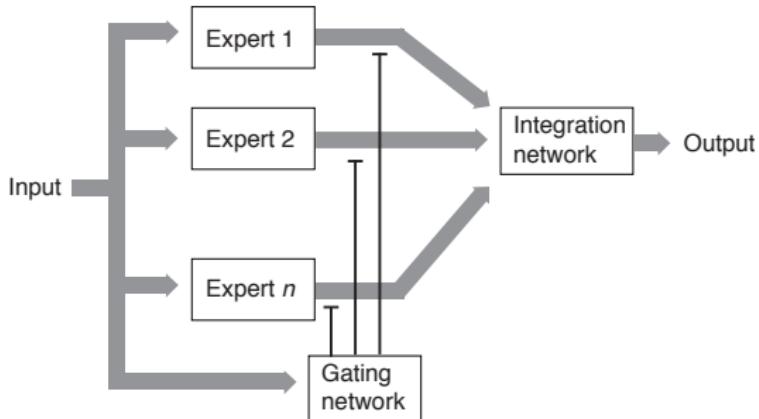


# Fundamentals of Computational Neuroscience 2e

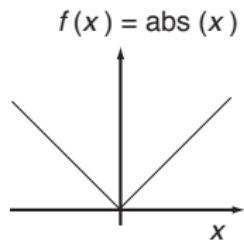
December 31, 2009

Chapter 9: Modular networks, motor control, and reinforcement learning

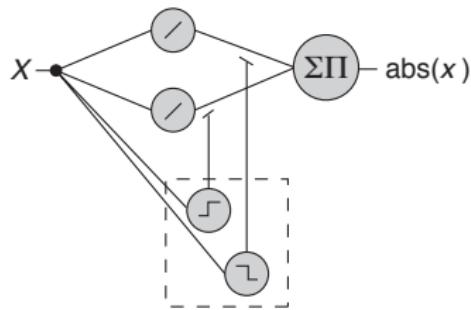
# Mixture of experts



A. Absolute function

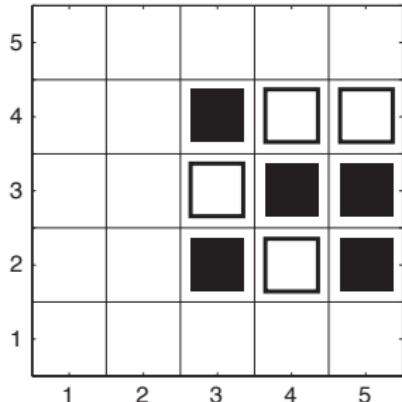


B. Mixture of expert for absolute function

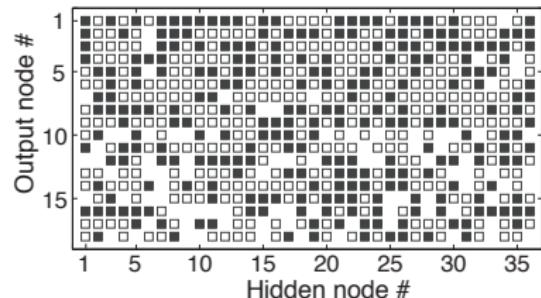


# The ‘what-and-where’ task

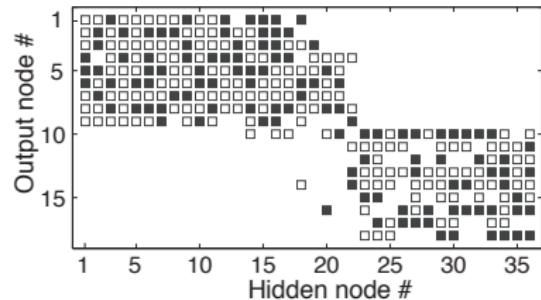
A. Model retina with sample image



B. Without bias towards short connections



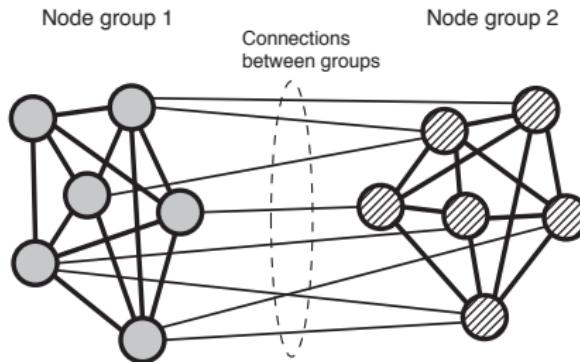
C. With bias towards short connections



Jacobs and Jordan (1992)

