



CENTER FOR
**Brains
Minds+
Machines**

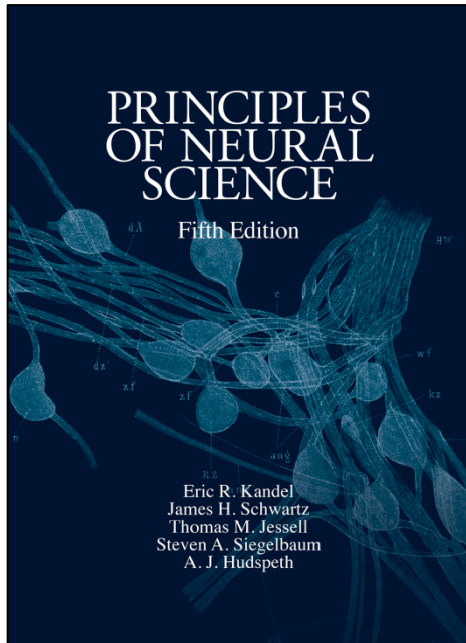
Tutorial on Cognitive Neurosciences

Brains, Minds & Machines Summer School 2018

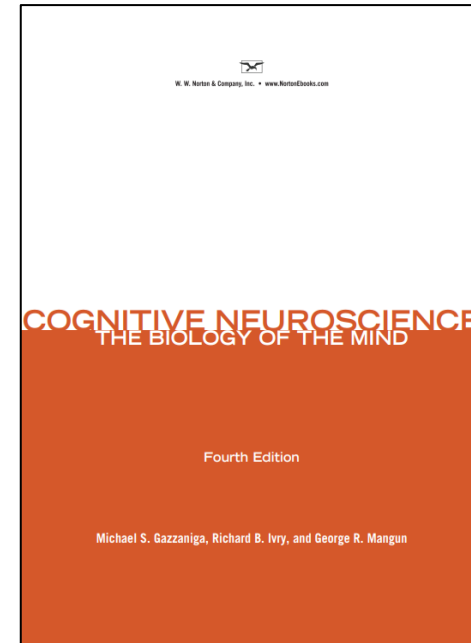
Frederico Azevedo

(fazevedo@mit.edu)

Classic textbooks



Kandel et al.
Principles of Neural Science.
5th ed.



