BROWN

April 26, 2012

Dear David Sheinberg and the Department of Neuroscience Search Committee:

I here submit my application for a tenure-track Assistant Professor position in Computational Neuroscience in the Brown University Department of Neuroscience. I believe my background and experiences are well suited for your search for a candidate "developing and using computational approaches to address fundamental issues of neural information processing".

I am a Computational Neuroscientist with training in Dynamical Systems Theory Mathematics and Human Electrophysiological Brain Imaging. I use computational neural modeling as a tool to understand human neural information processing with cellular and circuit-level detail. I collaborate closely with animal neurophysiologists and clinicians and my research has proven to have direct relevance to understanding neurological disorders. As one example, my modeling has recently led to a new theory of the origin of disrupted thalamocortical rhythms in Parkinson's Disease, a hypothesis now being testing in monkey and mouse model systems in collaboration with researchers at Brown. I also have proven successful in obtaining external funds to support my research, including a recent National Science Foundation award from the Collaborative Research in Computational Neuroscience program.

My main motivation for joining the Brown Neuroscience faculty as Research Assistant Professor last summer was to integrate my expertise with the many groups that are leaders in understanding neural dynamics across a variety of species. In the short time I have been at Brown, I have formed many exciting new collaborations. I view the tenure-track position in Computational Neuroscience as the opportunity to strengthen these connections and to develop new collaborations as part of the growth of my research program. I also look forward to the opportunity to teach the excellent students at Brown University, and I would be particularly interested in running courses jointly through the Division of Applied Mathematics as a means to encourage theoretically strong students to neuroscience disciplines.

I look forward to the opportunity to discuss how my research program fits with the visions of the Department of Neuroscience and the Brown Institute for Brain Science.

Sincerely,

Stephanie R. Jones

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Curriculum Vitae

Stephanie R. Jones, PhD
Assistant Professor (Research) in Neuroscience
Brown University

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SFH, Rm 460
185 Meeting Street
Providence, RI 02912
Tel: 401-863-5193

Home Address: 20 Del Prete Drive
Hingham, MA 02043
Tel: 617-921-2412 (cell)

Email: Stephanie_Jones@Brown.edu

Education

Undergraduate: Boston College, Chestnut Hill, MA
BA in Mathematics (Computer Science minor), 1993
Magna Cum Laude

Graduate: Boston College, Chestnut Hill, MA
MA in Mathematics, 1995

Boston University, Boston, MA
PhD in Mathematics, 2001

Postdoctoral Training

Research Fellow Massachusetts General Hospital, Boston, MA
Athinola A. Martinos Center for Biomedical Imaging
2001-2005

Postgraduate Honors and Awards

Dean's Fellowship, Boston College, 1993-1995
Alfred A. Bennet Teaching Award, Boston College, 1993
Phi Beta Kappa, National Honor Society, Boston College, 1993
Claflin Distinguished Scholar Award, Harvard Med. School, 2008
MGH ECOR Award, Mass. General Hospital, 2010
Scholars in Medicine Dr Lynne Reid /Shore Fellowship, Harvard Med. School, 2011

Faculty Academic Appointments

2005-6/2011 Instructor, Harvard Medical School, Boston, MA
7/2011-present Lecturer, Harvard Medical School, Boston, MA
7/2011-present Assistant Professor (Research), Brown University, Providence, RI

Appointments at Hospitals

2005-present Assistant in Neuroscience, Radiology, Martinos Center for Biomedical Imaging
Massachusetts General Hospital, Boston, MA
2011-present Associate Scientist, Newborn Medicine
Fetal-Neonatal Neuroimaging and Developmental Science Center
Children's Hospital Boston, Boston, MA

Peer reviewed publications (chronological)

