Richard S. Zemel

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Department of Computer Science
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Degrees

Ph.D., Department of Computer Science, University of Toronto, December, 1993.
Dissertation: *A Minimum Description Length Framework for Unsupervised Learning.*
Supervisor: Dr. Geoffrey Hinton.

M.Sc., Department of Computer Science, University of Toronto, March, 1989.
Dissertation: *TRAFFIC: A Connectionist Model of Object Recognition.*

B.A., Department of History and Science, Harvard University, 1984.
Dissertation: *Old Ideas and New Viewpoints in Artificial Intelligence.*

Employment

2000-	**Dept. of Computer Science, Univ. of Toronto** Assistant Professor
1996-2000	**Dept. of Psychology (joint appointments in Dept. of Computer Science and Cognitive Science), Univ. of Arizona** Assistant Professor
1994 - 96	**Department of Psychology, Carnegie Mellon University** Postdoctoral Fellow
1993 - 94	**Salk Institute, Computational Neurobiology Laboratory** Postdoctoral Fellow
1991 - 92	**Public Optical, Inc.** Consultant (part-time)
1987	**Carnegie Group Inc.** Project Manager
1984 - 86	**Carnegie Group Inc.** Senior Engineer
1982 - 84 (summer)	**Dept. of Computer Science, Carnegie Mellon University** Research Assistant

Honors and Awards

Young Investigator Award, Office of Naval Research, 1998-2002.

National Sciences and Engineering Research Council Postgraduate Scholarship, 1989-1991.

Ontario Graduate Scholarship, University of Toronto, 1989-1990.

U.S. Alumni Fellowship, University of Toronto, 1987-1988.

B.A. degree *magna cum laude*, Harvard University, 1984.

John Harvard Scholarship, 1980-1984.

Richard King Mellon National Merit Scholarship, 1980-1984.

Presidential Scholar, 1980.

Professional Affiliations

Editorial Board

Cognitive Science journal

Encyclopedia of Cognitive Science, MacMillan Publishers

Society Memberships

Society for Neuroscience

Cognitive Neuroscience Society

Research Awards

Principal Investigator, National Sciences and Engineering Research Council Research Grant, 2000-2005. Total award amount: $125,000.

Principal Investigator, Office of Naval Research, Young Investigator Award, 1998-2002. Total award amount: $281,000.

Co-Principal Investigator, National Institutes of Health, Program Project Grant, 1997-2002. PI: J. McClelland. Co-investigator on 2 sections, one with M. Behrmann; other with J. McClelland, R. O'Reilly, & D. Plaut. Total award amount: $1.1M.

Principal Investigator, McDonnell-Pew Program in Cognitive Neuroscience, Postdoctoral Training Grant, 1995-1998. Total award amount: $90,000.

Publications

Articles in Refereed Journals

Zemel, RS & Mozer, MC (2001). Localist attractor networks. *Neural Computation*. In press.

Zemel, RS, Behrmann, M, Mozer, MC, & Bevalier, D (2001). Experience-dependent perceptual grouping and object-based attention. *Journal of Experimental Psychology: Human Perception and Performance*. In press.

Zemel, RS & Pillow, J (2000). Encoding multiple orientations in a recurrent network. *Neurocomputing*, 32-33, pp. 609-616. Preliminary version appeared in: *Proceedings of the 1999 Computational Neuroscience Meeting*.

Behrmann, M, Zemel, RS, & Mozer, MC (2000). Occlusion, symmetry, and object-based attention: Reply to Saiki (2000). *Journal of Experimental Psychology: Human Perception and Performance*, 26:4, pp. 1497-1505.

Pouget, A, Dayan, P, & Zemel, RS (2000). Information processing with population codes. *Nature Reviews Neuroscience*, 1, pp. 125-132.

Zemel, RS, Dayan, P, & Pouget, A (1998). Probabilistic interpretation of population codes. *Neural Computation*, 10:2, pp. 403-430.