# Coupled attractor networks

A. Coupled attractor networks

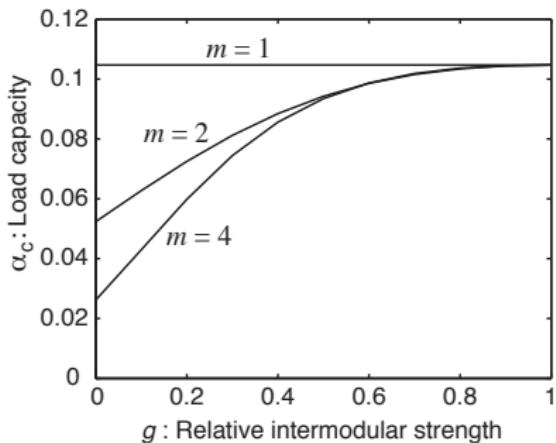


B. The left-right universe with letters

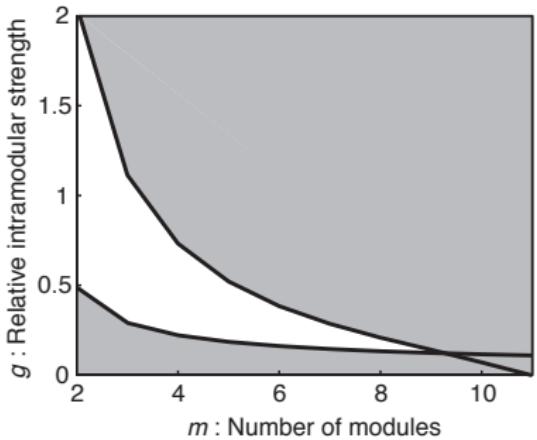
0000011100000	11111111110000
0000011100000	11111111111100
0000111110000	1110000001110
0000110111000	11100000111100
0001100011000	11100011100000
0011100011100	11111111000000
0011111111100	11111111000000
0111111111110	11100011100000
01111000001110	11100000111100
01111000001110	11100000011110
01111000001110	11111111111100
01111000001110	1111111111100000