1. **Jones SR**, Pinto DJ, Kaper TJ, Kopell N. Alpha-frequency rhythms desynchronize over long cortical distances: a modeling study. *Joural of Computational Neurosci*. 2000;9(3):271-91.
2. **Jones SR**, Mulloney B, Kaper TJ, Kopell N. Coordination of cellular pattern-generating circuits that control limb movements: the sources of stable differences in intersegmental phases. *Journal of Neurosci*. 2003;23(8):3457-68.
3. Garabedian CE, **Jones SR***, Merzenich MM, Dale A, Moore CI. Band-pass response properties of rat SI neurons. *Journal of Neurophysiology*. 2003;90(3):1379-91.
   First author contribution on computational neural modeling component.
4. Pinto DJ, **Jones SR**, Kaper TJ, Kopell N. Analysis of state-dependent transitions in frequency and long-distance coordination in a model oscillatory cortical circuit. *Journal of Computational Neurosci*. 2003;15(2):283-98.
5. Devor A, Ulbert I, Dunn AK, Narayanan SN, **Jones SR**, Andermann ML, Boas DA, Dale AM. Coupling of the cortical hemodynamic response to cortical and thalamic neuronal activity. *Proc Natl Acad Sci* U S A. 2005;102(10):3822-7.
6. **Jones SR**, Kopell N. Local network parameters can affect inter-network phase lags in central pattern generators. *Journal of Math Biology*. 2006;52(1):115-40.
7. **Jones SR**, Pritchett DL, Stufflebeam SM, Hamalainen, M, Moore CI. Neural Correlates of Tactile Detection: A Combined MEG and Biophysically Based Computational Modeling Study. *Journal of Neurosci*. 2007;27(40):10751-10764.
8. Boas DA, **Jones SR**, Devor A, Huppert TJ, Dunn AK, Dale AM. A Vascular Anatomical Network Model of the Spatio-Temporal Response to Brain Activation. *Neuroimage*. 2008;40(3):1116-29.
9. **Jones SR**, Pritchett DL, Stufflebeam SM, Sikora M, Hamalainen MS, Moore CI. Quantitative Analysis and Biophysically-Realistic Modeling of the MEG Mu Rhythm: Rhythmogenesis and Modulation of Sensory Evoked Responses. *Journal of Neurophysiology*. 2009;102(6):3554-72.
10. Ziegler DA, Pritchett DL, Hosseini-Varnamkhast P, Suzanne Corkin, Hamalainen MS, Moore CI, **Jones SR**. Transformations in Oscillatory Activity and Evoked Responses in Primary Somatosensory Cortex in Middle Age: A Combined Computational Neural Modeling and MEG Study. *Neuroimage*. 2010;52(3):897:912.
11. **Jones SR*,** Kerr CE*, Wan Q, Pritchett DL, Hamalainen MS, Moore CI. Cued Spatial Attention Drives Representation-Specific Modulation of The Alpha Rhythm in Primary Somatosensory Cortex. *Journal of Neurosci*. 2010;30(41):13760-5.
    **** Joint first author contributions.***
12. Vierling-Claassen D, Cardin JA, Moore CI, **Jones SR**. Computational Modeling Of Distinct Neocortical Oscillations Driven By Cell-Type Selective Optogentic Drive: Separable Resonant Circuits Controlled By Low-Threshold Spiking And Fast-Spiking Interneurons. *Frontiers in Human Neuroscience*: Special Issue on Origin and Consequences of Rhythmic activity. 2010 Nov 22, 4:198
13. Carlen M, Konstantinos M, Siegle JH, Cardin JA, Fatai F, Vierling-Claassen D, Ruhlmann C, **Jones SR*,** Deissertoth K, Sheng M, Moore CI, Tsai L. ACritical Role for NMDAR Parvalbumin Interneurons for Gamma Rhythm Induction and Cognitive Function. *Molecular Psych*. 2011 4/11.
    **** Senior author contribution on computational neural modeling component.***

14. Kerr CE*, **Jones SR*,** Wan Q, Pritchett DL, Wasserman RH, Wexler A, Villanueva JJ, Shaw JR, Kaptchuk TJ, Littenberg R, Hamalainen MS, Moore CI. . Effects of Mindfulness Meditation Training on Cortical Dyamics: A MEG Study of Alpha Rhythm Modulation in SI. *Brain Research Bulletin*. 2011 85(3-4):96-103.
**** Joint first author contributions.***
15. Wan Q, Kerr CE, Pritchett D, Hamalainen M, Moore CI, **Jones SR**. Dynamics of Dynamics Within A Single Data Acquisition Session: Variation in Neocortical Alpha Oscillations in Human MEG. *PLoS ONE*. 2011;6(9):e24941

Publications in peer review

16. Kerr CE, Sacchet M, Wan Q, Pritchett D, Lee A, Hamalainen M, Moore CI, **Jones SR.** Spatial Attention Modulates Alpha and Beta Prefrontal and Somatosensory Cortex *Journal of Neurosci*.
17. Kerr CE, Sacchet M, Lazar S, Moore CI, **Jones SR.** Starting with the body: Somatosensory attention and sensory cortical alpha rhythm modulation in mindfulness meditation *Fronteirs in Human Neurosci.*

Professional educational materials

2011	**Jones SR**. "Biophysically Principled Computational Neural Network Modeling of Magneto-/Electro- Encephalography Measured Human Brain Oscillations". Chapter in Springer Neuromethods textbook series (#67) Neuronal Network Analysis; Editors: T. Fellin and M. Hallasa. 2011
2013 publication	Vierling-Claassen D. and **Jones SR**. "Neural Rhythms". Chapter in Computational Neuroscience textbook From Neurons to Cognition: Computational Neuroscience MIT Press; Editor: M. Arbib.

Funding Information

Current

2011-2014	NSF CRCNS 1131850 – Role: PI (Co-PI Dr. Christopher Moore), $830,000 "Contributions of Thalamus and Basal Ganglia to Neocortical Beta Oscillations"

Pending

Submitted Feb. 2012	NIH R21 HD075054-01– Role: PI, $275,000 "Electrophysiological Cortical Abnormalities in Periventricular Leukomalacia"
Submitted March 2012	Harvard Catalyst CHB Pilot Research Grant – Role: PI, $50,000 "Electrophysiological basis of cortical abnormality in children with encephalopathy of prematurity"
Submitted April 2012	Letter of intent to Brown University Translational Innovative Partnership Award Role: PI (Co-PI Dr. Wael Assad), $50,000 "Targeting Deep Brain Stimulation to minimize cortical beta rhythms in Parkinson's Disease based on novel computational modeling predictions "
Submitted April 2012	Letter of intent to March of Dimes Prematurity Research Grants Role: Co-PI (PI Dr. Yoshio Okada of CHB), $457,809 "Electrophysiological basis of cortical abnormality in children with encephalopathy of prematurity"

