MGH/MIT/HMS
Athinoula A. Martinos Center
FOR BIOMEDICAL IMAGING

April 27th, 2012

Dear Search Committee

I write to apply for your **tenure track, Assistant Professor position in the area of Computational Neuroscience**. I received my **Ph.D. in Physics** from the University of Wisconsin-Madison in 2001. After a **complex systems** postdoctoral fellowship in the Center for Non-linear Studies of Los Alamos National Laboratory I pursued a **computational neuroscience** postdoctoral fellowship in Emery Brown's Neurostatistics Research Laboratory at Massachusetts General Hospital. Since 2007 I have been an **Instructor at Harvard Medical School** and a Research Associate in the Brain and Cognitive Sciences Department at MIT.

My multidisciplinary background in computational neuroscience, complex systems and physics has allowed me to research how neuronal networks collectively represent information and how such representations dynamically evolve over time. I am particularly interested in methods for determining the importance of complex (higher than second order) spatio-temporal spike pattern structure and have developed several machine learning based algorithms to detect such structures in population data. The above research is funded by a **NIH K-25 Mentored Career Award**, of which I am the PI. Much of this work has involved close, hands-on collaboration with experimental neuroscientists, and has been instrumental in uncovering the collective functional structures by which associative memories are dynamically stored and retrieved in the frontal cortex, the role collective activity plays in encoding natural scenes in the primate V1 and the mechanisms by which ongoing cortical states represent external stimuli in the rat barrel cortex. Beyond studying specific neural systems, I have also developed practical neural data analysis methodologies with broader application by multiple labs.

My research would fit well into the Brown Neuroscience Department with its many researchers who focus on network based coding and computation, including work by John Donoghue on motor ensemble encoding, Michael Frank on circuit based working memory processing and David Sheinberg on dynamic neuronal representations, as well as others. I believe that my background in physics and complex systems will also allow me to bridge research interests across other departments in the Brown Institute for Brain Science such as Applied Mathematics and/or Physics.

Recommendation letters have been requested from Professors Emery Brown (MIT), Ziv Williams (Harvard Medical School) and Gordon Pipa (U. Osnabruck, Germany).

Thank you for considering my application.

Sincerely,

Robert Haslinger

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Research Interests

Neuroscience	Learning by networks, dynamic cortical representations, population codes, association formation, working memory, natural scenes vision; sensory-motor integration; interaction of stimuli with internally generated cortical states.
Computational Neuroscience	Statistical methods for neurobiological data analysis, distributed computation, complex networks, reservoir computing, pattern discovery, machine learning and data mining, self-organization.

Education:

May 2001	***Ph.D. in Physics***. University of Wisconsin - Madison, Madison, Wisconsin. "*The Surface Order Parameter Symmetry of YBCO."* Advisor: Prof. Robert Joynt
May 2000	***M.A. in Physics***. University of Wisconsin-Madison, Madison, Wisconsin.
May 1995	***B.S. in Physics and Math***, *Magna Cum Laude*, Union College, Schenectady,NY

Positions:

1/2007 - Present	***Instructor,*** Department of Radiology, Harvard Medical School, Cambridge, MA.
1/2007 - Present	***Assistant in Neuroscience***, Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA.
1/2007 - Present	***Research Affiliate***, Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA.
7/2004 - 12/2006	***Postdoctoral Research Fellow*** with Prof. Emery Brown, Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA.
7/2001- 6/2003	***Postdoctoral Research Fellow*** with Dr. David Pines, Center for Nonlinear Studies, Los Alamos National Laboratory, Los Alamos, NM.

