

Paul Miller: Curriculum Vitae

email: pmiller@brandeis.edu URL: <http://people.brandeis.edu/~pmiller>

Positions and Employment

- 2014-2017 **Associate Professor of Biology**, Brandeis University, Waltham, MA.
Designed & Taught Dynamical Systems and Computational Neuroscience.
- 2007-2013 **Assistant Professor of Biology**, Brandeis University, Waltham, MA.
Taught Computational Neuroscience; Designed and taught Principles of Biological Modeling; co-taught Stochastic Processes (MATH56); led Systems/Computational Neuroscience Journal Club.
Mentored 5 Ph.D. students (three in neuroscience, two in physics).
6 journal publications (+ 3 under review), 5 (+3) as corresponding author;
1 book chapter
Neuroscience Undergraduate Advising Head and Liaison for Study Abroad
Co-PI on IGERT Theory Grant, with ongoing participation in cross-disciplinary training through both the IGERT Theory and the Quantitative Biology program.
- 2006-2007 **Lecturer in Biology**, Brandeis University, Waltham, MA
Taught Computational Neuroscience and Computational/Systems Neuroscience Journal Club. (1 publication)
- 2000-2006 **Postdoctoral Research Fellow**, Department of Physics, Brandeis University, Waltham (supervised by Professor Xiao-Jing Wang, who is now at Yale University).
Neuroscience: Modeling of cognitive processes. (4.5 publications)
Developed and investigated models of working memory and decision-making using computational models of spiking neurons.
Compared the different effects of noise on discrete short-term memory states with its effect on a continuous memory state via simulations and mathematical analysis.
Neuroscience: Modeling biochemical reactions. (1.5 publications)
Analyzed and simulated stochastic reactions to determine the stability of a molecular switch, based on protein phosphorylation, for long-term memory in the brain.
Management: Organized the purchasing and installation of a 43-node Beowulf computer cluster.
Teaching: Taught the sophomore physics course "Oscillations and Waves".
- 1997-2000 **Postdoctoral Research Fellow**, Department of Physics, Georgetown University, Washington, DC
Physics and mathematical/computational methods. (9 publications)
Developed analytical and numerical modeling skills by solving problems with strongly-coupled superconductors and Josephson junctions.
Training: Attended a graduate class on computational neuroscience.

Teaching: Taught and supervised students as a teaching assistant and co-instructor in a novel course, 'The Quantum World Around Us' primarily for non-scientists.

- 1994-1995 **Postdoctoral Research Fellow**, Department of Physics, University of Bristol, U.K. Developed a semiclassical theory for superconductors in a magnetic field. (1 publication).
- 1995-1996 **Teaching and Head of Science**, Nkhotatkota Secondary School, Malawi. Headed the Science Department, and taught Mathematics, Physical Science and English at secondary level, working for Voluntary Service Overseas (U.K.).
- 1994 **Research placement**, Oak Ridge National Laboratory, USA. Extensive use of the Intel IPSC/5 massively parallel supercomputer, for modeling of superconductors in a magnetic field during my Ph.D. (1 publication)
- 1987-1988 **Student Researcher**, G.E.C. Hirst Research Centre, Wembley, U.K. Produced and tested high-T_c superconductor samples; developed software for automation of the testing process. (4 publications)

Education

Ph.D. in Physics: Oct 1991 - Oct 1994 (awarded Dec.1994) University of Bristol, U.K. Completed a Ph.D. in the Theory Group, entitled 'De Haas - van Alphen oscillations in the vortex state', supervised by Prof B. L. Györfy.

Undergraduate: Oct 1988 - Jul 1991. Cambridge University, Peterhouse, U.K. B.A. Honors course in Natural Sciences, specializing in Physics and Theoretical Physics. Awarded a **scholarship** each year, and graduated with **1st Class Honors**.

Publications

46. Christie IK, Miller P, Van Hooser SD: Cortical amplification models of experience-dependent development of selective columns and response sparsification. J Neurophysiol 118:874-893 (2017).
45. Cannon J, Miller P: Stable control of firing rate mean and variance by dual homeostatic mechanisms. J Math Neurosci 7:1 (2017).
44. Cannon J, Miller P: Synaptic and intrinsic homeostasis cooperate to optimize single neuron response properties and tune integrator circuits. J Neurophysiol 116:2004 (2016).
43. Miller P: Dynamical systems, attractors, and neural circuits. F1000Res. Faculty Rev-

992 (2016).

