Modelling Natural Action Selection

Action selection is a fundamental problem in biology and ecology. It requires determining available alternatives, executing those most appropriate, and resolving conflicts among competing goals and possibilities.

Using advanced computational modelling, this book explores cutting-edge research into action selection in nature from a wide range of disciplines, from neuroscience to behavioural ecology, and even to political science. It delivers new insights into both detailed and systems-level attributes of natural intelligence and demonstrates advances in methodological practice. Contributions from leading researchers cover issues including whether biological action selection is optimal, neural substrates for action selection in the vertebrate brain, perceptual selection in decision making, and interactions between group and individual action selection.

This major integrated review of action selection in nature contains a balance of review and original research material, consolidating current knowledge into a valuable reference for researchers, while illustrating potential paths for future studies.

Anil K. Seth is a Reader in the School of Informatics at the University of Sussex, an EPSRC Leadership Fellow, and Co-Director of the Sackler Centre for Consciousness Science. His research crosses the fields of computational neuroscience, consciousness science, and neurorobotics. In addition to contributing new insights into the mechanisms of action selection, he has developed new ways to link brain activity to conscious experience and he is well known for his research on the statistical analysis of causality.

Tony J. Prescott is Professor of Cognitive Neuroscience at the University of Sheffield where he teaches courses on computational neuroscience and biomimetic robotics. His research lies within the biological and brain sciences, and concerns understanding the evolution, development, and function of natural intelligence. He is particularly well known for his work on modelling the neural substrates for action selection, and building robot models of animal and human behaviour.

Joanna J. Bryson is a Reader in the Department of Computer Science at the University of Bath. She conducts interdisciplinary research on the origins, structure, and construction of human and animal-like intelligence, and is involved in topics ranging from the evolution of altruistic communication to the ethical role of robots in our society. She is recognised for her work in systems AI and the design of action selection. Her most recent work is centred on the application of modelling to understanding the evolution of human social structures and culturally derived behaviour more generally.
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Edited by

ANIL K. SETH
University of Sussex

TONY J. PRESCOTT
University of Sheffield

JOANNA J. BRYSON
University of Bath
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Foreword

The sea pen leads a simple life. After floating on the deep-sea currents as a juvenile, it settles down onto a comfortable patch of sand and begins its largely immobile adult life, growing into a feathery shape and swaying in the water while ensnaring whatever edible morsels pass its way. It hardly moves on its own; it just passively filters the world that goes by. No choices need be made, for there are no actions to take. As such, the sea pen will not feature prominently in this book.

For other more active (and more behaviourally interesting) species, life presents a stream of decision points, at which actions must be chosen: stay or move on, ingest or pass by, approach or avoid, wait or strike, court/accept or decline. These are all essentially forms of the exploitation/exploration trade-off that organisms must balance throughout their lives, whenever resources are distributed in space or time and the individual can actively seek them. This is the realm of natural action selection. How do organisms do it?

Action selection mechanisms are decision mechanisms. Like the study of decision mechanisms used for making inferences – a common topic in research on (human) judgement and decision making – the study of action selection mechanisms aims to uncover what the mechanisms are that people and other animals use, how they work, and when and where they work well or do not work – that is, the conditions under which they do or do not produce adaptive (or rational) behaviour. Research on human inference has revealed that there are multiple decision mechanisms that people can use in particular situations – the mind’s adaptive toolbox – and often several of these can produce similar outcomes. The chapters in this book reveal the range of possible action selection mechanisms that can be used as well. Some of the simple heuristics that have been identified for human inference show that decisions can be made without fully comparing different alternatives on multiple incommensurate dimensions (e.g., by ignoring conflicting dimensions and just deciding on the basis of one factor); some of the models in this book show similar shortcuts or rules of thumb that can work in action selection. One difference between standard decision-making research and that on natural action selection is that, in the former, the possible alternatives that can be selected in an inference task are generally known or specified by the researcher, e.g., which city is larger, Detroit or Milwaukee? The possible actions that an animal might take in nature may not always be explicitly identified and, without knowing precisely the range of possibilities, studying the mechanisms that select among them becomes more difficult.
In the human inference literature, the study of the contents of the adaptive toolbox has led to a further question beyond asking how people choose between alternatives in an inferential task: how do people choose what mechanism to use to make their inferences in a particular task? That is, how do people choose which tool to use from the adaptive toolbox? This is an open and challenging question, with different possible answers; sometimes the environment will determine the choice, depending on what types of information are available; other times, individuals may learn through experience or can be taught what decision mechanisms are good to employ in particular settings. If there are multiple competing action selection mechanisms in a given situation – not just multiple competing actions themselves – then this kind of meta-selection question will also be important in the study of natural action selection.

Specifying the action selection mechanisms that inhabit the mind's adaptive toolbox means specifying how they work – but how can this be determined? This is also a main theme of this book: exploring the methods that are being employed at the cutting edge of research for understanding the operation of action selection mechanisms. Experiments and field observations are necessary for generating data on action selection in action, but the data must be understood in terms of a theory. Here the theories are instantiated as models, which because they often operate at multiple levels – cognitive, neural, and social – are complex enough that they are best implemented as computer simulations. Ideally, multiple competing models then specify further data to be collected to distinguish between them, and the new data constrain the models (and the theoretical understanding) further, in an ongoing feedback loop. In this book we see multiple stages of that process, and the current state of understanding to which it has led.

