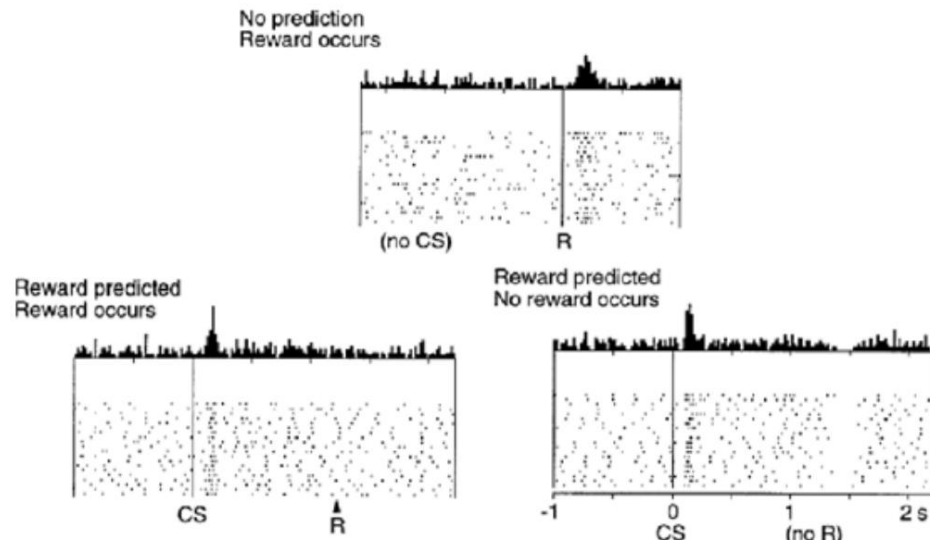# Neural Networks

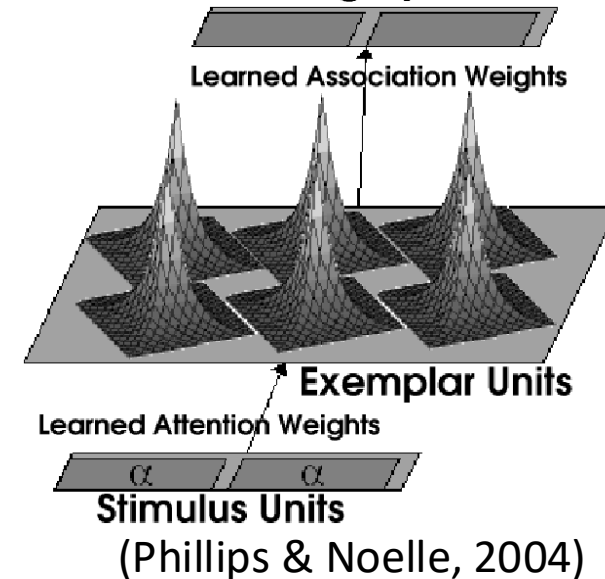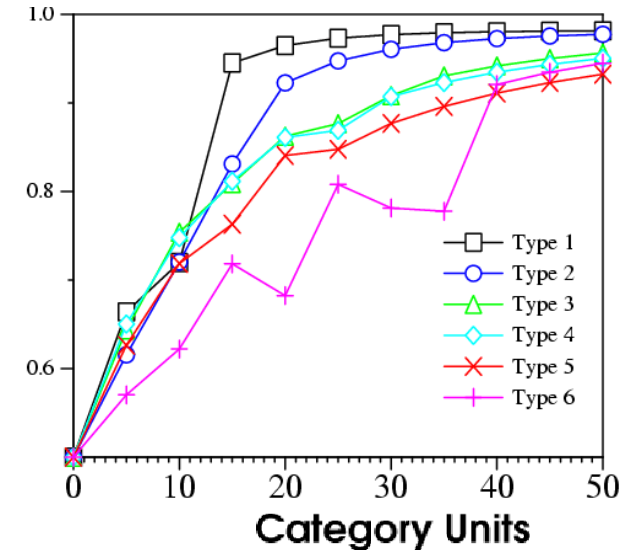*Cognitive Science and Neural Networks*

CSCI 4850/5850

Cognitive Neuroscience

- Neural networks can also help us understand how the brain works

- By modeling constraints based on anatomical and physiological constraints, one can predict their mechanisms

- Results can be verified against human and/or animal performance data

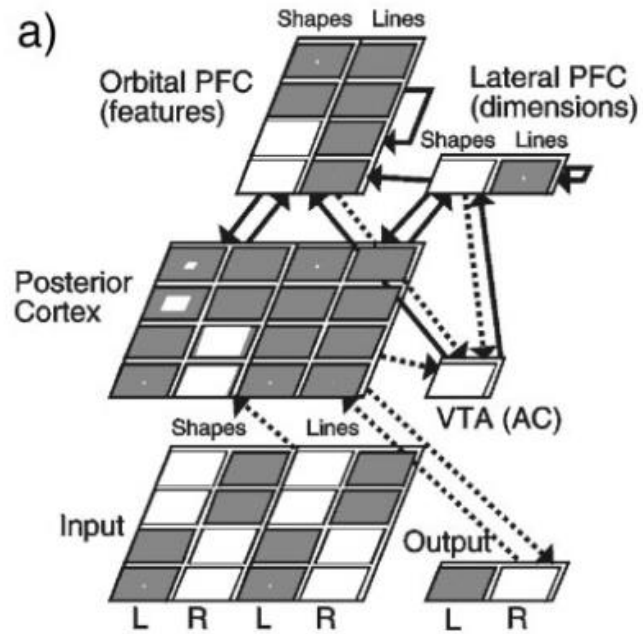Dopamine Response to Conditioned Stimulus (CS) and Reward (R) (Shultz et al., 1997)

No prediction
Reward occurs

(no CS)   R

Reward predicted
Reward occurs

Reward predicted
No reward occurs

CS   R

-1   0   1   2 s
CS   (no R)

TD learning happens in the brain!