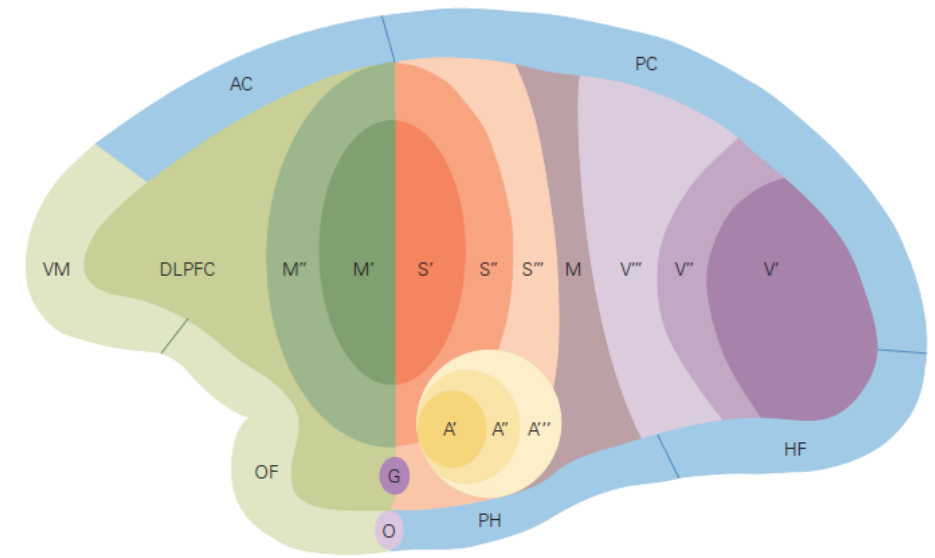
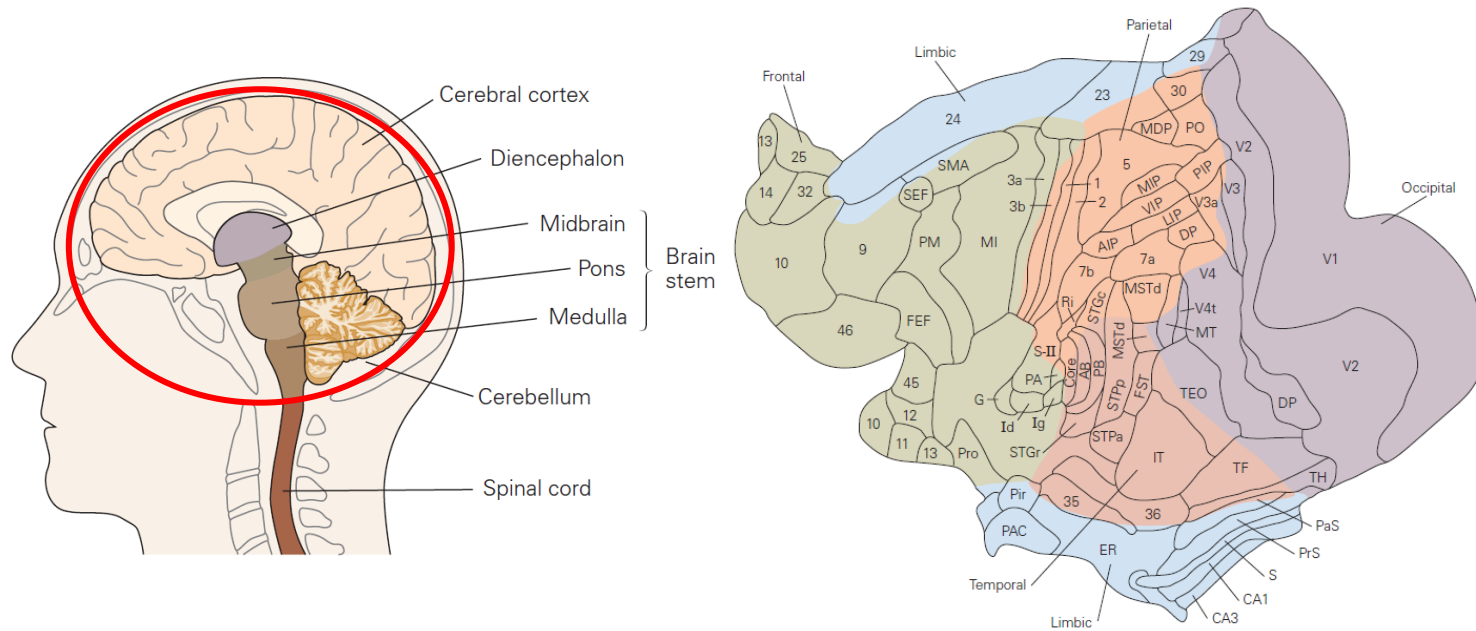
Gazzaniga et al.
Cognitive Neuroscience: the biology of the mind.
4th ed.