Past

2011-2012 Harvard Med. Sch., Scholars in Medicine Dr Reid Fellowship – Role: PI, $50,000
"Making Beta Waves: Integrating Mathematical Neural Modeling and Optogenetics to Rescue Parkinsonian Brain Activity"

2010-2011 MGH ECOR Internal Funding Award– Role: PI, $50,000
"Computational and Electrophysiology Investigation of a Beta Origin Hypothesis"

2008-2010 Harvard Medical School, Claflin Distinguished Scholar Award – Role: PI, $100,000
"Computational Modeling of Hemo-Neural Interactions Relevant to Epilepsy"

2005-2010 NIH K25 MH072941 – Role: PI $836,313
"Neurodynamics of Attention MEG, EEG and Modeling"

Major Administrative Leadership Positions

2009-present Co-founder and executive member of the "Cognitive Rhythms Collaborative," an NSF funded mechanisms to bring together theoretical and experimental researchers from multiple Boston area institutes (BU, Brown, MGH, MIT) for discovery and training to understand mechanisms of brain rhythms and their connection to cognition and disease.

Report of Technological and Other Scientific Innovations

2007
2009
2011
Developed publicly available mathematical neural model of generalizable cortical column circuitry to study current dipole MEG/EEG signals and LFP, using shareware NEURON; http://senselab.med.yale.edu/modeldb/ShowModel.asp?model=136803

Teaching of Students in Courses

1993-1995 Graduate Teaching Fellow (Calculus, Multivariate Calculus)
Dept. of Mathematics, Boston College, Chestnut Hill, MA

1996-1998 Graduate Teaching Fellow (Differential Equations)
Dept. of Mathematics, Boston University, Boston, MA

1995-1997 Summer-Term Faculty Instructor (Algebra, Pre-Calculus, Calculus)
AHANA Student Programs, Boston College, Chestnut Hill, MA

1998-1999 Part-time Faculty Instructor (Multivariate Calculus)
Dept. of Mathematics, Boston College, Chestnut Hill, MA

2008 Co-instructor in Neuroscience Graduate Course (Neural Dynamics)
Brain and Cognitive Science Dept, MIT, Cambridge, MA

Report of Regional, National and International Invited Teaching and Presentations (since 2001)

2001 Symposium Presentation: "Dynamics of CPG Motor Control"
SIAM Dynamical Systems Theory Conference, Snowbird, UT (peer reviewed)
2002 Symposium Presentation: "Neural Modeling of CPG Generation"
Society for Neuroscience 2001 Annual Meeting, Orlando, FL (peer reviewed)
2003 Invited Seminar: "Neural Control of Swimming: Insights from Modeling"
Dept. of Biological Sciences, Smith College, Northhampton, MA (Organizer: Olivio)
2007 Invited Seminar: "Mathematics in Biomedical Imaging"
Dept. of Math and Statistics, Mount Holyoke, South Hadley, MA (Organizer: Pollatsek)

2007	Invited Seminar: "Neural Correlates of Tactile Detection: A MEG and Modeling Study" Martinos Center for Biomedical Imaging / Brainmap Seminar Massachusetts General Hospital, Charlestown, MA (Organizer: Rosen)
2007	Symposium Presentation: "Neural Correlates of Tactile Detection" 4th annual COSYNE meeting, Salt Lake City, UT (peer reviewed)
2009	Invited Seminar: "Neural Correlates of Tactile Detection: A Combined MEG and Biophysically Based Computational Modeling Study" Center for Brain and Memory, Boston University, Boston, M. (Organizer: Stern)
2010	Invited Seminar: "From Neurons to Perception: Using Computational Neural Modeling to Study Human Imaging Signals" Martinos Center for Biomedical Imaging / Brainmap Seminar Massachusetts General Hospital, Charlestown, MA (Organizer: Rosen)
2010	Invited Seminar: "From Neurons to Perception: MEG Imaging & Neural Modeling of Somatosensory Attention & The Effects of Meditation" Department of Neuroscience, Wellesley College, Wellesley, MA (Organizer: Weiss)
2010	Invited Seminar" "From Neurons to Perception: Using Computational Neural Modeling to Study the Neural Dynamics of Human Imaging Signals" Huck Institute for Neurosciences, Penn State, University Park, PA.(Organizer: Wenger)
2011	Invited Lecturer: "Computational Neural Modeling of MEG Signals" Autumn School – The Multimodal Brain MEG Center, University of Tuebingen, Tuebingen, Germany (Organizer: Preissl)
2012	Invited Seminar: "A Proposed Role for Non-lemniscal/Pallidal Thalamus in Cortical Beta Rhythmogenesis: From Mechanism to Meaning" Cognitive Rhythms Collaborative: Beta Rhythms Minisymposium Boston University, Boston, MA (Organizer: Kopell)
2012	Invited Seminar: "From Neurons to Perception: Using Computational Neural Modeling to Study the Neural Dynamics of Human Brain Imaging Signals" Neurology Grant Rounds, Rhode Island Hospital, Providence, RI (Organizer: Friedman)
2012	Invited Lecturer: "Computational Neural Modeling To Study Brain Development: A Bridge Linking Electrophysiological & Structural Changes" Fetal Neonatal Neuroimaging and Developmental Science Center Children's Hospital Boston, Boston, MA. (Organizer: Grant)

