

## Appointments and Education

### University of Maryland (College Park, MD)

Jan 2025 **Assistant Professor**, Fischell Department of Bioengineering, Neuroscience & Cognitive Science.

Fall 2024 **Visiting Assistant Professor**, Fischell Department of Bioengineering.

### Massachusetts Institute of Technology (Boston, MA)

Fall 2022 **Visiting Scientist**, McGovern Institute for Brain Research.

### Georgia Institute of Technology (Atlanta, GA)

2019–2024 **Postdoctoral Fellow**, Wallace H. Coulter Department of Biomedical Engineering.

2017–2018 **Postdoctoral Fellow**, School of Chemical and Biomolecular Engineering.

### Cornell University (Ithaca, NY)

2011–2017 **Ph.D.**, Electrical and Computer Engineering.

(Thesis: statistical modeling and inference in biological data)

Minor in Cognitive Neuroscience

Minor in Applied Mathematics

2015 **M.S.**, Electrical and Computer Engineering.

### University of Rochester (Rochester, NY)

2007–2011 **B.S.**, Electrical and Computer Engineering.

**B.A.**, Mathematics.

Minor in Music; Cumulative GPA 3.86/4.00 (magna cum laude)

## Selected Honors and Awards

2023–2027 NIH BRAIN K99/R00 Pathway to Independence Award

2020 OHBM Annual Meeting Oral Presentation - Selected 4.5% OHBM abstracts

2016 EMBS Student Paper Competition Finalist - Top 0.4% EMBS conference proceedings

2016 Travel Award, IEEE International Conference of EMBS

2016 Conference and Research Travel Grant, Cornell University

2015 "Top 10%" Paper Recognition, IEEE International Conference on Image Processing

2011–2012 Goldman Sachs & Co. Scholarship - Top 0.15% applicants in America

2012 Edgar Maeyer Fellowship, Cornell University

2011 John M. Olin Fellowship, Cornell University

2011 ECE Faculty Award, University of Rochester - most accomplished ECE student(s)

2010 Deans' Prizes, Undergraduate Research Symposium, University of Rochester

2009 Distributed REU Award, Computing Research Association - Top 15% applicants in America, funded summer research at Brown University

2009 First Place, Concerto Competition, University of Rochester

2011– Phi Beta Kappa Honor Society

2009– Tau Beta Pi Honor Society

## Research & Publications

(\* corresponding authors, + equal contributions, my mentees, working papers (W), journal articles (J), conference papers (C), technical papers (T). See more details on my [webpage](#).)

### Modeling & inferences in causal interactions among brain networks

- J1 **N. Xu\***, P.C. Doerschuk, S.D. Keilholz<sup>+</sup>, R.N. Spreng<sup>+</sup>. “Spatiotemporal functional interactivity among large-scale brain networks.” *Neuroimage*, 227:117628 (2021). doi: [10.1016/j.neuroimage.2020.117628](https://doi.org/10.1016/j.neuroimage.2020.117628).
- J2 **N. Xu\***, R.N. Spreng, P.C. Doerschuk. “Initial validation for the estimation of resting-state fMRI effective connectivity: A generalized correlation approach.” *Frontiers in Neuroscience*, 11:271, (2017).doi:[10.3389/fnins.2017.00271](https://doi.org/10.3389/fnins.2017.00271)
- C1 **N. Xu\***, X. Zhang, W-J Pan, J.L. Smith, J.W. Allen, V.D. Calhoun, S.D. Keilholz. “Time-varying causal interactions in the functional brain networks: Modeling and Validation.” Organization for Human Brain Mapping 2024 Annual Meeting (OHBM 2024a).
- C2 **N. Xu\***, R.N. Spreng, S.D. Keilholz. “Investigation of spatiotemporal functional interactivity among large-scale brain networks” Organization for Human Brain Mapping 2020 Annual Meeting (OHBM 2020a). (**Oral Presentation**)
- C3 **N. Xu\***, P.C. Doerschuk, R.N. Spreng, “What are the most talkative brain regions?” he 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2016 (EMBC 2016b).(**Late breaking research paper**)
- C4 **N. Xu\***, R.N. Spreng, P.C. Doerschuk, “Directed interactivity of large-scale brain networks: Introducing a new method for estimating resting-state effective connectivity MRI.” The 21st IEEE International Conference on Image Processing, 2014 (ICIP 2014). doi:[10.1109/ICIP.2014.7025712](https://doi.org/10.1109/ICIP.2014.7025712)
- C5 **N. Xu\***, R.N. Spreng, P.C. Doerschuk, “Directed interactivity of large-scale brain networks: Introducing a new method for estimating brain connectivity MRI.” Cognitive Neuroscience Society 2014 Annual Meeting (CNS 2014).

