

COMPUTATIONAL MODELS OF BRAIN AND BEHAVIOR

EDITED BY DR. AHMED A. MOUSTAFA

WILEY Blackwell

A comprehensive introduction to the world of brain and behavior computational models

This unique resource 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 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 and graduate students, and researchers involved in computational neuroscience modeling research.


DR. AHMED A. MOUSTAFA, PhD is a Senior Lecturer in Cognitive and Behavioral Neuroscience at the MARCS Institute for Brain, Behavior, and Development, School of Social Sciences and Psychology, Western Sydney University. He has published more than 100 papers in high-ranking journals including *Science*, *Proceedings of the National Academy of Science*, *Journal of Neuroscience*, and *Brain, Neuroscience and Biobehavioral Reviews*.

Cover Design: Wiley

Cover Image: © liuzishan/Gettyimages

www.wiley.com/wiley-blackwell

WILEY Blackwell

 Also available
as an e-book

ISBN 978-1-119-15906-3



9 781119 159063

EDITED BY
MOUSTAFA

**COGNITIVE MODELS
OF BRAIN AND BEHAVIOR**

WILEY
Blackwell

Computational Models of Brain and Behavior

Edited by Dr Ahmed A. Moustafa

WILEY Blackwell

This edition first published 2018
© 2018 John Wiley & Sons, Ltd

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, except as permitted by law. Advice on how to obtain permission to reuse material from this title is available at <http://www.wiley.com/go/permissions>.

The right of Ahmed A. Moustafa to be identified as the author of the editorial material in this work has been asserted in accordance with law.

Registered Office(s)

John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA
John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial Office

The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

For details of our global editorial offices, customer services, and more information about Wiley products visit us at www.wiley.com.

Wiley also publishes its books in a variety of electronic formats and by print-on-demand. Some content that appears in standard print versions of this book may not be available in other formats.

Limit of Liability/Disclaimer of Warranty

While the publisher and authors have used their best efforts in preparing this work, they make no representations or warranties with respect to the accuracy or completeness of the contents of this work and specifically disclaim all warranties, including without limitation any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives, written sales materials or promotional statements for this work. The fact that an organization, website, or product is referred to in this work as a citation and/or potential source of further information does not mean that the publisher and authors endorse the information or services the organization, website, or product may provide or recommendations it may make. This work is sold with the understanding that the publisher is not engaged in rendering professional services. The advice and strategies contained herein may not be suitable for your situation. You should consult with a specialist where appropriate. Further, readers should be aware that websites listed in this work may have changed or disappeared between when this work was written and when it is read. Neither the publisher nor authors shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

Library of Congress Cataloging-in-Publication Data

Names: Moustafa, Ahmed, 1977- editor.

Title: Computational models of brain and behavior / [edited by] Ahmed Moustafa.

Description: First edition. | Hoboken, NJ : Wiley, [2017] | Includes bibliographical references and index. |

Identifiers: LCCN 2017012507 (print) | LCCN 2017014332 (ebook) | ISBN 9781119159070 (pdf) | ISBN 9781119159186 (epub) | ISBN 9781119159063 (hardback)

Subjects: LCSH: Computational neuroscience. | Neurobiology—Mathematical models.

Classification: LCC QP357.5 (ebook) | LCC QP357.5 .C627 2017 (print) | DDC 612.8/233—dc23

LC record available at <https://lcn.loc.gov/2017012507>

Cover image: © liuzishan/Gettyimages
Cover design by Wiley

Set in 10/12pt Warnock Pro by SPi Global, Chennai, India
Printed and bound in Singapore by Markono Print Media Pte Ltd

10 9 8 7 6 5 4 3 2 1

Computational Models of
Brain and Behavior

This book is dedicated to Rasha, Kristina, Marwa, Hasan, Angelina, and Haneen.

Notes on Contributors

Rick A. Adams is an academic clinical lecturer in psychiatry at University College London (UCL). He studied medicine at Cambridge University and did his clinical training and PhD at University College London, the latter under Professor Karl Friston. His research focuses on using techniques from computational psychiatry to understand schizophrenia and psychosis, and he co-organizes a computational psychiatry course at UCL.