42. Miller P: Itinerancy between attractor states in neural systems. *Curr Op Neurobiol* 40:14 (2016).

41. Sadacca BF, Mukherjee N, Vladusich T, Li JX, Katz DB, Miller P: The behavioral relevance of cortical neural ensemble responses emerges suddenly. *J Neurosci* 36:655 (2016).

40. Sountsov P, Miller P: *Spiking neuron network Helmholtz machine*, *Frontiers in Computational Neuroscience* 9:46 (2015).

39. Van Hooser SD, Escobar GM, Maffei A, Miller P: *Emerging feed-forward inhibition allows the robust formation of direction selectivity in the developing ferret visual cortex*. *J Neurophysiol* 111:2355-2373 (2014).

38. Cousins KAQ, Dar JH, Wingfield A, Miller P: *Acoustic masking disrupts time-dependent mechanisms of memory encoding in word-list recall*. *Memory & Cognition* 42:622-638 (2014).

37. Miller P: *Decision Making, Models*. In: Jaeger D., Jung R. (Ed.) *Encyclopedia of Computational Neuroscience: SpringerReference* (Springer-Verlag Berlin Heidelberg, 2013. DOI: 10.1007/SpringerReference_348377).

36. Miller P: *Decision Making, Threshold*. In: Jaeger D., Jung R. (Ed.) *Encyclopedia of Computational Neuroscience: SpringerReference* (Springer-Verlag Berlin Heidelberg, 2013. DOI: 10.1007/SpringerReference_348377).

35. Miller P: *Stabilization of memory states by stochastic facilitating synapses*. *J Math Neurosci* 3:19 (2013).

34. Miller P: *Stimulus number, duration and intensity encoding in randomly connected attractor networks with synaptic depression*, *Front Comput Neurosci*. 7:59 (2013).

33. Vogels TP, Froemke RC, Doyon N, Gilson M, Haas JS, Liu R, Maffei A, Miller P, Wierenga CJ, Woodin MA, Zenke F, Sprekeler H: *Inhibitory synaptic plasticity: spike timing-dependence and putative network function*, *Front Neural Circuits* 7:119 (2013).

32. Miller P, Katz DB: *Accuracy and response-time distributions for decision-making: linear perfect integrators versus nonlinear attractor-based neural circuits.*, *J Comput Neurosci* 35:261 (2013).

31. Bourjaily M, Miller P: *Dynamic afferent synapses to decision-making networks improve performance in tasks requiring stimulus associations or discriminations*. *J Neurophysiol*, *J Neurophysiol* 108:513 (2012).

30. Miller P, Bourjaily M: *Excitatory, inhibitory and structural plasticity produce correlated connectivity in random networks trained to solve paired-stimulus tasks*. *Front Comput Neurosci* 5:37 (2011).

29. Bourjaily M, Miller P: *Synaptic plasticity and network connectivity requirements to produce stimulus-pair specific responses in recurrent networks of spiking neurons*. PLoS Comput Biol, 7:e1001091 (2011).
28. Miller P, Katz DB: *Stochastic transitions between states of neural activity*. In "The Dynamic Brain: An Exploration of Neuronal variability and Its Functional Significance", edited by Ding M and Glanzman DL, Oxford University Press (2011).
27. Piqado T, Cousins KC, Wingfield A, Miller P: *Effects of degraded sensory input on memory for speech: Behavioral data and a test of biologically constrained computational models*. Brain Res 1365:48-65 (2010). PMID: 20875801
26. Miller P, Wingfield A: *Distinct effects of perceptual quality on auditory word recognition, memory formation and recall in a neural model of sequential memory*. Front Syst Neurosci 4:14 (2010). PMID: 20631822
25. Miller P, Katz DB: *Stochastic transitions between neural states in taste-processing and decision making*. J Neurosci 30:2559-70 (2010). PMID: 20164341
- 24 Jun JK, Miller P, Hernández A, Zainos A, Lemus L, Brody CD, Romo R: *Heterogeneous population coding of a short-term memory and decision task*. J Neurosci 30:916-29 (2010). PMID: 20089900
23. Jones LM, Fontanini A, Sadacca BF, Miller P, Katz DB: *Natural stimuli evoke dynamic sequences of states in sensory cortical ensembles*. PNAS 104:18772-7 (2007) PMID: 18000059.
22. Miller P, Wang X-J: *Stability of discrete memory states to stochastic fluctuations in neuronal systems*. Chaos 16:026109 (2006) PMID: 16822041.
21. Miller P, Wang X-J: *Inhibitory control by an integral feedback signal in prefrontal cortex: a model of discrimination between sequential stimuli*. PNAS 103:1268-1317 (2006) PMID: 16371469.
20. Miller P, Wang X-J: *Power-law neuronal fluctuations in a recurrent network model of parametric working memory*. Journal of Neurophysiology 95:1099-1114 (2006) PMID: 16236788.
19. Miller P: *Analysis of spike statistics in neuronal systems comparing a continuous attractor with multiple, discrete states*. Neural Computation 18:1268-1317 (2006) PMID: 16764505.
18. Miller P, Zhabotinsky AM, Lisman JE, Wang X-J: *The stability of a stochastic CaMKII switch: dependence on the number of enzyme molecules and protein turnover*. PLoS Biology 3:e107 (2005) PMID: 15819604.

