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April 27, 2012

Professor David Sheinberg
Search Committee Chair
Department of Neuroscience
Brown University
Providence, RI

Dear Professor Sheinberg:

I would like to apply for the tenure-track position in Computational Neuroscience in the Department of Neuroscience at Brown University. My formal education is in Theoretical Physics and Applied Mathematics, and I received my PhD from the University of Western Australia. I have spent the last seven years completing post-doctoral work in Mathematical Neuroscience at the University of Sydney, and in Computational Neuroscience and Neural Computation at Los Alamos National Laboratory.

My research combines dynamical systems theory with techniques from machine learning, information theory, signal processing, Bayesian inference, and probabilistic models of natural sensory data to address outstanding and interesting problems in Computational Neuroscience. I am particularly interested in neural processing of sensory information, and in the role of representations in cognition and high-level vision. I have published some of my work in high-impact journals, and given invited talks and seminars.

I have found teaching and research supervision to be a demanding, but positive and rewarding experience. My current approach to teaching and supervision is primarily derived from attending lectures and seminars, lecturing to first-year students, co-supervising a PhD student, and attending a teacher-training course. I feel capable of taking up the challenge of teaching and student supervision at Brown University.

In addition to my research and teaching responsibilities, I have been the organizer of regular seminar series run in the School of Physics at the University of Sydney, and in the Center for Nonlinear Studies at Los Alamos National Laboratory.

Given the chance to work in the Department of Neuroscience at Brown University, I would continue with my current research, and I would initiate new collaborations with faculty at Brown University. This would allow me to take advantage of local expertise and build upon my own expertise developed during my PhD and postdoctoral positions. I would also look forward to mentoring graduate students and starting up an independent research group.

Thank you for your consideration. I look forward to hearing from you regarding my application.

Yours sincerely,

Peter Loxley

encl: Research Statement, Teaching Statement, Curriculum Vitae, and three representative publications.

Peter N Loxley

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Education

- Ph.D. (2005), Physics,
  The University of Western Australia, WA, Australia.
- Hons. 1st Class (1998), Physics,
  The University of Sydney, NSW, Australia.
- B.Sc. (1996), Chemistry and Physics
  Murdoch University, WA, Australia.

Prizes and Awards

- *Inaugural Societies of Australia Eureka Prize for Interdisciplinary Research* (2003).

  I received a share of this prize for my contribution towards the winning 2003 entry "For outstanding and ground-breaking research in the development of the first successful model of generation of brain electrical activity".
- *Australian Postgraduate Award* (1999-2002).

  This scholarship funded my PhD studies.
- *Shiroki Prize* (1998)

  I received this prize for the best Physics Honours project at University of Sydney in 1998.

Employment

- Postdoctoral Research Fellow (2009-2012)
  Center for Nonlinear Studies, Theoretical Division, Los Alamos National Laboratory.
- Postdoctoral Research Fellow (2005-2008)
  Complex Systems Group, School of Physics, The University of Sydney.
- Casual Lecturer (2002)
  School of Physics, The University of Western Australia.

Teaching

- Associate PhD supervisor: supervisor for Hal Henke at The University of Sydney (2006-2008).
- Lecturer: 10 lectures and exam for the 1st year course *Conceptual Physics*, at The University of Western Australia (2002).
- Attended Foundations of University Teaching and Learning program at The University of Western Australia (2002).

Professional Activities

- Organizer: *Center for Nonlinear Studies Postdoctoral Seminar Series*, Center for Nonlinear Studies, Theoretical Division, Los Alamos National Laboratory, USA (2010-2011).
- Organizer: *Complex Systems Seminar Series*, School of Physics, The University of Sydney, Australia (2006-2008).
- Member of the National Institute for Theoretical Physics.
- Journal Refereeing: most recently for Journal of Applied Physics, and Physica B.