Grants Awarded

5/2007 - 4/2011	***NIH Grant K25 NS052422***: External Stimulus and Evoked State: A Laminar Study. (PI) *$900,000.*
9/2011	***International Neuroinformatics Coordinating Facility (ICNF) Training Course Grant***: To design and run a week long neuroinformatics summer school. To be held in Osnabruck Germany in July 2012. (Co-PI) *18,000 €.*

Grants Submitted

Submitted Nov 2011	***NSF Collaborative Efforts in Computational Neuroscience Grant:*** To study primate functional network structures responsible for associative learning (Co-PI)
Submitted Jan 2012	***NSF Integrative Organismal Systems Grant:*** To study movement coding in primate pre-motor networks (Co-PI)

Awards and Honors

2005	***Methods in Computational Neuroscience Fellowship***, scholarship for young researchers to study computational neuroscience at Woods Hole Marine Biology Laboratory.
2001	***NSF-SFI Graduate Student Fellowship***, scholarship to study complex systems science at the Santa Fe Institute.
1997	**Emanuel R. Piore Award**, for distinguished achievement in physics, University of Wisconsin - Madison.
1995	***Phi Beta Kappa***, Union College, Schenectady, NY.
1994	***Hans Heinbach Memorial Prize***, for excellence in German literature, Union College, Schenectady, NY.
1993	***James Henry Turnbull Prize***, for distinguished achievement in physics, Union College, Schenectady, NY.

Professional Activities

Course Director	Advanced Statistical Modeling of Neuronal Data (ICNF Summer Course), 2012 (in development), Osnabruck, Germany.
Organizer	Multi-scale Complex Dynamics in the Brain (COSYNE10 - Workshop), 2010, Snowbird, UT. (Co-Organizer with Gordon Pipa)
Program Committee	Bernstein Conference for Computational Neuroscience, 2009 (BCCN), Frankfurt am Main, Germany.
Journal Reviewer	Neural Computation, Journal of Computational Neuroscience, Network, Neuro Image, Computational Intelligence and Neuroscience, PLoS Computational Biology, Physical Review Letters, Physical Review B, Physical Review E.
Grant Reviewer	National Science Foundation - Physics of Living Systems.
Judge	Boston Science Fair, 2011, Boston, MA.
Co-founder	Martinos Center Working Group on Computational Neuroscience.

Teaching (G: Graduate, U: Undergraduate courses)

2008 (G)	***Course 9.917 Neural Dynamics***, Co-Instructor with Professors C. Moore and A. Graybiel, Department of Brain and Cognitive Sciences, MIT.
1995-1996 (U)	***Introductory Physics-Mechanics***, Teaching Assistant, University of Wisconsin Madison.

Students (Research Preceptor for)

2012	***Miguel Angel Escalona,*** Brain and Cognitive Science MIT (visiting). Project title: *Tracking network structure as a function of ongoing brain state.*
2010-2011	***Laura Lewis***, Brain and Cognitive Sciences MIT. Project title: *Modeling neuronal patterns in hippocampal place cells.*
2010	***Neal Dach***, Brain and Cognitive Sciences MIT. Project title: *Inferring sleep state from spikes and local field potentials.*
2008	***Monica Linden***, Brain and Cognitive Sciences, MIT. Project title: *Thalamic activity that drives visual cortical plasticity. Nat. Neurosci. 12:390 (2009).*

Publications:

19. Gerhard P., **Haslinger R.**, and Pipa G. '*Multivariate Time Rescaling Theorem for Neural Population Models.'* Neural Computation. 23:1452-83 *(2011).*

18. Coleman J., Nahmani M., Gavornik J.P., **Haslinger R.**, Heynen A.J, Bear M.F., and Erisir A. '*Rapid structural remodeling of thalamocortical synapses in mouse primary visual cortex following monocular deprivation.'* Journal of Neuroscience 30:9670-82 *(2011).*

17. **Haslinger R.**, Pipa G., and Brown E.N. '*Discrete Time Rescaling Theorem: Determining Goodness of Fit for Discrete Time Statistical Models of Neural Spiking*.' Neural Computation, 22:2477-2506, *(2010).*

16. **Haslinger R.**, Klinker K.L., and Shalizi C.R. *'The Computational Structure of Spike Trains.'* Neural Computation, 22:121-57, *(2010).*

15. Linden M.L., Heynen A.J., **Haslinger R.**, and Bear M.F. *'Thalamic activity that drives visual cortical plasticity.'* Nature Neuroscience, 12:390-392, (2009).

