Stanford

Shaul Druckmann

Associate Professor of Neurobiology, of Psychiatry and Behavioral Sciences
and, by courtesy, of Electrical Engineering

Bio

ACADEMIC APPOINTMENTS

- Associate Professor, Neurobiology
- Associate Professor, Psychiatry and Behavioral Sciences
- Associate Professor (By courtesy), Electrical Engineering
- Member, Bio-X
- Member, Wu Tsai Neurosciences Institute

HONORS AND AWARDS

- Award for Excellence in Graduate Teaching, Stanford University (2023)
- McKnight Scholar, McKnight Foundation (2021)
- Sloan Research Fellow, Sloan Foundation (2021)

LINKS

- Druckmann lab website: https://www.druckmannlab.com

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

Our research goal is to understand how dynamics in neuronal circuits relate and constrain the representation of information and computations upon it. We adopt three synergistic strategies: First, we analyze neural circuit population recordings to better understand the relation between neural dynamics and behavior, Second, we theoretically explore the types of dynamics that could be associated with particular network computations. Third, we analyze the structural properties of neural circuits.

Teaching

COURSES

2025-26

- Introduction to Mathematical Tools in Neuroscience: NEPR 209 (Win)
- Neuroscience Computational Core: NEPR 208 (Spr)

2024-25

- Introduction to Mathematical Tools in Neuroscience: NEPR 209 (Win)
- Neuroscience Computational Core: NEPR 208 (Spr)

2023-24

- Introduction to Mathematical Tools in Neuroscience: NEPR 209 (Win)
- Neuroscience Computational Core: NEPR 208 (Spr)

2022-23

- Introduction to Mathematical Tools in Neuroscience: NEPR 209 (Win)
- Neuroscience Computational Core: NEPR 208 (Spr)

STANFORD ADVISEES

Doctoral Dissertation Reader (AC)

Lorna Jayne, Chelsea Li, Christopher Minasi

Postdoctoral Faculty Sponsor

Taiga Abe

Doctoral Dissertation Advisor (AC)

Benyamin Abramovich Krasa, Matthew Bauer, Kyung Geun Kim, Balint Kurgyis, Jiaming Lu

Doctoral Dissertation Co-Advisor (AC)

Minseung Choi

Doctoral (Program)

Kwon Ko

GRADUATE AND FELLOWSHIP PROGRAM AFFILIATIONS

- Neurosciences (Phd Program)

Publications

PUBLICATIONS

- **Recurrent connections facilitate occluded object recognition by explaining-away.** *Nature communications*
  Kang, B., Midler, B., Chen, F., Druckmann, S.
  2026
- **Long-term unsupervised recalibration of cursor-based intracortical brain-computer interfaces using a hidden Markov model.** *Nature biomedical engineering*
  Wilson, G. H., Stein, E. A., Kamdar, F., Avansino, D. T., Pun, T. K., Gross, R., Hosman, T., Singer-Clark, T., Kapitonava, A., Hochberg, L. R., Simeral, J. D., Shenoy, K. V., Druckmann, et al
  2025
- **Brain-wide analysis reveals movement encoding structured across and within brain areas.** *Nature neuroscience*
  Wang, Z. A., Kurgyis, B., Chen, S., Kang, B., Chen, F., Liu, Y., Liu, D., Svoboda, K., Li, N., Druckmann, S.
  2025
- **Age and learning shapes sound representations in auditory cortex during adolescence.** *eLife*
  Praegel, B., Chen, F., Dym, A., Lavi-Rudel, A., Druckmann, S., Mizrahi, A.
  2025; 14
- **Inner speech in motor cortex and implications for speech neuroprostheses.** *Cell*
  Kunz, E. M., Abramovich Krasa, B., Kamdar, F., Avansino, D. T., Hahn, N., Yoon, S., Singh, A., Nason-Tomaszewski, S. R., Card, N. S., Jude, J. J., Jacques, B. G., Bechefsky, P. H., Iacobacci, et al
  2025
- **A recurrent neural circuit in Drosophila temporally sharpens visual inputs.** *Current biology : CB*
  Pang, M. M., Chen, F., Xie, M., Druckmann, S., Clandinin, T. R., Yang, H. H.