Category Units

Learned Association Weights

Exemplar Units

Learned Attention Weights

Stimulus Units
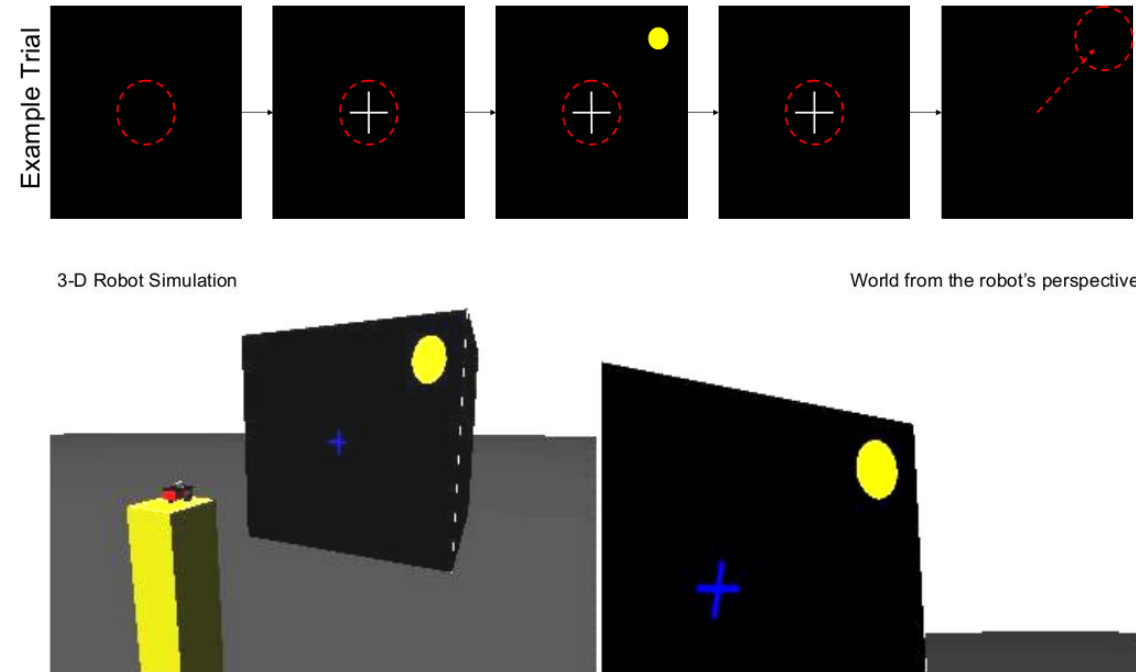
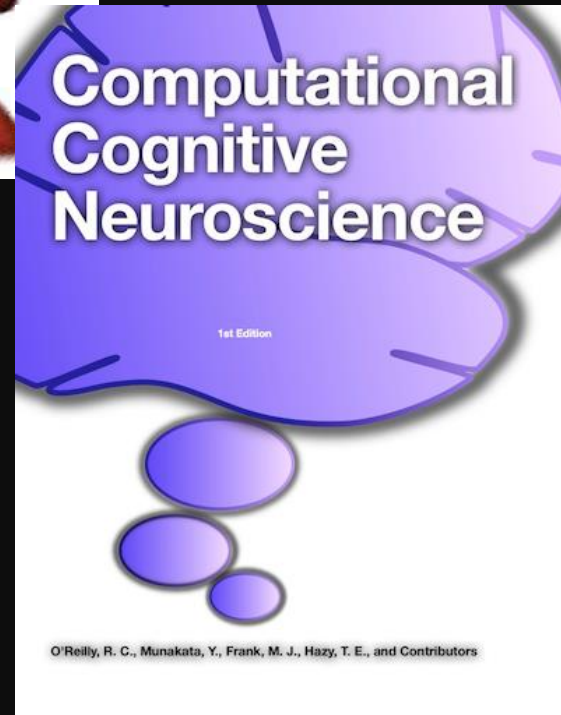(Phillips & Noelle, 2004)

Cognitive Neuroscience
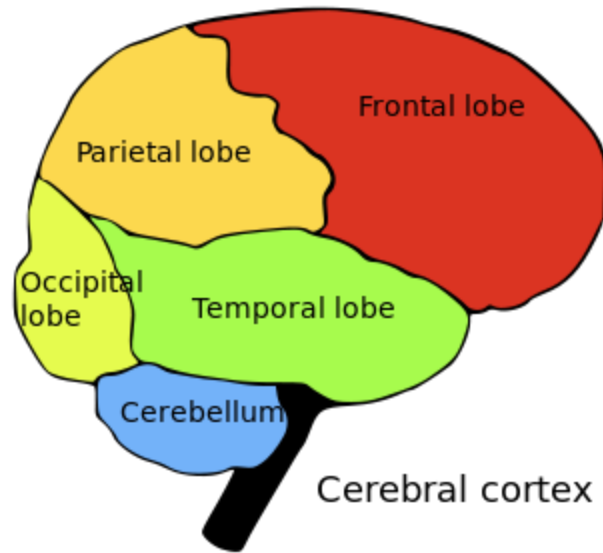
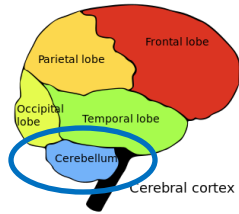(O'Reilly et al., 2002)