17. Miller P, Brody CD, Romo R, Wang X-J: *A recurrent network model of somatosensory parametric working memory in the prefrontal cortex*. Cereb Cortex 13:1208-1218 (2003) PMID: 14576212.
16. Freericks JK, Nikolić BK, Miller P: *Temperature dependence of Superconductor-Correlated Metal-Superconductor Josephson junctions*. Applied Physics Letters 82:970-972 (2003). Virtual Journal of Applications of Superconductivity Vol.4, Issue 4 (2003). Erratum: Applied Physics Letters 83:1275 (2003).
15. Nikolić BK, Freericks JK, Miller P: *Suppression of the "quasiclassical" proximity gap in correlated-metal-superconductor structures*. Physical Review Letters 88:77002-1--4 (2002). Virtual Journal of Nanoscale Science & Technology Vol. 5, Iss. 7.
14. Freericks JK, Nikolić BK, Miller P: *Optimizing the Speed of a Josephson Junction with Dynamical Mean Field Theory*. Int. J. Mod. Phys. B 16:531-561 (2002).
13. Nikolić BK, Freericks JK, Miller P: *Equilibrium Properties of Double-Screened-Dipole-Barrier SINIS Josephson Junctions*. Phys. Rev. B 65:064529 (2002); Virtual Journal of Applications of Superconductivity 2 Iss. 3.
12. Nikolić BK, Freericks JK, Miller P: *Reduction of Josephson critical current in short ballistic SNS weak links*. Phys. Rev. B 64:212507 (2001).
11. Freericks JK, Nikolić BK, Miller P: *Tuning a Josephson junction through a quantum critical point*. Phys. Rev. B 64:54511 (2001). Erratum: Phys. Rev. B 68:99901 (2003).
10. Miller P, Freericks JK: *Microscopic self-consistent theory of Josephson junctions including dynamical correlations*. Journal of Physics: Condensed Matter 13:3187-3213 (2001).
9. Freericks JK, Miller P: *Dynamical Charge Susceptibility of the Spinless Falicov-Kimball Model*. Phys. Rev. B 62:10022-10032 (2000).
8. Miller P, Freericks JK, Nicol EJ: *Possible experimentally observable effects of vertex corrections in superconductors*. Phys. Rev. B 58:14498-14510 (1998).
7. Miller P, Györfy BL: *Theoretical Investigations of the Vortex Lattice and de Haas - van Alphen Oscillations in the Superconducting State*. Journal of Physics: Condensed Matter 7:5579-5606 (1995).
6. Litak G, Györfy BL, Miller P: *A recursion method for solving the Bogoliubov Equations for Inhomogeneous Superconductors*. Physica C 251:263-273 (1995).
5. Miller P, Györfy BL, Janko B: *On the Coexistence of Superconductivity and Charge Density Waves*. Physica C 210:343-349 (1993).
4. May PW, Harrison MR, Jedamzik D, Kolinsky PV and Miller P: *Substrate-Temperature Dependence of Thin-Films of BiSrCaCuO Deposited by the Laser Ablation Method*. Superconductor Science and Technology 1:333-335 (1989).

