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HIGH SCHOOL:
Stuyvesant High School, Manhattan
First in Class of 1957

COLLEGE:
Dartmouth College, B.A.
First in Class of 1961
A.P. Sloan National Scholar
Phi Beta Kappa Prize
NSF Undergraduate Research Fellow

GRADUATE WORK:
Stanford University, M.S., 1961-1964
NSF Graduate Fellowship
Woodrow Wilson Graduate Fellowship

Rockefeller University, Ph.D., 1964-1967
Rockefeller University Graduate Fellowship

POST-GRADUATE ACTIVITIES:

1. Assistant Professor of Applied Mathematics, M.I.T., 1967-1969.

2. Senior Visiting Fellow of the Science Research Council of England, 1969.

3. Norbert Wiener Medal for Cybernetics, 1969.

4. A.P. Sloan Research Fellow, 1969-1971.

5. Associate Professor of Applied Mathematics, M.I.T., 1969-1975.

6. Professor of Mathematics, Psychology, and Biomedical Engineering, Boston University, 1975-.

7. Invited lectures in Australia, Austria, Belgium, Bulgaria, Canada, Denmark, England, Finland, France, Germany, Greece, Hong Kong, Israel, Italy, Japan, The Netherlands, Norway, Qatar, Scotland, Singapore, Spain, Sweden, Switzerland, and throughout the United States.

8. Editor of the journals *Adaptive Behavior*; *Applied Intelligence*; *Behavioral and Brain Sciences* (Associate Editor for Computational Neuroscience); *Autism Open Access Journal; Behavioural Processes*; *Brains, Minds, and Media*; *Cognition and Brain Theory*; *Cognitive Brain Research*; *Cognitive Computation, Cognitive Neurodynamics*; *Cognitive Processing*; *Cognitive Science*; *Current Opinions in Cognitive Neurodynamics*; *IEEE Expert*; *IEEE Transactions on Neural Networks*; *Information Sciences*; *International Journal of Cognitive Science*; *International Journal of Humanoid Robotics*; *International Journal of Hybrid Intelligent Systems; International Journal of Neural Systems; International Journal of Uncertainty, Fuzziness, and Knowledge-Based Systems*; *Journal of Cognitive Neuroscience*; *Journal of Experimental Neuroscience, Journal of Mathematical Psychology*; *Journal of Theoretical Neurobiology*; *Mathematical Biosciences*; *Mind and Society*; *Neural Computation*; *Nonlinear Analysis*.

9. Editorial board member of the book series Advanced Information and Knowledge Processing, Springer-Verlag; Mathematical Modeling: Theory and Applications, Kluwer.

10. Founder and Editor-in-Chief of the journal *Neural Networks*, 1987-2010.

11. Founder and First President of the International Neural Network Society and member of the founding INNS Board of Governors, 1987-1988.

12. Founder and Director, Center for Adaptive Systems, Boston University, 1981-.

13. Principal Investigator, Boston Consortium for Behavioral and Neural Studies (Congressional Center of Excellence), 1986-1993.

14. Wang Professor of Cognitive and Neural Systems, Boston University, 1989-.

15. Founder and Chairman, Department of Cognitive and Neural Systems, Boston University, 1991-2007.

16. IEEE Neural Networks Pioneer Award, 1991.

17. Boston Computer Society Thinking Technology Award, 1992.

18. INNS Leadership Award, 1992.

19. Fellow, American Psychological Association (APA), 1994.

20. Principal Investigator, Center for Automated Vision and Sensing Systems (Congressional Center of Excellence), 1995-2000.

21. Fellow, Society of Experimental Psychologists (SEP), 1996.

22. Information Sciences Award, Association for Intelligent Machinery, 2000.

23. Principal Investigator, Center for Intelligent Biomimetic Image Processing and Classification (Congressional Center of Excellence), 2001-2007.