Zemel, RS & Sejnowski, TJ (1998). A model for encoding multiple object motions and self-motion in area MST of primate visual cortex. *The Journal of Neuroscience*, 18:1, pp. 531-547.

Behrmann, M, Zemel, RS, & Mozer, MC (1998). Object-based attention and occlusion: Evidence from normal subjects and a computational model. *Journal of Experimental Psychology: Human Perception and Performance*, 24:4, pp. 1011-1036.

Gray, M, Pouget, A, Zemel, RS, Nowlan, SJ, & Sejnowski, TJ (1998). Reliable disparity estimation through selective integration. *Visual Neuroscience*, 15, pp. 511-528.

Zemel, RS & Hinton, GE (1995). Developing population codes by minimizing description length. *Neural Computation*, 7:3, pp. 549-564.

Zemel, RS, Williams, CKI, & Mozer, MC (1995). Lending direction to neural networks. *Neural Networks*, 8:4, pp. 503-512.

Dayan, P & Zemel, RS (1995). Competition and multiple cause models. *Neural Computation*, 7:3, pp. 565-579.

Dayan, P, Hinton, GE, Neal, R, & Zemel, RS (1995). The Helmholtz Machine. *Neural Computation*, 7:5, pp. 889-904.

Mozer, MC, Zemel, RS, Behrmann, M, & Williams, CKI (1992). Learning to segment images using dynamic feature binding. *Neural Computation*, 4:5, pp. 647-662.

Refereed Conference Papers

Zemel, RS & Pitassi, T. (2000). A gradient-based boosting algorithm for regression problems. To appear in: *NIPS-13: Advances in Neural Information Processing Systems 13*.

Cowen, S, Zemel, RS, Kudrimoti, H, Gerrard, J, & McNaughton, B (2000). Spike train segmentation and recognition: Identifying the neural correlate of decisions. *Proceedings of the 2000 Computational Neuroscience Meeting*.

Zemel, RS & Mozer, MC (2000). A generative model for attractor dynamics. *NIPS-12: Advances in Neural Information Processing Systems 12*. (pp. 80-86). S. A. Solla, T. K. Leen & K.-R. Muller (Eds.). Cambridge, MA: MIT Press.

Yang, Z & Zemel, RS (2000). Managing uncertainty in cue combination. *NIPS-12: Advances in Neural Information Processing Systems 12* (pp. 869-875). S. A. Solla, T. K. Leen & K.-R. Muller (Eds.). Cambridge, MA: MIT Press.

Zemel, RS & Dayan, P (1999). Distributional population codes and multiple motion models. *NIPS-11: Advances in Neural Information Processing Systems 11*. (pp. 174-180). Cambridge, MA: MIT Press.

Zemel, RS & Dayan, P (1997). Combining probabilistic population codes. *IJCAI-97: Fifteenth International Joint Conference on Artificial Intelligence* (pp. 1114-1119). San Francisco, CA: Morgan Kaufmann.

Zemel, RS, Dayan, P, & Pouget, A (1997). Probabilistic interpretation of population codes. *NIPS-9: Advances in Neural Information Processing Systems 9* (pp. 676-683). M. C. Mozer, M. I. Jordan, & T. Petsche (Eds.). Cambridge, MA: MIT Press.

Zemel, RS, & Sejnowski, TJ (1995). Grouping components of three-dimensional moving objects in area MST of visual cortex. In G. Tesauro, D. S. Touretzky, & T. K. Leen (Eds.), *NIPS-7: Advances in Neural Information Processing Systems 7* (pp. 165-172). Cambridge, MA: MIT Press.

Zemel, RS, & Hinton, GE (1994). Developing population codes by minimizing description length. In *NIPS-6: Advances in Neural Information Processing Systems 6* (pp. 11–18). J. D. Cowan, G. Tesauro, J. Alspector (Eds.). San Mateo, CA: Morgan Kaufmann.