Committee Service

2006-2007	Society for Neuroscience, Committee on Women in Neuroscience, Mentor
2001-present	Association for Women in Mathematics Mentor Network, Mentor

Professional Societies

1995-2001	American Mathematical Society, Member
1995-2002	Society for Industrial and Applied Mathematics, Member
1997-present	Society of Neuroscience, Member

Editorial Activities

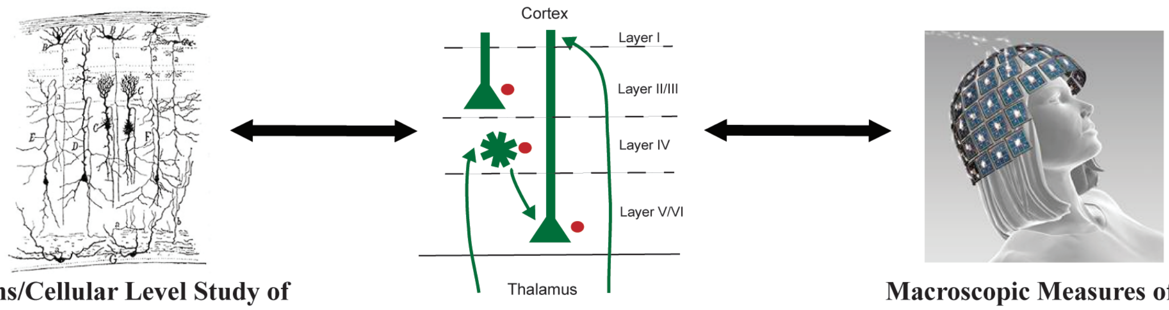
Reviewer	Journal of Computational Neurosci., Journal of Neurosci., Neural Computation, PNAS, Neuroimage, Neuroscience, IEEE sensors, Frontiers in Neurosci., Cerebral Cortex

Updated April 26th, 2012

Overview

I use computational neural modeling as a tool to understand human neural information processing with cellular and circuit-level detail. This unique bridge drives bidirectional hypothesis generation between human neuroimaging and experimental animal model studies. In addition to collaborating extensively with animal neurophysiologists, cognitive neuroscientists and clinicians, I also collect my own human magnetoencephaolography (MEG) data, and I have developed the leading model in interpreting these macroscopic human signals with the biophysical detail necessary to link them to invasive animal studies.

Computational Neural Modeling as a Translational Tool to Understand Human Information Processing with Cellular and Circuit Level Detail



Systems/Cellular Level Study of Neural Dynamics in Animal Model Systesm

Macroscopic Measures of Neural Dynamics in Human Information Processing

A central conviction of my work is that understanding the emergence and modulation of neural dynamics at the circuit level is key to understanding how the brain processes information. I therefore focus my modeling on discovering the mechanisms underlying these dynamics and their impact on neural computation. My specific focus is thalamocortical systems, as this network is crucial to understanding healthy brain function, and its failure is a hallmark of many neurologic and psychiatric diseases. As one example, my modeling has recently led to a new theory of the origin of disrupted thalamocortical rhythms in Parkinson's Disease (PD), a hypothesis now being testing in monkey and mouse model systems as described below.

My main motivation for joining the faculty at Brown last summer was to integrate my expertise with the many groups that are leaders in understanding neural dynamics and thalamocortical function across a variety of species. In the short time I have been at Brown, I have formed many exciting new collaborations: I view this tenure-track faculty position as the opportunity to strengthen these connections and to develop new collaborations as part of the growth of my research program.

In this statement, I first describe my prior training in integration of mathematics and neuroscience and the results of one of my main contributions to the field, developing biophysically principled modeling linking mechanism to function in complex neocortical signals. I then describe my current and future goals including a main theme of my research revealing the computational importance of neural rhythms in healthy function and neuropathology, recent adaptation of my methods to studying healthy and abnormal brain development, and my goals for method development to bridge modeling scales.
[Underlined text has links to the respective sections in this .pdf].

Training in Integration of Mathematics and Neuroscience

Since the beginning of my career, I have used mathematics to study neuroscience in direct collaboration with neurophysiologists. I received my Mathematics PhD with a Dynamical Systems Theory discipline from Boston University under the direction of Professors Nancy Kopell and Tasso Kaper. My dissertation focused on applying geometrical singular perturbation theory to study mechanisms controlling frequency and stability in oscillating neural circuits. In one project, I collaborated with neurophysiologist Prof. Brian Mulloney at UC

Davis to study motor unit activity from the crayfish swimmerette central pattern generator (CPG) system. Mathematical modeling led to predictions on network architectures that could maintain stable phase-relationship between motor units during changes in swimming speed. These modeling results were validated by later experimental data in Dr. Mulloney's laboratory (Jones et al. *J Neurosci*. 2003; Jones and Kopell *J Math Biol*. 2006). In a second project, I studied the dynamics and stability of neocortical rhythms (Jones et al. *J. of Comp Neurosci*. 2000; Pinto, Jones et al. *J Comp Neurosci*. 2003). This work served as a foundation for a main theme of my current research studying the computational importance of brain rhythms.

