

Joel Zylberberg

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Education

University of California, Berkeley, California

Ph.D. (2012), M.A. (2010), Physics

Advisor: Mike DeWeese

Dissertation: *From scenes to spikes: understanding vision from the outside in*

Simon Fraser University, Burnaby, British Columbia

B.Sc. (2008), Physics (with First Class Honors)

Academic and Research Positions

Assistant Professor, Department of Physics and Astronomy, York University, Toronto, Ontario (starting 2019)

Assistant Professor, Department of Physiology and Biophysics, University of Colorado School of Medicine, Aurora, Colorado (2015 - 2018)

Member of the Computational Bioscience Program, Medical Scientist Training Program, and Center for Neuroscience

Affiliate Professor, Department of Applied Mathematics, University of Colorado, Boulder, Colorado (2016 - 2018)

Azrieli Global Scholar, Learning in Machines and Brains Program, Canadian Institute for Advanced Research (CIFAR), Toronto, Ontario (2016 - 2018)

Acting Assistant Professor, Department of Applied Mathematics, University of Washington, Seattle, Washington (2012 - 2015)

Honors & Awards Received

Major Awards

Sloan Research Fellowship (2017)

Google Faculty Research Award (2017)

Canadian Institute for Advanced Research (CIFAR) Azrieli Global Scholar Award (2016)

Howard Hughes Medical Institute (HHMI) International Student Research Fellowship (2011)

Natural Sciences and Engineering Research Council of Canada (NSERC) PGS-D Doctoral Scholarship (2011; declined in order to take HHMI Fellowship)

Fulbright Science and Technology Ph.D. Fellowship (2008)

NSERC Julie Payette Research Scholarship (2008)

NSERC Andre Hamer Prize (2008; I declined this prize in order to pursue my studies abroad)

Smaller awards (subset)

CNS Conference Travel Grant (2013, 2015)

CoSyNe Conference Travel Grant (2011, 2013)

Travel grant to attend Okinawa Computational Neuroscience Course (2012)

"Outstanding Graduate Student Instructor" award from UC Berkeley (2011)

Publications

E. Christensen, A. Abosch, J. Thompson*, and J. Zylberberg*. Inferring sleep stage from local field potentials recorded in the subthalamic nucleus of Parkinson's patients. To appear in *Journal of Sleep Research*. (* co-senior authors who contributed equally to this work)

N.A. Cayco Gajic, J. Zylberberg, and E. Shea-Brown (2018). A moment-based maximum entropy model for fitting higher-order interactions in neural data. *Entropy* 20: 489.

C. Federer and J. Zylberberg (2018). A self-organizing short-term dynamical memory network. *Neural Networks* 106: 30-41.

J. Zylberberg and B. Strowbridge (2017). Mechanisms of persistent activity in cortical circuits: possible neural substrates for working memory. *Annual Review of Neuroscience* 40: 603-627.

J. Zylberberg, A. Pouget, P.E. Latham, and E. Shea-Brown (2017). Robust information propagation through noisy neural circuits. *PLoS Computational Biology* 13: e1005497.

J. Zylberberg*, J. Cafaro*, M. Turner*, E. Shea-Brown, and F. Rieke (2016). Direction-selective circuits shape noise to ensure a precise population code. *Neuron* 89: 369-383. (* co-first authors who contributed equally to this work)

J. Zylberberg, R. Hyde, and B.W. Strowbridge (2016). Dynamics of robust pattern separability in the hippocampal dentate gyrus. *Hippocampus* 26: 623-632.

J. Zylberberg and E. Shea-Brown (2015). Input nonlinearities can shape beyond-pairwise correlations and improve information transmission by neural populations. *Physical Review E* 92: 062707.

N.A. Cayco Gajic, J. Zylberberg, and E. Shea-Brown (2015). Triplet correlations among similarly tuned cells impact population coding. *Frontiers in Computational Neuroscience* 9: 57.

Y. Hu, J. Zylberberg, and E. Shea-Brown (2014). The sign rule and beyond: Boundary effects, flexibility, and noise correlations in neural population codes. *PLoS Computational Biology* 10: e1003469.

