengths/weaknesses PRA
26	Niger	Government officers, farmers, gardeners, herders, traders as respondents and participants (96)	Interviews; PRA	Regional maps	(S) Low-cost, fast and explores human dynamics at regional level; allows to underline new elements; results are action-oriented, planning development more focused on indigenous issues (W) Perception-based study can induce strong bias during sampling and mapping, reducing representativeness; local definitions may cause confusion; map combining is time consuming; information is conceptual and qualitative, and cannot be expressed quantitatively
27	Bangladesh	Villagers (well-off and not so well-off) as participants	FGD; PRA	Spatial maps	(S) Importance of using spatial maps for developing an effective and sustainable community-based arsenic mitigation planning; reduction of costs by providing alternative safe water options; platform to enhance information about community needs
28	Kenya	Local women (35) and men (14) as participants	PRA	Resource maps; historical time lines; transect walks	(S) Shortening distance between researcher and researched; encouraging local reflections; checking male and female viewpoints to explore gender differences in community; greatly contributing to understanding of resource diversity

(continued)

Table 13.1 (continued)

#	Location	Participation	Data collection methods	PRA tools (incl. maps/models)	Strengths/weaknesses PRA
29	Sri Lanka	Villagers (50) as participants	PRA	Participatory maps; preference and pair-wise ranking tables; Venn diagrams	(S) Effective method to receive community participation; good starting point for development activities; deals with all three parameters of sustainability: social, economic, and environmental
30	Bangladesh	Marginalized and landless farmers, school teachers, local political leaders (50) as respondents and participants	PRA survey; interviews; FGDs	Public participatory Geographical Information System map; mental maps	(S) Increasing utility of community information for arsenic mitigation; improving participation and empowering local groups; enhancing trust-building; integrating the different viewpoints of various groups; fostering common vision
31	Philippines	Farmers, and children ≥ 10 years; illiterate as well as literate (166 households, 456 individuals) as respondents and participants	PRA; key informant interviews	Community maps; transect map; cropping calendar; mind maps	
32	Vanuatu	Locals living traditionally and professionals living in the community; elite class and community members (82) as participants	PRA	Community timelines; area maps; organizational and decision-making diagrams; community volcanic emergency plan; hazard map	(S) Success of working groups dependent on individual composition; gender-separated participatory exercises valuable for identifying and voicing gender and power issues, avoiding restricted discourse with only the powerful. (W) Inter-gender community interactions as failure and difficult to mediate. Despite open communication and reversal of power hierarchies during PRA, participants seemed well aware that they would return to their normal societal roles afterwards

(continued)

Table 13.1 (continued)

#	Location	Participation	Data collection methods	PRA tools (incl. maps/models)	Strengths/weaknesses PRA
33	Tanzania	Villagers, men (66) and women (39); agricultural agro-pastoralists, pastoralists; as respondents	Risk questionnaire	Risk mapping	(S) Useful tool for understanding perceptions of risk to livelihoods in semi-arid Tanzania; cost-effective way of gaining insights to help improve research design and to inform policy development (W) Risk mapping is not participatory in truest sense but identification is essential for development and focus of projects, designed for poverty alleviation
34	Mali	Villagers (505 from five villages) as participants	RRA	Community maps	(S) Allowing to: interact with certain groups, such as women (simply infeasible when visiting individual households), observe dynamics of villages literally 'at work', and lead to more nuanced understanding of dynamics within these villages and their relationships with outsiders (W) Community mapping may lead to biased estimates

(continued)

Table 13.1 (continued)

#	Location	Participation	Data collection methods	PRA tools (incl. maps/models)	Strengths/weaknesses PRA
35	India	Rural people (1301), varying in gender, casts, illiteracy, level of poverty, as respondents and participants	PRA; FGDs; interviews	Community maps; households cards; matrix ranking	(S) Revealing factors of eye problems not revealed before
36	Mexico	Local people (all men) as informants and participants	RRA/PRA; interviews;	Transect walks; comparative exercises; vegetation maps and forest cover	(S) Indigenous knowledge is valuable source of information about biodiversity trends (W) Potential gender bias, but prevailing culture made it difficult to speak with women

Note FGD = focus group discussion; PRA = Participatory Rural Appraisal; RRA = Rapid Rural Appraisal; S = strengths; W = weaknesses

13.4 Findings and Discussion

Table 13.1 shows the methodological aspects of the 36 reviewed studies (see references for bibliographical details).

From Table 13.1, we draw a number of inferences. We observe that almost all studies were conducted in developing countries. Given our focus on PRA and community-based research methods this is perhaps not surprising. Still it is remarkable that the majority of the studies did not take place in Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies (Henrich et al. 2010). It is a marked difference from published papers in top tier management journals on action research that almost exclusively took place in WEIRD countries (Bleijenbergh et al. 2018).

In regards to RQ(1), the characteristics of participation of PRA studies, we have a couple of interesting findings. We noted a large variety in the duration of the studies, this ranged from a single day to several years. Obviously, the period that field activities in the studies take differs a lot. This can be related to the study designs; some studies basically employed a survey approach, whereas other studies involved more time-consuming participation in several phases of the research process. As PRA typically involves individual and group activities, most studies are therefore characterized by active participation (labeled ‘participants’ in Table 13.1). However, in other studies, individuals function as data source, e.g. filling out questionnaires or being interviewed (‘respondents’), or as expert or informant in interviews (‘informant’). In line with the goals of PRA, the research objects were primarily local and indigenous people: farmers, fishermen, foresters, herders, traders. However, again there appeared much variation, some studies involved individuals as data source (mainly as respondents and informants) whereas others focused on groups (often as participants). There was also variation in the heterogeneity of the sources, often local villagers and community members are involved whereas in other studies, various other stakeholders such as government officials and elites were involved. This last group was more often involved as key informants than as participants. Also remarkable was that due to religious and cultural reasons, men and women often are part of different groups. In quite some studies elderly were an important source of information about historical facts, and sometimes even children participated. As it was not a methodological issue, we did not systematically register the concerns the local people dealt with. However, they were almost invariably at least severe such as about biodiversity, climate change, and diseases and sometimes life-threatening issues as arsenic poisoning, flooding, and volcanic hazard. The picture that emerges from this differs from operational research that seems to be dominated by management representatives of Western companies and organizations.

The second research question, RQ(2), focuses on data collection methods that were employed. Many studies used a multi-method approach. The most mentioned types were: questionnaire, diverse types of interviews, focus group discussion, and various mapping and modeling methods, often separately referred to as PRA. This finding shows how PRA should be not be considered as a data collection method, rather as a typology of an approach that focuses on incorporating people living in rural areas.

RQ(3) inquired the various tools of PRA. There were differences in this, but in many studies, PRA is differentiated into various tools in which local people participate in all kinds of drawing and mapping exercises and discussion of the results (sometimes described as FGD). Examples of the mentioned tools are: community mapping, cropping calendars, land use mapping, risk mapping, organization mapping, resource mapping, social mapping, transect walks, and Venn diagrams. We noticed that the term model was sometimes used to indicate the statistical analyses that were conducted (e.g. a regression model) or in a broader meaning of exemplary, framework or theory (e.g. a research process model) rather than a materialization of meanings or relations in a graphical display that we envisaged in our literature review. However, these included studies definitely met the search terms, so they were PRA, community-based, and used a modeling or mapping approach. It merely shows that the term models is ambiguously used in the literature and also in common language. We encountered many different models with interesting labels such as: dynamic bio-economic non-linear model of goat and charcoal production, model for sustainable cost-effective animal disease management, model illustrating decoupling and recoupling social-ecological mechanisms for long-term conservation of biodiversity, participatory action research model for women's empowerment and a resource symbiosis model.

For operational researchers it might be worth considering the numerous options with which they may not be familiar, but which can be of added value to the commonly used methods. For example, as part of a project a transect walk in neighborhoods and the buildings of companies and organizations will increase the insights. One of the studies (#25) provides an overview of learning skills related to (social) mapping. It might increase cognitive knowledge and spatial distribution about the social structure and institutions. It would also be promoting the affective domain by eliciting attitudes, beliefs and norms about the topic of interest and the cultural models and stereotypes in the community. And it might improve psychomotor skills by drawing, summarizing and presenting data. Furthermore, as these bottom-up methods also use the community as the starting point, they include a way of communication which is familiar to the community members. We add to this that it will increase the active stance of participants, resulting in more involvement and motivation and potentially better outcomes of modeling sessions.

We finally inquired the reported advantages and disadvantages of PRA for answering RQ(4). We found that quite some papers did not provide methodological reflections at all whereas other papers go at great length discussing them. We differentiated a set of content-related and one on methodological categorizations. The content-related advantages that we inferred: an instrument for change; capturing people's valuable, but often non-documented local knowledge (cultures, reflections, resource diversity, perceptions, values); involving and empowering socially and economically deprived groups; promoting in-depth understanding of power relations and contextual factors related to the problem issues; improving quality of results and enabling action and implementation; explore gender differences in a community; fostering transparency, trust and empowerment; consensus building (fostering a common vision, integrating different viewpoints). The following methodological advantages were found: a (group) learning tool; mapping is an ongoing verification of the interpretation of the interviewee's statements; method triangulation and improving data quality; enlarging problem ownership; flexibility; shorten the distance between the researcher and the researched; low costs and fast; receiving community participation.

One overarching critique of PRA approaches is whether solutions to all problems will exclusively be found within local communities (Bar-On and Prinsen 1999). This relates to a potential gap between identifying and solving problems within a community itself. External help and outside or 'Western' knowledge (Chambers 1994b) might also be useful for dealing with complex issues. Another reported disadvantage is a simplistic notion of community, when represented as homogeneous, static, and harmonious might conceal power relations and masks biases in interests and needs based on age, class, caste, ethnicity, religion, and gender. The weakness of inter-gender community interactions is a failure common to many PRA activities which is difficult to mediate despite open communication and efforts to reduce power hierarchies during PRA activities. This is related to bias during sampling and mapping which might impair representativeness. Other issues that were mentioned: start-up time needed to do the workshops themselves; some tools were new, unfamiliar, and difficult (e.g. ranking and exploring); success of working groups depend on composition and less on facilitator skills; local definitions may cause confusion; map combining is very time consuming; awareness of return to normal societal roles afterwards.

13.5 Conclusion

Our study leads to the following recommendations how future OR may profit from insights of other research areas, in particular, PRA. In the PRA literature, we noticed the importance of ownership and engagement. Translated to OR, this would mean that ownership of the problems to be solved needs to be in the hands of the stakeholders. This involves that the main effort of OR practitioners would lie in enabling them to analyze their own problems and finding solutions. Acknowledging that stakeholders' problems cannot be solved without the knowledge of those stakeholders, emphasizes the importance of the

OR practitioner's role of knowledge elicitation. PRA studies showed how this way of working leads to strong engagement of the communities in the problem analyzing and solving process, which subsequently leads to commitment to change and implementation of solutions. This engagement and involvement of the stakeholders in analyzing and solving their own problems results in empowerment of stakeholders. Whereas commitment to change is seen as an important aim of OR interventions, for PRA, the main outcome can be described as empowerment. Commitment seems to relate to the willingness to act, while empowerment seems to be related to the ability to act. When looking at the objectives of OR interventions from a PRA perspective, this would mean focusing more on the abilities of stakeholders to implement changes instead of on the willingness to contribute to implementation of changes. When building further on the belief related to PRA that change can happen from within, this entails that the intervention should be accommodated to ways of working and communicating that are familiar to the stakeholders and enable them to the utmost extent to analyze and solve their problems. This may require flexibility of the practitioners and an extensive toolbox, to enable them to choose different methods depending on the group they work with. In conclusion, intriguing non-operational, PRA, perspectives may advance future OR and OR applications.

In line with the previous chapters, the importance of participatory modeling and stakeholder engagement is emphasized, in particular the importance of developing competences in stakeholder selection (see also De Gooyert, Chapter 12) and enabling developmental processes where ownership of actions is embedded in the situated stakeholders (see also Burger, Chapter 11).

Appendix A

Reviewed papers (numbers refer to Table 13.1).

1. Debnath, R., & Bardhan, R. (2018). Resource symbiosis model through bricolage: A livelihood generation assessment of an Indian village. *Journal of Rural Studies, 60*, 105–121.

2. Lara, C., Crispín, A., & Téllez M. (2018). Participatory rural appraisal as an educational tool to empower sustainable community processes. *Journal of Cleaner Production, 172*, 4254–4262.
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14

The Merits of Transparent Models

Konstantinos V. Katsikopoulos

14.1 Introduction

The July 2018 Inter-Parliamentary Meeting at the Atlantic Council called for transparency in the practices of the technology sector regarding political campaigning (Transatlantic Commission on Election Integrity 2018, p. 1): "We encourage technology companies to … dramatically increase transparency … and raise public awareness about ways messages and news can be manipulated". A few days later, the House of Commons asked from the UK Government to "… provide the appropriate body with the power to audit … companies, including algorithmic auditing" (Committee on Digital, Culture, Media and Sport Committee 2018, p. 21).

The General Data Protection Regulation of the European Union (see Kharlamov, Chapter 17) has made a legal move toward greater transparency of algorithms. It requires companies to provide customers

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intelligible and easily accessible information about the use of their personal data. For example, for criminal profiling, citizens have been given the right of getting meaningful information about the logic involved in a computer-based classification of their conduct.

At the time of the writing of this chapter, the US has no comparable regulation. As *The New York Times* has reported, a man from Wisconsin, Eric Loomis, has been sentenced six years in prison in part based on the prediction of an algorithm about the risk of Mr. Loomis committing further crimes. Because the algorithm is proprietary, the defendant was not given the chance to inspect its logic and be able to challenge it in court (Liptak 2017). The judge was provided with a risk assessment based on the algorithm and seems to have agreed with it. But it is unclear to what extent the judge was able to scrutinize the logic of the algorithm.

Algorithms and their predictions are examples of output delivered by Operational Research (OR) models. The starting point of the present chapter is that, for such OR model output to be useful, an additional kind of model services is required. In the social and behavioral sciences, such as economics and psychology, intermediate services of models include that models provide "insights", "new perspectives", "platforms for further discussion" and "coherent stories" (Morgan and Grüne-Yanoff 2013, p. 145; for more comments, see Katsikopoulos 2014). This chapter will explore how increasing the *transparency* of OR models can improve the intermediate services of these models and hence the usefulness of the models.

More specifically, the chapter will make three contributions. In Sect. 14.2, we will survey the literature in the social and behavioral sciences and OR—broadly construed to include the overlapping disciplines of machine learning and what is often called analytics—in order to derive and analyze a definition of transparency for OR models. Even though the models discussed in this chapter are mathematical, the arguments made are applicable to verbal, conceptual models as well. We will argue that this notion of model transparency is conceptually closely related to model *simplicity*. In Sect. 14.3, we will use examples from practice to demonstrate how the lack of transparency/simplicity has decreased the usefulness of models. In Sect. 14.4, we will discuss two applications of models that illustrate the merits of model transparency/simplicity. A summary and connections to other chapters in the book will be provided in Sect. 14.5.

14.2 A Definition of Model Transparency

We start from the premise that *transparency* is largely a synonym of *clarity*. Now, as any academic who has delivered a math lecture to undergraduate students knows, clarity might mean different things to different people. More specifically, some pupils might be satisfied with learning the model, even if by that they just mean memorizing the equation or whatever formalism describes the model. More demanding pupils might also want to understand how exactly the model works—for instance, can one say that this term in the equation is 'more important' for computing the model's output than that term is, and what does that exactly mean? Finally, good pupils, as well as teachers, often say that a formalism becomes clear to them only after they have been able to explain it to someone else.

We submit that these three issues—*understanding, learning, teaching*—are key ingredients of model transparency. In an upcoming book on human-behavior-inspired models for making predictions and decisions in the field (Katsikopoulos et al., in press), we define a model as *transparent to a group of users if they can understand, learn and teach it*.

Of course, this is not the only possible definition of model transparency, and one might want to add other dimensions to transparency or remove any of the three dimensions suggested above. Here we focus on analyzing this one definition, by discussing just the understanding, learning and teaching of models. We will argue that all three of these three dimensions are linked to model simplicity.

14.2.1 Understanding Models

First, note that, as Morgan and Grüne-Yanoff (2013) point out, models that relate to human behavior are also developed outside the social and human sciences. A difference is that whereas models in, say, psychology and economics typically aim at describing how people behave, in other disciplines there are models prescribing how people should behave. For example, this is the case in disciplines such as machine learning and analytics. The case of machine learning is particularly interesting for our purposes here. This is so because machine learning is a part of artificial intelligence and the latter has been traditionally concerned with human behavior and cognition.

Lipton (2016) focuses on the transparency of machine learning models—such as the recidivism prediction model mentioned in the Introduction—to decision-makers and other stakeholders, including journalists and politicians. He starts by basically identifying model transparency with understanding. Then, he zooms in and discusses model simulatability as a main form of model understanding.

According to Lipton, simulatability means that a model's user can contemplate the whole model at once. This contemplation can be aided by artifacts such as graphical representations of the model. Some modelers insist on such representations, including Leo Breiman, an early pioneer of machine learning. Breiman suggested the translation of predictive models to decision trees (Breiman et al. 1984; Breiman 2001). Lipton explicitly writes that "an interpretable model *is* a simple model" (Lipton 2016, p. 4, emphasis added). Model simplicity, of course, is notoriously difficult to pin down. Lipton suggests thinking of simplicity indexed by the size of a model, measured by the number of its parameters or its mathematical flexibility. On the other hand, Cutting (2000) almost denies the usefulness of the concept of simplicity in cognitive modeling.

In our opinion, simplicity is a useful property of a model, especially in behavioral OR where one needs to take into account how users of models interact with them. Whereas sometimes model simplicity might indeed be in the eye of the beholder, we neither believe that such cases are as prevalent as others like Cutting would say, nor as prohibitive for engaging in conversation with model users on whether they find a model to be simple enough, and useful, or not. For example, Rubinstein's (1998) models of economic behavior, often employing mathematics at the level of high-school algebra, is an example of models that most academics find simple. Detailed examples of our own idea of simple models, for OR use, will be given in Sect. 14.4. For more comments on simple prescriptive models, see Katsikopoulos et al. (2018).

