What movement knows about age: Reading motor reserve in mice and people

Talmo D. Pereira, PhD · Assistant Professor, Director of AI and Research Computing, Salk Institute for Biological Studies

Over the past three years my lab has built a home cage monitoring system for continuous behavioral recording in mice, together with the pose tracking and analysis pipeline it requires. The system has now generated more than 100,000 animal-hours of video. Using this data, we can predict a mouse's age to within a few days from roughly 40 minutes of free behavior sampled across a single day. This works from kinematics alone, with no task and no neural recording. The result raises a question the measurement cannot answer: what is behavior reporting here? Age itself is not a mechanism; something in the motor system is changing over time, and behavior is sensitive enough to resolve it to days.

Our hypothesis is that behavior is reporting **motor reserve**. In biomechanics, reserve is the difference between neuromusculoskeletal capacity and task demand, and compensation is the alteration in movement trajectory or muscle recruitment used to meet demand when reserve falls short (van der Kruk et al. 2021). The substrate is well documented: healthy people lose roughly 40% of their motor units by age 71, and surviving units enlarge through collateral reinnervation of denervated fibers (Piasecki et al. 2016), while failure to expand motor unit size is what separates sarcopenic from non-sarcopenic older men (Piasecki et al. 2018). Function can be preserved well into later life, and impairment can appear abruptly once compensation no longer suffices. Reserve is currently quantified as a residual between measured pathology and measured impairment, developed largely in cognitive and Parkinson's research rather than healthy motor aging (Chung et al. 2020). We propose that inferred control is a more direct readout, and that this is testable: if so, the informative variable is not the movement a body produces but the control it takes to produce it.

Separating movement from control has not been possible in an intact, behaving animal. We recently developed **MIMIC-MJX**, a framework that recovers the control signals underlying observed movement (Zhang et al. 2025). It inverts the process that generates movement: we train neural network controllers to actuate an anatomically realistic musculoskeletal body model in physics simulation, rewarded for producing the forces that reproduce a real animal's kinematics. The resulting controller is a working model of that individual's motor system, a **digital twin** whose muscle activations and control strategy we can read out directly and perturb *in silico*. Kinematics tell us what a body did; the twin tells us what it took to do it. These inferences are verifiable against physiology: in mouse forelimb reaching, controllers actuating muscle-based models predicted recorded EMG better than less biologically realistic torque-driven models (Leonardis et al. 2025).

This gives us an operational handle on compensation: **match on kinematics, contrast on control**. Holding the movement fixed isolates the recruitment half of the definition above, so two individuals producing the same trajectory while requiring different recruitment, coactivation and effort differ in reserve in a way no kinematic measure can detect. Here I propose to test whether motor reserve defined this way is **comparable across species**: whether mouse and human motor aging can be expressed in the same terms, despite bodies and behavioral repertoires that have almost nothing in common.

Aim 1: Does the behavioral clock generalize to humans? We will build an in-lab human motion capture system and attempt to reproduce the mouse result in healthy adults across the adult age range, using free movement plus a short battery that stresses compensation. There is no guarantee this transfers. Human movement does carry an age signal, but the evidence comes from free-living accelerometry rather than biomechanics-grade kinematics (McIntyre et al. 2021), and in mice the strength of the signal depends on which behaviors are sampled. Mice are also inbred, environmentally matched and recorded across a full lifespan, while people are none of these and will give us minutes of data rather than days. If precision survives, behavioral age is a general property of motor systems; if it degrades, the gap tells us how much of the mouse result depends on genetic and environmental homogeneity.

Aim 2: Does the clock survive the move from kinematics to control? Kinematic features are specific to the body that produced them. Cross-species comparison is possible but has required careful normalization, such as regressing gait parameters on walking velocity to compare mouse and human parkinsonism (Broom et al. 2017). Control policies may provide a more principled common space, since they are defined over the plant being controlled (the body, in the control-theoretic sense) rather than over the movement itself. We will refit age prediction in the space of inferred control in both species and ask whether the signature of aging is homologous. If it is, we have a coordinate system in which mouse and human motor aging can be compared directly. If not, aging acts on the particulars of a body rather than on a general control strategy, which is itself a substantive claim about the target of motor aging.

Aim 3: Compensation and collapse. If behavioral age is reserve, aging should appear at the control level as progressive compensation for movements that stay kinematically unchanged. Three predictions follow. First, control should diverge before kinematics, which would explain why motor aging appears to arrive suddenly. Second, reversibly perturbing a healthy young adult with added load, induced fatigue or joint constraint should transiently shift control toward the aged phenotype. This is the causal test, possible only in humans, who can be perturbed and released. Third, in our longitudinal mouse cohorts, individuals whose control age runs ahead of their chronological age should decline kinematically earlier. Neither species can do this alone: a full lifespan is only available in mice, and reversible perturbation is only available in people.

Risk and falsification. What we have never done is work in humans, and every core claim here can fail. Human prediction may not reach useful precision, control features may not transfer across species, and control may not lead kinematics. The deepest risk is technical: many muscle activation patterns produce the same kinematics, so a recovered controller is not automatically the right one. We will therefore treat inferred control as a measure of reserve only where it predicts quantities we measure independently: surface EMG and ground reaction forces in the human studio, the graded response to perturbation, and prospective kinematic decline in the mouse cohorts. If it fails those tests, what we have is a high-dimensional summary of behavior rather than a readout of reserve, and we will report it as such. If it works, reserve becomes something we can measure rather than estimate by subtraction, and we gain a way to ask when any nervous system is spending down its capacity. That is the question underneath aging, and underneath every neurodegenerative disease.

