Decision Theory: Principles and approaches

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to our advisors: Don Berry, Morrie De Groot and Jay Kadane,
and to their advisors: Jay Kadane, Jimmy Savage and Herman Chernoff.

Preface

Goals

The goal of this book is to give an overview of fundamental ideas and results about rational decision making under uncertainty, highlighting the implications of these results for the philosophy and practice of statistics. The book grew from lecture notes from graduate courses taught at the Institute of Statistics and Decision Sciences at Duke, at the Johns Hopkins School of Public Health, and at the University of Washington. It is designed primarily for graduate students in statistics and biostatistics, both at the master and PhD level. However, the interdisciplinary nature of the material should make it interesting to students and researchers in economics (choice theory, econometrics), engineering (signal processing; risk analysis), computer science (pattern recognition and artificial intelligence), and scientists who are interested in the general principles of experimental design and analysis.

Rational decision making has been a chief area of investigation in a number of disciplines, in some cases for centuries. Several of the contributions and viewpoints are relevant to both the education of a well rounded statistician and to the development of sound statistical practices. Because of the wealth of important ideas, and the pressure from competing needs in current statistical curricula, our first course in decision theory aims for breadth rather than depth. We paid special attention to two aspects: bridging the gaps among the different fields that have contributed to rational decision making, and presenting ideas in a unified framework and notation while respecting and highlighting the different and sometimes conflicting perspectives.

With this in mind, we felt that a standard textbook format would be too constraining for us and not sufficiently stimulating for the students. So our approach has been to write a "tour guide" to some of the ideas and papers that have contributed to making decision theory so fascinating and important. We selected a set of exciting papers and book chapters, and developed a self contained lecture around each one. Some lectures are close to the source, while other stray far from their original inspiration. Naturally, many important articles have been left out of the tour. Our goal was to select a set that would work well together in conveying an overall view of the fields and controversies.

We decided to cover three areas: the axiomatic foundations of decision theory; statistical decision theory; and optimal design of experiments. At many universities, these are the subject of separate courses, often taught in different departments and schools. Current curricula in statistics and biostatistics are increasingly emphasizing interdisciplinary training, reflecting similar trends in research. Our plan reflects this need. We also hope to contribute to increased interaction among the disciplines by training students to appreciate the differences and similarities among the approaches.

We designed our tour of decision theoretic ideas so that students might emerge with their own overall philosophy of decision making and statistics. Ideally that philosophy will be the result of contact with some of the key ideas and controversies in the different fields. We attempted to put contributions of each article in some historical perspective and to highlight developments that followed. We also developed a consistent unified notation for the entire material and emphasized the relationships among different disciplines and points of view. Most lectures include current day materials, methods and results, and try at the same time to preserve the viewpoint and flavor of the original contributions.

With few exceptions, the mathematical level of the book is basic. Advanced calculus and intermediate statistical inference are useful prerequisites, but an enterprising student can profit from most of the the book even without this background. The challenging aspect of the book lies in the swift pace at which each lecture introduces new and different concepts and points of view.

Some lectures have grown beyond the size that can be delivered during a one-hour-and-a-half session. Some others merge materials that were often taught as two separate lectures. But for the most part, the lecture-session correspondence should work reasonably well. The style is also closer to that of transcribed lecture notes than that of a treatise. Each lecture is completed by worked examples and exercises that have been helpful to us in teaching this material. Many proofs, easy and hard, are left to the student.

Acknowledgments

We have intellectual debt to more people than we can list, but a special place in this list is occupied by courses we took and lecture notes we read. Giovanni's course at Duke was initially developed from two main sources. The first are lectures from Teddy Seidenfeld's course on the Foundations of Statistics. Giovanni only took it five times —he will firmly hold he did not choose the stopping rule: left to his own devices he would have taken that class forever. The second are lectures from Schervish's course on Advanced Statistics, from which his book on the "Theory of Statistics" would ultimately develop. We also had access to a very insightful bootleg of Charles Stein's lecture notes at Stanford, from an edition of the course taught by Persi Diaconis.

Dennis Lindley reviewed an early draft and gave very constructive

comments and encouragment. Other anonymous reviewers gave helpful feedback. Bruno Sansó used our notes it to teach his class at the University of California at Santa Cruz, and gave us detailed comments. We used our notes in teaching for over a decade. Many students braved earlier drafts, gave useful feedback through questions, conversations, solutions to problems, and sometimes highly informative puzzled looks. Marty Macintosh shared his precious correspondence with Herman Chernoff.

Both of us are grateful to Hedibert Lopes, with whom our long journey to writing this book had started back in the mid nineties. His notes from Giovanni's classes were used extensively in early versions of this book, and some figures, problems, and examples still carry his hallmark.

Lurdes is thankful to Sergio Wechsler who opened the door to new ways of thinking about statistics and introducing her to decision theory. She thanks Giovanni for inviting her to this journey, which through bumps and laughter, has been a lifetime experience. She cannot wait for the next one [well, give and take some time off for her recovery from the thrill!]. She wishes to thank the loving support from her brothers Roberto, Carlos and Silvio and from her uncles Masao, Olinda and Tadazumi. Finally, her loving gratitude goes to her parents, Satie and Kasuo, and her grandmother Matta, for the inspiring memories and lessons that guide Lurdes.

Giovanni still has mixed feelings about the day Marco Scarsini handed him a copy of Wald's book on decision functions, with the assigment of reporting about it to an undergraduate discussion group. Later Michele Cifarelli, Guido Consonni, Morrie DeGroot, Jay Kadane, Teddy Seidenfeld, Mark Schervish, Nick Polson, Don Berry, Pietro Muliere, Peter Müller, and David Matchar fueled his intellectual passion for rational decision making. Giovanni's wife Francesca is a statistician who, despite her impact on national policy making at various levels, is a bit bored by the kind of decision theory her husband favors, and perhaps baffled by the scant influence all the talking about rationality has had on his personal behavior. Nevertheless, she has been fully supportive of this never-ending project, in more ways than one can list. Giovanni thinks working with Lurdes has been absolutely fantastic. He has not told her yet, but he is already thinking about notation changes for the second edition....

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