14.2.2 Learning and Teaching Models

To the extent that a pre-requisite for learning and teaching anything is having understood it, the arguments in the previous paragraph suggest that model simplicity would support the learning and teaching of models as well.

Probing a bit deeper, one needs to define what learning a model might be. We think that memorizing the description of the model is a minimum but it is not enough. In a broad sense, evidence for having learned anything can be provided by thinking and working with it. According to the influential educational psychologist Jerome Bruner, thinking is going beyond the information given (Bruner 1973). If a model user goes beyond the formal description of a model and "plays" with it—as experts often encourage novices to do—they must have learned something about it, or at least be in the process of learning. Playing with a model could be changing the input and observing how the output changes. Or it could be interrogating the model to find out why, or under which conditions, this particular input will lead to this particular output.

An overly mathematically flexible model where multiple parameters interact would, all things being equal, put the bar higher for playing with and interrogating the model (although there would of course be individual differences). Because model simplicity is broadly construed to be a function of the number of parameters and the flexibility of the mathematical form of the model—for more on this, see references in Katsikopoulos (2011)—we again conclude that model simplicity supports the learning of models.

Teaching is a form of learning, so the previous points also apply to teaching. Additionally, in OR, interacting with the client so as to enrich their understanding of the model services offered, and thus their trust in these services, is a key part of the job of the analyst. This applies also when viewing the analyst as a facilitator, where teaching would move beyond dictating, instructing and the like, instead aiming at supporting (Franco and Montibeller 2010). As anyone who has worked with clients knows, "keep it simple stupid" can be a very useful maxim.

This section used the literature in the social and behavioral sciences and OR—broadly construed to include the overlapping disciplines of analytics and machine learning—in order to derive and analyze a definition of transparency for OR models. The definition says that a model is transparent to a group of users if they can understand, learn and teach it. We argued that this notion of model transparency is conceptually closely related to model simplicity. In the next two sections, we will, respectively, use examples from practice to demonstrate how the lack of transparency/simplicity has decreased the usefulness of models, and how the existence of transparency/simplicity has increased the usefulness of models.

14.3 How the Lack of Model Transparency Can Hurt

Here, we will discuss two examples of how the lack of model transparency can hurt. First, consider again the case of Eric Loomis, the Wisconsin man mentioned in the Introduction. Justice Ann Walsh Bradley ruled against Mr. Loomis' appeal of his being sent to prison partly based on a report produced by a secret recidivism prediction algorithm called Compas (marketed by Northpointe Inc). This is an extreme case of lack of model transparency. It can also serve as a case study in how strange and unsatisfactory interacting with a non-transparent model can be.

According to *The New York Times*, Justice Bradley seemed uneasy with her court's decision (Liptak 2017). She cited a report by *ProPublica*, a non-profit organization, about Compas, which concluded that black defendants in Broward County, Florida were far more likely than white defendants to be incorrectly judged as more likely to reoffend. At the same time, she also noted that Northpointe had disputed

ProPublica's analysis. In the end, the Wisconsin Supreme Court said that the report added valuable information, and that in any case Mr. Loomis would have gotten the same sentence, based on other factors such as his criminal history and his attempting to flee the police.

This argumentation and counter-argumentation seems strange. If Mr. Loomis would have gotten the same sentence without the Compas report, then the information added by the report is beginning to appear to be less valuable (or at least less impactful). If so, why was it included? Perhaps there is some unique insight, or some other intermediate model service, that was provided by the underlying algorithm? Doubtful. As far as we understand, nobody in the trial had the chance to benefit from such model services since nobody—except Northpointe—had the chance to interact with the algorithm. It is difficult to interact with non-transparent models. In this case, where the model was secret, it was impossible to interact with the model.

This first example referred to one person. The second example refers to more than one billion people. By 2020, the Chinese government is to have installed its *Social Credit System*, where individuals' and businesses' economic and social reputation (their credit) will be assessed by standardized algorithms. We are not going to discuss the philosophy underlying this policy. Actually, any such discussion would be constrained by the lack of transparency of the policy.

According to the *UK Business Insider*, the exact methodology for computing social credit is secret (Ma 2018). Some instances of infractions have been provided, and they include bad driving, smoking in non-smoking zones, buying too many video games and posting fake news online. Perhaps more guidance will be provided in the future. In any case, given the vast volume, diversity and complexity of individual and business behaviors that need to be scored, it is not clear at all how the underlying credit-scoring model can be understood by anyone, layperson or expert. Achieving model simplicity here seems to require significant ingenuity. But it is necessary to do. Without model simplicity, how can there be any insight or platform for further discussion about what makes a good citizen or business? Will it have to be only up to the team developing the credit-scoring algorithms?

14.4 How Model Transparency Can Help

In this section, we will go through two examples illustrating the merits of simple/transparent models. Both models presented are inspired by descriptions of human behavior, transformed so that they achieve accurate predictions in the field, in problems where more computationally complex models did not perform as well.

The models of this section belong to the family of *psychological heuristics*, which are behavioral OR models. Psychological heuristics were discussed in our chapter in *Behavioral Operational Research: Theory, Methodology and Practice* (Kunc et al. 2016). As with the present one, that chapter also included simple, transparent and effective models, for example for decreasing civilian casualties at military checkpoints in Afghanistan (Keller and Katsikopoulos 2016). The present chapter discusses two different applications. These applications are not sampled from a narrow range of OR work, but refer to political science and medicine. For additional applications of psychological heuristics, see Katsikopoulos et al. (in press).

The human-behavior-inspired approach of psychological heuristics might, at a first glance, appear similar to that of *expert systems* (Jackson 1998). But it differs in three crucial aspects: first, instead of the emphasis of the expert-systems approach on building a large base of information, the heuristics approach focuses on identifying a few key pieces of information and studies how it can be processed, so as to lead to superior performance. Second, the heuristics are kept simple and transparent, in order to increase user buy-in and third, the performance—of heuristics and of competing models—is evaluated empirically, based on machine-learning methodologies such as out-of-sample and out-of-population tests.

14.4.1 Keys to the White House

In the 2016 US presidential election, the polls had predicted Hillary Clinton's victory by a large margin and on election day statistician Nate Silver predicted a 71.4% chance for her. Big data, polls and prediction markets were confidently unanimous in their forecasts.

Allan Lichtman, a professor of history, on the other hand, predicted that Donald Trump would win. Lichtman did not rely on big data, complex algorithms or polls. Around 1980, he had developed the *Keys to the White House* model that works with a different logic (Lichtman 2016). It does not deliver ostensibly precise probabilities of winning but simply a prediction of who will win. The model is based on a historical analysis of the public's behavior in every US presidential election from 1860 to 1980.

A key is an issue that matters for US voters (in OR terminology, it is an attribute, in psychology, it would be called a cue and in machine-learning terminology, it is a feature). Below find the 13 keys, each stated as a proposition that can be labeled as *true* or *false*.

- *Key 1: Incumbent-party mandate.* After the midterm elections, the incumbent party holds more seats in the US House of Representatives than it did after the previous midterm elections.
- *Key 2: Nomination contest.* There is no serious contest for the incumbent-party nomination.
- *Key 3: Incumbency.* The incumbent-party candidate is the sitting president.
- *Key 4: Third party.* There is no significant third-party or independent campaign.
- *Key 5: Short-term economy.* The economy is not in recession during the election campaign.
- *Key 6: Long-term economy.* Real annual per capita economic growth during the term equals or exceeds mean growth during the two previous terms.
- *Key 7: Policy change.* The incumbent administration effects major changes in national policy.
- *Key 8: Social unrest.* There is no sustained social unrest during the term.
- *Key 9: Scandal.* The incumbent administration is untainted by major scandal.
- *Key 10: Foreign or military failure.* The incumbent administration suffers no major failure in foreign or military affairs.
- *Key 11: Foreign or military success.* The incumbent administration achieves a major success in foreign or military affairs.

- *Key 12: Incumbent charisma.* The incumbent-party candidate is charismatic or a national hero.
- *Key 13: Challenger charisma.* The challenging-party candidate is not charismatic or a national hero.

How to combine the keys? Lichtman proposed a simple rule: "*If six or more keys are false, the challenger will win*".

As an example, consider the 2012 election, where Mitt Romney challenged Barack Obama. Lichtman counted all keys as true except 1, 6 and 12, and correctly predicted that Obama would win. Some of the keys, such as whether the candidate is the sitting president, require no judgment, while others, such as charisma, do. Lichtman deals with this problem by defining standards and criteria. For instance, in Lichtman's definition, charismatic leaders include Franklin D. Roosevelt, Dwight Eisenhower, John F. Kennedy and Barack Obama in 2008 (but no longer in 2012).

In late September of 2016, Lichtman considered the keys to be settled and made a count. Six keys turned against Hillary Clinton, the incumbent-party candidate:

Key 1: The democrats got crushed in the midterm elections.
Key 3: The sitting president was not running.
Key 4: There was a significant third-party campaign by libertarian Gary Johnson, anticipated to get 5% or more of the votes.
Key 7: There was no major policy change in Obama's second term.
Key 11: Nor did Obama have any smashing foreign policy successes.
Key 12: Hillary Clinton is not charismatic (unlike, say, Franklin Roosevelt).

Because six keys were false, the rule predicted that Donald Trump would win. This particular election was certainly not easy to predict, and a tally of six was the minimum required for an upset of the incumbent party. Now, there is one important caveat. According to Lichtman, the keys predict the majority vote, which Trump did not get. Thus, the 13-keys rule got the president right, but not the majority vote. No prediction rule is perfect, however, and the rule was closer to the outcome than were polls and big-data algorithms. And its predictions have been accurate for all elections since 1984 when it was fixed.

The 13-key rule is transparent. It is simpler than big-data models, and it can be understood and learned by laypeople and also taught to laypeople. By virtue of its transparency, the rule reveals an intriguing political logic that contradicts current campaign wisdom: The keys all refer to the party holding the White House and their candidate, not about the challenger (with the exception of the challenger charisma key—since 1984, this key has been negative only once, when Barack Obama was the challenger in 2008). The keys deal with the economy, foreign policy successes, social unrest, scandal and policy innovation. If people fared well during the previous term, the incumbent candidate will win, otherwise lose. If the challenger wins, the reasons have little to do with him or her, but solely with the perceived performance of the incumbent party in the previous term and their candidate. In sum, the rule delivers intermediate services, such as a coherent story, political insights and new perspectives and creates a platform for further discussion.

14.4.2 Prioritizing Treatment in Emergencies

On the morning of September 11, 2001, when Louis Cook of the emergency medical services division of the *New York Fire Department* and his paramedics arrived at the site, they were asked to set up a triage area in Tower 1 that just had been hit. But before much could be achieved, a second aircraft hit Tower 2, which soon collapsed. After Tower 1 also collapsed, the emergency services experienced havoc, resulting in immense loss of lives among the rescue teams.

The remaining rescuers in the teams entered the chaos of the collapse zone and used a rule to help identify those victims who needed help first. The rule is called *simple triage and rapid treatment* (START). START was developed by members of the Hoag Hospital in Newport Beach, California and it is widely used in the US (Super 1984).

START classifies injured victims into those who need immediate treatment and those whose treatment can be delayed. A version of START is given in Fig. 14.1 (adapted from Luan et al. 2011). START is a *fast-and-frugal decision tree*, meaning that attributes are

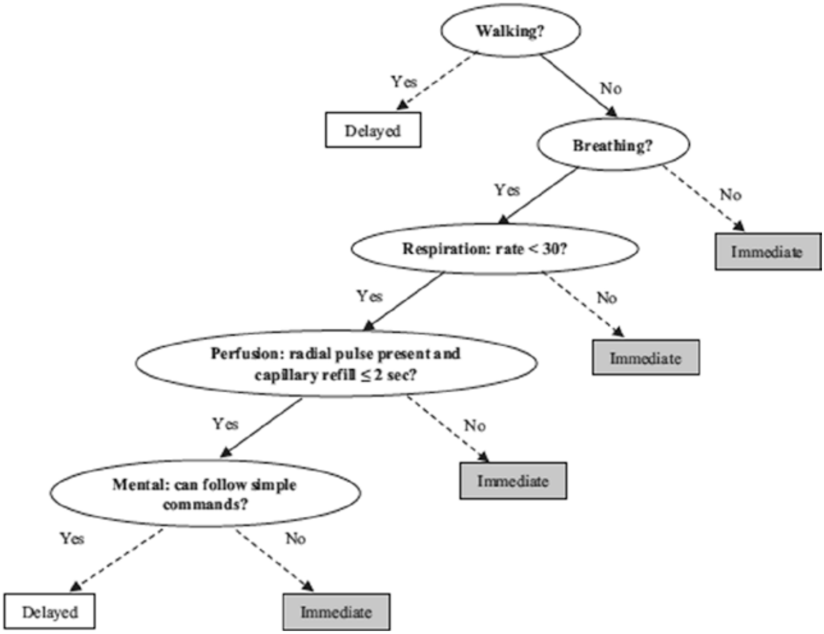

Fig. 14.1 Simple triage and rapid treatment (START), a classification rule for identifying those victims in emergencies who need help immediately and those who do not (Super 1984; adapted from Luan et al. 2011)

checked sequentially and a classification can be made after each check (Martignon et al. 2008).

The first check is whether the person can walk. If yes, treatment is delayed. If no, the second check is whether the person is breathing. If no, treatment is immediate. If yes, there are three further, more technical, questions where a negative answer always leads to immediate treatment. Only if all of these checks are answered positively, is treatment delayed.

How does a rescuer utilize the output of this simple rule? S/he marks the victim after classification with tags whose color reflects the class, that is, the severity of the injury. A yellow tag signifies that delaying treatment is acceptable, a red tag shows that immediate care is needed and white means dead or non-salvageable.

START is a transparent model. Based on its endorsement by experts such as Lewis Cook and its adoption by practitioners across the US, rescuers seem to have no problems understanding and learning it. START makes the rationale for the treatment of a victim clear and thus avoids repeated treatment and enables efficient communication among rescuers and others involved in emergency treatment.

14.5 Summary and Connections to Other Chapters

This chapter made three contributions. First, we surveyed the literature in the social and behavioral sciences and OR—broadly construed to include the overlapping disciplines of machine learning and analytics—in order to derive and analyze a definition of transparency for OR models. We argued that this notion of transparency is conceptually closely related to simplicity. Second and third, we used examples from practice to demonstrate the merits of model transparency/simplicity, as well as the problems caused by the lack of it.

Transparent models provide capabilities for OR analysts and their clients to reap intermediate model services such as insights, new perspectives, platforms for new discussions and coherent stories (Morgan and Grüne-Yanoff 2013). Additionally, it should be noted that the examples of Sect. 14.4 demonstrated that transparent models can deliver ultimate services, such as accurate predictions and performance superior to that of more computationally complex, and typically less transparent, models. This is a well-established, though often neglected, result (Katsikopoulos et al. 2018).

To the extent that transparent models can foster thinking and reasoning within broader analytical frameworks, the material presented in this chapter can also be linked to several other chapters in this book. In fact, the heuristics discussed in Sect. 14.4 are based on people's core psychological capacities such as ordering and counting (and others, such as the capacities for recognition, visual tracking, and so on; see Katsikopoulos et al., in press). More generally, the approach to heuristics presented in this chapter is an empowering one (Bond 2009; Katsikopoulos 2014; Hertwig and Grüne-Yanoff 2017). As discussed by Burrow (Chapter 9), the goal of OR is to strike a balance between optimism and pessimism in our clients. We believe that we should be studying how transparent models can help with getting the balance right.

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Part IV

Capabilities Beyond Models

15

Achieving a Balance Between Behavioral Theory and Behavioral Practice in Transformation Projects

Jonathan Malpass and Stephen Cassidy

15.1 Introduction

Organizations need to transform. It is a simple statement, and an obvious one, and there are many reasons for transformation including reaction to crisis (Hardie and Howarth 2009) or new technologies (Markus and Benjamin 1997), identification of new opportunities (Hockerts and Wüstenhagen 2010) or as the result of mergers (Atkinson and Gary 2016). Transformation programs have been studied across many sectors: the defense industry (James 2008; Takahashi 2008), agriculture (Reardon et al. 2009), information technology (Cross et al. 1997), health care (Lynch et al. 2014), government (West 2004; Klievink and

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Janssen 2009), human resources (Beer 1997) and television (Hujanen 2002) are just a few examples. Telecommunications is one sector that has seen profound changes in recent years and is subject to a variety of transformation needs (Bohlin and Levin 1998; Schienstock and Tulkki 2002). Indeed, BT is no stranger to transformation programs, constantly needing to evolve: becoming a private company; the move from monopoly to a competitive market; coping with the digital revolution and the growth of mobile telephony; moving from being a telecommunications company to providing subscription television and IT services.

However, not all transformation projects are successful. In the UK, the National Health Service abandoned the digital transformation of patient records at the cost of £10 billion (*The Guardian* 2013); in the US, the United States Air Force spent more than $1 billion on the development of enterprise resource planning software system before it was decided that the project would not yield the hoped-for benefits (Reuters 2012).

A 2013 McKinsey study (AIPMM 2013) suggests that 70% of transformation programs fail. Commonly cited reasons for failure include: a lack of urgency, a lack of leadership unity, lack of a vision and communication, failing to anchor change in an organization's culture (Kotter 1995), a lack of employee buy-in to the change (Markus and Benjamin 1997), a gap between design and reality, unrealistic planning (Anthopoulos et al. 2016) and change fatigue (Gleeson 2017). The question therefore is why do so many transformation projects fail?