14. Devor A., Hillman E., Tian P. Waeber C., Teng I.C., Ruvinskaya L., Shalinsky M.H., Zhu H. **Haslinger R.**, Narayanan S.N., Ulbert I., Dunn A.K., Lo E.N., Rosen B.R., Dale A.M., Kleinfeld D., and Boas D. *'Stimulus-induced changes in blood flow and 2-deoxyglucose uptake dissociate in ipsilateral somatosensory cortex.'* Journal of Neuroscience, 12:14347-14357, *(2008).*

13. Shalizi C.R., **Haslinger R.**, Rouquier J.B., and Moore C.M., *'Automatic filters for the detection of coherent structure in spatiotemporal systems.'* Physical Review E., 73:036104-036120, *(2006).*

12. **Haslinger R.**, Ulbert I., Moore C.I., Brown E.N., and Devor A., *'Analysis of LFP phase predicts sensory response of barrel cortex.'* Journal of Neurophysiology, 96:1658-1663, *(2006).*

11. Shalizi C.R., Shalizi K.L., and **Haslinger R.**, *'Quantifying Self Organization.'* Physical Review Letters, 93:118701-118705, *(2004).*

10. **Haslinger R.** and Chubukov A. *'Condensation energy in strongly coupled superconductors.'* Physical Review B, 68:214508-214527, *(2003).*

9. Morr D., Chubukov A., **Haslinger R.** and Finkelstein A. *'First order superconducting transition near a ferromagnetic quantum critical point.'* Physical Review Letters, 90:077002-077006, *(2003).*

8. **Haslinger R.** and Chubukov A. *'Condensation energy in strongly coupled superconductors.'* Physical Review B., 67:140504(R)-140508(R), *(2003).*

7. **Haslinger R.**, Chubukov A. and Abanov Ar. *'ARPES in the normal state of the cuprates: comparing the marginal Fermi liquid and spin fluctuation scenarios.'* Europhysics Letters, 58:271-277, *(2002).*

6. **Haslinger R.**, and Joynt R. *'Ohmic losses in valence-band photoemission experiments.'* Journal of Electron Spectroscopy, 77:31-36, *(2001).*

5. **Haslinger R.**, Chubukov A., and Abanov Ar. *'Spectral function and conductivity in the normal state of the cuprates.'* Physical Review B., 63:020503-0250507, *(2001).*

4. **Haslinger R.**, and Shannon H. *'X-ray photoemission spectroscopy as a probe of gap opening in many-electron systems.'* Journal of Physics - Condensed Matter, 13:10089-10103, *(2001).*

3. **Haslinger R.**, and Joynt R. *'C-axis Josephson tunneling in twinned YBCO crystals.'* Journal of Physics - Condensed Matter, 12:8179-8190, *(2000).*

2. **Haslinger R.**, and Joynt R. *'Theory of percolative conduction in polycrystalline high temperature superconductors.'* Physical Review B., 61:4206-4214, *(2000)*

1. **Haslinger R.**, Joynt R., and Betouras J. *'C-axis Josephson tunneling in YBCO.'* Journal of Physical Chemistry, 59:2026-2029, *(1998).*

Publications under review

4. **Haslinger R.**, Pipa G., Lewis L, Nikolic D., Williams Z. and Brown E.N. *'Encoding through patterns: regression tree based neuronal population models.'* In review at Neural Computation

3. **Haslinger R.**, Pipa G., Lima B., Singer W., Brown E.N. and Neuenschwander S. *'Context matters: the illusive simplicity of V1 macaque receptive fields.'* In revision at PLoS One.

2. Schumacher J., **Haslinger R.**, and Pipa G. *'A Bayesian approach for detecting nonlinear synchronization.'* In review at Physical Review E.

1. Williams Z., **Haslinger R. ***, and Rollin C. Hu* *'Neuron controlled avatar - functional integration of neural activity across widely distributed networks.'* In revision at Cell.

