

# *Models of Information Processing in the Basal Ganglia*



edited by

**James C. Houk, Joel L. Davis,  
and David G. Beiser**

# Models Of Information Processing In The Basal Ganglia Computational Neuroscience

**Robert Hecht-Nielsen, Thomas  
McKenna**



## **Models Of Information Processing In The Basal Ganglia Computational Neuroscience:**

*Models of Information Processing in the Basal Ganglia* James C. Houk, Joel L. Davis, David G. Beiser, 1995 This book brings together the biology and computational features of the basal ganglia and their related cortical areas along with select examples of how this knowledge can be integrated into neural network models Recent years have seen a remarkable expansion of knowledge about the anatomical organization of the part of the brain known as the basal ganglia the signal processing that occurs in these structures and the many relations both to molecular mechanisms and to cognitive functions This book brings together the biology and computational features of the basal ganglia and their related cortical areas along with select examples of how this knowledge can be integrated into neural network models Organized in four parts fundamentals motor functions and working memories reward mechanisms and cognitive and memory operations the chapters present a unique admixture of theory cognitive psychology anatomy and both cellular and systems level physiology written by experts in each of these areas The editors have provided commentaries as a helpful guide to each part Many new discoveries about the biology of the basal ganglia are summarized and their impact on the computational role of the forebrain in the planning and control of complex motor behaviors discussed The various findings point toward an unexpected role for the basal ganglia in the contextual analysis of the environment and in the adaptive use of this information for the planning and execution of intelligent behaviors Parallels are explored between these findings and new connectionist approaches to difficult control problems in robotics and engineering Contributors James L Adams P Apicella Michael Arbib Dana H Ballard Andrew G Barto J Brian Burns Christopher I Connolly Peter F Dominey Richard P Dum John Gabrieli M Garcia Munoz Patricia S Goldman Rakic Ann M Graybiel P M Groves Mary M Hayhoe J R Hollerman George Houghton James C Houk Stephen Jackson Minoru Kimura A B Kirillov Rolf Kotter J C Linder T Ljungberg M S Manley M E Martone J Mirenowicz C D Myre Jeff Pelz Nathalie Picard R Romo S F Sawyer E Scarnat Wolfram Schultz Peter L Strick Charles J Wilson Jeff Wickens Donald J Woodward S J Young

Computational Models of Brain and Behavior Ahmed A. Moustafa, 2017-11-13 A comprehensive Introduction to the world of brain and behavior computational models This book provides a broad collection of articles covering different aspects of computational modeling efforts in psychology and neuroscience Specifically it discusses models that span different brain regions hippocampus amygdala basal ganglia visual cortex different species humans rats fruit flies and different modeling methods neural network Bayesian reinforcement learning data fitting and Hodgkin Huxley models among others Computational Models of Brain and Behavior is divided into four sections a Models of brain disorders b Neural models of behavioral processes c Models of neural processes brain regions and neurotransmitters and d Neural modeling approaches It provides in depth coverage of models of psychiatric disorders including depression posttraumatic stress disorder PTSD schizophrenia and dyslexia models of neurological disorders including Alzheimer s disease Parkinson s disease and epilepsy early sensory and perceptual processes models of olfaction higher systems level models and low level models

