INDIE GARWOOD

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EDUCATION

Doctor of Philosophy | Health Sciences and Technology (HST) — Sept. 2017 – June 2023
Massachusetts Institute of Technology and Harvard Medical School — Cambridge, MA

- Medical Engineering and Medical Physics (MEMP)
- Thesis: Probing the depths of unconsciousness with multifunctional neurotechnology
- Concentration Area: Brain and Cognitive Sciences
- NIH T32 Neurobiological Engineering Trainee
- HST Introduction to Clinical Medicine: 12-week clinical clerkship based at Mount Auburn Hospital
- GPA: 5.0/5.0

Bachelor of Science in Engineering | Biomedical Engineering — Sept. 2013 – Apr. 2017
University of Michigan – Ann Arbor — Ann Arbor, MI

- Concentration Area: Biochemical Engineering
- GPA: 4.0/4.0

RESEARCH EXPERIENCE

Perelman School of Medicine – Neurosurgery — May 2024 – Current
Postdoctoral Researcher | Provost's Fellow — Philadelphia, PA
University of Pennsylvania | Advisor: Bijan Pesaran

- Studying multiregional neural communication in the context of coordinated visual-motor behavior.
- Implementing high-density electrophysiology and multiregional calcium imaging in non-human primates

Neuroscience Statistics Research Lab & Bioelectronics Group — Aug. 2017 – Apr. 2024
Postdoctoral Associate | The Picower Institute for Learning and Memory — Cambridge, MA
Massachusetts Institute of Technology | Advisors: Emery Brown, Polina Anikeeva, and Earl Miller

- Developed multifunctional neurotechnology to investigate mechanisms of cognition and consciousness, with a focus on the cortical mechanisms of ketamine anesthesia.
- Translated fiber-based neural probes from rodents to non-human primates; designed and fabricated multifunctional devices that integrate with commercial setups and withstand rigorous sterilization protocols.
- Designed and lead experiments to investigate the role of elevated cortical acetylcholine during ketamine anesthesia in non-human primates; measured electrophysiology, oximetry, and behavior during the induction of and recovery from ketamine anesthesia.
- Derived and implemented statistical methods to characterize neural dynamics during ketamine anesthesia from non-human primate cortical local field potentials and human electroencephalography; extended these methods to account for multimodal and multisite electrophysiology recordings.
- Refined methods to quantify cortical dynamics and cognitive neural activity during neuromodulation experiments using electrophysiology recordings and state-space models.
- Implanted chronic fiber-based probes in mice for validation of optogenetic transfection of cortical interneurons; performed mouse photopharmacology experiments.

Peripheral Neural Engineering and Urodynamics Lab — May 2015 – July 2017
University of Michigan – Ann Arbor | Advisor: Tim Bruns — Ann Arbor, MI

International Program for the Advancement of Neurotechnology — June – July 2016
Center for Molecular Neurobiology | Advisor: Ileana Hanganu-Opatz — Hamburg, Germany

Foerster Lab — Sept. 2013 – May 2016
University of Michigan – Ann Arbor | Advisor: Bradley Foerster — Ann Arbor, MI

SKILLS

***In vivo* techniques**: Sterile technique; in NHPs: acute electrophysiology (single unit recordings, LFP, laminar recordings), intracranial infusions, anesthesia monitoring; in mice: craniotomies, chronic device implantation, intracranial infusions, electrophysiology, drug administration

Data science and statistics: State-space models, generalized linear models, Kalman filters, multitaper spectral analysis, principal component analysis, goodness of fit assessment, cross-validation

Device fabrication and validation: Machining (mill, lathe), thermal drawing, microfabrication, microfluidic characterization, electrochemical impedance spectroscopy, microscopy

Programming: MATLAB, Python (NumPy, SciPy, Matplotlib, Pandas), github

FELLOWSHIPS

Provost's Postdoctoral Fellowship | University of Pennsylvania 2024

MathWorks Fellowship | MIT School of Engineering 2021-2022, 2022-2023

Graduate Student Research Fellowship | National Science Foundation 2017-2022

Neurobiological Engineering Training Program | MIT, NIH 5T32EB019940-07 2019-2020