### Investigating functional brain dynamics across rodents and humans

- W1 **N. Xu**, L. Zhang, W-J Pan, Z. Li, B. Yousefi, K-H Chuang, S.D. Keilholz “Network dynamics similarities and differences across rodents and human brains.” (Working paper)
- J3 N. Anumba, M.A. Kelberman, W. Pan, A. Marriott, X. Zhang, **N. Xu**, D.Weinshenker, S.D. Keilholz “The Effects of Locus Coeruleus Optogenetic Stimulation on Global Spatiotemporal Patterns in Rats” bioRxiv. doi:[10.1101/2024.05.23.595327](https://doi.org/10.1101/2024.05.23.595327)
- J4 L. Meyer-Baese, N. Anumba, T. Bolt, L. Daley, T.J. LaGrow, X. Zhang, **N. Xu**, W-J Pan, E. Schumacher, S.D. Keilholz “Variation in the Distribution of Large-scale Spatiotemporal Patterns of Activity Across Brain States” *Frontiers in Neuroscience* (preprint) ([bioRxiv](#))
- J5 **N. Xu\***, D.M. Smith, G. Jenö, D.T. Seeburger, E. Schumacher, S.D. Keilholz “The interaction between random and systematic visual stimulation and infraslow quasiperiodic spatiotemporal patterns of whole brain activity.” *Imaging Neuroscience* (ex: *Neuroimage*, IF: 7.4), 1:1–19 (2023) doi: [10.1162/imag\\_a\\_00002](https://doi.org/10.1162/imag_a_00002) ([GitHub](#))
- J6 **N. Xu\***, B. Yousefi, N. Anumba, T. J. LaGrow, X. Zhang, S.D. Keilholz “QPPLab: A generally applicable software package for detecting, analyzing, and visualizing large-scale quasiperiodic spatiotemporal patterns (QPPs) of brain activity.” [Invited submission to] *SoftwareX*. bioRxiv doi:[10.1101/2023.09.25.559086](https://doi.org/10.1101/2023.09.25.559086) ([GitHub](#))
- J7 D.T. Seeburger, **N. Xu**, M. Ma, S. Larson, C. Godwin, S.D. Keilholz, E.H. Schumacher. “Time-varying functional connectivity predicts fluctuations in sustained attention in a serial tapping task.” *Cognitive, Affective, and Behavioral Neuroscience* (2024) doi: [10.3758/s13415-024-01156-1](https://doi.org/10.3758/s13415-024-01156-1)

