Zachary T. Pennington, PhD

Department of Neuroscience
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Current Position

2023 – present **Instructor, Icahn School of Medicine at Mount Sinai**
Advisor: Dr. Denise Cai

Education & Training

2018 – 2022 **Icahn School of Medicine at Mount Sinai**
Postdoctoral Fellowship, Department of Neuroscience
Advisor: Dr. Denise Cai

2018 **University of California, Los Angeles (UCLA)**
PhD, Behavioral Neuroscience and Quantitative Psychology
Advisor: Dr. Michael Fanselow

2010 **University of California, Los Angeles (UCLA)**
BA, Psychology
Advisor: Dr. J. David Jentsch

2008 **Pasadena City College**
AA, Psychology

Grants & Fellowships

Current Funding:

2023 – 2028 **Pathway to Independence Award, National Institute of Mental Health, K99MH131792 ($999,000)**
"Disentangling the consequences of trauma"

This work demonstrates that stress-induced plasticity within the basolateral amygdala and ventral hippocampus support distinct changes in fear and anxiety-related behaviors. My future lab will utilize projection-specific manipulations of neuronal activity and protein synthesis within these regions, in combination with calcium imaging, to define microcircuits governing stress-induced changes in defensive behavior.

2023 – 2025 **Young Investigator Award, Behavior Brain Research Foundation ($70,000)**

"Contributions of the anterior hypothalamic nucleus to post-trauma stress sensitization"

Utilizing an unbiased brain-wide approach, I have highlighted a critical and previously unknown role of the anterior hypothalamic nucleus (AHN) in regulating stress susceptibility. Future work from my lab hopes to define how targeting AHN neuron subpopulations might be leveraged to treat stress-related mental health disorders.

2024 – 2025 **Postdoc Innovator Award, Friedman Brain Institute, Icahn School of Medicine at Mount Sinai ($25,000)**

"Contributions of GABAergic neurons in the anterior hypothalamic nucleus to defensive behavior"

2023 – 2025 **National Institute of Mental Health, R56MH132959 (Co-Investigator, $783,000)**

"Fear and anxiety circuit mechanisms in anterior hypothalamic nucleus"

Fellowships, Awards and Honors

2024	Travel Award, American College of Neuropsychopharmacology
2024 – 2025	Postdoc Innovator Award, Friedman Brain Institute, Icahn School of Medicine at Mount Sinai
2023 – 2028	Pathway to Independence Award, National Institute of Mental Health
2023 – 2025	Young Investigator Award, Behavior & Brain Research Foundation
2022	McKnight Foundation Doupe Fellow
2022	Outstanding Citizen Award, Nash Family Department of Neuroscience, Icahn School of Medicine at Mount Sinai
2018 – 2019	Postdoctoral Fellow, Ruth L. Kirschstein NRSA Institutional Research Training Grant (Icahn School of Medicine at Mount Sinai), National Institute of Drug Abuse
2017 – 2018	Dissertation Year Fellowship, University of California, Los Angeles
2017	Teaching Practicum Program Fellow, University of California, Los Angeles
2016	Teaching Practicum Program Fellow, University of California, Los Angeles
2015 – 2017	Ruth L. Kirschstein Predoctoral Individual National Research Service Award, National Institute of Mental Health (F31)
2015	Society for Neuroscience Travel Award, UCLA Brain Research Institute
2012 – 2014	Predoctoral Fellow, Ruth L Kirschstein NRSA Institutional Research Training Grant (University of California, Los Angeles), National Institute of Drug Abuse
2012	Travel Award, Behavior, Biology and Chemistry: Translational Research in Substance Use Disorders

2012	Graduate Summer Research Mentorship Fellowship, University of California, Los Angeles
2008	Opal Jones Trust Scholarship in Psychology, Pasadena City College
2008	Valedictorian, Pasadena City College

Diversity, Equity, and Inclusion:

At each step in the academic ladder, individuals from underrepresented groups face substantial hurdles that impede their ability to thrive. These hurdles produce great harm, both for the individual and society at large. We must make sweeping changes to improve upon the situation. As a person that struggled with mental illness, a high-school dropout, and a community college graduate, I am where I am today because people saw my potential and mentored me. I am committed to extending the same caring hand to those from non-traditional and under-represented backgrounds. As a graduate student, I tutored homeless youth and served as a mentor for the UCLA Psychology Undergraduate Research Journal. As a postdoctoral fellow, I have helped acquire diversity supplements to support undergraduates from underrepresented backgrounds and have mentored these students in preparation for graduate school. As chair of the Neuroscience Postdoctoral Association, I co-led the development of a fellowship to help graduate students from underrepresented backgrounds secure postdoc positions and am helping to develop youth outreach activities. Throughout my career, I hope to improve upward mobility at all stages of education and to promote an inclusive environment.

Publications:

Preprints:

1. **Pennington ZT**, LaBanca AR, Abdel-Raheim SD, Bacon ME, Mahmoud AN, Sompolpong P, Baggetta AM, Zaki Y, Ko B, Dong Z, Smith ACW, Kenny PJ, Cai DJ (2024). An anterior hypothalamic circuit gates stress vulnerability. *bioRxiv*, 2024.10.28.620614v1. doi: 10.1101/2024.07.03.601770. [link]

   This work, funded by a BBRF Young Investigator Award, harnessed unbiased whole-brain activity mapping to identify circuits that are functionally remodeled by prior adversity. This revealed that the anterior hypothalamic nucleus (AHN) displays heightened stress reactivity in previously stressed mice. Further, I identified a key role of the AHN in gating stress vulnerability by scaling valence signals from the amygdala. My own lab will seek to further define how the AHN regulates stress responses and how AHN cell populations might be targeted in disease treatment.

2. Dong Z, Dong Z, Feng Y, Diego K, Baggetta AM, Sweis BM, **Pennington ZT**, Lamsifer SI, Zaki Y, Sangiuliano F, Philipsberg PA, Morales-Rodriguez D, Kircher D, Slesinger P, Shuman T, Aharoni D, Cai DJ (2024). Simultaneous dual-color calcium imaging in freely-behaving mice. *bioRxiv*, 2024.07.03.601770. doi: 10.1101/2024.07.03.601770. PMID: 39005306. [link]

Research Reports:

3. **Pennington ZT**, LaBanca AR, Sompolpong P, Abdel-Raheim SD, Ko B, Christenson Wick Z, Feng Y, Dong Z, Francisco TR, Bacon ME, Chen L, Fulton SL, Maze I, Shuman T, Cai DJ (2024). Dissociable contributions of the amygdala and ventral hippocampus to stress-induced changes in defensive behavior. *Cell Reports*, 43(11):114871. doi: 10.1016/j.celrep.2024.114871. PMID: 39427320. [link]

   This work forms the basis of my K99/R00 award aimed at understanding the non-associative consequences of stress on fear and anxiety-related behaviors. My future lab will seek to define microcircuits governing these stress-induced changes in defensive behavior.

4. Zaki Y, **Pennington ZT**, Morales-Rodriguez D, Bacon ME, Ko B, Francisco TR, LaBanca AR, Sompolpong P, Dong Z, Lamsifer S, Chen HT, Carrillo Segura S, Christenson Wick Z, Silva AJ, Rajan K, van der Meer M, Fenton A, Shuman T, Cai DJ (2024). Offline ensemble co-reactivation links memories across days. *Nature*. doi: 10.1038/s41586-024-08168-4. PMID: 39506117. [link]

5. Feng Y, Diego KS, Dong Z, Christenson Wick Z, Page-Harley L, Page-Harley, V, Schnipper J, Lamsifer SI, **Pennington ZT**, Vetere LM, Philipsberg PA, Soler I, Jurkowski A, Rosado CJ, Khan NN, Cai DJ, Shuman, T (*in press*). Distinct changes to hippocampal and medial entorhinal circuits emerge across the progression of cognitive deficits in epilepsy. *Cell Reports*. [link]

6. Dong Z, Mau W, Feng Y**, Pennington ZT**, Chen L, Zaki Y, Rajan K, Shuman T, Aharoni D, Cai DJ (2022). Minian, an open-source miniscope analysis pipeline. *eLife*, 11:e70661. doi: 10.7554/eLife.70661. PMID: 35642786 [link]

7. **Pennington ZT**, Diego KS, Francisco TR, LaBanca AR, Lamsifer SI, Liobimova O, Shuman T, Cai DJ (2021). ezTrack-A Step-by-Step Guide to Behavior Tracking. *Current Protocols*, 1(10):e255. doi: 10.1002/cpz1.255. PMID: 34610215. [link]

   I guided a team of undergraduates as they wrote the initial draft of this manuscript, as well as subsequent revisions.

