Alipasha Vaziri, Ph.D.

PROFESSOR, LABORATORY OF NEUROTECHNOLOGY AND BIOPHYSICS

Brain functions rely on the coordinated dynamics of a vast number of highly interconnected neurons. To discern how these dynamics lead to behavior, Vaziri seeks to capture and manipulate neuronal activity over large brain volumes at high speed, depth, and single-cell resolution across species. His lab develops imaging techniques addressing these demands to generate functional maps of neuronal circuits up to the level of a whole brain in behaving animals.

A major goal of systems neuroscience is to understand how sensory information is represented in and processed by the brain, and ultimately leads to complex behavior. Maps of how neurons connect are essential to achieving this goal but have not been sufficient due to the extremely interconnected and recurrent nature of neuronal networks. In many cases, brain functions are thought to emerge from highly distributed networks of local circuits interacting via long-range neuronal connections. However, the ability to study such large-scale functional circuits has been hampered by the lack of tools and methods capable of manipulating neuronal activity in specific spatiotemporal patterns while also capturing the dynamic activity of the entire network at high spatial and temporal resolutions.

Vaziri's lab develops and applies new neurotechnologies for large-scale, high-speed interrogation of neuroactivity at single-cell resolution. Over the years, the lab has developed a portfolio of different optical neurotechnologies that have expanded the conventional limits on imaging speed, spatial resolution, depth, and volume. They have demonstrated this capability by recording activity from the entire brain of *C. elegans* and larval zebrafish at high speed and single-cell resolution.

The lab recently extended these capabilities to the rodent brain, which strongly scatters light and thus limits imaging depth. They have developed neurotechnologies that enable detection of neuroactivity across large volumes of brain tissue and at single-cell resolution in freely behaving animals as well as those under head-fixed conditions. Their most recent method, hybrid multiphoton sculpted light microscopy (HyMS), has enabled for the first time near-simultaneous recording of activity at different depths in the mouse brain and at a high speed (up to 17 Hz). It can capture activity in entire cortical columns and subcortical regions encompassing up to 12,000 neurons at single-neuron resolution. This technological achievement represents the first volumetric calcium imaging of subcortical brain regions and one of the deepest (1.22 mm) optical recordings of neuroactivity in intact brain tissue. The unmatched performance of this method has established a new frontier for volumetric and deep-tissue imaging of neuroactivity.

However, developing these technologies is not the end goal of the lab's research program. They endeavor to make these tools accessible to other researchers, to enable biological discoveries, and to extend thefrontiers in neuroscience by making it possible to solve a qualitatively new range of neurobiological questions. Thus, Vaziri has applied these technologies not only to specific biological questions in his own lab but also in close collaborations with other neuroscience labs.

Vaziri envisions that the insights gained from these studies will go beyond uncovering biological mechanisms and may ultimately lead to conceptually new and generalizable information theoretical frameworks and models of computation by neuronal networks.

EDUCATION

M.Sc. in physics, 2000
Ph.D. in physics, 2003
University of Vienna

POSTDOC

National Institute of Standards and Technology
and the University of Maryland, 2003–2005

POSITIONS

Associate, 2005–2007
McKinsey & Company

Research Specialist, 2007–2011
Howard Hughes Medical Institute

Assistant Professor, 2011–2014
Director, Quantum Phenomena and Nanoscale Biological Systems Interdepartmental Research Platform, 2012–2015
Associate Professor, 2014–2015
University of Vienna

Group Leader, 2011–2015
Research Institute for Molecular Pathology

Associate Professor, 2015–2020
Professor, 2020–
Associate Director, Kavli Neural Systems Institute, 2016–2023
Director, Kavli Neural Systems Institute, 2023–2024
Director, Elizabeth R. Miller Brain Observatory, 2024–
The Rockefeller University

AWARDS

WWTF Vienna Research Groups for Young Investigators Award, 2010

Human Frontier Science Program Young Investigators' Award, 2012

Prize of the City of Vienna, 2014

Fellow Member of Optica, 2022

SELECTED PUBLICATIONS

Demas, J. et al. High-speed, cortex-wide volumetric recording of neuroactivity at cellular resolution using light beads microscopy. *Nat. Methods* 18, 1103–1111 (2021).

Lin, Q. et al. Cerebellar neurodynamics predict decision timing and outcome on the single-trial level. *Cell* 180, 536–551 (2020).

Weisenburger S. et. al. Volumetric Ca2+ imaging in the mouse brain using hybrid multiplexed sculpted light (HyMS) microscopy. *Cell* 177, 1–17 (2019).

Skocek O. et. al. High-speed volumetric imaging of neuronal activity in freely moving rodents. *Nat. Methods* 15, 429–432 (2018).

Prevedel, R. et al. Simultaneous whole-animal 3D imaging of neuronal activity using light-field microscopy. *Nat. Methods* 11, 727–730 (2014).