Mohit H. Adhikari is a postdoctoral researcher at the Center for Brain and Cognition at the University of Pompeu Fabra. His current research focus is computational modeling of resting state functional data, particularly from human stroke patients.

Merav Ahissar is a professor of psychology, she holds the Joseph H. and Belle R. Braun Chair in Psychology, and is a member of the Edmond and Lily Safra Center for Brain Sciences at the Hebrew University. She studies theories of perceptual learning, and developed in collaboration with Professor Shaul Hochstein, the Reverse Hierarchy Theory of perception and perceptual learning, initially for vision and later for audition. She also studies abnormal learning processes among populations with learning disabilities, with an emphasis on reading disability. She developed the Anchoring Hypothesis Theory, which proposes that dyslexics use sound statistics inefficiently in forming auditory simple and linguistic precepts. She uses behavioral, computational, event-related potential (ERP), and imaging tools.

F. Frédéric Alexandre is a director of research at Inria, the French Institute for Research in Computer Science and Automation. He is the head of the Mnemosyne group, working in computational neuroscience in the Bordeaux Neurocampus, at the Institute of Neurodegenerative Diseases. His research interests are concerned with the emergence of intelligent behavior, by means of computational neuroscience, machine learning, artificial intelligence, and cognitive modeling, in tight loop with neuroscience and the medical domain.

Adel Alturki is a PhD student in electrical engineering at the University of Missouri-Columbia. He obtained dual Master's degrees in electrical engineering and applied mathematics from Western Michigan University in 2011. He is presently on leave from his position as instructor at Yanbu Industrial College, Saudi Arabia. His research interests include computational neuroscience, artificial intelligence, and control systems.

Natalia Arias-Trejo is a professor in the Faculty of Psychology, National Autonomous University of Mexico (UNAM). Her fields of research include psycholinguistics, early lexical networks, and intellectual disability. Key publications are Abreu-Mendoza, R. A. & Arias-Trejo, N. (2015). Numerical and Area Comparison Abilities in Down Syndrome. *Research in Developmental Disabilities*; Arias-Trejo, N., Cantrell, L. M., Smith, L., & Alva-Canto, E. A. (2014). Early Comprehension of the Spanish Plural. *Journal of Child Language*; Arias-Trejo, N. & Plunkett, K.

(2013). What's in a Link: Associative and Semantic Priming Effects in the Infant Lexicon. *Cognition*.

Michael C. Avery received a BSc in mathematics and biochemistry in 2007 from Virginia Tech, a PhD in cognitive neuroscience from the University of California, Irvine in 2013, and is currently a postdoctoral researcher in the Systems Neurobiology Laboratories at the Salk Institute. He is interested in understanding the circuit-level computations that give rise to cognitive functions and how their failures may lead to mental disorders.

Fariba Bahrami received her PhD in biomedical engineering from the University of Tehran. She was awarded a scholarship for her PhD at the Technical University of Munich, Germany. Since 2013 she has been an associate professor at the University of Tehran. Her main fields of interest are biological system modeling, computational neuroscience, human motor control, and rehabilitation. In 2012, she was awarded the Institute of Electrical and Electronics Engineers (IEEE) Women-In-Engineering Award for her tremendous contribution to biomedical engineering in Iran.

Jyotika Bahuguna is a researcher at Forschungszentrum Jülich, Germany. She received her doctoral degree in computational neuroscience from Bernstein Center Freiburg and KTH Royal Institute of Technology, Stockholm, Sweden, in 2016. She is interested in the structure–function relationship in neuronal networks, the role of spike-time dependent plasticity on network function, and neural coding. She is currently developing large-scale mathematical models to investigate basal ganglia activity dynamics in healthy and pathological states, especially Parkinson's disease.

Jeffrey M. Beck received a BSc in mathematics from Harvey Mudd College and a PhD in applied mathematics from Northwestern University. He was a postdoctoral fellow in

the Department of Brain and Cognitive Sciences at the University of Rochester and also at the Gatsby Computational Neuroscience Unit at UCL. He is now an assistant professor of neurobiology and biomedical engineering at Duke University.