References

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2. Piasecki M, Ireland A, Jones DA, McPhee JS (2016) Age-dependent motor unit remodelling in human limb muscles. *Biogerontology* 17:485–496.
3. Piasecki M, Ireland A, Piasecki J, et al. (2018) Failure to expand the motor unit size to compensate for declining motor unit numbers distinguishes sarcopenic from non-sarcopenic older men. *J Physiol* 596:1627–1637.
4. Chung SJ, Lee JJ, Lee PH, Sohn YH (2020) Emerging concepts of motor reserve in Parkinson's disease. *J Mov Disord* 13:171–184.
5. McIntyre RL, Rahman M, Vanapalli SA, et al. (2021) Biological age prediction from wearable device movement data identifies interventions for healthy aging. *Front Aging* 2:708680.
6. Broom L, Ellison BA, Worley A, et al. (2017) A translational approach to capture gait signatures of neurological disorders in mice and humans. *Sci Rep* 7:3225.
7. Leonardis E, Nagamori A, Thanawalla A, et al., Azim E, Pereira TD (2025) Massively parallel imitation learning of mouse forelimb musculoskeletal reaching dynamics. *arXiv* 2511.21848.
8. Zhang CY, …, Olveczky BP, Pereira TD (2025) MIMIC-MJX: neuromechanical emulation of animal behavior. *arXiv* 2511.20532. In review at *Nature Methods*.

Talmo D. Pereira, Ph.D.

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BIO

I am an Assistant Professor and Director of the Center for AI and Research Computing at the Salk Institute for Biological Studies. I lead a research lab that focuses on the development and application of computational tools for neuroscience and biology more broadly. I started my lab as a Salk Fellow in November 2021, a faculty-level appointment that gives advanced PhD students the opportunity to achieve early independence and bypass the traditional postdoctoral training stage by providing startup funds, lab space, and the ability to hire lab staff at any level. My lab (talmolab.org) focuses on the development of deep learning-based computational methods for recognition and modeling of complex biological systems, with applications ranging from neuroscience to cancer and plant biology. My recent work has demonstrated how advances in deep learning and computer vision can enable quantitative phenotyping of complex behaviors through the development and application of approaches for markerless motion capture (sleap.ai). This work has been published in *Nature Methods* and featured in *The Scientist*, *Nature Lab Animal*, *Nature Toolbox*, *Quanta Magazine* and others. Prior to joining Salk, I worked as a research intern in Perception at Google AI working on pose-based action recognition, and received my PhD in Neuroscience from Princeton University where I was also a recipient of the NSF Graduate Research Fellowship and the Porter Ogden Jacobus Fellowship—Princeton University's top graduate student honor.

EDUCATION

Ph.D. in Neuroscience, Princeton University 2021

M.S. in Neuroscience, Princeton University 2017

B.S. in Bioinformatics & Computational Biology, University of Maryland, Baltimore County 2015

EXPERIENCE

Salk Institute for Biological Studies, Assistant Professor & Director of AI and Research Computing June 2026–
Salk Harnessing Plants Initiative, Salk Cancer Center, Neuroscience T32
Principal Investigator of a lab that builds computational tools that leverage deep learning and computer vision to tackle otherwise intractable problems in neuroscience, cancer biology, plant biology and more. Additionally, leading an engineering group to modernize the scientific computing infrastructure at Salk using AI.

Salk Institute for Biological Studies, Salk Fellow Nov 2021–May 2026
Salk Harnessing Plants Initiative, Salk Cancer Center, Neuroscience T32
Principal Investigator of a lab that builds computational tools that leverage deep learning and computer vision to tackle otherwise intractable problems in neuroscience, cancer biology, plant biology and more.

Google AI, PhD Research Intern Jun 2019 – Dec 2019
Research internship at Google AI in Machine Perception. Developed deep learning systems for human action recognition.

Princeton University, Graduate Student Jul 2015 – Oct 2021
Advisors: Mala Murthy and Joshua Shaevitz
Using fruit flies (*Drosophila melanogaster*) as a model, I worked on understanding how the brain integrates sensory information to pattern behavioral sequences. To do this, I developed hardware as well as computational methods that leverage computer vision, deep learning, signal processing and unsupervised machine learning for quantifying behavior through few shot pose estimation and manifold embedding.

Marine Biological Laboratory, Course Participant Jun 2015
Brains, Minds & Machines Summer Course at Woods Hole.

Caltech, Amgen Summer Undergraduate Research Scholar Jun 2014 – Aug 2014
Advisor: David J. Anderson
Worked on computational analysis of aggressive behaviors in fruit flies using methods in computer vision for animal tracking

and supervised machine learning for timeseries segmentation.

MIT, Workshop Participant Jan 2014
Quantitative Methods in Biology Workshop

MIT, Summer Student, Visiting Student Jun 2013 – Aug 2013, Jan 2014 – May 2014
Advisor: H. Sebastian Seung
Worked on image processing algorithms for large scale (100-1000s GiB) electron microscopy image alignment/registration for connectomic reconstruction.

University of Maryland, Baltimore County, Undergraduate Researcher Jan 2013 – Jun 2015
Advisor: Ivan Erill
Developed computational algorithm for GPU-accelerated transcription factor DNA binding site prediction in large scale (10-100s GiB) metagenomic sequencing data to characterize transcriptional regulatory networks.

Broad Institute of MIT and Harvard, Summer Student Jun 2012 – Aug 2012
Advisor: Jon Madison
Worked on characterizing interactions between proteins associated with psychiatric disease in the axon initial segment via immunochemical assays.

