Haim Sompolinsky

Curriculum Vitae

Professor of Physics, Racah Institute of Physics
William N. Skirball Professor of Neuroscience
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Personal Information

Born: Copenhagen, Denmark, 1949
Israeli citizen: 1951
Married with five children

Education

Harvard University, Theoretical Physics, Postdoctoral research, 1980-1982
Bar-Ilan University, Physics, Ph.D., 1980
Bar-Ilan University, Physics, M.Sc., 1973
Bar-Ilan University, Physics and Mathematics, B.Sc., 1972

Positions

1986-Present	Professor of Physics, Hebrew University
2006-Present	Visiting Professor of Molecular and Cellular Biology, Harvard University
2001-2005	Visiting Professor, Center for Neural Systems and Courant Institute, NYU
1983-2000	Visiting Research Associate, Bell Laboratories
1982-1986	Associate Professor of Physics, Bar-Ilan University
1980-1982	Postdoctoral Fellow with Prof. B. Halperin, Harvard University
1972-1980	Graduate Research Fellow with Profs. M. Luban and S. Havlin, Bar-Ilan University

Other Experience and Professional Memberships

2009-Present	Member, Executive Board of Edmond and Lily Safra Center for Brain Sciences, Hebrew University
2007-Present	Director, Swartz Theoretical Neuroscience Program, Harvard University
2006-Present	Member, Steering Committee, Center for Brain Science, Harvard University
1999-Present	Faculty, Methods in Computational Neuroscience Course, Woods Hole
1995-Present	Member, USA Society for Neuroscience
1995-Present	Associate Editor, Neural Computation
1992-Present	Member, Israel Society for Neuroscience
1992-Present	Member, Federation of European Neuroscience Societies
1992-Present	Founding member of the Interdisciplinary Center for Neural Computation (ICNC), Hebrew University
2007-2009	Director, ICNC
2006	Member, International Review Committee of the Department of Physics, Swiss Federal Institute of Technology, Zurich
1996-2003	Faculty, Advanced Course in Computational Neuroscience, IBRO/FENS
1992-1999	Member, Executive Board of ICNC

Honors

2011	Swartz Prize for Theoretical and Computational Neuroscience of the US Society for Neuroscience
2008	Landau Prize for Brain Science
2008	Foreign Honorary Member of the American Academy of Arts and Sciences
2007	William N. Skirball Chair in Neuroscience, Hebrew University
2005	Hebrew University Presidential Award for Outstanding Researcher
1980	Rothschild Fellowship for Postdoctoral Research
1979	Chaim Weizmann Post-Doctoral Fellowship
1977	Sir Isaac Wolfson Prize for Excellence in Doctoral Research, Bar-Ilan University
1974	Bar-Ilan University Fellowship for Excellence
1973	Landau Prize for Outstanding M.Sc. Research
1972	Spiers Prize for Best Undergraduate Student, Bar-Ilan University

Teaching Experience

- Theory of Neural Networks
- Computational Neuroscience
- Statistical Physics of Learning and Memory
- Advanced Topics in Neurophysics
- Physics, Neuroscience and Free Will
- Phase Transitions and Critical Phenomena
- Classical Electromagnetism
- Statistical Physics of Random Systems
- Spin Glasses
- Quantum Mechanics

Major Research Interests

Sompolinsky's research goal is to uncover the fundamental principles of the organization, the dynamics and the function of the brain, viewing the brain through multiscale lenses, spanning the molecular, the cellular, and the circuit levels. To achieve this goal, Sompolinsky has developed new theoretical approaches to computational neuroscience based on the principles and methods of statistical physics, and physics of dynamical and stochastic systems. This new field, Neurophysics, builds in part on Sompolinsky's earlier work on critical phenomena, random systems, spin glasses, and chaos. His research areas cover theoretical and computational investigations of cortical dynamics, sensory processing, motor control, neuronal population coding, long and short-term memory, and neural learning. The highlights of his research include theories and models of local cortical circuits, visual cortex, associative memory, statistical mechanics of learning, chaos and excitation-inhibition balance in neuronal networks, principles of neural population codes, statistical mechanics of compressed sensing and sparse coding in neuronal systems, and the Tempotron model of spike time based neural learning. He also studies the neuronal mechanisms of volition and the impact of physics and neuroscience on the foundations of human freedom and agency.