Amongst the plethora of reasons, one key issue that we have identified is the various *tensions* between the different stakeholders. Transformation programs involve stakeholders at different levels in an organization, and across different organizational domains. Tensions between stakeholders arise from their different conceptualizations of the problem, different perspectives (Bryde 2005; AlWaer et al. 2008; see also Chapter 6 by Giordano et al.), biases (Wang and Dewhirst 1992; Montibeller and von Winterfeldt 2015; see also Chapter 9 by Burrow), drivers, motives and skillsets. These different perspectives are determined by the roles as conceived in traditional organizations, and the resulting tensions often lead to the failure of change projects.

Tensions can be eased, and even overcome, through negotiation and collaboration (Tartas and Mirza 2007). We propose that negotiation and collaboration can be facilitated through OR-derived boundary objects (Carlile 2002, 2004; Bechky 2003), such as a simulation model.

This chapter discusses the various tensions which can result in transformation programs going wrong; we begin by discussing the limitations of the *central design model*, i.e. a top-down approach which fails to consider the different actors in the transformation process. We then propose a three-level model for transformation projects and make the conjecture that the inter-stage tensions create problems that, without being addressed, will cause the project to fail. We then describe the principle of boundary objects as a means to help overcome these tensions. We then use, as an example, a major transformation project recently undertaken by BT in which understanding and addressing the tensions were key to its successful execution.

Whilst this chapter focuses on a transformation project, the learning points can be applied to many other OR projects. In addition to the three-stage model, we highlight the vital skill that the academic-consultant must develop: to understand the strategic requirement for transformation, and to balance this need with a pragmatic approach to implementing a project. The role of the consultant should not simply be to design a theoretically correct solution but to understand the behaviors of the various stakeholders that may render a solution useless.

This chapter seeks to focus on the various stakeholders and the tensions that exist between them.

Firstly, what do we mean by *transformation* as opposed to *change*? Organizational transformation and change often mean the same but for the purpose of this chapter, we make a distinction between the two terms; we recognize that *transformation* often applies to radical change (Henderson 2002), or to systemic change (Gass 2010), such as reinventing an organization, and *change* applies to projects designed to enable organizations 'to do things differently'.

Transformation, in this context, is a change of sufficient magnitude to warrant an organizational change, not just *scalar* changes to the individual functions, i.e. in volume or quality. Rather we are concerned with *qualitative* changes in those functions (i.e. adjustments to their function) and their relationship with the whole.

15.2 The Central Design Model

In this section we discuss a traditional approach to transformation projects which we refer to as the *central design model* which is predicated on the idea, widespread amongst organizations, that is the dominant logic of Taylorism, i.e. the inherent assumption that organizational functions do not change (Stoller 2015).

The *central design model* can be defined as:

i. it is top-down, i.e. decisions are made by the appropriate senior executive and affects employees at various levels below them; and
ii. people are extensions of the machine, rather than treated as sentient human beings that can add value of their own and from unique perspectives.

One of the limitations of this model is that information variety and currency is lost when funneled to a central design function, the consequences of which are often discovered late in the implementation cycle. This loss of information causes latency in decision making and often results in inappropriate, untimely or inadequate decisions. A second limitation is that, in transformational change as we define it, a top-down organizational model mitigates against the changes to the model that are necessary.

Such an organization is fit to cope with certain changes in volume and quality; but changes in *what* is delivered require redesigns of the structure. This requires the design to have a complete view of the requirements and solution (and all information necessary to make these judgments). In organizations where qualitative changes in their products are needed frequently, centralizing the design function in this way is no longer adequate. In an increasingly dynamic economy this is increasingly the case. The different domains within the company need to be able to flex their function.

15.3 The Three-Level Transformation Model

The main premise of this chapter is that transformation projects are born from the need for an organizational change. According to the central design model, a transformation project can be viewed as having three levels (Fig. 15.1): the strategic level where the key transformation decision is taken; the design/planning level and the implementation level.

Eisenhardt and Zbaracki (1992) define a strategic decision as one that is "important, in terms of the actions taken, the resources committed, or the precedents set". This decision to change is made by someone who has a clear understanding of the need for transformation. However, it is not normally possible for the decision maker to be able to embrace all the complexity and scale of the problem, nor possess all of the necessary domain skills to design and implement the change in detail and so the 'design/planning level' and the 'implementation level' are devolved to others. To further compound matters, the design/planning level is not always carried out by people with sufficiently deep knowledge of the operational level.

Transformational changes are by their nature so complex that some simplification has to be made to help form a plan. The normal default is

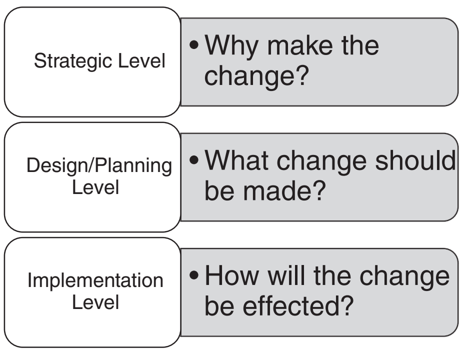

Fig. 15.1 The three levels of a transformation project

to take a Taylorised view of the world, splitting the problem into known domains and adopting generalized assumptions. However, simplifying the complexity in this way restricts the scope of possible change, and makes the required transformation difficult to effect.

Finally, the implementation level is where the day-to-day operations occur and where the transformation has to be executed.

In this model, we define three sets of actors:

1. *The Decision Maker*: The strategic level is characterized by the decision maker. This could be an individual—a CEO or a business owner—or a group of people, such as a board of directors. The decision maker identifies a need for change and sets the direction of that change.
2. *The Designer/Planner*: The key actors of the design/planning level are a number of domain experts, i.e. the person/people who can translate the strategic requirement into a deliverable solution. Such experts could be external consultants or people with detailed knowledge of the organization.
3. *The Implementer*: The third level comprises implementers—employees—the people who have to effect the change but also those whom the transformation affects most.

The dominant logic of Taylorism, introduced in the previous section, extends to the different levels of change-related roles we identify: Decision Maker, Designer/Planner and Implementer—carrying with them the implication of a 'waterfall' of decisions and execution. The separation of roles in this way tends to separate their perspectives (as described above), leading to tensions as these different concerns work their way through the process. If the process is linear, the changes in perspective along the sequence cause departures from the assumed plan which, if they remain unchecked, results in the project encountering some difficulty. Successful change management requires a more flexible and integrated connection between these three roles, 'vertical' flexing, and in the same way to domain roles, 'horizontal' flexing.

15.4 The Tensions

The central design model, and its three levels, give rise to a number of *tensions* that if unaddressed will cause transformations projects to fail, or at least fail to deliver the full benefits. The four key tensions (Fig. 15.2) are:

1. *The Decision Maker-Designer/Planner Tension*: The decision to transform is made by a 'power-broker' but the design of the transformation is carried out by one or more 'domain experts'. This tension arises because the domain experts often base their design on a simplified view of the world afforded by models; they also need to be able to meet the requirements stipulated by the power broker which are often based on an untested ambition. Sometimes, the initial idea for strategic change is unachievable, but the domain expert still has to satisfy the power-broker's request; the use of theoretically correct solutions may be the domain expert's aim, but that aim and the decision maker's ambition may have to be tempered.

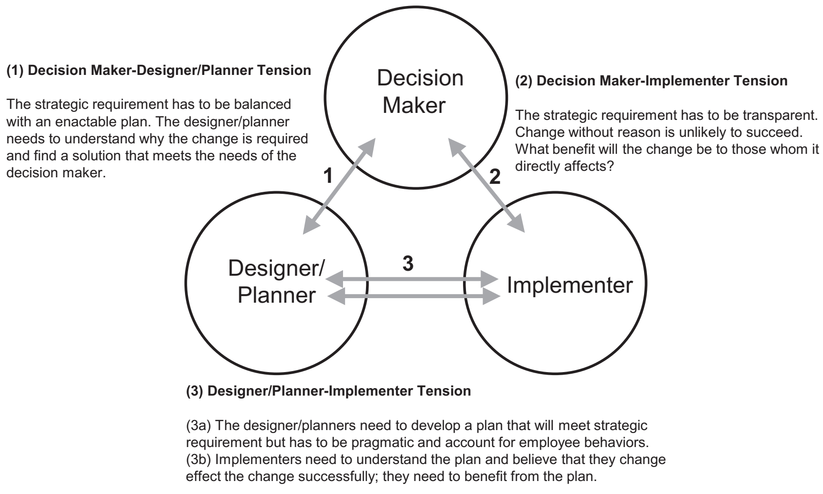

Fig. 15.2 The three-stage tension model

2. *The Decision Maker-Implementer Tension*: Whilst the 'power-broker' sets the course for transformation, it is the employees who have to enact that transformation. The tension here is caused by the change to the status quo; it is imperative that the implementers see the need for the transformation and that they believe the plan will be of benefit to them.
3. *The Designer/Planner-Implementer Tension*: The 'domain expert' may have a clear idea of how a solution can be developed but they have to understand how those implementing the change will react. If the designers make assumptions such as employees making rational decisions (e.g. ones that benefit the organization) and adhering to processes, will assumptions made still hold? Will the implementers behave in the 'rational' manner or will they operate according to their own bounded rationality (e.g. deviating from the prescribed process to the benefit of a customer)?
4. *The Implementer-Designer/Planner Tension*: Not only do the implementers need to see the benefit of the change, they also need to believe that the plan for change can be successfully effected, so the domain expert needs to deliver a solution that will be accepted by the 'implementers'. The tension between people whose lives are being affected and the solution designer needs to be managed.

A further cause of the Decision Maker-Designer/Planner Tension is the failure of the domain expert to be part of the debate where the decision takes place. This was one of the reasons cited for OR consultants lacking the influence they need (Eden 1982). Indeed, this is a common event in practice. The strategic decision often occurs before any engagement with the domain expert, not so much by whim but by necessity. The Decision Maker-Designer/Planner Tension is created by default. It is only once the Design stage begins to do the practical realities of delivering the strategic objective become clear.

These tensions have been described in the vertical dimension, but they can also exist in the horizontal dimension, i.e. within each level, across organizational functions and can lead to antagonistic relationships, where versions of zero-sum games between the actors arise. What we seek is an accommodation between the domains and roles such that a holistic solution is found, which is able to absorb the different skills and knowledge of the participants continually. If this can be found, the solution will be better optimized, and also more stable because it has arisen from the participation of the actors including the three levels of stakeholder. The solution will already have taken into account the limitations imposed by the 'real world' as opposed to encountering them at a late stage in the process. Corrections are more expensive at late stages; the stakes are higher, personal investments are greater, the room for maneuver limited, and so positions more entrenched.

15.5 Boundary Objects

A boundary object can be described as an artifact that supports collaboration across specialist groups and serve as a bridge between intersecting social worlds (Nicolini et al. 2012). Whilst there is also criticism of the concept (Zeiss and Groenewegen 2009), a device that facilitates a common purpose between the three roles described in the previous section and integrates their knowledge in new ways—enhanced by data technology—can only benefit transformation projects.

By encouraging cross-disciplinary collaboration, this approach also helps build a self-organizing teams culture (Heylighen 2001; Gassmann and Von Zedtwitz 2003), which distributes elements of decisions to the roles best equipped to make them. The likely results of putative strategies are evidenced and reviewed until an acceptable balance between them is achieved. The ultimate goal is developed and shared, and counterbalances local metrics—which, having been derived historically from a top-down (hence limited) conception of the problem space, amount to a suboptimal whole.

15.6 Case Study: Compaction of the PSTN Network

The tensions between the actors described above, and their resolution in practice, will now be illustrated by a significant case study from BT. The company is retiring the technology of its PSTN (public switched telephony network), and migrating to voice over IP (Internet Protocol). The existing software-controlled circuit-switched network had been built over the 1980s and 1990s in a huge 'digitization' program to expand significantly the scale of the old electro-mechanical network that preceded it.

This digital network had grown to some 20 million phone lines at its peak. Over its lifetime new telephony services have been added and regulation, introduced in the 1980s, has introduced further levels of complication. Furthermore, the network consumes significant electrical power and the equipment is no longer manufactured, so repair is mostly achieved by redistributing redundant, but still working, equipment.

To achieve power savings and reduce fault rates, both the switching technology and the underlying transmission network both need to be reduced in size as closely as possible to the reduction in demand, through a process known as *compaction*. Compacting both technology platforms in tandem involves complex interrelationships between the two. Sequencing the geographic areas to be migrated is determined by the distribution of customer types, the regional availability of capacity in the new technology and the consequent maintenance costs, impacted as they are by the knock-on effects on travel patterns of field maintenance engineers. The planning of this sequencing and other specialist operations are achieved by a diminishing pool of specialist skills, owing to retirement.

All these factors need to be taken into account in a decade-long sequence of migrations in which there must be no detriment to the levels of service experienced by the customer. The size and complexity of the migration program easily qualifies as 'transformational' as we define it in this chapter.

In terms of the characterization of tensions, these existed in the two directions we have described. The first being strategy, design/planning and implementation; and the second between the different business and specialist domains at each peer level. To illustrate the first, compaction targets had been set at the strategy level, driven by business predictions. At the strategic level, even understanding whether the means to achieve these targets *could* exist is itself a complex task, and the answer can only emerge from detailed activity involving considerable expertise and imagination of the planners—which at this point had yet to occur. In turn, the resource required at the implementation level could not be known at this stage, and whether another priority would intervene when the time for implementation came.

In the second direction, between peer domains, conflicting requirements needed to be reconciled. We will describe just a few. At the planning level, a number of factors connect the business and expertise domains. For example, the operational cost of engineering time would need to be justified by network savings made, but the cost of the network over the whole migration period has a very complex relationship with the sequencing of the work chosen. Apparently uneconomic activity in the short term can affect future costs in complex ways. A second difficult interaction was between the compaction activities of the switching platform and the transport network. Actions taken in one affect the ability to achieve actions in the other—again in complex (nonlinear) ways. At the implementation level, maintenance and migration compete for the same engineers, introducing further interrelationships.

The General Manager responsible for the technology realized that the plan could not be wholly determined top-down. He actively promoted self-organizing teams and a culture of exploration and discussion. This approach needed to apply not only in his area, but had to include the relationship with the other domains across the company that would need to cooperate in a self-organized solution. These included, as can be construed from the previous discussion, Finance, HR, other technology platforms, Customer Facing Units, Portfolio Strategy, Field Engineering and more. Whilst the culture was encouraged through regular meetings and management activity, there still remained the practical issue of creating a means by which the 'n-squared' interactions between all the negotiating parties could be achieved. The need for this was doubly important as, to keep up enthusiasm for the change in culture, it was important for everyone to see that it would be possible to achieve more in practice.

To this end, a technological element was introduced. A decision tool was developed, over a period of two years, with the close involvement of data experts and planning experts from the operational areas.

The resulting tool acted as a key Boundary Object (Carlile 2002, 2004; Bechky 2003), allowing negotiations to take place between the domains (vertically and at peer level) in ways that had not been possible before. What is most significant to note is that the resulting optimized migration plans were not created by the decision tool, rather they were created by a new way in which people could interact, and the culture the tool helped engender.

The decision tool ingested data from the network and from workflow and people systems. This included inventory, topology, power consumption, fault rates, resulting maintenance work types and many other factors from over 30 databases. The effect on the people who provided the data was greater engagement with what it meant in terms of the program, and hence they were motivated to ensure that data flowing into the decision tool was improved.

The model underpinning the decision tool encompassed a number of factors such as the rules concerning technically allowable configurations, service implications, topological and sequencing constraints, etc., each developed with the relevant domain experts. These experts could now see that decision mechanisms would emerge which would make sense from their perspective. These technology and sequence rules were turned into algorithms which operated on the data. Financial factors in the model could all be flexed so that different assumptions could be made and experimented with.

The whole result of this was not a model that made decisions itself, but acted as a negotiating partner at the table, shared by all the domain experts. Those experts would discuss a technical strategy, financial assumptions and, when an approach seemed worth trying, the model would show the different domain owners the projected effect on all the domains over the whole multi-year migration period. It would be clear to all if one of these effects was unacceptable.

One example was a projected surge in demand for skilled engineers at a point in the future when nearly all would have retired. Others might show insufficient cost reduction *beyond* the normal business case period, or that certain approaches might not maintain service levels as required. In each case, the domain experts would think again and discuss new approaches, each one tried until an acceptable solution was found.

Peers at the design/planning level could now see the sense of flexing their own local targets if the result was that the overall strategic purpose would benefit sufficiently. This indeed occurred in significant ways. At this point, owing to the very fine-grain data in the model, the strategy could be translated into the task-by-task sequence of the entire migration. Thus, a new connection was also achieved *vertically.* The strategic level could see the business impacts over the period, incorporating accepted financial assumptions, based on sound engineering rules, supported by data which represented the true state of the network.

Similarly, the planners could see that the strategy was based in reality, and so could commit to ownership of the implementation plan. It is interesting to note further that some of the plans which resulted actually *exceeded* the targets that had previously been proposed top-down, and since they had been created as much bottom-up, the plan adopted had everyone's backing and confidence. Of course when any factor changed (new traffic patterns, cost assumptions, geographical factors, etc.) the model can easily be rerun.

Through this way of working we have avoided the translation of an abstracted strategy into a whole sequence of bilateral negotiations and working parties. In this more usual process, putative changes are propagated through these sequences of interactions, until eventually these decision loops come into contact, and changes to previously agreed plans are found necessary. This means that the solution might never converge, and at the very least takes an inordinate length of time—often long enough for the problem itself to evolve and introduce new levels of change. The normal alternative approach is to derive plans in larger scale groups and plenaries, necessarily in more of a top-down manner. As discussed earlier, for this to be possible, there needs to be considerable information (and cognitive) attenuation in the interactions between the different domains. A dilemma therefore results between generating sufficient detail to implement the plan successfully but without full convergence on an optimal solution, as against attenuating the information such that the resulting plan is suboptimal in implementation.