2024

- **A high-throughput behavioral screening platform for measuring chemotaxis by C. elegans.** *PLoS biology*
  Fryer, E., Guha, S., Rogel-Hernandez, L. E., Logan-Garbisch, T., Farah, H., Rezaei, E., Mollhoff, I. N., Nekimken, A. L., Xu, A., Seyahi, L. S., Fechner, S., Druckmann, S., Clandinin, et al
  2024; 22 (6): e3002672

- **Transforming a head direction signal into a goal-oriented steering command.** *Nature*
  Westeinde, E. A., Kellogg, E., Dawson, P. M., Lu, J., Hamburg, L., Midler, B., Druckmann, S., Wilson, R. I.
  2024

- **Brain-wide neural activity underlying memory-guided movement.** *Cell*
  Chen, S., Liu, Y., Wang, Z. A., Colonell, J., Liu, L. D., Hou, H., Tien, N., Wang, T., Harris, T., Druckmann, S., Li, N., Svoboda, K.
  2024; 187 (3): 676

- **Temporal scaling of motor cortical dynamics reveals hierarchical control of vocal production.** *Nature neuroscience*
  Banerjee, A., Chen, F., Druckmann, S., Long, M. A.
  2024

- **Mapping the neural dynamics of locomotion across the Drosophila brain.** *Current biology : CB*
  Brezovec, B. E., Berger, A. B., Hao, Y. A., Chen, F., Druckmann, S., Clandinin, T. R.
  2024

- **A high-performance speech neuroprosthesis** *NATURE*
  Willett, F. R., Kunz, E. M., Fan, C., Avansino, D. T., Wilson, G. H., Choi, E., Kamdar, F., Glasser, M. F., Hochberg, L. R., Druckmann, S., Shenoy, K. V., Henderson, J. M.
  2023

- **A high-performance speech neuroprosthesis.** *Nature*
  Willett, F. R., Kunz, E. M., Fan, C., Avansino, D. T., Wilson, G. H., Choi, E. Y., Kamdar, F., Glasser, M. F., Hochberg, L. R., Druckmann, S., Shenoy, K. V., Henderson, J. M.
  2023

- **An efficient behavioral screening platform classifies natural products and other chemical cues according to their chemosensory valence in C. elegans.** *bioRxiv : the preprint server for biology*
  Fryer, E., Guha, S., Rogel-Hernandez, L. E., Logan-Garbisch, T., Farah, H., Rezaei, E., Mollhoff, I. N., Nekimken, A. L., Xu, A., Fechner, S., Druckmann, S., Clandinin, T. R., Rhee, et al
  2023

- **Hypothalamic neurons that mirror aggression.** *Cell*
  Yang, T., Bayless, D. W., Wei, Y., Landayan, D., Marcelo, I. M., Wang, Y., DeNardo, L. A., Luo, L., Druckmann, S., Shah, N. M.
  2023

- **Unraveling the Entangled Brain: How Do We Go About It?** *Journal of cognitive neuroscience*
  Druckmann, S., Rust, N. C.
  2022: 1-4

- **Regional cytoarchitecture of the adult and developing mouse enteric nervous system.** *Current biology : CB*
  Hamnett, R., Dershowitz, L. B., Sampathkumar, V., Wang, Z., Gomez-Frittelli, J., De Andrade, V., Kasthuri, N., Druckmann, S., Kaltschmidt, J. A.
  2022

- **Towards a more general understanding of the algorithmic utility of recurrent connections.** *PLoS computational biology*
  Larsen, B. W., Druckmann, S.
  2022; 18 (6): e1010227

- **Transforming representations of movement from body- to world-centric space.** *Nature*
  Lu, J., Behbahani, A. H., Hamburg, L., Westeinde, E. A., Dawson, P. M., Lyu, C., Maimon, G., Dickinson, M. H., Druckmann, S., Wilson, R. I.
  1800

- **Modularity and robustness of frontal cortical networks.** *Cell*
  Chen, G., Kang, B., Lindsey, J., Druckmann, S., Li, N.

2021

- **Targeted photostimulation uncovers circuit motifs supporting short-term memory.** *Nature neuroscience*
  Daie, K., Svoboda, K., Druckmann, S.
  2021

- **Decoding spoken English from intracortical electrode arrays in dorsal precentral gyrus.** *Journal of neural engineering*
  Wilson, G. H., Stavisky, S. D., Willett, F. R., Avansino, D. T., Kelemen, J. N., Hochberg, L. R., Henderson, J. M., Druckmann, S., Shenoy, K. V.
  2020; 17 (6): 066007

- **Approaches to inferring multi-regional interactions from simultaneous population recordings: Inferring multi-regional interactions from simultaneous population recordings.** *Current opinion in neurobiology*
  Kang, B., Druckmann, S.
  2020; 65: 108–19

- **A comparison of neuronal population dynamics measured with calcium imaging and electrophysiology.** *PLoS computational biology*
  Wei, Z. n., Lin, B. J., Chen, T. W., Daie, K. n., Svoboda, K. n., Druckmann, S. n.
  2020; 16 (9): e1008198

- **Neural ensemble dynamics in dorsal motor cortex during speech in people with paralysis.** *eLife*
  Stavisky, S. D., Willett, F. R., Wilson, G. H., Murphy, B. A., Rezaii, P., Avansino, D. T., Memberg, W. D., Miller, J. P., Kirsch, R. F., Hochberg, L. R., Ajiboye, A. B., Druckmann, S., Shenoy, et al
  2019; 8