Leadership and Public Activities

- Led the establishment of Neurophysics, a new discipline that applies the principles of statistical physics to the study of the collective dynamics and distributed information processing in neuronal systems.

- Co-founded Hebrew University's Interdisciplinary Center for Neural Computation (ICNC) and served as its Director. ICNC is a world-renowned center for research and education in computational neuroscience, comprising 25 laboratories and 70 graduate students. It was twice awarded the EU Center of Excellence grant.

- Member of the founding team of the new Edmond and Lily Safra Center for Brain Sciences (ELSC) at the Hebrew University, and serves on its Executive Committee. ELSC is committed to expanding and modernizing neuroscience at the Hebrew University and strives to become one of the leading neuroscience institutes worldwide.

- Member of the Steering Committee of Harvard's Center for Brain Science, leading computational neuroscience research and education at Harvard.

- Director of Swartz Theoretical Neuroscience Program at Harvard.

- Member of the Faculty of the EU Advanced Course in Computational Neuroscience, facilitating the training of new generations of interdisciplinary researchers in neuroscience in Europe and elsewhere.

- Member of the Faculty of Methods for Computational Neuroscience Course at the MBL, Woods Hole, USA.

- Public lecturer and TV guest on scientific perspectives on human choice, and on issues related to science and religion.

- Organized international meetings and workshops in systems and computational neuroscience, most recently:

    - The 2009 Annual Meeting of the Sloan Swartz Computational Neuroscience Centers
    - The 2010 Meeting of Tri-Centers for Computational Neuroscience
    - The 2011 COSYNE Workshop on Compressed Sensing and the Brain
    - The 2012 Okinawa Institute for Science and Technology Spring Course on Random Matrix Theory for Complex Systems

Support

Sompolinsky's research has been supported by generous grants from the Israeli Science Foundation, the USA-Israel Binational Science Foundation, NIH, NSF, McDonnell Foundation, Swartz Foundation, and the Gatsby Charity Foundation.

Invited Lectures (2011):

November 2011. Design principles for local cortical circuits. Presented at the *12th Otto Loewi Meeting on Neuron and Synaptic Complexity*, Eilat, Israel.

November 2011. The quest for the emergent brain. Keynote address presented at the *Dynamical Neuroscience Satellite Symposium XIX*, Washington DC.

October 2011. The cortical column: the brain's computational engine. Presented at the *Gatsby Meeting on Advances in Neuroscience*, London.

September 2011. Is random connectivity a design principle in cortex? Presented at the *EMBO Conference on the Assembly and Function of Neuronal Circuits*, Ascona, Switzerland.

September 2011. The curses and blessings of high dimensions. Presented at the *Inaugural Champalimaud Neuroscience Symposium*, Lisbon.

August 2011. Chaos in neuronal networks. Presented at the *Methods in Computational Neuroscience Course*, Marine Biological Laboratory (MBL), Woods Hole, Massachusetts.

July 2011. Feature selectivity in random cortical circuits. Presented at the *Sloan Swartz Meeting on Theoretical Neuroscience*, Janelia Farm, Howard Hughes Medical Institute, Maryland.

June 2011. Computational neuroscience in the next ten years. Presented at the *Neural Coding Meeting*, Allen Institute for Brain Science, Seattle.

May 2011. Learning temporal spiking patterns. Presented at the *Annual Gatsby Meeting on Computational Neuroscience*, Columbia University, New York.

May 2011. Sensory selectivity in random cortical networks. Presented at the *Center for Brain Science (CBS) Annual Retreat*, Harvard University, Cambridge, Massachusetts.

April 2011. Sensory processing in random cortical networks. Presented at the *Workshop on Neuronal Response Variability and Cortical Computation,* Banbury Center, Cold Spring Harbor, New York.