Pavlovian and instrumental conditioning linking information theory to neurobiology and more Covers computational approximations to intellectual disability in down syndrome Discusses computational models of pharmacological and immunological treatment in Alzheimer s disease Examines neural circuit models of serotonergic system from microcircuits to cognition Educates on information theory memory prediction and timing in associative learning Computational Models of Brain and Behavior is written for advanced undergraduate Master s and PhD level students as well as researchers involved in computational neuroscience modeling research Computational Models for Neuroscience Robert Hecht-Nielsen,Thomas McKenna,2012-12-06 Formal study of neuroscience broadly defined has been underway for millennia For example writing 2 350 years ago Aristotle asserted that association of which he defined three specific varieties lies at the center of human cognition Over the past two centuries the simultaneous rapid advancements of technology and conse quently per capita economic output have fueled an exponentially increasing effort in neuroscience research Today thanks to the accumulated efforts of hundreds of thousands of scientists we possess an enormous body of knowledge about the mind and brain Unfortunately much of this knowledge is in the form of isolated factoids In terms of big picture understanding surprisingly little progress has been made since Aristotle In some arenas we have probably suffered negative progress because certain neuroscience and neurophilosophy precepts have clouded our self knowledge causing us to become largely oblivious to some of the most profound and fundamental aspects of our nature such as the highly distinctive propensity of all higher mammals to automatically seg ment all aspects of the world into distinct holistic objects and the massive reorganiza tion of large portions of our brains that ensues when we encounter completely new environments and life situations At this epoch neuroscience is like a huge collection of small jagged jigsaw puz zle pieces piled in a mound in a large warehouse with neuroscientists going in and tossing more pieces onto the mound every month **Neural Information Processing with Dynamical Synapses** Si Wu,Michael K Y Wong,Misha Tsodyks,2015-01-08 **Computational Neuroscience** James M. Bower,1998 Publishes 103 of the 196 papers presented at the conference representing a cross section of the general areas considered subcellular cellular network systems and methodology Specific topics include perturbative M sequences for auditory systems identification representing odor quality space a **Operative Neuromodulation** Damianos E. Sakas,Brian A. Simpson,2007-12-03 Neuromodulation is a rapidly evolving multidisciplinary biomedical and biotechnological field The two volumes present the state of the art in established and emerging applications for pain spasticity movement disorders bladder and bowel dysfunction cardiovascular disease epilepsy psychiatric illness impairment of hearing and vision and computational neuromodulation Experts describe the neural networks involved and the appropriate surgical approaches provide clinical guidelines technical descriptions of implanted devices proposals for refinements and personal views on future prospects of the field The immense therapeutic potential is highlighted which arises from the close collaboration of biomedical scientists and biotechnological engineers in this area and signifies the transition from the conventional resective

surgery to functional neuroprosthetic surgery Vol I and neural networks surgery Vol II which uses neuro engineering to improve impaired neural function Vol 2 describes the techniques and procedures applied by direct a contact with the central nervous system or cranial nerves in order to modulate the function of neural networks as in the case of motor cortex stimulation for pain or vagus nerve stimulation for epilepsy or b in deeply located structures inside the nervous system in order to alter the function on specific networks as in the case of deep brain stimulation for Parkinson s disease *From Animals to Animats 8* Stefan Schaal,2004 New research on the adaptive behavior of natural and synthetic agents

*Evolution, Complexity and Artificial Life* Stefano Cagnoni,Marco Mirolli,Marco Villani,2013-12-21 Evolution and complexity characterize both biological and artificial life by direct modeling of biological processes and the creation of populations of interacting entities from which complex behaviors can emerge and evolve This edited book includes invited chapters from leading scientists in the fields of artificial life complex systems and evolutionary computing The contributions identify both fundamental theoretical issues and state of the art real world applications The book is intended for researchers and graduate students in the related domains

**The Role of the Interactions via Movements in the Spatial and Temporal Representation of External Objects** Daya Shankar Gupta,Masahiro Shinya,David W. Franklin,2022-09-12

**Neuroeconomics** Paul W. Glimcher,Ernst Fehr,Colin Camerer,Russell Alan Poldrack,2008-10-10 Neuroeconomics is a new highly promising approach to understanding the neurobiology of decision making and how it affects cognitive social interactions between humans and societies economies This book is the first edited reference to examine the science behind neuroeconomics including how it influences human behavior and societal decision making from a behavioral economics point of view Presenting a truly interdisciplinary approach Neuroeconomics presents research from neuroscience psychology and behavioral economics and includes chapters by all the major figures in the field including two Economics Nobel laureates An authoritative reference written and edited by acknowledged experts and founders of the field Presents an interdisciplinary view of the approaches concepts and results of the emerging field of neuroeconomics relevant for anyone interested in this area of research Full color presentation throughout with carefully selected illustrations to highlight key concepts

**Decision Making: Neural and Behavioural Approaches** ,2013-01-10 This well established international series examines major areas of basic and clinical research within neuroscience as well as emerging and promising subfields This volume explores interdisciplinary research on decision making taking a neural and behavioural approach Leading authors review the state of the art in their field of investigation and provide their views and perspectives for future research Chapters are extensively referenced to provide readers with a comprehensive list of resources on the topics covered All chapters include comprehensive background information and are written in a clear form that is also accessible to the non specialist