24. Charles River Laboratories prize, Society for Behavioral Toxicology, 2002.

25. Fellow, American Psychological Society (APS), 2002.

26. Membership in Acoustical Society of America, American Association for the Advancement of Science, American Mathematical Society, American Psychological Association, American Society for Engineering Education, Association for Behavior Analysis, Association for Psychological Science, Association for Research in Vision and Ophthalmology, Association for the Advancement of Artificial Intelligence, Biologically Inspired Cognitive Architectures Society, Cognitive Neuroscience Society, Cognitive Science Society, European Neural Network Society, International Neural Network Society, Memory Disorders Research Society, New York Academy of Sciences, Optical Society of America, Organization for Computational Neuroscience, Psychonomic Society, Schizophrenia International Research Society, Sigma Xi, Society for Artificial Neural Networks in Medicine and Biology, Society for Computational Modeling of Associative Learning, Society for Industrial and Applied Mathematics, Society for Mathematical Biology, Society for Mathematical Psychology, Society for Neuroscience, SPIE, Vision Sciences Society.

27. INNS Helmholtz Award, 2003.

28. Principal Investigator, Founding Director and Chairman of the Governing Board, CELEST: Center of Excellence for Learning in Education, Science, and Technology (an NSF Science of Learning Center), 2004-2009.

29. IEEE Fellow, 2005.

30. American Educational Research Association (AERA) Inaugural Fellow, 2008.

31. Advisory Board member for the new Springer journal *Cognitive Computation*, 2009.

32. Member, Rafik B. Hariri Institute for Computing and Computational Science and Engineering, Boston University, 2011.

33. Steering Committee, Center for Computational Neuroscience and Neural Technology (CompNet), Boston University, 2011.

34. INNS Fellow, 2012.

PATENTS

1. Carpenter, G.A. and Grossberg, S., U.S. Patent #5,142,590: Pattern recognition system. Filed: November 27, 1985. Issued: August 25, 1992. European Patent #0244483; Issued: July 15, 1992.

2. Carpenter, G.A. and Grossberg, S., U.S. Patent #4,914,708 and #5,133,021: System for self-organization of stable category recognition codes for analog patterns. Filed: June 19, 1987. Issued: April 3, 1990 and July 21, 1992.

3. Carpenter, G.A. and Grossberg, S., U.S. Patent #5,311,601: Pattern recognition system with variable selection weights. Filed: January 12, 1990. Issued: May 10, 1994.

4. Carpenter, G.A., Grossberg, S., and Reynolds, J.H., U.S. Patent #5,214,715: Predictive self-organizing neural network. Filed: January 31, 1991. Issued: May 25, 1993.

5. Carpenter, G.A., Grossberg, S., and Rosen, D.B., U.S. Patent #5,157,738: Rapid category learning and recognition system. Filed: December 19, 1990. Issued: October 20, 1992.

6. Grossberg, S. and Cohen, M.A., U.S. Patent #5,040,214: Pattern learning and recognition apparatus in a computer system. Filed: March 8, 1989. Issued: August 13, 1991.

7. Grossberg, S. and Mingolla, E., U.S. Patent #4,803,736: Neural networks for machine vision. Filed: July 23, 1987. Issued: February 7, 1989.

LIST OF PUBLICATIONS
BOOKS

1. Editor, **Mathematical psychology and psychophysiology**. Providence, RI: American Mathematical Society, 1981 (co-distributed by Erlbaum Associates).

2. **Studies of mind and brain: Neural principles of learning, perception, development, cognition, and motor control**. Norwell, MA: Kluwer Academic Publishers, 1982.

3. **Neural dynamics of adaptive sensory-motor control: Ballistic eye movements** (with M. Kuperstein). Amsterdam: North-Holland, 1986.

4. **The adaptive brain, I: Cognition, learning, reinforcement, and rhythm**. Amsterdam: North-Holland, 1987.

5. **The adaptive brain, II: Vision, speech, language, and motor control**. Amsterdam: North-Holland, 1987.

6. **Neural networks** (with G.A. Carpenter). Optical Society of America, Special Issue of *Applied Optics*, 1987.

7. **Neural networks and natural intelligence**. Cambridge, MA: MIT Press, 1988.

8. **Neural dynamics of adaptive sensory-motor control: Expanded edition** (with M. Kuperstein). Elmsford, NY: Pergamon Press, 1989.

9. **Neural network models of conditioning and action** (with M. Commons and J. Staddon). Hillsdale, NJ: Erlbaum, 1991.

10. **Pattern recognition by self-organizing neural network**s (with G.A. Carpenter). Cambridge, MA: MIT Press, 1991.

11. **Neural networks for vision and image processing** (with G.A. Carpenter). Cambridge, MA: MIT Press, 1992.