March 2011. Compressed sensing and its potential application in neuroscience. Presented at the *COSYNE Workshop on Compressed Sensing and the Brain*, Snowbird, Utah.

List of Publications

A. Computational Neuroscience

Sompolinsky H., and Lee D. *The Theory of Neural Computation*. Book in preparation.

Ganguli S., and Sompolinsky H. (2012). Compressed sensing, sparsity, and dimensionality in neuronal information processing and data analysis. *Annual Review of Neuroscience*. **35**:485–508

Rubin R., Guetig R., and Sompolinsky H. (in press). Neural Coding and Decoding With Spike Times. In *Spike Timing: Mechanism and Function, Frontiers in Neuroscience Series*. Victor J. and Di Lorenzo P., Editors.

Rokni U., and Sompolinsky H. (2012) How the brain generates movement. *Neural Computation.* **24**:289-331

Rubin R., Monasson R., and Sompolinsky H. (2010). Theory of spike timing-based neural classifiers. *Physical Review Letters*, **105**:218-102.

Rajan K., Abbott L.F., and Sompolinsky H. (2010). Inferring stimulus selectivity from the spatial structure of neural network dynamics. *Advances in Neural Information Processing*, MIT Press, Cambridge MA. **23:** 1975-1983

Ganguli S., and Sompolinsky H. (2010). Short-term memory in neuronal networks through dynamical compressed sensing. *Advances in Neural Information Processing*, MIT Press, Cambridge MA. 23: 667-675

Burak Y., Rokni U., Meister M., and Sompolinsky H. (2010). Bayesian model of dynamic image stabilization in the visual system. *Proceedings of the National Academy of Sciences USA*, **107**:19525-19530.

Ganguli S. and Sompolinsky H. (2010). Statistical mechanics of compressed sensing. *Physical Review Letters,* **104**:188701.

Rajan K., Abbott L.F., and Sompolinsky H. (2010). Stimulus-dependent suppression of chaos in recurrent neural networks. *Physical Review E*, **82**:011903.

Abbott L.F., Rajan K., and Sompolinsky, H. (2010). Interactions between intrinsic and stimulus evoked activity in recurrent neural networks. In *Neuronal Variability and Its Functional Significance*. Glanzman D. and Ding M., (Eds.), Oxford University Press.

Burak Y., Lewallen S., and Sompolinsky H. (2009). Stimulus-dependent correlations in threshold-crossing spiking neurons. *Neural Computation*, **21**:2269-2308.

Guetig R. and Sompolinsky H. (2009). Time-warp–invariant neuronal processing. *PLoS Biology*, **7**:e1000141.

Ganguli S., Huh D., and Sompolinsky H. (2008). Memory traces in dynamical systems. *Proceedings of the National Academy of Sciences USA*, **105**:18790-18795.

Witten I.B., Knudsen E.I., and Sompolinsky H. (2008). A Hebbian learning rule mediates asymmetric plasticity in aligning sensory representations. *Journal of Neurophysiology*, **100**:1067-1079.

Pitkow X., Sompolinsky H., and Meister M. (2007). A neural computation for visual acuity in the presence of eye movements. *PLoS Biology*, **5**:e331.

Safran M., Flanagin V., Borst A., and Sompolinsky H. (2007). Adaptation and information transmission in fly motion detection. *Journal of Neurophysiology*, **98**:3309-3320.

Gutig R. and Sompolinsky H. (2006). The tempotron: a neuron that learns spike timing-based decisions. *Nature Neuroscience*, **9**:420-428.

Shamir M. and Sompolinsky H. (2006). Implications of neuronal diversity on population coding. *Neural Computation*, **18**:1951-1986.

Loewenstein Y., Mahon S., Chadderton P., Kitamura K., Sompolinsky H., Yarom Y. and Häusser M. (2005). Bistability of cerebellar Purkinje cells modulated by sensory stimulation. *Nature Neuroscience*, **8**:202-211.

Borst A., Flanagin V.L., and Sompolinsky H. (2005). Adaptation without parameter change: dynamic gain control in Reichardt motion detectors. *Proceedings of the National Academy of Sciences USA*, **102**:6172-6176.

