

Erik J. Peterson

CONTACT INFORMATION

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RESEARCH INTERESTS

I build models and do theory and at the intersection of biology, computer science, and cognition. I work with a broad range tools from artificial neural networks to biophysical neural models.

EDUCATION

Colorado State University, Fort Collins, CO

Ph.D, Psychology

2012

M.S., Psychology

2009

California Polytechnic State University, San Luis Obispo, CA

B.S., Chemistry and Biochemistry; Minor, Philosophy

May 2004

SCIENTIFIC POSITIONS

Carnegie Mellon University - Pittsburgh, PA

Research Fellow (Research Scientist)

2018 - Present

Biologically-inspired methods for cooperative AI. Game theory. Reinforcement learning. Curiosity learning.

Kernel, LLC - Los Angeles, CA

Senior Research Scientist

2017 - 2018

Technical lead building a *real-time* system for complex spatio-temporal field shaping in deep brain stimulation.

U.C. San Diego - San Diego, CA

Postdoctoral Fellow

2014 - 2017

Novel theoretical accounts and biophysical modeling of neural oscillations. Advised and developed projects using machine-learning to analyze electrophysiological time-series data.

University of Pittsburgh - Pittsburgh, PA

Postdoctoral Fellow

2012 - 2013

Theoretical and empirical analysis of human decision making. Machine learning analysis of fMRI data.

Colorado State University - Fort Collins, CO

Graduate Research Assistant

2006 - 2012

Human reinforcement learning and category learning. Modelling and fMRI data analysis. Software development.

Biosearch Technologies - Novato, CA

Research Assistant II

2004 - 2006

Optimization of high-throughput chemistry. Reporter gene development.

Lawrence Livermore National Laboratory - Livermore, CA

Research Assistant

2003 - 2004

Self-assembly of virus particles to build functional nanostructures. Mechanisms of “ink” transfer in Dip Pen Nano-lithography.

PUBLICATIONS

Papers

- **Peterson EJ** & Verstynen T, A way around the exploration-exploitation dilemma, bioRxiv 671362v5 (2019). Under review at *Nature Neuroscience*.

- **Peterson EJ** & Verstynen T, Artificial astrocyte networks, *In prep.* (2019).
- Izhikevich L, Gao R, **Peterson EJ** & Bradley Voytek, Measuring the average power of neural oscillations, bioRxiv 441626 (2018). Under review at *J. Neurosci. Methods*.
- **Peterson EJ**, Müyesser NA, Verstynen T & Dunovan K, Keep it stupid simple, ArXiv 1809.03406 (2018). Under review at *Neurons, Behavior, Data analysis, and Theory*.
- Agarwal A, Kumar AV, Dunovan K, **Peterson EJ**, Verstynen T & Sycara K, Better safe than sorry: evidence accumulation allows for safe reinforcement learning, ArXiv 1809.09147 (2018).
- **Peterson EJ** & Voytek B, Homeostatic mechanisms may shape the type and duration of oscillatory modulation, bioRxiv 615450v1 (2018). Under review at *J Neurophys.*
- **Peterson EJ** & Voytek B, Learning with discrete representations using continuous chaotic neural populations *In prep* (2019).
- **Peterson EJ** & Voytek B, Healthy oscillatory coordination is bounded by single-unit computation, bioRxiv 309427, (2018).
- Matar Haller[1], Thomas Donoghue[1], **Erik Peterson**[1], Paroma Varma, Priyadarshini Sebastian, Richard Gao, Torben Noto, Robert T. Knight, Avgusta Shestyuk, Bradley Voytek, Parameterizing neural power spectra, bioRxiv 29985 (2018). [1]: Co-first. Under review at *Nature Neuroscience*.
- **Peterson EJ** & Voytek B, Alpha rhythmically alters gain by modulating excitatory-inhibitory background activity, bioRxiv 185074v2 (2017).
- Gao RD, **Peterson EJ**, Voytek B, Inferring synaptic excitation/inhibition balance from field potentials, *Neuroimage* Sep;158:70-78 (2017).
- **Peterson EJ**, Burke QR, Campbell AM, Belger A, Voytek B, 1/f neural noise is a better predictor of schizophrenia than neural oscillations, bioRxiv 113449v4 (2017)
- Cole SR, **Peterson EJ**, van der Meij R, Hemptinne C, Starr PA, & Voytek B, Nonsinusoidal oscillations underlie pathological phase-amplitude coupling in the motor cortex in Parkinson's disease, *J Neurosci* 37(18) (2017)
- **Peterson EJ** and Voytek B, Balanced oscillatory coupling improves information flow, bioRxiv 030304v2 (2016).
- **Peterson EJ** and Seger CA, In model-based fMRI significant is less than specific., bioArxiv 429621 (2017).
- **Peterson EJ**, Seger CA and Anderson CA, Many Hats: Changes in the Striatal Bold Signal Across Stimulus, Preparation, Response and Feedback, *Journal of Neurophysiology* 110(7) 1689-1702 (2013).
- Seger CA and **Peterson EJ**, Categorization = Decision Making - Generalization, *Neurosci Biobehav Rev* 37(7) pp1187-1200 (2013).
- Seger CA, Dennison CM, Lopez-Paniagua DL, **Peterson EJ**, and Roark AA, Dissociating Hippocampal and Basal Ganglia Contributions to Category Learning Using Stimulus Novelty and Subjective Judgments, *Neuroimage* 55(4), pp1739-53 (2011).
- Seger CA, **Peterson EJ**, Cincotta C, Lopez-Paniagua DL and Anderson C, Dissociating the Contributions of Independent Corticostriatal Systems to Visual Categorization Learning Through the Use of Reinforcement Learning Modeling and Granger Causality Modeling, *NeuroImage* 50(2) pp644-656 (2010).
- Bedoukian MA, Whitesell J, **Peterson EJ**, Clay C and Partin KM, The Stargazin C Terminus Encodes an Intrinsic and Transferable Membrane Sorting Signal, *J. Biol. Chem.*, 283(3), pp1597-1600 (2008).
- Johansson HE, Johansson MK, Wong AC, Armstrong ES, **Peterson EJ**, Grant RE, Roy MA, Reddington MV and Cook RM, BTI1, an Azoreductase with pH Dependent Substrate Specificity, *Appl Environ Microbiol* Jun;77(12):4223-5 (2012).

