Kai Fox

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Education

Stanford University   Sep. 2017 - Dec. 2021

Stanford, CA 94305

B.S. Mathematics.

Publications & Writing

Mohammed A.M. Osman, **Kai Fox**, and Joshua I. Stern. "A Hopfield network model of neuromodulatory arousal state." *bioRxiv.* 2024. [bioRxiv]

Kai Fox, Daniel Birman, and Justin L. Gardner. "Gain, not concomitant changes in spatial receptive field properties, improves task performance in a neural network attention model." *eLife.* 2023. [eLife] [code]

Kai Fox, Daniel Birman, and Justin L. Gardner. "Behavioral benefits of spatial attention explained by multiplicative gain, not receptive field shifts, in a neural network model." *bioRxiv.* 2022. [bioRxiv] [code]

Kai Fox, and Jay McClelland. "Towards a mathematical theory of biologically plausible backpropagation and evolution of weight symmetry in dynamical neural networks." *Unpublished.* 2021. [notes]

Kai Fox, and Jay McClelland. "How can biological neural networks compute the signals they need to learn effectively?" *Undergraduate Research Seminar.* 2021. [poster pdf]

Kai Fox, Daniel Birman, and Justin L. Gardner. "Behavioral benefits of spatial attention explained by multiplicative gain, not receptive field shifts, in a neural network model." *Vision Sciences Society.* 2021. [poster pdf] [code]

Brian Q. Geuther, Sean P. Deats, **Kai Fox**, Stephen A. Murray, Robert E. Braun, Jacqueline K. White, Elissa J. Chesler, Cathleen M. Lutz. Vivek Kumar. "Robust Mouse Tracking in Complex Environments using Neural Networks." *Nature Communications Biology.* 2019. [Nature]

Experience

Sabatini Lab, Harvard Med. & Kempner Institute   Jun. 2024 -

Boston, MA 02115

- Developed novel models integrating anatomical and physiological structure of the basal ganglia and its thalamic projections into classical and modern algorithmic accounts of basal ganglia function based on temporal difference learning.

Data Core Head, Datta Lab, Harvard Medical School May. 2023 - Jun. 2024
Boston, MA 02115

- Coordinated modern open science data practices across six theoretical and experimental research groups in three different universities. Managed and developed data acquisition, storage, and analysis pipelines for neurophysiological and behavioral data. Created protocols for cross-institution data access, standardization, and publishing using DataJoint and NWB.
- Developed first-of-kind machine learning models to disentangle animal morphology and posture in body position measurements, enabling unsupervised animal behavior analysis across species, sexes, genotypes, and other variables.
    - Detailed characterization of variation in body shape, and its impact on unsupervised animal behavior analysis.
- Assisted postdoctoral researchers in developing research programs – e.g., formulating and implemented ML-based mathematical framework for quantification and visualization of high-dimensional relationships between behavioral units, and creating pipelines for measuring phase-responses of coupled neural signals.

Math Tutor, Stanford University Sept. 2021 - Dec. 2021
Stanford, CA 94305

- Tutored undergraduate students in multivariable calculus as well as applied and theoretical linear algebra.

McClelland (PDP) Lab, Stanford University Jun. 2020 - Sept. 2021
Stanford, CA 94305

- Developed theoretical tools for interrogating the dynamics of biologically plausible backpropagation in rate-based dynamical models of the brain.
- Investigated conditions for self-organization of networks into symmetric weight configurations, and identified a promising biologically plausible alternative to enforced weight symmetry.

Gardner Lab, Stanford University Mar. 2019 - May 2023
Stanford, CA 94305

- Developed versatile, parameterized neural network models of spatial attention in the human visual system amenable to artificial physiology experiments.
- Investigated mechanisms of spatial attention's role in perceptual decision making, with explicit goals of which facets of proposed models can account for behavioral differences with and without attention.
- Co-authored manuscript and presented research.

Knutson Lab, Stanford University Mar. 2018 - Sept. 2018
Stanford, CA 94305

- Developed flexible machine learning and data analysis pipelines for study of fMRI data.
    - Designed interfaces for organization and plotting to enable flexible analysis of high dimensional data, and implemented feature selection algorithms to identify significant brain loci during human decision making.
- Collaborating with a postdoctoral researcher, analyzed explanatory factors in economic and social media decision making and predictive ability of neural data using these tools.

Kumar Lab, The Jackson Laboratory   Oct. 2015 - Aug. 2017

Bar Harbor, ME 04609

- Worked alongside a postdoctoral research assistant to develop and apply state-of-the-art neural networks for high-throughput study of addiction-related behavior in mice. Developed software pipelines for training and performance analysis of neural networks, engineered neural network structures and introspective techniques to guide future designs, and developed pipelines for automated processing of newly recorded video data on remote servers.
- Spearheaded an initiative to build the first ever video database of addiction-related mouse behavior suitable for modern machine learning. Responsibilities included: organizing existing interface software, developing pipelines for data distribution, and analyzing data quality, leading a team of part-time and full-time interns, as well as postdoctoral fellows working part-time on the project.
- Applied, combined, and improved upon techniques shown to be successful for unsupervised study of video and animal behavior.

Skills

Programming.	Python, Javascript, R, C/C++, Bash, SQL, Matlab, HTML/CSS, Java.
ML Technologies.	Numpy/Scipy/Pandas, JAX, Tensorflow, PyTorch, Keras, scikit-learn, OpenCV, HPC, SageMath, and Mathematica
Neuro technologies.	(Keypoint-, Jax-, Depth-)MoSeq. DataJoint, NWB.
Coursework.	Primary coursework includes undergraduate courses in linear algebra, real analysis, topology, geometry, statistics, and differential equations, as well as psychology, theoretical and computational neuroscience, computer science, and artificial intelligence.
Extracurricular.	Over three years was section leader and production manager for Stanford Talisman, a vocal ensemble focused on world music and culture, where role involved vocal education, community building, music recording and production, and video editing. Also a member and choreographer for Chocolate Heads Movement Ensemble, a contemporary dance group.