8. Blaze J, Navickas A, Phillips HL, Heissel S, Plaza-Jennings A, Miglani S, Asgharian H, Foo M, Katanski CD, Watkins CP, **Pennington ZT**, Javidfar B, Espeso-Gil S, Rostandy B, Alwaseem H, Hahn CG, Molina H, Cai DJ, Pan T, Yao WD, Goodarzi H, Haghighi F, Akbarian S. Neuronal Nsun2 deficiency produces tRNA epitranscriptomic alterations and proteomic shifts impacting synaptic signaling and behavior. *Nature Communications*. 2021 Aug 13;12(1):4913. doi: 10.1038/s41467-021-24969-x. PMID: 34389722; PMCID: PMC8363735. [link]

9. Lichtenberg NT, Sepe-Forrest L, **Pennington ZT**, Lamparelli AC, Greenfield VY, Wassum KM (2021). The medial orbitofrontal cortex-basolateral amygdala circuit regulates the influence of reward cues on adaptive behavior and choice. *Journal of Neuroscience*, 41(34): 7267-7277. PMID: 34272313. doi: 10.1523/JNEUROSCI.0901-21.2021. [link]

10. Rajbhandari AK, Octeau CJ, Gonzalez S, **Pennington ZT**, Mohamed F, Trott J, Chavez J, Ngyuen E, Keces N, Hong WZ, Neve RL, Waschek J, Khakh BS, Fanselow MS (2021). A

Basomedial Amygdala to Intercalated Cells Microcircuit Expressing PACAP and Its Receptor PAC1 Regulates Contextual Fear. *Journal of Neuroscience*, 41(15):3446-3461. doi:10.1523/JNEUROSCI.2564-20.2021 [link]

11. Shuman T, Aharoni D, Cai DJ, Lee CR, Chavlis S, Page-Harley L, Vetere LM, Feng Y, Yang CY, Mollinedo-Gajate I, Chen L, **Pennington ZT**, Taxidis J, Flores SE, Cheng K, Javaherian M, Kaba CC, Rao N, La-Vu M, Pandi I, Shtrahman M, Bakhurin KI, Masmanidis SC, Khakh BS, Poirazi P, Silva AJ, Golshani P (2020). Breakdown of spatial coding and interneuron synchronization in epileptic mice. *Nature Neuroscience,* 23(2): 229-238. doi: 10.1038/s41593-019-0559-0. PMID: 31907437. [link]

12. **Pennington ZT**, Trott JM, Rajbhandari AK, Li K, Walwyn WM, Evans CJ, Fanselow MS (2020). Chronic opioid pretreatment potentiates the sensitization of fear learning by trauma. *Neuropsychopharmacology,* 45(3): 482-490. doi: 10.1038/s41386-019-0559-5. PMID: 31787748; PMCID: PMC6968993. [link]

This paper demonstrates the ability of chronic opioid administration to potentiate aversive learning in a withdrawal-independent and anxiety-independent manner. This provides a novel mechanism that could potentially contribute to the high comorbidity between opioid use disorder and PTSD. Future work from my lab will seek to define the circuit and pharmacological mechanisms underlying this change, as well as the extent to which it is an opioid-specific phenomena.

13. **Pennington ZT**, Dong Z, Feng Y, Vetere LM, Page-Harley L, Shuman T, Cai DJ (2019). ezTrack: An open-source video analysis pipeline for the investigation of animal behavior. *Scientific Reports,* 9(1): 19979. doi: 10.1038/s41598-019-56408-9. PMID: 31882950; PMCID: PMC6934800. [link]

This paper documents and validates the open-source behavioral tracking software I developed during my postdoc. This software is used across 6 continents and has been cited over 150 times since 2019. In my future lab I plan to extend this software's capabilities to benefit the broader research community.