* Indicates authors contributed equally

Publications in preparation

1. **Haslinger R.**, Rollin C. Hu and Williams Z. *'Dissociable forms of information encoding by frontal cortical neurons'*

Selected Talks

2012 *Encoding through patterns: regression tree based neuronal population models*. Statistical Analysis of Neuronal Data Meeting (SAND), Pittsburgh, PA, USA. (Contributed Talk)
2012 *Uncovering relevant collective structure in neuronal population data*. Dept. of Neurobiology, Yale University, New Haven, CT. USA (Invited Talk)
2010 *Discrete and multivariate time rescaling for neuronal spiking data*. Statistical Analysis of Neuronal Data Meeting (SAND), Pittsburgh, PA, USA. (Contributed Talk)
2010 *What do we mean by multiscale*. Computational and Systems Neuroscience Meeting (COSYNE), workshop, Salt Lake City, UT, USA. (Invited Talk)
2009 *Including local field potentials in parametric models of neuronal spiking*. Computational and Systems Neuroscience Meeting (COSYNE), workshop, Salt Lake City, UT, USA. (Invited Talk)
2009 *Beyond the receptive field*. Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA, Group of Prof. Ann Graybiel. (Invited Talk)
2008 *The neurophysiological basis of local field potentials*. Max - Planck Institute for Brain Research, Frankfurt, Germany, Group. of Prof. Wolf Singer. (Invited Talk)
2008 *Modeling the relation between spikes and local field potentials*. IEEE Conference on Decision and Control, Cancun, Mexico, workshop. (Invited Talk)
2006 *Ongoing cortical states and the response to somatosensory stimuli*. Department of Brain and Cognitive Sciences, MIT, Cambridge, MA, Group of Prof. Christopher Moore. (Invited Talk)
2004 *The neural generation of MEG signals*. Center for BioDynamics, Boston University, Boston, MA, Group of Prof. Nancy Kopell. (Invited Talk)

Selected Conference Abstracts

12 **Haslinger R.**, Lewis L., Williams Z., Brown E.N. *Beyond second order: modeling spiking population patterns with logistic regression trees.* Cosyne, Salt Lake City, UT. *(2011)*
11. **Haslinger R.**, Gerhard F., Pipa G. *Statistical tests for neural population models – The multivariate time rescaling theorem*, Society for Neuroscience, San Diego, CA. *(2010)*
10. **Haslinger R.**, Pipa G., Brown E.N. *Discrete time rescaling theorem: Determining goodness of fit for discrete time models of neural spiking.* Cosyne, Salt Lake City, UT. *(2010)*
9. **Haslinger R.**, Pipa G., Lima B., Brown E.N., Neuenschwander S. *Network activity predicts contextual modulation of single-cell response to natural scenes in monkey V1*. Society for Neuroscience, Chicago, IL. *(2009)*
8. **Haslinger R.**, Pipa G., Lima B., Brown E.N., Neuenschwander S. *The effect of global context on the encoding of natural scenes.* Trends in Complex Systems. Dresden, Germany. *(2009)*
7. **Haslinger R.**, Pipa G., Lima B., Brown E.N., Neuenschwander S. *The effect of global context on the encoding of natural scenes*. Computational Neuroscience, Berlin, Germany. *(2009)*
6. **Haslinger R.**, Pipa G., Lima B., Brown E.N., Neuenschwander S. *The effect of global context on the encoding of natural scenes.* Cosyne, Salt Lake City, UT. *(2009)*
5. **Haslinger R.**, Shalizi C.R. *The computational structure of spike trains*. Society for Neuroscience, Chicago, IL. *(2008)*
4. **Haslinger R.**, Klinkner K.L, Shalizi C.R. *The computational structure of spike trains.* Cosyne. Salt Lake City, UT. *(2008)*
3. **Haslinger R.**, Andermann M.L., Brown E.N., Moore C.I. *Point process models of the neural response to inter-vibrissae interactions.* Cosyne, Salt Lake City, UT. *(2007)*
2. **Haslinger R.**, Andermann M.L., Brown E.N., Moore C.I. *Neural coding of complex vibrissa deflection patterns.* Society for Neuroscience. Atlanta GA. *(2006)*
1. **Haslinger R.**, Ulbert I., Brown E.N., Moore C.I., Devor A. *Laminar analysis of trial to trial variability in rat barrel cortex.* Society for Neuroscience. Washington, DC. *(2005)*