Hinton, GE, & Zemel, RS (1994). Autoencoders, Minimum Description Length, and Helmholtz free energy. In *NIPS-6: Advances in Neural Information Processing Systems 6* (pp. 3–10). J. D. Cowan, G. Tesauro, J. Alspector (Eds.). San Mateo, CA: Morgan Kaufmann.

Zemel, RS, Williams, CKI, & Mozer, MC (1993). Directional-unit Boltzmann machines. In C. L. Giles, S. J. Hanson, & J. D. Cowan (Eds.), *NIPS-5: Advances in Neural Information Processing Systems 5* (pp. 172-179). San Mateo, CA: Morgan Kaufmann.

Mozer, MC, Zemel, RS & Behrmann, M (1992). Learning to segment images using dynamic feature binding. In J. E. Moody, S. J. Hanson, & R. P. Lippmann (Eds.), *NIPS-4: Advances in Neural Information Processing Systems 4* (pp. 436-443). San Mateo, CA: Morgan Kaufmann.

Mozer, MC, Zemel, RS & Behrmann, M (1992). Discovering and using perceptual grouping principles in visual information processing. *Proceedings of the 14th Annual Conference of the Cognitive Society*. Bloomington, IN: Lawrence Erlbaum.

Zemel, RS & Hinton, GE (1991). Discovering viewpoint-invariant relationships that characterize objects. In R. P. Lippmann, J. E. Moody, & D. S. Touretzky (Eds.), *NIPS-3: Advances in Neural Information Processing Systems 3* (pp. 299-305). San Mateo, CA: Morgan Kaufmann.

Zemel, RS, Mozer, MC, & Hinton, GE (1990). TRAFFIC: Object recognition using hierarchical reference frame transformations. In D. S. Touretzky, (Ed.), *NIPS-2: Advances in Neural Information Processing Systems 2* (pp. 266-273). San Mateo, CA: Morgan Kaufmann.

Book Chapters

Zemel, RS & Pillow, J (2000). An information-theoretic objective for population codes. To appear in: *Statistical Theories of Cortical Function*. MIT Press.

Zemel, RS (2000). Cortical belief networks. To appear in R. Hecht-Neilsen (Ed.), *Theories of Cortical Processing*. Springer-Verlag.

Becker, S & Zemel, RS (1999). Unsupervised learning with global objective functions. To appear in M. A. Arbib (Ed.), *The Handbook of Brain Theory and Neural Networks, Volume II*. MIT Press.

Zemel, RS (1994). Minimizing description length and neural networks. In M. A. Arbib (Ed.), *The Handbook of Brain Theory and Neural Networks*. MIT Press.

Manuscripts In Preparation

Zemel, RS & Peterson, M (2001). Location dependence in novel object perception.

Zemel, RS & Pillow, J (2000). Representing multiple values in a population code.

Invited Talks at Conferences & Workshops

Invited Workshop Speaker, *The Neural Code: Multilevel and Computational Approaches*, Edinburgh, Scotland, 2001.

Invited Symposium Speaker, *Neural Networks, Neuroscience, and Cognitive Science Symposium*, Cold Spring Harbor, 2000.

Invited Symposium Speaker, Cognitive Neuroscience Society Meeting, 1999.

Invited Speaker, *Statistical Theories of Cortical Function Workshop*, NIPS-11, 1998.

Invited Speaker, *Biological Neural Networks Workshop*, Office of Naval Research, 1998.

Invited Speaker, *Theories of Cortical Processing Workshop*, La Jolla, 1998.

Invited Speaker, *Population Coding Workshop*, NIPS-9, 1996.

Invited Speaker, *Neural Information and Coding: Techniques and Algorithms Workshop*, NIPS-8, 1995.

Invited Speaker, *Vision and Attention Workshop*, NIPS-7, 1994.

Invited Speaker, Joint Caltech/UCSD Symposium on Neural Computation, 1994.