- Cheung CL, Rubinstein AI, **Peterson EJ**, Chatterji A, Sabirianov RF, Mei W, Lin T, Johnson JE and DeYoreo JJ, Steric and Electrostatic Complementarity in the Assembly of Two-Dimensional Virus Arrays, *Langmuir* 26 (5) pp3498–3505 (2010).

Posters

- **Peterson EJ** & Verstynen T, A way around the exploration-exploitation dilemma, presented at Conference on Cognitive Computational Neuroscience (CCN), Berlin Germany, 2019.
- **Peterson EJ** & Verstynen T, Artificial astrocyte networks, presented at The Bernstein Conference, Berlin Germany, 2019.
- **Peterson EJ** & Voytek B, Homeostasis and oscillatory modulation, presented at Society for Neuroscience (SFN), San Diego CA, 2018.
- **Peterson EJ**, Müyesser NA, Dunovan K & Verstynen T, Combining heuristics with counterfactual play in reinforcement learning, presented at Conference on Cognitive Computational Neuroscience (CCN), Philadelphia PA, 2018
- **Peterson EJ** & Voytek B, The tradeoff between oscillatory coordination and neural computation, presented at Society for Neuroscience (SFN), Washington DC, 2017.
- **Peterson EJ** & Voytek B, Gain control across cortical layers can be mediated by balanced oscillatory coupling, presented at Society for Neuroscience (SFN), San Diego, CA 2016.
- Haxby S & **Peterson EJ**, Learning with discrete representations using continuous chaotic neural populations, presented at Society for Neuroscience (SFN), San Diego, CA 2016.
- Gao R, **Peterson EJ**, & Voytek V, Spiking correlates and temporal variability of oscillatory frequency modulation, presented at Society for Neuroscience (SFN), San Diego, CA 2016.
- Rosen BQ, **Peterson EJ**, Campbell AM, Belger A & Voytek B, Spectral 1/f noise differences account for apparent oscillatory band-specific effects in Schizophrenia, presented at Society for Neuroscience (SFN), San Diego, CA 2016.
- L. Izhikevich L, **Peterson EJ** and Voytek B, Neural oscillatory power is not Gaussian distributed across time, presented at Society for Neuroscience (SFN), San Diego, CA 2016.
- **Peterson EJ** & Wheeler MW, The diversity of distributed decisions, presented at Society for Neuroscience (SFN), San Diego, CA 2015.
- **Peterson EJ** & Voytek B. Spike-field coupling does not imply spike-spike coupling, presented at Society for Neuroscience (SFN), San Diego, CA 2015.
- Noto T, Gao R, **Peterson EJ**, Voytek B. Neural network properties can be inferred from electrophysiological power spectral geometry, presented at Society for Neuroscience (SFN), San Diego, CA 2015.
- Cole SR, **Peterson EJ**, de Hemptinne C, Starr PA, Voytek B. Deep brain stimulation increases motor cortical 1/f noise and decouples high gamma amplitude from beta phase, presented at Society for Neuroscience (SFN), San Diego, CA 2015.
- **Peterson EJ** & Seger CS, A precise problem in model-based fMRI?, presented at Cognitive Neuroscience Society Meeting (CNS), San Francisco, CA, May 2013.
- **Peterson EJ** & Seger CS, Evidence for generalizable reward representations in the basal ganglia examined using fMRI and reinforcement learning, International Meeting of the Basal Ganglia Society 11, Eilat, Israel, March 2013.
- **Peterson EJ** & Wheeler M, Looking everywhere for the right model of perceptual decision making, Computational Neuroscience Poster Session, Center for the Neural Basis of Cognition, Pittsburgh, PA, January 2013.
- **Peterson EJ** & Seger CA, Many Hats: Using fMRI to Characterize the Roles and Reward Sensitivity of the Striatum Across Stimulus, Response and Feedback., International Meeting of the Basal Ganglia Society 10, Long Branch, NJ, 2010.