(Phillips & Noelle, 2006)

Biologically Plausible Models
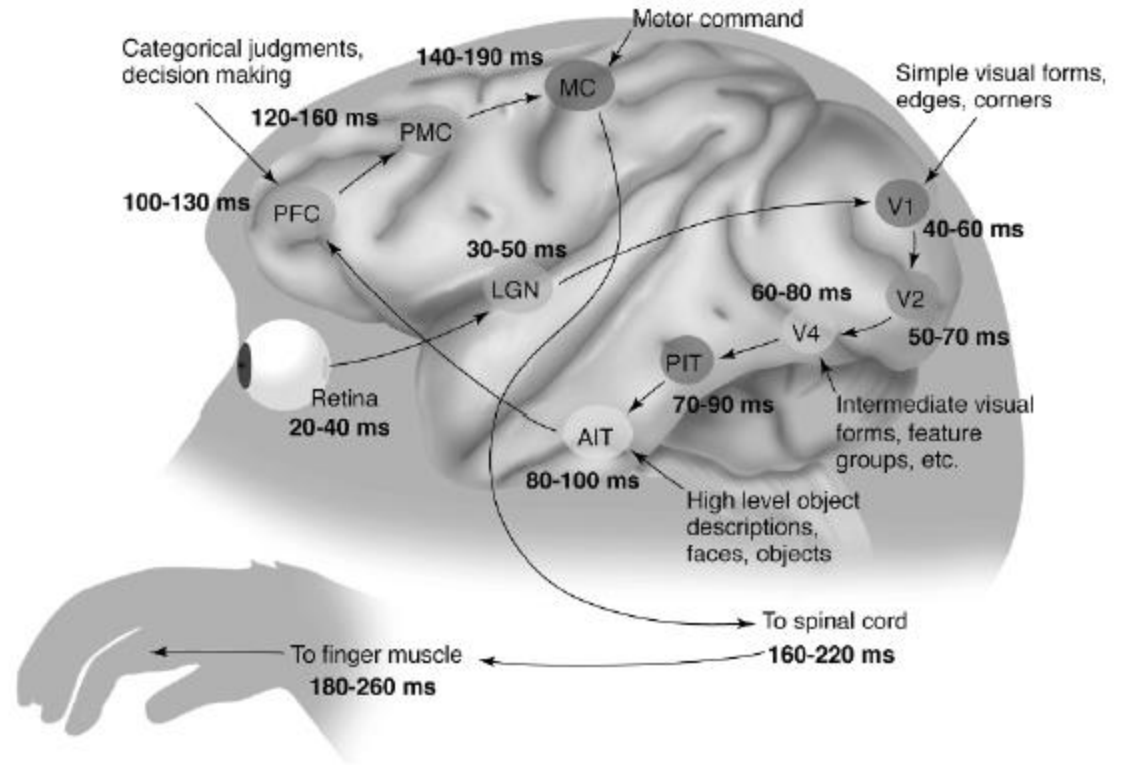
Computational
Cognitive
Neuroscience

1st Edition

O'Reilly, R. C., Munakata, Y., Frank, M. J., Hazy, T. E., and Contributors

Neural Organization

(Thorpe and Faber-Thorpe)

Cerebellum – Forward Model (Wolpert and Kowato)