- J8 N. Anumba , E. Maltbie , W-J Pan, T-J LaGrow ,**N. Xu**, S.D. Keilholz “Spatial and spectral components of the BOLD global signal in rat resting-state functional MRI.” *Magnetic Resonance in Medicine*, 90.6: 2486-2499 (2023). doi: [10.1002/mrm.29824](https://doi.org/10.1002/mrm.29824)
- J9 **N. Xu\***, [L. Zhang<sup>+</sup>](#), [S. Larson<sup>+</sup>](#), Z. Li, W-J Pan, K-H Chuang, S.D. Keilholz “Rodent whole-brain fMRI data preprocessing toolbox.” *Aperture Neuro*, 3:1 (2023). doi:[10.52294/001c.85075](https://doi.org/10.52294/001c.85075) ([GitHub](#)).
- J10 **N. Xu\***, T.J. LaGrow, N. Anumba, X. Zhang, B. Yousefi, A. Lee, Y. Bassil, G.P. Clavijo, V. Khalilzad, E. Maltbie, L. Meyer-Baese, M. Nezafati, H. Watters, W-J Pan\*, S.D. Keilholz\* “Functional connectivity of the brain across rodents and humans.” *Frontiers in Neuroscience*, 272 (2022). doi:[10.3389/fnins.2022.816331](https://doi.org/10.3389/fnins.2022.816331).
- J11 S.D. Keilholz, E. Maltbie, X. Zhang, B. Yousefi, W. Pan, **N. Xu**, M. Nezafati, T.J. LaGrow, and Y. Guo, “Relationship between basic properties of BOLD fluctuations and calculated metrics of complexity in the Human Connectome Project.” *Frontiers in Neuroscience*, 14 (2020). doi: [10.3389/fnins.2020.550923](https://doi.org/10.3389/fnins.2020.550923).
- C6 S. Dhawan, D. Seeburger, **N. Xu**, C. Baer, A. Hart, M. Karkare, C. Rich, S. Sorme, A. Duarte, S.D. Keilholz, E.H. Schumacher. “The effect of sleep quality on dynamic network connectivity during rest and n-back task performance.” *Cognitive Neuroscience Society 2024 Annual Meeting (CNS 2024)*.
- C7 N. Anumba, M. Kelberman, **N. Xu**, W-J Pan, D. Weinshenker, S.D. Keilholz. “The Effects of Locus Coeruleus Stimulation on Quasi-Periodic Patterns in Rats.” *Organization for Human Brain Mapping 2024 Annual Meeting (OHBM 2024b)*.
- C8 **N. Xu**, D.M. Smith, [G. Jenö](#), D.T. Seeburger, E.H. Schumacher, S.D. Keilholz. “The interaction between visual stimulation and intrinsic infraslow whole brain activity in humans.” *Organization for Human Brain Mapping 2023 Annual Meeting (OHBM 2023a)*.
- C9 N. Anumba, M. Kelberman, **N. Xu**, W-J Pan, D. Weinshenker, S.D. Keilholz1. “Effects of locus coeruleus activity on quasi-periodic patterns.” *Organization for Human Brain Mapping 2023 Annual Meeting (OHBM 2023b)*.
- C10 M. Kelberman, N. Anumba, C. Smith, WJ. Pan, PG. Clavijo, **N. Xu**, A. Marriott, E. Kim, S. Keilholz, D. Weinshenker, “Effects of optogenetic locus coeruleus stimulation on functional connectivity in a rat model of Alzheimer’s disease.” *Alzheimer’s Association International Conference 2022 (AIAC 2022)*.
- C11 D.T. Seeburger, **N. Xu**, C. Godwin, [M. Ma](#), S.D. Keilholz, E.H. Schumacher. “Identifying the Neural Mechanisms of Zone State Performance using Time-varying Functional Connectivity Methods.” *Cognitive Neuroscience Society 2022 Annual Meeting (CNS 2022a) (Oral Presentation)*
- C12 Y-J Lee, [D.T. Seeburger](#), [S. Dhawan](#), T. Nguyen, **N. Xu**, [M. Ma](#), A. Abbas, W. Majeed, G. Thompson, S.D. Keilholz, E.H. Schumacher. “Investigating the relationship between sustained attention and quasi-periodic brain activity patterns with the psychomotor vigilance task.” *Cognitive Neuroscience Society 2022 Annual Meeting (CNS 2022b)*.
- C13 **N. Xu**, D.M. Smith, [G. Jenö](#), D.T. Seeburger, E.H. Schumacher, S.D. Keilholz. “Quasi-periodic patterns and BOLD response entrained by visual stimulation in the human brain” *Organization for Human Brain Mapping 2021 Annual Meeting (OHBM 2021)*.
- C14 W-J Pan, V. Khalilzad-Sharghi, E. Maltbie, X. Zhang, **N. Xu**, S.D. Keilholz. “Frequency-domain correlation within cerebral functional systems in rats.” *Organization for Human Brain Mapping 2020 Annual Meeting (OHBM 2020b)*.

### Assessing functional brain dynamics in neurological disorders

- W2 **N. Xu**, J. Smith, J. Allen<sup>+</sup>, S.D. Keilholz<sup>+</sup>. “Spatiotemporal interactions in visual-vestibular networks affected by different severity of post-concussive vestibular syndromes.” (Working paper funded by NIH K99)

- C15 **N. Xu**, J. Smith, J. Allen, S.D. Keilholz. "Dynamic spatiotemporal interactions in vestibular networks affected by concussive syndromes." The Organization for Human Brain Mapping Annual Meeting 2022 (OHBM 2022)
- C16 A. Trofimova, J. Smith, **N. Xu**, S. Keilholz, R. Gore, J.W. Allen. "Hyperconnected" Vestibular State in Subacute and Chronic Post-Concussive Vestibular Dysfunction Using Dynamic Whole Brain Functional Connectivity Analysis. The Annual Meeting of the American Society of Functional Neuroradiology 2023 (ASFNR 2023)