NIDCR, NIH, HHMI STIP High School Scholar Jun 2010 – Jun 2011
Advisor: Abner L. Notkins
Characterized the learning and memory impairment induced by knockout of a type-1 diabetes-associated neuroendocrine transport gene in mice via behavioral pharmacology.

PUBLICATIONS

1. Aidan Sirbu, Charles Y Zhang, Yuanjia Yang, Bence P Ölveczky, **Talmo D Pereira**, and Blake A Richards. A latent control model for realistic rodent motion. 2026. (In submission to *NeurIPS*.)

2. F C Kiffer*, R T Scott, M Martens, A Mayo, Y Li, M Mendoza, S Gautam, J Huang, M Bathwal, S Jaikumar, A Mahajan, L M Sanders, A J Eisch*, and **Talmo Pereira***. Automated behavioral segmentation and markerless pose tracking of mice during spaceflight. *bioRxiv*, 2026

3. France Rose, Monika Michaluk, Timon Blindauer, Bogna M Ignatowska-Jankowska, Liam O'Shaughnessy, Greg J Stephens, **Talmo D Pereira**, Marylka Y Uusisaari, and Katarzyna Bozek. Deep imputation for skeleton data (DISK) for behavioral science. *Nat. Methods*, pages 1–12, December 2025

4. Eric Leonardis, Akira Nagamori, Ayesha Thanawalla, Yuanjia Yang, Joshua Park, Hutton Saunders, Eiman Azim, and **Talmo Pereira**. Massively parallel imitation learning of mouse forelimb musculoskeletal reaching dynamics. In *Data on the Brain & Mind @ NeurIPS*, December 2025

5. Charles Y Zhang, Yuanjia Yang, Aidan Sirbu, Elliott T T Abe, Emil Wärnberg, Eric J Leonardis, Diego E Aldarondo, Adam Lee, Aaditya Prasad, Jason Foat, Kaiwen Bian, Joshua Park, Rusham Bhatt, Hutton Saunders, Akira Nagamori, Ayesha R Thanawalla, Kee Wui Huang, Fabian Plum, Hendrik K Beck, Steven W Flavell, David Labonte, Blake A Richards, Bingni W Brunton, Eiman Azim, Bence P Ölveczky*, and **Talmo D Pereira***. MIMIC-MJX: Neuromechanical emulation of animal behavior. *arXiv [q-bio.NC]*, December 2025. (In revision at *Nature Methods*.)

6. Catalin Mitelut, Marielisa Diez Castro, Ralph E Peterson, Maria Gonçalves, Jennifer Li, Madeline Gamer, Simon R O Nilsson, **Talmo D Pereira***, and Dan H Sanes*. Continuous monitoring and machine vision reveals that developing gerbils exhibit structured social behaviors prior to the emergence of autonomy. *PLoS Biol.*, 23(9):e3003348, September 2025

7. Yuan Cheng, Yusi Chen, Myungji Kwak, Ross P Kempner, Rudramani Singha, Jared Winslow, Runqi Liu, Umais Khan, Tessa Spangler, Alvi Khan, **Talmo Pereira**, Matthew Whiteway, Evan S

Schaffer, Nuttida Rungratsameetaweemana, Nan Yang, and Herbert Zheng Wu. Asymmetric social representations in the prefrontal cortex for cooperative behavior. *bioRxiv*, page 2025.08.27.672249, August 2025. (Accepted at *Nature*.)

8. Caroline Jia, Andrea Tran, Faith Aloboudi, Ella Say, Nick Thao, Christopher R Lee, Kanha Batra, Amanda Nguyen, Aneesh Bal, Nathaniel N Nono, Jeremy Delahanty, May G Chan, Laurel R Keyes, Reesha R Patel, Romy Wichmann, Felix Taschbach, Yulong Li, Marcus Benna, **Talmo D Pereira**, Hao Li, and Kay Tye. Social exclusion amplifies behavioral responses to physical pain via insular neuromodulation. *bioRxiv*, page 2025.05.09.653162, May 2025

9. Isla Duporge, **Talmo Pereira**, Santiago Castiello de Obeso, Julius G Bright Ross, Stephen J Lee, and Allyson G Hindle. The utility of animal models to inform the next generation of human space exploration. *NPJ Microgravity*, 11(1):7, February 2025

10. Austin A Coley, Kanha Batra, Jeremy M Delahanty, Laurel R Keyes, Rachelle Pamintuan, Assaf Ramot, Jim Hagemann, Christopher R Lee, Vivian Liu, Harini Adivikolanu, Jianna Cressy, Caroline Jia, Francesca Massa, Deryn LeDuke, Moumen Gabir, Bra'a Durubeh, Lexe Linderhof, Reesha Patel, Romy Wichmann, Hao Li, Kyle B Fischer, **Talmo Pereira**, and Kay M Tye. Predicting future development of stress-induced anhedonia from cortical dynamics and facial expression. *bioRxiv*, page 2024.12.18.629202, December 2024

11. Caleb Weinreb, Jonah E Pearl, Sherry Lin, Mohammed Abdal Monium Osman, Libby Zhang, Sidharth Annapragada, Eli Conlin, Red Hoffmann, Sofia Makowska, Winthrop F Gillis, Maya Jay, Shaokai Ye, Alexander Mathis, Mackenzie W Mathis, **Talmo Pereira**, Scott W Linderman, and Sandeep Robert Datta. Keypoint-MoSeq: parsing behavior by linking point tracking to pose dynamics. *Nat. Methods*, 21(7):1329–1339, July 2024

12. Reesha R Patel, Makenzie Patarino, Kelly Kim, Rachelle Pamintuan, Felix H Taschbach, Hao Li, Christopher R Lee, Aniek van Hoek, Rogelio Castro, Christian Cazares, Raymundo L Miranda, Caroline Jia, Jeremy Delahanty, Kanha Batra, Laurel R Keyes, Avraham Libster, Romy Wichmann, **Talmo D Pereira**, Marcus K Benna, and Kay M Tye. Social isolation recruits amygdala-cortical circuitry to escalate alcohol drinking. *Res. Sq.*, pages rs.3.rs–4033115, March 2024 (Accepted at *Nature Neuroscience*.)