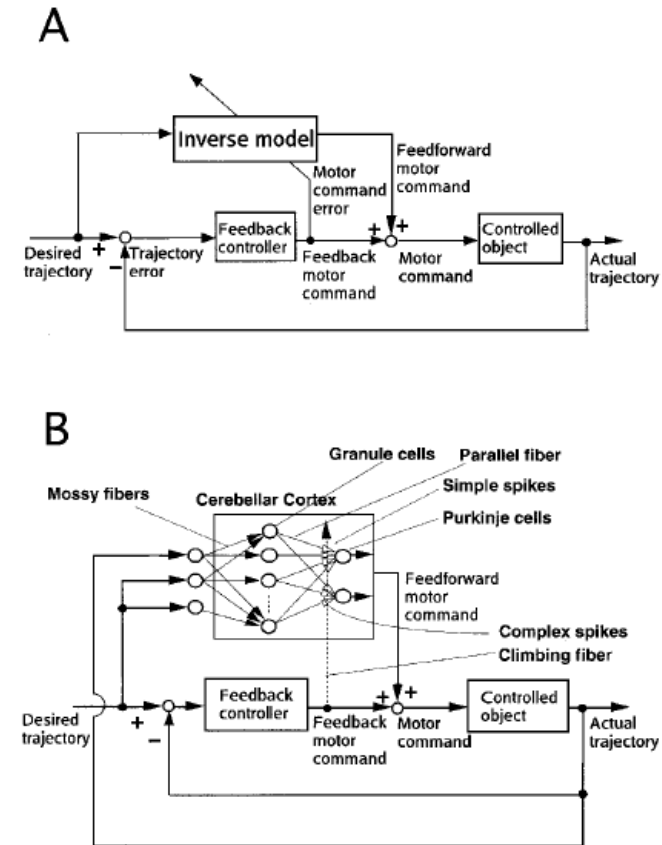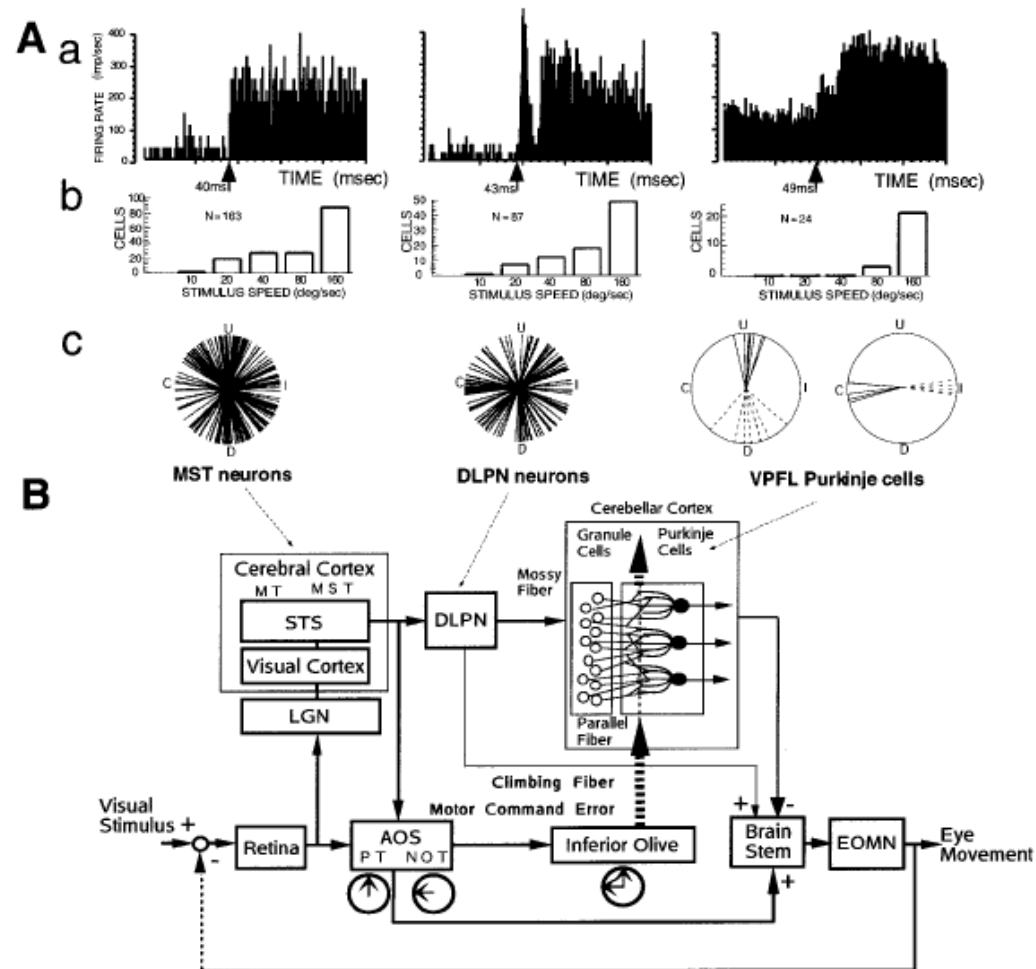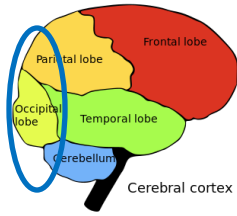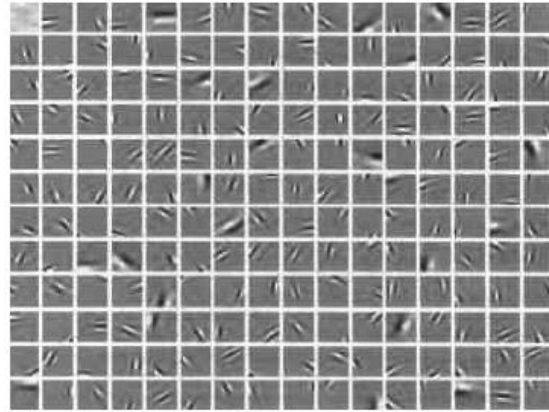