12. **Models of neurodynamics and behavior** (with J.G. Taylor). Tarrytown, NY: Elsevier Science Inc., 1994. Special Issue of *Neural Networks*.

13. **Neural networks for automatic target recognition** (with H. Hawkins and A. Waxman). Tarrytown, NY: Elsevier Science Inc., 1995. Special Issue of *Neural Networks*.

14. **Neural control and robotics: Biology and technology** (with R. Brooks and L. Optican). Oxford, UK: Elsevier Science Ltd., 1998. Special Issue of *Neural Networks*.

15. **Spiking neurons in neuroscience and technology** (with W. Maass and H. Markram). Exeter, UK: Elsevier Science Ltd., 2001. Special Issue of *Neural Networks*.

16. **Vision and brain** (with D. Field and L. Finkel). Exeter, UK: Elsevier Science Ltd., 2004. Special Issue of *Neural Networks*.

17. **Social cognition: From babies to robots** (with A. Meltzoff, J. Movellan, and N. Newcombe). Oxford UK: Elsevier Science Ltd., 2010. Special Issue of *Neural Networks*.

ARTICLES

1. Nonlinear difference-differential equations in prediction and learning theory. *Proceedings of the National Academy of Sciences*, 1967, **58**, 1329-1334.

2. A prediction theory for some nonlinear functional-differential equations, I: Learning of lists. *Journal of Mathematical Analysis and Applications*, 1968, **21**, 643-694.

3. A prediction theory for some nonlinear functional-differential equations, II: Learning of patterns. *Journal of Mathematical Analysis and Applications*, 1968, **22**, 490-522.

4. Global ratio limit theorems for some nonlinear functional differential equations, I. *Bulletin of the American Mathematical Society*, 1968, **74**, 93-100.

5. Global ratio limit theorems for some nonlinear functional differential equations, II. *Bulletin of the American Mathematical Society*, 1968, **74**, 101-105.

6. Some nonlinear networks capable of learning a spatial pattern of arbitrary complexity. *Proceedings of the National Academy of Sciences*, 1968, **59**, 368-372.

7. Some physiological and biochemical consequences of psychological postulates. *Proceedings of the National Academy of Sciences*, 1968, **60**, 758-765.

8. On the global limits and oscillations of a system of nonlinear differential equations describing a flow of a probabilistic network. *Journal of Differential Equations*, 1969, **5**, 531-563.

9. On variational systems of some nonlinear difference-differential equations. *Journal of Differential Equations*, 1969, **6**, 544-577.

10. Embedding fields: A theory of learning with physiological implications. *Journal of Mathematical Psychology*, 1969, **6**, 209-239.

11. On learning, information, lateral inhibition, and transmitters. *Mathematical Biosciences*, 1969, **4**, 255-310.

12. On the production and release of chemical transmitters and related topics in cellular control. *Journal of Theoretical Biology*, 1969, **22**, 325-364.

13. On the serial learning of lists. *Mathematical Biosciences*, 1969, **4**, 201-253.

14. Some networks that can learn, remember, and reproduce any number of complicated space-time patterns, I. *Journal of Mathematics and Mechanics*, 1969, **19**, 53-91.

15. On learning of spatiotemporal patterns by networks with ordered sensory and motor components, I: Excitatory components of the cerebellum. *Studies in Applied Mathematics*, 1969, **48**, 105-132.

16. On learning and energy-entropy dependence in recurrent and nonrecurrent signed networks. *Journal of Statistical Physics*, 1969, **1**, 319-350.

17. A global prediction (or learning) theory for some nonlinear functional-differential equations. In J.A. Nohel (Ed.), **Studies in applied mathematics, advances in differential and integral equations**, Vol. 5. Philadelphia: SIAM, 1969, pp.64-70.

18. Learning and energy-entropy dependence in some nonlinear functional-differential systems. *Bulletin of the American Mathematical Society*, 1969, **75**, 1238-1242.

19. Some networks that can learn, remember, and reproduce any number of complicated space-time patterns, II. *Studies in Applied Mathematics*, 1970, **49**, 135-166.

20. Neural pattern discrimination. *Journal of Theoretical Biology*, 1970, **27**, 291-337.

21. Schizophrenia: Possible dependence of associational span, bowing, and primacy vs. recency on spiking threshold (with J. Pepe). *Behavioral Science*, 1970, **15**, 359-362.