We have instead shown how a boundary object in the form of a powerful simulation tool, can elicit tacit knowledge in action and enable multiple contributing domain experts and business strategy stakeholders can achieve optimal solutions through the creation of a self-organizing team culture. The solutions found are emergent from this process since they involve multi-party interactions and tacit knowledge, and exceed in deliverability solutions which are the result of a priori algorithmic top-down ways of structuring transformation programs.

15.7 Discussion

The model of tensions in transformation projects suggests that there exists a *trilemma*; resolving this issue is essential to a successful project. However, there is no 'right' answer: it is a matter of finding the balance that best serves all parties.

The concept of a *trilemma* can be defined as a difficult choice from three options, each of which is (or appears) unacceptable or unfavorable (Obstfeld et al. 2005; White and Lee 2009). There are two logically equivalent ways in which to express a trilemma: it can be expressed as a choice among three unfavorable options, one of which must be chosen, or as a choice amongst three favorable options, only two of which are possible at the same time.

When applied to the Three-Level Transformation Model, it can be argued that it is difficult, if not impossible, to achieve a theoretically correct solution at the same time as having a solution that meets the strategic objective and that can be deployed successfully. It is, therefore, necessary to manage the needs of all three sets of actors and the tensions between them: to achieve a balance between academic rigor and real-world pragmatism at the same time as managing the tensions between the various stakeholders.

This is not to say that academic rigor should be rejected in favor of a pragmatic solution. It is a case of understanding when a model is *good enough* rather than seeking perfection, i.e. *satisficing* (Simon 1956) rather than optimizing. If a model requires a factor that can only be estimated through a costly data collection step, it would be pertinent to question the value of doing so.

It may also be the case that academic rigor is used to highlight the folly of a strategic decision. The pursuit, say, of ever better forecasts may be something that is of benefit to a business but only achieved (if at all) via the collection of ever more costly data. The potential for a minor increase needs to be balanced by the academic objectivity afforded by a theoretical approach.

Conversely, theoretical models often make assumptions for simplicity, e.g. a linear function is easier to understand and apply than a logarithmic function (Akerloff 1970) even if it is known that behavior does not strictly follow the former. It is therefore essential to understand whether the assumption holds in a given situation; one issue that we have seen recur results from the assumption that because a model/approach has succeeded in one organization it will succeed in another.

Domain experts need to be consulted in the transformation process and a single view of the change needs to be achieved. Left to their own devices, the Implementer may well develop a plan that is suitable for their world but unworkable at a higher or broader level. But, they do know the micro-level issues that exist which can easily derail a plan. Similarly, without understanding the general academic principles of a method, the Implementer can overlook or misinterpret issues that need to be addressed in order for a successful design to be delivered.

However, rigorous adherence to theoretically correct methodology can lead to issues. Transformation projects are often constrained by time and budgets; expensive, time-consuming data collection phases may be important to the success of a project but they may fail to capture every factor. The 'success' of a project needs to be balanced with the success of a methodology.

Domain experts need to be aware of the business environment as an approach that has succeeded in one organization may not work in another. Failure to understand the micro-level behaviors can quickly render a seemingly appropriate method useless.

Similarly, there is no one view-point that can prevail. It is not a question of who is right, but how to proceed.

The aim of this chapter is to highlight one reason that transformation projects fail, namely tensions between different stakeholders, and to highlight the use of an OR-derived boundary object as a facilitation tool for negotiation and collaboration. We have highlighted the need for the OR consultant, as the domain expert, to be able to understand the needs of the organization—both strategic and implementation—which is vital to the success of the OR project.

As such, this chapter has clear links with several others in this volume: planning is essential, but can be subject to bias (see Burrow, Chapter 9) or ambiguity (see Giordano et al., Chapter 6); the inclusion of stakeholders in the process is vital, as discussed by de Gooyert (Chapter 12), and the idea of a bottom-up, rather than a top-down, design is the subject of Chapter 13 by Korzilius and van Arensbergen.

In the context of Behavioral Operational Research, there is a great deal of conscious competence: OR academics and practitioners are highly skilled in developing tools. There is also a great deal of conscious capability: the ability to negotiate and facilitate. We believe that the ability to use OR tools as boundary objects can create a sense of shared understanding of the need for transformation and collaboration amongst the various stakeholders.

We leave the last word to Colin Eden who presented the case of the consultant–client relationship stating: "it is not altogether unlikely that the success or failure of OR projects can be totally accounted for by considering the ability of the consultant to manage social processes" (Eden 1982).

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16

Conjoined Capability, Collective Behavior and Collaborative Action: What's the Connection?

Leroy White

16.1 Introduction

Researchers working on group decision making (GDM) are concerned with the issue of processes during which a group of decision makers, for example, senior managers, work through organizational issues with the aim of reaching a consensus. However, the more traditional literature on GDM focuses on the selection of outcomes, which reflects a classic decision making perspective, in which decision makers are assumed to make consistent choices that maximizes the value for the organization. As a consequence, this literature hardly addresses the social issues involved in decision making situations (Raiffa 1968; Janis and Mann 1977; DeSanctis and Gallupe 1987). Recently, it was emphasized that it is important to consider the role that *social processes* play in group decision making, not only in terms of responding to the exchange of information, generating an understanding of its meaning, and agreeing on

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the way forward, but also in terms of the relational aspect and collective behavior within the group (White 2016).

In most scholarly accounts of supported group decision making, the technological capabilities of the process dominate the discussions, where the role of the participants is relegated to merely contributing to the analysis (Steiner 1972; Goodman and Leyden 1991; Chilberg 1989; Eden and Ackerman 2004), working within a Soft OR perspective reversed this emphasis to focus on the group (or stakeholders) themselves, in order to obtain a better understanding of the potential for an effective GDM intervention. They suggested that the effects and benefits emerge on the basis of complex social interactions involved in the use of GDM by individuals within the group and the organizations in which they are embedded. They were concerned that a perspective is taken capable of explaining the social processes at play in facilitated group decision making that went beyond, merely, group productivity (Steiner 1972; Eden 1995; Eden and Ackermann 1998; Ackermann et al. 2018). This chapter aims to further the discussion on supported group decision making and will focus on the social process demands and collective behavior in the use of GDM methods. In particular, the chapter will explore the role of the social relationships of participants within a GDM context. To do this a social network perspective is developed, where the question of whether social network ties are an important factor in GDM interventions will be explored. It will be proposed that the networks of the participants matter and may affect the quality of the processes and even the outcomes of facilitated group decision processes.

16.2 Background

Recent decades have seen a number of debates and comments attempting to understand the processes for decision making using facilitated group decision making (or Group Decision Support Systems, GDSS) and/or Soft OR. These dilemmas tend to be complex and only hazily defined. They reflect debates in other areas of management, some of which have challenged the view that somehow "the rational processes of analysis are expected to carry the day" (Eden and Ackermann 1998). Put simply, there are two broad intellectual streams in the description and explanation of decisions or action with regards to group decision making. First characterizes actors as having goals independently arrived at, as acting autonomously and as wholly self-interested (e.g. Raiffa 1968; Granovetter 2018). It is based primarily on the principle action of maximizing utility. The second sees actors as socialized and that action and/or decision making are governed by social norms, rules and obligation (see Poole and DeSanctis 1990). The foremost strands of this stream lie in its ability to describe action and decision making in a social context and to explain the way action is shaped, constrained and redirected by the social circumstance. However, both these streams have serious defects.

The first view, which has dominated research on decision making, flies in the face of empirical reality in that action and decisions are shaped and constrained by the social context in which they are embedded. This view tends to ignore the significance of interactive conflict, biases, confusion, complexity and other behavioral characteristics surrounding decision making. The second view seems to suggest that the action is a product of the environment or context, but that there are no internal springs of agency that give an actor purpose or direction. It should be said that these difficulties and dilemmas have not gone unrecognized by the researchers from both traditions (see Shapira 1997; White 2016; Franco and Hamalainen 2016).

With regards to the group decision making setting, the first view considers that a model or process provides a comprehensive representation of the situation and often with a hortatory commitment to the authority of the approach, which can easily legitimize the exclusion of beliefs and attitude of the actors involved. It might be assumed that the process considers the interests of all the members of the group, or, if wider interests are represented through the process, it might be assumed that they see the reality of the situation in accordance with the logic of the process when it suggests a particular course of action. With the second view, instead of expecting and possibly demanding agreement on action supported according to the logic of a single rationality, action seems to be based on an awareness of the limitations and precarious nature of knowledge and respect for alternative views (Poole and DeSanctis 1990). Action seems to be one that is based on being open-minded to multiple subjectivities and the need to address situations where particular subjectivities are difficult to reconcile with the rationality of the process or model in use (Taket and White 2000). Thus, this perspective would need to rest on the development of theories of action that do not accept a narrow conception of individual rationality (Blau 2017).

It is often suggested that the concept of *bounded rationality* (Simon 1978, 1979) revised the assumption of rational decision making to account for the fact that perfectly rational decisions are often not feasible in practice. Simon pointed out that most people are only partly rational, and are in fact emotional/irrational in the remaining part of their actions. The core ideas of bounded rationality are elementary and by now familiar (for relevance to OR see Pidd [2003]). He claimed that boundedly rational decision makers experience limits in formulating and solving complex problems and in processing (receiving, storing, retrieving, transmitting) information. He suggested that decision makers employ the use of heuristics to make decisions rather than a strict rigid rule of optimization. They do this because of the complexity of the situation, and their inability to process and compute the expected utility of every alternative action (see Cyert and March 1992; March and Simon 1993; Marengo et al. 2000). As managers have to make decisions about how and when to decide, Eden and Ackermann (1998) proposed that research on GDSS/Soft OR should take account of bounded rationality by explicitly specifying the decision making procedures. This puts the study of decision making procedures and processes high on the research agenda (Pidd 2003). Thus, the need for dealing with the social processes at play in group decision processes is highlighted as increasingly important.

The above discussion only touches the surface of a long and wide ranging debate that have affected research on facilitated group decision making. Recently an overview of behavior in groups was covered (White 2016). Here, behavioral issues in OR can be seen to occur at two complementary levels. First there is a referral to autonomous individuals, who are usually sovereign in their capacity to assemble information and/or knowledge and, consequently, able to modify their practices

(Checkland 1985). Second is a view that assumes that OR processes can occur in systems characterized by high levels of interdependency and interconnectedness among participants (Mingers and White 2010). *Interdependency* here refers to the fact that none of the participants has enough autonomy or power to translate the information into actions on his or her own (Friend and Hickling 2005; Huxham 1990). Between these two views is a context, in which individuals are embedded in systemic relations in which behavior and learning are important (Simon 1991) and depend on social relations or social networks (White 2008, 2016).

In essence, taking a more relational view allows emergent, group-level cognitive constructs to be hypothesized. However, it is also recognized that this emergent level perspective involves numerous individuals and usually produces systemic outcomes that cannot be easily specified (Eden 1992; Friend and Hickling 2005) and, as such, can considerably increase the complexity of unpacking what is going on during the interactions of different stakeholders (Rouwette 2011). Here we think taking the perspective of *conjoined capability* would help. By this it is meant that there is a shared sense of a capability that drives synchronous action and collective behavior.

16.2.1 Conjoined Capability

In terms of the social processes of group decision making the work by researchers on Soft OR often highlight the requirements of the process and its relationship to the role a facilitated GDM may play (Eden and Ackermann 2004). In particular, Eden and Ackermann (1998, 2004) focused on the crucial significance of core capabilities, and an emphasis on stakeholder management as well as stakeholder analysis.

Addressing core capability is not only concerned with managing the process of group decision making context such as strategy development, but also with carrying out change that creates *coordinated and cooperative action.* Eden and Ackermann (1998) argued that this is the single most important consideration when working in group decision making environment with managers. Core capability is an emphasis on developing coordinated and cooperative action that will change organizations rather than be analysis that is ignored. In this way social and psychological interactions are the bedrock of conjoined capability. Here actors should be able to work together acknowledging capabilities, dependencies and social roles (Mangham and Overington 1987), in other words, their social networks. There are major forces for resisting changes to the current social relationships or networks, and so these changes need to be negotiated. The outcome of this process is labeled as the new 'collaborative action', and this is embedded in social relations. In particular, the new order occurs from negotiations that arise from the members of the network understanding the interactions and capabilities between the other members in the network (Bandura 1986). Therefore, the question of interest is—for the participants in a facilitated group decision making process—would an understanding of the social networks of the members of the group affect political feasibility which would lead to a collaborative action? And would this knowledge help in the negotiation or establishment of a new social order in the group?

Conjoined capability also relates to how far the participants in process are involved in issue formulation, being listened to and having a voice. However, it is distinct from having influence over outcomes. More interesting, research in this field has identified a link suggesting that the extent to which participants consider the input of other members positively influence the feelings of attachment and trust in the member of the group over time (Bandura 1986; Rowley 1997). Other researchers claim that decision making groups can use procedures that improve the chances of gaining cooperation and commitment to decisions without sacrificing the quality of decisions in the process (DeSanctis and Gallupe 1987). When the members of the group show a strong consideration of the other members' inputs and capability the group sees the process as fairer, and consequently develop greater emotional commitment to the decision, greater attachment to the group and greater trust in the decisions (Korsgaard et al. 1995).

16.2.2 Collaborative Action

The second essence of a relational view refers to *communicative* use. This use seems to imply that essentially through dialogue, emotional exchanges are enhanced and take place through social interaction (Eden et al. 1992). This is associated with issues regarding consensus, the prioritization and salience of the issue, and the criteria against which potential solutions should be assessed. At one level communicative use would lead to technical deliberations and agreement around simple actions. But where there is high issue divergence, communicative use leads to 'politically aware' deliberations and strategic-type processes. Here, it may not be possible for a dialogue to bring consensus in that stakeholders may try to impose their views on others (Friend and Hickling 2005; Stenfors et al. 2007). This leads to the second concern for this chapter: *collaborative action*.

16.2.3 Social Networks, Social Embeddedness, Collaborative Action and Group Decision Making

Interests in collaborative action, networks and group decision making is not new. Researchers such as Bavalas (1952), Leavitt (1951), and Guetzkow and Simon (1955) were interested in what effect patterns of interaction have upon the decision making in groups. They explored the network relations and their effects on the development of the organization's structure and the performance of the group (see also Beer 1956). They found that the structure of the network affected the performance of groups in problem-solving situations. Today, the scholarly discipline is growing in the field of management (Sparrowe et al. 2001; Borgatti and Foster 2003). Researchers have clearly demonstrated the extent to which networks pervade and affect action within organizations (see Cross and Pruzak 2002). The core premise is that social networks are conduits for resources (Burt 2000). That is, the configuration of the network of social relationships—both within and outside the organization—is the way through which necessary resources for the network can be accessed. There is even now a growing interest in networks and group decision making (Oh et al. 2004; Jones and Eden 1981; Rulke and Galaskiewicz 2000; Ackermann and Eden 2011).

Network analysis focuses on the relationship or linkages among two or more persons (Scott 2000). Social network analysis depends on two key principles. The first is the principle of dyadic or social relations. A core belief underlying modern social network analysis is the importance of understanding the interactions between actors (rather than a focus exclusively on the attributes of actors). Here, researchers found that social action and outcomes are affected by actors' relations, lending more relational, contextual and systemic understandings to the explanation of action (Borgatti and Foster 2003). The second principle that gives social network research its distinctiveness is the emphasis on embeddedness. Here, action is seen as embedded in networks of interpersonal relationships (Granovetter 1985; Uzzi 1996). People in organizations and as representatives of organizations tend to enter exchange relationships, not with complete strangers, but with friends, or acquaintances. Embeddedness at the group decision making level can refer to a preference for interacting with those within the network rather than those outside it.

This interest pictures the decision maker as engaging in many short interactions on a wide variety of topics and issues (both within a group decision making environment and outside), which suggests a network of weak ties, each connecting the decision making to some specific work domain. Such patterns would be consistent with Granovettor's (1973) argument that these weak ties can provide an effective structural response potentially resulting in new or creative insights. However, in contrast, other aspects of a decision maker's job (such as loyalty and mentoring) suggest that strong ties predominate in most managerial networks (Burt 2004). There are now many studies focusing on managers' organizational networks and how these might affect his/her work. However, in relation to group decision making there is very little research that looks at how social networks develop in the use of supported GDM/Soft OR interventions (Qureshi 2000; White 2002, 2009). GDM/Soft OR interventions are highly interactive processes. Would the consideration of social network be appropriate to shed light on the interaction among actors and insights into the processes of

GDM/Soft OR? Some of these issues were raised in an early study by Jones and Eden (1981). They suggested that "being aware of … networks is to be aware of individuals as political 'entry points' to influence others". Here we will be interested in whether social network ties are an important factor in fGDP.

16.3 The Research

A case study approach (see Yin 2004) was selected as the most appropriate method for exploring some initial thoughts and refining questions on the subject of social networks and facilitated group decision making. A case study approach can play an important exploratory role in building a framework for future studies and is often used in management research (see Eisenhardt 1989; McCutcheon and Meredith 1993). The case reported here was part of a larger action research program on strategy development for the top team of a large children's charity in the UK. It was carried out during 2004–2005. The charity was engaged in a series of reorganization as a result of changing government policy on children services (Department of Education and Skills 2003). This reorganization work was taking place within a context of changing partnership relations between the organization and local authorities and other charities. This reflects a bigger move within the whole UK public services from traditional contractual arrangements toward more collaborative ways of working (Latham 1994).

In the case of England, successive governments and policy-makers have held modernizing intentions for the delivery of public services, which are predicated upon an assumption that the environment for the delivery of public services is turbulent and an urgent requirement to drive necessary change. The case is set in a context where collaboration and innovation are increasingly central to organizational effectiveness, and thus more attention needs to be paid to the sets of relationships that people rely on to make decisions or develop strategies. In this way, the research was mainly focused on the top team of the charity and involved using a series of facilitated group decision making or Soft OR workshops. In terms of group decision making, we have highlighted that the technology alone can only accomplish so much in pursuit of decision making goals and may demand more than sophisticated methods. It also requires attending to the often idiosyncratic ways that people seek out knowledge and learn from and solve problems with other people. With this in mind, the case described below revolves around a program of work to help an organization through a transformational change process.