Figure 2. A, The general feedback-error-learning model. B, The cerebellar feedback-error-learning model (CBFELM) (Kawato, 1999). The "controlled object" is a physical entity that needs to be controlled by the CNS, such as the eyes, hands, legs, or torso.
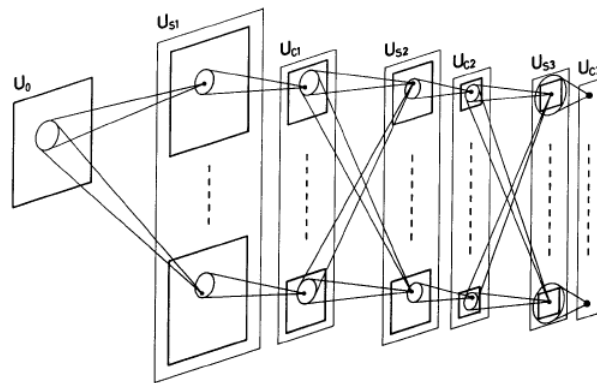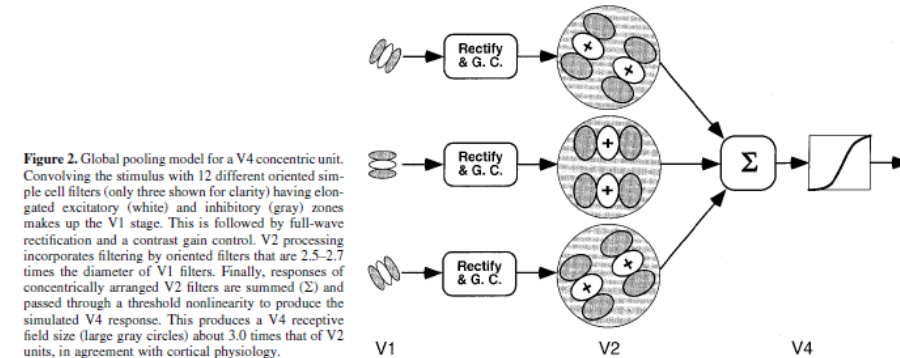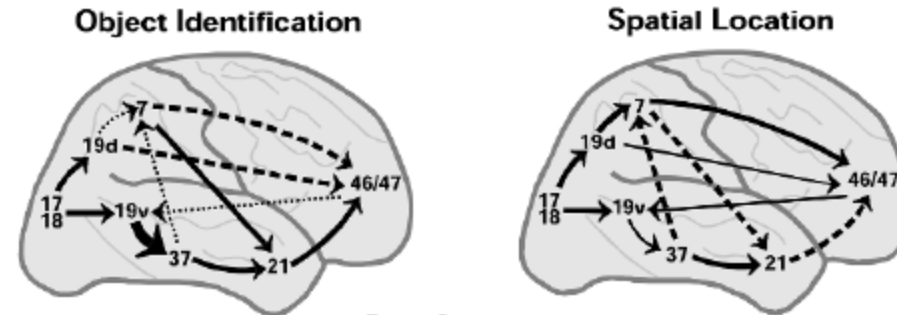
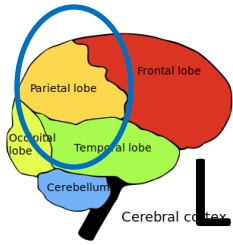# Occipital Lobe
Primary Visual Cortex

(Olshausen and Field)

Figure 2. Global pooling model for a V4 concentric unit. Convolving the stimulus with 12 different oriented simple cell filters (only three shown for clarity) having elongated excitatory (white) and inhibitory (gray) zones makes up the V1 stage. This is followed by full-wave rectification and a contrast gain control. V2 processing incorporates filtering by oriented filters that are 2.5–2.7 times the diameter of V1 filters. Finally, responses of concentrically arranged V2 filters are summed (Σ) and passed through a threshold nonlinearity to produce the simulated V4 response. This produces a V4 receptive field size (large gray circles) about 3.0 times that of V2 units, in agreement with cortical physiology.

(Wilson and Wilkinson)

(Fukushima)

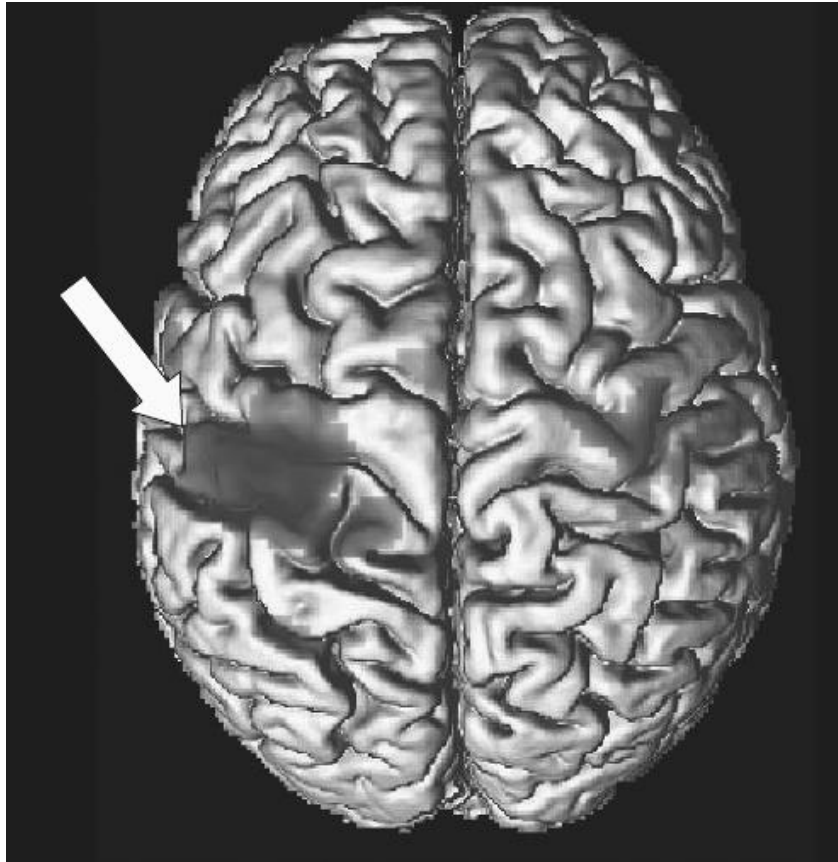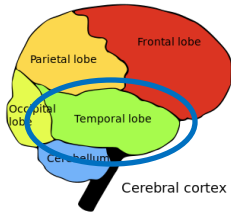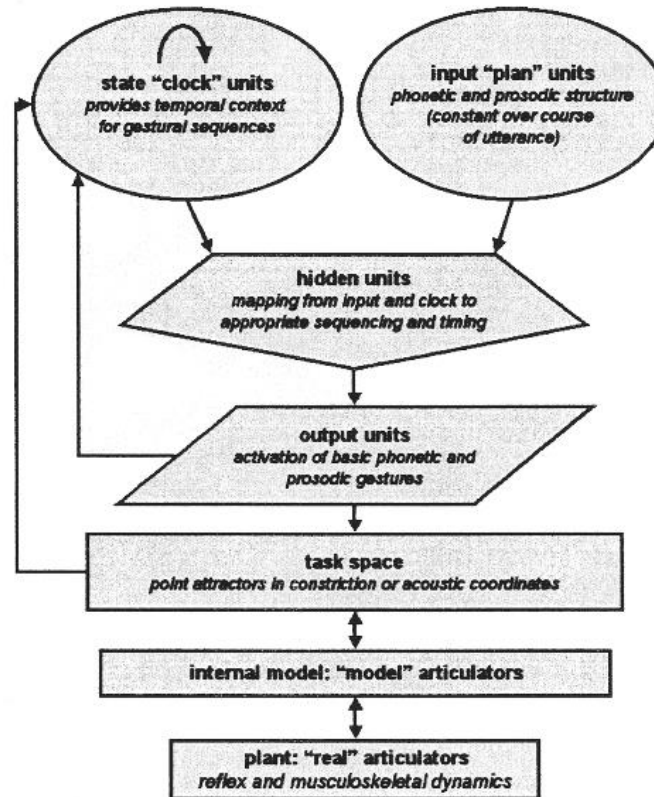(McIntosh)