Cognition: the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses*

Neuroscience: the science of the structure and function of the nervous system

How the brain enables the mind

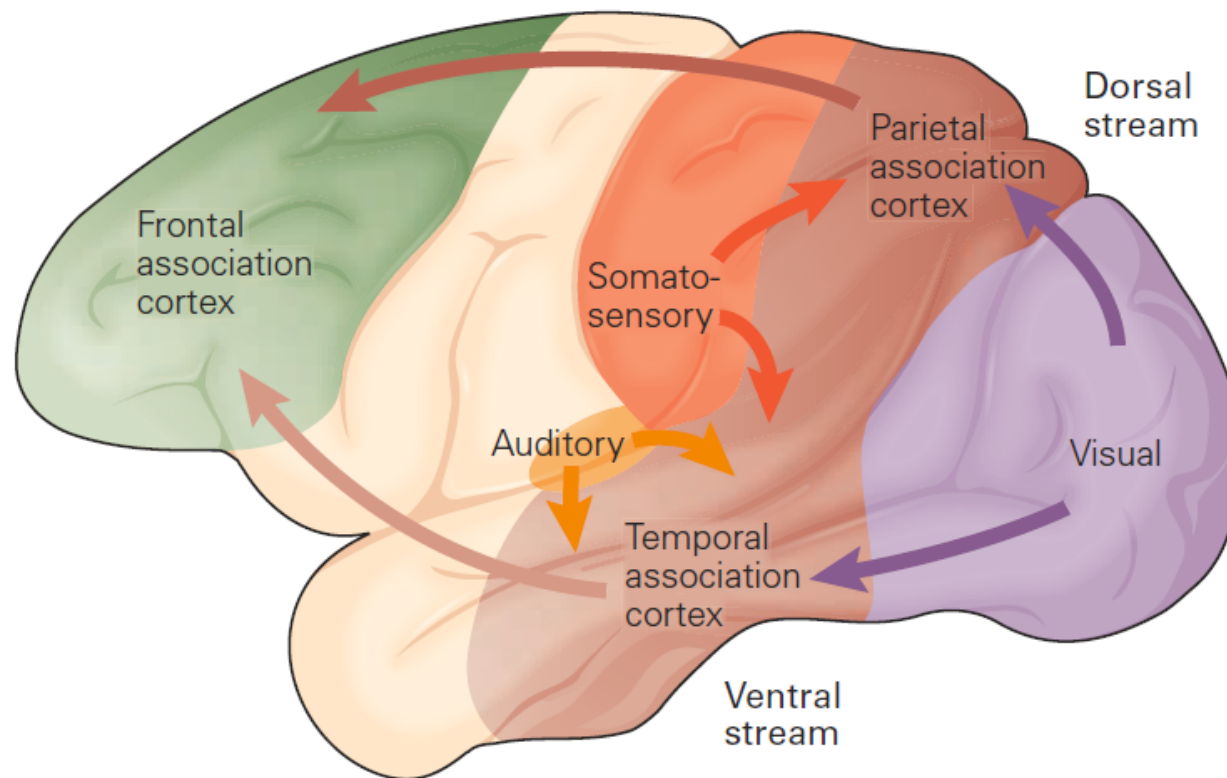
From anatomy to function



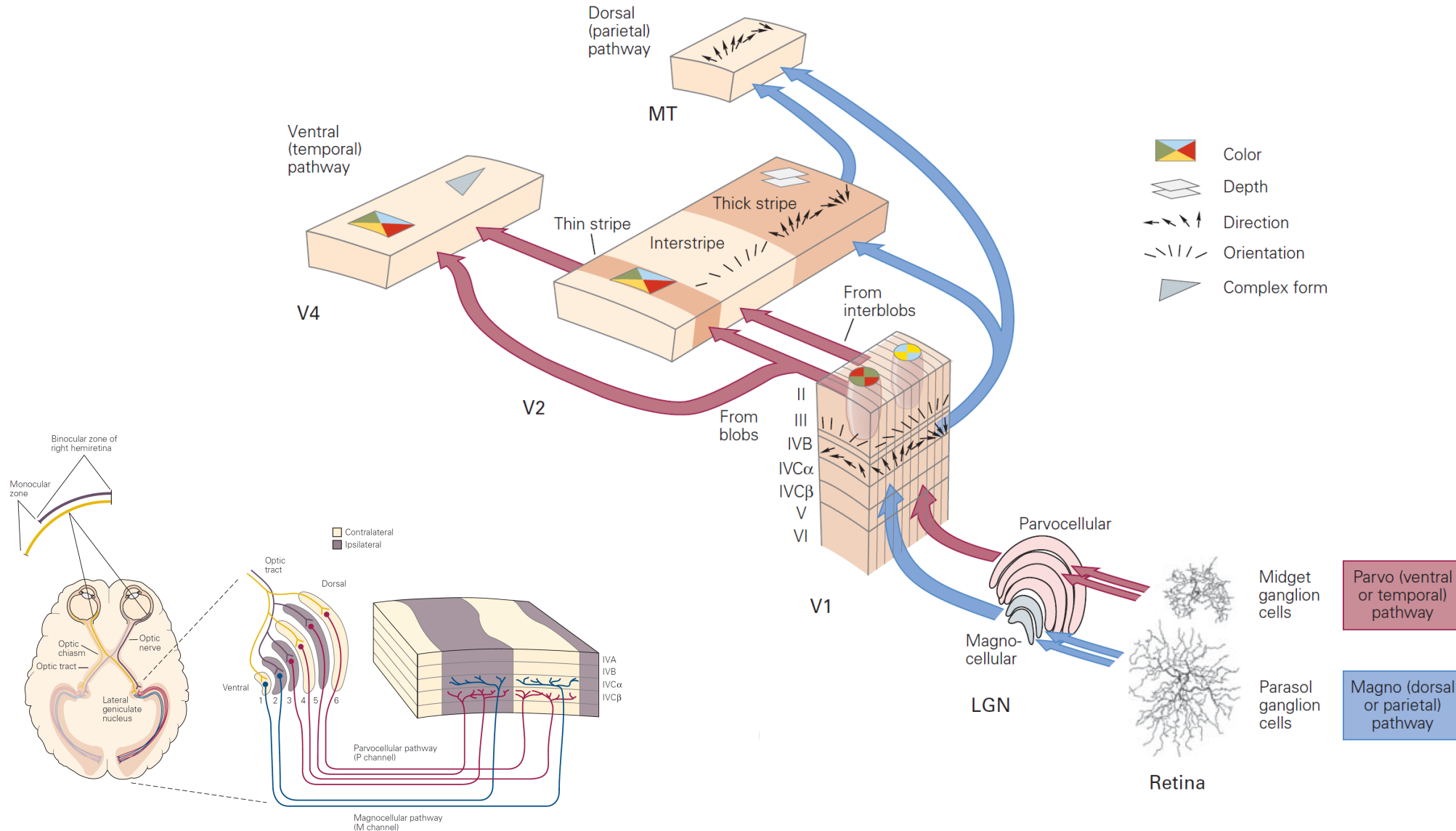
Core cognitive processes

- Perception
- Action
- Attention
- Learning & Memory
- Language, Emotion, etc ...