**3D image reconstruction from cyro-EM images: statistical characterization of spherical virus particles**

- J12 **N. Xu\***, P.C. Doerschuk. "Computation of real-valued basis functions which transform as irreducible representations of the polyhedral groups." *SIAM Journal on Scientific Computing*, 43:6 (2021). [doi:10.1137/20M1318183](https://doi.org/10.1137/20M1318183), [arXiv:1701.01348](https://arxiv.org/abs/1701.01348) ([GitHub](#)).
- J13 **N. Xu**, P.C. Doerschuk. "Reconstruction of stochastic 3-D signals with symmetric statistics from 2-D projection images motivated by cryo-electron microscopy." *IEEE Transactions on Image Processing*, 28:11 (2019). [doi:10.1109/TIP.2019.2915631](https://doi.org/10.1109/TIP.2019.2915631)
- J14 **N. Xu**, D. Veessler, P.C. Doerschuk and J.E. Johnson. "Allosteric effects in bacteriophage HK97 procapsids revealed directly from covariance analysis of cryo EM data." *Journal of Structural Biology*, 202:2 (2018). [doi:10.1016/j.jsb.2017.12.013](https://doi.org/10.1016/j.jsb.2017.12.013)
- J15 P.C. Doerschuk, Y. Gong, **N. Xu**, T. Domitrovic, J.E. Johnson. "Virus particle dynamics derived from cryo-EM Studies." *Current Opinion in Virology*, 18:57 (2016). [doi:10.1016/j.coviro.2016.02.011](https://doi.org/10.1016/j.coviro.2016.02.011)
- C17 **N. Xu**, P.C. Doerschuk, "Statistical characterization of ensembles of symmetric virus particles: 3-D stochastic signal reconstruction from electron microscope images." The 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2016 (EMBC 2016a). **(EMBS Student Paper Competition Open Finalist)** [doi:10.1109/EMBC.2016.7591598](https://doi.org/10.1109/EMBC.2016.7591598)
- C18 **N. Xu**, P.C. Doerschuk, "Reconstruction for stochastic 3-D signals with symmetric statistics in noise: electron microscopy of virus particles." The 22nd IEEE International Conference on Image Processing, 2015 (ICIP 2015). [doi:10.1109/ICIP.2015.7351039](https://doi.org/10.1109/ICIP.2015.7351039)  
**(1 of Top 127 papers recognized as "Top 10%")**  
**(1 of Top 34 papers demonstrated in the "Show & Tell" session)**
- C19 **N. Xu**, Y. Gong, Q. Wang, Y. Zheng, P.C. Doerschuk, "Characterizing heterogeneity among virus particles by stochastic 3D signal reconstruction." *SPIE Optics + Photonics 2015* (SPIE 2015). [doi:10.1117/12.2193791](https://doi.org/10.1117/12.2193791)
- C20 **N. Xu**, Yunye Gong, Yili Zheng, Qiu Wang, Peter C. Doerschuk, "3-D statistical characterization of the heterogeneity of biological macromolecular complexes by electron microscopy." *Optical Society of America, Signal Recovery and Synthesis* (SRS 2014) [doi:10.1364/SRS.2014.STu3F.4](https://doi.org/10.1364/SRS.2014.STu3F.4)

**Other journal and technical articles**

- J16 **N. Xu**<sup>+</sup>, D.S. Patel<sup>+</sup>, H. Lu. "Digging Deeper: Methodologies for High-Content Phenotyping and Knowledge-Abstraction in *C. elegans*." *Lab Animal*, 48:7 (2019). [arXiv:1904.01096](https://arxiv.org/abs/1904.01096)
- T1 Mathematics Senior Thesis on *Energy Efficiency in Wireless Sensor Networks*:  
**N. Xu**, O. Yang, A. Vosoughi, "Energy Efficient Sensing and Communication in Wireless Sensor Networks Based on Lattice Percolation", 2011. Available [[Online](#)].
- T2 Thesis for DREU Grant project on *Design of Test Algorithms for VLSI Circuits*:  
**N. Xu**, J. Dworak, "Exploring bits identities of ATPG sets in fault detection and generating high quality patterns to excite/observe targeted faults", 2009. Available [[Online](#)].

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## Invited Talks (Selected)

- 1 “Advanced mathematical modeling and analysis in biomedical data: unraveling the complexities of brain networks and virus structures.” Georgia Tech, Electrical & Computer Engineering Seminar, Feb 2024.
- 2 “Statistical learning and dynamic analysis in functional neuroimaging data.” University of Illinois Urbana-Champaign, Bioengineering Seminar, Feb 2024.
- 3 “Advanced mathematical modeling and analysis in biomedical imaging” University of Maryland, Bioengineering Seminar, Feb 2024.
- 4 “Modeling and inferences in spatiotemporal dynamics among the functional brain networks.” University of Washington Medicine Diabetes Institute, the Brain, Body and Appetite Research Collaborative Science Seminar, Dec 2023.
- 5 “Causal interaction modeling and inference within brain networks.” MIT’s McGovern Institute for Brain Research, Sep 2022.
- 6 “Infraslow brain dynamics modulated by visual stimulation in human brains.” Georgia Tech-Emory University, Coulter Biomedical Engineering Seminar, Oct 2021.
- 7 “Investigation of spatiotemporal functional interactivity among large-scale brain networks.” OHBM Annual Meeting, Online Virtual Meeting (due to COVID-19), Jun 2020.
- 8 “Statistical inferences on brain cognitions measured by functional MRI.” Emory University, School of Medicine, Department of Psychiatry and Behavioral Science, Mar 2017.
- 9 “Mathematical modeling and novel inferences on biological data.” Emory College of Art and Sciences, Physics Department, Mar 2017.
- 10 “Statistical characterization of ensembles of symmetric virus particles: 3-D stochastic signal reconstruction from electron microscope images.” The 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Aug 2016.
- 11 “Statistical image reconstruction for symmetric virus particles.” Scripps Research Institute, Department of Integrative Structural & Computational Biology, Dec 2015.