J. Zylberberg and M.R. DeWeese (2013). Sparse coding models can exhibit decreasing sparseness while learning sparse codes for natural images. *PLoS Computational Biology* 9: e1003182.

P. King, J. Zylberberg, and M.R. DeWeese (2013). Inhibitory interneurons decorrelate excitatory cells to drive sparse code formation in a spiking model of V1. *Journal of Neuroscience* 33: 5475-5485.

J. Zylberberg, D. Pfau, and M.R. DeWeese (2012). Dead leaves and the dirty ground: low-level image statistics in transmissive and occlusive imaging environments. *Physical Review E* 86: 066112.

J. Zylberberg, J. Murphy, and M.R. DeWeese (2011). A Sparse Coding Model with Synaptically Local Plasticity and Spiking Neurons Can Account for the Diverse Shapes of V1 Simple Cell Receptive Fields. *PLoS Computational Biology* 7: e1002250.

J. Zylberberg and M.R. DeWeese (2011). How should prey animals respond to uncertain threats? *Frontiers in Computational Neuroscience* 5: 20.

G. Zhao, L. Pogosian, A. Silvestri, and J. Zylberberg (2009). Cosmological Tests of General Relativity with Future Tomographic Surveys. *Physical Review Letters* 103: 241301.

- G. Zhao, L. Pogosian, A. Silvestri, and J. Zylberberg (2009). Searching for modified growth patterns with tomographic surveys. *Physical Review D* 79: 083513.
- C. Vockenhuber *et al.* (2008). Improvements of the DRAGON recoil separator at ISAC. *Nuclear Instruments and Methods in Physics Research B* 266: 4167-4170.
- J. Zylberberg *et al.* (2007). Charge-state distributions after radiative capture of helium nuclei by a carbon beam. *Nuclear Instruments and Methods in Physics Research B* 254: 17-24.
- J. Zylberberg, A.A. Belik, E. Takayama-Muromachi, and Z.-G. Ye (2007). Bismuth Aluminate: A New High- T_C Lead-Free Piezo-/ferroelectric. *Chemistry of Materials* 19: 6385-6390.
- J. Bechhoefer, Y. Deng, J. Zylberberg, C. Lei, and Z.-G. Ye (2007). Temperature dependence of the capacitance of a ferroelectric material. *American Journal of Physics* 75: 1046-1053.
- J. Zylberberg and Z.-G. Ye (2006). Improved dielectric properties of bismuth-doped LaAlO_3 . *Journal of Applied Physics* 100: 086102.

Preprints & Submitted Manuscripts

- J. Zylberberg. Untuned but not irrelevant: The role of untuned neurons in sensory information coding. Submitted, and available at bioRxiv via doi: 10.1101/134379.
- W. Kindel, E. Christensen, and J. Zylberberg. Using deep learning to reveal the neural code for images in primary visual cortex. Submitted, and available at arXiv:1706.06208 [q-bio.NC].
- M. Lintz, J. Essig, J. Zylberberg, and G. Felsen. Spatial representations in the superior colliculus are modulated by competition among targets. Submitted.

Patents

- J. Zylberberg, E. Christensen, A. Abosch, and J. Thompson. Deep Brain Stimulation Using Artificial Neural Networks. Filed Nov. 9, 2018. U.S. Patent Application No. 62/758,484.

Successful Proposals

Current Research Funding

- Canadian Institute for Advanced Research (CIFAR), Catalyst Grant:** Teaching computers to think about images the way brains do (2018–2019). Role: P.I. (along with Alona Fyshe; this is a collaborative grant) (\$50,000 CAD \approx \$38,000 USD)
- University of Colorado, Physiology Pilot Grant:** The functional role of cerebellar input to the superior colliculus in controlling orienting movements (2018–2019). Role: P.I. (along with Gidon Felsen and Abigail Person; this is a collaborative grant) (\$50,000)
- A.P. Sloan Foundation, Sloan Research Fellowship in Neuroscience** (2017–2019). Role: P.I. (\$60,000)
- Canadian Institute for Advanced Research (CIFAR), Catalyst Grant:** Identifying the brain's learning rules from in vivo neural data (2017–2018). Role: P.I. (along with Blake Richards; this is a collaborative grant) (\$52,950 CAD \approx \$42,253 USD)
- Canadian Institute for Advanced Research (CIFAR), Azrieli Global Scholar Award for Learning in Machines and Brains** (2016–2018). Role: P.I. (\$100,000 CAD \approx \$77,000 USD)

