Society for the
Neural Control of Movement

NCM SATELLITE MEETING DETAILED DAILY PROGRAM

NCM Satellite Meeting, Santa Fe, New Mexico
April 29 & 30 2018
All sessions will be held at the Hilton Santa Fe Buffalo Thunder Hotel

The Complexity of the Nervous System

The science of complexity is fundamentally concerned with the study of many-body adaptive systems -- for example, an ant colony or a country's economy. The brain is arguably the ultimate complex adaptive system, as it is made up of billions of individual entities (neurons) with countless interconnections that interact across multiple spatial and temporal timescales in order to learn about the body and the environment.

Beginning in the last third of the twentieth century, and progressing rapidly in the last 20 years, significant progress has been made in both the tools and the frameworks and theories of complexity science. These include theories of scaling, collective behavior, frameworks for inferential learning, and information processing, in addition to the techniques of non-linear control theory, network theory, information theory, and agent-based modeling. While neuroscience continues to be transformed by formal tools such as network science, information theory and Bayesian inference, the more general frameworks of non-linear control, collective behavior and computation, and scaling are less well known to the neuroscience community.

The Santa Fe Institute (SFI) is at the center of these theoretical efforts. In this one day short-course, SFI faculty will review recent progress in complexity science. They will introduce the fundamental tools and concepts required to understand adaptive neural phenomena in a way that is accessible even to those largely unfamiliar with the mathematics of complex adaptive systems. Each session will include significant discussion, led by SFI faculty members and a discussant drawn from the NCM community. The goal is to demonstrate what the tools of complexity science can and cannot do, and to illustrate the power of these tools to make sense of complicated data. Furthermore, they will aim to refute some of the more egregious examples of the misapplication and over-interpretations of network theory, information theory, and collective computation as applied to neural case studies.

The satellite symposium is organized by the Santa Fe Institute.

Sunday April 29

17:00 – 19:00 Satellite Registration

18:00 – 19:00 Satellite Drinks Reception, Jernez Terrace

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Monday April 30

08:00 - 08:30 Registration

08:30 – 09:30 **Introduction to complex systems – the science of networks of adaptive agents**
David Krakauer, Santa Fe Institute

What is complexity and why does it need a new science? I shall introduce the fundamental challenge of complex systems, the methods that are emerging to address the challenge, and some recent frameworks and theories of complexity. The brain is a complex system that has often been treated as if it were a simple system with a single optimal level of analysis. What might complexity neuroscience look like?

9:30 – 9:45 **Coffee Break**

09:45 – 12:00 **Machine learning, "deep neural networks", and the brain**
Artemy Kolchinsky, Santa Fe Institute

In recent times, so-called "deep neural networks" have led to a revolution in machine learning, delivering unprecedented performance on a wide variety of difficult tasks. This tutorial will discuss the fundamentals of machine learning, how and why deep neural networks work, and what machine learning and neuroscience can tell each other.

12:00 – 13:00 Lunch

13:00– 14:00 **Criticality and Robustness in Networks of Neurons**
Michelle Girvan, Santa Fe Institute and University of Maryland

Experimental evidence suggests that networks of neurons operate near a critical point, i.e., the boundary between an order-disorder phase transition. Criticality provides the order needed for coherent function while at the same time allowing the system the flexibility that is associated with the disordered state. Mathematical models of phase transitions in neuronal networks help us to identify features of the brain's wiring that are key for optimal information processing.

14:00 – 15:00 **Why we sleep; Unravelling neural reorganization from repair**
Geoffrey West, Santa Fe Institute

A mechanistic framework for why we sleep and for understanding and predicting quantitatively how sleep changes across organisms and as individuals grow will be presented. Combined with a comprehensive analysis of human

sleep data for total sleep time, REM sleep, cerebral metabolic rate, brain size, and synaptic density the theory shows how this can distinguish between sleep used for neural reorganization versus repair and how these change during ontogeny, including how they relate to REM and non-REM sleep. A dramatic transition is revealed at 2.4 years old in humans akin to the phase transition as when water freezes to ice.

15:00 – 15:30 **Coffee Break**

15:30 – 16:30 **Towards principles of collective computation for adaptive systems**
Jessica Flack, Santa Fe Institute

I will introduce a framework for studying how adaptive systems, from brains to societies to ai, accumulate & integrate information during collective computation, given noisy data, processing constraints, a finite population of imperfect sensors, and in the absence of a clear termination criterion. I will then illustrate the potential power of this framework to a) facilitate explicit comparison across these (seemingly very different) systems by guiding question choice and experimental design, and b) identify general computational principles.

16:30 – 17:30 **Panel – Questions and General Discussion**
David Krakauer, Artemy Kolchinsky, Michelle Girvan, Geoffrey West, Jessica Flack, and NCM Discussants

19:30 – 21:30 **Opening Reception for Annual Meeting,**
Please Note: If you registered to attend the Satellite Meeting ONLY and want to attend the dinner, tickets can be purchased at the registration desk.