One issue that surfaced was that of organizational interfaces. At the operational level, the main interface between the charity and their partners was around child protection. At the more strategic level, the charity was more susceptible to institutional forces and behavior, such as government policy and competition for funding. It is at this point that the charity established the need to reflect about and learn from their partnership experience, so that coordinated strategy for improvement could be developed. The researcher was invited to provide methodological support for its strategy planning efforts and guide the stakeholders through a participative decision making process.

16.4 The Approach

In the first phase of the work, the relationships among the top team were assessed, and social network analysis (Scott 2000) was employed to map the relationships. In the second phase, the network maps were used in conjunction with Soft OR methods to facilitate knowledge creation and sharing for the group. The final phase involved reflections on the process as well as surfacing insights into the social and technical aspects of the intervention to facilitate knowledge flow in the team.

In the first phase some of the members of the team were interviewed and some documents provided by the charity were analyzed to map the process and identify issues and boundaries. Here, semi-structured interviews were performed, which were used to create a cognitive map of the situation (Eden 1992; Eden and Ackermann 2004). The outputs from the mapping exercise were the basis for further work on the future direction of the organization. Next, each member of the top team was surveyed using a standard social network questionnaire to identify membership and relations with each actor. Conducting the survey is a straightforward process of obtaining a list of all the people on the defined network and simply to ask all members of the group to characterize their relationship with each other. Indeed, very informative social network patterns can be generated from a 10 to 15 minute survey.

The interviews were designed to solicit responses about who talks to whom about work, who trusts whom, and who advices whom on important matters. In this process, it is important to ensure that the kinds of relationships measured are appropriate for the task at hand and not unnecessarily inflammatory. Organizations are very different in their tolerance for disclosure of various kinds of relations. In this case, considerable attention was paid to shaping the questions asked so that they were helpful to the specific issue the organization was grappling with, while at the same time not unnecessarily disruptive to existing relationships. The network survey consisted of questions examining bounded networks (Cross and Parker 2004). In the bounded networks, four questions were asked to elicit network patterns representing information seeking, awareness, social closeness and information access within the group. For information seeking, the respondents were asked how often they sought information or advice on projects, work, or operations from each person in the group. For awareness, they were asked about the extent to which they understood the knowledge and skills of each person. For social closeness, they were asked how often they met with each person for non-work-related (social) activities. For information access, they were asked about the extent to which each person was accessible within a sufficient time frame when they needed information or advice.

Using the data collected from the interviews and the survey, matrices were constructed to reflect the extent to which each actor was connected to every other actor in the network. The results were arranged in binary matrices, where each cell X_{ij} corresponded to *i*'s relation to *j* as reported by *i*. If *i* reported a response about *j*, then the cell X_{ij} was coded as 1; otherwise, the cell X_{ij} was coded 0. The interactions were represented in 9 by 9 actor-by-actor matrices and Netdraw was used to graphically display the relations between actors. The network plots were intended to show descriptive evidence of interaction between members of the group. These were used in phase two of the work as part of the facilitated intervention. In this phase, the network maps were used in with the cognitive maps in a series of Soft OR workshops to facilitate knowledge creation and sharing for the group. The workshops were attended by the whole team and each session was scheduled for 3 hours and there were 3 sessions. The sessions were facilitated by the author.

For the final phase, some simple metrics calculated using UCINET (Borgatti et al. 1992) to depict structure and the quadratic assignment procedure QAP (Krackhardt 1987, 1988) was used to determine correlations to explore embedded relationships, i.e. whether there were any associations between perceptions of fairness, who seeks advice from whom, interaction, influence and so on. These metrics were used to evaluate the case.

16.5 Findings

This section mainly reports the findings from the second and third phase of the study. For the second phase—the Soft OR workshops—network plots or graphs were developed for each of the network relations collected by the survey. The plots provide descriptive evidence concerning the network structure and the embeddedness of the network members. The plots and data produced were used in the first workshop which started with a review of the relationships and then moved to the cognitive map to explore the broader issues. During this workshop, it was found that visually assessing the patterns of relationships that exist revealed a number of interesting and actionable points and several intervention opportunities, which linked in well with the cognitive map and the Soft OR approach. During the session, the group explored the network diagrams. This allowed the members to assess and discuss the positions of other members. For example, Fig. 16.1 is the network based on whom others depend on to solve problems (i.e. it reveals the experts) and it showed that people were generally willing to tap into certain member's expertise. From the figure, it can be seen that Jane is an obvious recipient for request and advice. She is highly central, but it can also be seen that other members play similar roles such as Murray and Sarah. A lengthy discussion resulted after this network was presented.

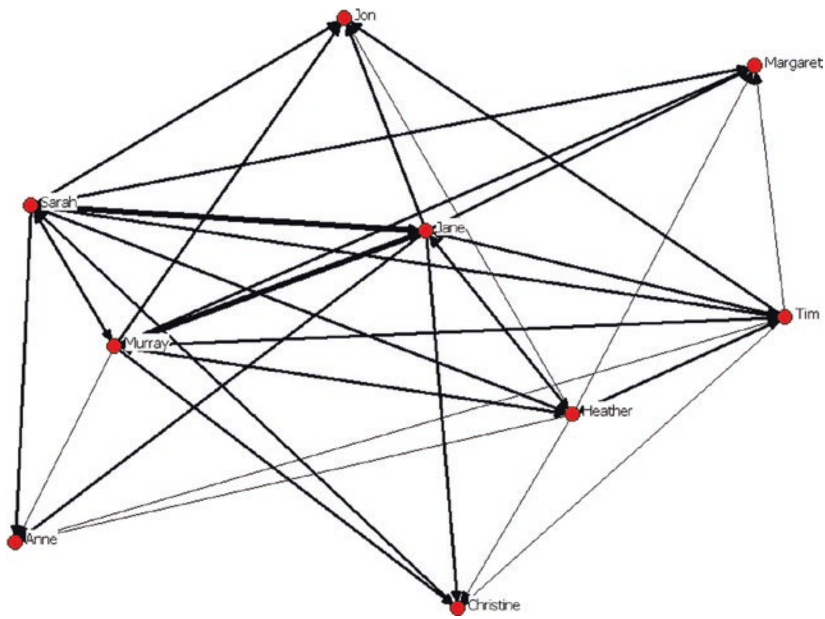

Fig. 16.1 Who do you go to solve problems?

This is related to conjoined capability in the following way. In reviewing the networks, the members of the group focused on those they believed had considerable potential to get things done in the organization direction (i.e. power). Here, the participants debated positions surfacing which was, up till then, unshared knowledge. They saw that some people tapped into other member's expertise, while other members appeared to be bottlenecks (gatekeepers) in sharing information. Since conjoined capability is concerned with a coordinated and cooperative means to carrying out change, the actors were able to acknowledge that they should work together acknowledging dependencies, and social roles. The maps helped the members of the team to learn about the other members' connections, revealing where the 'real' action was in the group. Also, there was a growing awareness that knowledge of the networks allowed them to assess and discuss the types and structures of networks they work in.

Table 16.1 Degree and betweenness centrality measures (Freeman 1979)

Name	OutDegree	InDegree	FlowBet
Sarah	33.000	16.000	6.861
Murray	32.000	16.000	6.802
Jane	32.000	18.000	9.885
Tim	29.000	16.000	6.233
Heather	28.000	16.000	6.609
Margaret	0.000	18.000	0.000
Jon	0.000	19.000	0.000
Christine	0.000	18.000	0.000
Anne	0.000	17.000	0.000

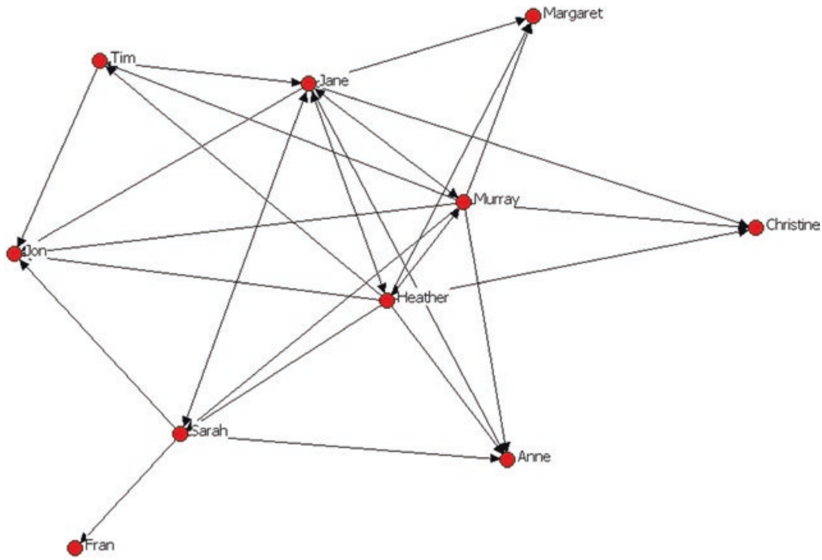

Fig. 16.2 Perceptions of fairness

From the use of the network diagrams, (and the metrics provided see Table 16.1) the members seemed to understand and were responding to those who were good at bridging and bonding roles, and also on which relationships were the most pronounced. Other diagrams were used (e.g. Fig. 16.2) to extract insights and knowledge about other types of relationships, and a number of formal and informal relationships were recognized, such as those typically reflected in reporting lines—for example chief executive and supervisor, etc.—and informal relationships reflecting other, more social, links (who sees whom outside work for social activities, etc.). An understanding of these social ties was key for the members, particularly in the discussion of their new understanding of the network (the negotiated social order).

The appreciation of networks helped the managers in the network talk openly about who seeks information from whom, and without fear. They also discussed how knowledge of other proximate members' social networks enriched the quality of their decision making process. They were able to test each others' motive and encourage the evaluation of the burgeoning strategy from the perspective of interest of organization rather than from a functional interest. It appeared that the members had a deeper sense of identifying with the network. During the discussions of the strategy in subsequent sessions, through the use of Soft OR, knowledge of the networks they were embedded in helped in reshaping and resolving the issues and solutions identified.

In general it was found that combining network diagrams and measures with Soft OR were constructive in that they aided discussions on the roles the members of the network play (such as brokerage, boundary spanners, etc.) and how these roles may be adopted in relation to newly formed social order as a result of the facilitated group decision sessions.

16.6 Discussion and Conclusion

It has been known for some time that social relationships are important for group decision making (Leavitt 1951; Guetzkow and Simon 1955; Beer 1956) and that the facilitated group decision making is a social process (Eden and Ackermann 1998). Yet despite the importance of social interaction as a vehicle for better GDM/Soft OR processes, little is known about the relational characteristics that facilitate these processes. The study presented offers some initial thoughts (and to some degree evidence, Table 16.2) of at least three relational characteristics that are important to understanding the social processes of facilitated GDM: (1) understanding of conjoined capability is embedded in relations relating to the knowledge of others expertise, (2) conjoined

Table 16.2 QAP correlations, means and standard deviations

	Fairness	Solve problems	Interaction	Advice	Influence	Partnership
Fairness		0.01	0.54**	0.64**	0.1	0.1
Solve problems			1	0.137	0.3**	0.23**
Interaction				0.148	0.02	0.5**
Advice					0.16	0.20
Influence						0.20
Mean (density)	2.63	2.22	2.14	3.14	2.33	2.89
Std dev	1.20	1.32	1.94	1.40	1.97	1.78

*$p < 0.05$, **$p < 0.01$

capability is embedded in networks about the perceived fairness of others and (3) positive social relations relate to consensus building and outcomes from facilitated GDM processes. These were explored in the evaluation of the case study. For this some measures from the networks were calculated using UCINET. In particular, routines for the network density measures and inter-network correlations using QAP were computed (Table 16.2). Density measures provided information about the overall network and cohesion (range 2.14–3.14). After the workshops a survey of relationships was conducted to compare to the original networks to examine any changes in the relationships of the members.

In terms of characteristic (1) it can be seen that perceptions of others as experts (Solve problems) were positively and strongly correlated with who influenced whom (Influence) (coefficient = 0.3, $p < 0.01$). Power is often derived from the influence of one stakeholder over another, and an understanding of expertise and influence seem to relate to political feasibility. This understanding, it is suggested here, helps people to change their opinions safely within the group and embed action. In contrast, discovering that a person is not helpful reduces the likelihood of interacting with them, which means that knowledge of their expertise and how best to access them begins to fade.

In terms of characteristic (2) perception of others fairness (Fairness) was strongly associated with whom they share information with on a regular basis (Interaction) (coefficient = 0.54, $p < 0.01$) and with whom they seek advice (Advice) (coefficient = 0.64, $p < 0.01$). Without a facilitated group decision intervention, people may lock into a limited set of other people with whom they frequently interact, which might be efficient but may not be useful to the group if other people are a better source of information or advice. Knowledge of peoples' perceptions of others fairness is linked to the perceptions of procedural fairness. Changes as a result of this knowledge should enable a new social order. Other researchers, such as Eden and Ackermann (2004), have noted that any new social order has to be negotiated. This is possible when there is some attention paid to social learning (i.e. learning arising from understanding other members networks, Bandura [1986, 1989]), and this creates the conditions of possibility of stabilizing the newly negotiate social order. Thus, action is influenced by the perceptions of other proximate individuals in their social networks (Bandura 1986).

In terms of characteristic (3), there was a strong sense that knowing about other members networks helped the group reach an agreement of future directions and consensus quite quickly. The case indicated that in dealing with complex details in the sessions there was a need to draw on the social relations. There was also a need to appreciate the relations of the other members have with each other, i.e. an awareness of the networks of others. This encouraged the team worked in a coordinated and cooperative way facilitating agreement building which the thought was strong and would last.

Of course, this study has significant limitations as well. Despite these empirical limitations, it is felt that the study provides a platform for further theorizing on social processes social embeddedness and Soft OR. In addition, we suggest that a dynamic extension of the model presented here could, in future research, provide new insight into social networks and group decision making.

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17

Behavioral Aspects of the New General Data Protection Regulation: A Consumer-Centric Approach to Operations

Alexander Kharlamov

17.1 Introduction

Have you ever considered how much data you generate on a daily basis? Have you ever thought of how much of that data you are giving away for free? Curiously, people often think about the first question much more than they do about the other. Recent advances in the internet connected technology led to the increase in data availability. Personal data has recently become one of the most valuable assets for businesses around the globe. With over 2.5 quintillion bytes of data (Marr 2018) generated each day, companies now have real chance to better capture and understand customer preferences, wants, and needs. The availability of large volumes of data has given rise to the Data-Driven Business Models (DDBM), which look at how the data can be exchanged, traded, and used in order to develop new and improved customer experiences.

Yet, despite the increased availability of personal data there is a lot of uncertainty about its quality. Even large datasets containing many months

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of data from millions of users do not guarantee that the insights derived from these datasets will be meaningful. This underlying uncertainty about the quality of personal data complicates the use of Data as a Service (DaaS) and inhibits direct exchange between customers who supply personal data and businesses who demand personal data (e.g. Pogrebna 2015). Under these circumstances, concerns have been raised as to whether personal data from large numbers of consumers is being exploited by large data provides as companies are willing to pay large amounts of money in order to obtain customer personal data, while consumers tend to give away their personal data for free. This results in a situation when the lion share of data-related profits are streamed to small number of personal data-trading giants.

In order to address personal data concerns, on May 25, 2018, a new General Data Protection Regulation (GDPR) came into effect in the European Union (EU). The regulation was meant to protect personal data of the EU citizens, providing guidance on how data should be collected, used, and stored. While the regulation was meant to catalyze consumer interest toward personal data as well as make consumer decisions in the domain of personal data more aware and optimal, it is now clear that GDPR-related customer requests are relatively rare and, despite the EU effort, only a narrow group of individuals continue to engage with their new digital economy rights (Choudhari 2018).

In this chapter, we investigate why individuals fail to engage with this domain of their life. Specifically, we consider a set of well-known behavioral regularities (biases and heuristics) from decision-theoretic research in order to understand the impact of these regularities on customer engagement with their right under GDPR. We then discuss how considered behavioral aspects affect the underlying business models and business model innovation.

17.2 Personal Data and Data-Driven Business Models

In the 2000s it became apparent that personal data can reshape product and service design and innovation by putting consumer at the core of the production and supply chain decision making process.

Indeed, insights from consumer personal data were meant to revolutionize industries by offering ways to better understand consumer preferences and behavior and, through this route, design consumer-centric (consumer-driven) products and services. Yet, by the early 2010s it became clear that consumer-driven approach is becoming difficult to implement. Systems and institutions have formed which implied that consumers were distanced from the personal data collection mechanisms. In fact, businesses designed 'vertical' databases where context-free information about consumers would be stored. So, instead of becoming a novel engine for product and service innovation progress, data became yet another marketing tool. Instead of relying on simple demographics, the new marketing techniques incorporated so-called *neodemographics* approaches which offered more sophisticated ways of clustering population and creating behavioral segmentations using data science techniques.

Literature in operations, business models and IoT distinguished between two types of DDBMs: *backward induction* DDBMs and *forward looking* DDBMs (Pogrebna and Guo 2015). Backward induction DDBMs imply that businesses first produce goods and services and then use consumer personal data to better understand their target audience or identify additional audiences not considered throughout the product and service design process. In other words, the goal of a backward induction DDBM is to find customers for existing products and services. In other words, the data engagement process is done backwards: from the end offering to consumers. The goal of the forward looking DDBM is completely orthogonal. Forward looking models aim to study the behavior and preferences of various consumer groups and then based on insights from consumer personal data develop new products and services, i.e. 'tailor' offerings to consumers (Ng et al. 2015). In other words, forward looking DDBMs work as a forward process from consumer preferences to new offerings. In the current digital economy backward induction DDBMs prevail. By in large, businesses tend to use consumer personal data to 'nudge' users toward purchasing their offerings and not as a tool for active co-creation with consumers.