This modelling approach can thus be characterised as ‘understanding by building’. But once the action selection models have been built and understood, we can also use the models as a way to explore how to change things in important application areas. The applications, like the models, can be at different levels of description. At the neural level, important health implications emerge from understanding clinical conditions such as Parkinson’s disease and obsessive–compulsive disorder as disruptions of action selection. And by better knowing how natural action selection works at this level, we can gain better understanding of what is going on when things go wrong – tweaking the models to achieve ‘understanding by breaking’ – and insights into possible ways of addressing those problems.

At the individual and social level, we may want to help people choose better courses of actions for themselves and others – avoiding the third piece of chocolate cake, or promoting the election of innovative leaders. Again by modelling and understanding the processes of action selection at these levels of description, we can develop, and test, ideas for how to change the action selection process in desired directions, before trying them out in the real world. These methods could involve giving people and groups new ways of selecting their actions – new tools for choosing what and when to eat, or new voting mechanisms, for instance – or could rely on changing the environmental cues that they receive, to ‘nudge’ people into making different selections. And modelling can help us determine which approach may be more effective, changing environments or changing minds or norms.
Hence, the work in this book is important. And it is incumbent on readers not just to passively filter and accept what is written here, but to actively choose to ingest or pass by, approach or avoid, accept or decline, and above all explore and exploit the ideas presented herein.

Peter M. Todd
Preface

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Contributors

Yasushi Ando
Department of Computer Science, University of Bath, UK

Andrew G. Barto
Department of Computer Science, University of Massachusetts, Amherst, MA, USA

Max Berniker
Bayesian Behavior Lab, Rehabilitation Institute of Chicago, Northwestern University, Chicago, IL, USA

Rafal Bogacz
Department of Computer Science, University of Bristol, UK

Matthew M. Botvinick
Princeton Neuroscience Institute and Department of Psychology, Princeton University, NJ, USA

Joanna J. Bryson
Department of Computer Science, University of Bath, UK

Jonathan M. Chambers
Department of Psychology, University of Sheffield, UK

Paul Cisek
Department of Physiology, University of Montréal, QC, Canada

Guy Cowlishaw
Institute of Zoology, Zoological Society of London, London, UK

Frederick L. Crabbe
Computer Science Department, U.S. Naval Academy, Annapolis, MD, U.S.A.

Eddy J. Davelaar
Department of Psychological Sciences, Birkbeck College, University of London, UK
List of contributors

Anna Dornhaus
Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ, USA

Michael J. Frank
Departments of Psychology and Cognitive and Linguistic Sciences, Brown University, Providence, RI, USA

Nigel R. Franks
School of Biological Sciences, University of Bristol, UK

Kevin N. Gurney
Adaptive Behaviour Research Group, Department of Psychology, University of Sheffield, UK

Thomas E. Hazy
Department of Psychology, University of Colorado Boulder, Boulder, CO, USA

Russell A. Hill
Department of Anthropology, Durham University, UK

James C. Houk
Northwestern University Medical School, Chicago, IL, USA

Alasdair I. Houston
Centre for Behavioural Biology, University of Bristol, UK

Mark D. Humphries
Adaptive Behaviour Research Group, Department of Psychology, University of Sheffield, UK

Konrad Körding
Bayesian Behavior Lab, Rehabilitation Institute of Chicago, Northwestern University, Chicago, IL, USA

Tim Kovacs
Department of Computer Science, University of Bristol, UK

Michael Laver
Department of Politics, New York University, NY, USA

Hagen Lehmann
Department of Computer Science, University of Bath, UK
List of contributors

Brian S. Logan
School of Computer Science, University of Nottingham, UK

James A. R. Marshall
Department of Computer Science, University of Bristol, UK

James L. McClelland
Center for the Neural Bases of Cognition, Carnegie Mellon University, Pittsburgh, PA, USA

John M. McNamara
Centre for Behavioural Biology, University of Bristol, UK

Yael Niv
Princeton Neuroscience Institute and Department of Psychology, Princeton University, NJ, USA

Randall C. O'Reilly
Department of Psychology, University of Colorado Boulder, Boulder, CO, USA

Richard A. Pettifor
Institute of Zoology, Zoological Society of London, London, UK

Robert Planqué
Department of Mathematics, VU University Amsterdam, The Netherlands

Tony J. Prescott
Adaptive Behaviour Research Group, Department of Psychology, University of Sheffield, UK

Sean A. Rands
Centre for Behavioural Biology, University of Bristol, UK

J. Marcus Rowcliffe
Institute of Zoology, Zoological Society of London, London, UK

Anouk Scheres
Department of Psychology, University of Arizona, Tucson, AZ, USA

Michel Schilperoord
Complex and Adaptive Systems Laboratory, University College Dublin, Ireland

William I. Sellers
Faculty of Life Sciences, University of Manchester, UK
List of contributors

Ernest Sergenti
Department of Politics, New York University, NY, USA

Anil K. Seth
Sackler Centre for Consciousness Science, and School of Informatics, University of Sussex, Brighton, UK

Scott J. Sherman
Department of Neurology, University of Arizona, Tucson, AZ, USA

Tom Stafford
Adaptive Behaviour Research Group, Department of Psychology, University of Sheffield, UK

Mark D. Steer
Centre for Behavioural Biology, University of Bristol, UK

Marius Usher
Department of Psychology, Birkbeck College, University of London, UK

Kunlin Wei
Bayesian Behavior Lab, Rehabilitation Institute of Chicago, Northwestern University, Chicago, IL, USA

Julian Zappala
School of Computer Science, University of Nottingham, UK

Jiaxiang Zhang
Department of Computer Science, University of Bristol, UK