

Jacob M. Graving

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Max Planck Institute of Animal Behavior · University of Konstanz, Department of Biology ·
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Research Interests

Interpretable and scalable machine learning for computational behavioral science, including self-supervised representation learning, Bayesian and causal inference, and probabilistic modeling of complex systems.

Experience

2020–present

Research Scientist

Advanced Research Technology Unit, Max Planck Institute of Animal Behavior

- Led independent research at the interface of machine learning and behavioral science, developing general-purpose tools for measuring and modeling animal behavior in both laboratory and field environments.
- Designed and maintained scalable ETL pipelines for multimodal behavioral datasets, ensuring data integrity and reproducibility across experimental systems.
- Worked closely with interdisciplinary collaborators—including software engineers, neuroscientists, and field biologists—to build AI-driven tools for behavior analysis and experimental optimization.
- Applied Bayesian inference, causal modeling, and uncertainty quantification to large-scale time series and experimental datasets to generate interpretable, data-driven insights.
- Provided technical guidance and mentorship across multiple collaborative projects, promoting reproducible science and statistical rigor.

Education

2021 **Dr.rer.nat., Biology** (0,0 ‘summa cum laude’)

Department of Collective Behaviour, Max Planck Institute of Animal Behavior

Department of Biology, University of Konstanz

Centre for the Advanced Study Collective Behaviour, University of Konstanz

International Max Planck Research School (IMPRS) for Organismal Biology

Thesis: ‘Deep Learning and Computer Vision Methods for Measuring and Modeling Animal Behavior’ **Supervisor:** Prof. Iain Couzin

2015 **M.Sc., Biology** *Department of Biological Sciences, Bowling Green State University*

Focus: Quantitative Behavior, Neuroscience

2013 **B.Sc., Biology** *Department of Biological Sciences, Bowling Green State University*

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.

- Provides 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.

- Developed a generalized contrastive learning framework for dimensionality reduction and visualization of time-series data using transformer-based sequence modeling.
- Demonstrated recovery of latent factors and interpretable structure from high-dimensional behavioral and synthetic datasets.
- Provides 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

- Led development of 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>

- Led Bayesian modeling and statistical analysis of 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). Deep-PoseKit, 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/deeposekit

- 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.

Skills

Programming Languages: Python

Core Expertise: Bayesian inference, causal inference, statistical modeling, machine learning, deep learning, computer vision, image analysis, data visualization

Libraries & Frameworks: PyTorch, JAX, NumPyro, Stan, TensorFlow, scikit-learn, OpenCV

Tools: Git, LaTeX, Jupyter