

The Computational Neurobiology of Reaching and Pointing



A Foundation for Motor Learning

Reza Shadmehr and Steven P. Wise

The Computational Neurobiology Of Reaching And Pointing A Foundation For Motor Learning Computational Neuroscience

Dagmar Sternad



The Computational Neurobiology Of Reaching And Pointing A Foundation For Motor Learning Computational Neuroscience:

The Computational Neurobiology of Reaching and Pointing Reza Shadmehr, Steven P. Wise, 2004-10-28 An introduction to the computational biology of reaching and pointing with an emphasis on motor learning Neuroscience involves the study of the nervous system and its topics range from genetics to inferential reasoning At its heart however lies a search for understanding how the environment affects the nervous system and how the nervous system in turn empowers us to interact with and alter our environment This empowerment requires motor learning The Computational Neurobiology of Reaching and Pointing addresses the neural mechanisms of one important form of motor learning The authors integrate material from the computational behavioral and neural sciences of motor control that is not available in any other single source The result is a unified comprehensive model of reaching and pointing The book is intended to be used as a text by graduate students in both neuroscience and bioengineering and as a reference source by experts in neuroscience robotics and other disciplines The book begins with an overview of the evolution anatomy and physiology of the motor system including the mechanisms for generating force and maintaining limb stability The sections that follow Computing Locations and Displacements Skills Adaptations and Trajectories and Predictions Decisions and Flexibility present a theory of sensorially guided reaching and pointing that evolves organically based on computational principles rather than a traditional structure by structure approach The book also includes five appendixes that provide brief refreshers on fundamentals of biology mathematics physics and neurophysiology as well as a glossary of relevant terms The authors have also made supplemental materials available on the Internet These web documents provide source code for simulations step by step derivations of certain mathematical formulations and expanded explanations of some concepts

Routledge Handbook of Motor Control and Motor Learning Albert Gollhofer, Wolfgang Taube, Jens Bo Nielsen, 2013 This text offers a comprehensive survey of neurophysiological behavioural and biomechanical aspects of motor function Adopting an integrative approach it examines the full range of key topics in contemporary human movement studies explaining motor behaviour in depth from the molecular level to behavioural consequences

Computational Theories and Their Implementation in the Brain Lucia Vaina, Richard E. Passingham, 2017 David Marr is known for his research on the brain in the late 60s and 70s becoming one of the main founders of Computational Neuroscience when neuroscience was in its infancy Written by distinguished contributors this book evaluates the extent to which his theories are still valid and identifies areas that need to be altered

Neurobiology of Language Gregory Hickok, Steven L. Small, 2015-08-15 Neurobiology of Language explores the study of language a field that has seen tremendous progress in the last two decades Key to this progress is the accelerating trend toward integration of neurobiological approaches with the more established understanding of language within cognitive psychology computer science and linguistics This volume serves as the definitive reference on

the neurobiology of language bringing these various advances together into a single volume of 100 concise entries The organization includes sections on the field's major subfields with each section covering both empirical data and theoretical perspectives Foundational neurobiological coverage is also provided including neuroanatomy neurophysiology genetics linguistic and psycholinguistic data and models Foundational reference for the current state of the field of the neurobiology of language Enables brain and language researchers and students to remain up to date in this fast moving field that crosses many disciplinary and subdisciplinary boundaries Provides an accessible entry point for other scientists interested in the area but not actively working in it e.g. speech therapists neurologists and cognitive psychologists Chapters authored by world leaders in the field the broadest most expert coverage available

[Objective Biometric Methods for the Diagnosis and Treatment of Nervous System Disorders](#) Elizabeth B. Torres, 2018-06-29 Objective Biometric Methods for the Diagnosis and Treatment of Nervous System Disorders provides a new and unifying methodological framework introducing new objective biometrics to characterize patterns of sensory motor control underlying symptoms Its goal is to radically transform the ways in which disorders of the nervous system are currently diagnosed tracked researched and treated This book introduces new ways to bring the laboratory to the clinical setting to schools and to settings of occupational and physical therapy Ready to use graphic user interfaces are introduced to provide outcome measures from wearable sensors that automatically assess in near real time the effectiveness of interventions Lastly examples of how the new framework has been effectively utilized in the context of clinical trials are provided Provides methods and their implementation using real data and simple computer programs that students and researchers from less technically trained fields can use Describes the motivation for methods according to the problem domain in light of existing methods for each chapter along with their lack of neuroscientific foundation and invalid statistical assumptions Accompanied by a companion website which contains Appendices with MATLAB codes and data samples to generate the graphics displayed in all chapter figures Features videos illustrating the experimental set up for scenarios and methods described in each chapter Includes step by step explanations of paradigms in each clinical or typical sample population to enable reproducibility of the study across different clinical phenotypes and levels of expertise in sports the performing arts or mere individual academic predispositions preferences