Parietal Lobe
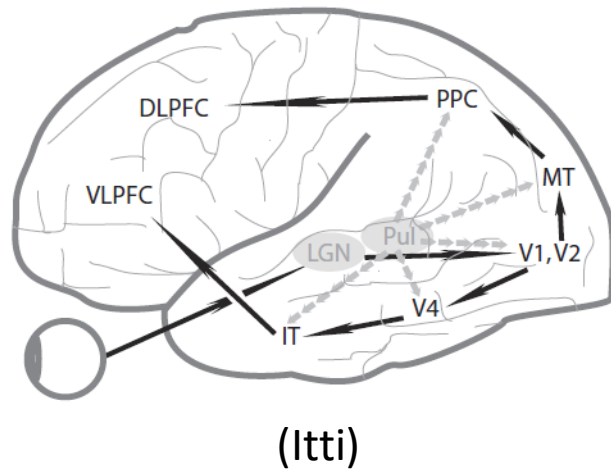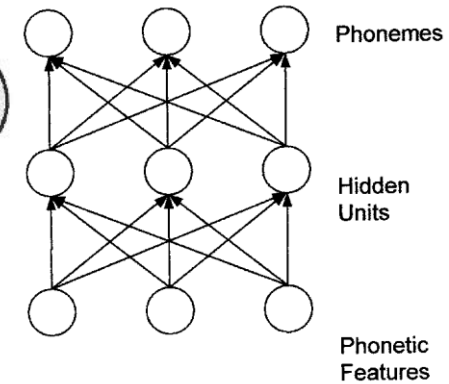# Long-term Motor/Processing Skills
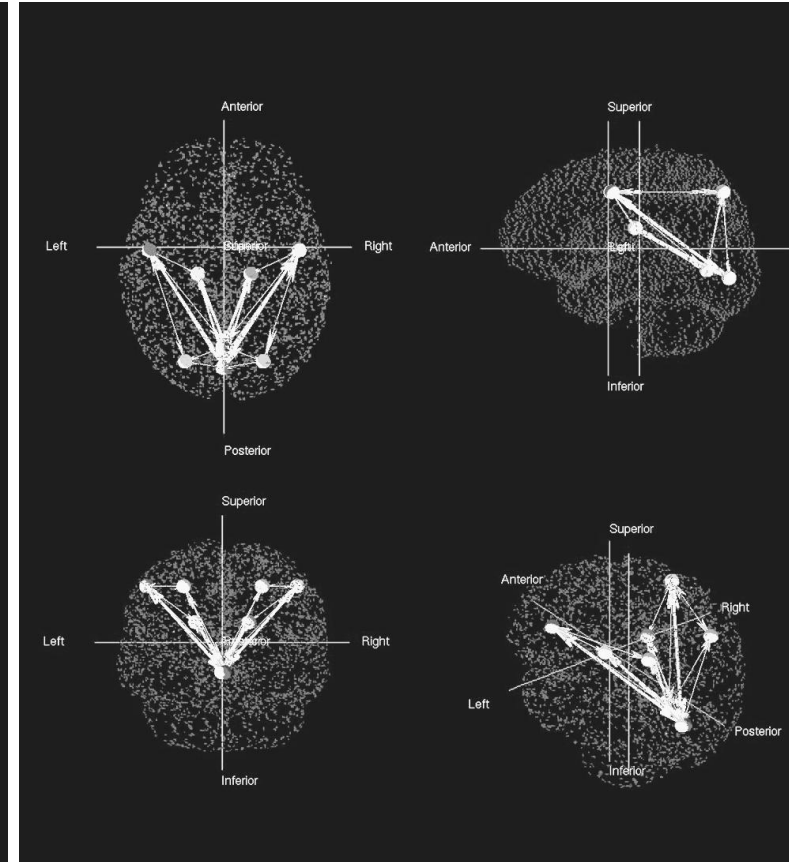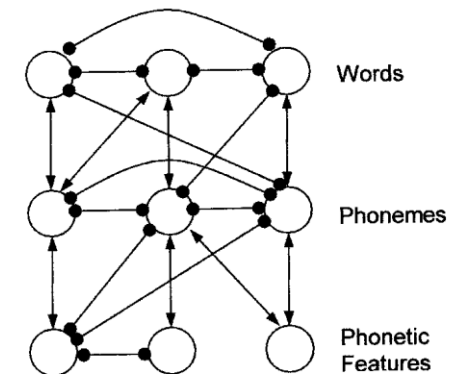
(van Horn)