Completed Research Funding

- Google Inc., Google Faculty Research Award in Computational Neuroscience:** Using deep learning to automatically "crack" neural population codes (2017–2018). Role: P.I. (\$40,377)

Competitively Allocated Facilities

Allen Institute for Brain Science, OpenScope: Identifying the role of top-down feedback connections in cortical learning and inference (2018–2019). Role: P.I. (along with Blake Richards, Yoshua Bengio, and Tim Lillicrap; this is a collaborative project) (~50 2-photon Ca^{2+} imaging sessions in mouse visual cortex)

Invited Talks & Seminars (subset)

- Neuroscience Seminar, Allen Institute for Brain Science, Seattle, Washington (Aug. 2018)
- Workshop on Interactions Between Brain Areas, Computational and Systems Neuroscience (CoSyNe) Conference, Breckenridge, Colorado (Mar. 2018)
- Visual Science Seminar, York University, Toronto, Ontario (Feb. 2018)
- Computational Neuroscience Seminar, Krembil Research Institute, Toronto, Ontario (Jan. 2018)
- Computational Neuroscience Seminar, Western University, London, Ontario (Jan. 2018)
- Computer Science Colloquium, University of Victoria, Victoria, British Columbia (Aug. 2017)
- Information Theory Tutorial, International Conference on Mathematical Neuroscience, Boulder, Colorado (Jun. 2017)
- Neuroscience Seminar, National Institutes of Health (NIH), Bethesda, Maryland (May 2017)
- Neuroscience Seminar, Institut d'Investigacions Biomediques August Pi Sunyer, Barcelona, Spain (Dec. 2016)
- Dynamics and Complex Systems Seminar, University of Colorado, Boulder, Colorado (Sept. 2016)
- Rocky Mountain Regional Neuroscience Group Annual Conference, Aurora, Colorado (May 2016)
- Workshop on Connecting Network Architecture and Network Computation, Banff International Research Station (BIRS), Banff, Alberta (Dec. 2015)
- Methods of Information Theory Workshop, Computational Neuroscience Society Conference, Prague, Czech Republic (Jul. 2015)
- Computational Neuroscience Seminar, University of Washington, Seattle, Washington (Jun. 2015)
- Neuroscience Seminar, Stanford University, Stanford, California (Mar. 2015)
- Brain and Cognitive Sciences Seminar, Massachusetts Institute of Technology (MIT), Cambridge, Massachusetts (Feb. 2015)
- Systems Biology Seminar, University of Texas Southwestern Medical Center, Dallas, Texas (Jan. 2015)
- Mathematics and Neuroscience Seminar, University of Texas, Austin, Texas (Jan. 2015)
- Communications, Networks, and Systems Seminar, University of Southern California, Los Angeles, California (Jan. 2015)
- Mathematics Seminar, Monash University, Melbourne, Australia (Nov. 2014)
- Workshop on Biological and Bio-Inspired Information Theory, Banff International Research Station (BIRS), Banff, Alberta (Oct. 2014)
- Biophysics Seminar, Simon Fraser University, Burnaby, British Columbia (Sept. 2014)
- eScience Institute Seminar, University of Washington, Seattle, Washington (Feb. 2014)
- Seminar on Computational Neuroscience, Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland (Oct. 2013)
- Computational Neuroscience Seminar, University of Washington, Seattle, Washington (Feb. 2012)

Contributed Talks (subset)

Computational Neuroscience Society (CNS) Conference, Prague, Czech Republic. *Limited-Range correlations, when modulated by firing rate, can substantially improve neural population coding* (Jul. 2015)

Computational Neuroscience Society (CNS) Conference (40-minute "featured oral presentation" at main meeting), Paris, France. *Consistency requirements determine optimal noise correlations in neural populations* (Jul. 2013)