List of References

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Christopher Moore, Ph.D. (Christopher_Moore@brown.edu) Department of Neuroscience Brown University 185 Meeting Street Providence, RI 02912 Phone: 401-863-1045	***Ziv Williams, M.D.*** (zwilliams1@partners.org) Department of Neurosurgery MGH-HMS Center for Nervous Systems Repair Massachusetts General Hospital 15 Parkman Street, WAC 745-K Boston, MA 02114 Phone: 617-643-4114
Ann Graybiel, Ph.D. (graybiel@mit.edu) McGovern Institute for Brain Research Massachusetts Institute of Technology 43 Vassar Street Building 46, Room 6133 Cambridge, MA 02139 Phone: 617-253-5785	***Cosma Shalizi, Ph.D.*** (cshalizi@stat.cmu.edu) Department of Statistics 229C Baker Hall Carnegie Mellon University 5000 Forbes Avenue Pittsburgh, PA 15213-3890 Phone: 412-268-7826

Research Statement: Robert Haslinger

I am interested in how neuronal networks learn. That is, which collective dynamical structures do networks use to code new information, and how do these structures evolve as environmental conditions or computational requirements change? Towards this end I develop statistical modeling techniques to detect, in real neurobiological data, collective network structures relevant for coding and processing. My work has shown that neuronal populations code collectively (via their temporally correlated spiking) and adaptively (modulating such correlations to reflect the computation/task being performed or learned.) I collaborate heavily with experimentalists, and also perform computational work to further both analysis methodologies and our theoretical understanding of distributed learning/computation in networks.

Collaborative Experimental Studies

Learned Pre-frontal Network Structure: Networks evolve through learning. As a direct demonstration of this I showed that when the functional role of a cell in a network changes, so does the structure of its interactions with the rest of the network. *Prof. Ziv Williams (Dept. Neurosurgery HMS)* and I trained primates to receive reward by controlling the firing rate of a single "effector" neuron chosen randomly from recorded frontal populations. I tracked the evolution of functional interactions within the population (using a generalized linear network model (GLM) with a Bayesian sparsity prior) as the monkey learned this task. I found that as the task was learned, the effector neuron, and only that neuron, formed new interactions with other cells in the network. These interactions were not accompanied by overall changes in activity, but rather indicated a reorganization of how activity in the network was coordinated. Moreover, the interaction structure would reorganize if the effector was changed to a different neuron, i.e. that neuron would become more tightly coupled as the monkey relearned the task. These results demonstrate that not only are functional network interactions extremely fluid, adapting to changing environmental conditions, but they are also highly specific, targeting information relevant to the task being performed. *This joint senior author paper is in its second review at Cell*.

Distributed Encoding of Associations: I have also shown that higher cognitive functions, such as the formation of sensory-motor associations, are encoded collectively, as spatiotemporal patterns of spikes across frontal networks. *Prof. Ziv Williams (Dept. Neurosurgery HMS)* and I trained monkeys to perform associative learning tasks and then used generalized linear network models to determine which functional structures stored the learned tasks. We found that learned associations are stored collectively, both in precise network-wide patterns of firing rates and in the detailed structure of interactions between neurons. Moreover, these learned representations are robust, with the same patterns of network activity reactivated during later association recall. This *first author study* is amongst the first efforts to study higher cognitive function with respect to collective network activity rather than by single units or mean field activity such as recorded by fMRI and is being *prepared for submission to Nature*.