3. May PW, Harrison MR, Jedamzik D, Kolinsky PV, Miller P, Chad RJ: *Superconducting Thick-Films of BiSrCaCuO Deposited Using a Free Lasing Infrared ND-YAG Laser*. Electronics Letters 24:1204-1205 (1988).
2. May PW, Boyle WJO, Harrison MR, Jedamzik D, Miller P: *Superconducting Thick-Films of BiSrCaCuO by 2 Spin-On Methods*. Superconductor Science and Technology 1:71-74 (1988).
1. May PW, Boyle WJO, Jedamzik D, Miller P: *Production of Superconducting Thick-Films by a Spin-On Process*. Superconductor Science and Technology 1:1-4 (1988).

Research Support

Current

- Oct 2014-Oct 2017, PI on Swartz Foundation Grant to Brandeis University
 (funds two postdocs and computational neuroscience training)
 \$135,000 total per year, renewable annually
- Jun 2013-May 2018, 1mth on NIH R01EY02212 (S. Van Hooser, PI)
 Project: *Circuit mechanisms underlying experience-dependent development*"

Completed

- 0.5mths on NSF SBE-0354378 (R. Sekuler, PI) Total Award: \$407,168 over 10 years
 09/01/2004-02/28/2015

Project: *Imitation and human skill learning*

NSF Science of Learning Center grant to Boston University

- P.I. on NIH R01 Grant, DC009145 \$1 360 000 total award, 08/01/2008-07/31/2014.

Project: *Cortical Network Models of Taste Processing: Dynamics and Plasticity*, in collaboration with Don Katz (Psychology, Brandeis).

- Swartz Foundation, \$110 000 total award 09/01/2008-08/31/2010

Project: *Network model for learning associative transitive inference*.

This study is a computational and theoretical investigation of how the connectivity structure and plasticity rules in the cortex and hippocampus leads to different roles for combining information to solve a cognitive task.

- P.I. on NIH K25, MH064497 \$324 318 total award, 12/01/2001-11/30/2006

Mentored Quantitative Research Career Development Award.

Network requirements of parametric working memory

The study is a computational and theoretical investigation of how neurons need to be connected to generate memory of a continuous quantity and enable solution of a vibrotactile frequency discrimination task.

- Oct 1999: Pittsburgh Supercomputer Grant

Self-consistent solutions in superconducting systems (1000hrs).

Training Grants

2011-2016 Co-PI on the IGERY Theory Training Grant, "Geometry and Dynamics".
2011-2021 Key faculty for the T90/R90 NIH Computational Neuroscience Training Grant (Eve Marder PI)

Professional Memberships

1991-1994 Institute of Physics (U.K.)
1997-2000 American Physical Society
2000-2013 Society for Neuroscience (U.S.)

Awards

Dec 2001: Mentored quantitative research career development award from the National Institutes of Health (NIH-NIMH).
Oct 1988-91: Awarded a scholarship each year by Peterhouse, Cambridge (for undergraduate achievement.)

Invited Talks

Taste, temporal coding, attractor processing, and the driving of behavior. AChemS Meeting, Orlando, FL, April 2016.
Information processing in the brain by attractor state itinerancy. SUNY Stonybrook, NY. November 2015.
Computational approaches linking hearing loss and cognitive processing. Society for Neuroscience Meeting, Washington DC, November 2014
Non-sticky attractors in models of cortical processing. Sloan-Swartz Meeting, Seattle, WA June 2014
Structural and functional plasticity combine to enhance performance in initially random networks trained to solve cognitive tasks. Sloan-Swartz Meeting, San Diego, June 2012
Decision-making without perfect integration of evidence: connecting mathematical psychology to biology. IISc, Bangalore, India, June 2012
Slow changes with fast neurons: stochastic transitions in models of taste-processing and decision-making. NCBS, Bangalore, India, June 2012
Behaviorally relevant network states revealed through analysis of trial-to-trial variability in cortical activity CRCNS PI Meeting, St Louis, MO, June 2012
Inhibitory plasticity leads to stimulus-pair selectivity and direction selectivity by cross-inhibition. CoSyNe workshop, Snowbird UT, February 2012.
Memory, associations and solving cognitive tasks by plasticity in randomly connected neural circuits. Learning and Plasticity workshop, Marseilles, France, November 2011.
Linear and nonlinear models of decision-making in neural circuits. CRCNS PI Meeting, Princeton, NJ, October 2011.
A brief history of decision-making models. ICARUS meeting, Watertown, MA, October 2011.
Memory, associations and solving cognitive tasks by plasticity in randomly connected neural circuits. Columbia University, NY, September 2011.
Stochastic transitions between discrete states in models of taste processing and decision-making. Workshop on Dynamic Coding in Neural Signals, Boston University, MA, July 2011.
Biconditional Discrimination via Synaptic Plasticity in Random Networks. Boston University, June 2011.
Say that again. How auditory recall depends on verbal stimulus quality

