Preface

This book originated from a curious and serendipitous mix of personal and professional factors several years ago. We (Basabdatta Sen Bhattacharya and Fahmida N Chowdhury) first met in 2010, during a luncheon at the WCCI (World Congress in Computational Intelligence) in Barcelona, Spain. At that conference, Fahmida had co-organized and presented an NSF-NIH (US National Science Foundation and US National Institutes of Health) grant-writing workshop with NIH scientist Patricia Mabry. Some of the potential funding areas from both of those US agencies could involve neuro-computational modeling of various disorders. Basabdatta was already working on using computational models in understanding biomarkers in brain-signals corresponding to neurological disorders. Against this backdrop, our conversation turned to health-related applications of mathematical and computational modeling; and it is during these discussions that we questioned whether there were any uniform standards for validating models with real data obtained from experimental psychology (or from other sources). We continued this discussion via email, which eventually led to the development of a workshop at the 2013 OCNS (Organisation for Computational Neurosciences) Annual Meeting in Paris, France; the workshop was titled "Validating neuro-computational models of neurological and psychiatric disorders". The workshop was run jointly by Basabdatta Sen Bhattacharya and Rosalyn Moran, and was an interesting mix of talks—speakers included Piotr Suffczyński, Dimitris Pinotsis, Udo Ernst, Andre Marreiros, Ingo Bojak and Rosalyn Moran with an opening overall introductory talk by Basabdatta Sen Bhattacharya. Post-workshop, the idea was presented to Springer, who has a 'tie-up' with the OCNS annual meetings and offers interested parties to forward proposals for edited compilations on the workshops organised for its series on Computational Neurosciences, eds. A. Destexhe, R. Brette. We do not claim that this book represents a comprehensive overview or analysis of existing model validation procedures used by research groups and laboratories across the field of computational neuroscience. Rather, the book is a snapshot of some of the major work in modeling and validation, coming from a diverse group of researchers in the field.

We are convinced that this effort is very timely, because the field of computational neuroscience has now matured to the point where proper validation of the various models proposed by different research groups would be required in order

for the field to grow in a more cohesive and meaningful fashion. Otherwise, we run the risk of getting stagnated by the incompatibility of data formats, problems with reproducibility, and, most importantly, lack of any real impact in terms of usability in the fields of health and medicine.

The issue of model validation has received attention from many traditional fields of science and engineering; indeed, there is general agreement that validation is the process of determining to what extent a model represents the real world from the perspective of the intended uses of the model. A look at a 1978 report entitled "Methods and Examples of Model Validation—An Annotated Bibliography", by J. Gruhl and N. Gruhl from MIT Energy Laboratory, reveals just how extensive the topic is: even 36 years ago, the bibliography in this report was 74 pages long. It is worth quoting a short paragraph from this report, where the authors provide a list for validation approaches:

- Comparison with other empirical models
- Comparison with theoretical or analytical models
- Comparison with hand calculations or reprogrammed versions of model components
- Data splitting on observed data, by time or region
- Obtain new estimation/prediction data with time, new experiments, or in-simulated environments
- Examination of reasonableness and accuracy, that is, comparison with understanding
- Examination of appropriateness and detail.

This list was generated by and for engineers, but the concept is quite applicable to other fields, including computational neuroscience. Indeed, many researchers are already using these ideas, although we did not find in the published literature any collective presentation and explicit discussion of the issues involved. Perhaps this book will fill that gap. To that effect, the Introductory Chapter of this book (by Rosalyn Moran) captures the essence and the connections between the various modeling and validation approaches presented in the book. Thus, it is strongly recommended that the Introductory Chapter be read first, to set the context for the rest of the book. The sequence of the chapters follows the exposition presented in the introduction; however, each chapter is self-contained, and can be read independently. It is worth mentioning—at the risk of stating the obvious—that ultimately, validation of these models will have to come from the user communities, and therefore, validation techniques must be developed in close cooperation with the experimental scientists, with clear understanding of end-user goals. Our sincere and humble hope is that this book will bring model validation issues to the forefront and serve as a significant step toward generating a more unified and coordinated effort toward this crucial issue in our research enterprise.

We could not have done this work without support and encouragement from our employers, the US National Science Foundation and the University of Lincoln, UK. We are grateful to Rosalyn Moran, who not only played a leading part in the CNS workshop but provided immense help, support and guidance during planning and

editing of the book; suffice it to say that the book would not be what it is without her input. Basabdatta Sen Bhattacharya would like to thank Péter Érdi for his review of the first draft of the workshop proposal; the final title as well as the 'body' of the workshop theme was a modified version based on his feedback. We are grateful to our families, friends and colleagues for their support and understanding.

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