Engineering Honors Scholarship | University of Michigan – Ann Arbor 2013-2017

AWARDS

Society for Neuroscience Trainee Professional Development Award 2022

James B. Angell Scholar | University of Michigan – Ann Arbor 2015-2016
Awarded for 8 consecutive semesters of 4.0 GPA

William J. Branstrom Freshman Prize | University of Michigan – Ann Arbor 2014
Awarded to top 5% of freshman class

PUBLICATIONS

Garwood, I.C., Major, A.J., Antonini,M.-J., Correa, J., Lee, Y., Sahasrabudhe, A, Mahnke, M.K., Miller, E.K.*, Brown, E.N.*, Anikeeva, P.* (2023). Multifunctional fibers enable modulation of cortical and deep brain activity during cognitive behavior in macaques. *Science Advances*. doi:10.1126/sciadv.adh0974
(* – equal contributions)

Garwood, I.C.*, Chakravarty, S.*, Donoghue, J.A., Mahnke, M.K., Kahali, P., Chamadia, S., ... Brown, E.N. (2021). A hidden Markov model reliably characterizes ketamine-induced spectral dynamics in macaque local field potentials and human electroencephalograms. *PLoS computational biology*. doi:10.1371/journal.pcbi.1009280

Rice, I.C., Zimmerman, L.L., Ross S.E., Berger, M.B., Bruns, T.M. (2017). Time-Frequency Analysis of Increases in Vaginal Blood Perfusion Elicited by Long-Duration Pudendal Neuromodulation in Anesthetized Rats. *Neuromodulation*, 20(8), 807-815. doi:10.1111/ner.12707

Chakravarty, S.*, Donoghue, J.A.*, Waite, A.S., Mahnke, M.K., **Garwood, I.C.**, Gallo, S., Miller, E.K.*, Brown, E.N.* (2023). Closed-loop control of anesthetic state in non-human primates. *PNAS Nexus*. doi:10.1093/pnasnexus/pgad293

Sahasrabudhe, A.*, Rupprecht, L.E.*, Orguc, S.*, Khudiyev, T.*, Tanaka, T., Sands, J., Zhu, W., Tabet, A., Manthey, M., Allen, H., Loke, G., Antonini, M.J., Rosenfeld, D., Park, J., **Garwood, I.C.**, ... Anikeeva, P. (2023). Multifunctional microelectronic fibers enable wireless modulation of gut and brain neural circuits. *Nature Biotechnology*. doi:10.1038/s41587-023-01833-5

Lee, Y., Koehler, F., Dillon, T., Loke, G., Kim, Y., Marion, J., Antonini, M.J., **Garwood, I.C.**, ... Anikeeva, P. (2023). Magnetically actuated fiber-based soft robots. *Advanced Materials*. doi:10.1002/adma.202301916

Cajigas, I., Davis, K.C., Meschede-Krasa, B., Prins, N.W., Gallo, S., Naeem, J.A., Palermo, A., Wilson, A., Guerra, S., Parks, B.A., Zimmerman, L., Gant, K., Levi, A.D., Dietrich, W.D., Fisher, L., Vanni, S., Tauber, J.M., **Garwood, I.C.**, ... Jagid, J. (2021). Implantable brain–computer interface for neuroprosthetic-enabled volitional hand grasp restoration in spinal cord injury. *Brain Communications*. doi:10.1093/braincomms/fcac143

Antonini, M. J.*, Sahasrabudhe, A., Tabet, A., Schwalm, M., Rosenfeld, D., **Garwood, I.C.**, ... Anikeeva, P. (2021). Customizing MRI-Compatible Multifunctional Neural Interfaces through Fiber Drawing. *Advanced Functional Materials*. doi:10.1002/adfm.202104857