Interactions Between Stimuli and Ongoing Cortical States: Cortical networks are spontaneously active, with afferent stimuli subtly modulating their internal states, not driving them. Such interactions represent computation, and can be observed even at the mean field level as *Prof. Anna Devor (Dept. Neuroscience, UCSD)*, *Prof. Christopher Moore (Dept. Neuroscience, Brown University)* and I showed using (extracellular) field potential (LFP) and multi unit (spiking) activity (MUA) recorded in rat barrel (whisker) cortex. Anesthetized cortex exhibits slow (~1Hz) LFP oscillations generated by the synchronized hyper and de-polarization of neurons. I showed that the phase of these collective state changes (oscillations) strongly alters the MUA response to whisker deflection. Thus the interaction between stimuli and internal state is a complex dynamic process. Prior studies only considered the 'static' hyper and depolarization of neurons. *This first author paper appeared in: the Journal of Neurophysiology 96:1658 (2006)*.

Collective Processing of Natural Scenes Vision: Canon holds that V1 neurons are driven by stimuli in small regions of the visual field (classical receptive field, CRF). In collaboration with *Prof. Gordon Pipa (Dept. Neuroinformatics, U. Osnabruck, Germany)* and *Prof. Sergio Neuenschwander (Brain Institute, UFRN, Natal, Brazil)*, I devised a protocol to determine how strongly V1 macaque neurons are driven by the surround (region outside CRF) of natural scenes stimuli. Using a statistically rigorous GLM model and deviance analysis, I found that V1 neurons respond dramatically and dynamically to natural stimuli outside the CRF. Further, high frequency oscillations in the collective state (LFP) induce a precise timing to the spike response. CRF stimuli are, in fact, responsible for only a small part (4%) of a V1 neuron's drive. These results show that naturalistic stimuli are processed collectively, using the full network dynamics and have profound implications for theoretical studies of vision (often CRF based) *This first author paper is in second review at PLoS One*.

Developing New Statistical Methodologies

Beyond Second Order Correlations: In addition to my experimental collaborations, I have developed novel techniques for detecting higher order collective structure in neuronal population activity. In collaboration with *Prof. Emery Brown (Dept. Brain and Cog. Sciences, MIT)* I developed a machine learning based algorithm that deduces how complex *patterns* of spikes, across a population, encode stimuli. I used a regression tree to hierarchically cluster patterns with similar encoding properties into groups much smaller in number than the original patterns (which scale as 2^N). This dimensionality reduction approach produces an encoding model that embraces the higher order pattern complexity but avoids the combinatorial problem. We used this method to show that populations of cat primary visual cortex (V1) neurons encode visual (grating) stimuli collectively using precise patterns of activity (synchronized spike doublets and triplets). This shows that networks code via their full dynamical structure, not just their pairwise interactions. *This first author paper is in review at Neural Computation.*

Computation by Spike Trains: *Prof. Cosma Shalizi (Dept. Statistics, Carnegie Mellon)* and I used a similar approach to cluster temporal patterns of rat barrel cortex neuron spikes based upon how they predicted the neurons' future spiking. The clusters are predictive, represent different internal dynamical states of the neuron, and can be used to make a hidden Markov model (HMM) of the spike generation process. We used the HMM to quantify the computation (dynamically informative structure), in the information theoretic sense, being performed by neurons that were stimulated by whisker deflection. *This first author paper appeared in: Neural Computation 22:121 (2010)*. This and the previous study address a fundamental analysis problem: reducing the dimensionality of spatio-temporal spike patterns large populations express.