- **Peterson EJ** and Seger, CA, Reward-level dependent activity proceeding and following response selection: an fMRI study, presented at SFN2009, Chicago, IL, Fall 2009.
- **Peterson EJ** and Seger, CA, To Do the Right Thing: Temporal Difference Learning As Tool to Dissect the Role of Feedback in the Striatum, presented at Cognitive Neuroscience Society Meeting (CNS), San Francisco, CA, May 2007.
- Wong MK, Armstrong ES, **Peterson EJ**, Grant RE, Cook RM, and Johnanssen HJ, The BIT1 Azoreductase Colormetric and Fluorometric Reporter System, presented at Experimental Biology 2009, New Orleans, April 2009.
- Sowers BA, **Peterson EJ**, Grant RE, Lin WY, Dick DJ and Cook RM, Optimization of Probe Performance in Real-Time PCR through an Understanding of Synthesis Impurities, presented at Quantitative PCR, San Diego (CA) March, 2005.
- **Peterson EJ**, Weeks BL, De Yoreo JJ, and Schwartz PV, Effect of Environmental Conditions on Dip Pen Nanolithography of Mercaptohexadecanoic Acid, J. Phys. Chem B (2004), 108 (39), pp15206-15210.

Theses

- EJ. Peterson, [Rewards are Categories?](#), PhD Dissertation (2012).

TALKS

- *Artificial astrocyte networks*, SFN (Nanosymposium), Chicago, Oct 2019.
- *Build your own brainwaves*, Nerd Nite, Los Angeles, Feb 2018.
- *Conflicted data science*, Open San Diego, San Diego, Feb, 2016.
- *The electronic dance club brain*, Nerd Nite, San Diego, Oct 2016.
- *In theory you're paying attention*, Ignite, San Diego, Nov 2016.
- *Science ambassador*, Science Hack Day, San Francisco, Oct, 2014.

SOFTWARE

Code for all projects is available as Open Source Software.

- [glia_playing_atari](#): An implementation of artificial astrocyte networks, in Python and PyTorch.
- [infomercial](#): Simulate agents who seek information and reward in equal measure, in Python and PyTorch.
- [azad](#): RL agents that use simple heuristics, in Python and PyTorch.
- [fakespikes](#): Model spiking as a statistical process, in Python.
- [pacpy](#): Calculate phase-amplitude coupling in Python (and Matlab).
- [chinoise](#): Create simple LFP simulations, with 1/f noise.
- [danalysis](#): A very basic library for studying recurrence matrices.
- [pacological](#): Spiking simulations of good and bad PAC.
- [syncological](#): A detailed look at the synchronization and coding fidelity of gamma oscillations.
- [bw](#): Toy simulations to try and better interpret peak bandwidth in power spectra.
- [kdf](#): A language agnostic key-value interface for hdf5.
- [rl](#): A python library for fitting reinforcement learning models to behavioral data
- [modelmodel](#): analyze and simulate (model-based) fMRI in python
- [fmrilearn](#): a set of helper functions to analyze fMRI data in scikit-learn
- [roi](#): A specialized module for doing parametric ROI analyses of fMRI data.
- [ds](#): A python module for dynamical systems analysis. It's for learning not for real work.
- [accumulate](#): Compare decision making theories baed on information accumulation across every possible 2 choice trial (of length L).
- [bigstats](#): A python library for calculating statistics, incrementally.

- [similarity](#): Some similarity measures for perceptual categories.
- [simplepsychtoolbox](#): A set of simple functions for doing common tasks with Psychtoolbox.
- [artificialGrammar](#): Create and analyze artificial grammars
- [seq](#): First, second and third order effects in behavioral (or other) data.

TEACHING

- *Fall 2018*: Guest lecture in Neural and Cognitive Models of Adaptive Decisions (85-435 & 85-735) at Carnegie Mellon.
- *Fall 2014 - 2017*: Multiple guest lectures in Introduction to Data Science (COGS 9) at U.C. San Diego.
- *Fall 2014 - 2017*: Multiple guest lectures in Data Science In Practice (COGS 108) at U.C. San Diego.
- *Fall 2012*: Taught upper-division laboratory, Sense and Perception (PSY 457) at Colorado State University.
- *Spring 2011*: Taught upper-division laboratory, Neuroanatomy (PSY 459) at Colorado State University.

Professional Activities

- *Summer 2014*: Summer school in Theoretical Neuroscience, University of Waterloo

AWARDS

- 2010 Editor's Choice Award, Systems Neuroscience Section NeuroImage
- 2003 Undergraduate Summer Research Fellowship, Lawrence Livermore National, Laboratory Livermore CA.