14. Kosarussavadi S*, **Pennington ZT***, Covell C, Blaisdell AP, Schlinger BA (2017). Across sex and age: Learning and memory and patterns of avian hippocampal gene expression. *Behavioral Neuroscience*, 131(6): 483-491. doi: 10.1037/bne0000222. PMID: 29189019. [link]

**Joint first authors*

15. **Pennington ZT**, Anderson AS, Fanselow MS (2017). The ventromedial prefrontal cortex in a model of traumatic stress: Fear inhibition or contextual processing? *Learning & Memory*, 24(9): 400-406. doi: 10.1101/lm.046110.117. PMID: 28814465; PMCID: PMC5580532. [link]

16. Lichtenberg NT, **Pennington ZT**, Holley SM, Greenfield VY, Cepeda C, Levine MS, Wassum KM (2017). Basolateral amygdala to orbitofrontal cortex projections enable cue-triggered reward expectations. *Journal of Neuroscience*, 37(35): 8374-8384. doi: 10.1523/JNEUROSCI.0486-17.2017. PMID: 28743727; PMCID: PMC5577854. [link]

17. James AS, **Pennington ZT**, Tran P, Jentsch JD (2015). Compromised NMDA/glutamate receptor expression in dopaminergic neurons impairs instrumental learning, but not

Pavlovian goal-tracking or sign-tracking. *eNeuro,* 2(3): e0040-14. doi: 10.1523/ENEURO.0040-14.2015. PMID: 26464985; PMCID: PMC4586930. [link]

Reviews:

18. Fanselow MS, **Pennington ZT** (2018). A return to the psychiatric dark ages with a two-system framework for fear. *Behaviour Research and Therapy*, 100:24-29. doi: 10.1016/j.brat.2017.10.012. PMID: 29128585; PMCID: PMC5794606. [link]

This review, in addition to an accompanying commentary (Fanselow & Pennington, 2017), argues against a perspective piece suggesting that fear could not be studied in non-human animals. If true, such a perspective would have sweeping implications for biomedical research on fear and anxiety disorders. As faculty, I hope to not only produce novel biological insights into the mechanisms of behavior but influence how we translate these findings to medical conditions in humans.

19. Jentsch JD, Ashenhurst JR, Cervantes MC, Groman SM, James AS, **Pennington ZT** (2014). Dissecting Impulsivity and its relationship to addictions. *Annals of the New York Academy of Sciences*, 1327: 1-26. doi: 10.1111/nyas.12388. PMID: 24654857; PMCID: PMC4360991. [link]

20. Jentsch JD, **Pennington ZT** (2014). Reward, interrupted: Inhibitory control and its relevance to addictions. *Neuropharmacology,* 76B: 479-486. doi: 10.1016/j.neuropharm.2013.05.022. PMID: 23748054; PMCID: PMC4023480. [link]

Commentaries:

21. **Pennington ZT**, Cai DJ (2021). Propranolol inhibits reactivation of fear memory. *Biological Psychiatry,* 89(12):1111-12. doi: 10.1016/j.biopsych.2021.04.007. PMID: 34082886. [link]

22. **Pennington ZT**, Fanselow MS (2018). Indirect targeting of subsuperficial brain structures with transcranial magnetic stimulation reveals a promising way forward in the treatment of fear. *Biological Psychiatry*, 84(2): 80-81. doi: 10.1016/j.biopsych.2018.05.003. PMID: 31178062. [link]

23. Fanselow MS, **Pennington ZT** (2017). The Danger of LeDoux and Pine's Two-System Framework for Fear. *American Journal of Psychiatry*, 174(11): 1120-1121. doi: 10.1176/appi.ajp.2017.17070818. PMID: 29088929. [link]

Invited Talks:

2024	Hypothalamus Gordon Research Conference (Lewiston, ME)
2024	Neurobiology of Stress Conference (Boston, MA)
2024	University of California, Los Angeles, Behavioral Neuroscience Seminar (Los Angeles, CA)
2024	University of Colorado, Boulder, Behavioral Neuroscience Seminar (Boulder, CO)
2024	Yale Division of Molecular Psychiatry Seminar Series (New Haven, CT)

2023	American College of Neuropsychopharmacology (Tampa, FL)
2023	Pavlovian Society (Austin, TX)
2022	University of Texas, Southwestern, El Paso. Learning Technology Seminar Series (Virtual)

Professional Activities and Service

2022 – present **Co-Director, Emerging Scholars Program, Icahn School of Medicine at Mount Sinai**

2022 – present **Founder/Organizer, Faculty Search Support Group, Icahn School of Medicine at Mount Sinai**

- *Organized mock chalk-talk session with faculty and trainees.*
- *Organized application review session with faculty input.*
- *Coordinated postdocs being able to attend departmental chalk-talks.*

2024 **Organizer, Symposium on Diversity, Inclusion and Training at the Icahn School of Medicine at Mount Sinai**

2023 **Instructor, Cold Spring Harbor Laboratory**

Imaging Structure and Function in the Nervous System

2021 – present **Founder/Organizer, Sinai Anxiety Fear and Trauma Journal Club, Icahn School of Medicine at Mount Sinai**

- *Multi-lab journal club designed to facilitate collaboration and to create a safe place for trainees to refine their science and presentation skills.*

2021 – 2022 **Chair, Neuroscience Postdoctoral Association, Icahn School of Medicine at Mount Sinai**

- *Helped orchestrate multiple career panels for postdocs.*
- *Created grant-writing resources to help postdocs identify and secure funding.*
- *Organized job-search support group for postdocs going on faculty search.*
- *Hosted socials to facilitate sense of welcome amongst postdoc community.*

2021 **Instructor, 2021 Virtual Miniscope Workshop**

Organized by Drs. Daniel Aharoni, Denise Cai and Tristan Shuman

2019 **Instructor, CAJAL Advanced Neuroscience Training Programme, Université de Bordeaux:**

Principles and implementation of Miniscope imaging and analysis

2019 – present **Committee Member, Neuroscience Postdoctoral Association, Icahn School of Medicine at Mount Sinai**

2018 – 2021 **Committee Member, Mount Sinai Neuroscience Seminars, Icahn School of Medicine at Mount Sinai**

2015 – 2017 **Graduate Student Mentor, UCLA *Undergraduate Research Journal of Psychology***

Teaching

Academic Courses

2022 – present **Invited Lecturer, Icahn School of Medicine at Mount Sinai**

Courses:

- *Neuro Core Unit 3, Behavioral and Cognitive Neuroscience*
- *Techniques and Approaches in Neuroscience*

2016 – 2017 **Instructor, University of California, Los Angeles (UCLA)**

Average Overall Rating: 8.4/9 (N = 70)

Courses:

- *Psych 15, Introductory Psychobiology (2 school quarters)*

2012 – 2018 **Teaching Assistant, University of California, Los Angeles (UCLA)**

Average Overall Rating: 8/9 (N = 291)

Courses:

- *Psychology 110, Fundamentals of Learning (1 school quarter)*
- *Psychology 115, Principles of Behavioral Neuroscience (3 school quarters)*
- *Psychology 116, Behavioral Neuroscience Laboratory (6 school quarters)*
- *Neuroscience M101L, Neuroscience Laboratory (1 school quarter)*

Workshops

2023 **Instructor, Cold Spring Harbor Laboratory**

Imaging Structure and Function in the Nervous System

2021 **Instructor, 2021 Virtual Miniscope Workshop**

Organized by Drs. Daniel Aharoni, Denise Cai and Tristan Shuman

2019 **Instructor, CAJAL Advanced Neuroscience Training Programme, Université de Bordeaux**

Principles and implementation of Miniscope imaging and analysis

Research Advising

Research Mentor at Icahn School of Medicine at Mount Sinai

2024 – Present Afra Mahmud, Undergraduate Researcher in Cai Lab
- *Author on Pennington et al. BioRxiv, 2024*

