

Overview of the Handbook

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This handbook seeks to cover its topic, rationality, in an interdisciplinary way, more than any other existing handbook on this topic. Surely it cannot fulfill this intention completely. The topic is just too large. But it intends to reach broad representativity at least in its two main disciplines, philosophy and psychology. In addition, it presents some insights from disciplines such as artificial intelligence, behavioral and microeconomics, and neuroscience, although these areas are only partially covered here. The current program is already very ambitious.

The handbook is not organized along disciplinary lines of psychology and philosophy. This would be in clear contradiction to our interdisciplinary endeavor. Rather, it is organized along the common themes that occur in both fields, albeit often in different forms and under different names. In our introductory chapter, we propose various distinctions for classifying the overwhelming research on rationality. Certainly, the most important one is that between theoretical and practical rationality. This distinction is mirrored in the headings of part II and part III, the two main parts of this handbook. These parts are preceded by part I, which addresses some fundamental or propaedeutic matters concerning the history, some paradigms, and some key issues of research on rationality. The handbook concludes with part IV, which presents further facets of rationality that are relevant for both theoretical and practical rationality.

Each of the four parts consists of several sections, which in turn each contain several chapters, so that we ended up with 15 sections and 65 chapters. The order of chapters within a section does not have a particular significance. We just had to find one that creates connections between the different disciplinary backgrounds of the authors. The assignment of chapters to sections was more difficult. The field is so variegated and interlinked that no classification can be perfect. Still, we hope that we have organized the handbook in a way that makes it easy to read.

In our **introductory chapter**, we systematize the field by means of four binary distinctions: theoretical versus practical rationality, normative versus descriptive theories of rationality, individual versus social rationality, and outcome- versus process-oriented accounts of rationality. Since the distinctions can be combined with each other, we end up with a system of 16 compartments. Our chapter says something about most of the 16 compartments and uses this system not only to give guidance to the readers of this handbook but also to suggest a new classification system for researchers in human rationality. We recommend all readers to study this introductory chapter. This will certainly make it easier to orient oneself in, and to contextualize, the rich material collected in this handbook.

Part I: Origins and Key Issues of Rationality

The chapters in **section 1** deal with the history of rationality research and the cortical and evolutionary foundations of rational thinking. In chapter 1.1, *Thomas Sturm* describes the history of philosophical conceptions of rationality, which were just as much psychological conceptions. Since this history is so enormously rich, he just focuses on the emergence of the distinction between a descriptive and a normative perspective, which is so important for the entire handbook. This philosophical chapter is then complemented by chapter 1.2, in which *Jonathan Evans* summarizes the younger history of the psychology of reasoning from his personal point of view. Then, in chapter 1.3, *Gerhard Schurz* looks even farther back in time by speculating about the evolution of rationality. In chapter 1.4, *Vinod Goel* deals with the material basis of rationality, the brain. He presents findings from cognitive neuroscience and brain imaging on which cortical networks are involved in different kinds of rational thinking.

The chapters in **section 2** are concerned with some substantial philosophical and psychological topics of rationality. The section begins with chapter 2.1, in which

John Broome deals with the relation between rationality and reasoning. Both keywords are extensively used in this handbook, but they do not seem to denote exactly the same matter. The terms are also used quite differently in philosophy and psychology. In chapter 2.2, *Ralph Wedgwood* discusses the distinction between theoretical and practical rationality. This is also the top-level distinction in this handbook. The next chapters present various cognitive approaches to rationality. In chapter 2.3, *Philip Johnson-Laird* gives an overview of the theory of mental models, which is a far-reaching framework for explaining accurate and fallacious human reasoning. Another cognitive framework is the heuristics and biases approach, which is presented and critically discussed in chapter 2.4 by *Klaus Fiedler*, *Johannes Prager*, and *Linda McCaughey*. An equally influential framework is established by dual-process theories of reasoning. This framework and the related empirical evidence are presented by *Karl Christoph Klauer* in chapter 2.5. We could have placed the Bayesian reasoning theories here, too, as these theories also have a quite universal ambition. However, the relevant chapter by *Chater and Oaksford* fits even better in the section that is particularly dedicated to probabilistic reasoning. The last chapter in section 2 is a big jump toward artificial intelligence. In their chapter 2.6, *Johan van Benthem*, *Fenrong Liu*, and *Sonja Smets* outline the logico-computational perspective on rationality. They show how this approach can be efficiently used to solve rationality problems in computers. This chapter also creates a bridge to section 3 in part II, which is about logical and deductive reasoning.