To develop a research program where I could use my mathematical neural modeling to study *human* neural information processing, I conducted post-doctoral studies at the Martinos Center for Biomedical Imaging at Massachusetts General Hospital (MGH). I first applied signal-processing techniques to analyze hemodynamic data and aided development of a 2-D vascular network model to study spatio-temporal properties of blood flow and oxygenation with Dr. Anders Dale (Devor et al. *PNAS* 2005; Boas, Jones, et al. *Neuroimage* 2008). At this time, I also initiated a long-standing collaboration with Dr. Christopher Moore. In our initial project, I developed a model of primary somatosensory cortex (SI) to understand mechanisms creating sensory-driven transformations in the responses of SI neurons (Garabedian, Jones, et al. *J Neurophysiol*. 2003). These results predicted that a key band pass phenomena depended crucially on a slow time constant form of synaptic inhibition. Recent optogenetic experiments in the Moore lab targeting a specific class of interneuron that generates slow inhibition have directly confirmed these early predictions. Elucidating the role inhibitory neurons in information processing continues to be a focus of my current research (Vierling-Classen et al. *Frontiers in Human Neurosci*. 2011; Carlén et al. *Molecular Psych*. 2011).

At MGH, I realized there was an almost total absence of computational neural modeling tools for understanding human electrophysiological brain imaging signals such as MEG/EEG in a biophysically principled manner, greatly hindering their interpretation at the cellular- and systems-level. To build the multi-area expertise required for addressing this need, I received an NIH Mentored Quantitative Research Career Award (K25) for training in the theory, acquisition and analysis of human MEG/EEG data. A crucial component of this training was learning the physics regulating magnetic and electrical fields generated in the brain that produce MEG/EEG signals. Integrating these disciplines, I constructed a first-of-its-kind neocortical model that is biophysically and synaptically principled, and accurately reproduces macroscopic current dipole signals from MEG (Jones et al. *J Neurosci*. 2007; Jones et al. *J Neurophysiol*. 2009; Ziegler et al. *Neuroimage* 2010). This model provides an essential interpretation of these macroscopic human imaging signals at the cellular and circuit level.

Biophysically Principled Modeling Linking Mechanism to Function in Complex Neocortical Signals

This unique model has direct relevance to understanding neural information processing in humans. The first application was to study neural mechanisms underlying tactile detection. Using MEG, we found neural correlates of successful detection of threshold inputs in human SI. The model provided a biophysically grounded interpretation of these evoked responses, suggesting a specific role for inputs to supragranular layers in creating the events that predicted perception. These results were highlighted in the editor's 'This Week in the Journal' section and had a cover byline in the *Journal of Neuroscience* (Jones et al. *J Neurosci*. 2007).

In addition, the model results led to novel predictions on the origin of spontaneous low frequency (7-14 Hz alpha and 15-29 Hz beta) cortical rhythms that we found impact detection probabilities (Jones et al. *J Neurophysiol*. 2009). We later found these lower frequency rhythms are modulated with cued attention (Jones et al. *J Neurosci*. 2010), change with healthy aging (Ziegler et al. *Neuroimage* 2010), and are more rapidly allocated with practice (Wan et al. *PLoS One* 2011, Kerr and Jones et al. *Brain Res Bulletin* 2011). Predictions from this research are guiding experimental testing in multiple labs at Brown, as described below.

Current/Future Research

I. Revealing the Computational Importance of Neural Rhythms in Healthy Function & Neuropathology

A key theme of my research is to understand whether neural rhythms are beneficial to neural information processing or are epiphenomenal by-products of circuit activity. Neural rhythms are the most prominent electrical signal measured non-invasively in humans. Modulations in rhythms correlate with changes in brain state (e.g. attention, sleep) and abnormalities are used as a biomarker of neuropathology (e.g. PD). Elucidating the mechanism and functions of rhythms is critical to understanding their computational importance and to targeting therapies to improve pathological symptoms. I am developing modeling tools to study these themes.

Modeling guides mouse, monkey and human testing of rational microstimulation protocols for PD patients Beta frequency (15-29 Hz) neocortical rhythms are disrupted in PD, an illness originating in failure of the basal ganglia (BG). My combined human MEG and computational neural modeling results make direct and novel predictions as to the origin of this maladaptive alteration in sensorimotor beta rhythms in PD. Specifically, the model predicts that enhancement of cortical beta activity arises from the stochastic interaction of two ~10 Hz rhythms driving distinct neocortical layers. We are currently elaborating this model to include the multiple brain areas, including basal ganglia and thalamic circuits, which may generate these drives. This research is being conducted in collaboration with Dr. Chris Moore at Brown: In November 2011, we received an NSF *Collaborative Research in Computational Neuroscience* award to expand the model and test its predictions with *in vivo* electrophysiology and optogenetic techniques in mice.