Mathematical Modelling in Motor Neuroscience: State of the Art and Translation to the Clinic, Gaze Orienting Mechanisms and Disease, 2019-07-18 Mathematical Modelling in Motor Neuroscience State of the Art and Translation to the Clinic Gaze Orienting Mechanisms and Disease Volume 249 the latest release in the Progress in Brain Research series highlights new advances in the field with this new volume presenting interesting chapters on a variety of topics including Sequential Bayesian updating Maps and Sensorimotor Transformations for Eye Head Gaze Shifts Role of the Midbrain Superior Colliculus Modeling Gaze Position Dependent Opsoclonus Eye Position Dependent Opsoclonus in Mild Traumatic Brain Injury Saccades in Parkinson's disease hypometric slow and maladaptive Brainstem Neural Circuits for Fixation and Generation of

Saccadic Eye Movements and much more Provides the authority and expertise of leading contributors from an international board of authors Presents the latest release in the Progress in Brain Research series Includes the latest information on mathematical modeling in motor neuroscience **Encyclopedia of Neuroscience, Volume 1** Larry R. Squire, 2009-06-12

The Encyclopedia of the Neuroscience explores all areas of the discipline in its focused entries on a wide variety of topics in neurology neurosurgery psychiatry and other related areas of neuroscience Each article is written by an expert in that specific domain and peer reviewed by the advisory board before acceptance into the encyclopedia Each article contains a glossary introduction a reference section and cross references to other related encyclopedia articles Written at a level suitable for university undergraduates the breadth and depth of coverage will appeal beyond undergraduates to professionals and academics in related fields Beyond the Brain Benoit Hardy-Vallée, 2009-03-26

Cognitive science faces a major methodological and conceptual change since the 90 s Whereas the brain was traditionally conceived as being the only seat of intelligence many researches emphasize the entrenchment of the brain in body context and culture In 2006 a conference was held at the Universit du Qu bec Montr al UQAM and allowed researchers from various fields to interact and discuss such issues Cognitio 2006 was an occasion for philosophers cognitive scientists and biologists to present the latest developments in their discipline and this book aims at providing a general overview of current research on embodied situated and distributed cognition **Cortical Evolution in Primates** Steven P. Wise, 2023-11-27

Cortical Evolution in Primates provides a stand alone resource for neuroscience graduate students and established neuroscientists who have an interest in cortical evolution and primates Discussions of both cortical evolution and primates often rely on terms and concepts unfamiliar to many neuroscientists but such readers will have no need to look elsewhere to understand the text or figures in this book As well as reviewing the pertinent terminology and taxonomy Wise explores the palaeontology adaptations and paleoecology of primates Through summarizing a neglected source of data fossil primates the book harnesses the power of comparative neuroanatomy to examine how cortical maps changed during private evolution including nine proposals on why the cortex changed Together these topics inform a full understanding of cortical evolution in primates Wise concludes that the cortex expanded more recently than most neuroscientists suspect and it happened many times Furthermore cortical expansion occurred independently in several major primate lineages as ancestral primates adapted to the ecosystems of their time and place Natural selection favored the expansion of cortical areas with neural representations that provided a selective advantage to ancestral primates in those times and those places *Cognitive Neuroscience Society ... Annual Meeting Abstract Program* Cognitive Neuroscience Society. Meeting, 2005 *Neural basis of social learning, social deciding, and other-regarding preferences* Steve W C Chang, Masaki Isoda, 2015-03-02

Humans and many other social animals decide or learn when necessary what to do in a given social situation by assessing a range of variables related to social states e g competitive or cooperative others overt behavior e g response choices and outcomes others covert mental states e g beliefs

intentions and desires and one's own interpersonal inclination e.g. other regarding preferences and generosity Recent studies in social neuroscience have begun to uncover how such social variables are processed encoded and integrated in the brain The goal of the current Research Topic is to promote a better understanding of neural basis of social learning social decision making and other regarding preferences

Non-Invasive Brain Stimulation: New Prospects in Cognitive Neurorehabilitation Carlo Professor Miniussi, Giuseppe Professor Vallar, 2012-12-06 Cognitive deficits are a common consequence of neurological disease and there is evidence that specific cognitive training may be effective in rehabilitation Behavioural dysfunction following neurological disease constitutes one of the major causes of disability worldwide exerts a major impact on the daily life of affected individuals and their families also with a financial burden both for patients and the society in general Therefore the adequate treatment of cognitive dysfunction is a much relevant issue with social and economical implications over and above the neuropsychological problem per se Several investigations emphasise the fact that interacting with neural activity by means of cortical stimulation can affect cognitive performance A number of studies have reported enhanced performance in specific cognitive tasks in patients with several types of neurological disease after receiving Non Invasive Brain Stimulation NIBS to specific cortical areas namely Transcranial Magnetic Stimulation and transcranial Electrical Stimulation In general the evidence highlights the possibility of inducing changes in cortical excitability which in turn may lead to a plastic reorganization of dysfunctional networks responsible for the impaired cognitive functions Despite these advances a number of important questions remain open regarding the use of stimulation techniques in cognitive rehabilitation This special issue puts together international leading experts in the field to review and discuss recent advances as to whether NIBS techniques alone or combined with behavioural cognitive rehabilitation can lead to performance enhancements and why The issue is timely and promises to have a huge impact across many domains of clinical and basic neuroscience