Volen Retreat, Woods Hole, MA, April 2009.
Slowing down the brain: how do fast neural processes give us time to think?
Quantitative Biology Retreat, Brandeis University, January 2009.
Associativity versus Specificity: learning to solve an Exclusive-Or task via biological plasticity. Physics Department Colloquium, Brandeis September 2008.
Associativity versus Specificity: learning to solve an Exclusive-Or task via biological plasticity. S.I.A.M. Life Sciences Meeting, Montreal, Quebec, August 2008.
Processing and Timing by Stochastic Integration .Mathematical Biology Workshop, Montreal, Quebec, September 2007.
Functions of a Continuous Attractor in Working Memory.
N.I.P.S. workshop December 2006.
Stability to noise fluctuations in memory systems of the brain.
Gordon Research Conference, Tilton, NH, June 2006.
De Haas-van Alphen oscillations in the vortex state.
Condensed Matter and Materials Physics Conference, Leeds, UK, December 1994.
Large-scale simulations of the superconducting vortex lattice.
Massively Parallel Supercomputer Conference, Taormina, Sicily, October 1994.
The Bogoliubov-de Gennes equations in a magnetic field: a chain of vortices.
Bogoliubov-de Gennes Equations Workshop, Bristol University, UK, October 1993.

Contributed Talks

Perceptual decision-making with discrete attractor states rather than linear perfect integrators based on models of taste processing. Decision-Making Workshop, Bristol, UK, Dec 2012.
Recall of word sequences via short-term plasticity in a temporal context model. Swartz Meeting, Cambridge, MA, July 2009.
Associativity versus Specificity in Learning a Sequential Memory Task. Swartz Meeting, Princeton, July 2008.
Taste Processing and Timing by Stochastic Integration. Attractor Dynamics Workshop, Trieste, Italy, June 2008.
Discrimination of Temporally Separated Stimuli by Integral Feedback Control. Sloan Conference, California Institute of Technology, Pasadena, CA, July 2005.
Parametric Working Memory with positively and negatively monotonic tuning curves. Sloan Conference, Boston, MA, June 2002.
Self-consistent equations of current flow in equilibrium Josephson junctions. American Physical Society, Minneapolis, MN, March 2000.
Effects of barrier material on critical current (I_c) in Josephson junctions. American Physical Society, Atlanta, GA, March 1999.
Vertex corrections for the 3D Holstein model. American Physical Society, Los Angeles, CA, March 1998.

Service

Regular reviewer for the National Science Foundation; CNS meeting; CoSyNe meeting; and the following journals: Neuron; Public Library of Science; Cerebral Cortex; Journal of Neurophysiology; Journal of Neuroscience; Frontiers in Neuroscience; Neural Computation; Brain Research; Chaos; Biological Cybernetics; IEEE Trans Neural Networks; Physical Review E; and Journal of Computational Neuroscience.

Associate Editor: Frontiers in Computational Neuroscience.

Curator: Decision Making Section, Encyclopedia in Computational Neuroscience (Springer).

Co-organized the 2013 Sloan-Swartz Meeting for Computational Neuroscience at Brandeis (July 2013).

Co-organized the 2015 Swartz Meeting for Computational Neuroscience at Janelia Farm (August 2015).

Brandeis University Faculty Senate (2015-2018)

Brandeis University Undergraduate Curriculum Committee (2016-2018)

Brandeis University Neuroscience Undergraduate Advising Head (2011-)

Brandeis University Volen Center Steering Committee (2017-)

Contributor to Society for Neuroscience Webinar on Masters Programs in Neuroscience, August 2015.