Stanford

E.J. Chichilnisky

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

Bio

ACADEMIC APPOINTMENTS

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

PROFESSIONAL EDUCATION

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

LINKS

- Lab Site: http://neurosurgery.stanford.edu/research/chichilnisky/

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

The goal of our research is to understand how the neural circuitry of the retina encodes visual information, and to use this knowledge in the development of artificial retinas for treating incurable blindness.

In our basic research, we use unique large-scale multi-electrode recordings to study visually evoked activity in hundreds of retinal ganglion cells of multiple types, simultaneously. We ask questions such as these:

• How do patterns of activity in many cells represent the visual scene?

• What distinct aspects of vision are mediated by different cell types?

• How reliably can the brain infer visual stimuli from retinal signals?

• Can we mimic the function of the retina with computational models?

We use this knowledge in the development of advanced artificial retinas. Although artificial retinas exist today, they provide only limited visual function to patients. Our goal is to build a device that can produce a naturalistic visual signal by mimicking the neural code of the retina. We ask questions such as these:

• What patterns of retinal activity can be produced by electrode arrays?

• How can we optimize stimulation to send the most effective visual signal?

• How can we engineer an implanted device that provides effective artificial vision?

In the long run, our understanding of the retinal circuitry and how to interface effectively to it will be relevant for developing many other interfaces to the brain, both for treating disease and for augmenting human capabilities.

PROJECTS

- retinal circuitry - Stanford University
- retinal prostheses - Stanford University

Teaching

COURSES

2018-19

- Brain Machine Interfaces: Science, Technology, and Application: NSUR 287, PSYCH 287 (Spr)
- Experimental Immersion in Neuroscience: NSUR 249 (Win)
- Neuroscience Systems Core: NEPR 203 (Aut)

2017-18

- Brain Machine Interfaces: Science, Technology, and Application: NSUR 287, PSYCH 287 (Spr)
- Neuroscience Systems Core: NEPR 203 (Aut)

2016-17

- Brain Machine Interfaces: Science, Technology, and Application: PSYCH 287 (Spr)
- Neuroscience Systems Core: NEPR 203 (Aut)

2015-16

- Neuroscience Systems Core: NEPR 203 (Aut)

STANFORD ADVISEES

Med Scholar Project Advisor

Sasi Madugula

Doctoral Dissertation Advisor (AC)

Sasi Madugula

GRADUATE AND FELLOWSHIP PROGRAM AFFILIATIONS

- Neurosciences (Phd Program)

Publications

PUBLICATIONS

- **Probing Computation in the Primate Visual System at Single-Cone Resolution.** *Annual review of neuroscience*
  Kling, A., Field, G. D., Brainard, D. H., Chichilnisky, E. J.
  2019

- **Temporal resolution of single photon responses in primate rod photoreceptors and limits imposed by cellular noise.** *Journal of neurophysiology*
  Field, G. D., Uzzell, V., Chichilnisky, E. J., Rieke, F.
  2018

- **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., Wandell, B., Chichilnisky, E. J.
  2018

- **Epiretinal stimulation with local returns enhances selectivity at cellular resolution.** *Journal of neural engineering*
  Fan, V. H., Grosberg, L. E., Madugula, S. S., Hottowy, P., Dabrowski, W., Sher, A., Litke, A. M., Chichilnisky, E. J.
  2018

- **Pathway-Specific Asymmetries between ON and OFF Visual Signals** *JOURNAL OF NEUROSCIENCE*
  Ravi, S., Ahn, D., Greschner, M., Chichilnisky, E. J., Field, G. D.
  2018; 38 (45): 9728–40

- **Electrical stimulus artifact cancellation and neural spike detection on large multi-electrode arrays** *PLOS COMPUTATIONAL BIOLOGY*
  Mena, G. E., Grosberg, L. E., Madugula, S., Hottowy, P., Litke, A., Cunningham, J., Chichilnisky, E. J., Paninski, L.
  2017; 13 (11): e1005842

- **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
  2017: jn 00750 2016-?

- **YASS: Yet Another Spike Sorter**
  Lee, J., Carlson, D., Shokri, H., Yao, W., Goetz, G., Hagen, E., Batty, E., Chichilnisky, E. J., Einevoll, G., Paninski, L., Guyon, Luxburg, U. V., Bengio, S., et al
  NEURAL INFORMATION PROCESSING SYSTEMS (NIPS).2017

- **Neural Networks for Efficient Bayesian Decoding of Natural Images from Retinal Neurons**
  Parthasarathy, N., Batty, E., Falcon, W., Rutten, T., Rajpal, M., Chichilnisky, E. J., Paninski, L., Guyon, Luxburg, U. V., Bengio, S., Wallach, H., Fergus, R., Vishwanathan, S., et al
  NEURAL INFORMATION PROCESSING SYSTEMS (NIPS).2017

