CNeuro2025 Lecture Abstracts

Markus Meister

Abstract 1 – Basic Lecture:

The Unbearable Slowness of Being: Why Do We Live at 10 bits/s?

This talk is about the neural conundrum behind the slowness of human behavior. The information throughput of a human being is about 10 bits/s. In comparison, our sensory systems gather data at 10^9 bits/s. The stark contrast between these numbers remains unexplained and touches on fundamental aspects of brain function: what neural substrate sets this speed limit on the pace of our existence? Why does the brain need billions of neurons to process 10 bits/s? Why can we only think about one thing at a time? The brain seems to operate in two distinct modes: the ‘‘outer’’ brain handles fast high-dimensional sensory and motor signals, whereas the ‘‘inner’’ brain processes the reduced few bits needed to control behavior. Plausible explanations exist for the large neuron numbers in the outer brain, but not for the inner brain, and I propose new research directions to remedy this.

This is a perspective talk that gives a new outlook on human behavior and cognition and suggests some major open questions for brain science. A good preparation would be reading our recent review paper: Zheng, J., and M. Meister. 2025. The unbearable slowness of being: Why do we live at 10 bits/s? Neuron. 113:192–204.

Abstract 2 – Advanced Lecture:

Rapid Learning of Complex Tasks - from Phenomena to Algorithms

Animals learn certain complex tasks remarkably fast, sometimes after a single experience. To bring such phenomena into the laboratory, we have studied the unconstrained behavior of mice in a labyrinth. The animal eagerly explores the new environment, making about 2000 turning decisions per hour. It quickly discovers the location of a reward in the maze and then navigates back to that location at will. It learns to make correct 10-bit choices after only 10 reward experiences. It also finds an error-free route back to the entrance on the first attempt. How can one explain such one-shot learning of complex actions in a novel environment? I will propose an algorithm that learns the structure of an arbitrary environment, discovers useful

targets during exploration, and navigates back to those targets by the shortest path. It makes use of a behavioral module common to all motile animals, namely the ability to follow an odor gradient by trial and error.

We show how the brain can generate internal “virtual odors” that serve as tags for locations of interest. This “endotaxis" algorithm can be implemented with a 3-layer neural circuit using only biologically realistic structures and learning rules. Components of this scheme are found in brains from insects to humans, suggesting that nature may have evolved a general mechanism for search and navigation on the ancient backbone of chemotaxis.

A good preparation would be reading these articles:

Meister, M. 2022. Learning, fast and slow. Current Opinion in Neurobiology. 75:102555.

Rosenberg, M., T. Zhang, P. Perona, and M. Meister. 2021. Mice in a labyrinth show rapid learning, sudden insight, and efficient exploration. eLife. 10:e66175.

Zhang, T., M. Rosenberg, Z. Jing, P. Perona, and M. Meister. 2024. Endotaxis: A neuromorphic algorithm for mapping, goal-learning, navigation, and patrolling. eLife. 12:RP84141.

Jing, Z., and M. Meister. 2024. A Fast Algorithm for All-Pairs-Shortest-Paths Suitable for Neural Networks. Neural Computation. 36:2710–2733.