Udo Boehm is a PhD candidate in mathematical psychology. He received his bachelor's degree in psychology in 2009 and his Master's degree in behavioral and cognitive neurosciences (cognitive modeling) in 2012. His main research interests are mathematical models of decision making and Bayesian statistics.

Luke J. Chang is currently an assistant professor in psychological and brain sciences at Dartmouth College. He completed a BA at Reed College, an MA at the New School for Social Research, a PhD in clinical psychology at the University of Arizona, a predoctoral clinical internship in behavioral medicine at the University of California—Los Angeles (UCLA), and a postdoc at the University of Colorado Boulder. His research program is focused on understanding the neurobiological and computational mechanisms underlying emotion and social interactions.

Chong Chen, MD, PhD (medicine, Hokkaido University), was formerly at the Department of Psychiatry, Hokkaido University Graduate School of Medicine, and is now a research scientist at Riken Brain Science Institute. He studies the neurobiological basis of stress and depression and is particularly interested in computational psychiatry.

Jin Hyun Cheong graduated from Princeton University with a BA in psychology and certificates in neuroscience and finance. Postgraduation, he worked as a research assistant at the Princeton Neuroscience Institute and investigated the computational and neural foundations of optimal human decision making. Currently, he is a graduate student at Dartmouth College and is interested in applying computational, behavioral, psychophysiological, and neuroimaging

methods to investigate how emotions and social cognition impact economic choices and behavior.

Jeremiah Y. Cohen is an assistant professor in the Solomon H. Snyder Department of Neuroscience and the Brain Science Institute at the Johns Hopkins University School of Medicine. His laboratory studies neurophysiology underlying reward and decision making. He was trained as a postdoctoral fellow at Harvard University and received his PhD in neuroscience at Vanderbilt University.

Vassilis Cutsuridis is an accomplished computational neuroscientist and cognitive systems researcher at the Foundation for Research and Technology Hellas (FORTH). His research aims to decipher how brain circuits and patterns of neural activity give rise to mental experience and how such an understanding can help design brain-mimetic algorithms for complex data analysis and systems with autonomous behavior. He has published over 70 peer reviewed papers and four edited books.

Gustavo Deco is Institució Catalana de Recerca i Estudis Avançats (ICREA) research professor and full professor at the Universitat Pompeu Fabra, where he heads the Computational Neuroscience Group and directs the Center for Brain and Cognition. Recognized as a world leader in computational neuroscience, he has pioneered work in dynamical modeling of human brain activity. He is a European Research Council Advanced Grantee and core member of the Human Brain Project. He has published four books, over 210 international journal papers, and 30 book chapters.

Shyam Diwakar is an assistant professor and lab director of the Computational Neuroscience Laboratory, School of Biotechnology and a faculty fellow at the Center for International Programs at Amrita University, India. He is a co-investigator of a National virtual labs initiative and other projects funded by the Department of Science

and Technology (DST) and the Department of Biotechnology (DBT), Government of India. He was awarded the Sir Visvesvaraya Young Faculty Research Fellowship in April 2016 by DeitY, Government of India, and the Nvidia Innovation award in 2015.

Seif Eldawlatly is an assistant professor at the Computer and Systems Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt. He received his PhD in electrical and computer engineering from Michigan State University in 2011 and his MSc and BSc degrees in computer and systems engineering from Ain Shams University in 2006 and 2003, respectively. His research focuses on developing machine learning and signal processing algorithms for brain-machine interfaces and visual prostheses.

G. Bard Ermentrout received a BA and MA in mathematics from the Johns Hopkins University, and a PhD in biophysics and theoretical biology from the University of Chicago in 1979. He is a distinguished university professor of computational biology and a professor of mathematics at the University of Pittsburgh. He is interested in the applications of dynamical systems to problems in biology with a particular emphasis in neuroscience. He is an avid, if feckless, gardener.

