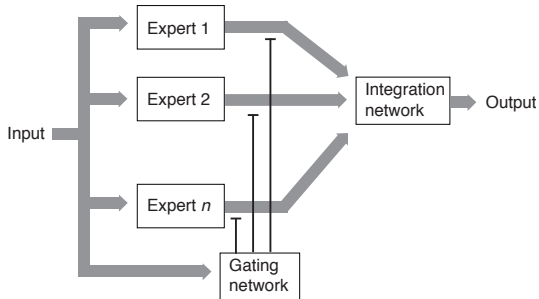


# Fundamentals of Computational Neuroscience 2e

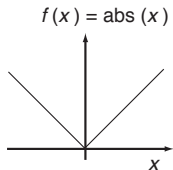
December 31, 2009

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

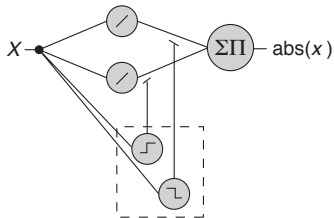
# Mixture of experts



A. Absolute function

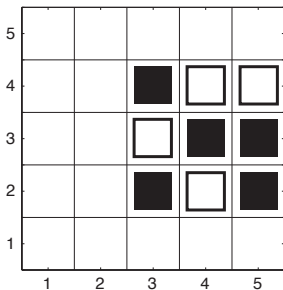


B. Mixture of expert for absolute function

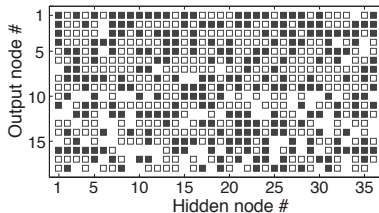


# The 'what-and-where' task

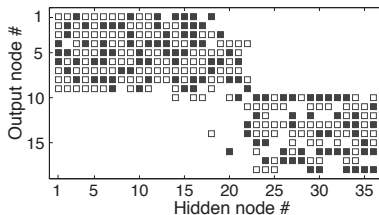
A. Model retina with sample image



B. Without bias towards short connections



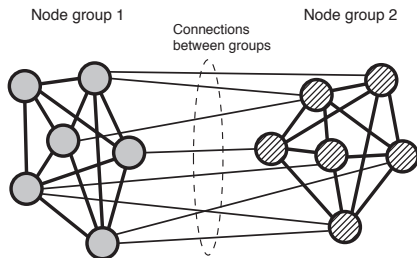
C. With bias towards short connections



Jacobs and Jordan (1992)

# Coupled attractor networks

## A. Coupled attractor networks

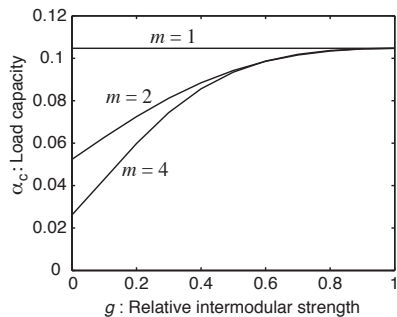


## B. The left-right universe with letters

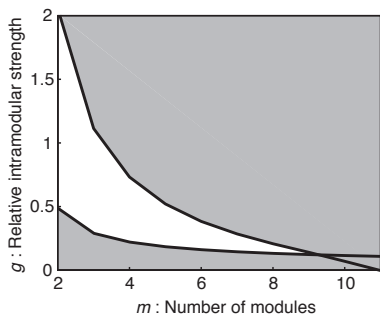
000011100000	111111110000
000011100000	111111111100
000011110000	111000000110
000110110000	111000011100
0001100011000	1110001110000
0011100011100	1111111000000
0011111111100	1111111000000
0111111111110	1110001110000
0111000001110	1110000011100
0111000001110	1110000001110
0111000001110	1111111111100
0111000001110	1111111110000