13. Liezl Maree, Shayan Afshar, Stefan Oline, Eric J Leonardis, Annegret L Falkner, and **Talmo D Pereira**. Multi-view triangulation-enabled annotation for multi-animal 3d pose in sleap. In *Measuring Behavior 2024*, 2024

14. Elizabeth M Berrigan, Lin Wang, Hannah Carrillo, Kimberly Echegoyen, Mikayla Kappes, Jorge Torres, Angel Ai-Perreira, Erica McCoy, Emily Shane, Charles D Copeland, Lauren Ragel, Charidimos Georgousakis, Sanghwa Lee, Dawn Reynolds, Avery Talgo, Juan Gonzalez, Ling Zhang, Ashish B Rajurkar, Michel Ruiz, Erin Daniels, Liezl Maree, Shree Pariyar, Wolfgang Busch*, and **Talmo D Pereira***. Fast and efficient root phenotyping via pose estimation. *Plant Phenomics*, 6:0175, April 2024

15. Kevin Luxem, Jennifer J Sun, Sean P Bradley, Keerthi Krishnan, Eric Yttri, Jan Zimmermann, **Talmo D Pereira***, and Mark Laubach*. Open-source tools for behavioral video analysis: Setup, methods, and best practices. *Elife*, 12, March 2023

16. Fergil Mills, Christopher R Lee, James R Howe, Hao Li, Shan Shao, Maria N Keisler, Mackenzie E Lemieux, Felix H Taschbach, Laurel R Keyes, Matilde Borio, Hannah S Chen, Reesha R Patel, Alexa L Gross, Jeremy Delahanty, Christian Cazares, Liezl Maree, Romy Wichmann, **Talmo D Pereira**, Marcus K Benna, Cory M Root, and Kay M Tye. Amygdalostriatal transition zone neurons encode sustained valence to direct conditioned behaviors. *bioRxiv*, page 2022.10.28.514263, October 2022. (Under consideration at *Science*.)

17. Aaditya Prasad, Uri Manor, and **Talmo Pereira**. Exploring the role of image domain in self-supervised DNN models of rodent brains. In *SVRHM 2022 Workshop @ NeurIPS*, October 2022

18. **Talmo D. Pereira**, Nathaniel Tabris, Arie Matsliah, David M Turner, Junyu Li, Shruthi Ravindranath, Eleni S Papadoyannis, Edna Normand, David S Deutsch, Z. Yan Wang, Grace C McKenzie-Smith, Catalin C Mitelut, Marielisa Diez Castro, John D'Uva, Mikhail Kislin, Dan H Sanes, Sarah D Kocher, Samuel S-H, Annegret L Falkner, Joshua W Shaevitz, and Mala Murthy. Sleap: A deep learning system for multi-animal pose tracking. *Nature Methods*, 19(4), 2022

19. Philippe Bourrianne, Stanley Chidzik, J Cohen, Peter Elmer, Thomas Hallowell, Todd J Kilbaugh, David Lange, Andrew M Leifer, Daniel R Marlow, Peter D Meyers, Edna Normand, Janine Nunes, Myungchul Oh, Lyman Page, **Talmo Pereira**, Jim Pivarski, Henry Schreiner, Howard A Stone, David W Tank, Stephan Thiberge, and Christopher Tully. Inexpensive multipatient respiratory monitoring system for helmet ventilation during COVID-19 pandemic. *J. Med. Device.*, 16(1):011003, February 2022

20. Z Yan Wang, Grace C McKenzie-Smith, Weijie Liu, Hyo Jin Cho, **Talmo Pereira**, Zahra Dhanerawala, Joshua W Shaevitz, and Sarah D Kocher. Isolation disrupts social interactions and destabilizes brain development in bumblebees. *Curr. Biol.*, May 2022

21. Gabriella EC Gall, **Talmo D. Pereira**, Alex Jordan, and Yasmine Meroz. Fast estimation of plant growth dynamics using deep neural networks. *Plant Methods*, 18(1):1–11, 2022

22. **Talmo D. Pereira**, Joshua W Shaevitz, and Mala Murthy. Quantifying behavior to understand the brain. *Nature Neuroscience*, pages 1–13, November 2020

23. Jessica M Jones, William Foster, Colin R Twomey, Justin Burdge, Osama M Ahmed, **Talmo D. Pereira**, Jessica A Wojick, Gregory Corder, Joshua B Plotkin, and Ishmail Abdus-Saboor. A machine-vision approach for automated pain measurement at millisecond timescales. *Elife*, 9, August 2020

24. Adam S Charles, Benjamin Falk, Nicholas Turner, **Talmo D. Pereira**, Daniel Tward, Benjamin D Pedigo, Jaewon Chung, Randal Burns, Satrajit S Ghosh, Justus M Kebschull, et al. Toward community-driven big open brain science: Open big data and tools for structure, function, and genetics. *Annual Review of Neuroscience*, 43, 2020

