

## **Anish Mitra, M.D., Ph.D.**

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### **EDUCATION AND TRAINING**

#### **Adult Psychiatry Residency**, Stanford Hospital, 2019/07 – 2022/06

- Research Track with focus on cognitive neuroscience
- Clinical focus in brain stimulation, including TMS and ECT

#### **Post-Doctoral Fellowship**, Stanford Bioengineering, 2019/10 – present

- Advisors: Karl Deisseroth (co-mentor: Nolan Williams)
- First author publication under review at *Nature Medicine*; second author publication in *Science Advances*, contributing author on 6 publications in journals including *Neuron*
- K08 award from NIMH

#### **M.D., Ph.D.**, Washington University in Saint Louis, 2010 – 2019

- Ph.D. in neuroscience with graduate advisor Marcus Raichle
- Thesis: ‘*Spatio-temporal Principles of Infra-Slow Brain Activity*’

#### **M.S.** in Biology, Stanford University, 2008 – 2010

- Focus in Biophysics
- Thesis: ‘*Single Cell Models of Cortex-Wide Activity*’

#### **B.S.** in Mathematics (minor in Biology), Stanford University, 2005 – 2009

- Graduation with Distinction in the Honors Mathematics
- Outstanding Undergraduate Thesis Award in Mathematics

### **HONORS**

- K08, Clinical Investigator Award (impact score 14, pending start date), 2022
- Hot Topics Award, International Society of Brain Stimulation, 2022
- Outstanding Resident Award, National Institutes of Mental Health, 2021
- Innovator Grant Winner, Stanford Department of Psychiatry, 2020
- James O’Leary Prize for Best Doctoral Research in Neuroscience at Washington University in Saint Louis, 2019
- Peter Halstead Hudgens Award for clinical and research excellence in Psychiatry, Washington University in Saint Louis, 2019
- Hugh M. Wilson Award for clinical research and excellence in radiology, Washington University in Saint Louis, 2019
- Ruth L. Kirschstein National Research Service Award (F30) from the National Institutes for Mental Health, 2014-2019
- Young Investigator Travel Fellowship Winner, Organization for Computational Neuroscience, 2017
- John Merlie Travel Fellowship Winner at the Society for Neuroscience, 2017
- Young Investigator Travel Fellowship Winner, ColdSpring Harbor, 2017
- Outstanding Abstract and Travel Prize, Organization for Human Brain Mapping, 2015

- Stanford Undergraduate Prize for Outstanding Honors Thesis in Mathematics, 2009
- National Champion, American Parliamentary Debate Association National Championship, 2008
- Putnam Mathematics Competition Top 500, 2007
- National Merit Scholar, 2005
- Academic Presidential Scholar, 2005

## **RESEARCH EXPERIENCE**

**Postdoctoral Scholar** in Karl Deisseroth’s lab (co-mentor: Nolan Williams), Departments of Bioengineering and Psychiatry at Stanford University, 2019/10 – present

- Discovered the first cell-specific description of controllable spatio-temporal motifs in cortex-wide spontaneous activity through cortex-wide imaging of calcium fluorescence
- First optical demonstration of the mouse “default mode network”
- Invented a new methodology for all-optical imaging and control of widespread cortical activity
- Discovered how retrosplenial cortex sends “top-down” signals to visual areas to influence visual perception and hallucinations in a novel mouse behavioral paradigm
- Discovered a novel mechanistic spatio-temporal biomarker of treatment resistant depression in humans with predictive power over depression diagnosis, severity, and responsiveness to TMS treatment
- Selected Publications:
  - **Mitra, A.**, ..., Deisseroth, K.\*, Williams, N.\*, under review at *Nature Medicine*
  - **Mitra, A.**, ..., Deisseroth, K., In preparation
  - **Mitra, A.\***, Kochalka, J.\*, ..., Deisseroth, K., In preparation
- Grants:
  - K08, Clinical Investigator Award (impact score 14, pending start date), NIMH

**Graduate Student** in Marcus Raichle’s lab, Departments of Radiology and Neurobiology at Washington University in Saint Louis, 2011 – 2019.