- **Novel Model-based identification of retinal ganglion cell subunits**
  Shah, N., Brackbill, N., Tikidji-Hamburyan, A., Rhoades, C., Goetz, G. A., Sher, A., Litke, A., Paninski, L., Simoncelli, E., Chichilnisky, E. J.
  ASSOC RESEARCH VISION OPHTHALMOLOGY INC.2016

- **Spatial extent of inputs to primate ganglion cells in natural viewing conditions**
  Brackbill, N., Shah, N., Goetz, G. A., Tikidlji-Hamburyan, A., Rhoades, C., Sher, A., Litke, A., Chichilnisky, E. J.
  ASSOC RESEARCH VISION OPHTHALMOLOGY INC.2016

- **Identification of a Retinal Circuit for Recurrent Suppression Using Indirect Electrical Imaging.** *Current biology*
  Greschner, M., Heitman, A. K., Field, G. D., Li, P. H., Ahn, D., Sher, A., Litke, A. M., Chichilnisky, E. J.
  2016; 26 (15): 1935-1942

- **Axon activation with focal epiretinal stimulation in primate retina**
  Grosberg, L. E., Hottowy, P., Jepson, L. H., Ito, S., Kellison-Linn, F., Sher, A., Dabrowski, W., Litke, A., Chichilnisky, E. J.
  ASSOC RESEARCH VISION OPHTHALMOLOGY INC.2015

- **Anatomical Identification of Extracellularly Recorded Cells in Large-Scale Multielectrode Recordings** *JOURNAL OF NEUROSCIENCE*
  Li, P. H., Gauthier, J. L., Schiff, M., Sher, A., Ahn, D., Field, G. D., Greschner, M., Callaway, E. M., Litke, A. M., Chichilnisky, E. J.

2015; 35 (11): 4663-4675

- **Mapping nonlinear receptive field structure in primate retina at single cone resolution.** *eLife*
  Freeman, J., Field, G. D., Li, P. H., Greschner, M., Gunning, D. E., Mathieson, K., Sher, A., Litke, A. M., Paninski, L., Simoncelli, E. P., Chichilnisky, E. J.
  2015; 4

- **High-fidelity reproduction of spatiotemporal visual signals for retinal prosthesis.** *Neuron*
  Jepson, L. H., Hottowy, P., Weiner, G. A., Dabrowski, W., Litke, A. M., Chichilnisky, E. J.
  2014; 83 (1): 87-92

- **Retinal Representation of the Elementary Visual Signal (vol 81, pg 130, 2014)** *NEURON*
  Li, P. H., Field, G. D., Greschner, M., Ahn, D., Gunning, D. E., Mathieson, K., Sher, A., Litke, A. M., Chichilnisky, E. J.
  2014; 82 (2): 500

- **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.
  2014; 34 (14): 4871-4881

- **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.
  2014; 34 (10): 3597-3606

- **Retinal representation of the elementary visual signal.** *Neuron*
  Li, P. H., Field, G. D., Greschner, M., Ahn, D., Gunning, D. E., Mathieson, K., Sher, A., Litke, A. M., Chichilnisky, E. J.
  2014; 81 (1): 130-139

- **Focal Electrical Stimulation of Major Ganglion Cell Types in the Primate Retina for the Design of Visual Prostheses** *JOURNAL OF NEUROSCIENCE*
  Jepson, L. H., Hottowy, P., Mathieson, K., Gunning, D. E., Dabrowski, W., Litke, A. M., Chichilnisky, E. J.
  2013; 33 (17): 7194-7205

- **Efficient Coding of Spatial Information in the Primate Retina** *JOURNAL OF NEUROSCIENCE*
  Doi, E., Gauthier, J. L., Field, G. D., Shlens, J., Sher, A., Greschner, M., Machado, T. A., Jepson, L. H., Mathieson, K., Gunning, D. E., Litke, A. M., Paninski, L., Chichilnisky, et al
  2012; 32 (46): 16256-16264

- **Modeling the impact of common noise inputs on the network activity of retinal ganglion cells** *JOURNAL OF COMPUTATIONAL NEUROSCIENCE*
  Vidne, M., Ahmadian, Y., Shlens, J., Pillow, J. W., Kulkarni, J., Litke, A. M., Chichilnisky, E. J., Simoncelli, E., Paninski, L.
  2012; 33 (1): 97-121

- **Cone photoreceptor contributions to noise and correlations in the retinal output** *NATURE NEUROSCIENCE*
  Ala-Laurila, P., Greschner, M., Chichilnisky, E. J., Rieke, F.
  2011; 14 (10): 1309-U127