Statistical Tests of Model Quality: Statistical models must be tested for goodness of fit. I realized that a commonly used goodness of fit test (time rescaling) for spike trains only applied to instantaneous events in continuous time. Spikes are not instantaneous events (~ms width) and are commonly binned prior to modeling. I realized that this discrete/continuous time distinction was preventing accurate model evaluation. I developed a discrete time version of the rescaling theorem that corrects for binning. This new test is as easy to apply as the continuous time version, is directly applicable to any experimental study of neuronal spiking, and was *published as a first author paper in: Neural Computation 22:2477* (2010). In collaboration with *Prof. Gordon Pipa (U. Osnabruck, Germany)* I also extended the time rescaling test from single neurons to populations of neurons. *This second author paper was also published in Neural Computation 23:1452 (2011).*

Future Plans

The study of biological systems, such as the brain, must be firmly guided by experiment. At the same time, experiments are more fully understood through rigorous data analysis, and theoretical interpretation. I can provide Brown with a research program that not only develops (and through collaboration with experimentalists applies) statistically rigorous network analysis methodologies, but also seeks to explain (by leveraging my complex systems and physics backgrounds) how neuronal networks self-organize their dynamics to learn. I propose three interconnected foci.

Focus 1) Detecting Computationally Relevant Network Structure: A crucial challenge for neuroscience is to detect, in large networks (>100 neurons), the collective dynamics that represent stimuli or cognitive function. Building upon my prior work using GLMs and machine learning/regression tree algorithms to analyze network data, I will lead an effort to develop new methodologies that identify computationally relevant collective structure in population data. Crucial questions to be addressed are 1) How can collective functional structures (for example network interactions) which co-vary with stimuli, and therefore encode, be distinguished from collective structures that are merely present (noise correlations) and therefore do not encode? 2) When are higher (than second order) interactions important for coding and how much data is needed to reliably evaluate this? 3) Can the dimensionality of network activity be reduced by identifying sub-networks that carry the majority of encoding relevant information and are these sub-networks stable or distinct across stimuli?

Focus 2) Tracking Changes in Network Representation: A second challenge is to understand how the network structures of focus 1 evolve as new information is learned and/or as network state (LFP, attentional etc.) or function changes. My work with Prof. Williams suggests that network structure adapts to learn new functions, and that learned structures persist over time. Crucial questions to be addressed are 1) How can *changes* in network interactions/structure (under different conditions, stimuli, attentional, etc.) be identified as statistically significant? 2) How can such changes be smoothly tracked over time, and related to external covariates such as time-varying stimuli of changing cortical states (as perhaps reflected by LFP rhythms)? I previously demonstrated that LFPs can induce strong changes in the cortical MUA response to stimuli *J. Neurophysiol. 96:1658 (2006)* and am currently advising a student in a project to track changes in primate frontal functional network structure induced by different LFP dynamics. Focus 2 builds upon this work.

Focus 3) Learning through Self-organization of Recurrent Networks: Computation is a dynamic process requiring a continuous stream of information to be integrated with that already stored in a network's ongoing dynamics (working memory). Reservoir computers model large recurrent spiking networks that self organize their dynamics, via synaptic plasticity, to support complex information processing and persistent memory. Based upon my prior work in the self-organization of complex systems *Phys. Rev. Lett. 93:118701 (2004)* and via a new collaboration with *Prof. Claudio Mirasso (CSIC-UIB, Palma de Mallorca, Spain) and Prof. Gordon Pipa* I will use the reservoir framework to theoretically address the questions. 1) What functional network structures (recurrent dynamics) stably store information, how do they evolve as memory fades and how universal are they to changes in anatomical connectivity or neuronal heterogeneity? Are these same structures observed in experiment? 2) Do collective mean field dynamics (brain rhythms/LFPs) facilitate computation, perhaps by enforcing a collective timing code, or do they degrade computation, by synchronizing the network, and reducing its computational complexity? This focus's central goal is to provide a deeper theoretical underpinning for the first two experimentally driven foci.

Teaching Statement: Robert Haslinger

I believe that the most effective teaching emphasizes intuition first. Rigorous mathematical and scientific details are easier to grasp when the student first understands what the overarching concepts are and even the most complicated ideas can have simple intuition behind them. I have found this approach to be particularly effective when training students from experimental backgrounds in computational neuroscience or neuroscientific data analysis.

Prior Teaching Experience

Formal Teaching Experience: My first experience with formal teaching was as a graduate teaching assistant of Physics (to both engineers and pre-medical students) at the University of Wisconsin. I wrote and gave recitation sessions, conducted laboratories, wrote and graded homework and exams and counseled students.

