Antonio Fernandez-Ruiz, PhD

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Animals, including humans, display a remarkable array of flexible behaviors, as adaptive responses to changing environmental demands. They learn from experience and, based on it, make new inferences that guide decisions. These behaviors are supported by the finely tuned interactions between neuronal ensembles distributed across brain circuits. The overarching mission of my lab is to understand the algorithmic and mechanistic underpinnings of flexible behavior at the computational, systems, and cellular levels. We are particularly interested in understanding the types of complex behaviors animals exhibit in their natural habitats and identifying general principles across different tasks, cognitive domains and species. With this goal, we develop novel paradigms that capture the complexity of rodent's natural behaviors and allow quantitative and mechanistic dissection of both behavior and its neural bases. We combine different disciplines, including neuroscience, ethology, machine learning, engineering and materials science, to achieve a cell-type specific understanding of neural circuit mechanisms and computational operations in the context of rodent's natural behaviors. To overcome current technical limitations, we also develop novel tools and approaches for a more precise interrogation of neural circuit dynamics and behavior, with a particular emphasis in bridging across levels of biological organization. We are also interested in the application of our basic research to understand how neural circuit dysfunction leads to pathological activity and cognitive symptoms in brain disease. In addition, we are exploring the application of the tools we develop to deploy novel intervention strategies, such as closed-loop manipulations of neural dynamics, aimed at reversing pathological memory deficits.

Education

2011 - 2015	**PhD in Physics.** School of Physics, Complutense University of Madrid.
2009 - 2011	**MSc in Applied Physics.** School of Physics, Complutense University of Madrid.
2004 - 2009	**BSc in Biological Sciences** ("Licenciatura"). U. of Sevilla and Complutense U. of Madrid.

Research positions

07/2026-present	**Associate Professor**. Department of Neurobiology and Behavior, Cornell University
2021 - 2026	**Assistant Professor**. Department of Neurobiology and Behavior, Cornell University
2016 – 2021	**Postdoctoral Fellow**. NYU Neuroscience Institute, Langone Medical Center Advisor: György Buzsáki.
2016 - 2020	**Visiting Researcher**. Department of Physiology of Cognitive Processes, Max Plank Institute for Biological Cybernetics. Advisor: Nikos Logothetis
2015 - 2016	**Postdoctoral Fellow**. Department of Physiology, School of Medicine, University of Szeged. Advisor: Antal Berényi.
2013 - 2015	**Graduate Research Fellow**. Department of Applied Physics III, School of Physics, Complutense University of Madrid. Advisors: Sagrario Muñoz and Miguel Sancho.
2009 - 2013	**Graduate Research Fellow**. Cajal Institute. Supervisor: Oscar Herreras.
2008 - 2009	**Undergraduate Research Fellow.** Department of Applied Mathematics, School of Mathematics, Complutense University of Madrid. Advisor: Dr. Valeri Makarov
2008	**Visiting Student.** Xlab, George-August Universitat of Gottingen. Advisors: Prof. Erwin Neher and Prof. Eva-Maria Neher.

Honors and awards

2025 – 2029	**Pew Biomedical Scholar Award**
2024 - 2027	**MIND Prize**. Pershing Square Philanthropies
2023 - 2028	NIH DP2 **New Innovator Award**
2022	**Freedman Prize for Exceptional Basic Research**, Brain & Behavior Research Found.

