Antonio Fernandez-Ruiz, PhD

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The overarching mission of my research program is to understand **how neuronal dynamics in distributed brain circuits support complex cognitive functions** and how small imbalances can lead to pathological states. This process is supported by the fine-tuned coordination of different neuronal populations in distributed brain circuits. A major obstacle to answering this question are the limitations imposed by current technology, thus, part of my efforts is devoted to developing new methods for a more precise interrogation and manipulation of brain circuit dynamics in behaving animals. In my lab at Cornell, we investigate the computations and underlying cellular mechanisms that support the **role of hippocampo-cortical interactions in learning, memory and decision making in rodents during normal and pathological states**. We tackle these questions by developing and applying cutting-edge techniques such as large-scale silicon probe recordings with closed-loop optogenetic manipulations, multi-photon Ca2+ imaging, anatomical and physiological circuit mapping and advanced analytical methods. We investigate the alterations in hippocampal and cortical circuit dynamics underlying memory deficits in genetic mouse models of Alzheimer's disease and Schizophrenia. In addition, we develop novel intervention strategies, such as closed-loop optogenetic manipulations of neural dynamics, to revert pathological memory deficits.

Education

PhD in Physics **2011-2015**
School of Physics, Complutense University of Madrid.

MSc in Applied Physics **2009-2011**
School of Physics, Complutense University of Madrid.

Licenciatura in Biological Sciences
Master in Neurobiology **2007-2009**
School of Biological Sciences, Complutense University of Madrid.
BSc in Biology **2004-2007**
School of Biology, University of Sevilla.

Research positions

Assistant Professor **July 2021- present**
Nancy and Peter Meinig Family Investigator in the Life Sciences
Department of Neurobiology and Behavior, Cornell University.

Postdoctoral Fellow **Dec 2016 – July 2021**
NYU Neuroscience Institute, Langone Medical Center, New York University.
Supervisor: Prof. György Buzsáki.

Visiting Researcher **March 2016- present**
Department of Physiology of Cognitive Processes, Max Plank Institute for Biological Cybernetics.
Supervisor: Prof. Nikos Logothetis

Postdoctoral Fellow **Nov 2015 – Nov 2016**
Department of Physiology, School of Medicine, University of Szeged.
Supervisor: Prof. Antal Berényi.

Visiting researcher **April 2013 – Mar 2014**
NYU Neuroscience Institute, New York University Medical Center.

Supervisor: Prof. György Buzsáki.

Graduate Research Fellow **Sept 2009-Oct 2015**
Department of Applied Physics III, School of Physics, Complutense University of Madrid. Supervisors: Prof. Sagrario Muñoz. and Prof. Miguel Sancho

Graduate Research Fellow **Sept 2009- Oct 2015**
Cajal Institute, Spanish Research Council (CSIC). Superv.: Dr. Óscar Herreras.

Visiting Student **Mar 2008- April 2008**
Xlab, George-August Universitat of Gottingen. Supervisors:
Prof. Erwin Neher and Prof. Eva-Maria Neher.

Awards and fellowships

- **MIND Prize,** Pershing Square Research Foundation, 2024.
- **NIH New Innovator Award,** 2023
- Scialog Fellow, Research Corporation for Science Advancement, 2023
- **Klingenstein-Simons Neuroscience Fellowship**, 2022
- **Whitehall Research Grant**, 2022
- **Sloan Research Fellowship,** 2022.
- **NARSAD Young Investigator** Grant, 2020-2021
- NIMH **K99/R00** Pathway to Independence Award, 2019-2024
- **Sir Henry Wellcome Postdoctoral Fellowship**, 2016-2020
- **EMBO long-term postdoctoral fellowship**, 2015-2017.
- Austin Conference on Learning & Memory travel award, 2017.
- Max Planck - Prince of Asturias Collaboration Grant, 2015-2016.
- Participation award for the Brain Prize Master Class on Translational Neuroscience. 2016.
- 'La Caixa' PhD of Excellence Fellowship, 2013-2015
- EMBO Short-Term Fellowship, 2013.
- FENS travel award for the SfN meeting, 2013.
- SENC travel award for the SfN meeting, 2013.
- Travel award for IV ROE Symposium, 2011.
- Travel award for XIX SENC meeting, 2011.
- JAE Pre-doctoral Fellowship, CSIC, 2009-2013.
- Roche Continents 2008 Award
- Undergraduate Research Fellowship, Spanish Ministry of Education, 2008-2009.
- Xlab Fellowship for Introduction to Research, George-August Universitat, 2008.
- JAE Fellowship for Introduction to Research, CSIC, 2008.

Prizes

- **Freedman Prize for Exceptional Basic Research,** Brain and Behavior Research Found., 2022
- **Blavatnik Award** for Young Scientists in the Life Sciences**,** NY Academy of Sciences, 2020
- Havens Family Investigator, Brain & Behavior Research Foundation, 2020.
- Nancy and Peter Meinig Family Investigator in the Life Sciences, Cornell University, 2020.
- **Regeneron Prize for Creative Innovation**, 2020.
- **Peter and Patricia Gruber International Research Award**, Society for Neuroscience, 2019.
- Outstanding reviewer eNeuro 2018.
- NYU Outstanding Postdoc 2018.
- Best PhD dissertation 2015. Complutense University of Madrid. 2016.
- Extraordinary Prize of the Degree (highest GPA). Complutense University of Madrid. 2009.