More recently I co-instructed a graduate level Neural Dynamics class at MIT. I wrote and gave lectures, led didactic discussions, and mentored students on their class projects. Many of the students were from experimental backgrounds so the course focused on practical techniques to quantify the dynamics of neural data students recorded in the laboratory.

Summer Course in Neuroinformatics: I am co-directing (along with Professor Gordon Pipa of the University of Osnabruck) a weeklong summer course in neuroinformatics to be held in Germany during July 2012. *http://www.advanced-stat-modeling.de/* This course is funded by an International Neuroinformatics Coordinating Facility (ICNF) grant (co-PI). The course will instruct an interdisciplinary group of experimentalists and theorists in data analysis techniques (for single cells, networks and whole brain imaging) that have proven useful in the neurosciences.

***Mentoring*:** My first mentee was an experimentalist needing guidance on analyzing firing activity in the dorsal lateral geniculate nucleus of mice (dLGN), during viewing, lid closure and retinal activation. The goal was to show that lid closure did not eliminate retinal activity and that the retina and dLGN continued to exchange information. I tutored the student until she could carry out the statistical analyses necessary to validate this result. *Linden et.al. Nat. Neurosci 12:390 (2009)*.

More recently I trained a student lacking a strong mathematical background in population encoding and decoding models. We iterated tutoring with her reading papers and texts until she was could implement such models in her thesis work on the neuronal origins of anesthesia. She is also a co-author of mine on a pending Neural Computation paper.

I am currently training a visiting Ph.D. student from Spain in the statistical analysis of neuronal networks. We are researching how the functional structure of primate frontal networks evolves with (LFP reflected) changes in cortical state.

Outreach: For several years I have judged the Boston Science Fair. It is inspiring to see enthusiasm that young students (middle & high school) have for science. Secondary school outreach will be an important part of my future teaching effort.

Future Teaching Interests

Trained as a physicist, I spent much of my graduate and postdoctoral years at interdisciplinary research centers (the Santa Fe Institute for Complex Systems and the Center for Non-linear Studies at Los Alamos) before transitioning to computational neuroscience. Thus my scientific background and interests are broad and multidisciplinary (neuroscience, statistics, complex systems, and physics) and I am accustomed to teaching students from a wide range of backgrounds.

One course I'd like to develop at the undergraduate level is ***computational neuroscience from a data centered viewpoint***. Too often, theoretical insights are not properly translated into experimentally testable hypotheses. I envision this course as divided into three parts; modeling the biophysics of neurons and synaptic plasticity; encoding and decoding by single neurons and networks; learning by neurons and networks. These topics will be presented theoretically and then studied in Matlab or Python based computational laboratories using real data. E.g., when studying neuronal biophysics, the students will also fit statistical spiking (Generalized Linear) models to data and investigate how different biophysics are revealed by analyses useful for actual experiments. As another example, students will contrast different neural coding schemes (rate versus timing, or independent neuron versus collective population) both from the theoretical perspective of tuning curves and Fisher information and also by fitting encoding models to real data and applying Bayesian and state space decoding methods. This class aims to help experimentalist students think more abstractly about the implications of their experiments, and give theoreticians an appreciation for the complexity of real data so that their theories are testable.

I would also enjoy developing a ***graduate level neuroinformatics course*** emphasizing network (spiking and whole brain) analysis. The first half of this class would address standard topics: regression basics, generalized linear models and the Bayesian framework; point process models for describing single neurons and whole populations, model selection and goodness of fit measures; state space methods for describing hidden variables such as ongoing cortical states; inferring functional connectivity between brain regions. The second half will address newer methodologies; techniques for relating data from different spatial and temporal scales (spikes, LFPs, EEGs, hemodynamic responses etc.); and dimensionality reduction and data mining techniques (regression trees, support vector machines etc.) useful for analyzing large networks. The above described summer course in neuroinformatics will be used as the basis for this course