25. David Deutsch, Diego Pacheco, Lucas Encarnacion-Rivera, **Talmo D. Pereira**, Ramie Fathy, Jan Clemens, Cyrille Girardin, Adam Calhoun, Elise Ireland, Austin Burke, Sven Dorkenwald, Claire McKellar, Thomas Macrina, Ran Lu, Kisuk Lee, Nico Kemnitz, Dodham Ih, Manuel Castro, Akhilesh Halageri, Chris Jordan, William Silversmith, Jingpeng Wu, H Sebastian Seung, and Mala Murthy. The neural basis for a persistent internal state in drosophila females. *Elife*, 9, November 2020

26. **Talmo D. Pereira***, Diego E Aldarondo*, Lindsay Willmore, Mikhail Kislin, Samuel S-H Wang, Mala Murthy, and Joshua W Shaevitz. Fast animal pose estimation using deep neural networks. *Nature Methods*, 16(1):117, 2019

27. Aleksandra Badura, Jessica L Verpeut, Julia M Metzger, **Talmo D. Pereira**, Thomas J Pisano, Ben Deverett, Dariya E Bakshinskaya, and Samuel SH Wang. Normal cognitive and social development require posterior cerebellar activity. *eLife*, 7:e36401, 2018

28. Jan Clemens, Philip Coen, Frederic A Roemschied, **Talmo D. Pereira**, David Mazumder, Diego E Aldarondo, Diego A Pacheco, and Mala Murthy. Discovery of a new song mode in drosophila reveals hidden structure in the sensory and neural drivers of behavior. *Current Biology*, 28(15):2400–2412, 2018

29. Gecia Bravo Hermsdorff, **Talmo D. Pereira**, and Yael Niv. Quantifying humans' priors over graphical representations of tasks. In *International Conference on Complex Systems*, pages 281–290. Springer, 2018

30. A Giovannucci, EA Pnevmatikakis, B Deverett, **Talmo D. Pereira**, J Fondriest, MJ Brady, SS-H Wang, W Abbas, P Parés, and D Masip. Automated gesture tracking in head-fixed mice. *Journal of Neuroscience Methods*, 300:184–195, 2018

31. **Pereira, Talmo D** and Mala Murthy. To fight or not to fight. *Neuron*, 95(5):986–988, 2017

32. Andrea Giovannucci, Aleksandra Badura, Ben Deverett, Farzaneh Najafi, **Talmo D. Pereira**, Zhenyu Gao, Ilker Ozden, Alexander D Kloth, Eftychios Pnevmatikakis, Liam Paninski, et al. Cerebellar granule cells acquire a widespread predictive feedback signal during motor learning. *Nature Neuroscience*, 20(5):727, 2017

33. Elizabeth T Hobbs*, **Talmo D. Pereira***, Patrick K O'Neill, and Ivan Erill. A bayesian inference method for the analysis of transcriptional regulatory networks in metagenomic data. *Algorithms for Molecular Biology*, 11(1):19, 2016

FUNDING

Heyman Catalyst Collaboration Fund, Total costs: $750,000 2026 – 2029
Deconstructing and designing efficient adaptive learning agents through NeuroAI
Shared with Eiman Azim.

Bezos Earth Fund, Total costs: $18,000,000 2026 – 2029
ROOTS: AI-Driven Scalable Soil Carbon Storage and Plant Resilience
MPI. $3,800,000 to Pereira

NIH BRAIN Initiative U01 (U01DA063581), Total costs: $5,340,988 2026 – 2031
Computational Analyses of Family Auditory Communication: Linking Behavior, Vocalization, and Neural Dynamics
MPI. $807,500 to Pereira

Foresight Institute Neurotechnology for Safe AI Grant, Total costs: $100,000 2025 – 2026
Interpretable NeuroAI for Motor Control: Massively Parallel Imitation Learning of Musculoskeletal Dynamics
Sole PI.

NIH BRAIN Initiative U01 (U01NS136507), Total costs: $7,706,416 2024 – 2027
Understanding Sensorimotor Control Through Realistic Neuro-Biomechanical Simulation
MPI. $1,938,000 to Pereira

L.I.F.E. Foundation, Total costs: $100,000 2023 – 2025
VirtualNeuroLab: Building virtual brains from animal behavior using deep learning
Sole PI.

NASA HERO Human Research Program Omnibus, Total costs: $150,000 2023 – 2024
Automated deep learning for spaceflight rodent behavior quantification and health phenotyping
Sole PI.

NIH BRAIN Initiative R01 (RF1MH132653), Total costs: $2,623,223 2023 – 2026
cloudSLEAP: Maximizing accessibility to deep learning-based motion capture
Sole PI.

Salk Innovation Award, Total costs: $195,000 2023 – 2024
Building virtual brains from animal behavior using deep learning
Shared with Eiman Azim.

Project ALS, Total costs: $296,100 2023 – 2025
Detecting prodromal behavioral biomarkers of ALS using deep learning
Shared with Eiman Azim.

Salk Collaboration Award, Total costs: $225,000 2023 – 2024
AI-based behavioral phenotyping and nutritional control of pancreatic cancer outcomes
Shared with Christian Metallo and Danielle Engle. $75,000 to Pereira.

NSF Award (#2217975), Total costs: $530,819 2022 – 2025
Collaborative Research: Perception, Behavior and Learning in the Museum
Shared with Tom Albright and Sergei Gepshtein. ∼$100,000 to Pereira (Co-Investigator).

Salk Fellow Startup, Discretionary: $900,000, Equipment & Resources: $1,023,000 2021 –

AWARDS

Google Cloud Research Innovator 2023

Society for Social Neuroscience Open Science Award 2022
Award in recognition of promoting open science practices in social neuroscience via our work on SLEAP.

Harold M. Weintraub Graduate Student Award 2022
Prestigious annual award presented by the Fred Hutchinson Cancer Research Center in recognition of outstanding achievement in graduate studies in biological sciences.