Abel, J.H.*, Badgeley, M.A.*, Meschede-Krasa, B., Schamberg, G., **Garwood, I.C.**, Lecamwasam, K., ... Brown, E.N. (2021). Machine learning of EEG spectra classifies unconsciousness during GABAergic anesthesia. *PLoS ONE*. doi:10.1371/journal.pone.0246165

Frank, J.A., Antonini, M.J., Chiang, P.H., Canales, A., Konrad, D.B., **Garwood, I.C.**, ... Anikeeva, P. (2020). In vivo photopharmacology enabled by multifunctional fibers. *ACS chemical neuroscience*. doi:10.1021/acschemneuro.0c00577

Zimmerman, L.L., **Rice, I.C.**, Berger, M.B. and Bruns, T.M. (2018). Tibial nerve stimulation to drive genital sexual arousal in an anesthetized female rat. *The journal of sexual medicine*. doi:10.1016/j.jsxm.2018.01.007

Foerster, B.R., Nascimento, T.D., DeBoer, M., Bender, M.A., **Rice, I.C.**, Truong, D.Q., Bikson, M., Clauw, D.J., Zubieta, J.K., Harris, R.E., DaSilva, A.F. (2015). Excitatory and inhibitory brain metabolites as targets and predictors of effective motor cortex tDCS therapy in fibromyalgia. *Arthritis and Rheumatology*. doi:10.1002/art.38945

Manuscripts in Preparation

Garwood, I.C., Ballesteros, J.J., Donoghue, J.A., Mahkne, M.K., Anikeeva, P., Miller, E.K.*, Brown, E.N.* Synchronized gamma bursts induced by high dose ketamine result in altered states of consciousness.

Garwood, I.C.*, Major, A.J.*, Mahkne, M.K., Anikeeva, P.*, Miller, E.K.*, Brown, E.N.* Altered cholinergic signaling during ketamine anesthesia disrupts sensory processing.

Conferences and Presentations

Garwood, I.C., Major, A.J., Ballesteros, J.J., Donoghue, J.A., Mahkne, M.K., Miller, Anikeeva, P., E.K., Brown, E.N. Ketamine anesthesia induces coordinated multiarea gamma bursts and disruption of sensory processing in macaques. Society for Neuroscience 50th Annual Meeting, Washington, DC, November 2023. (Oral presentation)

Garwood, I.C., Major, A.J., Ballesteros, J.J., Donoghue, J.A., Mahkne, M.K., Anikeeva, P., Miller, E.K., Brown, E.N. Probing altered states of consciousness during ketamine anesthesia. Simian Collective, Chicago, IL, September 2023. (Oral presentation)

Garwood, I.C., Ballesteros, J.J., Donoghue, J.A., Mahkne, M.K., Anikeeva, P., Miller, E.K., Brown, E.N. The dynamics of the unconscious brain under ketamine anesthesia. Gordon Research Conference on Consciousness, Anesthesia and Evolutionary Biology, Easton, MA, June 2023. (Poster)

Garwood, I.C., Major, A.J., Mahkne, M.K., Miller, E.K., Brown, E.N., Anikeeva, P. Using multifunctional fibers to investigate the effect of local and systemic neuropharmacology on cognitive encoding. Society for Neuroscience 49th Annual Meeting, San Diego, CA, November 2022. (Poster)

Garwood, I.C., The dynamics of the unconscious brain under ketamine anesthesia. Picower Institute for Learning and Memory's 20th Anniversary Symposium, Cambridge, MA, September 2022. (Oral presentation, Program link)

Garwood, I.C., Major, A.J., Antonini, M.J., Correa, J., Mahkne, M.K., Miller, E.K., Brown, E.N., Anikeeva, P. Multifunctional fiber-based neurotechnology enables cortical recording and modulation in non-human primates. Materials Research Society Spring 2022 Meeting, Honolulu, HI, May 2022. (Poster)