I have also begun collaborating with Brown Medical School Neurosurgeon Dr. Wael Asaad to investigate predictions from the model in his monkey recordings and human PD patients undergoing deep-brain stimulation (DBS). We are using the model as a biophysically grounded analysis method for rational application of DBS paradigms in PD. We have submitted a pre-application (March 2012) for funding to assist our collaboration through the BIBS Translational Research Program provided by Johnson and Johnson.

I am particularly interested in adapting my modeling to study motor rehabilitation in other pathologies such as Stroke and Cerebral Palsy (see <u>brain development</u> section below). Circuit level modeling of ensemble activity of single neurons is a tool that can help guide the next generation of brain computer interface paradigms that rely on spiking activity. To learn more about how my research fits with the rehabilitation methods being established by the Brown Braingate group, I have attended several of John Donoghue's group meetings.

Understanding the computational importance of rhythms in attention and learning As mentioned above, our MEG data has shown that human cortical rhythms can predict perceptual performance and shifts in attention (Jones et al. *J. Neurosci*. 2010). A hypothesis we are testing is that rhythms can facilitate communication between distinct cortical areas, which is enhanced with cued attention. We are using MEG to test this prediction in humans (Sachett et al, *J. Neurosci*. in review). To dissect the computational importance of observed rhythms, we are developing models of multiple brain circuits tightly constrained by network architecture that regulate rhythmic interaction between hierarchically and reciprocally connected regions. We will use the model to dissect the coordination and filtering properties of rhythms during sensory processing.

We have also observed modulation of human brain rhythms with practice (Wan et al. *PLoS One* 2011, Kerr and Jones, et al. *Brain Res. Bulletin* 2011). In a longitudinal study, we found that with meditative practice (centered on body scan techniques) practitioners can learn to regulate their cortical rhythms with attention more efficiently. In collaboration with Dr. Cathy Kerr in the Contemplative Studies group at Brown, we are continuing to study the relationship between meditation, attention, and brain rhythms, with a long term goal of understanding the biophysical mechanisms of meditation that help alleviate pain and depression (Kerr et al. *Frontiers in Human Neurosci*. in review).

I also aim to expand my interests in the neural dynamics of learning with other experts in the field at Brown. Michael Frank and I are discussing integration of his reinforcement learning models with insights from my studies of dynamical interactions between cortical-BG circuits. Jerome Sanes and I are planning to examine the model's utility for understanding rhythmic patterns during motor learning, in his human EEG data.

Elucidating the role of inhibitory neurons in neural dynamics Elucidating the role of the rich diversity of chemically and electrically coupled inhibitory neurons in cortical dynamics is a current focus of my research. We have developed detailed models of two distinct interneuron types, fast spiking and low threshold spiking, which we showed can differentially regulate fast and slow network rhythms in a manner consistent with *in vivo* rodent data (Vierling-Claassen et al. *Frontiers in Human Neurosci*. 2011). In collaboration with Dr. Barry Connors and two graduate students (please see Teaching Statement), we are currently using modeling to study the influence of electrical gap-junction coupling on network rhythms based on his cortical slice data.

II. Studying Healthy and Abnormal Brain Development

Because of its physical properties, MEG is ideally suited for work with infants and children, and thus for studying development. The neural models I develop simulating MEG signals provide an innovative tool to directly interpret neurophysiological changes occurring during healthy and abnormal brain development. For this work, I am using a newly developed MEG/EEG system designed specifically for pediatric patients housed in the Fetal-Neonatal Neuroimaging and Developmental Science Center at Children's Hospital Boston (CHB). I maintain an Associate Scientist position at CHB to facilitate access and interaction with pediatric clinicians.

In collaboration with the center's director Dr. Ellen Grant, and pediatric MEG expert Dr. Yoshio Okada, our initial study integrates neural modeling with MEG imaging and MR-based diffusion tractrography to study sensorimotor pathologies in children born prematurely with Cerebral Palsy. To fund our multi-disciplinary research, I recently submitted an NIH R21 (Feb. 2012 submission), an application for pilot funding from CHB (March 2012), and a March of Dimes Foundation pre-proposal (April 2012).

III. Methods Development to Bridge Modeling Scales

Bridging scales of electrophysiological data in a mathematically principled way: The local field potential Building on the success of my MEG modeling, I am currently recruiting a postdoctoral student to use modeling to study the origins of extracellular local field potentials (LFP). This measure is widely employed in neuroscience, but there is little biophysically precise understanding of its origins. The laminar structure of my cortical model to study macroscopic MEG/EEG signals will be spatially expanded and coupled to Mawell's equations to solve this problem in a principled manner. Once implemented, this model will bridge single neuron activity, LFP and MEG/EEG signals, providing a novel tool for the comparison of results across modalities and species. Funding for the position is being provided by NSF support of the infrastructure of the Boston area "Cognitive Rhythms Collaborative (CRC)" -- a cohort of theorists and experimentalist from BU, MIT, MGH and Brown studying neural rhythms-- of which I am a founding and executive member.