Temporal Lobe
Long-term Memories

(Itti)

Bottom-Up Model

Phonemes

Hidden Units

Phonetic Features

state "clock" units
*provides temporal context
for gestural sequences*

input "plan" units
*phonetic and prosodic structure
(constant over course
of utterance)*

hidden units
*mapping from input and clock to
appropriate sequencing and timing*

output units
*activation of basic phonetic and
prosodic gestures*

task space
point attractors in constriction or acoustic coordinates

internal model: "model" articulators

plant: "real" articulators
reflex and musculoskeletal dynamics

(Byrd and Saltzman)

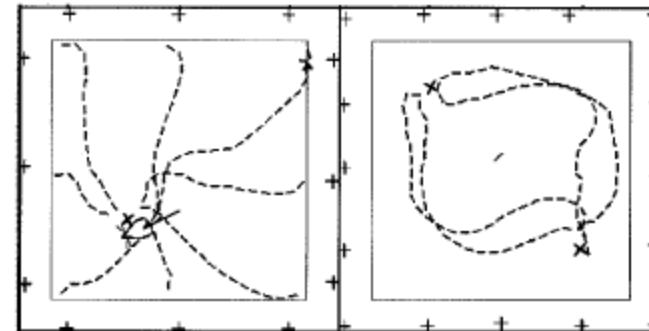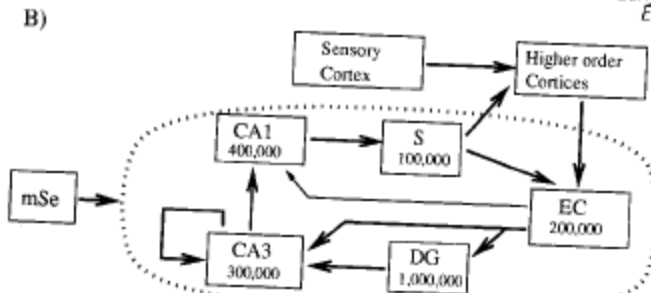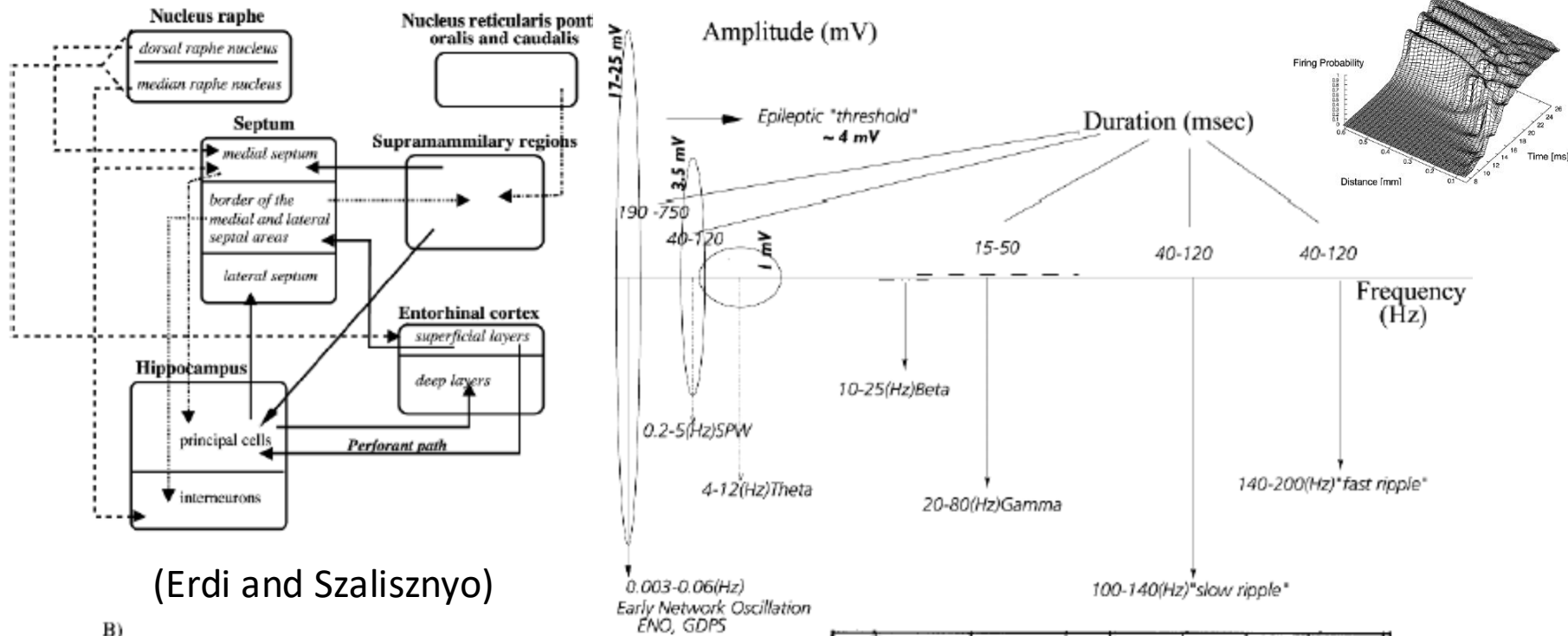**Interactive Activation Model**

