

# Preface

Strategic behavior is the key to social interaction, from the ever-evolving world of living beings to the modern theater of designed computational agents. Several crucial dimensions come together in acting strategically. One dimension is that of agents having individual goals and intentions that they try to realize by taking decisions based on their current information and preferences, which may involve influencing others as well. A second dimension of strategies is the longer temporal horizon of agents having plans for dealing with complex scenarios of events unfolding over time, where, in particular, it is essential to respond in an optimal manner to what others do, or sometimes also to lead the way. Merging all these individual strategies results in forms of group behavior in which stable patterns of behavior may emerge representing some sort of equilibrium that is optimal for all. More generally, what we see at work here is a third, social dimension of group structure and collective goals and actions.

Strategies are often associated with recreational games such as chess and bridge. Strategies can also be associated with games in the sense of economic game theory, covering many social interactions such as selling one's house or playing the stock market. Finally, strategies play a role in using or even designing social software such as proper protocols for holding meetings or working toward a treaty that limits global warming. In the course of such scenarios, optimal strategies may involve the most delicate phenomena, for example, a balance between public and private information or between public and private goals.

Given this variety of games and strategic behavior across so many different spheres of life, studies of strategies can be found in many disciplines. Game theory is one major source of insights, but there are others. Strategies occur as generalized algorithms in computer science, where games have become an influential model for multi-agent systems for interactive computation by large networks of processors. In logic, strategies have supplied new models for valid reasoning or successful model checking. In philosophy, strategies for planned intentional behavior have entered the realm of ethics, philosophy of action, and social philosophy. In mathematics, intuitions about strategies in infinite games fuel the search for new axioms in the foundations of set theory. And the list keeps growing. Strategies in evolutionary games are a powerful model in biology, and combinations of ideas from both classic and evolutionary games are making their way into the study of meaning in linguistics as a communicative equilibrium, and into cognitive science, where strategies provide the link between *knowing that* and *knowing how*, and, more generally, learnability of cognitive skills.

This book aims at understanding the phenomenon of strategic behavior in its proper width and depth. It is based on a workshop held at the Lorentz Center in Leiden in 2012, emanating from the NWO project "Strategies in Multi-agent Systems: From Implicit to Implementable" on strategies as a unifying interdisciplinary theme. The aim of the workshop was, by bringing together congenial experts, to create a comparative view of the different frameworks for strategic reasoning in social interactions occurring

in game theory, computer science, logic, linguistics, philosophy, and the cognitive and social sciences. The workshop participants were (and are) active researchers in these areas, and they engaged in wide-ranging outreach discussions. The authors of this book represent a fair sample of the people involved and the themes that emerged. We have grouped their contributions as follows.

## **Reasoning About Games**

Part 1 of this book is concerned with reasoning about information and rational interaction in the paradigmatic arena of games, with ideas coming mainly from the contemporary interface of game theory and logic. Eric Pacuit, in his chapter “Dynamic Models of Rational Deliberation in Games” develops an interesting perspective on strategic reasoning in dynamic games, in which players take turns. Pacuit shifts the focus from the usual solution concepts and players’ beliefs about other players’ choices, to the processes of deliberation that underlie the participants’ strategic choices in such dynamic games.

Next we have two chapters presenting distinct perspectives on strategies in dynamic games. In his chapter “Reasoning About Strategies and Rational Play in Dynamic Games,” Giacomo Bonanno focuses on the counterfactual considerations implicit in the definition of a strategy of a player: What would the player do at information sets that are actually never reached? Bonanno highlights the implications of such counterfactual beliefs on the belief revision of players in dynamic games. In the process, he provides a fresh look at what is meant by the rationality of a player in terms of her choices and beliefs.

Andrés Perea, on the other hand, considers strategies as plans of actions, concentrating on the choice part only, rather than the belief part. Assuming such a notion of strategy in his chapter “Finite Reasoning Procedures for Dynamic Games,” he shows that for finite dynamic games, the infinitely many conditions associated with the concept of common belief in future rationality can be tackled using a finitary procedure. In all, Part I provides the reader with the flavors of the various notions of strategies discussed in the literature on game theory.

