Thea Wu

50 College St, South Hadley, MA 01075

wu26r@mtholyoke.edu, 413-561-5017   Google Scholar   theaang.github.io

"Ng" is used in publications as the Cantonese transliteration of the surname "Wu"

RESEARCH SUMMARY

My current research investigates how cross-scale neural dynamics organize information flow across sleep and wake to support memory reorganization and neural plasticity. Integrating electrophysiology, neuroimaging, and computational modeling, I develop novel analytic frameworks across spatial and temporal scales to characterize mechanisms of traveling waves, cross-frequency coupling, communication subspaces, and neural criticality. By unifying empirical data with theory-driven models, I aim to identify fundamental principles by which distributed neural systems optimize communication, computational efficiency, and adaptive behavior.

EDUCATION

Mount Holyoke College, South Hadley, MA   Expected May 2026
B.A. with Honors in Neuroscience and Mathematics
GPA: 3.95/4.00   Full Tuition Grant (4 years)

PUBLICATIONS

1. **Ng, T.,** Noh, E., & Spencer, R. M. C. (2025). Bayesian meta-analysis reveals the mechanistic role of slow oscillation-spindle coupling in sleep-dependent memory consolidation. ***eLife, 13,*** RP101992.
https://doi.org/10.7554/eLife.101992   Data & Code

2. **Ng, T.*,** Barnes, M.*, Abedeen, A., Collignon, L., Patel, H., Vovcsko, N., & Spencer, R. M. C. ***(Submitted).*** Coordinated aperiodic and oscillatory local dynamics across wake and sleep stages enhances the consolidation of precise and accessible memories.   (* *Equal contribution. Led all data analysis*)   Preview

3. **Ng, T.,** Barnes, M., Delvey, C., Gaudette, L., Jones, B., Mooney, L., Orlovsky, I., Rodheim, K., Rusin, K., & Spencer, R. M. C. (*to be submitted in Dec 2025*). Hierarchical traveling wave trains coordinate slow oscillation-spindle coupling across cortical networks to mediate long-range memory transfer during sleep.   Preview

4. **Ng, T.*,** Janzen-Meza, J.*, Tolossa, G. B., Hoyniak, C., Spencer, R. M. C., Barch, D. M., Luby, J. L., Shew, W. L., & Hengen, K. B. (*to be submitted in Jan 2026*). Sleep restores critical neural dynamics across scales and measurement modalities.   Preview

5. **Ng, T.,** Abedeen, A., Sanchez, R., Mooney, L., & Spencer, R. M. C. (***Submitted***). *Somnopy*, an automated open-source framework for polysomnography data analysis in Python.   Package

In preparation

6. **Ng, T.,** Zaid, R., Mooney, L., Kamkar, L., & Spencer, R. M. C. (*In preparation,* **thesis**). Targeted memory reactivation synchronizes cross-frequency traveling wave trains that integrate sleep-wake neural dynamics for memory reorganization.   Proposal

7. **Ng, T.*,** Janzen-Meza, J.*, Tolossa, G. B., Hoyniak, C., Spencer, R. M. C., Barch, D. M., Luby, J. L., Shew, W. L., & Hengen, K. B. (*In preparation*). Long-term network criticality shapes neuropsychiatric development.

8. **Ng, T.,** Orlovsky, I., & Spencer, R. M. C. (*In preparation*). The directionality of emotional information flow across network interactions during encoding modulates memory performance.

9. **Ng, T.,** & Li, Y. (2022). The impact of introducing biased information on people's market expectations and risk preferences. *Unpublished manuscript,* Nanyang Technological University, Singapore.

CONFERENCE PRESENTATIONS

Oral & poster presentations

1. **Ng, T.,** Mooney, L., Orlovsky, I., Barnes, M., Delvey, C., Gaudette, L., Rusin, K., Rodheim, K., Jones, B., & Spencer, R. M. C. (June 2025). Decoding spatiotemporal dynamics of sleep spindles and their age-related effects on emotional memory consolidation. Presented at **SLEEP 2025***, The 39th Annual Meeting of the Associated Professional Sleep Societies (APSS)*, Seattle, WA.   Poster   Abstract

2. **Ng, T.,** Tian, L., Gupta, K., & Freiwald, W. (August 2024). Neural representations interact across brain regions dynamically during multi-step action sequences in macaque monkeys. Presented at *Chemers Neustein Summer Undergraduate Research Fellowship (SURF) Symposium*, The Rockefeller University, NY.   Poster

Poster presentations

3. **Ng, T.,** Janzen-Meza, J., Tolossa, G. B., Hoyniak, C., Spencer, R. M. C., Barch, D. M., Luby, J. L., Shew, W. L., & Hengen, K. B. (November 2025). A multimodal principle organizing critical neural dynamics across states and scales. Presented at *Society for Neuroscience **(SfN)** 2025 Annual Meeting*, San Diego, CA.   Poster