**Artificial Neural Networks as Models of Neural Information Processing** Marcel van Gerven,Sander Bohte,2018-02-01 Modern neural networks gave rise to major breakthroughs in several research areas In neuroscience we

are witnessing a reappraisal of neural network theory and its relevance for understanding information processing in biological systems The research presented in this book provides various perspectives on the use of artificial neural networks as models of neural information processing We consider the biological plausibility of neural networks performance improvements spiking neural networks and the use of neural networks for understanding brain function

*Principles of Noology* Seng-Beng Ho, 2016-06-29 The idea of this book is to establish a new scientific discipline noology under which a set of fundamental principles are proposed for the characterization of both naturally occurring and artificial intelligent systems The methodology adopted in *Principles of Noology* for the characterization of intelligent systems or noological systems is a computational one much like that of AI Many AI devices such as predicate logic representations search mechanisms heuristics and computational learning mechanisms are employed but they are recast in a totally new framework for the characterization of noological systems The computational approach in this book provides a quantitative and high resolution understanding of noological processes and at the same time the principles and methodologies formulated are directly implementable in AI systems In contrast to traditional AI that ignores motivational and affective processes under the paradigm of noology motivational and affective processes are central to the functioning of noological systems and their roles in noological processes are elucidated in detailed computational terms In addition a number of novel representational and learning mechanisms are proposed and ample examples and computer simulations are provided to show their applications These include rapid effective causal learning a novel learning mechanism that allows an AI noological system to learn causality with a small number of training instances learning of scripts that enables knowledge chunking and rapid problem solving and learning of heuristics that further accelerates problem solving Semantic grounding allows an AI noological system to truly understand the meaning of the knowledge it encodes This issue is extensively explored This is a highly informative book providing novel and deep insights into intelligent systems which is particularly relevant to both researchers and students of AI and the cognitive sciences

Emotion Explained Edmund T. Rolls, 2005 What produces emotions Why do we have emotions How do we have emotions Why do emotional states feel like something This book seeks explanations of emotion by considering these questions Emotion continues to be a topic of enormous scientific interest This new book a successor to *The Brain and Emotion* OUP 1998 describes the nature functions and brain mechanisms that underlie both emotion and motivation *Emotion Explained* goes beyond examining brain mechanisms of emotion by proposing a theory of what emotions are and an evolutionary Darwinian theory of the adaptive value of emotion It also shows that there is a clear relationship between motivation and emotion The book also examines how cognitive states can modulate emotions and in turn how emotions can influence cognitive states It considers the role of sexual selection in the evolution of affective behaviour It also examines emotion and decision making with links to the burgeoning field of neuroeconomics The book is also unique in considering emotion at several levels the neurophysiological neuroimaging neuropsychological behavioural

and computational neuroscience levels

### **Modeling Neural Circuits Made Simple with Python** Robert

Rosenbaum,2024-03-19 An accessible undergraduate textbook in computational neuroscience that provides an introduction to the mathematical and computational modeling of neurons and networks of neurons Understanding the brain is a major frontier of modern science Given the complexity of neural circuits advancing that understanding requires mathematical and computational approaches This accessible undergraduate textbook in computational neuroscience provides an introduction to the mathematical and computational modeling of neurons and networks of neurons Starting with the biophysics of single neurons Robert Rosenbaum incrementally builds to explanations of neural coding learning and the relationship between biological and artificial neural networks Examples with real neural data demonstrate how computational models can be used to understand phenomena observed in neural recordings Based on years of classroom experience the material has been carefully streamlined to provide all the content needed to build a foundation for modeling neural circuits in a one semester course Proven in the classroom Example rich student friendly approach Includes Python code and a mathematical appendix reviewing the requisite background in calculus linear algebra and probability Ideal for engineering science and mathematics majors and for self study