Marrying biophysically detailed dynamical models to probabilistic models of neural activity Many scales of neural modeling are used in computational neuroscience. At one end of the spectrum are probabilistic models that use a Bayesian framework to understand behavioral phenomena like learning and uncertainty. While powerful, these approaches typically lack biophysical interpretability. At the other extreme are biophysically detailed models that maintain cellular level correspondence to data, but whose complexity can be prohibitive, particularly in reciprocally interconnected networks necessary to understand complex behaviors. One of my goals is to advance methods to integrate modeling across these scales. In doing so, I think refinements of existing Bayesian models will emerge constrained by the dynamics imposed by biophysics and network connectivity. I have begun pursuing this goal with two groups at Brown. Thomas Serre and I are working toward integrating his probabilistic models of hierarchical visual scene processing with my biophysically detailed models of cortical circuits. As mentioned above, Michael Frank and I are discussing integration of his reinforcement learning models with my modeling of cortical-BG circuit dynamics.

Overview

I find great satisfaction in teaching. Throughout my career, I have aimed to excite students to real world applications of mathematics, focusing on neuroscience, through classroom teaching, curriculum development, seminars, research mentorship, and outreach programs. I have a particular interest in the advancement of women and underrepresented groups in mathematics and neuroscience with several outreach efforts centered on these groups. [Underlined text has links to corresponding sections in this .pdf]

I think one of the most important traits of a successful computational neuroscientist is to be able to describe high-level mathematical concepts to non-theoretical audiences in a meaningful way. I strive to be this person and have accepted numerous invitations to speak nationally and internationally.

One of my main goals in joining the Neuroscience faculty at Brown last summer was to work with the talented Brown students, an opportunity that was lacking in my prior hospital setting. I am now mentoring two undergraduate students, three graduate students and one post-doc with two more joining my group this summer. There are several courses within the Brown neuroscience curriculum that I would be excited to teach and a new computational neuroscience topics course I would like to develop.

Classroom Teaching

Prior Experience

My experience as a lead teacher in a classroom began during my master's program in Mathematics at Boston College (BC). I was supported by a teaching fellowship that required independent teaching of Calculus and Multivariate Calculus courses to undergraduate students (~30 students per class). This experience culminated in receipt of the Alfred A. Bennet Mathematics Teaching Award for teaching excellence.

During my PhD at Boston University (BU), I was supported as a teaching fellow in Differential Equations courses for large groups (>100) of undergraduate and graduate students running weekly review sessions and grading assignments. I also participated in teaching Computational Neuroscience to Brown University students during my graduate studies. Under the invitation of David Pinto, who was a joint Brown/BU postdoctoral student with Professors Barry Connors and Nancy Kopell, I gave a lecture on the mathematics of neural oscillators in his Computational Neuroscience course for graduate students. In addition, to further my teaching experiences, I returned to BC part-time for one semester as visiting faculty teaching Multivariate Calculus and spent a semester teaching Algebra at night in the continuing education program at Fisher College.

Most recently, I co-taught in a Neural Dynamics Course for graduate students at MIT, headed by Chris Moore and Ann Graybiel. I lectured on applying mathematical neural models to study functionally relevant neural rhythms, and mentored students in projects on spectral analysis of data and modeling neural dynamics.

Future Experience: Brown Neuroscience Curriculum

There are several courses I would be excited to help teach to Brown undergraduate and graduate students. The core courses include "The Brain: An Introduction to Neuroscience (0010)", "Neural Systems (1030)", and "Computational Neuroscience (1680)". I am also interested in teaching in the upcoming "Neural Dynamics" topics course run by Chris Moore, where I plan to give lectures on neural modeling as a tool to bridge cellular level recordings of neocortical dynamics in animal to non-invasive electrophysiological recordings in human. I am also interested in developing a graduate or senior level undergraduate topics course on "Neural Rhythms: From Mechanism to Function". This course will be based in part on two computational neuroscience textbook chapters I authored (please see Curriculum Development below). Topics would include an overview of the observations of neural rhythms throughout the brain, their functional relevance, and insights from neural modeling on their mechanisms and functions. I would be particularly interested in running courses jointly through the Division of Applied Mathematics as a means to encourage theoretically strong students to neuroscience disciplines.

Curriculum Development

I have recently been recruited to write two textbook chapters on computational neuroscience methods and applications that will serve as a basis for the Neuroscience topics course mentioned above. The first is a chapter on "Biophysically Principled Computational Neural Network Modeling of MEG/EEG Human Brain Oscillations" in the Springer Neuromethods textbook series (#67, 2011) Neuronal Network Analysis, edited by T. Fellin and M. Halassa. The second is a chapter on "Neural Rhythms" in the computational neuroscience textbook From Neurons to Cognition: Computational Neuroscience edited by M. Arbib, MIT Press, in press (2013). This textbook is being constructed specifically for classroom instruction and each chapter includes homework assignments, advanced project assignments, and power point lecture slides.

