# Jacob M. Graving

Max Planck Institute of Animal Behavior
University of Konstanz, Department of Biology
Centre for the Advanced Study of Collective Behaviour
Universitätsstr. 10
Konstanz, Germany 78464

✉ jgraving@gmail.com

🌐 jakegraving.com
🐦 twitter.com/jgraving
⭕ github.com/jgraving

| **Research Interests** | Computational models for the study of animal behavior, Bayesian statistical inference, machine/deep learning, computer vision, probabilistic programming, nonlinear dynamics |
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## Positions

**2020–present**

**Research Scientist**
Max Planck Institute of Animal Behavior

**Role:** Head of central machine learning research group tasked with developing novel, general-purpose methods for the study of animal behavior in laboratory and field environments using computer vision, machine/deep learning, and modern statistical techniques, such as Bayesian causal inference.

## Education

**2021**

**Ph.D. (Dr.rer.nat.), Biology**
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

**Advisor**: Prof. Dr. Iain D. Couzin
**Thesis Title**: "Computer Vision and Deep Learning Methods for Measuring and Modeling Animal Behavior"

**2015**

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

**Advisor**: Prof. Daniel D. Wiegmann
**Thesis Title**: "Nocturnal Homing in Amblypygids"

**2013**

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

## Publications

**In Revision**

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.

**In Review**

**Graving, J.M.**, Couzin, I.D. (2020). VAE-SNE: a deep generative model for simultaneous dimensionality reduction and clustering. bioR$\chi$iv: https://doi.org/10.1101/2020.07.17.207993

**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 https://doi.org/10.1038/s41467-020-19086-0

**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. https://doi.org/10.7554/elife.47994
bioR$\chi$iv: https://doi.org/10.1101/620245 Code: https://github.com/jgraving/deepposekit
Press: Quanta Magazine, Nature Methods, Nature News & Views, eLife Science Digests

**2018**

Alarcón-Nieto, G.*, **Graving, J.M.**\*, Klarevas-Irby, J.A.*, Maldonado-Chaparro, A.A., Mueller, I., and Farine, D.R. (2018) An automated barcode tracking system for behavioural studies in birds. Methods in Ecology and Evolution 9 (6), 1536-1547. https://doi.org/10.1111/2041-210X.13005 bioR$\chi$iv: https://doi.org/10.1101/201590 *contributed equally

| 2017 | **Graving, J.M.**, Bingman, V.P., Hebets, E.A., and Wiegmann, D.D. (2017). Development of site fidelity in the nocturnal amblypygid *Phrynus marginemaculatus*. Journal of Comparative Physiology A, 203(5), 313-328. https://doi.org/10.1007/s00359-017-1169-5 |
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| | Bingman, V.P., **Graving, J.M.**, Hebets, E.A., and Wiegmann, D.D. (2017). Importance of the antenniform legs, but not vision, for homing by the neotropical whip spider *Paraphrynus laevifrons*. Journal of Experimental Biology, 220(5), 885-890. https://doi.org/10.1242/jeb.149823 <br> Press: Discover Magazine, National Geographic |
| 2016 | Wiegmann, D.D., Hebets, E.A., Gronenberg, W., **Graving, J.M.**, and Bingman, V.P. (2016). Amblypygids: model organisms for the study of arthropod navigation mechanisms in complex environments. Frontiers in Behavioral Neuroscience, 10, 47. https://doi.org/10.3389/fnbeh.2016.00047 |

# Teaching

| 2019 | **ASAB 2019 Summer Conference, University of Konstanz** <br> Workshop Organizer and Lecturer <br> – Seminar on "Machine Learning in the Behavioral Sciences" <br> – Practical Workshop on "Quantifying Behavior with Machine Learning" |
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| 2016–2020 | **University of Konstanz, Department of Biology** <br> Lecturer and Project Advisor, Intensive Research Course for Master's Students <br> – Measuring Animal Behavior with Computer Vision <br> – Analyzing Behavioral Data <br> – Introduction to Programming in Python |
| 2013–2015 | **Department of Biological Sciences, Bowling Green State University** <br> Graduate Assistant <br> – Advanced Biostatistics <br> – Introduction to Biostatistics <br> – Population and Community Ecology <br> – Introductory Biology for Non-Science Majors <br> – Guest Lecture on "Arthropod Navigation", Animal Behavior |

# Invited Talks

| 2019 | **Revealing the Behavioral Algorithms of Social Animals** <br> Princeton Neuroscience Institute (PNI) <br> Princeton University, Princeton, New Jersey, USA <br> July 2, 2019 |
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| 2018 | **Perception and Motion in Locust Swarms** <br> Integrated Behavioral Research Group (IBRG) <br> Princeton University, Princeton, New Jersey, USA <br> March 16, 2018 |
| | **Perception and Motion in Locust Swarms** <br> Department of Biological Sciences Seminar Series <br> Bowling Green State University, Bowling Green, Ohio, USA <br> February 28, 2018 |

# Outreach

| 2017–2019 | **Konstanzer Lange Nacht Der Wissenschaft** <br> "Long Night of Science" Public Outreach Event <br> Volunteer <br> Konstanz, Germany |
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| 2016 | **Das Schwarmverhalten der Fische** <br> Public Seminar by Prof. Jens Krause <br> Volunteer Co-organizer |

Konstanz, Germany

| 2013–2014 | **Kid's Tech University, Bowling Green State University** |
| | Public Outreach Event for Schoolchildren Grades K–8 |
| | Volunteer |
| | Bowling Green, Ohio, USA |

# Advisees

| Graduate | Simon Gommel, M.S. Biology, University of Konstanz |
| | Taylor Carter, M.S. Biology, University of Konstanz |
| | Ingabritta Hormann, M.S. Biology, University of Konstanz |

| Undergraduate | Nicole Meister, B.S. Computer Science, Princeton University |
| | Chiara Hirschkorn, B.S. Biology, University of Konstanz |
| | Daniel Chae, B.S. Computer Science, Princeton University |
| | Connie Santangelo, B.S. Biology, Bowling Green State University |
| | Lindsey Cunningham, B.S. Biology, Bowling Green State University |
| | Tracy Togba, B.S. Biology, Bowling Green State University |

# Peer Review

| *Journals:* | eLife, Science Advances, PNAS, Methods in Ecology and Evolution |
| *Grants:* | IMPRS Project Grant, IMPRS Travel Grant |

# Skills

| *Languages:* | Python (Expert), R (Intermediate) |
| *Applications:* | Bayesian inference, statistical analysis, data visualization, machine learning, deep learning, computer vision, and image processing |
| *Libraries:* | Stan, TensorFlow, PyTorch, Numpyro, scikit-learn, OpenCV |