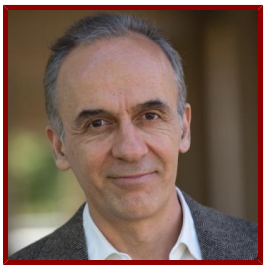
Stanford



E.J. Chichilnisky

John R. Adler Professor, Professor of Neurosurgery and of Ophthalmology and, by courtesy, of Electrical Engineering

Bio

BIO

E.J. Chichilnisky is the John R. Adler Professor of Neurosurgery, and Professor of Ophthalmology, at Stanford University, where he has worked since 2013. Previously, he worked at the Salk Institute for Biological Studies for 15 years. He received his B.A. in Mathematics from Princeton University, and his M.S. in mathematics and Ph.D. in neuroscience from Stanford University. His research has focused on understanding the spatiotemporal patterns of electrical activity in the retina that convey visual information to the brain, and their origins in retinal circuitry, using large-scale multi-electrode recordings. His ongoing work now focuses on using basic science knowledge along with electrical stimulation to develop a novel high-fidelity artificial retina for treating incurable blindness.

ACADEMIC APPOINTMENTS

- Professor, Neurosurgery
- Professor, Ophthalmology
- Professor (By courtesy), Electrical Engineering
- Member, Bio-X
- Member, Wu Tsai Human Performance Alliance
- Member, Wu Tsai Neurosciences Institute

HONORS AND AWARDS

- Stein Innovation Award, Research to Prevent Blindness (2018)
- Sayer Vision Research Award, Foundation for the National Institutes of Health (2014)
- John R. Adler Endowed Chair, Department of Neurosurgery, Stanford University (2014)
- Ralph & Becky O'Connor Endowed Chair, Salk Institute for Biological Studies (2012)
- McKnight Technological Innovation in Neuroscience Award, McKnight Foundation (2004)
- Basic Sciences Teaching Award, UCSD School of Medicine (2001)
- McKnight Scholar's Award, McKnight Foundation (2001)
- Alfred P. Sloan Foundation Research Fellowship, Alfred P. Sloan Foundation (2000)

PROFESSIONAL EDUCATION

- A.B., Princeton University , Mathematics (1985)
- M.Sc., Stanford University , Mathematics (1992)
- Ph.D., Stanford University , Neuroscience (1995)

PATENTS

- B. Murmann, D. Muratore, E.J. Chichilnisky, P. Tandon. "United States Patent 2020082081 Data-compressive sensor array", Leland Stanford Junior University, Apr 23, 2020
- G. Silva, M.L. Kraiche, G. Cauwenberghs, Y. Lo, W.R. Freeman, S. Ha, Jing Y, E.J. Chichilnisky. "United States Patent 10,603,493 Integrated nanowire array devices for detecting and/or applying electrical signals to tissue", University of California, San Diego, Oct 10, 2018
- E.J. Chichilnisky, Martin Greschner, Lauren Jepson. "United States Patent US9990861B2 Smart prosthesis for facilitating artificial vision using scene abstraction", Pixium Vision SA, May 28, 2014
- E.J. Chichilnisky, Lauren Jepson, Martin Greschner. "United States Patent US9452289B2 Method for identification of retinal cell types intrinsic properties", Pixium Vision SA, University of California, Salk Institute for Biological Studies, Mar 19, 2012
- Robert J. Greenberg, Matthew J. McMahon, Chris Sekirnjak, E. J. Chichilnisky. "United States Patent US8712538B2 Method and apparatus for visual neural stimulation", Second Sight Medical Products Inc, Salk Institute for Biological Studies, May 27, 2010

LINKS

- Lab Site: http://neurosurgery.stanford.edu/research/chichilnisky/
- Stanford Artificial Retina Project: http://artificial-retina.stanford.edu

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

The goal of our research is to develop an artificial retina -- an electronic implant that will restore vision to people blinded by retinal degeneration. We focus on a combination of basic and applied research to develop an implant that can reproduce the electrical signals that the retina normally transmits to the brain. To accomplish this goal, we work closely with collaborators in fields spanning neurophysiology, electrical engineering, materials science, retinal surgery, visual behavior, and computational neuroscience. This collaboration constitutes the Stanford Artificial Retina Project, funded in part by the Stanford Neurotechnology Initiative.