- Discovered the propagation structure of resting state fMRI in human subjects
- Obtained electrocorticography in human subjects to discover that infra-slow (<0.1 Hz) and higher frequency (>1 Hz) activity moves broadscale networks in different directions
- Found the first correspondence temporal structure in infra-slow activity between human electrocorticography and fMRI
- Established cortical layer specificity in infra-slow signaling by obtaining combined cortex-wide optical imaging of calcium fluorescence and laminar electrophysiology in mice
- Discovered reversal in signal flow through broadscale networks as a function of brain state, including wake versus sleep
- Selected Publications:
  - **Mitra, A.**, ..., Raichle, M. (2018). *Neuron*
  - **Mitra, A.**, ..., Raichle, M. (2016). *PNAS*
  - **Mitra, A.**, ..., Raichle, M. (2015). *Elife*
  - **Mitra, A.**, ..., Raichle, M. (2015). *PNAS*
  - Raut, R., Snyder, A., **Mitra, A.**, ..., Raichle, M. (2021). *Science Advances*
  - Kraft, A., **Mitra, A.**, ..., Moo, J. (2017). *PNAS*

- Mitra, A., ..., Raichle, M. (2014). *Journal of Neurophysiology*
- Mitra, A., ..., Constantino, J., Raichle, M. (2015). *Cerebral Cortex*
- Mitra, A., ..., Raichle, M. (2020). *Neuroimage*
- (Review) Mitra, A., Raichle, M. (2016). *Transactions of the Royal Society B*
- Grants:
  - F30, Ruth L. Kirchstein National Research Service Award, NIMH

#### **Machine Learning Researcher** at Google-X, 2009 – 2010

- Discovered a novel computational architecture whereby neural network visual object identification differs on the basis of context

#### **Undergraduate Research Assistant** in William Mobley's laboratory at Stanford School of Medicine, 2007-2009

- Implemented a novel single cell based computational model of hippocampal activity for drug screening

#### **Undergraduate Research Assistant** with Yakov Eliashberg in the Stanford Department of Mathematics, 2006 – 2010

- Developed novel mathematics to implement context dependence in neural networks
- Winner of the Best Undergraduate Thesis award in honors mathematics at Stanford

### **PROFESSIONAL SERVICES**

#### **Academic Service**

- Ad Hoc Reviewer for Journals: *Neuron* | *PNAS* | *Cerebral Cortex* | *Neuroimage* | *Biological Psychiatry* | *Journal of Neurophysiology* | *eLife* | *Science Translational Medicine* | *Frontiers in Neuroscience*
- Stanford Psychiatry Resident Selection Committee Member, 2019 – present

#### **Diversity and Outreach**

- Volunteer psychiatrist at Arbor Free Clinic, 2019 – present
  - Providing psychiatric care to patients unable to pay for services and mentorship of pre-medical and medical students interested in a career in psychiatry
- Member of the Stanford Bioengineering Postdoc Justice, Equity, Diversity, and Inclusion Team, 2020 – present
  - Monthly advising meetings with junior trainees on overcoming social barriers in research
- Volunteer with Inspiring Connections Outdoors (ISO), Sierra Club, Saint Louis, 2017 – 2019
  - Organized outdoor outings for inner city youth to explore and gain confidence in natural settings
- Volunteer Tutor at Washington University School of Medicine, 2011 – 2018
  - Provided free tutoring in anatomy, histology, and basic neuroscience courses
- Volunteer Tutor at East Palo Alto Stanford Academy, 2006 – 2010
  - Worked 1:1 with 3 middle school students over the course of 4 years on a bi-weekly basis on scholastic subjects and preparation for high school entrance exams

## **MENTORSHIP**

Star Mentor Award, Bio-X Undergraduate Summer Research Program, Stanford University, 2022

### **Current Mentees:**

- John Kochalka: graduate student, Stanford University, Neuroscience Program, 2020 – present

### **Past Mentees:**

- Benjamin Midler: undergraduate student, Stanford University | Bio-X Undergraduate Fellow, 2022 | current: undergraduate student, Stanford University
- Ryan Raut: graduate student, Washington University in Saint Louis | Department of Neuroscience, 2017 – 2019 | current: postdoctoral fellow at The Allen Institute for Neuroscience
- Tyler Blazey, graduate student, Washington University in Saint Louis | Department of Neuroscience, 2016 – 2019 | current: postdoctoral fellow at Washington University in Saint Louis

## **TEACHING**

Organizer and co-lecturer:

- Psychiatric Disease Pathology, course for psychiatry residents at Stanford Psychiatry, 2022

Teaching assistant for the following courses:

- Neuroanatomy for Graduate Students, Washington University in Saint Louis School of Medicine, autumn semester of 2014
- Anatomy for Medical Students, Washington University in Saint Louis School of Medicine, autumn semesters of 2012-2013

## **SELECTED TALKS**

- (Upcoming) Hot Topics Lecture, International Brain Stimulation Conference, Lisbon, Portugal, 2023
- (Upcoming) Special Seminar, Department of Psychiatry, Washington University in Saint Louis School of Medicine, 2022
- (Upcoming) Markou Seminar, Department of Psychiatry, University of California San Diego, 2022
- (Upcoming) Special Seminar, Department of Psychiatry, co-hosted by Brigham and Women's Hospital and the Harvard Medical School
- Clinical TMS Society Grand Rounds, 2022
- Young Investigator Award Lecture, Conference for Outstanding Residents in Psychiatry, National Institutes for Mental Health, 2021
- Invited speaker at the symposium on dynamics in fMRI, Organization for Computational Neuroscience Annual Meeting, 2017
- Invited speaker at the symposium of neural activity and neurovascular coupling, Royal Society B Special Conference, 2016

