Jacob M. Graving

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Summary

Research scientist and machine learning engineer with extensive experience in *statistical modeling*, *Bayesian inference*, and scalable *AI systems*. My work focuses on building interpretable models and reproducible pipelines to analyze high-dimensional, multimodal data—often in uncertain or noisy environments. I bring a strong record of leading cross-disciplinary research, mentoring teams, and translating complex data into interpretable, decision-relevant results. Experienced in collaborating with engineers and domain experts to deliver robust, deployable solutions grounded in scientific rigor.

Skills

Core strengths: Bayesian modeling, probabilistic programming, uncertainty quantification, deep learning, causal inference, time-series analysis

Tools: PyMC, NumPyro, Stan, PyTorch, JAX, TensorFlow, Git, Jupyter, R

- Built scalable pipelines for multimodal datasets and developed interpretable models for noisy real-world data
- Designed transformers and contrastive learning architectures for representation learning in behavioral time-series
- Mentored researchers on applied ML and open-source tools for behavioral science and neuroscience
- Proven ability to quickly adopt new technologies and apply them to real-world scientific problems

Experience

2020–present
Research Scientist
Advanced Research Technology Unit, Max Planck Institute of Animal Behavior

- Lead independent research at the interface of machine learning and behavioral science, developing general-purpose tools to measure and model animal behavior in both lab and field environments.
- Design and maintain scalable ETL pipelines for multimodal behavioral datasets, ensuring data integrity and reproducibility across experimental systems.
- Collaborate with interdisciplinary teams—including software engineers, neuroscientists, and field biologists—to build AI-driven tools for behavior analysis and experimental optimization.
- Apply Bayesian inference, causal modeling, and uncertainty quantification to large-scale time series and experimental data to generate interpretable, data-driven insights.
- Provide technical guidance and mentorship across collaborative projects, promoting reproducible science and statistical rigor.

Education

2021
Dr.rer.nat., Biology (0.0 'summa cum laude')
Max Planck Institute of Animal Behavior & University of Konstanz — *Germany*
International Max Planck Research School (IMPRS)
Thesis: Deep Learning and Computer Vision Methods for Measuring and Modeling Animal Behavior

2015
M.Sc., Biology — Bowling Green State University — *USA*
Focus: Animal Behavior, Neuroscience

2013
B.Sc., Biology — Bowling Green State University — *USA*

Recent & Selected Publications

In Prep
Graving, J.M. and Foster, J.J. (in prep). Unwrapping Circular Statistics: Bayesian Linear Models for Circular Data.

- Introduces a novel Bayesian generalized linear model framework for circular data by incorporating the von Mises distribution.
- Jointly models mean direction and variance to improve interpretability of circular outcomes.
- Offers practical guidelines and implementations using Bayesian toolkits such as PyMC and Stan.

Graving, J.M., Heins, C., Couzin, I.D. Revealing the Structure of Time-Series Data with Context Attraction-Repulsion Embeddings.

- Proposes a generalized contrastive learning framework for dimensionality reduction and visualization of time-series data using transformer-based sequence modeling.
- Demonstrates recovery of latent factors and interpretable structure from high-dimensional behavioral and synthetic datasets.
- Introduces a general tool for exploratory analysis and hypothesis generation in time-series modeling.

In Review
Bath, D.E., **Graving, J.M.**, Walter, T., Sridhar, V.H., Vizcaíno, J.P., Couzin, I.D. Collective detection and processing of distributed information by fish schools. In revision for *Current Biology*.
Code: github.com/jgraving/bayesian_beta_regression

- Developed a Bayesian model to analyze collective information processing in fish schools.
- Modeled 3 billion behavioral observations across 400+ conditions using JAX and NumPyro.
- Revealed how distributed sensing shapes group-level responses to environmental signals.

2025
Sayin, S., Couzin-Fuchs, E., Petelski, I., Günzel, Y., Salahshour, M., Lee, C.-Y., **Graving, J.M.**, Li, L., Deussen, O., Sword, G.A., Couzin, I.D. (2025). The behavioral mechanisms governing collective motion in swarming locusts. *Science*, 387(6737), 995–1000. https://doi.org/10.1126/science.adq7832
Code: https://github.com/jgraving/sayin_locust_mixture_model

- Led Bayesian modeling and statistical analysis of virtual reality (VR) behavioral data from locusts.
- Identified and solved a key methodological flaw in prior work—confounding of group coordination with group size.
- Helped validate the core findings and strengthen the paper's quantitative rigor.

2023
Koger, B., Deshpande, A., Kerby, J.T., **Graving, J.M.**, Costelloe, B. R., Couzin, I.D. (2023). Quantifying the movement, behaviour and environmental context of group-living animals using drones and computer vision. *Journal of Animal Ecology*. doi:10.1111/1365-2656.13904 *Code*: github.com/benkoger/overhead-video-worked-examples

- Co-developed a computer vision pipeline combining drone footage and deep learning to extract 3D behavioral and environmental data from animal groups in natural settings.
- Integrated spatial context reconstruction with fine-scale movement tracking to support large-scale behavioral ecology studies.

2020
Li, L., Nagy, M., **Graving, J.M.**, Bak-Coleman, J., Guangming X., Couzin, I.D. (2020). Vortex phase matching as a strategy for schooling in robots and in fish. *Nature Communications*, 11, 5408. doi:10.1038/s41467-020-19086-0

- Analyzed high-resolution posture data of schooling fish to test energy-optimization strategies predicted by robotic models.
- Applied deep learning–based pose estimation and mechanistic modeling to quantify fluid-mediated interactions and coordinated motion patterns.

2019
Graving, J.M., Chae, D., Naik, H., Li, L., Koger, B., Costelloe, B.R., Couzin, I.D. (2019). DeepPoseKit, a software toolkit for fast and robust animal pose estimation using deep learning. *eLife*, 8. doi:10.7554/elife.47994
Press: Quanta Magazine, Nature Methods, Nature News & Views, eLife Science Digests
Code: github.com/jgraving/deepposekit

- Created a general-purpose, few-shot deep learning framework for high-speed, high-accuracy animal pose tracking in Python/TensorFlow.
- Supervised development of key components including a custom annotation GUI and augmentation tools for low-data regimes.

Teaching

2023
Konstanz School of Collective Behavior, University of Konstanz

- Designed and led a workshop on "Probabilistic Machine Learning" for 30+ international PhD students, covering Bayesian inference, causal inference, and information theory in practice. https://www.exc.uni-konstanz.de/kscb/

2022
Deep Learning Workshop, Max Planck Institute of Animal Behavior

- Led an applied workshop introducing PyTorch and deep learning fundamentals to 15 researchers.

2019
ASAB 2019 Summer Conference, University of Konstanz

- Gave an invited seminar on "Machine Learning in the Behavioral Sciences" to an audience of 400+.
- Co-organized a workshop on behavioral quantification and modeling using ML methods (27 participants).

2016–2020
University of Konstanz, Department of Biology

- Co-developed and taught an intensive research course on collective behavior for Master's students.
- Supervised five Master's thesis projects across behavior, computation, and data science.
- Delivered lectures and practicals on computer vision for behavior analysis, data processing, and Python programming.