

# Cynthia R. Steinhardt

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## Present

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Postdoctoral Fellow at Zuckerman Mind Brain Behavior Institute working with Prof. Laurence Abbott on understanding how pulsatile electrical stimulation from neural implants and local electric fields drive coherent population-level neural dynamics, using a combination of biophysical and network modeling techniques.

## Education

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### Johns Hopkins University

*Ph.D. Biomedical Engineering*

2016–2022

### Princeton University

*B.A. Neuroscience, Concentration Cognitive Science*

2012–2016

## Ph.D. Thesis

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**Title:** *A Modeling Perspective on Developing Naturalistic Neuroprosthetics Using Electrical Stimulation*

**Advisor:** Professor Gene Y. Fridman

**Description:** Using biophysical and computational modeling of interactions between pulsatile and direct current electrical stimulation and vestibular afferents to characterize the relationship between parameters and induce firing patterns. Leveraging gained understanding of electrical stimulation parameters to create new stimulation algorithm for cochlear implants.

## Awards

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**2021:** Simons Society of Fellows Junior Fellowship

**2020:** Professional Development Innovation Initiative Award, Johns Hopkins University

**2017:** Fellowship in Computational Medicine, Johns Hopkins University

**2016–2021:** National Science Foundation Graduate Research Fellowship (GRFP)

**2015:** Dean's Fellowship, Princeton University

**2014:** Lambert Award for Neuroscience, Princeton University

## Patents

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**Steinhardt, C.R.** and Fridman, G.Y. (2020). Method and System for Processing Input Signals Using Machine Learning for Neural Activation (U.S. Provisional Patent No. 63/150,829). U.S. Patent and Trademark Office. Filed February 18, 2021

## Other Research Experience

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**2023:** Prof. Tamar Flash, Weizmann Institute (Israel): using differential geometry principles to understanding differences in motor control in healthy subjects and Parkinson's patient with and without treatment

**2020–2021:** Dr. Leonid Litvak, Medtronic: finite-element modeling of spinal cord stimulator (SCS) and spinal cord, control system for SCS

**2017–2019:** Dr. Kareem Zaghloul, NIH NINDS: applying linear systems techniques to predict network evoked responses to local biphasic current stimulation from human epilepsy patient ECOG electrodes

**2018:** Prof. Nitish Thakor, Johns Hopkins: designing robust classifier for decoding desired movement from upper-limb EMG and correcting for shifts of electrodes on myoarmband with amputees and healthy subjects

**2015–2016:** Prof. Tim Buschman, Princeton Neuroscience Institute: modeling cochlear/visual encoding and using gradient descent to find optimal stimulation pattern to produce same activation, preliminary testing of algorithm in rodents in vivo: craniotomies, virus injection surgeries, histologies, electrophysiology surgery, building electrodes and 3D-printing