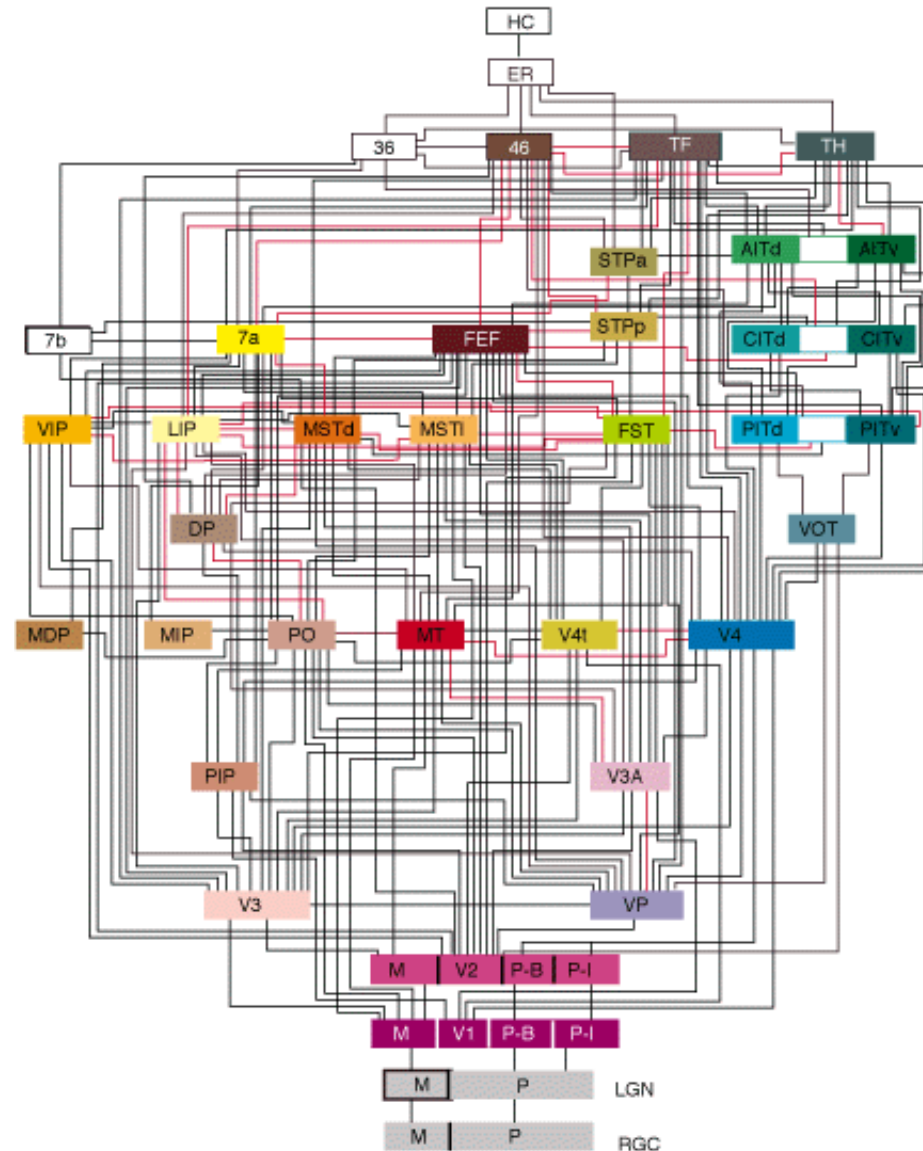
Two-streams model