- **Changes in physiological properties of rat ganglion cells during retinal degeneration** *JOURNAL OF NEUROPHYSIOLOGY*
  Sekirnjak, C., Jepson, L. H., Hottowy, P., Sher, A., Dabrowski, W., Litke, A. M., Chichilnisky, E. J.
  2011; 105 (5): 2560-2571

- **Correlated firing among major ganglion cell types in primate retina** *JOURNAL OF PHYSIOLOGY-LONDON*
  Greschner, M., Shlens, J., Bakolitsa, C., Field, G. D., Gauthier, J. L., Jepson, L. H., Sher, A., Litke, A. M., Chichilnisky, E. J.
  2011; 589 (1): 75-86

- **Functional connectivity in the retina at the resolution of photoreceptors** *NATURE*
  Field, G. D., Gauthier, J. L., Sher, A., Greschner, M., Machado, T. A., Jepson, L. H., Shlens, J., Gunning, D. E., Mathieson, K., Dabrowski, W., Paninski, L., Litke, A. M., Chichilnisky, et al
  2010; 467 (7316): 673-U54

- **Receptive Field Mosaics of Retinal Ganglion Cells Are Established Without Visual Experience** *JOURNAL OF NEUROPHYSIOLOGY*
  Anishchenko, A., Greschner, M., Elstrott, J., Sher, A., Litke, A. M., Feller, M. B., Chichilnisky, E. J.
  2010; 103 (4): 1856-1864

- **Loss of Responses to Visual But Not Electrical Stimulation in Ganglion Cells of Rats With Severe Photoreceptor Degeneration** *JOURNAL OF NEUROPHYSIOLOGY*
  Sekirnjak, C., Hulse, C., Jepson, L. H., Hottowy, P., Sher, A., Dabrowski, W., Litke, A. M., Chichilnisky, E. J.
  2009; 102 (6): 3260-3269
- **High-sensitivity rod photoreceptor input to the blue-yellow color opponent pathway in macaque retina** *NATURE NEUROSCIENCE*
  Field, G. D., Greschner, M., Gauthier, J. L., Rangel, C., Shlens, J., Sher, A., Marshak, D. W., Litke, A. M., Chichilnisky, E. J.
  2009; 12 (9): 1159-U20
- **The Structure of Large-Scale Synchronized Firing in Primate Retina** *JOURNAL OF NEUROSCIENCE*
  Shlens, J., Field, G. D., Gauthier, J. L., Greschner, M., Sher, A., Litke, A. M., Chichilnisky, E. J.
  2009; 29 (15): 5022-5031
- **Uniform Signal Redundancy of Parasol and Midget Ganglion Cells in Primate Retina** *JOURNAL OF NEUROSCIENCE*
  Gauthier, J. L., Field, G. D., Sher, A., Shlens, J., Greschner, M., Litke, A. M., Chichilnisky, E. J.
  2009; 29 (14): 4675-4680
- **Receptive Fields in Primate Retina Are Coordinated to Sample Visual Space More Uniformly** *PLOS BIOLOGY*
  Gauthier, J. L., Field, G. D., Sher, A., Greschner, M., Shlens, J., Litke, A. M., Chichilnisky, E. J.
  2009; 7 (4): 747-755
- **Spatio-temporal correlations and visual signalling in a complete neuronal population** *NATURE*
  Pillow, J. W., Shlens, J., Paninski, L., Sher, A., Litke, A. M., Chichilnisky, E. J., Simoncelli, E. P.
  2008; 454 (7207): 995-U37
- **Synchronized firing in the retina** *CURRENT OPINION IN NEUROBIOLOGY*
  Shlens, J., Rieke, F., Chichilnisky, E. J.
  2008; 18 (4): 396-402
- **Direction selectivity in the retina is established independent of visual experience and cholinergic retinal waves** *NEURON*
  Elstrott, J., Anishchenko, A., Greschner, M., Sher, A., Litke, A. M., Chichilnisky, E. J., Feller, M. B.
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- **High-resolution electrical stimulation of primate retina for epiretinal implant design** *JOURNAL OF NEUROSCIENCE*
  Sekirnjak, C., Hottowy, P., Sher, A., Dabrowski, W., Litke, A. M., Chichilnisky, E. J.
  2008; 28 (17): 4446-4456
- **Spatial properties and functional organization of small bistratified ganglion cells in primate retina** *JOURNAL OF NEUROSCIENCE*
  Field, G. D., Sher, A., Gauthier, J. L., Greschner, M., Shlens, J., Litke, A. M., Chichilnisky, E. J.
  2007; 27 (48): 13261-13272
- **Identification and characterization of a Y-like primate retinal ganglion cell type** *JOURNAL OF NEUROSCIENCE*
  Petrusca, D., Grivich, M. I., Sher, A., Field, G. D., Gauthier, J. L., Greschner, M., Shlens, J., Chichilnisky, E. J., Litke, A. M.
  2007; 27 (41): 11019-11027
- **Cone inputs to simple and complex cells in V1 of awake macaque** *JOURNAL OF NEUROPHYSIOLOGY*
  Horwitz, G. D., Chichilnisky, E. J., Albright, T. D.
  2007; 97 (4): 3070-3081
- **Information processing in the primate retina: Circuitry and coding** *ANNUAL REVIEW OF NEUROSCIENCE*
  Field, G. D., Chichilnisky, E. J.
  2007; 30: 1-30
- **The structure of multi-neuron firing patterns in primate retina** *JOURNAL OF NEUROSCIENCE*
  Shlens, J., Field, G. D., Gauthier, J. L., Grivich, M. I., Petrusca, D., Sher, A., Litke, A. M., Chichilnisky, E. J.
  2006; 26 (32): 8254-8266
- **Electrical stimulation of mammalian retinal ganglion cells with multielectrode arrays** *JOURNAL OF NEUROPHYSIOLOGY*
  Sekirnjak, C., Hottowy, P., Sher, A., Dabrowski, W., Litke, A. M., Chichilnisky, E. J.
  2006; 95 (6): 3311-3327