# Limit on modularity

A. Load capacity

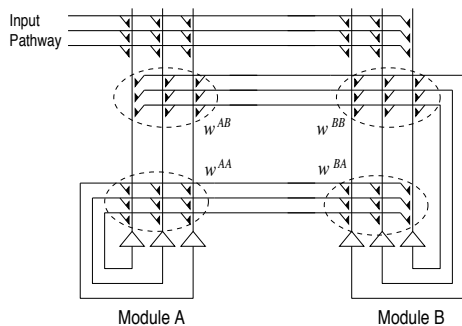


B. Bounds on intermodular strength

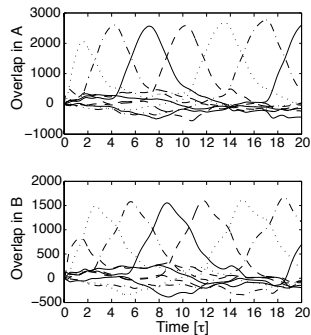


# Sequence learning

A. Modular attractor model

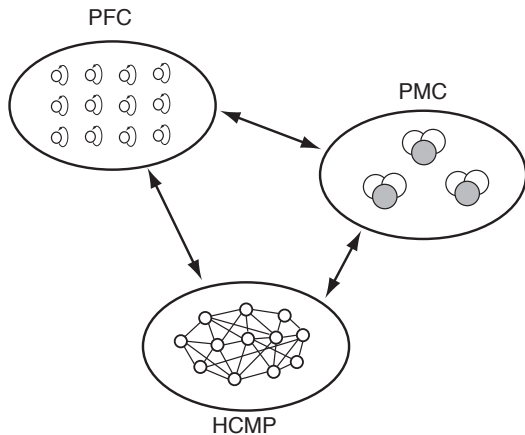


B. Time evolution of overlaps



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

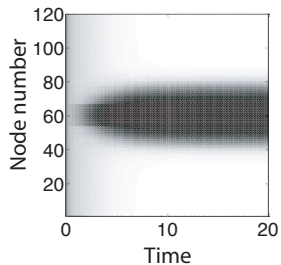
# Working memory



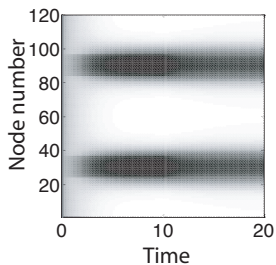
O'Reilly, Braver, and Cohen 1999

# Limit on working memory

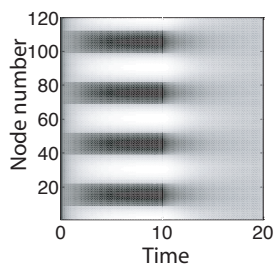
A. One object



B. Two objects

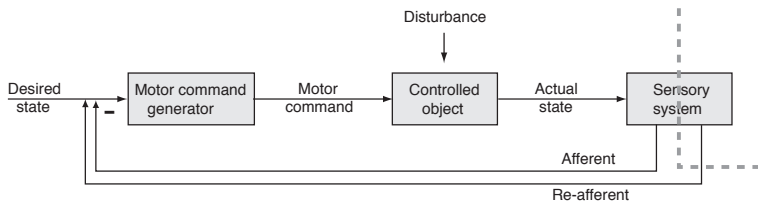


C. Four objects

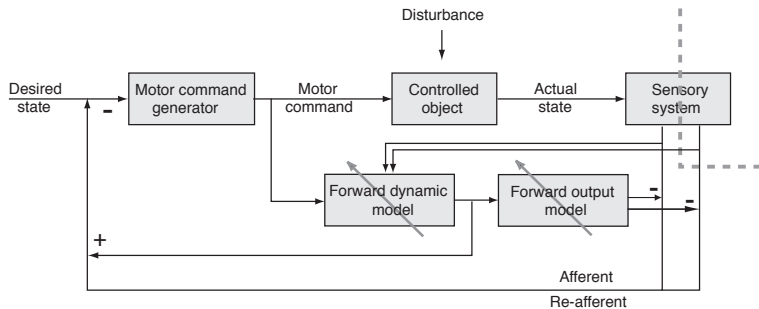




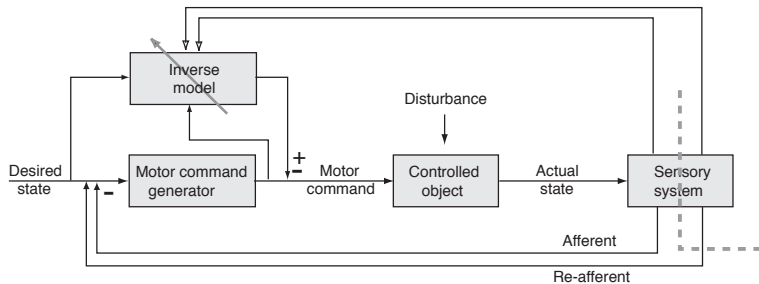
# Motor learning and control



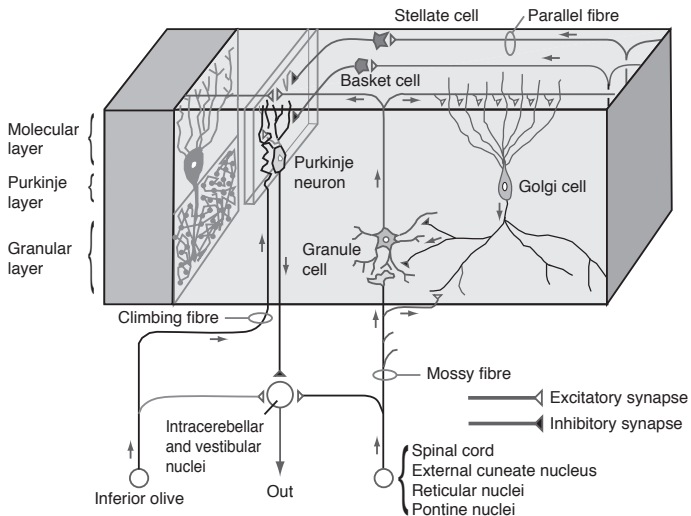
# Forward model controller



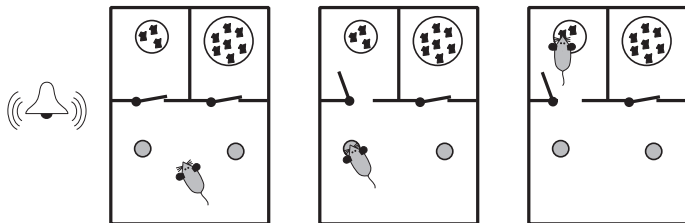
# Inverse model controller



# Cerebellum

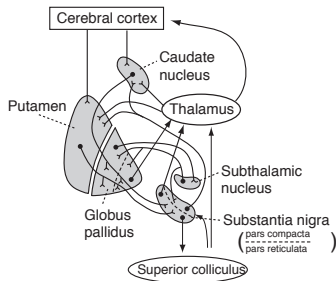


# Reinforcement learning

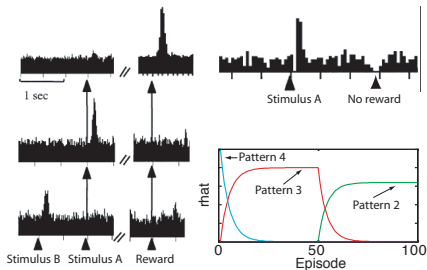


# Basal Ganglia

A. Outline of basic BG anatomy

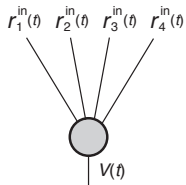


C. Recordings of SNc neurons and simulations

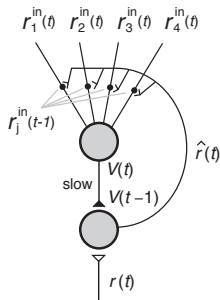


# temporal difference learning

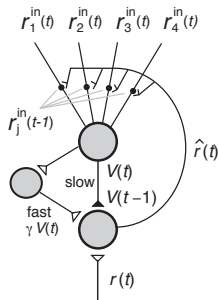
A. Linear predictor node



B. Temporal delta rule

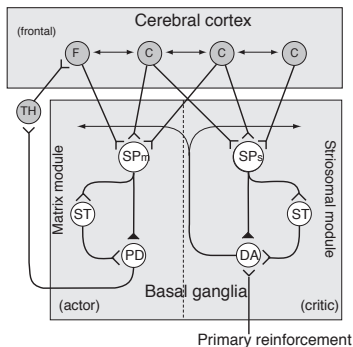


C. Temporal difference rule

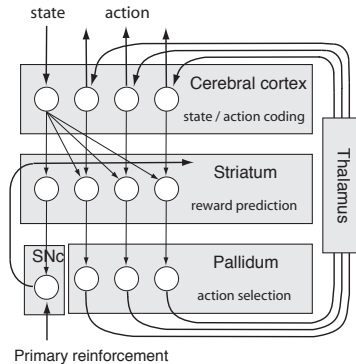