22. Embedding fields: Underlying philosophy, mathematics, and applications to psychology, physiology, and anatomy. *Journal of Cybernetics*, 1971, **1**, 28-50.

23. Spiking threshold and overarousal effects in serial learning (with J. Pepe). *Journal of Statistical Physics*, 1971, **3**, 95-125.

24. Functional-differential systems and pattern learning. In D. Chillingsworth (Ed.), **Lecture notes in mathematics**, Vol. 206. Berlin: Springer-Verlag, 1971, pp.147-150.

25. On the dynamics of operant conditioning. *Journal of Theoretical Biology*, 1971, **33**, 225-255.

26. Pavlovian pattern learning by nonlinear neural networks. *Proceedings of the National Academy of Sciences*, 1971, **68**, 828-831.

27. Neural expectation: Cerebellar and retinal analogs of cells fired by learnable or unlearned pattern classes. *Kybernetik*, 1972, **10**, 49-57.

28. A neural theory of punishment and avoidance, I: Qualitative theory. *Mathematical Biosciences*, 1972, **15**, 39-67.

29. A neural theory of punishment and avoidance, II: Quantitative theory. *Mathematical Biosciences*, 1972, **15**, 253-285.

30. Pattern learning by functional-differential neural networks with arbitrary path weights. In K. Schmitt (Ed.), **Delay and functional-differential equations and their applications**. New York: Academic Press, 1972, pp.121-160.

31. Contour enhancement, short-term memory, and constancies in reverberating neural networks. *Studies in Applied Mathematics*, 1973, **52**, 217-257.

32. Classical and instrumental learning by neural networks. In R. Rosen and F. Snell (Eds.), **Progress in theoretical biology**. New York: Academic Press, 1974, pp.217-257.

33. A neural model of attention, reinforcement, and discrimination learning. *International Review of Neurobiology*, 1975, **18**, 263-327.

34. Some developmental and attentional biases in the contrast enhancement and short-term memory of recurrent neural networks (with D. Levine). *Journal of Theoretical Biology*, 1975, **53**, 341-380.

35. Pattern formation, contrast control, and oscillations in the short-term memory of shunting on-center off-surround networks (with S.A. Ellias). *Biological Cybernetics*, 1975, **20**, 69-98.

36. On the development of feature detectors in the visual cortex with applications to learning and reaction-diffusion systems. *Biological Cybernetics*, 1976, **21**, 145-159.

37. On visual illusions in neural networks: Line neutralization, tilt aftereffect, and angle expansion (with D. Levine). *Journal of Theoretical Biology*, 1976, **61**, 477-504.

38. Adaptive pattern classification and universal recoding, I: Parallel development and coding of neural feature detectors. *Biological Cybernetics*, 1976, **23**, 121-134.

39. Adaptive pattern classification and universal recoding, II: Feedback, expectation, olfaction, and illusions. *Biological Cybernetics*, 1976, **23**, 187-202.

40. Redundant information in auditory and visual modalities: Inferring decision-related processes from the P300 component (with E. Donchin, K. Squires, and N. Squires). *Journal of Experimental Psychology*, 1977, **3**, 299-315.

41. Pattern formation by the global limits of a nonlinear competitive interaction in *n* dimensions. *Journal of Mathematical Biology*, 1977, **4**, 237-256.

42. A theory of human memory: Self-organization and performance of sensory-motor codes, maps, and plans. In R. Rosen and F. Snell (Eds.), **Progress in theoretical biology, Volume 5**. New York: Academic Press, 1978, pp.233-374.

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44. A theory of visual coding, memory, and development. In E. Leeuwenberg and H. Buffart (Eds.), **Formal theories of visual perception**. New York: Wiley Press, 1978.

45. Behavioral contrast in short-term memory: Serial binary memory models or parallel continuous memory models? *Journal of Mathematical Psychology*, 1978, **3**, 199-219.

46. Competition, decision, and consensus. *Journal of Mathematical Analysis and Applications*, 1978, **66**, 470-493.

47. Do all neural models really look alike? *Psychological Review*, 1978, **85**, 592-596.

48. Decisions, patterns, and oscillations in nonlinear competitive systems with applications to Volterra-Lotka systems. *Journal of Theoretical Biology*, 1978, **73**, 101-130.