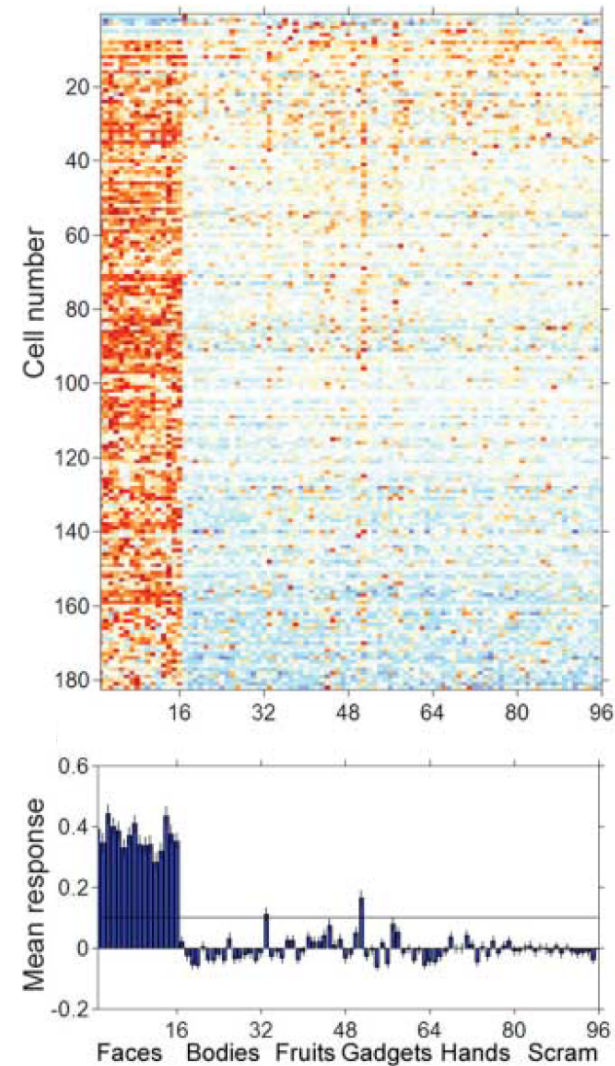
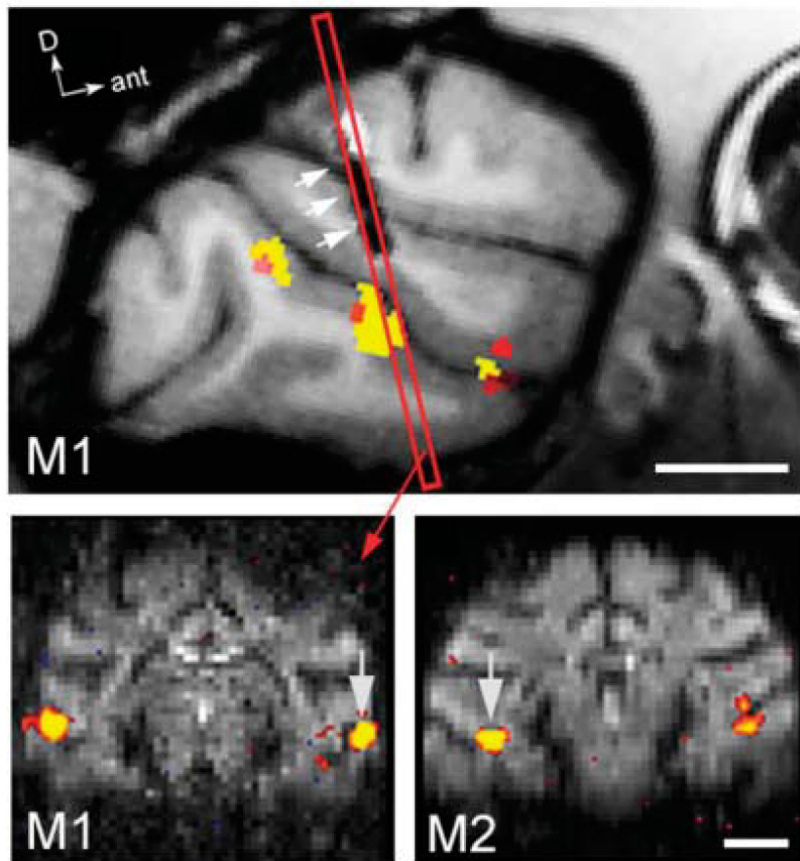
Visual processing