Since backward induction DDBMs are primarily aimed at increasing sales or attracting attention through better and more efficient marketing campaigns, they may lead to potential personal data exploitations.

Think of the notorious Cambridge Analytica which captured millions of personal data records (often without the user consent) in order to custom-engineer nudging tools which were then used in political campaigning. Under these circumstances, one of the main goals of GDPR was to prevent personal data misuse by a wide range of organizations.

17.3 The Context of GDPR

GDPR provides a legal definition of personal data as well as regulates rights and duties associated with these data. Specifically, GDPR specifies that personal data is "any information relating to an identified or identifiable natural person (data subject) …" (EU GDPR 2018). GDPR regulates the rights of EU citizens, irrespective of the business headquarters location. In other words, even if a particular company is located the non-GDPR country (US, China, Australia), as long as this company handles the data of the EU citizens, it should abide by the GDPR rules. It does not matter where the data was collected and where it was analyzed or stored—as long as any EU citizens' data is involved, the businesses must comply with it.

Non-compliance under GDPR results in serious consequences. Specifically, a business can be fined up to 4% of its annual global turnover or €20 million (whichever is greater). GDPR stresses that personal data collection, analysis, and usage should only take place if the actor of personal data (e.g. consumer) provided informed consent to these actions. Furthermore, it should be easy to provide as well as withdraw informed consent.

GDPR distinguishes between data controllers and data processors. Data controllers are organizations which "determine the purpose for which data are processed" and, therefore, bear full responsibility for the data in their possession. Data processor is an actor which "processes data on behalf of the data controller" (EU GDPR 2018).

GDPR also offers five new human rights—breach notification, right to access, right to be forgotten, data portability, and privacy by design. The right to breach notification implied that any data breach involving data of the EU citizens which may "result in a risk for the rights and freedoms of individuals" should be reported publicly within 72 hours of the time point when a business becomes aware of the breach. The right to access means that any data subject is entitled to request all data which is being held about them by data controller and the data controller must provide all requested data in an electronic format. Data controller also must provide information to the data subject regarding the purpose of this subject's data use as well as data on all parties which are involved into handling the data. The right to be forgotten under GDPR implies that data controller must erase all data associated with the data subject at the subject's request. The right to data portability ensures that the data subject may receive their personal data and potentially transmit that data to another controller. The privacy by design means that data controller should "implement appropriate technical and organizational measures… in order to meet the requirements of [GDPR] and protect the rights of data subjects".

17.4 GDPR and Business Model Innovation

GDPR is seen by many as a factor inhibiting business model innovation. Some GDPR critics even go as far as arguing that the regulation destroys the European markets for personal data. Yet, is it really so? While there are many important challenges which businesses need to overcome in their quest to be compliant, GDPR offers at least three important opportunities for fostering business model innovation:

1. Empowering consumers—one of the GDPR major goals is to get people more interested and aware about the use of their personal data. At the moment a large proportion of population is really ignorant about the whole digital domain. By understanding their data better, consumers may become more engaged in the business processes: as they become more aware of their digital footprint, they may understand their preferences better and, hence, increase the quality of their personal data used by businesses. In other words, by being more informed people will either not provide their data at all or they will provide really valuable data because they would know how these data is used and consent to this use.

2. Changing personal data culture—GDPR provides an opportunity to change the personal data culture in a sense that consumer can gain control over the data at any point in time. This allows consumers to explore new ways of engagement with businesses. For example, they can do so through multi-sided markets for data where they would exchange their personal data for price discounts, promotions, and other benefits.
3. Fostering the switch from backward induction to forward looking DDBMs—increased customer engagement also fosters the change from backward induction to forward looking DDBMs. If consumers pay more attention to the way in which their personal data is used, they are likely to co-create offerings with businesses more efficiently. In other words, instead of acting as *objects* of innovation when the changes are happening *to them*, they will become *subjects* of innovation when the changes will be happening *with them* (i.e. with their active involvement in the decision making process).

Yet, despite all these potential advantages, GDPR so far has not realized in the three favorable outcomes discussed above. While there are many reasons for this, one of the main contributing factors is human behavior and the way in which individual perceptions and robust behavioral regularities interact with the new rights under GDPR.

17.5 Human Behavior, Heuristics, and Biases

Rationality has been celebrated as one of the highest achievements of the human species. Traditional view on rationality and decision making implies that humans rely on logic, statistics and heuristics. One of the first ideals of human reasoning and inference was *logic* as defined by Aristotle (384 BC–322 BC). Later in the seventeenth century, *logic* was replaced by the *probability theory* which acknowledged the fundamental uncertainty of human conduct (Daston 1980). Up until mid-nineteenth century, probability theory was considered the ideal way for describing common sense through calculus (de Laplace 1902—originally published in 1814). Probability theory enabled the development of normative and descriptive models of decision making (Savage 1954).

Models of decision evolved as different theories of decisions and perspectives on probability developed. The most recognized interpretations of probability are classical, frequentist, logical, and subjective (Surowik 2002). This significantly influenced mathematical theories of decision making which are still being used today and are widely adopted by researchers in social and natural sciences (Bowers and Davis 2012; Vranas 2000). The classical view on decision making using probability theory articulated by Daniel Bernoulli and Pierre-Simon Laplace was that the probability of an event is the ratio of the number of favorable cases to the total number of cases being equally weighted. This view was followed by the frequentist idea common to statistical methods of hypotheses testing. The frequentist view is that the probability of an event equals the frequency of its occurrence in repeated trials. Another view on probability was developed by John Maynard Keynes, as *Logical* or *Objective* probability. This probability is connected with statements and can be deduced from the truth-value of the premises of the statement for which it is inferred. Finally, another widely accepted concept of probability adopted by Bruno de Finetti and Leonard Savage was the *Subjective* probability. According to this view, probability is a subjective degree of conviction related to a single event or repeated events and measured by psychometric methods (e.g. observation of gambling).

Subjective consideration of probability was introduced by means of one of the greatest contributions to statistics, the Bayes theorem (Savage 1961). It has been adopted as one of the main models of human reasoning (Chater et al. 2006). This theorem provided a foundation for a number of models, e.g. the Adaptive Control of Thought theory (ACT-R) proposed by Anderson (1996). ACT-R is a cognitive architecture aiming at defining the most basic and irreducible perceptual and cognitive operations of the human brain (Anderson 1996). Yet, empirical tests showed that such a model better describes mathematical and computer programming algorithms rather than human behavior.

One of the first decision making theories was proposed by Paul Samuelson (1938). He defined utility as desired level of satisfaction obtained from available decision strategies and assumed that an agent's goal is to maximize utility using a rational decision model. This marked the rise of the *perfectly rational* economic agent or *homo economicus*.

This agent had perfect information and applied principles of rationality to make an optimal decision. An assumption of perfect rationality was important for the development of simple and tractable models of behavior such as expected utility theory (Von Neumann and Morgenstern 1947). However, evidence from empirical research led researchers to challenge the concept of rationality by showing that 'well-behaved' axioms and assumptions of theories which had human rationality at its core fail in practice (Hilbert 2012; Kahneman 2003; Shah and Oppenheimer 2008; Simon 1955, 1969; Tversky and Kahneman 1974). One of the main and rather unrealistic assumptions about the classical rational decision maker was that he has a stable system of preferences as well as possesses advanced computational skills to find the highest possible point (optimal solution) on his preference scale (Simon 1955). However, despite the fact that the extent of the work of Allais (1953), Ellsberg (1961), and Lichtenstein and Slovic (1971), as well as Kahneman (2003) and Tversky and Kahneman (1974, 1993) challenged the classical view on rationality, the normative kernel is still present. The adoption of the classical view, i.e. normative approach to reasoning, is illustrated by the fact that reasoning errors are defined as the deviation from the norm governed by the laws of probability and statistics.

From Aristotle's view on logic (384 BC–322 BC) to heuristics defended by Gigerenzer (2001), rationality, behavioral models, and decision making have been hot topics. However, the behavioral science community is still far from converging to one unifying theory of decision making (Gigerenzer 2008). From *homo economicus* (term suggested by Thaler 2000) to *homo sapiens*, the evolution of how rationality is perceived, changed throughout the development of behavioral science (Thaler 2000). The latest developments suggest that there is no single right view on the subject. Humans rely on all those different ways of thinking depending on the circumstances (decision context), which amounts to an ecological view of rationality.

An ideal of rationality beyond human abilities dates back to even before the times of John Locke (1690) when the perspective of an omniscient God in a certain and deterministic nature was contrasted with humans living with uncertainties and inconsistencies. God was taken as the ideal of a super-intelligence, which Laplace characterized as:

> …an intelligence which could comprehend all the forces of which nature is animated and the respective situation of the beings who compose it – an intelligence sufficiently vast to submit these data to analysis … nothing would be uncertain and the future, the past, would be present to its eyes. (de Laplace 1902—originally published in 1814, p. 1325)

This point of view is still represented today in many decisions models such as Bayesian reasoning or expected utility maximization, considering that, when given unlimited time, boundless knowledge and unconstrained computational abilities human reasoning is well described under this divine light. Despite the fact that the 'old' view of *unbounded* (or divine) *rationality* was dropped in mid-twentieth century due to its relation to the theological doctrine, a similar perspective with rational utility-maximizing human at its core took over. The new perspective labeled *optimization* (specifically, *constrained optimization*) assumes that humans can be perfect optimizers. They can do so when the decision context allows them to be rational and when complexity of the decision problem is manageable to make appropriate calculations.

Constraints of the decision environment (or constraints of *decision architecture*) can be understood as, for example, having a finite amount of time, knowledge, attention, resources to spend on a given decision. One main difference between perfect (unbounded) rationality and all other visions of rationality is that under perfect rationality it is assumed that information search can go on endlessly while under bounded rationality this process is limited. The concept of limited information search consequently brings in the need for having a stopping rule, i.e. when to stop looking for information. Optimization from the optimization under constraints point of view is now focused on finding the stopping rule that "optimizes search with respect to the time, computation, money and other resources being spent" (Todd and Gigerenzer 2000, p. 729). The main rule holds that the search stops when the costs outweigh benefits, assuming that the mind is able to calculate the benefits and costs of searching for additional pieces of information.

The idea of optimization under constraints turns out to be even more demanding from agents' computational ability than the classical idea of unbounded rationality (Vriend 1996). Paradoxically, the assumption for

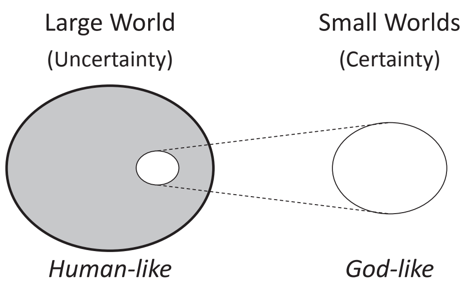

Fig. 17.1 Concept of small and large worlds (based on Savage 1961)

a limited search for information is that the mind has unlimited time and knowledge to evaluate the trade-offs of further information search (Todd and Gigerenzer 2000).

In order to keep using rational models of behavior which are based on perfect information and work around any informational limitations, Savage (1961) introduced the concept of small worlds (Fig. 17.1). On the one hand, the idea of small worlds enables most of the classical analysis: it described situations where 'optimal' solutions to a problem can be determined because all relevant alternatives, consequences, and probabilities are known and where the future is certain. This means that in a small world it is possible to hold perfect knowledge ('god-like' knowledge) and the conditions for rational decision theory are satisfied. On the other hand, a large world (or real-world scenario) describes situations of uncertainty that violates the conditions for rational decision theory where part of decision-relevant information is unknown and has to be estimated from smaller samples.

Despite an obvious misfit between the idea of humans as perfect optimizers and reality (large world), the view of the decision maker as the *homo economicus* remained accepted within the context of the small world (see Fig. 17.2) where everything that does not apply belongs to the large world.

It is considered that it is inappropriate to apply small-world norms of optimal reasoning to large worlds (Binmore 2009). Therefore, since conditions for rational decisions are not satisfied in large worlds (real-world scenarios), one cannot expect that models of rationality will

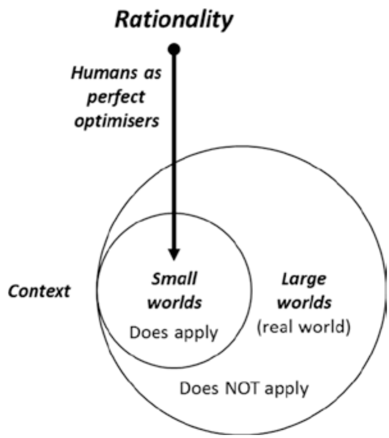

Fig. 17.2 Classical view of rationality reduced to small worlds

provide the 'right' answer and consequently rational expectations theory is not "taken seriously outside academic circles" (Soros 2009, p. 6).

It is critical to understand the implications of small and large world considerations in practice. Situations where small world theories (economics and behavior) were applied to large worlds sometimes led to disasters as even slight deviations from the model do matter, e.g. 2008's financial crash where almost perfect information in the form of high volumes of data was assumed to be the same as perfect information (Stiglitz 2010).

The segment of study of rationality in small worlds is essentially the study of constrained optimization popularized by Gigerenzer (1991). It introduces the concept of limitations into the study of decision making while still assuming that there exists an 'optimal' solution. This was one of the most widely known attempts of making the *homo economicus* more human. Stigler (1961) argues that humans do not have all the information necessary to make the perfect decisions available instantly, so they must search for it. This search is not free. There is a resource cost to the decision maker, e.g. time and money. The ideal of rationality is still present while the main difference from previous decision theories is that the search for more information is stopped when the benefits no longer exceed the cost of further search. In a way, this information/

effort trade-off is similar to Simon's (1997) *satisficing* heuristic which implies that the decision maker looks for 'good enough' solutions when the effort and the decision accuracy are balanced according to the situation. The difference is that Simon (1997) argues that models of rationality should represent actual cognitive capacities of humans, therefore accounting for natural limitations in cognitive capacities such as memory, attention, knowledge.

At first, this idea might sound reasonable, except it has one inconsistency. Humans are expected to be able to calculate the optimal stopping point in the decision making process (similar to the breakeven point in economics). While finding a breakeven point in a linear problem might be tangible, most of the real-world scenarios are not linear in their nature. Hence, such operation can easily be more demanding both psychologically and mathematically than assuming that people have unbounded rationality (Vriend 1996). This means that such theory is built on rationality norms, assuming that humans are perfect optimizers, therefore making such approach only applicable to small worlds. The paradox of optimization under constraints lies in the fact that a limited search for information relies on a mind that has unlimited time and knowledge to evaluate the cost-benefit of further information search (Todd and Gigerenzer 2000). Since humans are failing in these processes exhibiting a number of heuristics and biases, it is important to understand how these biases impact on the consumer propensity to engage with their new rights under GDPR.

17.6 GDPR and Human Behavior

In the spirit of the discussed approaches to human rationality, we consider how new digital economy rights under interact with the behavioral regularities (biases, heuristics, and other behavioral effects). The framework considers the following 12 behavioral regularities: overconfidence bias, self-serving bias, herding effect, loss aversion, framing effect, narrative fallacy, anchoring and adjustment, confirmation bias, representativeness bias, law of large numbers bias, default bias, and information avoidance. Regarding the GDPR-based rights, the focus is on the following five rights under GDPR: breach notification, right to access, right to be forgotten, data portability, and privacy by design. Resulting relationships form a basis of the Bias-GDPR Engagement Framework presented in Table 17.1. Considering how each of the behavioral regularities affects each of the rights, the effects range from strong positive (++), positive (+), neutral (0), negative (−), or strong negative (−). Some combinations can lead to inconclusive effects (+−). The remaining of this section will focus on each one of the behavioral regularizes and how it affects each one of the rights and ultimately how it affects consent.

Overconfidence bias refers to the tendency of people to exhibit reference group neglect. The bias was first introduced by Ola Svenson, who showed that when asked to estimate their driving ability the overwhelming majority of drivers thought that their ability was above average even though only half of drivers could be above average (Svenson 1981). If consumers suffer from the overconfidence bias, the bias is unlikely to have any impact on their breach notification and privacy by design, positive impact upon customer engagement with informed consent, negatively impact on right to be forgotten as well as data portability, and may or may not positively influence consumer engagement with the right to access.

Self-serving bias (e.g. Sherill 2007) reflects a human tendency to attribute successes to skill and failures to luck. Self-serving bias is likely to have neutral effect on such rights as right to access, data portability, and privacy by design but negatively impact on breach notification and right to be forgotten. People with self-serving bias are less likely to provide consent.

Herding effect (e.g. Rodgers and Zheng 2002) refers to a behavioral regularity when people follow others despite their personal preferences and beliefs. While herding effect outcome for GDPR engagement heavily depends on the way in which other people behave, it is likely to negatively impact almost all new rights as, by in large, people tend to ignore their new rights.

Loss aversion (Tversky and Kahneman 1991) implies that people feel losses more prominently than equal-sized gains. Loss averse people are likely to be interested in their personal data because they really care about the consequences of their personal data loss. Therefore, they are

Table 17.1 Behavioral aspects of consumer engagement with GDPR: Biases-GDPR engagement framework

		New rights under GDPR					Consent
		Breach notification	Right to access	Right to be forgotten	Data portability	Privacy by design	
Behavioral regularities	Overconfidence bias	0	+ –	–	–	0	+
	Self-serving bias	–	0	–	0	0	–
	Herding effect	+–	––	––	––	––	++
	Loss aversion	++	++	++	++	++	––
	Framing effect	+–	+–	+–	+–	+–	+–
	Narrative fallacy	+–	+–	+–	+–	+–	+–
	Anchoring and adjustment	––	––	––	––	––	++
	Confirmation bias	+–	+–	+–	+–	+–	+–
	Representative-ness bias	–	–	–	–	–	+
	Law of large numbers	–	–	–	–	–	++
	Default bias	+–	+–	+–	+–	+–	+
	Information avoidance	––	––	––	––	––	++

[++] strong positive effect; [−−] strong negative effect; [+−] inconclusive effect; [0] neutral effect; [+] positive effect; [−] negative effect likely to engage with all rights in a positive way but they would be less likely to give consent to their data being used by the businesses.