The design of the implant is based on knowledge acquired in our unique laboratory setting. We use large-scale multi-electrode recording from the retina to study normal light-evoked activity in hundreds of retinal ganglion cells of multiple types simultaneously, and then evoke similar patterns of activity by electrical stimulation. This approach provides a laboratory prototype for the artificial retina. We focus on several questions:

• what visual signals are transmitted by the diverse ganglion cell types to the brain?
• what computational models can accurately reproduce these diverse retinal signals?
• how can we precisely electrically stimulate retinal ganglion cells using an implant?
• how can retinal cell types be recognized and separately targeted by the implant?
• what are the constraints and algorithms for the electronic circuitry in the implant?
• how faithfully can the implant reproduce normal visual sensations in blind patients?

We anticipate that in addition to restoring vision, the artificial retina will allow us to transmit visual information to the brain in ways that are not possible with light stimulation, opening the door to visual augmentation -- creating visual sensations that were never before possible. It will also provide a unique and powerful research instrument for studying the diverse retinal pathways and how they contribute to vision. In the long run, our understanding of the retinal circuitry and how to interface to it effectively will be relevant for developing other interfaces to the brain – for treating disease, and for augmenting human capabilities.

PROJECTS

- retinal circuitry - Stanford University

- retinal prostheses - Stanford University

Teaching

COURSES

2024-25

- Experimental Immersion in Neuroscience: NSUR 249, STATS 249 (Aut)

2023-24

- Experimental Immersion in Neuroscience: NSUR 249, STATS 249 (Aut)
- NeuroTech Training Seminar: NSUR 239, STATS 242 (Aut)

STANFORD ADVISEES

Med Scholar Project Advisor

Leslie Ramos Cardenas

Doctoral Dissertation Reader (AC)

Amrith Lotlikar, Michael Sommeling

Postdoctoral Faculty Sponsor

Claire Baum, Aviv Sharon

Doctoral Dissertation Advisor (AC)

Madeline Hays, Bella Hofflich, AJ Phillips, Brian Zhou

GRADUATE AND FELLOWSHIP PROGRAM AFFILIATIONS

- Neurosciences (PhD Program)

Publications

PUBLICATIONS

- **Leveraging current steering and the biophysics of spike generation for cellular-resolution electrical stimulation of neurons.** *Cell reports*
  Vasireddy, P. K., Vilkhu, R. S., Lotlikar, A., Brown, J. B., Phillips, A. J., Gogliettino, A. R., Hays, M. R., Baum, C., Kato, E. J., Sharon, A., Hottowy, P., Sher, A., Litke, et al
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- **A Scalable 1024-Channel Ultra-Low-Power Spike Sorting Chip with Event-Driven Detection and Spatial Clustering.** *IEEE journal of solid-state circuits*
  Akhoundi, A., Yan, P., Landbrug, Y., Hays, M., Murmann, B., Chichilnisky, E. J., Muratore, D. G.
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- **A Scalable 1024-Channel Ultra-Low-Power Spike Sorting Chip With Event-Driven Detection and Spatial Clustering** *IEEE JOURNAL OF SOLID-STATE CIRCUITS*
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- **A Framework for Compressive On-chip Action Potential Recording.** *IEEE transactions on bio-medical engineering*
  Yan, P., Muratore, D. G., Chichilnisky, E. J., Murmann, B., Weissman, T.
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- **Cell-type specific repertoire of responses to natural scenes in primate retinal ganglion cells.** *Frontiers in cellular neuroscience*
  Kling, A., Brackbill, N., Rhoades, C., Gogliettino, A., Sher, A., Litke, A., Chichilnisky, E. J.
  2025; 19: 1600167