RESEARCH EXPERIENCES

SomNeuro Lab, University of Massachusetts Amherst

Undergraduate Research Student, partially funded   June 2023 – Present

Principal Investigator: Dr. Rebecca Spencer

Project 2: Traveling waves coordinate cross-frequency coupling   March 2024 – Present
• Investigated large-scale coordination of sleep dynamics by modeling inter-regional traveling wave trains and their role in memory consolidation across simultaneous behavioral, high-density PSG, fMRI, and DTI datasets.
• Designed flexible multi-Gaussian curve-fitting algorithms and unsupervised classifiers for detecting sleep spindles and slow oscillations, accounting for individual variability in oscillatory frequency and morphology.
• Implemented comprehensive analyses combining phase gradient directionality (PGD) and inter-wave temporal synchronization to quantify the spatial organization and propagation of traveling waves, revealing hierarchical information processing dynamics during nREM sleep.
• Characterized bidirectional interactions between traveling wave dynamics and slow oscillation-spindle coupling, demonstrating that the hierarchical timing structure of traveling waves predicts coupling phase and strength, whereas coupled traveling wave trains exhibit more consistent spatiotemporal propagation direction.
• Pioneered neural network models to simulate the occurrences and interactions of traveling waves during sleep.
• Improved and generalized computational behavioral methods, including the drift-diffusion model (DDM) and unequal-variance signal detection theory (UVSDT), to measure time-drifted changes in memory consolidation.
• Developed automated pipelines and interfaces in Python for high-density PSG data preprocessing, cleaning, spectral analysis, event detection, and spatiotemporal analysis.
• Advised other labmates in advanced time-series analysis, spectral analysis, data cleaning, and visualization.
• Facilitated the lab's transition to Python for the electrophysiology and neuroimaging analysis.

Project 3: TMR-evoked traveling waves unify sleep-wake memory dynamics   June 2025 – Present
• Developed a novel behavioral paradigm that separates neural signals across visual, auditory, motor, and spatial levels to decode how targeted auditory stimulation during nREM sleep reorganizes memory representations.

• Implemented an automatic closed-loop TMR protocol delivering auditory cues precisely at slow-oscillation up- and down-states to examine state-dependent modulation of memory reactivation and network synchronization.
• Developing multivariate pipelines that combine representational similarity analysis and cross-state decoding to track item-level memory reorganization across encoding, wake and sleep-dependent consolidation, and retrieval.
• Quantifying cross-frequency coupled traveling waves to identify shared, decodable propagation pathways linking slow oscillation-spindle waves during nREM sleep with theta-alpha waves during wake across the same cue-aligned trials, characterizing their computational role in memory reorganization.
• Extending dynamic system modeling and temporal renormalization group-based autoregressive metrics to test how proximity to criticality supports long-range communication and gains in memory precision and confidence.

Project 1: Bayesian meta-analysis in slow oscillation-spindle coupling   June 2023 – March 2024
• Applied the Bayesian hierarchical model in R to conduct a meta-analysis of 297 effect sizes, examining the relationship between memory consolidation and phase-amplitude coupling of neural oscillations during sleep.
• Applied advanced statistical analysis approaches, including non-linear hypothesis testing, leave-one-out cross-validation, distribution approximation & transformation, and simulation to include multi-level moderators in meta-analysis and solve complex statistical problems beyond the scope of existing functions.
• Re-evaluated the statistical power, robustness, and properties of the circular-linear regression in the phase-amplitude coupling, and developed novel standardization methods to approximate a normal distribution.
• Revealed that precise and strong SO-fast SP coupling in the frontal lobe predicts memory consolidation, with the strength of this association mediated by memory type, aging, and dynamic spatiotemporal features.

Washington University in St. Louis & NIH ENDURE program

Summer Research Fellowship, fully funded   June 2025 – Present

Principal Investigators: Drs. Keith Hengen, Deanna Barch, Joan Luby

• Leading research in neural criticality and computational efficiency across species and recording scales using human EEG, sEEG, fMRI, as well as LFP and spike datasets of rodents, by extending temporal renormalization group (tRG) theory to multiscale neural systems.
• Developed autoregressive (AR) and multivariate stochastic differential equation (SDE) models to simulate, decompose, and distinguish critical and oscillatory dynamics in continuous, discretized, and discrete signals, providing parameter optimization frameworks for empirical data analysis.
• Implemented AR modeling on empirical data to quantify criticality across temporal reaches and multiple signal representations, including filtered, envelope, and mode decomposed forms, enabling within- and between-stage analyses of how criticality evolves across wake-sleep transitions.
• Identified sleep as a restorative process that reestablishes critical neural dynamics and optimizes computation in humans, revealing distinct stage- and region-specific signatures across cortical and subcortical structures.
• Performed longitudinal analyses spanning infancy (9 months) through early childhood (8 years), characterizing developmental trajectories in the reemergence of criticality across sleep-wake transitions.
• Designed and trained a machine learning classifier to predict spontaneous awakening events based on pre-arousal fluctuations in neural criticality, contributing to early markers of arousal transitions.
• Integrating behavioral assessments with electrophysiological measures to examine how deviations from criticality correlate with individual differences in neuropsychiatric development.
* Due to NIH funding suspension, my ENDURE experience was fully funded by the Department of Psychiatry.