2022 - 2026	Scialog Fellow, Research Corporation for the Advancement of Science
2022 - 2025	**Klingenstein-Simons Neuroscience Fellow**, Kinship and Simons Foundations.
2022 - 2024	**Sloan Fellow**, Sloan Foundation
2022 - 2025	Whitehall Research Grant, Whitehall Foundation
2020	**Blavatnik Award for Young Scientists in the Life Sciences**, NY Academy of Science
2020	Nancy and Peter Meinig Family Investigator in the Life Sciences, Cornell University
2020	Havens Family Investigator, Brain & Behavior Research Foundation
2020	**Regeneron Prize for Creative Innovation**
2019	**Peter and Patricia Gruber International Research Award**, Society for Neuroscience
2020 – 2022	NARSAD Young Investigator Award
2019 - 2024	NIMH K99/R00 Pathway to Independence Award
2018	Outstanding Reviewer – eNeuro
2018	NYU Outstanding Postdoc
2017	Austin Conference on Learning & Memory travel award
2016 - 2020	Sir Henry Wellcome Postdoctoral Fellowship
2026	Participation award for the Brain Prize Master Class on Translational Neuroscience.
2015 – 2017	European Molecular Biology Organization (EMBO) long-term Postdoctoral Fellowship
2015 – 2016	Max Planck - Prince of Asturias Collaboration Grant
2016	Best PhD dissertation 2015. Complutense University of Madrid
2013 – 2015	'La Caixa' PhD of Excellence Fellowship
2013	EMBO Short-Term Fellowship
2013	FENS travel award for the Society of Neuroscience meeting
2013	Spanish Society for Neuroscience (SENC) travel award for the SfN meeting
2011	Travel award for IV Spanish Olfaction Network (ROE) Symposium
2011	Travel award for XIX SENC meeting
2009 – 2013	JAE Pre-doctoral Fellowship, Spanish Research Council (CSIC)
2008 - 2009	Undergraduate Research Fellowship, Spanish Ministry of Education
2008	Xlab Fellowship for Introduction to Research, George-August Universitat
2008	JAE Fellowship for Introduction to Research, CSIC
2008	Roche Continents Award
2009	Extraordinary Prize of the Degree. Complutense University of Madrid. (highest GPA)

Publications

(* denotes co-first author; # denotes co-last author)

At Cornell:

1) Chang H*, Chen W*, Karaba LA, Mei X, Harvey RE, Tang W, Fernandez-Ruiz A, Oliva A. (2026) Dynamic shifts in brain criticality support cognitive processing. **bioRxiv**, 10.64898/2026.03.12.711394

2) Zhao Z, Chang H, Park J, Liu C, Paudel P, Oliva A, Fernandez-Ruiz A. A wireless modular platform for neuro-behavioral recording and closed-loop manipulation in small animals. (2026) **Nature Methods** (accepted)

3) Tang W, Mei X, Harvey R, Carbajal-Leon E, Netzer T, Chang H, Oliva A, Fernandez-Ruiz A. (2026). Goal-directed hippocampal theta sweeps during memory-guided navigation. **Nature Neuroscience** (accepted) and bioRxiv 2025.08. 26.672489

4) Tang W*, Chang H*, Liu C, Perez-Hernandez S, Zheng W, Park J, Oliva A#, Fernandez-Ruiz A#. (2026). A hippocampal population code for rapid generalization. **Nature Neuroscience** (accepted) and bioRxiv 2025.03.15.643456

5) Vetere LM, Galas AM, Vaughan N, Feng Y, Wick ZC, Philipsberg PA, Liobimova O, Fernandez-Ruiz A, Cai DJ, Shuman T. (2026). Medial entorhinal-hippocampal desynchronization parallels the emergence of memory impairment in a mouse model of Alzheimer's disease pathology. **Cell Reports** (accepted) and bioRxiv 2025.01.15.633171

6) Robinson HL*, Todorova R*, Nagy GA, Gruzdeva A, Paudel P, Oliva A, Fernandez-Ruiz A. (2026). Large

sharp-wave ripples promote hippocampo-cortical memory reactivation and consolidation. **Neuron,** 114 (2), 226-236

7) Chang H*, Tang W*, Wulf A, Nyasulu T, Wolf M, Fernandez-Ruiz A#, Oliva A#. (2025). Sleep micro-structure organizes memory replay. **Nature**, 637:1161–1169.

8) Rocha-Almeida F, Conde AR, Fernandez-Ruiz A, Delgado-Garcia JM, Gruart A. (2025). Cortical and subcortical activities during food rewards versus social interaction in rats. **Scientific Reports,** 15: 4389

9) Karaba L*, Robinson H*, Harvey R, Fernandez-Ruiz A, Oliva A. (2024). A hippocampal circuit mechanism to balance memory reactivation during consolidation. **Science**, 385,738-743

10) Tiwari P,…,Fernandez-Ruiz A, Kwan AC, Vaidya VA. (2024).Ventral hippocampal parvalbumin interneurons gate the acute anxiolytic action of the serotonergic psychedelic DOI. **Neuron.** 22:3697-3714

11) Liu C*, Todorova R*, Tang W, Oliva A, Fernandez-Ruiz A. (2023) Associative and predictive hippocampal codes support memory-guided behaviors. **Science,** 382, eadi8237. [Preview in Science, 382,262-263]