American Physical Society (APS) March Meeting, Baltimore, Maryland. *Add HOC?: dendritic nonlinearities shape higher-than-pairwise correlations and improve coding in noisy (spiking) neural populations* (Mar. 2013)

Computational and Systems Neuroscience (CoSyNe) Conference (main meeting), Salt Lake City, Utah. *Consequences of learning a sparse code for natural images with spiking neurons and synaptically local plasticity rules* (Feb. 2011)

Canadian Society for Chemistry (CSC) Conference, Winnipeg, Manitoba. *BiAlO₃: a high-T_C ferroelectric and a performance enhancing additive to dielectric LaAlO₃* (May 2007)

Winter Nuclear and Particle Physics Conference (WNPPC), Banff, Alberta. *Recoil charge-state distributions in ¹²C(α, γ)¹⁶O at DRAGON*. (Feb. 2007)

Research Mentoring

Post-doctoral fellows

Jay Pina, York University (2019- ; observable correlates of learning in neural circuits)

Will Kindel, University of Colorado School of Medicine (2016-2018 ; using machine learning methods to interrogate the sensory systems). Now at Sandia National Laboratory.

Doctoral Students

Callie Federer, University of Colorado School of Medicine (2016 - ; self-organizing memory networks). Winner of NSF Graduate Research Fellowship (2017).

Shelly Jones, University of Colorado School of Medicine (2016 - ; role of gap junctions in the olfactory system). Winner of NIH National Research Service Award (Ph.D. Fellowship; 2018).

Elijah Christensen, University of Colorado School of Medicine (2017 - ; machine learning models of the visual system).

Doctoral Thesis Committee Participation

Matt Becker, University of Colorado School of Medicine (2016 - ; cerebellar motor control)

Jaclyn Essig, University of Colorado School of Medicine (2016 - ; target selection in the superior colliculus)

Master's Students

Gaurav Chanda, University of Washington (2014-2015; smoothness priors to improve nonlinear dimensionality reduction)

Undergraduate Students

Audrey Tsoi, University of Colorado School of Medicine (2018; modelling direction-selective neurons in retina)

Chelsey Wildenborg, University of Colorado School of Medicine (2016; encoding multiple stimulus features in neural population activities)

Jacob Jaminet, University of Colorado School of Medicine (2016; encoding multiple stimulus features in neural population activities)

Nile Graddis, University of Washington (2014-2015; representation of time in the hippocampus)

Jason Murphy, Berkeley City College and UC Berkeley Helen Wills Neuroscience Institute (2010-2011; fitting model V1 receptive fields with Gabor functions)

Marvin Thielk, UC Berkeley (2011; creating minimum-wiring configurations for network models with known inter-neuronal connectivity)

Teaching Experience

Undergraduate

Instructor, University of Washington, Applied Mathematics 402 *Introduction to dynamical systems and chaos* (Winter 2013, Winter 2014, Winter 2015)

Guest lecturer, University of Washington, Mathematics 498 *Undergraduate Mathematical Sciences Seminar* (Winter 2014)

Graduate Student Instructor, UC Berkeley, Physics C10 *Physics for future presidents* (Spring 2011); UC Berkeley, Physics 7B *Physics for Scientists and Engineers* (Fall 2010)

Graduate School

Instructor, University of Washington, Applied Mathematics 502 *Introduction to dynamical systems and chaos* (Winter 2013, Winter 2014, Winter 2015)

Co-Instructor, University of Colorado Denver, Neuroscience 7674 / Electrical Engineering 5375 *Engineering / Quantitative Neuroscience* (Fall 2016, Fall 2017)

Guest Lecturer, University of Colorado Denver, Neuroscience 7501 *Introduction to Neuroscience* (Fall 2016, Fall 2017, Fall 2018); University of Colorado Denver, Computational Bioscience 7711 *Methods and Tools in Biomedical Informatics* (Fall 2016, Fall 2017); University of Colorado Denver, Neuroscience 7657 *MatLab for Neuroscientists* (Summer 2016); University of Colorado Denver, Neuroscience 7610 *Fundamentals of Neurobiology* (Winter 2016); University of Colorado Denver, Computational Bioscience 7712 *Research Methods in Biomedical Informatics* (Winter 2016, Winter 2017, Winter 2018); University of Washington, Computer Science and Engineering 590 *Special topics – Molecular and Neural Computation* (Winter 2014); University of Washington, Applied Mathematics 500J *Special Topics in Applied Mathematics* (Spring 2013)