Porter Ogden Jacobus Fellowship 2019
Top honor for PhD students at Princeton University.

Princeton Intellectual Property Accelerator Fund 2019
Awarded $100,000 to develop AI framework for animal pose estimation.

Princeton University President's Prize 2015
Awarded honorific fellowship on admission to graduate program.

NSF Graduate Research Fellowship Program 2015
Awarded honorific fellowship on admission to graduate program.

The Barry Goldwater Scholarship and Excellence in Education Program 2014
Received an **Honorable Mention** from a pool of 1,166 nationwide nominees.

MARC Undergraduate Student Training in Academic Research 2013
The MARC U-STAR scholarship is an award funded by the NIH in an effort to support undergraduates in pursuing experiences and a career in research. Provides a research stipend, full academic scholarship, funding for lab expenses and travel.

UMBC Undergraduate Research Award 2012
Research grant awarded to undergraduates pursuing research on campus.

Howard Hughes Medical Institute Scholar 2012
Highly selective HHMI-sponsored program aiming to increase diversity in the biomedical sciences. Supports students with a research stipend, pre-professional advising and funding for summer research.

Meyerhoff Scholar 2011
Selective scholarship program at UMBC supporting underrepresented minorities pursuing a career in research in the STEM fields.

Broad Prize Scholar 2011

Broad Prize scholarships are awarded to graduating seniors who have a demonstrated record of improving their grades over the course of their high school career and have a financial need by the Eli and Edythe Broad Foundation. One of thirteen awardees in Montgomery County, MD.

SERVICE

Peer Review

Nature, *Cell*, *Nature Methods*, *Nature Biotechnology*, *Nature Neuroscience*, *Science Advances*, *Nature Communications*, *Cosyne*, *PNAS*, *eLife*, *Neuroinformatics*, *Scientific Reports*, *Neuron*, *Current Opinion in Neurobiology*, *International Journal of Computer Vision*, *Neurons, Behavior, Data analysis, and Theory*, *New Phytologist*

Editorial Board

Neuropsychopharmacology–Digital Psychiatry and Neuroscience 2023–

Study Section

NIH: Shared Instrumentations: NMR/X-ray/Computational Server/EM (S10) 2024, 2025

NIH: Neurobiology of Motivated Behavior 2023

Committees

Cosyne Program Committee 2023–

Core & Infrastructure Committee, Salk Institute 2023–

Structural Biology Faculty Search Committee, Salk Institute 2023

Salk Fellow Search Committee, Salk Institute 2023

Faculty Advisor, Biocomputation Initiative, Salk Institute 2022–

DEIB

Salk Heithoff-Brody Scholars Program, Salk Institute, Host PI 2022, 2023, 2024, 2025

- Hosted high school student interns from diverse backgrounds as part of Salk's Heithoff-Brody Scholars program.

Salk SURF Program, Salk Institute, Host PI 2023, 2024, 2025

- Hosted undergraduate student interns from diverse backgrounds as part of Salk's Summer Undergraduate Research Fellowship (SURF) program. - Advocated for funding and administrative support to expand the program (through JEDI).

DISCOVER Symposium, Salk Institute, Faculty Participant 2024, 2025

- Participated in inaugural Salk DISCOVER Symposium, aimed at identifying outstanding graduate students from diverse backgrounds who are candidates for recruitment to Salk labs. - Reviewed applications, gave talk, served on career panel, hosted mentee, facilitated social events.

Rising Stars Symposium, Salk Institute, Co-organizer 2024, 2025

- Co-organizer for inaugural Salk Rising Stars Symposium, aimed at identifying outstanding postdocs who have also made significant contributions to DEI. - Reviewed applications, gave talk, hosted mentee, facilitated social events.

Council on Diversity, Salk Institute, Chair 2023–2025

- Community council on institutional diversity, equity, inclusion and belonging, with representation from faculty, students, staff and administration.
- Deputized by the Salk President to lead efforts to transition the council from an advisory role to implementation.
- Coordinate with faculty, trainees, staff, administration, affinity groups and external resources to implement DEIB programming and policy.

Meyerhoff Scholar Program, UMBC, Recruitment 2023

Worked with director of Meyerhoff Scholars Program at UMBC to set up a self-funded campus visit to recruit URMs for Salk's SURF program.

Advisory Council on Diversity, Salk Institute, Chair 2022–2023

- Community council on institutional diversity, equity, inclusion and belonging, with representation from faculty, students, staff and administration.
- Oversaw refactoring of group structure with formal processes for raising, discussing and advising on community-initiated proposals and matters of concern.
- Hosted community social events.
- Set agenda and coordinated monthly discussion and advisory meetings.

Nurturing Equity in STem (NEST), Solving for Science, Participant 2023

Completed an anti-racist course aimed at educating academic faculty about the history, modern incarnations and strategies for preventing scientific racism.

Plan to Enhance Diversity, Salk Cancer Center, Member 2023

Member of committee designated to plan for diversity initiatives as part of the Salk Cancer Center.

Broad Institute Summer Research Program, Panelist 2023

Invited panelist to discuss the impact of Broad Institute's summer research program on my trajectory in science. Networked with students and alumni.

STARTneuro, UCSD, Seminar & Discussion 2023

Presented "my life in science" talk to community college transfer students to promote interest and engagement in research.

San Diego Pride Festival, Volunteer 2023

Volunteered at booth to represent and recruit for Salk.

Colors of the Brain, UCSD, Workshop 2023

Led tutorial on the use of AI-based methods for behavioral analysis for undergraduate research interns for summer program designed to recruit URMs in science.

Iniciativa Próxima, Yale, Application Review 2023

Reviewed applications for mentorship program at Yale targeted at unprivileged students in Brazil.