Invited Speaker, *Learning in Computer Vision and Image Understanding Workshop*, NIPS-6, 1993.

Invited Speaker, *Subsymbolic Information Processing in Biological Neural Circuits and Systems Workshop*, NIPS-5, 1992.

Invited Speaker, *Unsupervised Learning and Vision Workshop*, NIPS-4, 1991.

Selected Invited Colloquia/Seminars

Seminar, Rutgers University, 1999.

Colloquium, Wake Forest University Dept. of Computer Science, 1999.

Seminar, Technical University of Berlin, Germany, 1998.

Seminar, Salk Institute, 1998.

Colloquium, Brain Research Institute, Weizmann Institute of Technology, Israel, 1998.

Colloquium, University of California, Berkeley, Dept. of Optical Science, 1998.

Colloquium, University of California, Davis, Dept. of Neuroscience, 1998.

Seminar, ATR Human Information Processing Research Laboratories, Kyoto, Japan, 1997.

Colloquium, University of Colorado Dept. of Computer Science, 1997.

Colloquium, University of Arizona Dept. of Computer Science, 1996.

Seminar, Carnegie Mellon University Machine Learning, 1996.

Seminar, Georgetown Institute of Computational and Cognitive Science, 1996.

Seminar, Southern Ontario Neural Network, 1995.

Seminar, University of Maryland Dept. of Computer Science, 1995.

Seminar, Institute for Neural Computation, UCSD, 1995.

Seminar, CMU Machine Learning Group, 1995.

Seminar, Xerox PARC, 1993.

Seminar, University of California at San Diego, 1993.

Conference Presentations

Dayan, P & Zemel, R (1999). Statistical models and sensory attention. *International Conference on Artificial Neural Networks 1999*.

Zemel, RS & Dayan, P (1998). Moving targets: Interpreting population responses in area MT. *Society for Neuroscience Abstracts*, Vol. 24.

Zemel, RS, Behrmann, M, Mozer, MC, & Bevalier, D (1998). Experience-dependent perceptual grouping and object-based attention. *The Fifth Annual Meeting of the Cognitive Neuroscience Society*.

Peterson, M & Zemel, RS (1998). Location-specificity in memories of novel objects. *The 39th Annual Meeting of the Psychonomic Society*.

Zemel, RS & Behrmann, M (1996). A computational unification of object and spatial attention. *The Third Annual Meeting of the Cognitive Neuroscience Society*.

Gray, M, Pouget, A, Zemel, RS, Nowlan, SJ, & Sejnowski, TJ (1995). Selective integration: A model for disparity estimation. *Society for Neuroscience Abstracts*, Vol. 21.

Behrmann, M, Zemel, RS & Mozer, MC (1994). Object-based attention and occlusion. *The 35th Annual Meeting of the Psychonomic Society*.

Zemel, RS, Nowlan, SJ, & Sejnowski, TJ (1994). A computational model of motion processing in area MST: Learning to segment three-dimensional moving objects. *Society for Neuroscience Abstracts*, Vol. 20.

Zemel, RS & Hinton, GE (1993). Developing population codes for object instantiation parameters. *AAAI Fall Symposium Series: Machine Learning in Computer Vision*. Raleigh, NC, Oct., 1993.

Williams, CKI, Zemel, RS & Mozer, MC (1993). Unsupervised learning of object models. *AAAI Fall Symposium Series: Machine Learning in Computer Vision*. Raleigh, NC, Oct., 1993.