Technical Expertise

- Methods and Techniques: Mathematical Analysis, Dynamical Systems, Statistical Mechanics, Field Theory, Machine Learning, Bayesian Inference, Probabilistic Generative Models.
- Programing Languages: Matlab, C++, Fortran, Octave, Python.

Summer Schools and Courses Attended

- *Introducing Monte Carlo Methods with R* at Hilton Santa Fe Historic Plaza (2012).
- Institute for Pure and Applied Mathematics (IPAM) summer school on *Probabilistic models of cognition* at the University of California, Los Angeles (2011).

Invited Presentations

- Invited speaker: "Center for Nonlinear Studies Review", Los Alamos National Laboratory, USA (2010).
- Invited speaker: "Synthetic Cognition Group", Los Alamos National Laboratory, USA (2008).
- Invited speaker: "International Workshop on Magnetic Wires", San Sebastian, Spain (2001).

Conference Presentations and Presented Talks

- Poster presentation for "Grand Challenges in Neural Computation 2", Santa Fe, New Mexico, USA (2011).
- Postdoctoral Seminar, Center for Nonlinear Studies, Los Alamos, New Mexico, USA (2010).
- Postdoctoral Seminar, Center for Nonlinear Studies, Los Alamos, New Mexico, USA (2009).
- Poster presentation for "Inaugural Queensland Brain Institute Workshop on Mathematical and Computational Neuroscience", Brisbane, Australia (2006).
- Oral presentation for "Twelfth Gordon Godfrey Workshop on Condensed Matter Physics", Sydney, Australia (2002).
- Oral presentation for "The 8th Joint MMM-Intermag Conference", San Antonio, Texas, USA (2001).
- Oral presentation for "Australian Institute of Physics Postgraduate Conference" (WA branch), Pinjarra, Australia (1999).

Refereed Publications

10. P. N. Loxley, L. M. A. Bettencourt, and G. T. Kenyon, "Ultra-Fast detection of salient contours through horizontal connections in the primary visual cortex", *Europhysics Letters* **93**, 64001 (2011).
9. P. N. Loxley and P. A. Robinson, "Soliton Model of Competitive Neural Dynamics during Binocular Rivalry", *Physical Review Letters* **102**, 258701 (2009).
8. H. Henke, P. A. Robinson, P. M. Drysdale, and P. N. Loxley, "Spatiotemporal dynamics of pattern formation in the primary visual cortex and hallucinations", *Biological Cybernetics* **101**, 3 (2009).
7. P. N. Loxley, "Rate of magnetization reversal due to nucleation of soliton-antisoliton pairs at point-like defects", *Physical Review B* **77**, 144424 (2008).
6. P. N. Loxley and P. A. Robinson, "Energy approach to rivalry dynamics, soliton stability, and pattern formation in neuronal networks", *Physical Review E* **76**, 046224 (2007).
5. P. N. Loxley and P. A. Robinson, "Spike-rate adaptation and neuronal bursting in a mean-field model of brain activity", *Biological Cybernetics* **97**, 113 (2007).
4. P. N. Loxley and R. L. Stamps, "Theory for nucleation at an interface and magnetization reversal of a two-layer nanowire", *Physical Review B* **73**, 024420 (2006).

3. P. N. Loxley, "A graphical technique for finding equilibrium magnetic domain walls in multilayer nanowires", *Journal of Magnetism and Magnetic Materials* **249**, 187 (2002).

2. P. N. Loxley and R. L. Stamps, "Theory of domain wall nucleation in a two section magnetic wire", *IEEE Transactions on Magnetics* **37**, 2098 (2001).

1. P. A. Robinson, P. N. Loxley, S. C. O'Conner, C. J. Rennie, "Modal analysis of corticothalamic dynamics, electroencephalographic spectra, and evoked potentials", *Physical Review E* **63**, 041909 (2001).