Sompolinsky H. (2005). A scientific perspective on human choice. *In Judaism, Science, and Moral Responsibility, The Orthodox Forum Series*. Shatz, D. and Berger, Y. (Eds.), Rowman & Littlefield Publishers.

Van Vreeswijk C. and Sompolinsky H. (2005). Irregular activity in large networks of neurons. Chap. 9, pp. 341-402, in *Methods and Models in Neurophysics, Volume Session LXXX: Lecture Notes of the Les Houches Summer School 2003*. Chow C., Gutkin B., Hansel D., Meunier C., and Dalibard J. (Eds.), Elsevier, London.

Sompolinsky H. and White O.L. (2005). Theory of large recurrent networks: from spikes to behavior. Chap. 8, pp. 267-339, in *Methods and Models in Neurophysics, Volume Session LXXX: Lecture Notes of the Les Houches Summer School 2003.* Chow C., Gutkin B., Hansel D., Meunier C., and Dalibard J. (Eds.), Elsevier, London.

Shamir M. and Sompolinsky H. (2004). Nonlinear population codes. *Neural Computation*, **16**:1105-1136.

Goldberg J.A., Rokni U., and Sompolinsky H. (2004). Patterns of ongoing activity and the functional architecture of the primary visual cortex. *Neuron*, **42**:489–500.

White O., Lee D. and Sompolinsky H. (2004). Short term memory in orthogonal neural networks. *Physical Review Letters*, **92**:148102 .

Kang K., Shapely R., and Sompolinsky H. (2004). Information tuning of populations of neurons in primary visual cortex. *Journal of Neuroscience*, **24**:3726-3735.

Rokni U., Steinberg O., Vaadia E., and Sompolinsky H. (2003). Cortical representation of bimanual movements. *Journal of Neuroscience*, **23**:11577-11586.

Shriki O., Hansel D. and Sompolinsky H. (2003). Rate models for conductance-based cortical neuronal networks. *Neural Computation*, **15**:1809-1841.

Loewenstein Y. and Sompolinsky H. (2003). Temporal integration by calcium dynamics in a model neuron. *Nature Neuroscience,* **6**:961-967.

Gütig R., Aharonov R., Rotter S., and Sompolinsky H. (2003). Learning input correlations through nonlinear temporally asymmetric Hebbian plasticity. *Journal of Neuroscience*, **23**:3697-3714.

Litvak V., Sompolinsky H., Segev I., and Abeles M. (2003). On the transmission of rate code in long feedforward networks with excitatory-inhibitory balance. *Journal of Neuroscience*, **23**:3006-3015.

Kang K., Shelley M., and Sompolinsky H. (2003). Mexican hats and pinwheels in visual cortex. *Proceedings of the National Academy of Sciences USA*, **100**:2848-2853.

Loewenstein Y. and Sompolinsky H. (2002). Oscillations by symmetry breaking in homogeneous networks with electrical coupling. *Physical Review E*, **65**:1-11.

Shamir M. and Sompolinsky H. (2001). Correlation codes in neuronal networks. In *Advances in Neural Information Processing 14*. Dietterich T., Becker S., and Ghahramani Z. (Eds.), MIT Press, Cambridge MA.

Loewenstein Y., Yarom Y., and Sompolinsky H. (2001). The generation of oscillations in networks of electrically coupled cells. *Proceedings of the National Academy of Sciences USA*, **98**:8095-8100.

Rubin J., Lee D., and Sompolinsky H. (2001). The equilibrium properties of temporally asymmetric Hebbian plasticity. *Physical Review Letters*, **86**:364-367.

Sompolinsky H., Yoon H., Kang K., and Shamir M. (2001). Population coding in neuronal systems with correlated noise. *Physical Review E*, **64**:051904-11.

Kang K. and Sompolinsky H. (2001). Mutual Information of population codes and distance measures in probability space. *Physical Review Letters*, **86**:4958-4961.