Faramarz Faghihi obtained his BSc and MSc in medical biochemistry. After that, he studied computational biology as a research assistant at Heidelberg University, Germany. He did his PhD in theoretical and computational neuroscience at the Physics Institute, Göttingen University, Germany. His PhD project was on the modeling of information processing in the *Drosophila* olfactory system. Currently, he is an assistant professor at the Shahid Beheshti University, Tehran, Iran.

Shiva Farashahi received a BE in electrical engineering from the Ferdowsi University of Mashhad, Mashad, Iran, in 2011, and an MSc in biomedical engineering from the

University of Tehran, Tehran, Iran, in 2013. She is currently a PhD student at the Department of Psychological and Brain Sciences, Dartmouth College, Hanover, USA. Her research interests include computational modeling of neural circuits underlying cognitive processes, and decision making.

Feng Feng is a PhD student at the University of Missouri-Columbia, after practicing for 6 years as an analog/radio frequency engineer for Huawei Technologies Co., Ltd. His research interests include computational neuroscience, modeling and control of nonlinear dynamic systems, and systems analysis. To date, he has authored three journal articles.

Birte Forstmann is professor of cognitive neurosciences at the University of Amsterdam (UvA). She earned her PhD in 2006 at the Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany. After completing her postdoc in 2008 at UvA, she became a tenured research fellow at the Cognitive Science Center Amsterdam with a focus on model-based cognitive neurosciences. Since then she has contributed to a range of topics in cognitive neuroscience, experimental psychology, and mathematical psychology.

Dorota Frydecka, MA, MSc Eng, MD, PhD, is a medical doctor, psychologist, and computer scientist, currently working in the Department of Psychiatry at Wrocław Medical University. Her main interest is related to the genetic basis of psychotic disorders in relation to immune system and cognitive functions (Ministry of Science and Higher Education, Foundation of Polish Science, National Science Center). She has received numerous awards for her research achievements (i.e., European Psychiatric Association, European College of Neuropsychopharmacology).

C. R. Gallistel is distinguished professor emeritus at Rutgers University. He obtained his PhD in behavioral neuroscience from Yale University in 1963. He joined the

Psychology Faculty at the University of Pennsylvania, where he rose through the ranks to professor and chair. Subsequently, he was distinguished professor at UCLA and then at Rutgers, where he co-chaired the Center for Cognitive Science. His current research develops highly automated systems for screening genetically altered mice for alterations in basic cognitive functions.

Samuel J. Gershman received a BA from Columbia University and a PhD in psychology and neuroscience from Princeton University. He was a postdoctoral fellow in the Department of Brain and Cognitive Sciences at the Massachusetts Institute of Technology (MIT) and is currently an assistant professor in the Department of Psychology and Center for Brain Science at Harvard University.

Umut Güçlü is a PhD candidate at Radboud University, the Donders Institute for Brain, Cognition and Behaviour. Umut has a Master's degree in cognitive neuroscience and a bachelor's degree in artificial intelligence. Umut's research combines cognitive neuroscience and artificial intelligence techniques such as functional magnetic resonance imaging and artificial neural networks for studying how the human brain processes sensory information to represent and understand the world around us.

Vinay Guntu is a PhD student at the University of Missouri-Columbia. He has twice co-taught the computational neuroscience course, focusing on the software and hardware labs. His research interests include computational neuroscience, systems modeling, feedback controls, and emergent networks.

Ankur Gupta is an Edmond and Lily Safra Center for Brain Sciences postdoctoral fellow at the Hebrew University of Jerusalem, Israel. His long-term goal is directed toward understanding the role of decision making in movement production and control. Currently, he is working on the motor control of facial expression in primates. In the

past, he studied how multi-finger forces are generated and coordinated using neural network methods.

Mubashir Hassan received his Master's degree in pharmaceutical chemistry from Government College University Lahore in 2012. During his time in molecular science and bioinformatics (IMSB), he developed interests in the field of computational modeling, dynamic simulation, and computer aided drug designing techniques. Now, he is working on models of the pathways of neurodegenerative disorders such as Alzheimer's disease in order to come up with novel drugs through computational modeling and simulation studies.