Fellows & Faculty Mentorship Training, Salk, Participant 2022

Completed course based on curriculum from the Center for the Improvement of Mentored Experiences in Research (CIMER).

Advisory Council on Diversity, Salk Institute, Member 2022–2023

- Community council on institutional diversity, equity and inclusion, with representation from faculty, students, staff and administration.
- Worked on initiative to successfully recruit a Director of Diversity Strategy.
- Worked on initiative to revamp and open Salk's undergraduate summer research program to all institutions, targeting HBCUs, MSIs and community colleges.

Princeton Neuroscience Institute Graduate Program, Recruitment 2016–2021

Served on panels, gave talks, organized and hosted lab tours, provided 1-on-1 mentorship before the application and interview to prospective students applying to the Neuroscience PhD program.

SACNAS, Recruitment 2018

Recruited URMs at the Society for the Advancement of Chicanos/Hispanics and Native Americans in Science Conference with the Princeton Diversity and Inclusion team.

Princeton Diversity Hosting Weekend, Volunteer 2018

Hosted accepted URM graduate students, guided tours and served on panel.

ABRCMS, Recruitment 2016

Recruited URMs at the Annual Biomedical Research Conference for Minority Students with the Princeton Diversity and Inclusion team.

SUPERVISION

Postdoc/Staff Scientist: 2
Software Engineer: 7
Research Assistant: ‘10
PhD: 2
MS: 4
Undergraduate: 26
High School: 5
Alumni placement: MIT Brain and Cognitive Sciences PhD, Princeton Neuroscience PhD (x2), Harvard Computer Science PhD, NYU Bioengineering PhD, UCSD Data Science MS, Harvard Computer Science MS, Mt. Sinai School of Medicine MD, E11 Bio, AWS

TEACHING

CAJAL: Quantitative Approaches to Behaviour Course, Instructor 2026
Invited lecture and tutorial.

Jackson Labs: Machine Learning for Quantification of Behavior Course, Instructor 2025
Invited lecture and tutorial.

Salk EDGE Summer School, Instructor 2025
Taught 2 week module on computational neuroscience.

Zagreb Summer School NeuroData Program, Instructor 2025

CAJAL: Interacting with Neural Circuits, Instructor 2025
Invited lecture and tutorial.

UCSD (NEUG 221): Computational neuroethology, Instructor 2025
Designed and taught a graduate course in the fundamentals, methods and latest advances in computational neuroethology. More info on course website.

Jackson Labs: Machine Learning for Quantification of Behavior Course, Instructor 2024
Invited lecture and tutorial.

Zagreb Summer School NeuroData Program, Instructor 2024

Salk EDGE Summer School, Instructor 2024
Taught 2 week module on computational neuroscience.

CAJAL: Quantitative Approaches to Behaviour Course, Instructor 2024
Invited lecture and tutorial.

Computational and Systems Neuroscience (Cosyne): Main Tutorial, Instructor 2024
Invited to give main tutorial at the Computational and Systems Neuroscience conference. Will give a 4 hour workshop to over 300 attendees on deep learning-based pose tracking using SLEAP.

Jackson Labs: Machine Learning for Quantification of Behavior Course, Instructor 2023
Gave invited lecture and 2 hour tutorial.

CAJAL: Quantitative Approaches to Behaviour Course, Instructor 2022

Gave invited lecture and tutorial.

Jackson Labs: Machine Learning for Quantification of Behavior Course, Instructor 2022
Gave invited lecture and 2 hour tutorial.

UCSD (DSC 180AB): Imitating Behavior to Model the Brain, Instructor 2022
Designed and taught an undergraduate senior capstone course in data science at UCSD. Covered topics in deep reinforcement learning, computational ethology, and neuro-AI.

Princeton (Summer): Intro to Scientific Programming, Instructor 2017, 2018
Designed and taught an undergraduate summer course in computational methods in neuroscience at Princeton University.

Princeton (NEU457): Measurement and Analysis of Neural Circuit Dynamics, Teaching Assistant 2017
Professors: David Tank and Andrew Leifer
Designed problem sets, lectured and graded senior undergraduate and graduate level methods course in computational analysis of neural data at Princeton University.

Princeton (NEU201): Fundamentals of Neuroscience, Teaching Assistant 2016
Professor: Ilana Witten
Led discussion/recitation sections and graded exams and problem sets for introductory undergraduate neuroscience course at Princeton University.

MIT (Winter IAP): Intro to Computer Programming for Biologists, Instructor 2014
Designed and taught a graduate-level winter course in computational methods in biology at MIT.

UMBC (BIOL141): Introductory Biology, Teaching Assistant 2013
Professor: Phillip Sokolove
Served as undergraduate teaching assistant for discussion component of the introductory Biology class. Held weekly graded sessions for a class of 34 students.

UMBC (BIOL141): Introductory Biology, Supplemental Instruction Leader 2013
Professor: Phillip Sokolove
Held two weekly sessions of guided study for the introductory Biology class promoting collaborative learning in contrast to passive lecture-based instruction.