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## Technical Skills

Programming	MATLAB, C, C++, MATHEMATICA, R, PYTHON, JAVASCRIPT, SHELL SCRIPT
Software	Linux, MS Windows, L <sup>A</sup> T <sub>E</sub> X, UCSF Chimera, SPM, AFNI, FSL, ANTs, ImageJ, OMERO
Advanced Skills	Physical, mathematical & statistical modeling, Monte Carlo calculations, Design of statistical inference & machine learning & optimization algorithms, Design & implementation of software systems, Big data & image processing, Scientific computing, fMRI analysis, Computational neuroscience
Completed Grad-level Courses	Statistical signal processing & learning, Machine learning, Statistical principles, Theory of statistics, Statistical inference & decision, Funds of data compression, Functional data analysis, Matrix computations, Math programming I & II, Convex analysis, Applied stochastic processes

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## Professional Contributions

Member	CNS, OHBM, ASFNR, IEEE, IEEE SPS, IEEE EMBS
Referee	Journal: Security and Communication Networks, Frontiers in Neuroscience, Frontiers in Neural Circuits, Network Neuroscience, Neuroimage. Conference: OHBM Annual Meeting.

## Teaching, Mentoring & Managing Experience

### Georgia Tech and Emory University (Atlanta, GA)

- 2020– Mentor, *2 PhD research projects (School of Psychology, Dr. Eric Schumacher group)*
- Guided (weekly) a 3rd-year Ph.D. student, D.T. Seeburger, on dynamic analysis for identifying the neural mechanisms of zone state performance: published in C11 & J7.
  - Guided (weekly) a 3rd-year Ph.D. student, S. Dhawan, on BOLD data analysis for detecting infraslow dynamic patterns effected by psychomotor vigilance task: 1 CNS paper (C12).
- Fall 2021 Leader, *fMRI data processing workshop (BME)*
- Designed 2-hr weekly training on fMRI data processing for neural engineers and neuroscientists.
  - Expanded the use of data processing and analysis pipeline I developed in multiple research labs: Dr. Schumacher's lab in Psychology at Georgia Tech (using W6), Dr. Singer's and Dr. Keilholz's labs in Gatech-Emory BME and Dr. Chuang K-H's lab at the Centre for Advanced Imaging and Queensland Brain Institute in Australia (using J9).
- 2019–2021 Mentor, *4 undergraduate research projects (NEUR 2699, BMED 2699, BMED 4699)*
- C. Kadiresan(SysEng): developed a [database](#) (GT-VPN needed) for connectome of C. elegans.
  - G. Jenö (CS): published in C13 & J5.
  - L. Zhang (BME) and S. Larson (CS): published in J9, W1.
  - M. Ma (CS): published in C11, C12, J7.
- Summer 2018 Mentor, *NSF Emergent Behaviors of Integrated Cellular Systems (EBICS) REU project*
- Provided daily guidance for a biology undergraduate, D. Lee, from a minority ethnic group, on C. elegans neural image processing. Lee had 5 NSF REU presentations about this work.

### Cornell University (Ithaca, NY)

- Fall 2016 Teaching Assistant, *Introduction to Circuits for Electrical and Computer Engineering*
- Fall 2015 Teaching Assistant, *Random Signals in Communications and Signal Processing*
- 2014–2015 Mentor, *a research project of 8 master students (ECE 6930, ECE 6931)*
- Mentored a 1-year interdisciplinary MEng project "Simulator for Realistic Brain Signals."

## Professional References

### Sheila D. Keilholz, PhD

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*Postdoc primary advisor, K99 mentor*

### Jason W. Allen, MD, PhD

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*Postdoc mentor in brain disorders, K99 mentor*

### Eric H. Schumacher, PhD

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*Postdoc mentor in cognitive neuroscience*

### R. Nathan Spreng, PhD

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*PhD mentor in structural virology*