Andrew Heathcote was appointed as a research chair at University of Tasmania in 2015, where he founded the Tasmanian Cognition Laboratory (TasCL.org). He is also a professor at the University of Newcastle, where he founded the Newcastle Cognition Laboratory (NewCL.org) in 1997. His current research focuses on human memory and skill acquisition, and on the neural and cognitive processes that enable people to make rapid choices.

Stewart Heitmann received a BSc in computer science (1994) and a BSc in psychology (2007) from the University of Sydney. He was awarded a PhD from the University of New South Wales in 2013. He undertook postdoctoral training at the University of Pittsburgh. He is currently a research associate at the Queensland Institute of Medical Research (QIMR) Berghofer Medical Research Institute. His research interests include pattern formation in neural systems and its application to systems neuroscience.

Sagi Jaffe-Dax studies in the ELSC neural computation PhD program (formerly known as Interdisciplinary Center for Neural Computation [ICNC]) at the Hebrew University of Jerusalem. He is expected to finish his dissertation soon and to embark on new research in the field of developmental neuroscience.

Eshin Jolly graduated from the University of Rochester with a BA in psychology and cognitive neuroscience. Subsequently, he worked as a research assistant at Harvard University investigating the neural systems underlying social reasoning. Currently he is a graduate student at Dartmouth College, where he employs a diverse set of approaches including large-scale online experiments, computational modeling, and machine learning to understand how individuals make social decisions and derive value from social experiences.

Jeroen Joukes obtained his PhD in neuroscience at the Center for Molecular and Behavioral Neuroscience, Rutgers University—Newark, USA. His research interests include neural computations in space and time enabled by recurrent connectivity. He applies machine learning algorithms to neural data to gain understanding of the computations of the neural system.

Radwa Khalil is a PhD student and teaching assistant at Rutgers University—Newark, USA. She is interested in pursuing her research at a postgraduate level in translational and cognitive neuroscience using multidisciplinary approaches. She is seeking to combine state-of-the-art techniques for investigating physiological, cognitive, and/or psychological questions from clinical, educational, and socio-economic perspectives.

Bart Krekelberg is a professor of neuroscience at the Center for Molecular and Behavioral Neuroscience, Rutgers University—Newark, USA. His interests include the computations enabled by the recurrent connectivity of neural networks, the mechanisms underlying visual stability, and transcranial current stimulation. His laboratory combines a range of methods, including extracellular recordings in awake, behaving primates, functional imaging, quantitative psychophysics, transcranial stimulation, and computational modeling.

Jeffrey L. Krichmar received a BSc in computer science in 1983 from the University of

Massachusetts at Amherst, an MSc in computer science from the George Washington University in 1991, and a PhD in computational sciences and informatics from George Mason University in 1997. Currently, he is a professor in the Departments of Cognitive Sciences and Computer Science at the University of California, Irvine. His research interests include neurorobotics, models of cognition, and neuromorphic engineering.

Srinivasa B. Krothapalli is working in the Department of Neurological Sciences, Christian Medical College, Vellore, India as a senior scientist. He is the head of the Neurophysiology Laboratory and does both clinical and basic research.

Arvind Kumar is an assistant professor of computational neuroscience at KTH Royal Institute of Technology, Stockholm, Sweden. He is investigating the role of connectivity and dynamics in the transfer of information between neuronal networks, and how neuronal network dynamics can be controlled by external stimulation. One of the goals of his research is to develop mathematical models to understand the mechanisms underlying the emergence of disease-related aberrant network activity in the brain.

Carlo R. Laing received his PhD in applied mathematics from the University of Cambridge in 1998, with a thesis on coupled oscillator networks. After postdoctoral positions in the UK and at the Universities of Pittsburgh and Ottawa, he joined Massey University in 2002, where he is now an associate professor. His research interests cover nonlinear dynamics and computational neuroscience. He received the J. H. Michell Medal for outstanding new researchers from ANZIAM in 2008.