Framing effect (e.g. Levin et al. 2002) means that people make context-dependent decisions, i.e. dependent on a decision making frame they will select different actions. Narrative fallacy suggests that people like stories and they would be more likely to believe a carefully crafted story. Confirmation bias implies that people always seek facts and evidence which confirm their initial ideas about various phenomena. All the three behavioral regularities (e.g. Baron 2014) refer to context-dependency of human decision making, therefore, their effect on the GDPR compliance will heavily depend on the exact context which these biases reveal themselves in.

Anchoring and *adjustment effect* (e.g. Furham and Boo 2011) refers to a human propensity to evaluate outcomes relative to a particular reference point which they tend to use as an anchor in their decision making process. This effect is likely to mostly negatively impact on consumer engagement with GDPR and make people consent to the use of their data with higher probability.

Representativeness bias (e.g. Chen et al. 2007) is a human belief that two objects or phenomena are similar when they are not. Since representativeness bias is likely to be related to the human propensity to underestimate personal data risks due to the fact that they believe in the existence of more safeguards of data than challenges, we expect it to negatively affect GDPR customer engagement.

Law of large numbers (Tversky and Kahneman 1971) means that people believe that probability has memory (if something happened a lot in the past, it should not happen again in the near future). This law is also likely to have primarily negative effect on engagement with GDPR as people who believe the probability to have memory are likely to underestimate cyber risks and be more positive about the use of the data than necessary.

Default bias (e.g. Korobkin 1997) is a human tendency to accept current state of affairs and reflects reluctance to change. This bias is currently heavily exploited by the businesses. After GDPR came into effect, the overwhelming majority of businesses asked their customers to comply with new Terms and Conditions. Yet, in many cases customers were offered a default option to opt into all data sharing business processes. This led to many customers accepting the new Terms and Conditions without fully understanding the implications of their choices.

Information avoidance (e.g. Sweeny et al. 2010) refers to the human tendency to avoid available information even though this information is available. This effect is particularly prevalent in health-related decision making. For example, when people are asked whether they want to know their individual propensity to develop a serious condition (e.g. cancer or dementia) based on their family history, they tend to reject such opportunities.

17.7 Conclusion

In this chapter we considered how various behavioral regularities interact with new consumer GDPR rights. The value lies in the introduction of GDPR leading to changes in how industries deal with data as well as affecting consumer behavior on many levels. The recency of GDPR (launched mid-2018) brought many research opportunities and opened a knowledge gap. We offered a new Biases-GDPR Engagement Framework which summarizes how twelve main behavioral biases influence consumer propensity to exercise their five new rights. To our best knowledge no similar framework has been proposed as of writing this chapter. The outcome of the framework construction exercise reveals that most exiting biases negatively impact human propensity to engage with the new regulation. This explains why humans fail to take advantage of their new rights. Equally, this lack of human engagement with GDPR has detrimental effects on switching from backward-induction DDBMs to forward looking DDBMs.

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18

How Do We Know Anything? Philosophical Issues in the Collection and Interpretation of Operational Research Data

Ben Hardy and Philip Stiles

18.1 Introduction

The economist John Kay had some sage advice for statisticians: whenever you see the product of serious analysis or calculation you should always ask yourself "what is the question to which this number is the answer?" (Kay 2011). This seems a fairly straightforward piece of common-sense guidance, but it is a much more sophisticated and disquieting observation. It hints at the complex processes that produce simple numbers and numbers' tendency to give the illusion of a concrete answer.

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The shift from Operational Research (OR) to *behavioral* Operational Research (BOR) (see Franco and Hämäläinen 2016) means that ever more evanescent concepts, such as product sales, employee satisfaction scores and average call handling times, are being quantified. Many of these things are not discrete or concrete but are ephemeral and transient. Baked bean cans on a production line are discrete and concrete: perceptions of leadership are ephemeral and transient.

The key to improving measurement is twofold. One way is to improve our methods so that our counting is more accurate. The other is to examine the philosophical assumptions that underpin our research. BOR, as a field, has done this (see Becker 2016; White 2016; White et al. 2016), albeit tangentially by discussing research paradigms. This chapter aims to tackle the problem head-on, by looking at three different factors which affect measurement and the conclusions we draw from any measurement. These are the nature of reality, what (and how) we can know about it, and how we generate knowledge.

The researcher steeped in the natural sciences may view these questions in much the same way as the physicist Richard Feynman, who is reported to have said "philosophy is about as useful to scientists as ornithology is to birds; philosophy of science, as ornithology, is a civilizing hobby but of no real use to its objects" (Pernu 2008, p. 30). But the shift from OR to BOR also necessitates a shift from a natural science paradigm to a social science one, with the attendant need to consider underlying philosophical matters.

So, what if we do not? What if we ignore philosophy altogether? There are three potential problems that can arise from failing to pay heed to philosophical matters. The first is that we only capture a partial view of the area of study. The aphorism that 'what is measured is what gets done' may have a corollary that what is not measured does not get done. Some phenomena, such as trust in a supplier, are not readily captured and so may not be incorporated into models, despite being an important factor in determining transaction costs. The second problem is one of comparability between pieces of research. A lack of clarity about the philosophical underpinnings of a study—for example, how leadership was measured and how that measure pertains to a particular culture—may mean that attempts to compare studies, or synthesize them into a meta-analysis, leaves us comparing apples with oranges. The third problem is a fundamental one as we may not actually be measuring the thing that we think we are measuring (see Hardy and Ford 2014).

These three potential problems form an assay that we will use to assess the implication of philosophical concepts for BOR. In doing this we make three contributions. The first is to illustrate that the shift from OR to BOR requires a greater focus on philosophical issues than has hitherto been the case. The second is to enable researchers to identify where their research and proclivities might fall on a number of philosophical spectra. The third is to help researchers think about alternative methodological approaches which might, in turn, offer new understandings of BOR phenomena.

The rest of this chapter is laid out in three main parts. We begin by looking at the nature of reality and the assumptions we make about it—the 'there' that is out there. Then we turn to how we might capture that reality—what we can know about the 'there'. Having obtained our data we then will consider what it might or might not tell us about the world—the knowledge it produces. Finally, we trace the implications of this for Behavioral Operational Research and how those conducting such research might ensure their work is both sound and useful.

18.2 What Is the Nature of the 'There' Out There?

The study of the 'there' out there is known as *ontology*. Operational Researchers are likely to be familiar with the term as it is widely used in computer science to describe "a formal, explicit specification of a shared conceptualization" (Gruber 1993, in Breitman et al. 2007). As Gruber (1995) puts it "The term is borrowed from philosophy, where an Ontology is a systematic account of Existence. For AI systems, what "exists" is that which can be represented." (Gruber 1995, p. 908). This is a very thin ontological view which captures what can exist in an AI system. Philosophers take a broader view and the assumptions they make about the world and nature of reality can vary greatly.

At one end is a world where there is an external reality which can be measured and about which we can develop rules. This is the view taken by disciplines such as mechanical engineering and computer science. At the other end of the spectrum is the skeptical view that nothing can be ascertained with certainty. Between these two poles there are a number of other interpretations of how 'real' the world is.

18.2.1 Realist Perspectives

The natural sciences tend toward the realist end of the spectrum (Easterby-Smith et al. 2002). At the hard end of realism is "the view that entities exist independently of being perceived, or independently of our theories about them." (Phillips 1987, p. 205). This view believes that there is a single state of the world which exists independently of us and will go on existing whether we are there or not.

Realism, however, has its problems. First, the history of science furnishes an abundance of empirically successful theories that were "abandoned one after another" in the light of new information (Chakravartty 2017). Second, there is often a gap between, say, the laws of nature and the knowledge that scientists have of these laws. Third, there is a representation problem—how do we come to know about the mind-independent world?—a problem we shall address later when we discuss *epistemology*.

These difficulties have led to a softening of this position to internal realism (Putnam 1987). Here our understanding of the world depends on conceptual schema which combines both fact and convention. So, when we see a baked bean tin, our perception is dependent on the language we use to describe it but not, necessarily, on our matching it exactly with other baked bean tins we have seen—or the elementary particles which make it up. There is a flexible vagueness to our precision. As Putnam puts it "What is factual and what is conventional is a matter of degree. We cannot say, 'These and these elements of the world are the raw facts, the rest is the result of convention.'" (Putnam 1975).

There is no unique schema which captures the natural, mind-independent, properties of the world. It makes more sense to speak of the world having properties within a conceptual scheme—as BOR researchers do when they talk of paradigms. *Internal realism* suggests that there is a single external reality, but that it's very hard to get direct access to it—not least because it is bound up with convention. Instead we have to gather indirect evidence and use that to infer the nature of reality.

These realist positions are plausible for some natural science disciplines, particularly those in which elements of a system can be isolated effectively. The laws or principles identified in realist ontologies are regarded as immutable and fixed.

For social science the debate takes a rather different form. The idea of *hard realism* is fanciful. The very nature of a social concept means that it needs people to exist. As a consequence, it cannot, by definition, exist independent of people in the same way that a rolled steel joist can. Trust, for example, is not an objective entity which exists when there is no-one there. For trust to exist there must be some form of agreement between people on what trust is and how much of it there is.

The hardest realist position that the social scientist can adopt is internal realism, where there might be an entity out there e.g. the idea of trust, but it cannot be readily grasped. This ontological position permits scientific research on social phenomena.

18.2.2 Relativist Perspectives

In this case there is not a single objective state of the world 'out there' but rather there are *states of the world* which exist in relation to one another. When considering the effectiveness of a service level agreement (SLA), for example, there may be multiple states of the world. The SLA could have been great for the vendor but hopeless for the buyer. Or it might have caused long-term damage at the expense of short-term success. Or it may have worked for both buyer and supplier but not for end-users or other stakeholders. In short, there are many states of the world which are relevant to the issue.

This may feel hopeless to the researcher of a scientific bent, but it is not. If we can agree on particular definitions and constructions, we are in with a chance of being able to compare like with like. And this is what researchers often do. We may use definitions of class or socioeconomic status (for example, advertisers may use ABC1, C2DE social classes) to establish who is being served by a product. But class is an artificial entity produced by human endeavor—as are the classification systems to measure it. We might agree to use these definitions of class, but they do not capture the multiple ways in which people's social class or economic status might be constructed. They are *conventions*, in Putnam's (1975) terminology; but in this case it's all convention and no 'fact'.

Of course, sometimes there is no *truth* out there, nor can we agree on a convention. All we can do is describe what we have seen and try to give some hint of the bigger picture. The Duke of Wellington summarized it thus when asked to describe the Battle of Waterloo.

> The history of a battle is not unlike the history of a ball. Some individuals may recollect all the little events of which the great result is the battle won or lost, but no individual can recollect the order in which, or the exact moment at which, they occurred, which makes all the difference as to their value or importance……. (Macaulay 1849, p. 180)

The history of the Battle of Waterloo is, therefore, a *construction*, it is not a set of facts nor an account which can be true. Much of the data acquired in Operational Research when enquiring into the history of an event or situation fits into this category. This ontological position—*nominalism*—is that there is no 'truth'—there is no one state of the world, everything is constructed and that the facts that we consider are human creations.

When considering the nature of reality in BOR, therefore, we have a continuum between a hard realist position and a hard nominalist. On the one hand there is a real, independent world out there and on the other there is a world that is solely constructed by the actions of humans—and a number of points in between these two poles.

So why does this matter? The problem is that the assumptions we make about the nature of reality affect the kinds of data we collect, what we can know about a phenomenon of interest and the usefulness of its measurements. The behavioral part of Behavioral Operational Research means that we have to think carefully about the nature of things like trust, leadership or reputation. Assuming that something like trust is a concrete entity that can be measured like, well, concrete, may lead us to draw precise but fatuous conclusions from our research.

18.2.3 Critical Realism

Critical realism represents an attempt to navigate between the *Scylla* of the realism embodied in scientific and positivist positions and the *Charybdis* of relativism. It is something of an outlier in the philosophical literature in that it offers a structured ontological view. The key author, Roy Bhaskar, proposes a 'stratified account' or 'reality'. From an ontological point of view, he makes a distinction between the objects of the natural and social world—and hence the natural and social sciences. Critical realism proposes that there is a real, intransitive world out there; a view synonymous with *natural realism*. This real world, however, is not solely grasped through direct empirical observation, its nature can also be inferred from observations of other phenomena which imply that there is an underlying causal mechanism (Mingers 2000).

Critical realism treats social phenomena slightly different. It doesn't regard them as existing as concrete entities but rather as something that only exists in that they have an effect. So, leadership does not exist unless it exerts an effect on other people. If there are no people or effect then there is no leadership. Social phenomena are dependent on people producing and reproducing them. They also tend to be localized in place and time (Mingers 2000).

The stratified nature of critical realist ontology has important implications for Operational Research. Taking our leadership example, we might observe someone responding to a charismatic leader. This response is based on their behavior and their behavior is based on a series of electrical impulses in their brain. These impulses are depending on a series of chemical reactions, and these chemical reactions are dependent on molecules and atoms. This layered ontology has two important implications for research. Firstly, given that we are unlikely to get to the underlying 'real' world, are we using the correct level of analysis? This is rather like the difference between an analysis of events and a root cause analysis. The second is one of comparability. Are they using the same level of analysis as others? Different ontological layers may mean different pieces of research cannot be readily compared.

18.2.4 Ontological Implications for BOR

The ontological view taken by the researcher has implications for the three tests which we set out in the introduction. The first of these is whether we capture the totality of the problem. A realist might be quite confident that this is possible. A subjectivist might believe that it is impossible to capture the totality and so we can only have a conditional fragment. A critical realist might believe that it depends on the depth of analysis.

The second test was whether comparisons can be made across different pieces of research. Again, a realist might feel this is easy. A subjectivist would think that it is impossible. And a critical realist might believe it depends on the level of analysis.

The third test is whether we are measuring what we think we're measuring. Here the realist comes up short because of the problem of apprehending social phenomena. Concepts like trust or leadership are not concrete entities and so their presence has to be inferred and the process of inference introduces its own set of inaccuracies. The interpretivist is pretty confident that are grasping what they think they are grasping but largely because their claims are modest. The critical realist is less certain as it will depend on the ontological stratum being addressed. This process of grasping the nature of the world is what we now turn to.

OR researchers adopting a realist perspective embrace the view that the structure and reality of phenomena are beyond their actions.

Objective physical and social reality must be 'discovered' by crafting precise measures that will detect and gauge those dimensions of reality that interest the researcher. Understanding phenomena is thus primarily a problem of modeling and measurement, of constructing an appropriate set of constructs and an accurate set of instruments to capture the essence of the phenomenon. Much of OR, implicitly or explicitly, adopts this view. This is bound up with adoption of 'traditional' scientific method and assumptions in the early days of OR just after World War II (Ackoff 1979) and subsequently in the nature of assumptions about modeling in OR (Wierzbicki 2007).

Ontologically, non-realist perspectives emphasize the importance of subjective meanings and social processes in the construction and reconstruction of reality (Morgan 1983). This tradition does not presume that organizational structure or social relations are objectively known and unproblematic, but attempts to understand how and why individuals, through their socialization into, interaction with, and participation in, a social world, give it a certain status and meaning. A number of researchers within the BOR tradition have taken this approach, particularly to better embrace the social aspects of model building and developing a less reductionist version of reality than many realist perspectives would provide (White 2016).

A third perspective in OR has seen scholars reject the 'paradigm wars' (Kotiadis and Mingers 2014; Mingers 2000, 2003) and adopt critical realism as a way of existing in the space between realism and non-realism (Mingers 2015; Sayer 2000). The critical realist view attempts to reinvite a realist view of being in the ontological domain whilst accepting the relativism of knowledge as socially and historically conditioned in the epistemic-logical domain (Mingers 2000, 2003, 2015; Sayer 1992). According to Mingers, critical realism fits well with the debates on OR as an applied discipline (Mingers 2000, 2003). In particular, it has been suggested that critical realism could be the basis for understanding the social situatedness of OR (Keys 1997; Sayer 2000).

18.3 What Can We Know About What Is Out There?

If ontology is our assumptions about the 'there' out there then, when conducting research, we need to think about how we can know about what is out there. This is the field of *epistemology*, the study of knowledge. As with ontology, there are differing opinions, with a continuum between the view that we have direct unmediated access to the world and a more contingent view that our ability to apprehend the world is partial and conditional. In this section we will unpack these different views and then in the subsequent section look at another element of epistemology—the question of how we know whether things are true or not.

18.3.1 Positivism

Operational Researchers are most likely to be familiar with positivism and its allied positions. *Positivism* grew out of the values of the Enlightenment and aimed to challenge the power of Popes and Princes by arguing that individuals could apprehend and test the reality around them and didn't have to rely on those in power to tell them what was true and what was false.

Positivism aims to use standardized methods of inquiry which rely on information observable through the human senses. Hypotheses should be developed inductively and then tested with the aim of being able to predict phenomena as well as the necessary and sufficient criteria for their existence. Research should be as value-free as possible, so not contaminated by the researcher or their views of the world.

In order to achieve this, positivism makes a number of assumptions which include the observer being independent of what is observed, that problems can be understood if broken down into parts and that causal relationships and fundamental laws can be produced that explain and predict human behavior.

Experience teaches us that the assumptions underpinning positivism are not always tenable. Consultants appearing on a factory floor affects behavior and performance—as we know from the Hawthorne studies. So the assumption of independence is not that sound. Similarly, some systems are so interconnected that they cannot be broken into parts without disturbing the system as a whole. For example, a star analyst at a bank may be good at their job but also rely on an interconnected web of relationships to perform (Groysberg et al. 2004)—and this may be almost impossible to identify and quantify.