Progress in Motor Control Dagmar Sternad, 2008-12-25 It has become widely acknowledged and almost trivial to state that the study of the control and coordination of biological movement motor control is inherently multidisciplinary From the investigation of overt functional behavior to the intricacies of neuronal activations the issues are numerous and invite many different levels of analysis methods and perspectives Clearly the biological movement system is simultaneously a dynamical neurophysiological electrophysiological and intentional system in short a complex system in the technical sense of the word While multidisciplinary in motor control research is a necessity it also presents a stumbling block to developing a coherent body of knowledge that represents the science of the control and coordination of movement Research thrusts are developing from different academic backgrounds that are not easily understood by peers with entirely different disciplinary training Not only for the student of motor control but also for the advanced researcher it can be daunting to make connections for example between cognitive issues like planning or attention and functional properties of the peripheral nervous system between motor cortical activation and the biomechanics of the multi joint limb system Yet

all of these approaches aim to shed light on the same phenomenon the astonishing ability of biological systems to move perceive grow adapt use tools and do infinitely more things For the science of motor control to progress more integration of disciplines is therefore necessary *Human-in-the-Loop Robot Control and Learning* Luka Peternel, Jan Babič, Erhan Oztop, Tetsunari Inamura, Dingguo Zhang, 2020-01-22 In the past years there has been considerable effort to move robots from industrial environments to our daily lives where they can collaborate and interact with humans to improve our life quality One of the key challenges in this direction is to make a suitable robot control system that can adapt to humans and interactively learn from humans to facilitate the efficient and safe co existence of the two The applications of such robotic systems include service robotics and physical human robot collaboration assistive and rehabilitation robotics semi autonomous cars etc To achieve the goal of integrating robotic systems into these applications several important research directions must be explored One such direction is the study of skill transfer where a human operator's skilled executions are used to obtain an autonomous controller Another important direction is shared control where a robotic controller and humans control the same body tool mechanism car etc Shared control in turn invokes very rich research questions such as co adaptation between the human and the robot where the two agents can benefit from each other's skills or must adapt to each other's behavior to achieve effective cooperative task executions The aim of this Research Topic is to help bridge the gap between the state of the art and above mentioned goals through novel multidisciplinary approaches in human in the loop robot control and learning The Great Ideas of Clinical Science Scott O. Lilienfeld, William T. O'Donohue, 2012-12-06 The idea that there is a fundamental rift between researchers and practitioners should not come as a surprise to anyone familiar with the current literature trends and general feelings in the field of clinical psychology Central to this scientist practitioner gap is an underlying disagreement over the nature of knowledge namely that while some individuals point to research studies as the foundation of truth others argue that clinical experience offers a more adequate understanding of the causes assessment and treatment of mental illness The Great Ideas of Clinical Science is an ambitious attempt to dig beneath these fundamental differences and reintroduce the reader to unifying principles often overlooked by students and professionals alike The editors have identified 17 such universals and have pulled together a group of the most prolific minds in the field to present the philosophical methodological and conceptual ideas that define the state of the field Each chapter focuses on practical as well as conceptual points offering valuable insight to practicing clinicians researchers and teachers of any level of experience Written for student practitioner researcher and educated layperson this integrative volume aims to facilitate communication among all mental health professionals and to narrow the scientist practitioner gap **Secrets of Creativity** Suzanne Nalbantian, Paul M. Matthews, 2019-08-26 Secrets of Creativity What Neuroscience the Arts and Our Minds Reveal draws on insights from leading neuroscientists and scholars in the humanities and the arts to probe creativity in its many contexts in the everyday mind the exceptional mind the scientific mind the artistic mind and the pathological mind

Components of creativity are specified with respect to types of memory forms of intelligence modes of experience and kinds of emotion Authors in this volume take on the challenge of showing how creativity can be characterized behaviorally cognitively and neurophysiologically The complementary perspectives of the authors add to the richness of these findings Neuroscientists describe the functioning of the brain and its circuitry in creative acts of scientific discovery or aesthetic production Humanists from the fields of literature art and music give analyses of creativity in major literary works musical compositions and works of visual art