Part II: Theoretical Rationality

Sections 3–7 are concerned with the key issues of theoretical (or “epistemic” or “doxastic”) rationality and reasoning. The first term originates from philosophy and is, in fact, not as common in psychology, in which cognitive theories of reasoning are a very active research field. However, the philosophical term is much broader and thus serves as the heading for the following sections. Not surprisingly, this part of the handbook starts with the two dominating reasoning paradigms: deductive logic as already conceived in ancient philosophy and probabilistic thinking as developed since the middle of the 17th century. These two paradigms are represented in sections 3 and 4, respectively.

The chapters in **section 3** are concerned with deductive logic and reasoning. Of course, the principles of propositional and first-order logic have long been part of the basic knowledge of our disciplines. Yet we wanted

to explain at least in one place of this handbook what a logical proof is and how it is related to rational belief. This is done in chapter 3.1 by *Florian Steinberger*, who added some novel ideas to this classical topic. Propositional and first-order logic are also important in cognitive research on human reasoning. In chapter 3.2, *David O’Brien* presents the natural-logic account and some evidence in support of this account. In chapter 3.3, *Sangeet Khemlani* explains the cognitive foundations of syllogistic reasoning, which is a fragment of first-order logic. His approach is based on mental models as described in chapter 2.3.

Then, **section 4** is concerned with approaches from probability theory. In chapter 4.1, *Alan Hájek* and *Julia Staffel* explain the normative foundations of Bayesianism. Chapter 4.2 by *Stephan Hartmann* complements this by explaining the usefulness of the theory of so-called Bayes nets. A further complement is given in chapter 4.3 by *Arthur Merin*, which unfolds the probabilistic core of all considerations of relevance. This is important for accounts of reasoning, since premises or arguments are usually assumed to be relevant for their conclusions. In chapter 4.4, *Niki Pfeifer* presents his probability logic. In chapter 4.5, *Nick Chater* and *Mike Oaksford* defend their psychological perspective on rationality as conceived within Bayesianism. This, in turn, is complemented by chapter 4.6 by *Klaus Oberauer* and *Danielle Pessach*, who explain what, for (some) psychologists, conditionals have to do with probability. Chapter 4.7 by *Didier Dubois* and *Henri Prade* also proceeds from the assumption that beliefs, or epistemic states in general, come in degrees. This is why the chapter is placed in this section. Yet, in their account, rational degrees of belief do not behave like probabilities but in certain other ways. We think it is important to acknowledge that such alternatives exist.

Logic and probability theory are, of course, not the only paradigms of theoretical rationality and reasoning. In fact, many other frameworks exist, and many of them are not restricted to quantitative conceptions of degrees of belief, as in Bayesianism. These alternative accounts are represented in the remaining sections of part II.

The chapters in **section 5** are concerned with qualitative representations of belief and the related accounts of reasoning. In chapter 5.1, *Hans van Ditmarsch* presents the basic theory of doxastic and epistemic logic. Then, belief revision theory is concerned with the rational change of epistemic states. This normative account of belief revision is described in chapter 5.2 by *Hans Rott*. The dynamic account of belief revision theory is completed by ranking theory. This theory is laid out in chapter 5.3 by *Gabriele Kern-Isberner*, *Niels Skovgaard-Olsen*,

and *Wolfgang Spohn*. The dynamics of belief is also important in cognitive theories of defeasible reasoning. In chapter 5.4, *Lupita Estefania Gazzo Castañeda* and *Markus Knauff* describe the empirical results on human belief revision and defeasible reasoning. They also explain how qualitative and quantitative theories try to account for the empirical findings. Defeasible reasoning, finally, is closely related to argumentation, where (rational) arguments drive (rational) epistemic change. The psychological perspective on argumentation is presented in chapter 5.5 by *Ulrike Hahn* and *Peter Collins*. Chapter 5.6 by *John Woods* deals with the same matter from a philosophical perspective.

There is also a close relation between epistemic change, on the one hand, and conditional and counterfactual reasoning, on the other, although the relation is not easy to specify. The broad range of approaches to reasoning with conditionals and counterfactuals is the topic of **section 6**. It begins with chapter 6.1 by *William Starr*, who reviews the different attempts to capture the logic of conditional and counterfactual constructions. In psychology, so-called supposition theory has become prominent. This attempt to explain human conditional reasoning is represented in chapter 6.2 by *David Over* and *Nicole Cruz*. In chapter 6.3, *Ruth Byrne* and *Orlando Espino* explain how human reasoners deal with counterfactual inferences. A special, but psychologically particularly relevant, case of conditional reasoning, so-called utility conditionals, is treated by *Jean-François Bonnefon* in chapter 6.4.