Publications

Senior Author:

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

Liu C*, Todorova R*, Tang W, Oliva A, **Fernandez-Ruiz A.** (2023) *Associative and predictive hippocampal codes support memory-guided behaviors.* Science, 382 (6668), eadi8237.

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

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)

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

Soula, M., Maslarova, A., Harvey, R. E., 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.

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.*

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

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: 363-376.

Others:

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

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

Fernández-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.

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

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

Fernández-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

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

by Vinck and Perrenoud, 2019, Neuron, 3:358-360).

Oliva A, **Fernández-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.

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

Vöröslakos M, Takeuchi Y, Brinyiczki K, Zombori T, Oliva A, **Fernández-Ruiz A,** Kozák G, Kincses Z, Iványi B, Buzsáki G, Berényi A. (2018). *Direct effects of transcranial electric stimulation on brain circuits in rats and humans.* Nat Comm, 9 (1): 483.

Fernández-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.

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

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

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

Fernández-Ruiz A, Oliva A. (2016) *Distributed representation of "what" and "where" information in the parahippocampal region.* J Neurosci, 36:8286-8288.

Oliva A, **Fernández-Ruiz A**. (2016) *Incorporating single cell contribution into network models of ripple generation.* J Physiol, 595(1):9-10.

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

Schomburg EW*, **Fernández-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. (* equal contribution). (Preview by Buttler and Paulsen, 2014. Neuron, 84:251

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*. Cereb Cortex. 24:1738-52 (* equal contribution).

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.* Front Mol Neurosci 2;6:54.

Fernández-Ruiz A*, Schomburg EW*. (2013) *The rules of entrainment: are CA1 gamma oscillations externally imposed or locally governed?* J Neurosci 33:19045-19047. (* equal contribution).

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

Fernández-Ruiz A, Herreras O. (2013*) Identifying the synaptic origin of ongoing neuronal oscillations through spatial discrimination of electric fields*. Front Comput Neurosci 7:5.

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.* Front Neural Circuits. 6:71.

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.* J Neurosci. 32:5165-5176.

Invited speaker (selected)

RIKEN Center for Brain Science. Tokyo, 2024.
Blavatnik Science Symposium. NYC, 2024.
Stony Brook University. Stony Brook, 2024
Icahn School of Medicine at Mt. Sinai. NYC, 2024
NYU Neuroscience Institute. NYC, 2024.
46th Meeting of the Japan Neuroscience Society. Fukuoka, Japan, 2024.
Drexel University, Philadelphia, 2023.
Learning and Memory Conference, Huntington Beach, 2023.
Yale University, BSTP Seminar Series, 2023.
Hippocampus Spring Conference, Verona (Italy), 2023.
Bernstein Seminar 2022, University of Freiburg, Germany, 2022.
Neuroscience Institute, Brandeis University, 2022.
Syracuse University, 2022.
Donders Institute for Brain, Cognition and Behavior, Nijmegen, Netherlands, 2021
Friedrich Miescher Institute for Biomedical Research, Basel, Switzerland, 2021.
UCSD, La Jolla. 2020.
UCLA Medical School, LA. 2020.
Boston University, Boston. 2020.
Cornell University, Ithaca, 2020.
Janelia Research Campus, Ashburn, 2020.
Vanderbilt University, Nashville, 2020.
Case Western Reserve University School of Medicine, Cleveland, 2020.
Georgetown University Medical Center, Washington DC, 2020
Winter Conference on Learning and Memory, Park City 2020 (Organizer).
12th FENS Forum of Neuroscience, Glasgow, 2020.
Ludwig-Maximilians University of Munich, 2019.
Stanford University, 2019.
Max Planck Florida Instiute, Jupiter, 2019.
University of Maryland Medical School, Baltimore, 2019.
Gordon Research Conference on Inhibition, Sunday River, 2019.
Hippocampal Research Conference. Taormina, 2019 (Organizer).
Hippocampus Meeting, HHMI Janelia Research Campus, Ashburn, 2018.
17th Spanish Society for Neuroscience Meeting. Alicante, 2017 (Organizer).
Hippocampal Research Conference. Taormina, 2017.
Brain Prize Master Class on Translational Neuroscience. Copenhagen, 2016.
Max Planck Institute for Biological Cybernetics, Tübingen, 2016.
15th Biannual Conference of the Hungarian Neuroscience Society. Budapest, 2015.

Editorial service

Editor: eLife, Front. in Neuroscience
Referee: Science, Nature, Neuron, Nature Neuroscience, Nature Communications, Current Biology, Cell Reports, eLife, J. of Neuroscience, PLoS Biology, PLoS Computational Neuroscience, J. of Neurophysiology, Progress in Neurobiology, PLoS One, Frontiers, eNeuro, J. of Neuroscience Methods, J. of Physiology, Neuroscience

Teaching:

What is Intelligence? – Fall 2024
Neural Dynamics for Learning, Memory and Decision Making (BION4740) – Fall 2022 / 2024
Introduction to Neuroscience (BION2220) – Fall 2022/ 2024