The Interdisciplinary Handbook of Perceptual Control Theory Warren Mansell, 2020-05-16 Interdisciplinary Handbook of Perceptual Control Theory Volume II Living in the Loop brings together the latest research theory and applications from W T Powers Perceptual Control Theory PCT that proposes that the behavior of a living organism lies in the control of perceived aspects of both itself and its environment Sections cover theory the application of PCT to a broad range of disciplines why perceptual control is fundamental to understanding human nature a new way to do research on brain processes and behavior how the role of natural selection in behavior can be demystified how engineers can emulate human purposeful behavior in robots and much more Each chapter includes an author biography to set the context of their work within the development of PCT Presents case studies that show how PCT can be applied in different disciplines Illustrates the Test for the Controlled Variable TCV and the construction of functional models as fruitful alternatives to mainstream experimental design when studying behavior Shows how theory illuminates structure and functions in brain anatomy Compares and contrasts PCT with other contemporary interdisciplinary theories

Enhancing Performance for Action and Perception, 2011-07-06 This volume of Progress in Brain Research follows on from the 32nd International Symposium of the Groupe de recherche sur le syst me nerveux central GRSNC May 2010 and aims to provide an overview of the various neural mechanisms that contribute to learning new motor and sensory skills and to adapting to changed circumstances including the use of devices and implants to substitute for lost sensory or motor abilities brain machine interfaces The focus is on recent developments covering five major themes Mechanisms to improve motor performance Neuro rehabilitation of motor function Mechanisms to enhance sensory perception Cross modal interaction for enhancing sensorimotor performance Assistive technologies to enhance sensorimotor performance 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

Language Grounding in Robots Luc Steels, Manfred Hild, 2012-02-14 Written by leading international experts this volume presents contributions establishing the feasibility of human language like communication with robots The book explores the use of language games for structuring situated dialogues in which contextualized language communication and language acquisition can take place Within the text are integrated experiments demonstrating the extensive research which

targets artificial language evolution Language Grounding in Robots uses the design layers necessary to create a fully operational communicating robot as a framework for the text focusing on the following areas Embodiment Behavior Perception and Action Conceptualization Language Processing Whole Systems Experiments This book serves as an excellent reference for researchers interested in further study of artificial language evolution *Modularity in Motor Control: From Muscle Synergies to Cognitive Action Representation* Andrea d'Avella, Martin Giese, Yuri P Ivanenko, Thomas Schack, Tamar Flash, 2016-04-21 Mastering a rich repertoire of motor behaviors as humans and other animals do is a surprising and still poorly understood outcome of evolution development and learning Many degrees of freedom non linear dynamics and sensory delays provide formidable challenges for controlling even simple actions Modularity as a functional element both structural and computational of a control architecture might be the key organizational principle that the central nervous system employs for achieving versatility and adaptability in motor control Recent investigations of muscle synergies motor primitives compositionality basic action concepts and related work in machine learning have contributed to advance at different levels our understanding of the modular architecture underlying rich motor behaviors However the existence and nature of the modules in the control architecture is far from settled For instance regularity and low dimensionality in the motor output are often taken as an indication of modularity but could they simply be a byproduct of optimization and task constraints Moreover what are the relationships between modules at different levels such as muscle synergies kinematic invariants and basic action concepts One important reason for the new interest in understanding modularity in motor control from different viewpoints is the impressive development in cognitive robotics In comparison to animals and humans the motor skills of today s best robots are limited and inflexible However robot technology is maturing to the point at which it can start approximating a reasonable spectrum of isolated perceptual cognitive and motor capabilities These advances allow researchers to explore how these motor sensory and cognitive functions might be integrated into meaningful architectures and to test their functional limits Such systems provide a new test bed to explore different concepts of modularity and to address the interaction between motor and cognitive processes experimentally Thus the goal of this Research Topic is to review compare and debate theoretical and experimental investigations of the modular organization of the motor control system at different levels By bringing together researchers seeking to understand the building blocks for coordinating many muscles for planning endpoint and joint trajectories and for representing motor and behavioral actions in memory we aim at promoting new interactions between often disconnected research areas and approaches and at providing a broad perspective on the idea of modularity in motor control We welcome original research methodological theoretical review and perspective contributions from behavioral system and computational motor neuroscience research cognitive psychology and cognitive robotics

The Computational Neurobiology Of Reaching And Pointing A Foundation For Motor Learning Computational Neuroscience Book Review: Unveiling the Magic of Language

In an electronic era where connections and knowledge reign supreme, the enchanting power of language has been apparent than ever. Its ability to stir emotions, provoke thought, and instigate transformation is really remarkable. This extraordinary book, aptly titled "**The Computational Neurobiology Of Reaching And Pointing A Foundation For Motor Learning Computational Neuroscience**," published by a very acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound affect on our existence. Throughout this critique, we will delve into the book's central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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