- Invited speaker and travel fellowship recipient, Coldspring Harbor Meeting on Neural Correlations, 2015

## **PATENTS**

1. Williams, N. & **Mitra, A.** (2022). “Systems and Methods for Objective Diagnosis and Treatment of Major Depressive Disorder.” United States Patent Application, 63/368,606

## **PUBLICATIONS**

\*denotes equal contributions

### **Manuscripts in Progress**

31. **Mitra, A.**, Raichle, M., Geoly, A., Kratter, I., Deisseroth, K.\*, Williams, N.\* “Targeted Neurostimulation Reverses a Novel Spatio-Temporal Biomarker of Major Depression.” Under Review at *Nature Medicine*.

30. **Mitra, A.**, Kochalka, J., Quirin, S., Ramikrishnan, C., Kadur, C., Drinnenberg, A., Deisseroth, K. “Cortex-Wide States, Organized by Retrosplenial Cortex, Mediate Phantom Visual Perceptions.” In Preparation.

29. **Mitra, A.\***, Kochalka, J.\*, Ramikrishnan, C., Bradbury, S., Kadur, C., Deisseroth, K. “Controllable Spatio-Temporal Motifs in Spontaneous Cortex-Wide Activity.” In Preparation.

### **2022**

28. Carroll, C., Stanley, M., Irmén, R., **Mitra, A.**, Snipes, J., Raichle, M., Macauley, S. (2022). “Glycemic variability disrupts sleep through KATP channel activity.” *Journal of Bloodflow and Metabolism*, Vol. 42, pp. 99-100.

### **2021**

27. Raut, R. V., Snyder, A. Z., **Mitra, A.**, Yellin, D., Fujii, N., Malach, R., & Raichle, M. E. (2021). “Global waves synchronize the brain’s functional systems with fluctuating arousal.” *Science advances*, 7(30), eabf2709.

26. **Mitra, A.**, Snyder, A. Z., & Raichle, M. E. (2020). “Probabilistic flow in brain-wide activity.” *NeuroImage*, 223, 117321.

25. Newbold, D. J., Laumann, T. O., Hoyt, C. R., Hampton, J. M., Montez, D. F., Raut, R. V., **Mitra, A.**, Nielsen, A., Ortega, M., Dosenbach, N. U. (2020). “Plasticity and spontaneous activity pulses in disused human brain circuits.” *Neuron*, 107(3), 580-589.

### **2020**

24. Kraft, A. W., **Mitra, A.**, Rosenthal, Z., Dosenbach, N., Bauer, A., Snyder, A., Raichle, M., Bauer, A., Lee, J. (2020). “Electrically coupled inhibitory interneurons constrain long-range connectivity of cortical networks.” *Neuroimage*, 215, 116810.

23. Rosenthal, Z., Raut, R., Yan, P., Koko, D., Kraft, A. W., Czerniewski, L., **Mitra, A.**, Raichle, M., Lee, J. M. (2020). “Local perturbations of cortical excitability propagate differentially through large-scale functional networks.” *Cerebral Cortex*, 30(5), 3352-3369.

22. Raut, R., Mitra, A., Marek, S., Ortega, M., Snyder, A., Tanenbaum, A., Laumann, T., Dosenbach, N., Raichle, M. E. (2020). “Organization of propagated intrinsic brain activity in individual humans.” *Cerebral Cortex*, 30(3), 1716-1734.

## 2019

21. Raut, R. V., **Mitra, A.**, Snyder, A. Z., Raichle, M. E. (2019). On time delay estimation and sampling error in resting-state fMRI. *Neuroimage*, 194, 211-227.
20. Shah, M., Nguyen, R., Pao, L., Zhu, L., CreveCoeur, T., **Mitra, A.**, Smyth, M. (2019). "Role of resting state MRI temporal latency in refractory pediatric extratemporal epilepsy lateralization." *Journal of Magnetic Resonance Imaging*, 49(5), 1347-1355.

## 2018

19. **Mitra, A.\***, Kraft, A.\*, Wright, P.\*, Acland, B., Snyder, A., Rosenthal, Z., Culver, J., Lee, J., Raichle, M. (2018). "Spontaneous infra-slow brain activity has unique spatiotemporal dynamics and laminar structure." *Neuron*, 98(2), 297-305.