## **Formal Frameworks for Strategies**

Next, Part 2 of this book is concerned with formal frameworks for representing strategies, geared toward an analysis of their laws and their behavioral complexity, with an emphasis on combining techniques from logic, philosophy, computation, and automata theory. Nils Bulling, Valentin Goranko, and Wojciech Jamroga, in their chapter “Logics for Reasoning About Strategic Abilities in Multi-player Games,” provide a rich description of an approach to strategies from an external observer’s perspective, which has proved to be very useful in programming and verifying multi-agent systems. This approach, based on alternating-time temporal logic (ATL) and its variants, does not focus on players who reason based on the presumed

rationality of other players. Instead, the objects of analysis are the players' and groups' objective abilities to apply strategies guaranteeing that their goals are achieved, regardless of whether their opponents are rational and independently of the strategies applied by their opponents.

In their chapter "Using STIT Theory to Talk About Strategies," Jan Broersen and Andreas Herzig provide a detailed account of seeing-to-it-that (STIT) frameworks used in the analysis of strategies. They also investigate the connections between the STIT frameworks and the ATL frameworks described in the previous chapter, focusing on various properties of strategic reasoning.

The reader will encounter automata-theoretic approaches to strategies in the context of large dynamic games in the chapter "Automata and Compositional Strategies in Extensive Form Games," authored by Soumya Paul, R. Ramanujam, and Sunil Simon. They consider on-the-fly strategizing in games where the players only have a limited view of the game structures and hence need to resort to partial strategies for the relevant subgames.

This second part of the book ends with the chapter "Languages for Imperfect Information" by Gabriel Sandu, in which he looks into the game-theoretical semantics for different logics. The chapter mainly focuses on independence-friendly (IF) logics. Distinctive features of semantical games are considered, in accordance with different game-theoretical concepts, aiding in a logical analysis of games of imperfect information.

## Strategies in Social Situations

Finally, Part 3 of this book explores current uses of strategies in social situations with a range of examples coming from natural language use and scenarios in cognitive psychology and in the social sciences. Michael Franke and Robert van Rooij explore strategic aspects of communication in their chapter "Strategies of Persuasion, Manipulation, and Propaganda: Psychological and Social Aspects." Using decision theory and game theory, they first shine a light on the psychological question of what a communicator should undertake in order to manipulate someone else to adopt a certain opinion: Which information should she convey, and in which manner? Subsequently, the authors adapt DeGroot's model of opinion dynamics to tackle a more sociological question: Which individual agents should the manipulator address in order to effectively influence certain groups in society?

Jan van Eijck, in his chapter "Strategies in Social Software," shows how knowledge of design and analysis of algorithms in computer science may be fruitfully applied to mechanism design in social situations, taking into account that the participants in society may be aware of the mechanisms and may attempt to strategically turn these mechanisms to their own advantage. He illustrates his points by presenting various examples of strategic situations, such as a prisoner's dilemma with punishment for cheaters, the tragedy of the commons, and voting procedures.

## Wrapping Up

The book rounds off with Johan van Benthem's chapter "Logic of Strategies: What and How?," which presents some perspectives on the future of logical studies of strategies in the width suggested by this book.

Many common themes and working habits tie together the various chapters in this book, with logic often serving as the *lingua franca* that facilitates communication between fields. Moreover, many of the themes addressed by our authors cross between disciplines, where they often raise fundamental issues, such as the delicate interfaces of deliberate versus automated behavior, or of short-term versus long-term behavior, and more broadly, the interplay of theory and empirical reality, including the mixed world of today, where theory-driven design of social software and ICT hardware can lead to new forms of behavior.

We hope that this book will show the reader that strategies are a worthy subject of study in their own right, that they provide a common thread that connects many academic fields, from the humanities to the sciences, and that an improved understanding of strategies can also impact directly on how we behave and how we shape the social world around us.

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The picture on the front cover of this book is the woodblock print “Geisha Playing Go” by Kikukawa Eizan (1787–1867), from the collection of Erwin Gerstorfer, whom we would like to thank for his generous permission to use this beautiful print that conjures up the themes of this book.

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Johan van Benthem  
Sujata Ghosh  
Rineke Verbrugge

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