2024 - Present Madeline Bacon, Research Associate in Cai Lab
- *Author on Pennington et al. Cell Reports, 2024*
- *Author on Pennington et al. BioRxiv, 2024*

2023 - 2024 Shereen Abdel-Raheim, Undergraduate in Cai Lab
- *Author on Pennington et al. Cell Reports, 2024*
- *Author on Pennington et al. BioRxiv, 2024*
- *First author poster presentation at Mount Sinai Neuroscience Retreat 2024*
- *Poster presenter at SFN 2023*

2022 - 2024 Patlapa Sompolpong, Research Associate in Cai Lab
- *Author on Pennington et al. Cell Reports, 2024*
- *Author on Pennington et al. BioRxiv, 2024*
- *First author poster presentation at SFN 2023*
- *Poster presenter at SFN 2022*
- *Current position: Neuroscience PhD student, Emory University*

2020-2022 Alexa LaBanca, Research Associate in Cai Lab
- *Author on Pennington et al. Cell Reports, 2024*
- *Author on Pennington et al. BioRxiv, 2024*
- *Author on Pennington et al. Current Protocols in Neuroscience, 2021*
- *First author poster presentations at SFN 2021, SFN 2022, Mount Sinai Neuroscience Retreat 2021, Mount Sinai Neuroscience Retreat 2022*
- *Current position: Neuroscience PhD student, Icahn School of Medicine at Mount Sinai*

2019-2021 Taylor Francisco, Neuroscience and Behavior Student at Columbia
- *Author on Pennington et al. Cell Reports, 2024*
- *Author on Pennington et al. Current Protocols in Neuroscience, 2021*
- *First author poster presentation at SACNAS 2021.*
- *NIMH Diversity Supplement Awardee*
- *Subsequent position: Data Science MA student, Columbia University*

2021 Keziah Diego, Research Associate in Shuman Lab
- *Author on Pennington et al. Current Protocols in Neuroscience, 2021*
- *Current position: Medical student, U Chicago*

2021 Sophia Lamsifer, Research Associate in Shuman Lab

- *Author on Pennington et al. Current Protocols in Neuroscience, 2021*
- *Current position: Medical student, Yale School of Medicine*

2021 Olga Liobimova, Undergraduate Researcher in Shuman Lab

- *Author on Pennington et al. Current Protocols in Neuroscience, 2021*

Senior Thesis Mentor at UCLA

2018-2018 Kevin Li, Psychobiology

- *Author on Pennington et al. Neuropsychopharmacology, 2020*
- *First author poster presentation at UCLA Psychology Undergraduate Research Conference 2018*
- *Subsequent position: Medical student, UCSF Medical School*

2017-2018 Dimyana Hana, Neuroscience

- *First author poster presentation at UCLA Neuroscience Undergraduate Research Conference 2018*
- *Current position: Brand strategist & content creator*

2015-2016 Austin Anderson, Psychobiology

- *Author on Pennington et al. Learning & Memory, 2017*
- *First author poster presentation at UCLA Psychology Undergraduate Research Conference 2016*
- *Subsequent position: Medical student, Arizona College of Osteopathic Medicine*

2013-2014 Patricia Stan, Neuroscience

- *First author poster presentation at UCLA Psychology Undergraduate Research Conference 2014*
- *Subsequent position: Neuroscience PhD student, University of Pittsburgh*

2012-2013 Kyra Phillips, Psychology

- *First author poster presentation at UCLA Psychology Undergraduate Research Conference 2013*
- *Subsequent position: Psychobiology PhD student, University of Michigan Ann Arbor*

2012-2013 Taylor Clark, Psychology

- *First author poster presentation at UCLA Psychology Undergraduate Research Conference 2013*
- *Subsequent position: Neuroscience PhD student, UT Austin*

Press and Media

2021	Neuropsychopharmacology Press Release
2017	Society for Neuroscience Press Release

Reviewer:

Journal Review:

Neuropsychopharmacology, Reviewer (since 2021)

Biological Psychiatry, Reviewer (since 2023)

Journal of Neuroscience, Reviewer (since 2023)

Science Advances, Reviewer (since 2024)

References:

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