## 2017

18. Roland, J. L., Snyder, A., Hacker, C. D., **Mitra, A.**, Shimony, J. S., Limbrick, D. D., Raichle, M., Leuthardt, E. C. (2017). On the role of the corpus callosum in interhemispheric functional connectivity in humans. *Proceedings of the National Academy of Sciences*, 114(50), 13278-13283.
17. **Mitra, A.**, Snyder, A. Z., Tagliazucchi, E., Laufs, H., Elison, J., Emerson, R. W., ... & Raichle, M. (2017). "Resting-state fMRI in sleeping infants more closely resembles adult sleep than adult wakefulness." *PloS one*, 12(11), e0188122.
16. Kraft, A., **Mitra, A.**, Bauer, A. Q., Snyder, A. Z., Raichle, M. E., Culver, J. P., & Lee, J. M. (2017). "Visual experience sculpts whole-cortex spontaneous infraslow activity patterns through an Arc-dependent mechanism." *Proceedings of the National Academy of Sciences*, 114(46), E9952-E9961.
15. Laumann, T., Snyder, A., **Mitra, A.**, Gordon, E. M., Gratton, C., Adeyemo, B., Raichle, M., Petersen, S. (2017). "On the stability of BOLD fMRI correlations." *Cerebral Cortex*, 27(10), 4719-4732.
14. Siegel, J., **Mitra, A.**, Laumann, T., Seitzman, B., Raichle, M., Corbetta, M., & Snyder, A. Z. (2017). "Data quality influences observed links between functional connectivity and behavior." *Cerebral Cortex*, 27(9), 4492-4502.
13. McAvoy, M., **Mitra, A.**, Tagliazucchi, E., Laufs, H., & Raichle, M. E. (2017). "Mapping visual dominance in human sleep." *NeuroImage*, 150, 250-261.

## 2016

12. **Mitra, A.**, Snyder, A. Z., Hacker, C. D., Pahwa, M., Tagliazucchi, E., Laufs, H., Leudhardt, E., Raichle, M. (2016). "Human cortical-hippocampal dialogue in wake and slow-wave sleep." *Proceedings of the National Academy of Sciences*, 113(44), E6868-E6876.
11. **Mitra, A.**, & Raichle, M. (2016). "How networks communicate: propagation patterns in spontaneous brain activity." *Philosophical Transactions of the Royal Society B: Biological Sciences*, 371(1705), 20150546.

10. McAvoy, M., **Mitra, A.**, Coalson, R. S., d'Avossa, G., Keidel, J. L., Petersen, S. E., Raichle, M. (2016). "Unmasking language lateralization in human brain intrinsic activity." *Cerebral Cortex*, 26(4), 1733-1746.
9. Smyser, C., Snyder, A., Shimony, J., **Mitra, A.**, Inder, T., Neil, J. (2016). "Resting-state network complexity and magnitude are reduced in prematurely born infants." *Cerebral Cortex*, 26(1), 322-333.

## 2015

8. **Mitra, A.**, Snyder, A., Constantino, J. N., & Raichle, M. (2015). "The lag structure of intrinsic activity is focally altered in high functioning adults with autism." *Cerebral Cortex*, 27(2), bhv294.
7. **Mitra, A.**, Snyder, A., Tagliazucchi, E., Laufs, H., & Raichle, M. (2015). "Propagated infra-slow intrinsic brain activity reorganizes across wake and slow wave sleep." *Elife*, 4, e10781.
6. Brier, M., **Mitra, A.**, McCarthy, J., Ances, B., Snyder, A. (2015). "Partial covariance based functional connectivity computation using Ledoit–Wolf covariance regularization." *NeuroImage*, 121, 29-38.
5. Hugdahl, K., Raichle, M., **Mitra, A.**, Specht, K. (2015). "On the existence of a generalized non-specific task-dependent network." *Frontiers in Human Neuroscience*, 9, 430.
4. Palanca, B., **Mitra, A.**, Larson-Prior, L., Snyder, A., Avidan, M., Raichle, M. (2015). "Resting-state functional magnetic resonance imaging correlates of sevoflurane-induced unconsciousness." *Anesthesiology*, 123(2), 346-356.
3. **Mitra, A.**, Snyder, A., Blazey, T., Raichle, M. (2015). "Lag threads organize the brain's intrinsic activity". *Proceedings of the National Academy of Sciences*, 112(17), E2235-E2244.

## 2014

2. **Mitra, A.**, Snyder, A., Hacker, C., Raichle, M. (2014). "Lag structure in resting-state fMRI." *Journal of Neurophysiology*, 111(11), 2374-2391.
1. Power, J. D., **Mitra, A.**, Laumann, T., Snyder, A., Schlaggar, B., Petersen, S. (2014). "Methods to detect, characterize, and remove motion artifact in resting state fMRI." *NeuroImage*, 84, 320-341.