References

1. Robert Ecke (Director of CNLS)
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   Theoretical Division,
   Los Alamos National Laboratory.
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2. Luis Bettencourt (Sponsor)
   Santa Fe Institute
   `bettencourt@santafe.edu`
   +1-505-984-8800

3. Peter Robinson (Sponsor)
   School of Physics,
   The University of Sydney.
   `robinson@physics.usyd.edu.au`
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Research Statement

Peter Loxley

My research combines dynamical systems theory with techniques from machine learning, information theory, signal processing, Bayesian inference, and probabilistic models of natural sensory data to address outstanding and interesting problems in Computational Neuroscience. I am particularly interested in neural processing of sensory information, and in the role of representations in cognition and high-level vision. Given the chance to work in the Department of Neuroscience at Brown University, I would continue with my current research, and I would initiate new collaborations with faculty at Brown University. This would allow me to take advantage of local expertise and build upon my own expertise developed during my PhD and postdoctoral positions. I would also look forward to mentoring graduate students and starting up an independent research group.

The first research I undertook as a graduate student (1998) was to contribute to the development of a neurophysiologically-based model of EEG (electroencephalographic) spectra and ERPs (evoked response potentials) being developed at the University of Sydney. Through a mechanism involving delayed feedback of neural activity between the cortex and thalamus, our model reproduced the main cortical rhythms seen in awake and sleeping humans. This model was later used to investigate the onset and spread of epileptic seizures and to reproduce EEG spectra of petit mal and grand mal seizures. For this work, I received the Shiroki Prize in 1998; and in 2003 our group received the Inaugural Societies of Australia Eureka Prize for Interdisciplinary Research.

My doctoral work (1999-2004) was in the area of theoretical condensed-matter physics, and was completed in the School of Physics at the University of Western Australia. I applied non-perturbative techniques from quantum field theory in an effort to understand the statistical mechanics of thermally-activated nucleation leading to magnetization reversal in nanoscale ferromagnets. Some of my predictions were later confirmed and investigated further in computational models by researchers in the magnetic recording industry who were working on novel media for high-density magnetic memory devices. This work gave me a solid theoretical background to pursue a career in Computational Neuroscience.

My first postdoctoral position (2005-2008) was in the School of Physics at the University of Sydney, where I worked on an ARC-funded research project that involved modeling the dynamics of neural activity in the primary visual cortex. My first project was to include a mechanism for spike-rate adaptation in a neural population rate-based model. Introducing this mechanism allowed me to investigate neural processes that take place on both fast and slow timescales. I was particularly interested in modeling binocular rivalry: a perceptual phenomena that correlates with neural dynamics taking place in the primary visual cortex that is observable with fMRI and other brain imaging techniques. My work resulted in the first model able to describe the transition from binocular fusion to binocular rivalry as the visual stimulus is varied. I also discovered two alternative types of competitive neural dynamics that can take place during binocular rivalry. During this time, I also contributed to work on modeling the spontaneous formation of patterns of neural activation resulting from drug-induced visual hallucinations.

With this model we managed to reproduce some of the Klüver form constants used to qualitatively describe visual hallucinations.

My second postdoctoral position (2009-2012) was in the Center for Nonlinear Studies, part of the Theoretical Division at Los Alamos National Laboratory. The first project I worked on was constructing a neural model of the primary visual cortex that could reproduce some of the results we were seeing in rapid object detection tasks. These tasks were a series of psychophysics experiments conducted by our group on volunteer students. The model I constructed made use of physiologically-parameterized horizontal connections that are present in the primary visual cortex. I applied techniques from signal detection theory to show how well this model could discriminate between different "objects" used in the psychophysics experiments, and showed that it could reproduce human-like performance on ultra-fast time scales.