**2014:** Dr. Andrea Benucci, RIKEN Brain Science Institute (Japan): studying functional connectivity of the

## Publications

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- **Steinhardt, C.R.**, D.E. Mitchell, K.E. Cullen and Fridman, G. Y. (2022). Pulsatile electrical stimulation creates predictable, correctable disruptions in neural firing. *Neuron* (*in submission*)
- Adkisson, P., **Steinhardt, C.R.**, and Fridman, G. Y. (2023). Galvanic versus Pulsatile Effects on Decision-Making Networks: Reshaping the Neural Activation Landscape. *Neuron* (*in submission*)
- Adkisson, P., Fridman, G. Y., and **Steinhardt, C.R.** (2022, July). Difference in Network Effects of Pulsatile and Galvanic Stimulation. In 2022 44th Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC) (pp. 3093-3099). IEEE.
- **Steinhardt, C. R.**, and Fridman, G. Y. (2021). A Machine Learning-based Neural Implant Front End for Inducing Naturalistic Firing. In 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society, EMBC 2021 (pp. 5713-5718). Institute of Electrical and Electronics Engineers Inc.
- **Steinhardt, C.R.** and Fridman, G. Y. (2021). Direct current effects on afferent and hair cell to elicit natural firing patterns. *iScience*, 24(3), 102205.
- Tafazoli, S., MacDowell, C. J., Che, Z., Letai, K. C., **Steinhardt, C.R.**, and Buschman, T. J. (2020). Learning to control the brain through adaptive closed-loop patterned stimulation. *Journal of Neural Engineering*, 17(5), 056007.
- **Steinhardt, C.R.**, and Fridman, G. Y. (2020, July). Predicting Response of Spontaneously Firing Afferents to Prosthetic Pulsatile Stimulation. In 2020 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC) (pp. 2929-2933). IEEE.
- Taylor, C., Greene, P., D'Aleo, R., Breault, M. S., **Steinhardt, C.R.**, Gonzalez-Martinez, J., and Sarma, S. V. (2020, July). Correlates of Attention in the Cingulate Cortex During Gambling in Humans. In 2020 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC) (pp. 2548-2551). IEEE.
- **Steinhardt, C.R.**, Sacré, P., Sheehan, T. C., Wittig, J. H., Inati, S. K., Sarma, S., and Zaghoul, K. A. (2020). Characterizing and predicting cortical evoked responses to direct electrical stimulation of the human brain. *Brain Stimulation*, 13(5), 1218-1225.
- **Steinhardt, C.R.**, Sacré, P., Inati, S. K., Sarma, S. V., and Zaghoul, K. A. (2019, July). Investigation of Architectures for Models of Neural Responses to Electrical Brain Stimulation. In 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) (pp. 6892-6895). IEEE.
- **Steinhardt, C.R.**, Betthausen, J., Hunt, C., and Thakor, N. (2018, October). Registration of EMG Electrodes to Reduce Classification Errors due to Electrode Shift. In 2018 IEEE Biomedical Circuits and Systems Conference (BioCAS) (pp. 1-4). IEEE.
- Abouchar, L., Petkova, M. D., **Steinhardt, C.R.**, and Gregor, T. (2014). Fly wing vein patterns have spatial reproducibility of a single cell. *Journal of The Royal Society Interface*, 11 (97), 20140443.

## Selected Invited Talks & Conference Presentations

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- **Steinhardt, C.R.** and Abbott, L.F (2023, July) Investigating the Loss of Tone Discrimination by Cochlear Implant Users Using a Neural Network Model of the Auditory Stream. Collaborative Research in Computational Neuroscience. Tel Aviv, Israel. (Poster)
- **Steinhardt, C.R.** (2023, April) A Network Model for Investigating Processing Differences between Natural and Cochlear Implant Inputs to the Auditory System. Minnesota Neuromodulation Conference. Minneapolis, MN. (Poster)
- **Steinhardt, C.R.** and Fridman G.Y. (2022, Nov) Non-linear responses of neurons to pulsatile stimulation provide evidence of average population firing rate-based encoding schemas in sensory systems. Society for Neuroscience. San Deigo, CA. (Nanosymposium Talk)
- **Steinhardt, C.R.** (2022, October) Developing New Theories of Electrical Stimulation Starting from Neural Implants. Future Leaders in Biomedical Engineering. Rice University Department of Bioengineering, Houston, TX 77005 (Talk)
- **Steinhardt, C.R.** (2022, May) Comparison of the Effects of Pulsatile and Galvanic Stimulation on Vestibular Afferents in silico. XXXI Barany Society Meeting. Madrid, Spain. (Talk)
- **Steinhardt, C.R.** (2021, November) A Machine Learning-based Neural Implant Front End for Induce Naturalistic Firing. 2021 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC) (Virtual Talk)
- **Steinhardt, C.R.** (2021, July). Galvanic Stimulation: A New World of Possibilities for Driving Neural Populations, Invited Talk for Pinotsis Lab, University College London, London WC1E 6BT, UK (Talk)
- **Steinhardt, C.R.** (2021, June). Galvanic Stimulation: A New World of Possibilities for Driving Neural