From counterfactual reasoning, it is just a small step to causal reasoning and its subform, diagnostic reasoning. The importance of causal reasoning among our many reasoning activities cannot be overemphasized. This is a huge topic on its own. Thus, we devote the complete **section 7** to it. In chapter 7.1, *Judea Pearl* presents his influential account of causal (and counterfactual) inference in probabilistic or statistical terms. How this kind of reasoning actually works in humans is discussed by *Michael Waldmann* in chapter 7.2. The special case of diagnostic reasoning is dealt with by *Björn Meder* and *Ralf Mayrhofer* in chapter 7.3. This is what this handbook offers concerning theoretical or epistemic rationality and reasoning.

Part III: Practical Rationality

Sections 8–12 deal with the core topics of practical rationality and decision making. Again, the first term is familiar in philosophy, and the second is mostly used in psychology. The terms are not equivalent, but they are close enough to be treated under one heading. We

think that in this way, we can best highlight the interdisciplinary links and show how both research areas are connected.

This part of the handbook should of course start with accounts of individual decision making, which is the topic of **section 8**. In chapter 8.1, *Till Grüne-Yanoff* explains the main ideas of preference and utility theory. Next, chapter 8.2 by *Martin Peterson* presents standard decision theory and the normative arguments in its favor. However, this account has been criticized from the psychological as well as from the economic side. Indeed, prospect theory arose from the observation that people often deviate from expected utility maximization. This theory is explained by *Andreas Glöckner* in chapter 8.3. However, there are still further ways how beliefs and desires can be combined to determine a rational decision. Some of them are presented in chapter 8.4 by *Brian Hill*. Another critical view on economic decision theory comes from the theory of bounded rationality, which is influential in psychology and economics. This approach is reviewed in chapter 8.5 by *Ralph Hertwig* and *Anastasia Kozyreva*. The section ends with a chapter 8.6 by *Valerie Thompson*, *Shira Elqayam*, and *Rakefet Ackerman*, which is concerned with the connection between rationality and metacognition. The authors report empirical results that show that metacognitive control and monitoring processes are important for promoting our rational performance. Thinking about our own thinking makes us more rational. This chapter is quite general, and it might have fit under other headlines, but it also connects well to the previous chapters on practical rationality.

Then, **section 9** deals with game theory, the other standard theory of practical rationality. We treat here only so-called noncooperative game theory, which is, strictly speaking, still about individual practical rationality but in a social context. Chapter 9.1 by *Max Albert* and *Hartmut Kliemt* presents the classical theory, as it has been developed since the 1940s. In the 1980s, epistemic game theory emerged, which promises a more rigorous rationalization of the norms of game theory. This theory is described in chapter 9.2 by *Andrés Perea*. A different perspective is offered by evolutionary game theory, which is outlined by *J. McKenzie Alexander* in chapter 9.3. Again, these theories are criticized from the empirical point of view. This led to the rise of behavioral and psychoeconomics, which are sometimes (mistakenly) seen as fields of psychology but are still driven by the interests of economists. The many different ideas in this area are presented in chapter 9.4 by *Sanjit Dhami* and *Ali al-Nowaihi*.

In our introductory chapter, we explain why most research on rationality focuses on individual rationality.

In fact, **section 10** is the only section that really deals with social rationality in the proper sense. Therefore, it is not strictly limited to practical matters. In chapter 10.1, *Franz Dietrich* and *Kai Spiekermann* deal with social epistemology, which discusses the normative standards for group belief formation. Recently, related topics such as we-intentionality and collective rationality have developed into a larger philosophical field. These topics are presented in chapter 10.2 by *Hans Bernhard Schmid*. Communication, particularly linguistic communication, is a very special social and rational activity, which is the topic of chapter 10.3 by *Georg Meggle*. Rational choice theory has also become a strong paradigm in the social sciences. This line of research is explained by *Werner Raub* in chapter 10.4. A look into the history of philosophy, into political philosophy, and so on reveals that the standard theories of practical rationality go far beyond the scope of instrumental decision making. At least chapter 10.5 by *Julian Nida-Rümelin*, *Rebecca Gutwald*, and *Niina Zuber* discusses such extensions and under the label of “structural rationality.” Finally, in chapter 10.6, *Leda Cosmides* and *John Tooby* present their adaptationist account of rationality. Although their evolutionary account seeks to explain all forms of human rationality, their chapter mainly focuses on practical rationality.