- **Kilohertz frame-rate two-photon tomography.** *Nature methods*
  Kazemipour, A., Novak, O., Flickinger, D., Marvin, J. S., Abdelfattah, A. S., King, J., Borden, P. M., Kim, J. J., Al-Abdullatif, S. H., Deal, P. E., Miller, E. W., Schreiter, E. R., Druckmann, et al
  2019; 16 (8): 778–86

- **An orderly single-trial organization of population dynamics in premotor cortex predicts behavioral variability.** *Nature communications*
  Wei, Z., Inagaki, H., Li, N., Svoboda, K., Druckmann, S.
  2019; 10 (1): 216

- **Single-Cell Reconstruction of Emerging Population Activity in an Entire Developing Circuit.** *Cell*
  Wan, Y. n., Wei, Z. n., Looger, L. L., Koyama, M. n., Druckmann, S. n., Keller, P. J.
  2019

- **Active dendritic integration and mixed neocortical network representations during an adaptive sensing behavior.** *Nature neuroscience*
  Ranganathan, G. N., Apostolides, P. F., Harnett, M. T., Xu, N., Druckmann, S., Magee, J. C.
  2018

- **Schaffer Collateral Inputs to CA1 Excitatory and Inhibitory Neurons Follow Different Connectivity Rules** *JOURNAL OF NEUROSCIENCE*
  Kwon, O., Feng, L., Druckmann, S., Kim, J.
  2018; 38 (22): 5140–52

- **Nonlinear Dimensionality Reduction Via Polynomial Principal Component Analysis**
  Kazemipour, A., Druckmann, S., IEEE
  IEEE.2018: 1336–40

- **central brain.** *Science (New York, N.Y.)*
  Kim, S. S., Rouault, H., Druckmann, S., Jayaraman, V.
  2017; 356 (6340): 849-853

- **Angular velocity integration in a fly heading circuit** *ELIFE*
  Turner-Evans, D., Wegener, S., Rouault, H., Franconville, R., Wolff, T., Seelig, J. D., Druckmann, S., Jayaraman, V.
  2017; 6

- **Maintenance of persistent activity in a frontal thalamocortical loop** *NATURE*
  Guo, Z. V., Inagaki, H. K., Daie, K., Druckmann, S., Gerfen, C. R., Svoboda, K.
  2017; 545 (7653): 181-?

- **Multiplicative Updates for Optimization Problems with Dynamics**
  Kazemipour, A., Babadi, B., Wu, M., Podgorski, K., Druckmann, S.
  edited by Matthews, M. B.
  IEEE COMPUTER SOC.2017: 2025–29
- **Robust neuronal dynamics in premotor cortex during motor planning** *NATURE*
  Li, N., Daie, K., Svoboda, K., Druckmann, S.
  2016; 532 (7600): 459-?
- **Dynamical feature extraction at the sensory periphery guides chemotaxis** *ELIFE*
  Schulze, A., Gomez-Marin, A., Rajendran, V. G., Lott, G., Musy, M., Ahammad, P., Deogade, A., Sharpe, J., Riedl, J., Jarriault, D., Trautman, E. T., Werner, C., Venkadesan, et al
  2015; 4
- **From a meso- to micro-scale connectome: array tomography and mGRASP** *FRONTIERS IN NEUROANATOMY*
  Rah, J., Feng, L., Druckmann, S., Lee, H., Kim, J.
  2015; 9
- **Structured Synaptic Connectivity between Hippocampal Regions** *NEURON*
  Druckmann, S., Feng, L., Lee, B., Yook, C., Zhao, T., Magee, J. C., Kim, J.
  2014; 81 (3): 629-640
- **Mapping mammalian synaptic connectivity** *CELLULAR AND MOLECULAR LIFE SCIENCES*
  Yook, C., Druckmann, S., Kim, J.
  2013; 70 (24): 4747-4757
- **A Hierarchical Structure of Cortical Interneuron Electrical Diversity Revealed by Automated Statistical Analysis** *CEREBRAL CORTEX*
  Druckmann, S., Hill, S., Schuermann, F., Markram, H., Segev, I.
  2013; 23 (12): 2994-3006
- **Neuronal Circuits Underlying Persistent Representations Despite Time Varying Activity** *CURRENT BIOLOGY*
  Druckmann, S., Chklovskii, D. B.
  2012; 22 (22): 2095-2103
- **Effective Stimuli for Constructing Reliable Neuron Models** *PLOS COMPUTATIONAL BIOLOGY*
  Druckmann, S., Berger, T. K., Schuermann, F., Hill, S., Markram, H., Segev, I.
  2011; 7 (8)
- **Evaluating automated parameter constraining procedures of neuron models by experimental and surrogate data** *BIOLOGICAL CYBERNETICS*
  Druckmann, S., Berger, T. K., Hill, S., Schuermann, F., Markram, H., Segev, I.
  2008; 99 (4-5): 371-379