Seminars

Many opportunities to teach my research methods and results have taken the form of invited lectures to audiences including theoretical and neuroscience students, faculty, and clinicians. Most recently, I gave two lectures in the Autumn School lecture series on The Multimodal Brain run by the MEG Center Tubingen and The Graduate School of Neural and Behavioral Sciences of the International Max Planck Research School in Tubingen Germany (Oct. 2011).

This winter (Feb 2012) I accepted an invitation from Dr. Joseph Friedman in the Alpert Medical School at Brown to present clinically relevant aspects of my work to Neurology Grand Rounds group at Rhode Island Hospital. This lecture sparked the collaboration and grant proposal with Dr. Wael Assad discussed in my Research Statement. I also spoke (March 2012) to clinicians and researchers in the Fetal-Neonatal Neuroimaging and Development Science Center at Children's Hospital Boston on the developmental directions of my research.

Research Mentorship

Prior Mentoring

While at MGH, I co-mentored several MIT graduate students and technicians listed below.

David Ziegler, a graduate student of Susan Corkin at MIT, was co-mentored in a project combining MEG and modeling methods to study healthy aging (Ziegler et al. *Neuroimage* 2010). David is now a post-doc at UCSD.

Dominique Pritchett, a graduate student of Chris Moore at MIT, was co-mentored in MEG and modeling of human neocortical dynamics and perception leading to several co-author publications (Jones, Pritchett et al. *J. Neurosci.* 2007; Jones, Pritchett et al. *J. Neurophys.* 2009; Jones et al. *J. Neurosci.* 2010). Our human findings shaped part of his thesis study of neocortical dynamics and perception in rodents. Dominique is graduating this semester.

Qian Wan and Matthew Sacchet (a former Brown undergraduate, then working at MIT) were technicians in Chris Moore's lab who were co-mentored on MEG data analysis and dynamics and published under my senior authorship (Wan et al. 2010 *PLoS ONE*, Kerr, Sacchet et al. *J. Neurosci.* in review). They are now graduate students at Harvard and Stanford Universities, respectively.

Present Mentoring of Brown Post-doctoral, Graduate and Undergraduate Students

Post-Doctoral Students

Dorea Vierling-Classen spent the first two years of her post-doctoral student under my primary mentorship at MGH (Vierling-Claassen et al. *Frontiers in Human Neurosci.* 2011; Carlen et al. *Molecular Psych*. 2011). She is now supported on an NIH NRSA at Brown to combine modeling with neurophysiology training under the co-direction of Chris Moore.

Shane Lee will begin as a Brown Neuroscience post-doctoral student under my mentorship on June 1st 2012. Shane will be trained in the mathematical neuroscience funded by our NSF CRCNS award.

TBD computational neuroscience post-doctoral student I am in the processes of interviewing candidates for an NSF sponsored position provided to the Cognitive Rhythms Collaborative (CRC), a network of theoreticians and experimentalists in the Boston area (BU, Brown, MIT, MGH, Tufts) studying brain rhythms. This student will be trained in modeling local field potentials in a biophysically principled manner.

Graduate Students

Garrett Neske and Arthur Sugden are graduate students of Barry Connors who I am mentoring on projects modeling the influence of gap junction connectivity on neural network dynamics. Arthur has applied for a Brain Science Graduate Research Award to pursue interdisciplinary training under my mentorship.

Dani Rubenstein is a NIH-Brown GPP student doing a rotation project with me on modeling MEG mismatch negative data. We plan to continue our collaboration when he moves back to the NIH where he plans to continue with MEG research in Karen Berman's lab.

Undergraduate Students

Maxwell Sherman is a sophomore PLME student who has begun a computational neuroscience research project that will become his senior thesis project. We have received SRA funding from the medical school for Maxwell to do full time research under my direction this summer.

Roan LaPlante is a senior computer science major who I am working with on a MEG spectral data analysis project. Roan recently presented a poster of his results at a CRC offsite retreat (April 2012) and will be a co-author on a paper resubmission (Kerr et al. *J. Neurosci.* in review).

Outreach Programs

Advancing Women and Under-represented Groups in Mathematics and Neuroscience

During my graduate studies, I participated in several mathematics outreach programs designed to excite high school women to mathematics applications. I presented yearly math labs to high school girls in a program called Pathways Days for Young Women and lectured to large groups of high school students during Mathematics Field Days, each coordinated by Prof. Bob Devaney (one of my letter writers). In the summer months, I taught math preparation courses in a program aimed at preparing students from under-privileged communities for college level mathematics and general studies skills, called the Boston College AHANA (Asian, Hispanic, African and Native American) student programs.

More recently, I have been a mentor in two professional societies that focus on the advancement of women: The Association for Women in Mathematics Mentor Network, and The SFN Committee on Women in Neuroscience. In addition, I have accepted invitations to lecture to mathematics and neuroscience graduate students at three all women colleges: Smith College, Mount Holyoke and Wellesley.

Providence Outreach Programs for High School Students

Funds from my recently awarded CRCNS NSF grant will support a High School Computational Neuroscience Outreach Program, co-organized by Chris Moore. This program will include after school lectures and hands on projects, as well as summer research experiences, to educate Providence area High School students on Computational Neuroscience methods and applications.

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