Marc Landry is the deputy-director of the IINS Institute and of the Bordeaux Imaging Center, University of Bordeaux, France (<http://www.iins.u-bordeaux.fr/Team-leader-Marc-Landry-90>). He is also the coordinator of an international Master's program in

Neuroscience at the University of Bordeaux. One of his research focuses is to investigate the inhibition–excitation balance that regulates the activity of spinal neurons. Currently, he is the president of the Mediterranean Neuroscience Society (MNS) (www.mnsociety.net).

Itamar Lerner, PhD, is a postdoctoral researcher at the Center for Molecular and Behavioral Neuroscience, Rutgers University—Newark. His research includes combining neural network modeling with human behavioral experimentation in uncovering the mechanisms that contribute to learning and memory. In particular, he investigates the special role of sleep in enhancing cognitive functions of various levels of complexity, from simple paired-associates learning to gist extraction, language, and insight.

Christiane Linster is a professor of neurobiology and behavior at Cornell University. She was born and raised in Luxembourg, Luxembourg. She obtained a Master's in electrical engineering from the Technical University in Graz, Austria and a PhD in applied physics from the Pierre and Marie Curie University in Paris, France. After her appointments as a research associate at Harvard University and Boston University she moved to the Department of Neurobiology and Behavior at Cornell University. Her laboratory studies the neuromodulation of sensory perception of smell using computational and experimental approaches.

Yonatan Loewenstein received his PhD from the Hebrew University in 2004. Between 2004 and 2006 he was a postdoctoral fellow at MIT. Since 2007, he has held a faculty position in the Departments of Neurobiology and Cognitive Sciences, and is a member of the ELSC for Brain Sciences and the Federmann Center for the Study of Rationality at the Hebrew University of Jerusalem, Israel.

Madeleine M. Lowery is a professor in the School of Electrical and Electronic Engineering, University College Dublin. Her

research involves exploring nerve and muscle activity through mathematical modeling, analysis, and experimentation, to increase understanding of neuromuscular activity in healthy and diseased states, and to develop novel and improved rehabilitation strategies. Her research interests include electromyography, myoelectric prosthetic control, bioelectromagnetics, electrical stimulation, deep brain stimulation, and neural control of movement.

Alexander Ly is a PhD candidate, supervised by Eric-Jan Wagenmakers, at the University of Amsterdam. He received his interdisciplinary natural and social sciences bachelor's degree with a major in mathematics in 2009 and his Master's degree in mathematics in 2011. His main research interests are Bayesian model selection, machine learning, mathematical modeling, and asymptotic statistics.

William W. Lytton is a professor in physiology, pharmacology and neurology at State University of New York System (SUNY) Downstate, and works as a clinical neurologist at Kings County Hospital, seeing patients with a variety of brain ailments. His research is in computational neuroscience with a focus on the application of multiscale modeling to various disorders of the brain, including Alzheimer's, stroke, Parkinson's, epilepsy, and schizophrenia. He is author of *From Computer to Brain*, a basic textbook in the field.

Dora Matzke obtained her PhD in mathematical psychology in 2014 at the University of Amsterdam. She is currently assistant professor in the Psychological Methods Department at the University of Amsterdam. Her research focuses on formal models of response inhibition, multinomial processing tree models, and Bayesian inference.

Maarten Marsman is an assistant professor in psychometrics. He received his bachelor's degree in psychology in 2007, his Master's degree in survey methods in 2009, and successfully defended his doctoral thesis in psychometrics in 2014. His main research

interests are Bayesian and computational statistical methods in general, psychometrics, and educational measurement.

Ryan L. Miller graduated from North Dakota State University with a bachelor's degree in psychology and earned a doctorate in neurobiology and anatomy from Wake Forest School of Medicine, where he is currently employed as a postdoc. His primary research interests involve understanding the mechanistic bases for multisensory integration and how they shape the neural, and ultimately behavioral, response.

Maria D. Miranda was born in Florianópolis, Brazil. She received BSc (1983) and MSc degrees (1987) from Universidade Federal de Santa Catarina, and degree PhD (1996) from Escola Politécnica da Universidade de São Paulo (USP), all in electrical engineering. Currently, she is an assistant professor in the Department of Telecommunications and Control Engineering, Escola Politécnica, USP. Her research interests include statistical signal processing and adaptive filtering theory and applications.