The Rockefeller University: Summer Undergraduate Research Fellowship (SURF) Program

Summer Research Fellowship, fully funded   June 2024 – September 2024

Principal Investigators: Dr. Winrich Freiwald

• Researched inter-area interactions of neural representations under the mentorship of Dr. Lucas Tian and Dr. Winrich Freiwald in the Laboratory of Neural Systems, supported by the Rockefeller SURF Fellowship.

• Developed moment-to-moment logistic regression decoders to extract shape and location representations of visual-motor integration from multi-neuron activity recorded across multiple brain regions in macaque monkeys.
• Discovered dynamic shifts in inter-area communication of neural representation across various phases of multi-step action planning and execution sequences using cross-correlations and custom permutation tests.
• Adopted the model of communication subspace to explore brain connections at the sub-population level, and revealed the hierarchical directionality of communications during actions.
• Collaborated on a program-wide group project examining the neurobiological impacts of aging, focusing on impaired neurogenesis, cellular-immune interactions, and their roles in cognitive decline.

Polymath Jr.: A Collaborative Mathematical Research Program for Undergraduates
Research Assistant   June 2023 – August 2023
• Worked on a remote project on generative models in machine learning under the supervision of Dr. Ricardo Baptista from the California Institute of Technology.
• Researched the optimal transportation, Bayesian inferences, and data assimilation. Improved lab Python codes.

Nanyang Technological University
Research Assistant (remote)   August 2021 – July 2022
• Studied the impact of unconscious gender bias in the information processing and decision-making process in the Hong Kong recruitment market. Studied probability modeling and inference. Assisted in process tracing and computer simulation under the supervision of Dr. Yupeng Li.
• Collected data and conducted data analysis, built and assessed multiple logistic regression models.

University of Cambridge
Research Assistant (remote)   March 2021 – July 2021
• Under the guidance of Dr. Edoardo Gallo from the Department of Economics, studied the impacts of confirmation bias on investment decisions and effective strategies to reduce the extent of impacts by the intersection of psychology, probability, and economics.
• Worked on the design and collection of questionnaires, modeling, and data analysis in SPSS.

AEC Foundation, California
Volunteer Director of Student Research Program (remote)   February 2021 – December 2023
• Advised high school research-interested students in a non-profit organization to collect information from 100+ questionnaires about children with autism and data analysis. Facilitated further experiment design and implementation by computer-based experiments for attention checking. Mentored EEG analysis, cognition tasks, held meetings and workshops with special education families.

AWARDS AND FELLOWSHIPS

• **Curtis Smith Award**, Mount Holyoke College
*Awarded by the Neuroscience and Behavior Program to **one student** across all four class years for exceptional academic and research achievements in neuroscience, including $500 in research funding.*

• **Sanderson Prize**, Mount Holyoke College
Recognized for outstanding performance in the field of math by the Department of Mathematics and Statistics.

• **Chemers Neustein Summer Undergraduate Research Fellowship**, The Rockefeller University
Competitive summer research fellowship with 2% global admission rate, supporting independent laboratory work under faculty mentorship, including participation in journal clubs, scientific seminars, and presentations.

• **Full Tuition Grant**, Mount Holyoke College

RESEARCH INTERESTS

Systems and computational neuroscience; Cognitive functions, Mathematical and statistical modeling; Neural dynamics (oscillatory & aperiodic networks, criticality, and connectivity); Dynamic systems and neural network models; Mechanisms of memory, sleep, & plasticity; Multi-scale neural computation across brain states, modalities & developmental trajectories; Effects of aging, gender, disability, and neurological conditions on neural communication and cognition; ***Open, transparent, and reproducible science.***

RELEVANT SKILLS AND CERTIFICATIONS

• Expert in Python, R, MATLAB, interfaces including MNE-Python, Nipy, SPM, FSL, Stan, Fieldtrip, EEGLAB, and in developing reproducible analysis pipelines and research packages.
• Highly proficient with EEG, PSG, fMRI, sMRI, DTI, *in vivo* electrophysiology (LFP, spikes), behavioral paradigms, advanced statistical analysis, machine learning, multi-level modeling of neural data, cross-species comparative modeling, and novel theory & method development.
• Proficiently skilled in mathematical and computational modeling of dynamical systems, neural networks, spatiotemporal dynamics, stochastic and probabilistic processes, and functional and structural connectivity.
• Advanced proficiency in scientific writing, figure and graphical design, and publication preparation using LaTeX, Adobe Illustrator, and Photoshop.
• CITI-certified for human and animal research; experienced working with diverse populations, including children, older adults, non-human primates, and rodents.
• Fluent in English, Cantonese, Japanese, and Mandarin; strong presentation and communication skills.

PROFESSIONAL MEMBERSHIPS

• Member, *Society for Neuroscience (SfN)*
• Member, *Sleep Research Society (SRS)*
• Member, *American Psychological Association (APA)*