### Brain Computations and Connectivity

Edmund T. Rolls,2023-06-26 This is an open access title available under the terms of a CC BY NC ND 4.0 International licence It is free to read on the Oxford Academic platform and offered as a free PDF download from OUP and selected open access locations Brain Computations and Connectivity is about how the brain works In order to understand this it is essential to know what is computed by different brain systems and how the computations are performed The aim of this book is to elucidate what is computed in different brain systems and to describe current biologically plausible computational approaches and models of how each of these brain systems computes Understanding the brain in this way has enormous potential for understanding ourselves better in health and in disease Potential applications of this understanding are to the treatment of the brain in disease and to artificial intelligence which will benefit from knowledge of how the brain performs many of its extraordinarily impressive functions This book is pioneering in taking this approach to brain function to consider what is computed by many of our brain systems and how it is computed and updates by much new evidence including the connectivity of the human brain the earlier book Rolls 2021 Brain Computations What and How Oxford University Press Brain Computations and Connectivity will be of interest to all scientists interested in brain function and how the brain works whether they are from neuroscience or from medical sciences including neurology and psychiatry or from the area of computational science including machine learning and artificial intelligence or from areas such as theoretical physics

### **Contemporary Methods in Bioinformatics and Biomedicine and Their Applications**

Sotir S. Sotirov,Tania Pencheva,Janusz Kacprzyk,Krassimir T. Atanassov,Evdokia Sotirova,Galya Staneva,2022-03-11 This book gathers selected papers from the First International Symposium on Bioinformatics and Biomedicine Issues related to medicine and health care constitute one of the grand challenges faces by the mankind and this

naturally implies a growing interest in these problems among both researchers and scholars politicians and policymakers as well as economist The present values which gather selected papers from the First International Symposium on Bioinformatics and Biomedicine BioInfoMed 2020 is a recent response to this interests In the subsequent sections and chapters it covers a multitude of various topics related to bioinformatics biomedicine bioengineering as well as a broadly perceives healthcare Issues related to decision making in bioinformatics biomedicine and health care mathematical modelling in biomedicine and health care artificial intelligence in biomedicine and health care uncertainty and imprecision notably intuitionistic fuzzy sets with applications in bioinformatics and biomedicine biomedical approaches and applications biomedical imaging and image processing and excitable structures and motor activity are covered

Emotion and Decision Making Explained Edmund T. Rolls, 2014 What produces emotions Why do we have emotions How do we have emotions Why do emotional states feel like something What is the relation between emotion and reward value and subjective feelings of pleasure These are just some of the question considered in this book written by a leading neuroscientist in this field

*Anticipatory Behavior in Adaptive Learning Systems* Martin V. Butz, Olivier Sigaud, Giovanni Pezzulo, Gianluca Baldassarre, 2007-08-22 This book presents the refereed post proceedings of the Third International Workshop on Anticipatory Behavior in Adaptive Learning Systems Twenty full papers were chosen from among the many submissions Papers are organized into sections covering anticipatory aspects in brains language and cognition individual anticipatory frameworks learning predictions and anticipations anticipatory individual behavior and anticipatory social behavior

**Neural Masses and Fields: Modelling the Dynamics of Brain Activity** Karl Friston, 2015-05-25 Biophysical modelling of brain activity has a long and illustrious history and has recently profited from technological advances that furnish neuroimaging data at an unprecedented spatiotemporal resolution Neuronal modelling is a very active area of research with applications ranging from the characterization of neurobiological and cognitive processes to constructing artificial brains in silico and building brain machine interface and neuroprosthetic devices Biophysical modelling has always benefited from interdisciplinary interactions between different and seemingly distant fields ranging from mathematics and engineering to linguistics and psychology This Research Topic aims to promote such interactions by promoting papers that contribute to a deeper understanding of neural activity as measured by fMRI or electrophysiology In general mean field models of neural activity can be divided into two classes neural mass and neural field models The main difference between these classes is that field models prescribe how a quantity characterizing neural activity such as average depolarization of a neural population evolves over both space and time as opposed to mass models which characterize activity over time only by assuming that all neurons in a population are located at approximately the same point This Research Topic focuses on both classes of models and considers several aspects and their relative merits that span from synapses to the whole brain comparisons of their predictions with EEG and MEG spectra of spontaneous brain activity evoked responses seizures and fitting data to infer brain states and map physiological parameters



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