Richard S. Zemel

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Education

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

M.Sc. , Department of Computer Science, University of Toronto, 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.*

Honors and Awards

Principal Investigator , National Sciences and Engineering Research Council Research Grant, 2000-2005.

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

Co-Principal Investigator , National Institutes of Health, Program Project Grant, 1997-2002.

Principal Investigator , McDonnell-Pew Program in Cognitive Neuroscience Postdoctoral Training Grant, 1994-1998.

Postdoctoral Fellowship offered through National Science Foundation: Neural Processes in Cognition grant, 1994-1996 (declined).

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.

Research Interests

Human and machine vision, focusing on object recognition, attention, and motion analysis; computational models of cognitive and neural systems; perceptual learning and machine learning

Publications

Articles in Refereed Journals

Zemel, RS & Mozer, MC (2000). A generative model for attractor dynamics. *Neural Computation*. Accepted for publication.

Zemel, RS & Pillow, J (2000). Encoding multiple orientations in a recurrent network. *Neurocomputing, 32-33*, pp. 609-616.

Behrmann, M, Zemel, RS, & Mozer, MC (2000). Occlusion, symmetry, and object-based attention. *Journal of Experimental Psychology: Human Perception and Performance*. Accepted for publication.

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.

Articles Submitted to Refereed Journals

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

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 & Pillow, J (1999). Encoding multiple orientations in a recurrent network. *Proceedings of the 1999 Computational Neuroscience Meeting*.

Zemel, RS & Mozer, MC (1999). Localist attractor networks. To appear in: *NIPS-12: Advances in Neural Information Processing Systems 12*.

Yang, Z & Zemel, RS (1999). Generative model of visual cue combination. To appear in: *NIPS-12: Advances in Neural Information Processing Systems 12*.

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

Zemel, RS & Dayan, P (1998). Distributional population codes and multiple motion models. *NIPS-10: Advances in Neural Information Processing Systems 10*. Cambridge, MA: MIT Press.

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

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.

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

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 & 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, 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.

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

Acock, M & Zemel, RS (1986). AI software for automated material handling systems. *Proceedings of the 1986 Ultratech Conference.* Society of Manufacturing Engineers.

Book Chapters

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

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

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.

Conference Abstracts

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, Suzuki, S, Zemel, RS, & Rapcsak, SZ (1998). Intact and impaired object processing following dorsal visual system damage. *The Fifth Annual Meeting of the Cognitive Neuroscience 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.

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.

Research Fellowships

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: McClelland. Co-investigator on 2 sections, one with Behrmann; other with McClelland, O'Reilly, & Plaut. Total award amount: $1.1M.

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

Professional Experience

2000-	**Dept. of Computer Science, Univ. of Toronto** Assistant Professor
1996-2000	**Depts. of Psychology & Computer 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 Designed and implemented a novel application of neural networks and optimization techniques to lens design.
1987	**Carnegie Group Inc.** Project Manager Responsibilities: Managed a software project for factory scheduling. Supervised its installation in two Digital Equipment Corporation factories, where it is still in use today.
1984 - 86	**Carnegie Group Inc.** Senior Engineer Responsibilities: Design and development of decision systems for manufacturing applications. My duties ranged from feasibility studies to implementation and installation.
1982 - 84 (summer)	**Dept. of Computer Science, Carnegie Mellon University** Research Assistant Responsibilities: Research in knowledge acquisition and explanation-based reasoning.

Teaching Experience

2000 -	**Dept. of Computer Science, Univ. of Toronto** Instructor Courses: Machine Learning, Neural Networks.
1996 - 2000	**Depts. of Psychology & Computer Science, Univ. of Arizona** Instructor Courses: Foundations of Artificial Intelligence, Neural Networks, Computational Neuroscience, Sensation & Perception, Visual Attention
1998 (summer)	**Complex Systems Summer School, Santa Fe Institute** Guest Faculty Course: Computational Neurobiology.
1994 - 96	**Depts. of Psychology & Computer Science, Carnegie Mellon** Lecturer Courses: Computational Models of Neural Systems, Principles of Parallel Distributed Processing, Visual Perception.
1987 - 92	**Dept. of Computer Science, University of Toronto** Teaching Assistant & Lecturer Courses: Neural Networks, Data Structures and Algorithms, Introduction to Programming.

Academic Activities

Workshop Chair

1997 and 1998 Neural Information Processing Society Conferences

Workshop Organizer

1996 and 1999 Neural Information Processing Society Conferences

Program Committee

1996 International Conference on Artificial Neural Networks

Referee

Grant proposals: 3 National Science Foundation, 1 National Institutes of Health, 1 McDonnell-Pew

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 Artificial Neural Networks (ICANN)

Invited Talks at Conferences

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

Invited Symposium Speaker, Cognitive Neuroscience Society Meeting, 1999.

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

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

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

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

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

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

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

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

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

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

Canadian Institute for Advanced Research AI Workshop, June, 1991

Selected Invited Colloquia/Seminars

Seminar, Rutgers University, 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.