- **Prediction and decoding of retinal ganglion cell responses with a probabilistic spiking model** *JOURNAL OF NEUROSCIENCE*
  Pillow, J. W., Paninski, L., Uzzell, V. J., Simoncelli, E. P., Chichilnisky, E. J.
  2005; 25 (47): 11003-11013

- **Fidelity of the ensemble code for visual motion in primate retina** *JOURNAL OF NEUROPHYSIOLOGY*
  Frechette, E. S., Sher, A., Grivich, M. I., Petrusca, D., Litke, A. M., Chichilnisky, E. J.
  2005; 94 (1): 119-135

- **Detection sensitivity and temporal resolution of visual signals near absolute threshold in the salamander retina** *JOURNAL OF NEUROSCIENCE*
  Chichilnisky, E. J., Rieke, F.
  2005; 25 (2): 318-330

- **Precision of spike trains in primate retinal ganglion cells** *JOURNAL OF NEUROPHYSIOLOGY*
  Uzzell, V. J., Chichilnisky, E. J.
  2004; 92 (2): 780-789

- **What does the eye tell the brain?: Development of a system for the large-scale recording of retinal output activity** *IEEE-Nuclear-Science Symposium/ Medical Imaging Conference*
  Litke, A. M., Bezayiff, N., Chichilnisky, E. J., Cunningham, W., Dabrowski, W., Grillo, A. A., Grivich, M., Grybos, P., Hottowy, P., Kachiguine, S., Kalmar, R. S., Mathieson, K., Petrusca, et al
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- **Temporal resolution of ensemble visual motion signals in primate retina** *JOURNAL OF NEUROSCIENCE*
  Chichilnisky, E. J., Kalmar, R. S.
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- **Functional asymmetries in ON and OFF ganglion cells of primate retina** *JOURNAL OF NEUROSCIENCE*
  Chichilnisky, E. J., Kalmar, R. S.
  2002; 22 (7): 2737-2747

- **Characterizing neural gain control using spike-triggered covariance** *15th Annual Conference on Neural Information Processing Systems (NIPS)*
  Schwartz, O., Chichilnisky, E. J., Simoncelli, E. P.
  M I T PRESS.2002: 269–276

- **Receptive-field microstructure of blue-yellow ganglion cells in primate retina** *NATURE NEUROSCIENCE*
  Chichilnisky, E. J., Baylor, D. A.
  1999; 2 (10): 889-893

- **Trichromatic opponent color classification** *VISION RESEARCH*
  Chichilnisky, E. J., Wandell, B. A.
  1999; 39 (20): 3444-3458

- **Seeing gray through the ON and OFF pathways** *VISUAL NEUROSCIENCE*
  Chichilnisky, E. J., Wandell, B. A.
  1996; 13 (3): 591-596

- **PHOTORECEPTOR SENSITIVITY CHANGES EXPLAIN COLOR APPEARANCE SHIFTS INDUCED BY LARGE UNIFORM BACKGROUNDS IN DICHOPTIC MATCHING** *VISION RESEARCH*
  Chichilnisky, E. J., Wandell, B. A.
  1995; 35 (2): 239-254

- **FMRI OF HUMAN VISUAL-CORTEX** *NATURE*
  Engel, S. A., Rumelhart, D. E., Wandell, B. A., Lee, A. T., Glover, G. H., Chichilnisky, E. J., Shadlen, M. N.
  1994; 369 (6481): 525-525

- **FUNCTIONAL SEGREGATION OF COLOR AND MOTION PERCEPTION EXAMINED IN MOTION NULLING** *VISION RESEARCH*
  Chichilnisky, E. J., Heeger, D., Wandell, B. A.
  1993; 33 (15): 2113-2125