Erik J. Peterson

CONTACT INFORMATION

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RESEARCH INTERESTS

I am interested in curiosity as a mathematical idea, for use in machine learning and to predict animal behavior. I am interested in applied work as well. Curiosity and reinforcement learning in robots, drones, and design. I also study computation in the brain's other electrically active cells, astrocytes.

I am looking for a leadership role – in industry or academia.

SCIENTIFIC POSITIONS

Carnegie Mellon University - Pittsburgh, PA
Research Fellow (Research Scientist) **2018 - Present**
Curiosity learning. Reinforcement learning. Astrocyte computation. Deep neural networks. Game theory.

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. Biophysical modelling. Deep neural networks.

U.C. San Diego - San Diego, CA
Postdoctoral Fellow **2014 - 2017**
Novel theoretical accounts of neural oscillations. Biophysical modelling. Information and compression theory. Advised and developed machine-learning tools to analyze electrophysiological time-series data (FOOOF). Software development.

University of Pittsburgh - Pittsburgh, PA
Postdoctoral Fellow **2012 - 2013**
Theoretical and empirical analysis of human decision making. Machine learning analysis of fMRI data. Software development.

Colorado State University - Fort Collins, CO
Graduate Research Assistant **2006 - 2012**
Human reinforcement learning. 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.

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**

Publications

Papers

- Thomas Donoghue[1], Matar Haller[1], **Erik Peterson**[1], Paroma Varma, Priyadarshini Sebastian, Richard Gao, Torben Noto, Robert T. Knight, Avgusta Shestyuk, Bradley Voytek, Parameterizing neural power spectra into periodic and aperiodic components, *Nature Neuroscience* 23 1655-1665 (2020). [1]: Co-first.
- **Peterson EJ** & Verstynen T, A way around the exploration-exploitation dilemma, *bioRxiv* 671362v8 (2019).
- **Peterson EJ** & Voytek B, Homeostatic mechanisms may shape the type and duration of oscillatory modulation, *J Neurophys* 124(1) (2020). .
- 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, Combining imagination and heuristics to learn strategies that generalize, *Neurons, Behavior, Data analysis, and Theory* 3(4) (2020).
- Agarwal A, Kumar AV, Dunovan K, **Peterson EJ**, VerstynenT & Sycara K, Better safe than sorry: evidence accumulation allows for safe reinforcement learning, *ArXiv* 1809.09147 (2018).
- **Peterson EJ** & Voytek B, Healthy oscillatory coordination is bounded by single-unit computation, *bioRxiv* 309427 (2018).
- **Peterson EJ** & Voytek B, Alpha rhythmically alters gain by modulating excitatory-inhibitory background activity, *bioRxiv* 185074v2 (2017). Under review at Neuron (. . . again).
- Gao RD, **Peterson EJ**, Voytek B, Inferring synaptic excitation/inhibition balance from field potentials, *Neuroimage* 158 (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., *bioRxiv* 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) 1187-1200 (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), 1739-53 (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) 644-656 (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), 1597-1600 (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* 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) 3498–3505 (2010).

In prep

- **Peterson EJ** & Verstynen T, What can astrocytes compute?, *In prep.* (2020).
- **Peterson EJ** & Voytek B, Benefits and costs of oscillatory coding *In prep* (2020).
- **Peterson EJ** & Voytek B, Learning with discrete representations using continuous chaotic neural populations *In prep* (2020).

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 Bernstien 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 Azoredustase Colormatric and Fluormetric 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).

Software

- infomercial: Simulate agents who seek information and reward in equal measure (pytorch).
- explorationlib: Simulate biological exploration with many different kinds of agents and environments. Written in support of an upcoming book on biological exploration.
- azad: RL agents that use simple heuristics to generalize optimal play (pytorch).
- glia_playing_atari: An implementation of artificial *astrocyte* networks (pytorch).
- fakespikes: A general (fast) library to model spiking as a statistical process.
- pacpy: Calculate phase-amplitude coupling in Python (and Matlab).
- chinoise: Create simple LFP simulations, with realistic aperiodic noise.

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.

Teaching

- *Spring 2021*: Instructor/Course designer for Biologically Intelligent Exploration (85-435 & 85-735) at Carnegie Mellon.
- *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.

Activities

- *Summer 2014*: Summer school in Theoretical Neuroscience, University of Waterloo.
- *Summer 2003*: Undergraduate Summer Research Fellowship, Lawrence Livermore National, Laboratory Livermore CA.

Awards

- *2010*: Editor's Choice Award, Systems Neuroscience Section, NeuroImage.

Press

- *Brain's 'Background Noise' May Hold Clues to Persistent Mysteries*, Quanta Magazine, 2021 https://www.quantamagazine.org/brains-background-noise-may-hold-clues-to-persistent-mysteries-20210208/