Garwood, I.C., Major, A.J., Antonini, M.J., Correa, J., Mahkne, M.K., Miller, E.K., Brown, E.N., Anikeeva, P. Multifunctional fiber-based neurotechnology enables cortical neuromodulation in non-human primates. Society for Neuroscience 48th Annual Meeting, Virtual, November 2021. (Poster)

Rice I.C., Chakravarty, S., Donoghue, J.A., Kahali, P., Chamadia, S., Akeju, O., ... Brown, E.N., Detecting bursts in electroencephalography and local field potential spectrograms using a hidden Markov model. Society for Neuroscience 48th Annual Meeting, San Diego, CA, November 2018. (Poster)

Rice, I.C., Zimmerman, L.L., Ross, S.E., Berger, M.B., Bruns, T.M., Pudendal nerve stimulation elicits oscillations in vaginal blood flow. Society for Neuroscience 46th Annual Meeting, San Diego, CA, November 2016. (Poster)

Rice, I.C., Ross, S.E., Bruns, T.M. Peripheral nerve stimulation for female sexual dysfunction: slow oscillations in vaginal blood flow. University of Michigan BME Career Fair, Ann Arbor, MI, February 2016. *Awarded Best Overall Poster.* (Poster)

Rice, I.C., Ross, S.E., Bruns, T.M. Peripheral nerve stimulation for female sexual dysfunction: slow oscillations in vaginal blood flow. Biomedical Engineering Society Annual Meeting, Tampa, FL, October 2015. (Poster)

Invited Seminars

Neural interfaces for controlling brain states: From anesthesia to psychiatry — February 2024
Host: Brown University School of Engineering — Providence, RI

Probing the depths of anesthesia with multifunctional neurotechnology — April 2023
Host: Professor Mark Richardson, Massachusetts General Hospital — Boston, MA

Probing cortical and deep brain electrochemical signaling during cognitive behavior — January 2023
Host: Neurosurgery Department, National Institutes of Health — Bethesda, MD

Teaching and Mentoring Experience

Teaching Assistant: 9.07 Statistics for Brain and Cognitive Science — Fall 2023
Massachusetts Institute of Technology — Cambridge, MA

UROP Mentor: Optimization of multifunctional fibers — Spring 2022
Massachusetts Institute of Technology — Cambridge, MA

UROP Mentor: Optogenetic transfection of VIP cells — Spring 2021 – Winter 2022
Massachusetts Institute of Technology — Cambridge, MA

UROP Mentor: Thermal draw tower optimization — Fall 2020 – Fall 2021
Massachusetts Institute of Technology — Cambridge, MA

High School Research Mentor: Using HMMs to study neural oscillations — Spring 2021
Massachusetts Institute of Technology — Cambridge, MA

Teaching Assitant: MATLAB for Medicine — Summer 2018
Harvard Medical School — Boston, MA

Activities and Service

Ad-hoc Reviewer — 2023 – 2024
IOP Trusted Reviewer

IMES Diversity Equity and Inclusion Committee — 2021 – 2023
One of three elected student representatives advocating for increased inclusivity — MIT

Graduate Student Advisory Group for Engineering — 2021 – 2023
Serving on the DEI advisory committee to the Dean of Engineering, Prof. Anantha P. Chandrakasan — MIT

MEMP Application Assistance Program 2021, 2022
Provided one-on-one mentorship for students from underrepresented backgrounds applying to MEMP MIT

Student representative for the IMES Visiting Committee meeting 2022
One of eight students selected by IMES leadership to advocate for student priotrities in IMES MIT

IEEE EMBS International Student Conference 2021
Served as programming chair and moderator for conference with 55 attendees (Conference website) Virtual

Reject Injustice Through Student Empowerment 2020 – 2021
Worked with graduate students across MIT to advocate against racism, sexism, and other discrimination MIT

HST Joint Council Social Chair 2017 – 2018
Planned and organized departmental socials Harvard/MIT

Sexual Assault Prevention and Awareness Center 2015 – 2017
Completed ally training and organized advocacy resources for the College of Engineering UofM