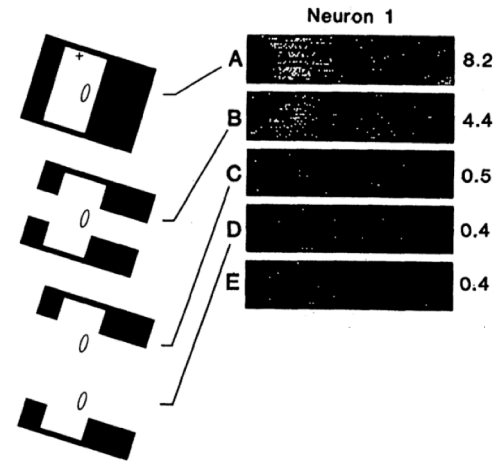
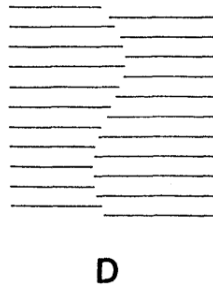
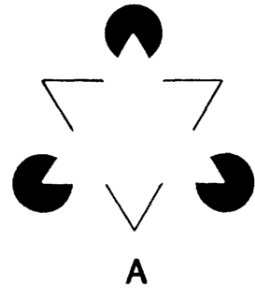
Distributed hierarchical processing