Zemel, RS & Acock, M (1986). Dispatcher: An intelligent approach to factory control. *Proceedings of the 1986 American Control Conference.*

Teaching Experience

Undergraduate Courses Taught

Machine Learning (Univ. of Toronto; new course)

Foundations of Artificial Intelligence (Univ. of Arizona; new course)

Sensation & Perception (Univ. of Arizona)

Graduate Courses Taught

Computation in Neural Networks (Univ. of Toronto; new course)

Computational Neuroscience (Univ. of Arizona; new course)

Neural Network Models (Univ. of Arizona; new course)

Visual Attention (Univ. of Arizona; new course)

Summer School Course

Neural Computation (Complex Systems Summer School, Santa Fe Institute; guest faculty member for week-long course)

Invited Tutorial

Computational Neuroscience (NIPS-13: Neural Information Processing Conference)

PhD Student Supervision

Jagdeep Dhillon, Dept. of Computer Science, Univ. of Toronto, PhD Advisor, 2000-present (ongoing).

Stephen Cowen, Dept. of Psychology, Univ. of Arizona, PhD Co-Advisor, 1998-present (ongoing). MSc received August, 2000.

MSc Student Supervision

David Towers, Dept. of Psychology, Univ. of Arizona, MSc Advisor, 1998-present (ongoing).

Postdoctoral Fellow Supervision

Zhiyong Yang, Dept. of Psychology, University of Arizona, 1998-1999.

PhD Committees

Hemant Kudrimoti, Dept. of Neuroscience, Univ. of Arizona, 1997-1999 (defended September, 1999).

Karen Reinke, Dept. of Psychology, Univ. of Arizona Member, 1996-1998 (defended October, 1998).

Alberto Paccanaro, Dept. of Computer Science, Univ. of Toronto, 2000-present (ongoing).

Pascal Poupart, Dept. of Computer Science, Univ. of Toronto, 2000-present (ongoing).

Jason Barker, Dept. of Psychology, Univ. of Arizona, 1998-present (ongoing).

Kari Hoffman, Dept. of Neuroscience, Univ. of Arizona, 1998-present (ongoing).

Other Student Supervision

Sofiya Vania, Dept. of Computer Science, Univ. of Arizona, Honors Thesis Co-Advisor, 1998-1999.

Jonathon Pillow, Dept. of Applied Mathematics, Univ. of Arizona, Honors Thesis Supervisor, 1997-1998.

Yeliang Zhang, Dept. of Computer Science, Univ. of Arizona, Graduate Independent Study Research Project Advisor, 1999-2000.

John Costello, Dept. of Applied Math, Univ. of Arizona, Graduate Independent Study Research Project Advisor, 1998-1999.

Sindy Richliks, Dept. of Applied Math, Univ. of Arizona, Graduate Independent Study Research Project Advisor, 1997-1998.

Administrative Positions

University Service

Graduate Committee, Univ. of Toronto Computer Science Department, 2000-2001.

Graduate Admissions Committee, Univ. of Arizona Psychology Department, Cognition & Neural Systems, 1998-2000.

Computing Resources Committee, Univ. of Arizona Psychology Department, 1998-2000.

Graduate Admissions Committee, Univ. of Arizona Committee on Neuroscience, 1998-2000.

Extra-University Service

Program Committee, 2001 Neural Information Processing Society Conference

Workshop Organizer, 1999 Neural Information Processing Society Conference

Workshop Chair, 1998 Neural Information Processing Society Conference

Workshop Chair, 1997 Neural Information Processing Society Conference

Workshop Organizer, 1996 Neural Information Processing Society Conference

Program Committee, 1996 International Conference on Artificial Neural Networks

Referee

Grant proposals: National Science Foundation, Mathematics of Information Technology and Complex Systems Network: Centers of Excellence, National Institutes of Health

Journal papers: *Nature; Science; Machine Learning; International Journal of Computer Vision; Neural Computation; Vision Research; Journal of Experimental Psychology; Cerebral Cortex; Cognitive Science; Graphics and Image Processing: Image Understanding; Neural Networks; IEEE Transactions on Neural Networks; Journal of Neuroscience*

Conference papers: International Joint Conference on Artificial Intelligence (IJCAI); National Conference on Artificial Intelligence (AAAI); Neural Information Processing Society (NIPS); International Conference on Computer Vision (ICCV); International Conference on Artificial Neural Networks (ICANN)