- **Decomposition of retinal ganglion cell electrical images for cell type and functional inference.** *Journal of neural engineering*
  Wu, E. G., Rudzite, A. M., Bohlen, M. O., Li, P. H., Kling, A., Cooler, S., Rhoades, C., Brackbill, N., Gogliettino, A. R., Shah, N. P., Madugula, S. S., Sher, A., Litke, et al
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- **Unexpected ON-OFF Responses of Smooth Monostratified Ganglion Cells in the Primate Retina**
  Hofflich, B., Kling, A., Cooler, S., Raval, V., Rieke, F., Manookin, M. B., Sher, A., Litke, A., Chichilnisky, E. J.
  ASSOC RESEARCH VISION OPHTHALMOLOGY INC.2025
- **Ex vivo Model for Surgical Implantation and Functional Testing of Electronic Retinal Implants**
  Cardenas, L., Baum, C., Chichilnisky, E. J.
  ASSOC RESEARCH VISION OPHTHALMOLOGY INC.2025
- **Understanding responses to multi-electrode epiretinal stimulation using a biophysical model.** *Journal of neural engineering*
  Vilkhu, R., Vasireddy, P., Kish, K. E., Gogliettino, A. R., Lotlikar, A., Hottowy, P., Dabrowski, W., Sher, A., Litke, A. M., Mitra, S., Chichilnisky, E. J.
  2024
- **Direct-Print 3D Electrodes for Large-Scale, High-Density, and Customizable Neural Interfaces.** *Advanced science (Weinheim, Baden-Wurttemberg, Germany)*
  Wang, P., Wu, E. G., Uluşan, H., Zhao, E. T., Phillips, A. J., Kling, A., Hays, M. R., Vasireddy, P. K., Madugula, S., Vilkhu, R., Hierlemann, A., Hong, G., Chichilnisky, et al
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- **Precise control of neural activity using dynamically optimized electrical stimulation.** *eLife*
  Shah, N. P., Phillips, A. J., Madugula, S., Lotlikar, A., Gogliettino, A. R., Hays, M. R., Grosberg, L., Brown, J., Dusi, A., Tandon, P., Hottowy, P., Dabrowski, W., Sher, et al
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  Wu, E. G., Brackbill, N., Rhoades, C., Kling, A., Gogliettino, A. R., Shah, N. P., Sher, A., Litke, A. M., Simoncelli, E. P., Chichilnisky, E. J.
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- **A 1024-Channel 268 nW/pixel 36×36 μm2/channel Data-Compressive Neural Recording IC for High-Bandwidth Brain-Computer Interfaces.** *IEEE journal of solid-state circuits*
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  Zaidi, M., Aggarwal, G., Shah, N. P., Karniol-Tambour, O., Goetz, G., Madugula, S. S., Gogliettino, A., Wu, E. G., Kling, A., Brackbill, N., Sher, A., Litke, A. M., Chichilnisky, et al
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  Madugula, S. S., Vilkhu, R., Shah, N. P., Grosberg, L. E., Kling, A., Gogliettino, A. R., Nguyen, H., Hottowy, P., Sher, A., Litke, A. M., Chichilnisky, E. J.
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- **High-fidelity reproduction of visual signals by electrical stimulation in the central primate retina.** *The Journal of neuroscience : the official journal of the Society for Neuroscience*