- Populations, Invited Talk for Churchland Lab, Columbia University, New York, NY 10027 (Talk)
- **Steinhardt, C.R.** (2021, June). Galvanic Stimulation: A New World of Possibilities for Driving Neural Populations, Invited Talk for Miller Lab, MIT, Cambridge, MA 02139 (Talk)
- **Steinhardt, C.R.** (2021, March). Designing a Neural Implant that Writes in Neural Code, Invited Talk for Buschman Lab, Princeton University, Princeton, NJ 08544 (Talk)
- **Steinhardt, C.R.** (2021, February). Designing a Neural Implant that Speaks the Neural Language, Invited Talk for Grill Lab, Duke University, Durham, NC 27708 (Talk)
- **Steinhardt, C.R.** (2020, December). Understanding Differences Between DC and Pulsatile Stimulation Through Vestibular Afferent Studies, Invited Talk for CCNY Neural Engineering group, The City College of New York, New York, NY 10031 (Talk)
- **Steinhardt, C.R.** (2020, September). The Mechanism of Direct Current Stimulation in Vestibular Afferents. Center for Hearing and Balance Seminar, Johns Hopkins University, Baltimore, MD (Talk)
- **Steinhardt, C.R.** (2020, August). Biomedical Engineering: Improving the Cochlear Implant. Neils Bohr Institute, Copenhagen, Denmark (Talk)
- **Steinhardt, C.R.** and Fridman G. Y. (2020, July). Predicting Response of Spontaneously Firing Afferents to Prosthetic Pulsatile Stimulation. 2020 42nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) (Montreal, Canada) (Talk)
- **Steinhardt, C.R.**, Sacré, P., Inati, S. K., Sarma, S. V., and Zaghoul, K. A. (2019, July). Investigation of Architectures for Models of Neural Responses to Electrical Brain Stimulation. University of Copenhagen Health Talk Lecture Series (Talk)
- **Steinhardt, C.R.**, Sacré, P., Inati, S. K., Sarma, S. V., and Zaghoul, K. A. (2019, July). Investigation of Architectures for Models of Neural Responses to Electrical Brain Stimulation. 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) (Berlin, Germany) (Talk)
- **Steinhardt, C.R.**, Betthausen, J., Hunt, C., and Thakor, N. (2018, October). Registration of EMG Electrodes to Reduce Classification Errors due to Electrode Shift. Poster session at the 2018 IEEE Biomedical Circuits and Systems Conference (BioCAS), Cleveland, Ohio. (Poster)
- **Steinhardt, C.R.**, Sheehan, T, Inati, S.K., Zaghoul, K.A. (2017, Nov). Characterizing neural responses to single pulse direct cortical stimulation in the human. Society for Neuroscience. Washington D.C. (Nanosymposium Talk)

## Leadership/Service

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**2022:** Chair of Nanosymposium at Society for Neuroscience: Electrical Stimulation, Magnetogenetics, and Optogenetics

**2020-2022:** Mentoring three master's students in research projects resulting in presentations & publications, JHU

**2020-2021:** Co-founder and President of Translational Neuroengineering Technologies Network, JHU

**2020:** Ad hoc reviewer for *Brain Stimulation*

**2019-2020:** Mentoring under-represented high school and college student in summer research projects that resulted in presentations & publications, JHU

## Teaching

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**Spring 2019:** Foundations of Computational Biology and Bioinformatics, JHU

**Spring 2018:** Systems and Controls, JHU

## Skills & Languages

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MATLAB, Simulink, Python, R, LABVIEW, Adobe Photoshop, Adobe Illustrator & InDesign

biophysical modeling, population network modeling, statistical hypothesis testing, finite-element modeling, supervising and unsupervised machine learning, linear systems theory, theoretical neuroscience, rodent electrophysiology

English (native), French (working), Japanese (working), Italian (basic), Hebrew (basic)