Words

Phonemes

Phonetic Features

(Chater Christiansen)
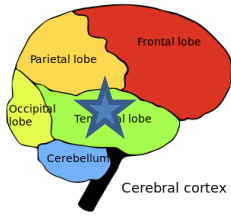
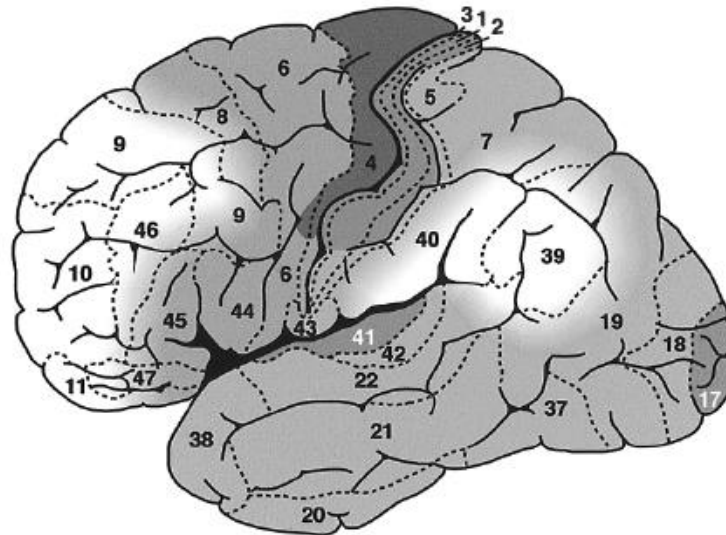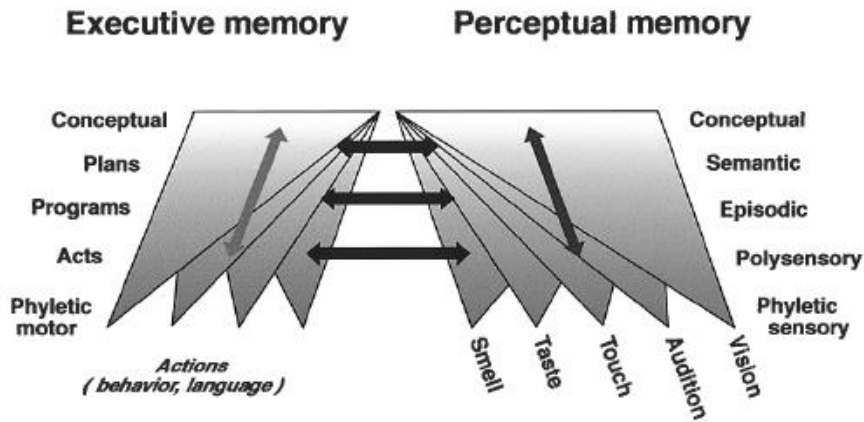# Hippocampus
Episodic and Place Memory

(Erdi and Szalisznyo)

(Burgess and O'Keefe)
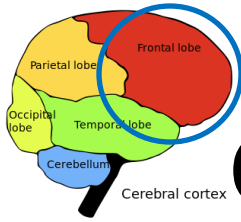
Frontal Lobe
Cognitive Control and Reasoning

(O'Reilly et al., 2002)

Executive memory   Perceptual memory

(Fuster)

(Fellous and Suri)
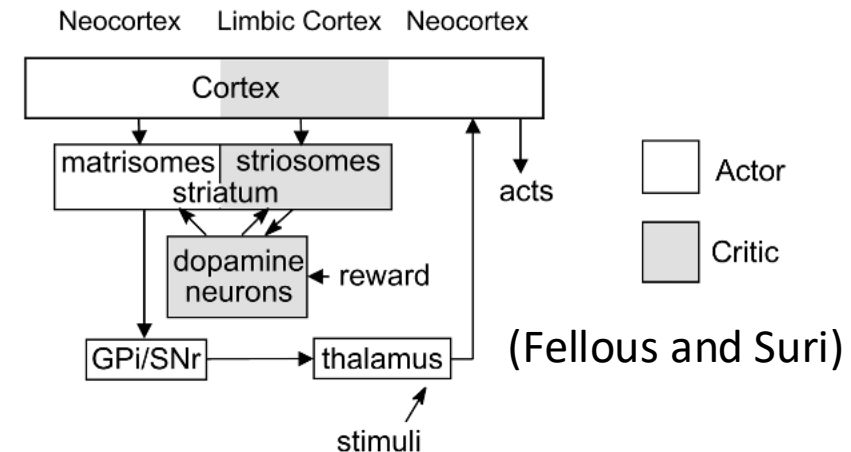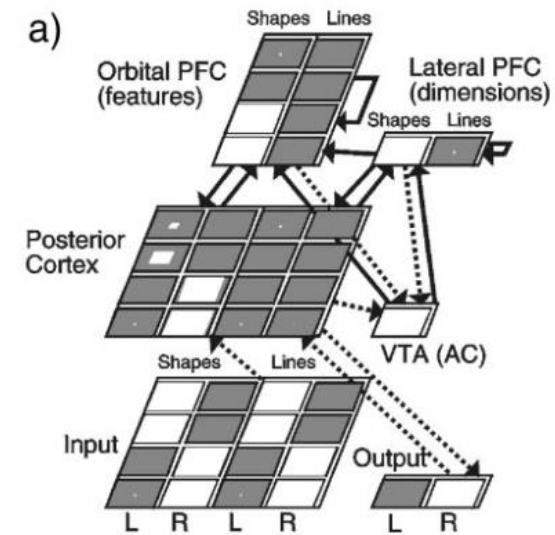
Have a Great Summer Break!