## Limit on modularity

A. Load capacity

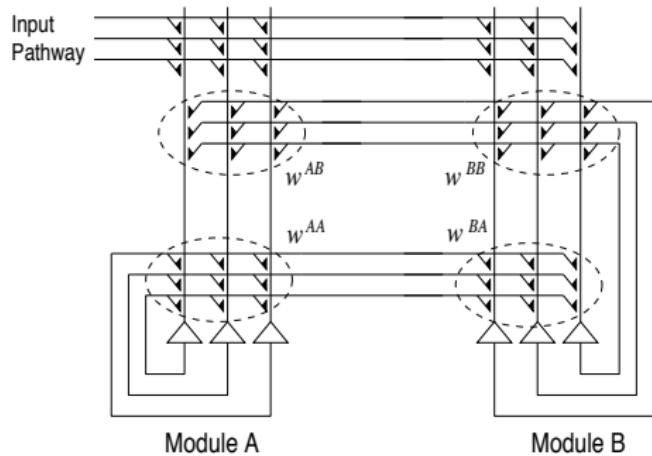


B. Bounds on intermodular strength

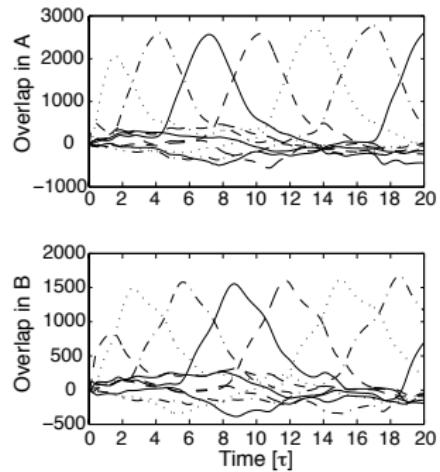


# Sequence learning

A. Modular attractor model

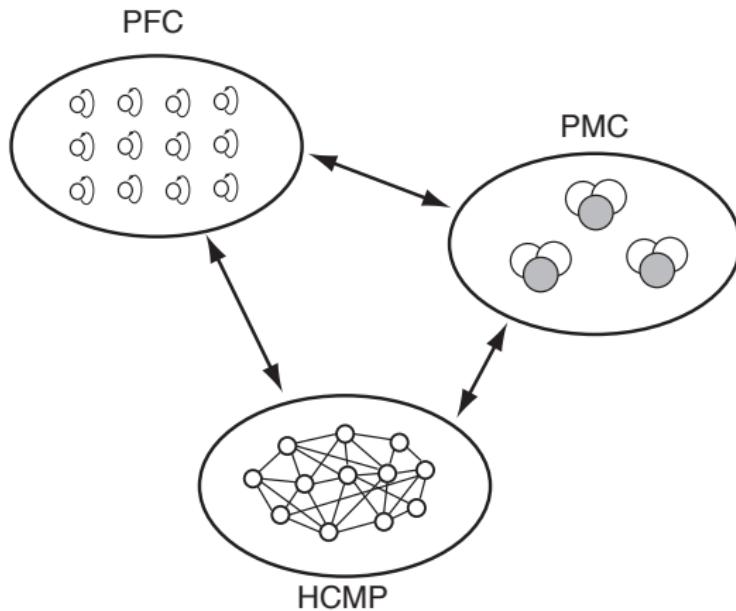


B. Time evolution of overlaps



Lawrence, Trappenberg and Fine (2006); (Sommer and Wennekers (2005))