49. Adaptive pattern classification and universal recoding: Parallel development and coding of neural feature detectors. In R. Trappl (Ed.), **Third European conference on cybernetics and systems research**. New York: Halstead Press, 1978, pp.375-383.

50. How does a brain build a cognitive code? *Psychological Review*, 1980, **87**, 1-51.

51. Biological competition: Decision rules, pattern formation, and oscillations. *Proceedings of the National Academy of Sciences*, 1980, **77**, 2338-2342.

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53. Human and computer rules and representations are not equivalent. *Behavioral and Brain Sciences*, 1980, **3**, 136-138.

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55. Adaptive resonance in development, perception, and cognition. In S. Grossberg (Ed.), **Mathematical psychology and psychophysiology**. Providence, RI: American Mathematical Society, 1981.

56. Psychophysiological substrates of schedule interactions and behavioral contrast. In S. Grossberg (Ed.), **Mathematical psychology and psychophysiology**. Providence, RI: American Mathematical Society, 1981.

57. Adaptation and transmitter gating in vertebrate photoreceptors (with G.A. Carpenter). *Journal of Theoretical Neurobiology*, 1981, **1**, 1-42.

58. Processing of expected and unexpected events during conditioning and attention: A psychophysiological theory. *Psychological Review*, 1982, **89**, 529-572.

59. Associative and competitive principles of learning and development: The temporal unfolding and stability of STM and LTM patterns. In S.I. Amari and M. Arbib (Eds.), **Competition and cooperation in neural networks**. New York: Springer-Verlag, 1982.

60. Why do cells compete? Some examples from visual perception. *The UMAP Journal*, 1982, **3**, 103-121.

61. A psychophysiological theory of reinforcement, drive, motivation, and attention. *Journal of Theoretical Neurobiology*, 1982, **1**, 286-369.

62. The quantized geometry of visual space: The coherent computation of depth, form, and lightness. *Behavioral and Brain Sciences*, 1983, **6**, 625-657.

63. Reply to commentators on "The quantized geometry of visual space: The coherent computation of depth, form, and lightness". *Behavioral and Brain Sciences*, 1983, **6**, 676-692.

64. Absolute stability of global pattern formation and parallel memory storage by competitive neural networks (with M.A. Cohen). *Transactions IEEE*, 1983, **SMC-13**, 815-826.

65. Dynamic models of neural systems: Propagated signals, photoreceptor transduction, and circadian rhythms (with G.A. Carpenter). In J.P.E. Hodgson (Ed.), **Oscillations in mathematical biology**. New York: Springer-Verlag, 1983, pp.102-196.

66. A neural theory of circadian rhythms: The gated pacemaker (with G.A. Carpenter). *Biological Cybernetics*, 1983, **48**, 35-59.

67. Neural substrates of binocular form perception: Filtering, matching, diffusion, and resonance. In E. Basar, H. Flohr, H. Haken, and A.J. Mandell (Eds.), **Synergetics of the brain**. New York: Springer-Verlag, 1983.

68. Adaptation and gain normalization: A comment on Ullman and Schechtman (1982). *Proceedings of the Royal Society of London* (B), 1983, **219**, 471-473.

69. Some global properties of binocular resonances: Disparity matching, filling-in, and figure-ground synthesis (with M.A. Cohen). In P. Dodwell and T. Caelli (Eds.), **Figural synthesis**. Hillsdale, NJ: Erlbaum, 1984, pp.117-151.

70. Some normal and abnormal behavioral syndromes due to transmitter gating of opponent processes. *Biological Psychiatry*, 1984, **19**, 1075-1118.

71. Some psychophysiological and pharmacological correlates of a developmental, cognitive, and motivational theory. In R. Karrer, J. Cohen, and P. Tueting (Eds.), **Brain and information: Event related potentials**. New York: New York Academy of Sciences, 1984, pp.58-142.

72. A neural theory of circadian rhythms: Aschoff's rule in diurnal and nocturnal mammals (with G.A. Carpenter). *American Journal of Physiology (Regulatory, Integrative, and Comparative Physiology)*, 1984, **247**, R1067-R1082.

73. Outline of a theory of brightness, color, and form perception. In E. Degreef and J. van Buggenhaut (Eds.), **Trends in mathematical psychology**. Amsterdam: North-Holland, 1984.