Shriki O., Sompolinsky H., and Lee D. (2001). An information maximization approach to overcomplete and recurrent representations. In *Advances in Neural Information Processing 13.* Leen T.K., Dietterich T.G., and Tresp V. (Eds.), MIT Press, Cambridge MA.

Shamir M. and Sompolinsky H. (2000). Thouless-Anderson-Palmer equations for neural networks. *Physical Review E*, **61**:1839-1844.

Lee D., Rokni U., and Sompolinsky H. (2000). Algorithms for independent components analysis and higher order statistics. In *Advances in Neural Information Processing 12.* Kearns M.J., Solla S.A., and Cohn D.A. (Eds.), MIT Press, Cambridge MA.

Lee D. and Sompolinsky H. (1999). Learning a continuous hidden variable model for binary data. In *Advances in Neural Information Processing 11.* Kearns M.J., Solla S.A., and Cohn D.A. (Eds.), MIT Press, Cambridge MA.

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Sompolinsky H. and Kim J. (1998). On-line Gibbs learning. I. General Theory. *Physical Review E*, **58**:2335-2347.

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Hansel D. and Sompolinsky H. (1998) Modeling feature selectivity in local cortical circuits. Chapter 13 in *Methods in Neuronal Modeling: From Synapse to Networks, Second Edition*. Koch C. and Segev I. (Eds.), MIT Press, Cambridge, MA.

Sompolinsky H. and Shapley R. (1997). New perspectives on mechanisms for orientation selectivity. *Current Opinion in Neurobiology*, **7**:514-522.

Ben-Yishai R., Hansel D., and Sompolinsky H. (1997). Traveling waves and the processing of weakly tuned inputs in a cortical network module. *Journal of Computational Neuroscience*, **4**:57-79.

Hansel D. and Sompolinsky H. (1996). Chaos and synchrony in a model of a hypercolumn in visual cortex. *Journal of Computational Neuroscience*, **3**:7-34.

Van Vreeswijk C. and Sompolinsky H. (1996). Chaos in neuronal networks with balanced excitatory and inhibitory activity. *Science*, **274**:1724-1726.

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Kim J.W. and Sompolinsky H. (1996). On-line Gibbs Learning. *Physical Review Letters*, **76**:3021-3024.

Barkai N., Seung H.S., and Sompolinsky H. (1995). Local and global convergence of on-line learning. *Physical Review Letters*, **75**:1415-1418.

Ben-Yishai R., Lev Bar-Or R., and Sompolinsky H. (1995). Theory of orientation tuning in visual cortex. *Proceedings of the National Academy of Sciences USA*, **92**:3844-3848.

Sompolinsky H., Barkai N., and Seung H.S. (1995). On-line learning of dichotomies: algorithms and learning curves. In *Advances in Neural Information Processing 7.* Cowan J.D., Tesauro G. and Alspector J., (Eds.), MIT Press, Cambridge MA.

Sompolinsky H., Barkai N., and Seung H.S. (1995). On-line learning of dichotomies: algorithms and learning curves. In *Neural Networks: The Statistical Mechanics Perspective*. Oh J., Kwon C. and Cho S., (Eds.), World Scientific, Singapore.

Sompolinsky H. and Tsodyks M. (1994). Segmentation by a network of oscillators with stored memories. *Neural Computation,* **6**:642-657.

Ginzburg I. and Sompolinsky H. (1994). Theory of correlations in stochastic neural networks. *Physical Review E*, **50**:3171-3191.

Ginzburg I. and Sompolinsky H. (1994). Correlation functions in a large stochastic neural network. In *Advances in Neural Information Processing 6*. Cowan J.D., Tesauro G. and Alspector J. (Eds.), MIT Press, Cambridge MA.

Barkai N. and Sompolinsky H. (1994). Statistical mechanics of maximum-likelihood density estimation. *Physical Review E*, **50**:1766-1769.

Seung H.S. and Sompolinsky H. (1993). Simple models for reading neuronal population codes. *Proceedings of the National Academy of Sciences USA*, **90**:10749-10753.