PRESENTATIONS

USC-Chen Institute Frontier Forum, Invited Speaker 2026

Janelia Research Campus, Invited Talk 2026
Simulated Bodies Symposium

Children's Hospital of Pennsylvania, Invited Seminar 2026

Computational and Systems Neuroscience (Cosyne), Invited Talk & Panelist 2026
Workshop: Circuits, Dynamics and Computations in Social Behavior

Adler Symposium, Invited Talk 2026

UC Riverside, Invited Departmental Seminar 2025

Project ALS Annual Symposium, Invited Speaker 2025

Foresight Neurotech Workshop, Invited Speaker 2025

US Research Software Engineer Annual Meeting, Speaker 2025

National Institutes of Mental Health, Invited Keynote Speaker 2025
NIMH Fellows Scientific Training Day

Computational Neuroethology Tetons Meeting, Invited Speaker 2025

University of Perugia Symposium, Invited Speaker 2025
Workshop: Demystifying mosquito sex: unraveling mosquito swarms with lab-based 3D video tracking

University of Edinburgh, Invited Seminar 2025
Centre for Discovery Brain Sciences

University College London, Invited Departmental Seminar 2025
Cell and Developmental Biology Department

USC-Chen Institute Frontier Forum, Invited Speaker 2025

Computational and Systems Neuroscience (Cosyne), Invited Talk & Panelist 2025
Workshop: Agent-based models in Neuroscience: Complex Planning, Embodiment, and Beyond

Computational and Systems Neuroscience (Cosyne), Invited Talk & Panelist 2025
Workshop: What makes us unique: Deconstructing the sources of individual differences

BrainMind Science Collective, Invited Speaker 2025

Salk Harnessing Plants Initiative Scientific Advisory Board Meeting, Speaker 2025

NASA Human Research Program Investigator's Workshop, Speaker 2025

Project ALS Annual Symposium, Invited Seminar 2024

University of Washington, Invited Departmental Seminar 2024
Department of Neurobiology & Biophysics

University of Utah, Invited Departmental Seminar 2024
Neurobiology Department

Neuroscience PhD Program, New York University-Langone, Invited Seminar/Workshop 2024

BRAIN Initiative Annual Meeting, Symposium Chair 2024
BRAIN Informatics in the AI Era

Gordon Research Conference, Invited Talk 2024
GRC: Neural Mechanisms of Acoustic Communication
GRS: Diversity in Animal Communication: Mechanisms, Behavior, and Ecology

Neuroscience Program, University of Illinois, Invited Departmental Seminar 2024

Computational and Systems Neuroscience (Cosyne), Invited Seminar/Tutorial 2024
Main Tutorial slot.

Winter Brain, Invited Talk 2024
Short course: Machine Learning methods to study animal behavior

Society for Neuroscience Annual Meeting, Social Chair 2023
Social: Open Science

Animal Behaviour Live Online Conference, Invited Talk 2023

COST-TEATIME, Invited Talk 2023

Computational Neuroethology Meeting, Invited Talk 2023

Janelia Research Campus, Invited Talk 2023
Simulated Bodies Symposium

STARTneuro Seminar, UCSD, Invited Talk 2023

Forum for the Future of Neuroscience, Invited Talk 2023

NeurodataWithoutBorders User Day Symposium, Invited Talk 2023

Colors of the Brain, UCSD, Invited Tutorial 2023

Deep Learning for Biology Seminar Series, UCSD, Invited Talk 2023

Society of Biological Psychiatry, Invited Talk 2023

Scripps Research, Invited Departmental Seminar 2023

Computational and Systems Neuroscience (Cosyne), Invited Talk 2023
Workshop: A wrinkle in time: Neuroscience at multiple timescales

NASA Horizons in Biosciences and Informatics Seminar Series, Invited Talk 2023

Annual NIH KOMP2-IMPC Meeting, Invited Talk 2022

Society for Neuroscience Annual Meeting, Minisymposium Chair 2022
Minisymposium: Advances in Behavioral Quantification to Understand the Brain

Society for Neuroscience Annual Meeting, Invited Talk 2022
Society for Social Neuroscience Open Science Prize Seminar

Center for Brain Science, Harvard University, Invited Talk 2022

NVIDIA GPU Technology Conference (GTC), Invited Talk 2022

Center for the Physics of Biological Function, CUNY, Invited Talk 2022
Symposium: Physics of Behavior

Mt. Sinai School of Medicine, Invited Departmental Seminar 2022

Center for Theoretical Neuroscience, Columbia University, Invited Talk 2022

Center for Computational Neuroscience, Flatiron Institute, Invited Talk 2022

4th International Mobile Brain/Body Interaction Conference (MoBI), Invited Talk 2022

Marmoset PI Meeting, Session Chair 2022

BRAIN Initiative BBQS Workshop, Breakout Chair 2022
Organismal Comparative Research Breakout Group, Brain Behavior Quantification and Synchronization (BBQS) Workshop

University of Oregon, Invited Departmental Seminar 2022

Society for Integrative and Comparative Biology (SICB) Meeting, Invited Talk 2022

NIDA-NIAAA Frontiers in Addiction Research Symposium, Invited Talk 2021

SymPOSEium, University of Minnesota, Invited Talk 2021

Computational Neuroethology Meeting, Invited Talk 2021

Computational Tutorial, Brain & Cognitive Sciences, MIT, Invited Talk 2020

American Physical Society March Meeting, Symposium Talk 2020

Computational and Systems Neuroscience (Cosyne), Poster 2020

Janelia Research Campus, Talk 2019
Junior Scientist Workshop on Machine Learning and Computer Vision

Computational and Systems Neuroscience (Cosyne), Poster 2019

Annual BRAIN Initiative Investigators Meeting, Poster 2019

Society for Neuroscience Conference, Poster 2018

Princeton Neuroscience Institute Departmental Retreat, Talk 2018

Princeton Bioengineering Colloquium, Invited Talk 2017

Computational and Systems Neuroscience (Cosyne), Workshop Organizer 2017
Workshop: Automated Tools for High Dimensional Neuro-Behavioral Analysis

Janelia Research Campus, Poster 2016
Action Selection Across the Animal Kingdom Conference

Society for Neuroscience Conference, Poster 2016