74. Absolute stability of pattern processing and parallel memory storage by competitive neural networks (with M.A. Cohen). In **Proceedings of the 1984 IEEE international conference on systems, man, and cybernetics**, 1984.

75. The microscopic analysis of behavior: Towards a synthesis of instrumental, perceptual, and cognitive ideas. *Behavioral and Brain Sciences*, 1984, **7**, 594-595.

76. Unitization, automaticity, temporal order, and word recognition. *Cognition and Brain Theory*, 1984, **7**, 263-283.

77. Neural dynamics of brightness perception: Features, boundaries, diffusion, and resonance (with M.A. Cohen). *Perception and Psychophysics*, 1984, **36**, 428-456.

78. Neuroethology and theoretical neurobiology. *Behavioral and Brain Sciences*, 1984, **7**, 388-390.

79. The role of learning in sensory-motor control. *Behavioral and Brain Sciences*, 1985, **8**, 155-157.

80. Neural dynamics of form perception: Boundary completion, illusory figures, and neon color spreading (with E. Mingolla). *Psychological Review*, 1985, **92**, 173-211.

81. A neural theory of circadian rhythms: Split rhythms, after-effects, and motivational interactions (with G.A. Carpenter). *Journal of Theoretical Biology*, 1985, **113**, 163-223.

82. The hypothalamic control of eating and circadian rhythms: Opponent processes and their chemical modulators. In N. Jaeger and L. Rensing (Eds.), **Temporal order**. New York: Springer-Verlag, 1985.

83. Neural dynamics of circadian rhythms: The mammalian hypothalamic pacemaker (with G.A. Carpenter). In J. Eisenfeld and C. DeLisi (Eds.), **Mathematics and computers in biomedical applications**. Amsterdam: Elsevier/North-Holland, 1985.

84. Neural dynamics of perceptual grouping: Textures, boundaries, and emergent segmentations (with E. Mingolla). *Perception and Psychophysics*, 1985, **38**, 141-171.

85. Category learning and adaptive pattern recognition: A neural network model (with G.A. Carpenter). In **Proceedings of the third Army conference on applied mathematics and computing**, 1985.

86. Nonlinear neural dynamics of visual segmentation (with E. Mingolla). In **Proceedings of the third Army conference on applied mathematics and computing**, 1985.

87. Four frames do not suffice. *Behavioral and Brain Sciences*, 1985, **8**, 294-295.

88. Cognitive self-organization and neural modularity. *Behavioral and Brain Sciences*, 1985, **8**, 18-19.

89. Brain metaphors, theories, and facts. *Behavioral and Brain Sciences*, 1986, **9**, 97-98.

90. Statistical mechanics of visual form perception: The resolution of uncertainty. In S. Diner, D. Farque, and G. Lochak (Eds.), **Dynamical systems: A renewal of mechanism**. Philadelphia: World Scientific Press, 1986, pp.201-221.

91. Adaptive compensation to changes in the oculomotor plant. In E. Keller and D. Zee (Eds.), **Adaptive processes in visual and oculomotor systems**. New York: Pergamon Press, 1986, pp.341-345.

92. The adaptive self-organization of serial order in behavior: Speech, language, and motor control. In E.C. Schwab and H.C. Nusbaum (Eds.), **Pattern recognition by humans and machines, Vol. 1: Speech perception**. New York: Academic Press, 1986, pp.187-294.

93. Neural dynamics of word recognition and recall: Attentional priming, learning, and resonance (with G.O. Stone). *Psychological Review*, 1986, **93**, 46-74.

94. Neural dynamics of speech and language coding: Developmental programs, perceptual grouping, and competition for short-term memory (with M.A. Cohen). *Human Neurobiology*, 1986, **5**, 1-22.

95. Neural dynamics of attention switching and temporal order information in short-term memory (with G.O. Stone). *Memory and Cognition*, 1986, **14**, 451-468.

96. Conditioning, expectancy, attention, and rhythm: The role of gated dipoles. In R. Campan and R. Zayan (Eds.), **Relevance of models and theories in ethology**. Privat, I.E.C., Toulouse, 1986, pp.109-123.

97. Adaptive resonance theory: Stable self-organization of neural recognition codes in response to arbitrary lists of input patterns (with G.A. Carpenter). **Proceedings of the Cognitive Science Society**, 1986.