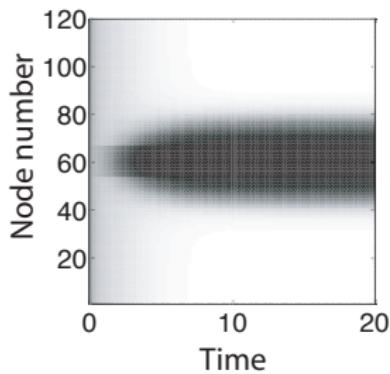
## Working memory



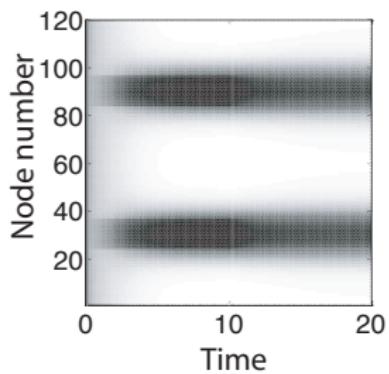
O'Reilly, Braver, and Cohen 1999

## Limit on working memory

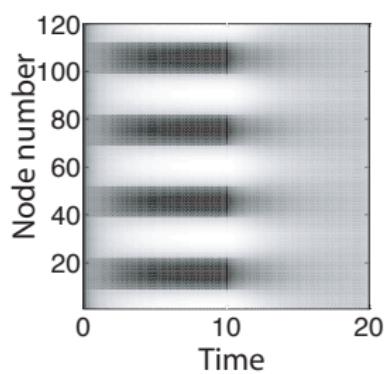
A. One object



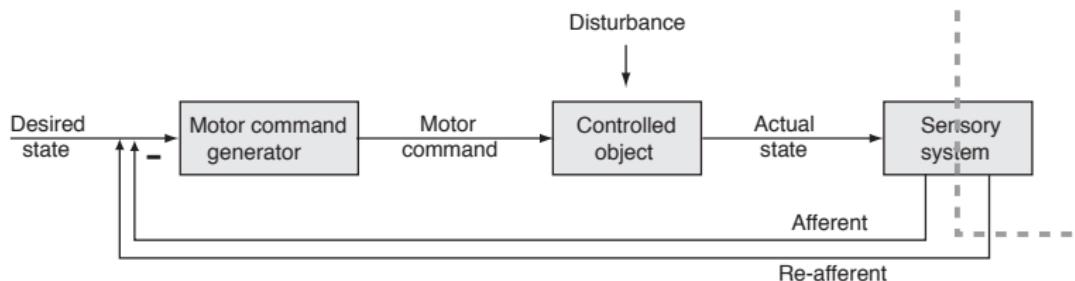
B. Two objects



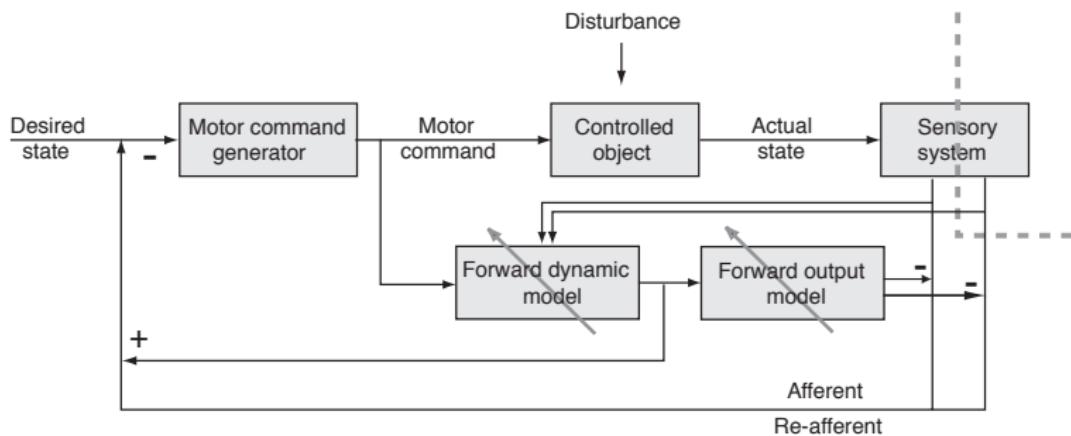
C. Four objects



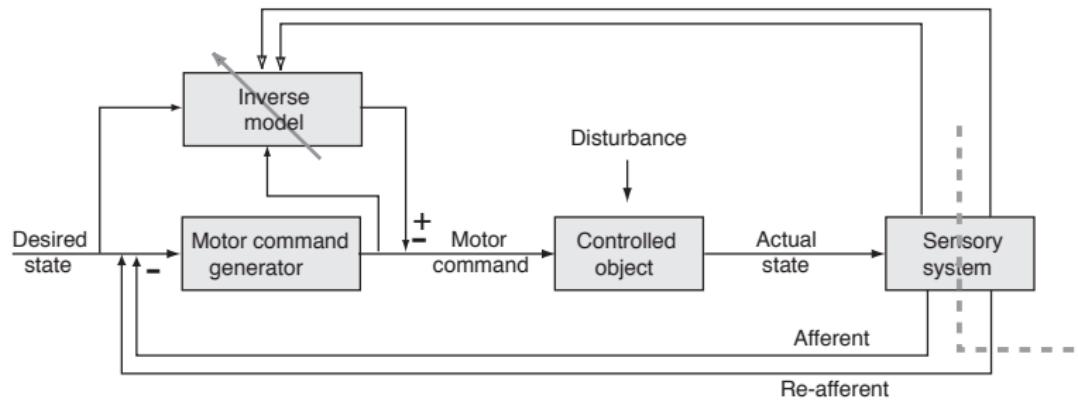
# Motor learning and control



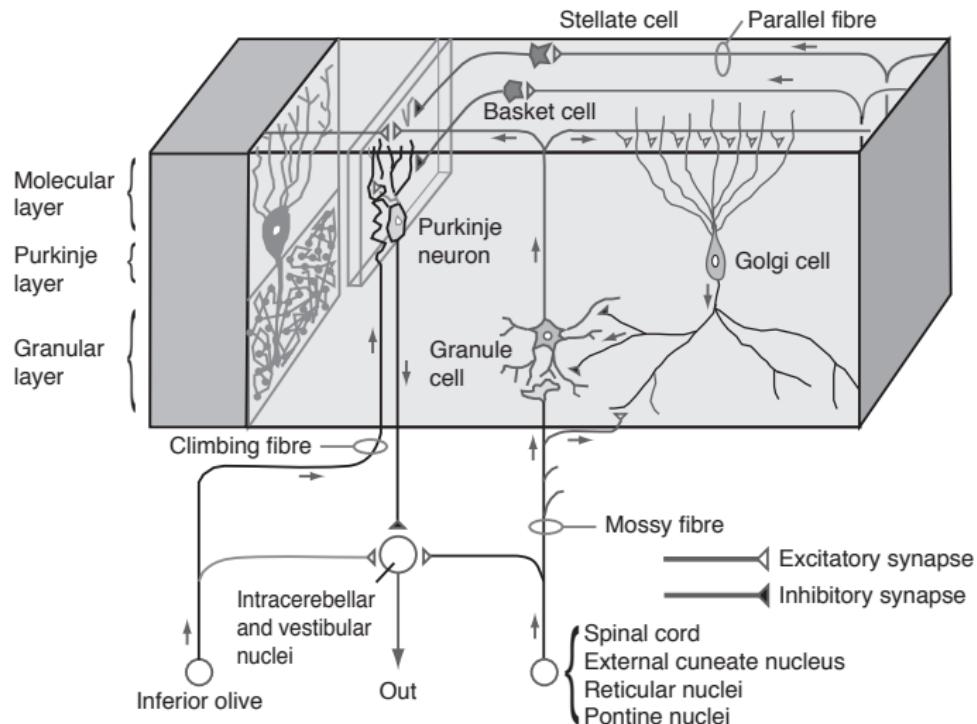
# Forward model controller



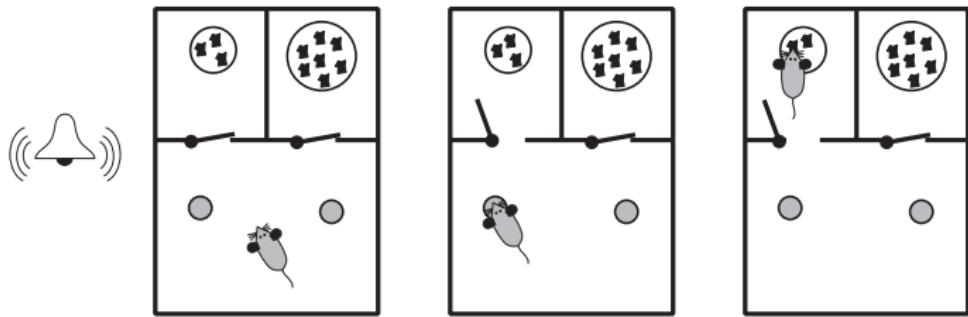
# Inverse model controller



# Cerebellum

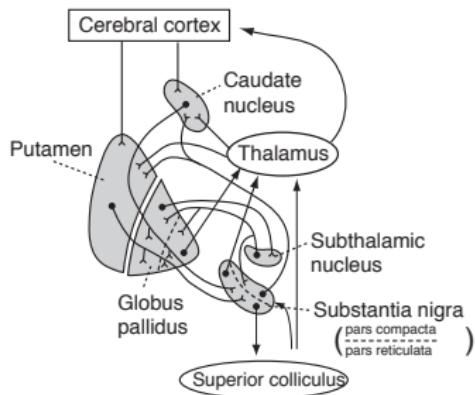


# Reinforcement learning

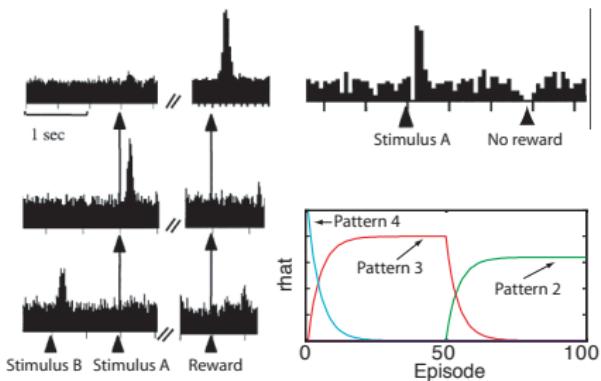