# Actor-critique and Q-learning

## B. Actor-critic model of BG

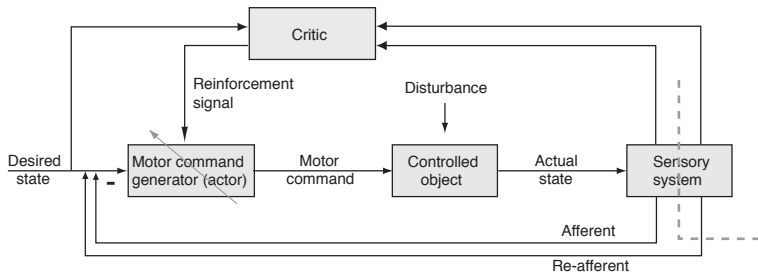


## D. Q-learning model of BG





# 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.
- Yaneer Bar-Yam (1997), **Dynamics of complex systems**, Addison-Wesley.
- Edmund T. Rolls and Simon M. Stringer (1999), **A model of the interaction between mood and memory**, in **Networks: Computation in neural systems** 12: 89–109.
- N. J. Nilsson (1965), **Learning machines: foundations of trainable pattern-classifying systems**, McGraw-Hill.
- O. G. Selfridge (1958), **Pandemonium: a paradigm of learning, in the mechanization of thought processes**, in **Proceedings of a Symposium Held at the National Physical Laboratory**, November 1958, 511–27, London HMSO.
- Marvin Minsky (1986), **The society of mind**, Simon & Schuster.
- Akira Miyake and Priti Shah (eds.) (1999), **Models of working memory**, Cambridge University Press.
- Daniel M. Wolpert, R. Chris Miall, and Mitsuo Kawato (1998), **Internal models in the cerebellum**, in **Trends Cognitive Science** 2: 338–47.
- Edmund T. Rolls and Alessandro Treves (1998), **Neural networks and brain function**, Oxford University Press.
- James C. Houk, Joel L. Davis, and David G. Beiser (eds.) (1995), **Models of information processing in the basal ganglia**, MIT Press.
- Richard S. Sutton and Andrew G. Barto (1998), **Reinforcement learning: an introduction**, MIT Press.
- Peter Dayan and Laurence F. Abbott (2001), **Theoretical Neuroscience**, MIT Press.