18.3.2 Social Constructionism

The opposing pole to strong positivism is *social constructionism*. This is the view that everything we know about the world is constructed by humans and not "the neutral discovery of an objective truth" (Castello and Botella 2007, p. 263). When taking this view, researchers try to capture the process of construction as well as what is constructed. So *how* the phenomenon of interest was produced is evaluated, as well as the *what* of what was produced, and the *why* it came to be produced that way.

This leads to a very different set of research practices and, consequently, a very different sort of output to positivist approaches. In a social constructionist approach, the aim is to get a broad understanding of what is going on and what it means, rather than generate mechanistic causal relationships.

An example of where social constructionism might offer a different perspective would be in examining customer satisfaction. This is a subjective experience which has significant consequences for businesses. Parameters such as waiting time, churn rates and so forth may correlate with customer satisfaction but one person's two-minute wait might have a very different impact on another. Even asking people directly how satisfied they are may not give a good measure. Satisfaction has several meanings, one is to fulfill an obligation ("she has satisfied the examiners"), another might be to be satiated ("the meal left me completely satisfied") or happiness ("I am happy with the service I received") (see Hardy and Ford 2014). Constructionist approaches would dig beneath the measurement and try to understand not just what satisfied people, but what that actually meant.

Social constructionism also allows researchers to participate in the research. More positivist approaches prescribe detachment and independence. Constructionist approaches, by contrast, acknowledge the researcher's presence and their influence (for good or ill) on the results. This is particularly important for those working in consulting who, by the nature of their work, cannot be detached and objective, as they are part of what they are studying.

Constructionist approaches are commonly associated with qualitative research, where researchers use verbal rather than numerical data to delineate phenomena. This has the advantage of allowing richer and more compelling descriptions (restaurant menus and sales brochures are seldom written in numbers) but it also means that the data produced are less easily analyzed and manipulated. There is also a perception that qualitative data are less rigorous.

The whole continuum between positivism and social construction could, in some ways, be thought of as a continuum between the immutable laws that positivism seeks to uncover and the endless uniqueness that constructionists seek to describe.

18.3.3 Moderate Positivist and Constructionist Positions

Between the extremes of strong positivism and constructionism are more moderate positions which sacrifice methodological purity in the interests of real-world practicality.

On the positivist side this may mean less of binary choice between truth and falsehood, a relaxing of assumptions about observer independence and an understanding of the contingent nature of the principles governing human behavior. It may also involve embracing more qualitative approaches or examining single cases which offer new insights into phenomena. These weaker positivist approaches are less about identifying laws and more about identifying regularities which might illuminate different aspects of Operational Research.

At the interpretivist end this might mean relaxing assumptions about uniqueness and the importance of rich description and qualitative research, for example by embracing simple counting techniques which enable the reader "to gain a sense of the flavor of the data as a whole." (Silverman 1993, p. 163). The idea that everything is unique and valued may also be relaxed, acknowledging that some events and sources of data are more significant than others. This may help identify regularities which can then be used to inform practice.

In essence, these more moderate positions make different forms of research possible. Researchers are not tied solely to the principles of positivist scientific research, nor are they adrift in the endless variety of constructionist approaches. These more moderate epistemological positions also allow the mixing of different methods of research in order to provide converging lines of evidence which give the confidence that something robust and usable has been discovered.

18.3.4 Epistemological Implications for BOR

As with ontology, we will examine the relationship between the different epistemological viewpoints and our three tests for research output. When looking at whether research captures all of the phenomena of interest, the positivist approach can fall short. Observer independence and attempting to isolate specific aspects of phenomena may mean, almost by definition, that only parts of the phenomenon are explored. Constructionist approaches are more likely to capture the totality of a phenomenon but, as the viewpoint suggests, this will only be one particular view and others may be just as relevant. The more intermediate positions allow these trade-offs to be more finely tuned to the objectives of the research.

When looking at comparability of research, the positivist approaches score well as they conform to similar standards. By the same token, constructionist approaches are, by definition, incomparable. That said, constructionists acknowledge this incomparability and see it as a virtue, rather than a deficiency. Again, the more moderate positions may allow comparability but may also produce such a variety of approaches that studies cannot be compared.

The question of whether the research actually measures what we think it measures is an important one. Positivist approaches may well not be measuring what they think they're measuring because they do not capture the totality of the phenomenon being measured, or are confounded by the dynamic and evolving nature of social phenomena. Constructionist approaches faithfully reproduce what they think they are reproducing because they are fully seized of the contingent nature of what can actually be grasped. More moderate positions walk a line between attempting to produce generalizable findings which can be transferred from context to context whilst not losing sight of the fact that what is being recorded is ephemeral and transient.

OR has its main roots in positivism; research conducted in the positivist tradition "has been the most widely used approach in BOR thus far" (Brocklesby 2016, p. 123). However, overreliance on this approach has brought criticism from within the OR discipline, as Linstone (1985, p. 80) notes, "reliance is placed on data and models, and combinations thereof, as the only legitimate modes of inquiry… in its most extreme form, modeling becomes an end rather than a means ('the Pygmalion complex'). Quantitative analyses tend to drive out qualitative analyses."

As a corrective to this dominance, a number of OR studies have sought to develop constructivist accounts. But more needs to be done. For example, Ormerod's (2014) analysis of OR case research published in the main OR journals shows that most pieces focus on the technical aspects of the model used, less common ones report on why it was used, and, even less commonly, there are those that report on outcomes. Ormerod concludes that the lack of attention to social process, including the nonlinear, iterative, and negotiated aspects of the model-use-in-practice requires a radical rethinking of how research in OR is conducted.

This discussion of ontology and epistemology might seem abstruse and barely relevant to the Operational Researcher, and there is a century of Operational Research to prove this point. But the shift to Behavioral Operational Research means that ignoring ontology and epistemology is less of an option.

Having spent some time on ontology and epistemology we want to turn to a subsection of epistemology which gets relatively little academic interest but is fundamental to research. The problem of knowledge.

18.4 How Do We Know Anything?

There is nothing new in wondering how we know things. Plato wrote about it and many other philosophers have subsequently. Knowledge, these philosophers observed, was justified, true belief (JTB as it is commonly abbreviated). We have a belief—that it's 14:00; that there are daffodils on the table; that the new R&D program is working. It is true—it *is* 14:00; there *are* daffodils on the table; the new R&D program *has* produced a number of prototypes. And there is a justification—the clock on the oven says 14:00; my wife commented on the lovely daffodils; we did change the R&D arrangements and appoint a new head of R&D. So far, so good, as JTB gives us knowledge. But is it enough?

The answer is, unfortunately, no. The problem is most commonly associated with the philosopher Edmund Gettier who suggested that JTB is not sufficient to produce knowledge (Gettier 1963). One of the more accessible examples of what has become known as a Gettier problem, the following hypothetical case: Imagine that you are driving past a field and see what looks like a sheep. Based on that observation, you believe that there is a sheep in the field. Your belief turns out to be correct, as the field does contain a sheep, but it is actually out of sight on the other side of a hill. What you actually saw was a dog disguised as a sheep. Do you really have knowledge that there is a sheep in the field? You have a true belief that is justified by seeing what looks like a sheep in a place where sheep are normally found, but philosophers generally say that your belief does not constitute knowledge (Chisholm 1989). That is, you do not know that there is a sheep in the field if all you have seen is a dog in disguise, even if a sheep that you have not seen is really there. You have got the right result but the wrong mechanism. In essence, you are right but you have not got knowledge.

This is of fundamental importance for Behavioral Operational Research and management research in general. People obsess with method—the dog identification business. But they are often in narrow disciplinary silos and so have little knowledge in the field surveying business. They find something that gives them JTB but it is not knowledge as the reason they are right lies elsewhere.

Picking up the example from earlier on, the new R&D program is bearing fruit and we do have a new head of R&D. But it was an employee who has been with the firm for 30 years who happened to go to a conference and learn a new technique, coupled with some new equipment coming on the market and on-site childcare which all contributed incrementally to increased R&D output.

The problem here is that much management research focusses on complex methods using mathematical tools to establish whether the data support the conclusion (i.e. whether there is J for the TB). But do authors and reviewers have sufficiently broad knowledge to question what was observed—the data and accuracy of their underlying assumptions—to establish that their findings are not just accidental, artifacts or luck?

18.5 A Plea for Philosophy to Be Considered

Considering philosophical problems in BOR may feel like a classic piece of ivory tower self-indulgence. The busy researcher under pressure to produce results may feel that there isn't time for this sort of thing. In the words of one manager "we don't need theories, we just need things that work". But this is at the heart of the problem. How do we know what things are and whether they will work?

When Operational Researchers turned to behavioral matters, it seemed a straightforward move. If problems of standardization and decision rules can be adduced when making things, surely the same sorts of things can be done with people? But crossing the Rubicon into the social realm opens up a set of problems which complicate the research process. The nature of the social world is rather different and more evanescent. This means that existing approaches might work, but they might also lead us badly astray. We may not be addressing what we think we are addressing.

The question of what to do about this is one to which thick textbooks are devoted. But these textbooks may not be read by the nonsocial scientist—not least because they can seem quite impenetrable. But it is important to grasp that there are philosophical foundations to any research endeavor and that failing to attend to them—particularly in the behavioral domain, can lead to research that either does not properly capture the totality of the phenomenon of interest, is not comparable with other work or simply does not measure what the researcher believes it to measure. As the sociologist R. H. Tawney commented when talking about sociology—although he could equally have been talking about BOR—"Sociology, like history, is department of knowledge which requires that facts should be counted and weighed, but which, if it omits to make allowance for the imponderables, is unlikely to weigh or even count them right" (Tawney 1971, p. 147).

This chapter is not intended to serve as a primer on philosophy, rather it is an attempt to illustrate to the Behavioral Operational Researcher that there is a layer of complexity that can undermine their research. By thinking about what there is and how we can know about it, more effective research can be undertaken and conclusions be weighted with an appropriate degree of confidence. People do not behave like things and, whilst there are some principles which are relatively stable, there many are simply transient regularities. An understanding of the philosophical principles which undergird BOR helps ensure that any regularities observed are appropriately qualified and their transience acknowledged.

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19

Future Directions

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19.1 Reflections on Our Journey to a Capabilities and Competences Perspective in BOR

The development of Behavioral Operational Research (BOR) is casting new perspectives on behavioral issues within models and behavioral concerns beyond models. This field grew out of the attempt to draw on insights from behavioral sciences and attempts to incorporate their methods into OR. The collection in this book is not only consolidating some areas defined in our previous book (Kunc et al. 2016) but also contributing to the longstanding controversies in OR and highlighting some new ones.

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Each of the chapters is devoted to understanding the underpinnings of modeling, cognitive processes and the reciprocal bearing of decision-making on behavioral processes. What seems clear from many of the chapters is that a type of reductionism that often characterizes OR falls short of a broader explanation of the phenomena where models, modeler and the subjects they serve interact, calling for an increase in scope in the practice of OR beyond modeling by drawing on behavioral insights.

Paralleling the behavioral turn in economics (Kahneman and Tversky 1979; Thaler 1980, 1985; Tversky and Kahneman 1974), there is a risk that BOR constrains itself to developing further empirical evidence on the suboptimality of human decisions in OR contexts and not challenge the OR orthodoxy by continually pointing toward the empirical inadequacy of standard rational choice models. Beyond this foundational interest, with our competences and capabilities perspective, we seek to encourage a more developmental agenda for BOR. Articulating a distinct contribution of OR, some of our chapters highlight the distinctly human competences and capabilities that OR offers to support conflict resolution, stimulate creative thinking and aid with complex group decision processes. Foregrounding human competences and capabilities, we emphasize the agency that we, as OR practitioners, wish to exert over our changing contexts, as we aid efforts of decision-makers to inquire into, structure, model, simulate and intervene in our environments with a view to improving on the status quo.

Yet, there is no consensus on the role that behavioral science ought to play in OR. Some of the chapters suggest that a more philosophical perspective combined with conceptual analysis may contribute to a better understanding of BOR.

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In terms of the contributions, the book addresses the following three concerns: (1) Is there a definition of Behavioral OR?, (2) Is BOR too speculative? and (3) Is there a difference between BOR and other disciplines that have been affected by the *behavioral turn*?

19.2 Is There a Definition of Behavioral OR?

In our previous book (Kunc et al. 2016), we made a distinction between behavior *with, in and beyond* models. In this book, we settled on *with(in) and beyond* to reflect the consistent debates in the literature on OR models and the process of OR (cf. Brocklesby 2016). By bringing to bear competences and capabilities on the study of (B)OR, we emphasize the importance of *contexts* or, in other words, engaged practice. For example, one aspect of context is to propose that the BOR practitioner extend their skill sets beyond the competences of a technician with modeling skills to become a participating stakeholder in transformation processes (Manzi, Chapter 10; Malpass and Cassidy, Chapter 15). Indeed, OR has long cultivated competences to aid with the participatory management of tensions to develop actionable insight. Here, some of our contributors emphasize the socially embedded nature of OR practice, highlighting the need for the understanding of social connections and associated processes of participatory research (Burger, Chapter 11; de Gooyert, Chapter 12; Korzilius and van Arensbergen, Chapter 13; White, Chapter 16).

However, our contributors also raised the importance of better understanding organizational contexts which are often complicated by conflicting stakeholder interests and ingrained beliefs. As such, one area for further development appears to be the longer-term engagement perspective of BOR in organizations, seeking to understand not just episodic interventions but helping to create adaptive organizing processes over time (Burrow, Chapter 9, Malpass and Cassidy, Chapter 15).

Finally, we believe there is an opportunity to enhance BOR with aspects addressed by Behavioral Operations Management (BOM), such as the use of normative models and experiments to pin down behaviors that can contribute or diminish the performance of organizational systems (Kunc, Chapter 1; Önkal et al., Chapter 2; Momen, Chapter 3) as well as established practices, e.g. project management (Wang et al., Chapter 8) and auctions (Engin and Vetschera, Chapter 4).

In our Preface, we proposed that any definition of BOR needs to encompass the behavioral sciences, but also ensure that the essence of OR is retained. Given we define the context of BOR as both with(in) (the model itself) and beyond (modeling in terms of practice and interventions), we believe that defining the behavioral aspects of OR cannot be subsumed into one specific area of behavioral sciences. A more nuanced understanding could be that BOR considers behavioral aspects related to incorporating behavior with(in) models and the impact of behavioral, social and organizational context on the process of OR. So what does this mean for the relevance of BOR for worldly relevant or socially urgent issues?

19.3 Is BOR Too Speculative?

The contributions in this book introduce some socially relevant perspectives on areas of key concern and with the potential for impact: the behaviorally aware design of public policy (Kharmalov, Chapter 17), the politically aware structuring of participatory community processes (Korzilius and van Arensbergen, Chapter 13) and the possibilities for engagement through transparent models (Katsikopolous, Chapter 14), as well as use of non-traditional OR models with impact on behavior (Ferretti, Chapter 7). Some of our contributors also highlight the relevance of BOR in supporting decision aiding and decision guiding processes for positive change (Ferretti, Chapter 7).

Moreover, by applying BOR in new contexts, BOR appears to offer a distinctive methodological vantage point. By inquiring into competences and capabilities of 'more-than' human behavior, BOR may well turn out to have prepared the conceptual repertoire that is urgently needed for a debate on emerging technologies in Operational Research (Wilson 2018).

A philosophical reflection on relations between decision-makers and their increasingly 'intelligent' technological counterparts may well be considered in light of the call for further ontological and epistemological development of BOR (Hardy and Stiles, Chapter 18). We think there is a need for more deep philosophical reflection and theorizing rather than more speculative punts scaffolded by weak theories and descriptive case studies. Finally, we return to the question of distinctiveness of BOR.

19.4 Is There a Difference Between BOR and Other Disciplines that Have Been Affected by the Behavioral Turn?

When we take OR as a discipline specialized in creating normative mathematical models, there should not be differences between BOR and other behavioral disciplines, e.g. behavioral finance (Momen, Chapter 3), given the interest in dealing with deviations from rationality (heuristics and biases). However, OR is more than mathematical models as there is a strong problem structuring component in its practice that calls for disciplines associated with social processes and systems thinking (Durbach and Stewart, Chapter 5; Manzi, Chapter 10). To summarize, BOR needs a more comprehensive repertoire of behaviorally informed approaches.

The growing interest in integrating behavioral insights into existing practices is signaled by many fields through the addition of the term 'behavioral' to their traditional conceptual repertoire. This focus can be seen as paralleled by the use of behavioral insights in Behavioral Operations Management, where it is characterized by an interest in enhancing operations performance (Kunc, Chapter 1). However, to date, behavioral insights in BOR appear to be of interest as long as they enhance its practitioners' ability to design, coordinate and learn from interdisciplinary working. Whether we will see a *proper* behavioral turn in OR may, to a significant extent, depend on whether OR practitioners will begin to see theoretical and methodological insights from other disciplines as constitutive of their own competences and capabilities. Which future for BOR would we like to develop?

19.5 The Future of BOR

Our competence and capability perspective on BOR has emphasized the support for more work on the social aspects of behavior (Giordano et al., Chapter 6; Burger, Chapter 11; de Gooyert, Chapter 12; Korzilius and van Arensbergen, Chapter 13) and the importance of contexts and organizational processes (Kunc, Chapter 1; Önkal et al., Chapter 2). Moreover, competences and capabilities for the deliberate shaping of future behaviors have been highlighted (Kunc, Chapter 1; Burrow, Chapter 9; Malpass and Cassidy, Chapter 15).

Future research may provide further insight into trust, legitimacy and commitment in and of modeling processes. Other avenues may include finding approaches to manage tensions between stakeholders, enabled and augmented through modeling and dialog, which has been a core competence of OR practitioners.

We hope that this book generates debates that they will lead to conceptual, methodological and theoretical advances in the areas our contributors have proposed in order to gain a more nuanced understanding of competence and capabilities for behavioral OR.

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