Tsodyks M., Mitkov I., and Sompolinsky H. (1993). Pattern of synchrony in inhomogeneous networks of oscillators with pulse interactions. *Physical Review Letters*, **71**:1280-1283.

Barkai N., Seung H.S., and Sompolinsky H. (1993). Scaling laws in learning of classification tasks. *Physical Review Letters*, **70**:3167-3170.

Grannan E.R., Sompolinsky H., and Kleinfeld D. (1993). Stimulus dependent synchronization of neuronal assemblies. *Neural Computation*, **5**:550-569.

Barkai N. and Sompolinsky H. (1993). Theory of learning from examples. In *International Joint Conference on Neural Networks*. IJCNN, Nagoya.

Sompolinsky H. (1993). Theoretical issues in learning from examples. In *Proceedings of the Third NEC Symposium on Computational Learning and Cognition*. SIAM.

Seung H.S., Opper M.A., and Sompolinsky H. (1992). Query by committee. In *Proceedings of the Fifth Annual Workshop on Computational Learning Theory*. Warmuth M.K. and Valiant L.G., (Eds.), Kaufmann, San Mateo, CA.

Tsodyks M. and Sompolinsky H. (1992). Processing of sensory information by a network of oscillators with memory. *International Journal of Neural Systems*, **3**:51-56.

Aranson I., Golomb D., and Sompolinsky H. (1992). Spatial coherence and temporal chaos in macroscopic systems. *Physical Review Letters*, **68**:3495-3498.

Barkai E., Hansel D., and Sompolinsky H. (1992). Broken symmetries in multilayered perceptrons. *Physical Review A*, **45**:4146-4161.

Seung H.S., Sompolinsky H., and Tishby N. (1992). Statistical mechanics of learning from examples. *Physical Review A*, **45**:6056-6091.

Hansel D. and Sompolinsky H. (1992). Synchronization and computation in a chaotic neural network. *Physical Review Letters*, **68**:718-721.

Sompolinsky H., Golomb D., and Kleinfeld D. (1991). Cooperative dynamics in visual processing. *Physical Review A*, **43**:6990-7011.

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Sompolinsky H., Seung S., and Tishby N. (1990). Learning in a two-layer neural network of edge detectors. *Europhysics Letters,* **13**:567-572.

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Sompolinsky H., Golomb D., and Kleinfeld D. (1990). Global processing of visual stimuli in a neural network of coupled oscillators. *Proceedings of the National Academy of Sciences USA*, **87**:7200-7204.

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Kleinfeld D. and Sompolinsky H. (1989). Associative network models for central pattern generators. Chap. 7 in *Methods in Neuronal Modeling: From Synapse to Networks*. Koch C. and Segev I., (Eds.), MIT Press, Cambridge, MA.

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Kleinfeld D. and Sompolinsky H. (1988). Associative neural network models for the generation of temporal patterns: theory and application to central pattern generators. *Biophysical Journal,* **54**:1039-1051.

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Sommer H.J., Crisanti A., Sompolinsky H., and Stein Y. (1988). The spectrum of large random asymmetric matrices. *Physical Review Letters,* **60**:1895-1898.

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Amit D.J., Gutfreund H., and Sompolinsky H. (1987). Information storage in neural networks with low levels of activity. *Physical Review A*, **35**:2293-2303.

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Amit D.J., Gutfreund H., and Sompolinsky H. (1987). Statistical mechanics of neural networks near saturation. *Annals of Physics NY*, **173**:30-67.

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B. Spin Glasses, Dynamics, and Condensed Matter

Hansel D. and Sompolinsky H. (1993). Solvable model of spatiotemporal chaos. *Physical Review Letters*, **71**:2710-2713.

Golomb D., Hansel D., Shraiman B., and Sompolinsky H. (1992). Clustering in globally coupled phase oscillators. *Physical Review A*, **45**:3516-3530.

Wolfus Y., Yeshurun Y., Felner I., and Sompolinsky H. (1989) Scaling Properties of the Irreversible Magnetization Curves of High Temperature Superconductors. *Physical Review B*, **39**:2701-2703.

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