Practical reasoning need not proceed in quantitative terms of probabilities, utilities, or the like. Deontic and legal reasoning, for instance, can rely on qualitative representations and processes. Such qualitative accounts are the topic of **section 11**. In chapter 11.1, *John Horty* and *Olivier Roy* present the current state of the art in deontic logic (i.e., the logic of obligations and permissions). Then, in chapter 11.2, *Shira Elqayam* deals with the psychological theories of deontic reasoning. Legal reasoning is sufficiently different from deontic logic to deserve a separate treatment. This is given in chapter 11.3 by *Eric Hilgendorf* and in chapter 11.4 by *Henry Prakken*. A surplus of these chapters is that they represent different legal cultures, which heavily determine the field: chapter 11.3 is embedded in German law, while chapter 11.4 is based on the Anglo-Saxon legal system.

Whenever we are engaged in practical reasoning and decision making, moral issues come into play. In fact, they often are more important than issues of rationality. However, morality is a different topic, which we do not tackle in this handbook. We only wanted to address a few connections to rationality. These connections are the topic of **section 12**, which consists of two philosophical chapters and a psychological one. Chapter 12.1 by *Christoph Fehige* and *Ulla Wessels* describes the relation between rationality and morality in philosophy, while

chapter 12.2 by *Michael Smith* deals with moral reasons, also from a philosophical point of view. But moral judgments are also a big topic in psychology. In chapter 12.3, *Alexander Wiegmann* and *Hanno Sauer* describe the psychological view on moral judgments and their relation to rationality. This concludes our chapters on practical rationality.

Part IV: Facets of Rationality

Sections 13–15 deal with further facets of rationality. Their topics are so distinct that they could not be subsumed under the headings of theoretical and practical rationality. In fact, most of the questions arise in *both* areas of human reasoning. For example, **section 13** is concerned with visual and spatial thinking. Such cognitive processes are an important complement to the many chapters in which reasoning is conceptualized, more or less explicitly, in linguistic or propositional terms. An important question in this context is the connection between logical and diagrammatic reasoning. In chapter 13.1, *Mateja Jamnik* takes the perspective of a computer scientist and argues that diagrams can help to reason logically. Another question is how humans and artificial intelligence systems reason about space and time. In chapter 13.2, *Marco Ragni* describes some differences and explains why people sometimes commit errors in spatial and temporal reasoning. In chapter 13.3, *Markus Knauff* explores whether visualization supports or hampers human reasoning. The empirical results show that it can indeed sometimes impede reasoning.

Another distinct topic is scientific rationality, which has theoretical as well as practical aspects, and which is, of course, of essential concern to us as scientists. The three chapters in **section 14** deal with different aspects of scientific rationality. One idea is that the sciences exercise a particularly sophisticated form of epistemic rationality, which may have stronger claims on objectivity. This idea is pursued in chapter 14.1 by *Line Edslev Andersen* and *Hanne Andersen*. Another topic is the value-freedom of science. This is the topic of chapter 14.2 by *Anke Bueter*. Finally, it is also important how scientific results are communicated to and perceived by the public. In chapter 14.3, *Rainer Bromme* and *Lukas Gierth* discuss the public understanding of science and its relation to scientific rationality.

The final **section 15** consists of still more chapters of psychological and even political interest. Chapter 15.1 by *Henry Markovits* explains how children learn to reason rationally. Chapter 15.2 by *Keith Stanovich*, *Maggie Toplak*, and *Richard West* presents the psychological

findings concerning the connection between intelligence and rationality—it is not quite as close as it may seem. Chapter 15.3 by *Stephanie de Oliveira* and *Richard Nisbett*, finally, reports how training can improve people's rational thinking and that such training does not even need to be intensive or time-consuming.

This is also an optimistic message at the end of this handbook, which offers a big journey through the state of the art in rationality research. We can only recommend again to start this journey with our introductory chapter. It gives a systematic structure to the field and should help our readers to make cross-connections between the philosophical and psychological methods, theories, and ideas represented in this handbook. Research in these (and some other) areas has been conducted separately for too long, an anachronism that this handbook aims to overcome.

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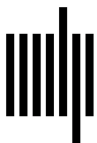
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