12) Harvey R, Robinson H, Liu C, Oliva A#, Fernandez-Ruiz A#. (2023) Hippocampo-cortical circuits for selective memory encoding, routing and replay. **Neuron** 111 (13), 2076-2090. e9

13) Fernandez-Ruiz A, Sirota A, Lopes-Dos-Santos V, Dupret D. (2023). Over and above frequency: Gamma oscillations as units of neural circuit operations. **Neuron** 5;111(7):936-953. (Review)

14) Oliva A, Fernández-Ruiz A, Karaba L. (2023) CA2 orchestrates hippocampal network dynamics. **Hippocampus** 33 (3), 241-251. (Review)

15) Soula M, Maslarova A, Harvey RE, Valero M, Brandner S, Hamer H, Fernandez-Ruiz A, Buzsaki, G (2023). Intricate epileptiform discharges affect memory in an Alzheimer's Disease mouse model. **PNAS.** 120 (34) e2302676120.

16) Vöröslakos M, Kim K, Slager N, Ko E, Oh S, Parizi S, Hendrix B, Seymour J, Wise K, Buzsáki G, Fernández-Ruiz A#, Yoon E#. (2022) HectoSTAR μLED optoelectrodes for large-scale, high-precision in vivo opto-electrophysiology. **Advanced Science,** 9(18): 2105414.

17) Fernández-Ruiz A, Oliva A, Chang H. (2022) High resolution optogenetics in space and time. **Trends In Neurosciences** 45:854-864. (Review)

18) Sharif F, Tayebi B, Buzsaki G, Royer S#, Fernández-Ruiz A#. (2021) Subcircuits of deep and superficial CA1 place cells support efficient place coding across heterogeneous environments. **Neuron**, 109:363-

Prior work:

1) Zutshi I, Valero M, Fernandez-Ruiz A, Buzsaki G. (2022) Extrinsic control and intrinsic computation in the hippocampal CA1 circuit. **Neuron**, 110 (4), 658-673. e5

2) Homberg,…, Fernandez-Ruiz A, et al., (2021) The continued need for animals to advance brain research. **Neuron,** 4;109(15):2374-2379.

3) Fernandez-Ruiz A, Oliva A, Soula M, Rocha-Almeida F, Nagy G, Martin-Vazquez G, Buzsáki G. (2021) Gamma rhythm communication between entorhinal cortex and dentate gyrus neuronal assemblies. **Science**, 2;372(6537): eabf3119.

4) Oliva A, Fernandez-Ruiz A, Leroy F, Siegelbaum S. (2020) Hippocampal CA2 ripples recruit social replay and promote social memory. **Nature**, 587: 264-269.

5) Buzsaki G., Fernandez-Ruiz A. (2019) Utility of the Idling Brain: Abstraction of new knowledge. **Cell** 178(3), 513-515.

6) Fernandez-Ruiz A*, Oliva A*, Fermino de Oliveira E, Rocha-Almeida F, Tingley D, Buzsáki G. (2019) Long-duration Hippocampal Sharp Wave Ripples Improve Memory. **Science,** 364 (6445), 1082-1086

7) Senzai Y*, Fernandez-Ruiz A*, Buzsáki G. (2019) Layer-specific physiological features and interlaminar interactions in the primary visual cortex of the mouse. **Neuron** 101,1-14.

8) Oliva A, Fernandez-Ruiz A, Fermino de Oliveira E, Buzsáki G. (2018) Origin of gamma frequency power during hippocampal sharp-wave ripples. **Cell Reports,** 25 (7), 1693-1700.

9) Barth AM, Domonkos A, Fernandez-Ruiz A, Freund TF, Varga V (2018) Hippocampal network dynamics during rearing episodes. **Cell Reports**, 23 (6), 1706.

10) Vöröslakos M, … Fernández-Ruiz A, …, Berényi A. (2018). Direct effects of transcranial electric stimulation on brain circuits in rats and humans. **Nature Communications**, 9 (1): 483.

11) Fernandez-Ruiz A, Oliva A, Nagy GA, Maurer AP, Berényi A, Buzsáki G. (2017) Entorhinal-CA3 dual-input control of spike timing in the hippocampus by theta-gamma coupling. **Neuron**, 93:1213-1226.

12) Buzsáki G, Fernandez-Ruiz A. (2017) Hippocampus: network physiology. In: Handbook of Brain Microcircuits, Ed: Sheperd GM and Grillner S. Oxford University Press. (book chapter).