Medical School

Lecturer, University of Colorado School of Medicine, *Molecules to Medicine* (Fall 2016, Fall 2017, Fall 2018)

Extra-Curricular Teaching Experience

Co-director of the *Colorado Biomedical Informatics Summer Training Program* (2016, 2017). This is an 8-week summer program, including coursework and research experience, that introduces minority undergraduates to computational biology. The program is funded by a NIH T15 grant.

Workshop designer and instructor, University of Washington STEM Bridge research experience for incoming undergraduates: sensory neural coding in the cockroach and mouse (2013).

Teaching assistant and workshop designer, University of Calgary, *Shad Valley program* (2004, 2005, 2008). This is a month-long summer program that introduces gifted high school students to advanced topics in science, engineering, and entrepreneurship.

Professional Service

Program Committee Member, Computational and Systems Neuroscience Conference (CoSyNe) (2016 - ongoing)

Member of Inaugural Editorial Board for *Neurons, Behavior, Data Analysis, and Theory (NBDT)* (2018 - ongoing)

Reviewer for publications: *eLife*; *PLoS Biology*; *Nature Neuroscience*; *Journal of Neuroscience*; *Nature Communications*; *PLoS Computational Biology*; *Vision Research*; *Journal of Neurophysiology*; *Neural Computation*; *Neural Information Processing Systems (NIPS) Conference*; *International Conference on Learning Representations (ICLR)*; *International Conference on Machine Learning (ICML)*; *Biological Cybernetics*; *Entropy*; *F1000 Research (Faculty of 1000)*; *IEEE Transactions on Molecular, Biological, and Multi-Scale Communications*; *Hearing Research*; *Frontiers in Computational Neuroscience*; *International Journal of Neural Systems*; *Journal of Zoology*; *CoSyNe conference*; *International Conference on Mathematical Neuroscience (ICMNS)*

Reviewer for funders: NSERC Discovery Grant proposals; Fields Institute for Research in Mathematical Sciences General Scientific Activity proposals.

Session Chair at the Computational and Systems Neuroscience Conference (CoSyNe) (2017, 2018), International Conference on Mathematical Neuroscience (ICMNS) (2017), and March Meeting of the American Physical Society (2013)

New Faculty Search Committee Member, Dept. of Physiology and Biophysics, University of Colorado School of Medicine (2016-2018)

Program Committee Member, International Conference on Mathematical Neuroscience (ICMNS) (2016)

Faculty Senator, University of Colorado School of Medicine (2016 - 2018)

Organizer of the Quantitative Systems Neuroscience Journal Club at the University of Colorado Medical School (2015 - 2018)

Co-organizer of the Boeing Distinguished Speaker Series in Applied Mathematics at the University of Washington (2012 - 2015)

Co-chair of the organizing committee for the 2007 Canadian Undergraduate Physics Conference (2007)

Science Policy Activities

Participant at Science and Technology in Society Forum, Kyoto, Japan (2017)

Participant at Canadian Science Policy Centre Conference, Ottawa, Ontario (2017)

Community Service

Postdoc Travel Awards Reviewer, University of Colorado Anschutz Medical Campus (2017 - 2018)

NSF Graduate Research Fellowship Applications pre-Reviewer, University of Colorado Anschutz Medical Campus (2017 - 2018)

Judge at Postdoctoral Research Day, University of Colorado Anschutz Medical Campus (2017, 2018)

Science Fair Judge, Laurelhurst Elementary School (2014)

Celebr8 Project Mentor, San Francisco Day School (2014)

Community Advisor, Simon Fraser University (2004-2005)

Founder and Director, *Computer Literacy Education Outreach* (CLEO) program of SFU Engineers Without Borders (2004-2006)

Professional Affiliations

Member, Organization for Computational Neurosciences

Member, Society for Neuroscience

Member, American Physical Society

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