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- **Focal electrical stimulation of human retinal ganglion cells for vision restoration.** *Journal of neural engineering*
  Madugula, S. S., Gogliettino, A. R., Zaidi, M., Aggarwal, G., Kling, A., Shah, N. P., Brown, J. B., Vilkhu, R., Hays, M. R., Nguyen, H., Fan, V., Wu, E. G., Hottowy, et al
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- **An RF-Ultrasound Relay for Adaptive Wireless Powering Across Tissue Interfaces.** *IEEE journal of solid-state circuits*
  So, E., Yeon, P., Chichilnisky, E. J., Arbabian, A.
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- **An RF-Ultrasound Relay for Adaptive Wireless Powering Across Tissue Interfaces** *IEEE JOURNAL OF SOLID-STATE CIRCUITS*
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- **Maximum a posteriori natural scene reconstruction from retinal ganglion cells with deep denoiser priors**
  Wu, E. G., Brackbill, N., Sher, A., Litke, A. M., Simoncelli, E. P., Chichilnisky, E. J.
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- **Individual variability of neural computations in the primate retina.** *Neuron*
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- **Nonlinear Decoding of Natural Images From Large-Scale Primate Retinal Ganglion Recordings.** *Neural computation*
  Kim, Y. J., Brackbill, N., Batty, E., Lee, J., Mitelut, C., Tong, W., Chichilnisky, E. J., Paninski, L.
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- **Spatially Patterned Bi-electrode Epiretinal Stimulation for Axon Avoidance at Cellular Resolution.** *Journal of neural engineering*
  Vilkhu, R. S., Madugula, S. S., Grosberg, L. E., Gogliettino, A. R., Hottowy, P., Dabrowski, W., Sher, A., Litke, A. M., Mitra, S., Chichilnisky, E. J.
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- **Automatic Identification of Axon Bundle Activation for Epiretinal Prosthesis** *IEEE TRANSACTIONS ON NEURAL SYSTEMS AND REHABILITATION ENGINEERING*
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- **Reconstruction of natural images from responses of primate retinal ganglion cells.** *eLife*
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- **A Data-Compressive Wired-OR Readout for Massively Parallel Neural Recording**
  Muratore, D., Tandon, P., Wootters, M., Chichilnisky, E. J., Mitra, S., Murmann, B.
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- **Unusual Physiological Properties of Smooth Monostratified Ganglion Cell Types in Primate Retina.** *Neuron*

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2019

- **Simulation of visual perception and learning with a retinal prosthesis** *JOURNAL OF NEURAL ENGINEERING*
  Golden, J. R., Erickson-Davis, C., Cottaris, N. P., Parthasarathy, N., Rieke, F., Brainard, D. H., Wandell, B. A., Chichilnisky, E. J.
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- **Epiretinal stimulation with local returns enhances selectivity at cellular resolution** *JOURNAL OF NEURAL ENGINEERING*
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  2019
- **Efficient characterization of electrically evoked responses for neural interfaces**
  Shah, N. P., Madugula, S., Hottowy, P., Sher, A., Litke, A., Paninski, L., Chichilnisky, E. J.
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  NEURAL INFORMATION PROCESSING SYSTEMS (NIPS).2019
- **Probing Computation in the Primate Visual System at Single-Cone Resolution** *ANNUAL REVIEW OF NEUROSCIENCE, VOL 42*
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  2018
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  Fan, V. H., Grosberg, L. E., Madugula, S. S., Hottowy, P., Dabrowski, W., Sher, A., Litke, A. M., Chichilnisky, E. J.
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  Ravi, S., Ahn, D., Greschner, M., Chichilnisky, E. J., Field, G. D.
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  Mena, G. E., Grosberg, L. E., Madugula, S., Hottowy, P., Litke, A., Cunningham, J., Chichilnisky, E. J., Paninski, L.
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- **Activation of ganglion cells and axon bundles using epiretinal electrical stimulation.** *Journal of neurophysiology*
  Grosberg, L. E., Ganesan, K., Goetz, G. A., Madugula, S. S., Bhaskhar, N., Fan, V., Li, P., Hottowy, P., Dabrowski, W., Sher, A., Litke, A. M., Mitra, S., Chichilnisky, et al
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- **YASS: Yet Another Spike Sorter**
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- **Recognizing retinal ganglion cells in the dark**
  Richard, E., Goetz, G., Chichilnisky, E. J.
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- **Spatially patterned electrical stimulation to enhance resolution of retinal prostheses.** *journal of neuroscience*
  Jepson, L. H., Hottowy, P., Mathieson, K., Gunning, D. E., Dabrowski, W., Litke, A. M., Chichilnisky, E. J.
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- **A polyaxonal amacrine cell population in the primate retina.** *journal of neuroscience*
  Greschner, M., Field, G. D., Li, P. H., Schiff, M. L., Gauthier, J. L., Ahn, D., Sher, A., Litke, A. M., Chichilnisky, E. J.
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