Błażej Misiak, MD, PhD, is a researcher in the Department of Genetics (Wrocław Medical University, Poland). His main interests include cognitive neuroscience, genetics and epigenetics of schizophrenia. He is the author of several articles published in international journals. Błażej has received a number of prestigious awards including the Polish Ministry of Health scholarship, the START scholarship provided by the Foundation for Polish Science, and the European College of Neuropsychopharmacology (ECNP) Fellowship Award.

Marie Z. Moftah is an associate professor in the Zoology Department, Faculty of Science, Alexandria University, and an invited professor at Bordeaux University, France (<http://loop.frontiersin.org/people/10502/overview>). She is a former president of the Mediterranean Neuroscience Society (MNS) (www.mnsociety.net). She obtained her PhD from New York

Medical College, Valhalla, USA in developmental biology (2001). Then, she pursued her postdoc at Bordeaux University, France in neuroscience: spinal cord regeneration after complete transection (2004–2005).

Luiz H. A. Monteiro was born in São Paulo, Brazil, in 1967. He received his PhD in physics from the Instituto de Física da Universidade de São Paulo in 1995. He is currently professor at the Escola de Engenharia da Universidade Presbiteriana Mackenzie and at the Escola Politécnica da Universidade de São Paulo. His research topics include studies on the dynamical behaviors appearing in complex networks of biological and electronic oscillators.

Ahmed A. Moustafa is currently a senior lecturer in cognitive and behavioral neuroscience at MARCS Institute for Brain, Behaviour, and Development and the School of Social Sciences and Psychology, Western Sydney University. Ahmed has published over 110 papers, some in high-ranking journals including *Science*, *Proceedings of the National Academy of Science*, the *Journal of Neuroscience*, *Brain*, *Nature* (Parkinsons' disease), *Neuroscience and Biobehavioral Reviews*, among others. Ahmed's research focus is on computational and experimental neuroscience, focusing on brain disorders.

Catherine E. Myers is a research scientist with the Department of Veterans Affairs New Jersey Health Care System, East Orange, USA, and professor of pharmacology, physiology and neuroscience at New Jersey Medical School of Rutgers University. She received her PhD in neural systems engineering from Imperial College of the University of London, UK. Her research focuses on the brain substrates of human learning and memory with application to understanding neuropsychiatric disorders.

Ajay Nair completed his BSc in biology, with a focus in engineering, at the Carnegie Mellon University. He is presently a 4th year MD student at Ross University and has been

conducting research in neuroscience in parallel, including providing assistance on computational neuroscience projects. He is the author of two journal publications. His research interests include computational neuroscience and neuropsychiatry.

Satish S. Nair a professor of electrical and computer engineering, and director of the Center for Computational Neurobiology at the University of Missouri—Columbia. He works in the area of computational neuroscience, and spans molecular, cellular, network, and behavioral levels. He is author of 151 refereed articles (79 journal, 72 conference), and 83 posters and abstracts. He is also active in research and educational training in neuroscience from faculty to K-12 levels.

Tristan T. Nakagawa is specially appointed researcher at Osaka University and invited researcher at the Center for Information and Neural Networks. He has studied oscillations and spontaneous dynamics in whole-brain computational models and currently studies pain perception and biomarkers in the context of brain–immune interactions.

Kae Nakamura is professor of neurophysiology at Kansai Medical University, Osaka, Japan. Dr Nakamura received an MD from Tokyo Medical University, and a PhD from Juntendo University, Tokyo. Her studies have focused on the neuronal mechanisms of higher cognitive function in primate, including procedural learning, the interaction between vision and saccadic eye movement, the executive function under conflict, and the role of dopamine and serotonin for reward- and punishment-based modulation in action.

Samuel A. Neymotin is research assistant professor in the Physiology and Pharmacology Department at SUNY Downstate Medical Center. He received a BSc in computer science from Queens College in 2001, an MSc in computer science from Columbia University in 2005, and a PhD in biomedical engineering from SUNY Downstate/NYU-Poly in 2012. He subsequently joined Yale