13) Oliva A, Fernandez-Ruiz A, Buzsáki G, Berényi A. (2016) Spatial coding and physiological properties of hippocampal neurons in the Cornu Ammonis subregions. **Hippocampus**, 26: 1593–1607.

14) Oliva A, Fernandez-Ruiz A, Buzsáki G, Berényi A. (2016) Role of hippocampal CA2 region in triggering sharp-wave ripples. **Neuron** 91:1342-1355.

15) Fernandez-Ruiz A, Oliva A. (2016) Distributed representation of "what" and "where" information in the parahippocampal region. **Journal of Neuroscience,** 36:8286-8288.

16) Oliva A, Fernandez-Ruiz A. (2016) Incorporating single cell contribution into network models of ripple generation. **Journal of Physiology**, 595(1):9-10.

17) Fernandez-Ruiz A (2016) Extracellular potentials in the hippocampus. Springer. (book).

18) Schomburg EW*, Fernandez-Ruiz A*, Berényi A, Mizuseki K, Anastassiou CA, Koch C, Buzsáki G. (2014) Theta phase segregation of input-specific gamma patterns in entorhinal-hippocampal networks. **Neuron**. 84:470-485.

19) Benito N*, Fernandez-Ruiz A*, Makarov VA, Makarova J, Korovaichuk A, Herreras O. (2014) Spatial blocks of coherent pathway-specific LFPs in the hippocampus reflect different modes of presynaptic synchronization. **Cerebral Cortex**. 24:1738-52

20) Enriquez-Barreto L, Cuesto G, Dominguez-Iturza N, Gavilán E, Ruano D, Sandi C, Fernández-Ruiz A, Martín-Vázquez G, Herreras O, Morales M. (2014) Learning improvement after PI3K activation correlates with de novo formation of functional small spines. **Frontiers in Molecular Neurosci** 2;6:54.

21) Fernandez-Ruiz A*, Schomburg EW*. (2013) The rules of entrainment: are CA1 gamma oscillations externally imposed or locally governed? **Journal of Neuroscience** 33:19045-19047.

22) Fernandez-Ruiz A, Muñoz S, Sancho M, Makarov VA, Herreras O. (2013) Cytoarchitectonic and dynamic origins of giant positive LFPs in the Dentate Gyrus. **Journal of Neuroscience** 33:15518-15532.

23) Fernández-Ruiz A, Herreras O. (2013) Identifying the synaptic origin of ongoing neuronal oscillations through spatial discrimination of electric fields. **Frontiers in Computational Neuroscience** 7:5.

24) Fernandez-Ruiz A, Makarov VA, Herreras O. (2012) Sustained increase of spontaneous input and spike transfer in the CA3-CA1 following long-term potentiation in vivo. **Frontiers in Neural Circuits**. 6:71.

25) Fernandez-Ruiz A, Makarov VA, Benito N, Herreras O. (2012) Schaffer-specific local field potentials reflect discrete excitatory events at gamma-frequency that may fire CA1 units. **Journal of Neuroscience**. 32:5165-5176.

Invited speaker (selected, since 2021 only)

2027 *sched.* Hippocampus Gordon Conference. California.
sched. University of Montreal. Montreal.
sched. University of California Berkeley. California.

2026 Federation of European Neuroscience (FENS) Forum. Barcelona.
2026 International Congress for Neuroethology. Vancouver.
UCSF Neuroscience Seminar Series
Hippocampus Green Meeting. Barcelona
Purdue Neuroscience, Neurotechnology and Neuro-AI Symposium
Rockefeller University Seminar Series. NYC.
2026 Materials Research Society Meeting. Honolulu.
Harvard Neurobiology Seminar Series
Scripps Research Institute. San Diego.
2025 Cold Spring Harbor Asia Conference, Suzhou (China).
SfN Meeting, San Diego.
University of Geneva (Switzerland)
University of Tubingen (Germany)
IMED Marseille (France)
Wu Tsai Neuroscience Institute Seminar Series, Stanford.
Janelia Research Campus.
20th Meeting of the Spanish Society of Neuroscience. Spain.
Klingenstein-Simons 2025 Neuroscience Meeting. NYC.
Hippocampus Spring Conference, Verona (Italy)
Winter Conference on Neural Plasticity. Fiji.
2024 Chronobiology Center, University of Pennsylvania
NIMH 75 Anniversary Symposium. Washington DC
RIKEN Center for Brain Science. Tokyo
Blavatnik Science Symposium. NYC
Stony Brook University. Stony Brook
Icahn School of Medicine at Mt. Sinai. NYC
NYU Neuroscience Institute. NYC
46th Meeting of the Japan Neuroscience Society. Fukuoka, Japan
2023 Drexel University, Philadelphia
Learning and Memory Conference, Huntington Beach
Yale University, BSTP Seminar Series
Hippocampus Spring Conference, Verona (Italy)
2022 Bernstein Seminar 2022, University of Freiburg, Germany
Neuroscience Institute, Brandeis University
Syracuse University. Syracuse, NY.
2021 Donders Institute for Brain, Cognition and Behavior, Nijmegen, Netherlands
Friedrich Miescher Institute for Biomedical Research, Basel, Switzerland