My current work is in the area of neural computation, and is concerned with understanding the functionality of neural circuits: what computation the circuits are performing, and how they process sensory information to achieve it. A technique called sparse coding leads to the development of receptive fields similar to those measured for simple and complex cells, and to the topographic arrangement of receptive fields found in many cortical maps, by learning from data consisting of natural image patches. I have used natural image patches and sparse coding to learn the parameters of Gabor functions. These functions are used in neuroscience to quantify simple and complex-cell receptive fields, tuning curves, and feature preferences. In my case, the Gabor functions also form a wavelet basis that is used to represent retinal images formed from visual input. The statistics (i.e. histograms) of the Gabor parameters contain potentially testable information about the distribution of simple-cell orientation preferences and spatial frequencies that would be optimal for capturing the statistics of natural image data in a compact representation. This representation is close to optimal for isolating the different sources contributing to a particular image.

If I had the opportunity to join the Department of Neuroscience at Brown University, I would continue my current research, and I would also take advantage of the research interests and expertise of faculty at Brown University by initiating new collaborations. My current collaborators include: Jascha Sohl-Dickstein from the *Redwood Center for Theoretical Neuroscience* at UC Berkeley; Peter Robinson from the *University of Sydney*; Garrett Kenyon from *Los Alamos National Laboratory*, and Luis Bettencourt from the *Santa Fe Institute*. Direct fits with neuroscience faculty at Brown include Professors Paradiso, Sheinberg, Bienenstock, and Donoghue. However, I would also welcome the opportunity to collaborate with other neuroscience faculty at Brown. I would look forward to the challenge of mentoring students in the Neuroscience Graduate Program, and helping them achieve their potential in research—I have been a member of many different research groups, and have been actively involved in helping fellow group members develop their research ideas. I have previous experience writing research grants (as a PI, and as a collaborator) for bodies such as the Australian Research Council (Future Fellowship); the Department of Energy Office of Science (BES); and LANL internal competitive grants for basic science (LDRD-ER). My plan would be to draw on this experience to build a strong and dynamic research program in Computational Neuroscience at Brown University.

Teaching Statement

Peter Loxley

My current approach to teaching and research supervision is primarily derived from attending lectures and seminars, lecturing to first-year students, co-supervising a PhD student, and attending a 3-day teacher-training course on the foundations of teaching and learning. To me, attempting to teach well always feels like a work in progress, requiring constant self-assessment and trying out new ideas.

I have found that attending lectures, and lecturing to first-year students has motivated me to work hard at delivering material in a pedagogical and engaging manner, and provided me with what I consider to be some of the basics for a successful presentation. These include: taking the time to be well prepared, keeping to the time limit, presenting information in a logical and coherent way, making the presentation as self-contained as possible, and making it interesting in content and perhaps provocative or memorable in some way. I have also experimented with different ways to keep the attention of first-year students who weren't always committed to the course material. I found that varying the medium of delivery seemed to help in this respect. For example, I tried alternating between presenting overhead slides, going through worked examples on the board by hand, giving active demonstrations of some of the key principals, showing computer simulations, and asking for class participation. Test results for my component of the course were generally good—indicating that most students had managed to grasp the course content either through the lectures and course notes I provided or through self-study. I also received positive verbal feedback from some students about my delivery of the course material.

My previous teaching experience includes preparing and delivering 10 one-hour lectures (a half semester) on conceptual physics to a group of approximately 50 medical students while I was a graduate student at the University of Western Australia. I also wrote the exam for this section of the course. At Brown University, I could teach courses related to my research on computational neuroscience and neural computation, neural modeling and dynamics, signal processing, probabilistic models and Bayesian inference, machine learning, and scientific computing. I could also teach foundational courses in Physics and Applied Mathematics.

I have co-supervised a PhD student (Hal Henke) during my postdoctoral position in the School of Physics at the University of Sydney. We worked together extending mathematical models of pattern formation to describe neural activation patterns that take place during visual hallucinations. I helped Hal to decide which problems he should address according to how significant they were, and whether they would be possible for him to make progress on. During this time we met regularly to discuss progress and difficulties. This work culminated in a joint publication together. Hal went on to receive his PhD after I left to start my second postdoctoral position.

Overall, I have found teaching and supervising to be highly demanding, but also a positive and rewarding experience. I feel I would be capable of taking up this challenge at Brown University.