98. Absolutely stable learning of recognition codes by a self-organizing neural network (with G.A. Carpenter). In J.S. Denker (Ed.), **Neural networks for computing**, Snowbird Conference Proceedings. New York: American Institute of Physics, 1986, pp.77-85.

99. Computer simulation of neural networks for perceptual psychology (with E. Mingolla). *Behavior Research Methods, Instruments, and Computers*, 1986, **18**, 601-607.

100. Cooperative self-organization of multiple neural systems during adaptive sensory-motor control. In D.M. Guthrie (Ed.), **Aims and methods in neuroethology**. Manchester University Press, 1987.

101. Neural dynamics of attentionally modulated Pavlovian conditioning: Blocking, inter-stimulus interval, and secondary reinforcement (with D.S. Levine). *Applied Optics*, 1987, **26**, 5015-5030.

102. Associative learning, adaptive pattern recognition, and cooperative-competitive decision making by neural networks (with G.A. Carpenter). In H. Szu (Ed.), **Optical and hybrid computing**. SPIE Proceedings, 1987.

103. The role of illusory figures in visual segmentation (with E. Mingolla). In S. Petry and G. Meyer (Eds.), **The perception of illusory contours**. New York: Springer-Verlag, 1987, pp.116-125.

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106. Cortical dynamics of three-dimensional form, color, and brightness perception, I: Monocular theory. *Perception and Psychophysics*, 1987, **41**, 87-116.

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108. A massively parallel architecture for a self-organizing neural pattern recognition machine (with G.A. Carpenter). *Computer Vision, Graphics, and Image Processing*, 1987, **37**, 54-115.

109. Neural dynamics of surface perception: Boundary webs, illuminants, and shape-from-shading (with E. Mingolla). *Computer Vision, Graphics, and Image Processing*, 1987, **37**, 116-165.

110. Masking fields: A massively parallel neural architecture for learning, recognizing, and predicting multiple groupings of patterned data (with M.A. Cohen). *Applied Optics*, 1987, **26**, 1866-1891.

111. Competitive learning: From interactive activation to adaptive resonance. *Cognitive Science*, 1987, **11**, 23-63.

112. Stable self-organization of sensory recognition codes: Is chaos necessary? *Behavioral and Brain Sciences*, 1987.

113. Neural dynamics of decision making under risk: Affective balance and cognitive-emotional interactions (with W. Gutowski). *Psychological Review*, 1987, **94**, 300-318.

114. Computing with neural networks: The role of symmetry (with G.A. Carpenter and M.A. Cohen). *Science*, 1987, **235**, 1226-1227.

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117. A neural network architecture for automatic trajectory formation and coordination of multiple effectors during variable-speed arm movements (with D. Bullock). In M. Caudill and C. Butler (Eds.), **Proceedings of the IEEE international conference on neural networks**, 1987, **IV**, 559-566.

118. ART 2: Self-organization of stable category recognition codes for analog input patterns (with G.A. Carpenter). In M. Caudill and C. Butler (Eds.), **Proceedings of the IEEE international conference on neural networks**, 1987, **II**, 727-736.

119. Invariant pattern recognition and recall by an attentive self-organizing ART architecture in a nonstationary world (with G.A. Carpenter). In M. Caudill and C. Butler (Eds.), **Proceedings of the IEEE international conference on neural networks**, 1987, **II**, 737-746.

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122. Neural dynamics of decision making under risk: Affective balance theory (with W. Gutowski). In M. Caudill and C. Butler (Eds.), **Proceedings of the IEEE international conference on neural networks**, 1987, **III**, 31-38.

123. A computational model of how cortical complex cells multiplex information about position, contrast, orientation, spatial frequency, and disparity (with J. Marshall). In M. Caudill and C. Butler (Eds.), **Proceedings of the IEEE international conference on neural networks**, 1987, **IV**, 203-214.

124. A neural network architecture for preattentive vision: Multiple scale segmentation and regularization (with E. Mingolla). In M. Caudill and C. Butler (Eds.), **Proceedings of the IEEE international conference on neural networks**, 1987, **IV**, 177-184.

125. A neural network architecture for attentionally-modulated Pavlovian conditioning: Conditioned reinforcement, inhibition, and opponent processing (with N.A. Schmajuk). In M. Caudill and C. Butler (Eds.), **Proceedings of the IEEE international conference on neural networks**, 1987, **II**, 795-804.

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