# Basal Ganglia

A. Outline of basic BG anatomy

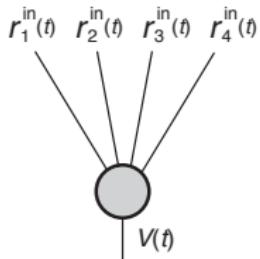


C. Recordings of SNC neurons and simulations

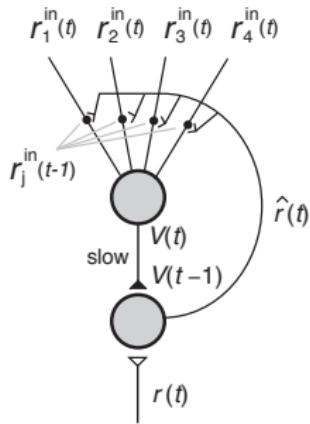


# temporal difference learning

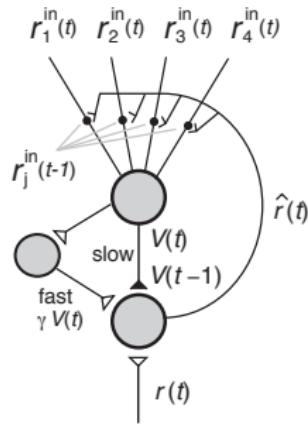
A. Linear predictor node



B. Temporal delta rule

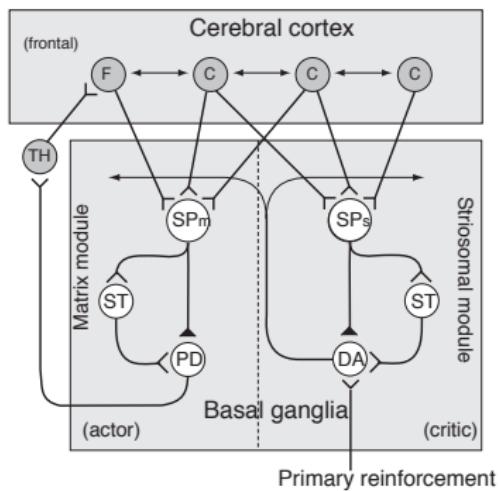


C. Temporal difference rule

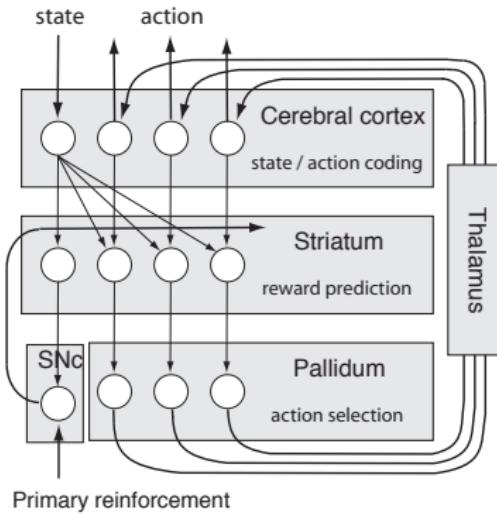


# Actor-critique and Q-learning

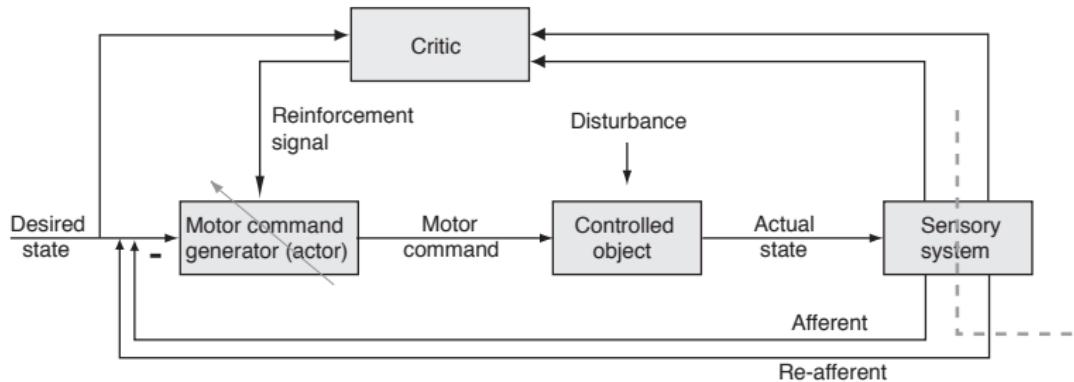
B. Actor-critic model of BG



D. Q-learning model of BG



# Actor-critique controller



## Further Readings

- Robert A. Jacobs, Michael I. Jordan, and Andrew G. Barto (1991), **Task decomposition through competition in a modular connectionist architecture: the what and where tasks**, in *Cognitive Science* 15: 219–250.
- Geoffrey Hinton (1999), **Products of experts**, in **Proceedings of the Ninth International Conference on Artificial Neural Networks**, ICANN '99, 1:1–6.
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- N. J. Nilsson (1965), **Learning machines: foundations of trainable pattern-classifying systems**, McGraw-Hill.
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- Peter Dayan and Laurence F. Abbott (2001), **Theoretical Neuroscience**, MIT Press.