Current funding:

06/2025 - 02/2030 NIH R01 MH120162 (Co-I, PI: Denise Cai)
Circuit Mechanisms of Retrospective Memory-Linking

08/2025 - 07/2029 Pew Biomedical Scholars Award (PI)
Neural mechanisms of foraging behavior

09/2023 - 08/2028 NIH DP2 MH136496 (PI)
How do animals learn the structure of their natural environment?

09/2024 - 07/2029 NIH R01 MH136355 (PI)
Mechanisms and functions of temporal coordination in the entorhinal-hipp. network

04/2023 - 01/2028 NIH R01 AG081934 (Co-I, PI: Chris Schaffer)
Metabolic and neural activity normalization by cerebral blood flow increase in AD/ADRD models

06/2022 - 05/2025 NIH R01 RF1AG072497 (Co-I, PI: Tristan Shuman)
Entorhinal-hippocampal interactions during progressive memory impairments in mouse models of Alzheimer's disease pathology

2/2025- 1/2027 RSCA Scialog (Co-PI with Marcelo Mattar and Mathew Lowett-Barron)
Understanding the neural basis of natural behavior with individualized RNNs

05/2024 - 07/2027 Pershing Square Foundation MIND Prize (PI)
Restoration of pathological neural dynamics to improve cognition in Alzheimer

7/2022- 6/2025 Whitehall Research Grant (PI)
Cellular mechanisms of memory-guided decision making

7/2022- 6/2025 Klingenstein-Simons Fellowship (PI)
Distributed brain dynamics for memory-guided behavior

Teaching and mentoring:

2023 - What is Intelligence? Course director.
2022 - Neural Dynamics. Course director.
2022 - Introduction to Neuroscience. Lecturer.
2024 NBB Presentation Series. Course director.

2021 - Thesis Committee Chair or Co-Chair: Can Liu, Jaehyo Park, Lindsay Karaba, Praveen Paudel, Hongyu Chang, Kushaan Gupta
2021 - Thesis Committee member: Anna Gruzdeva, Jason Gao, Austin Bunce (BME), Arron Hal (Drexel), Yiqing Lu (NYU)
2022- 1st Year Undergraduate Faculty Advisor (Cornell OUB)
2022 - Nexus Scholar Program, Undergraduate Research Advisor

Professional service:

Ad-hoc Editor: PNAS, eLife, Frontiers in Neuroscience
Ad-hoc reviewer: Science, Nature, Neuron, Nature Neuroscience, Nature Communications, PNAS, Current Biology, Cell Reports, eLife, Journal of Neuroscience, PLoS Biology, PLoS Computational Neuroscience, Journal of Neurophys, Progress in Neurobiology, PLoS One, eNeuro, Journal of Neuroscience Methods, Journal of Physiology, Neuroscience, Science Advances
Ad-hoc reviewer/ study section member: NIMH, NSF, Wellcome Trust, HFSP, Alzheimer Foundation, UKRI

2024 - NBB Seminar Series Committee
2024 - NBB Undergraduate Curriculum Committee
2023 Faculty search committee Cornell AI for Science
2023 Symposium organizer, Learning and Memory Conference. Huntington Beach.
2022 - NBB Graduate Program Admissions Committee
2022 NBB Diversity Weekend
2022, 2024 Faculty search committee Neurobiology and Behavior Department
2020 Symposium organizer, Winter Conference on Learning and Memory. Park City
2019 Symposium organizer, Hippocampal Research Conference. Taormina, Italy.
2013 - Member, Society for Neuroscience (SfN)
2013 - Member, Federation of European Neuroscience (FENS)