Face processing area

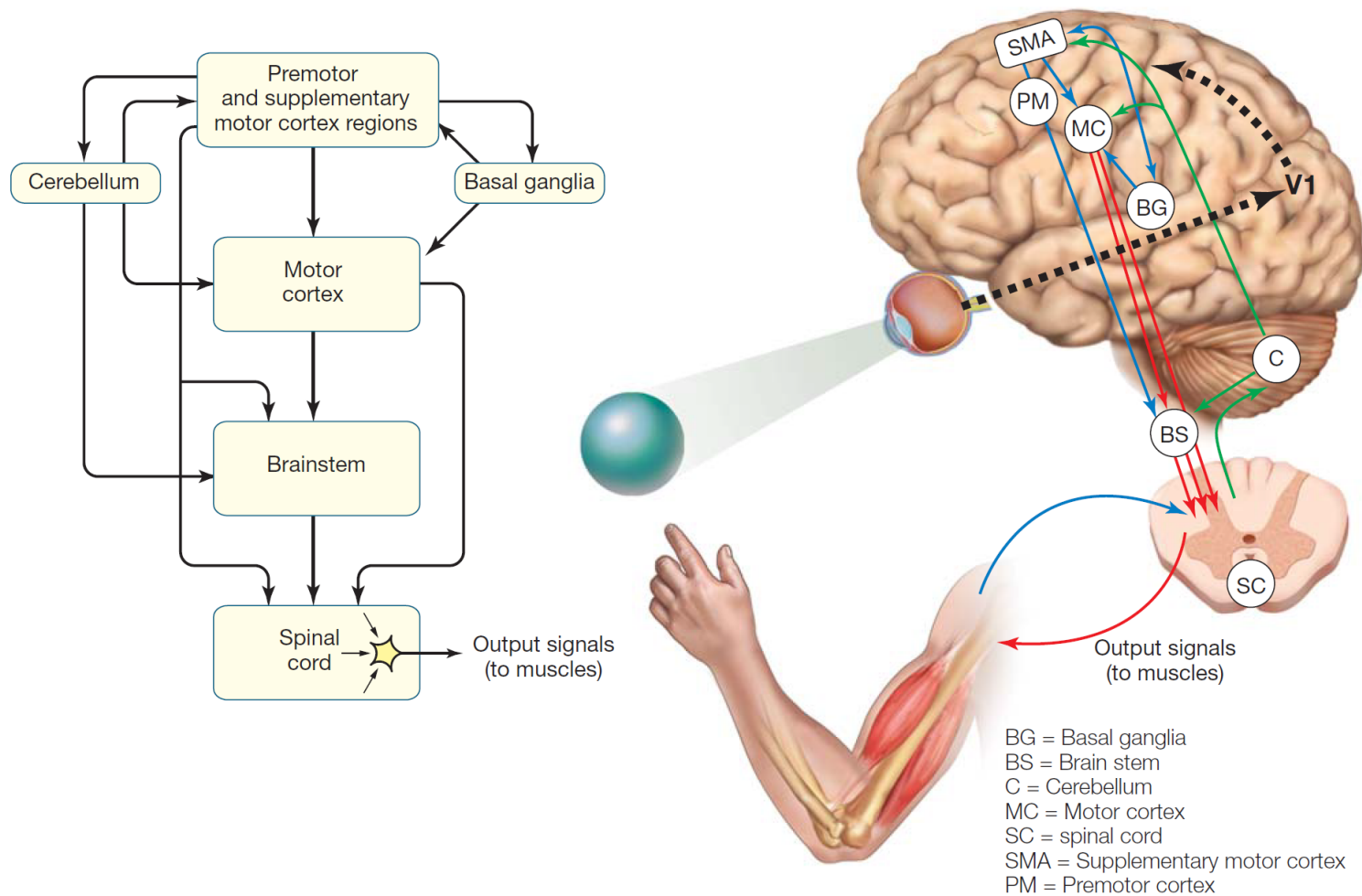


Context matters

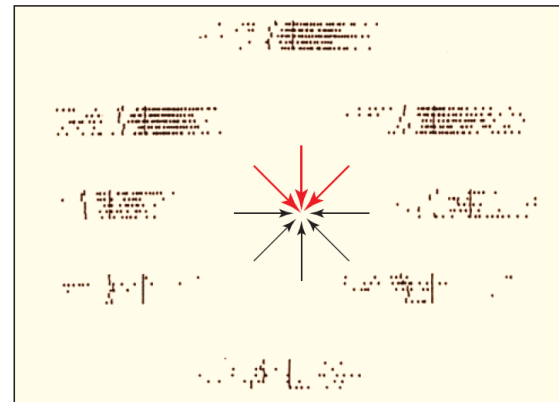
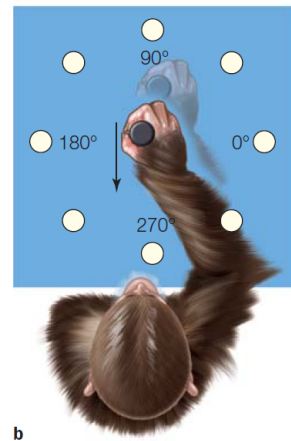
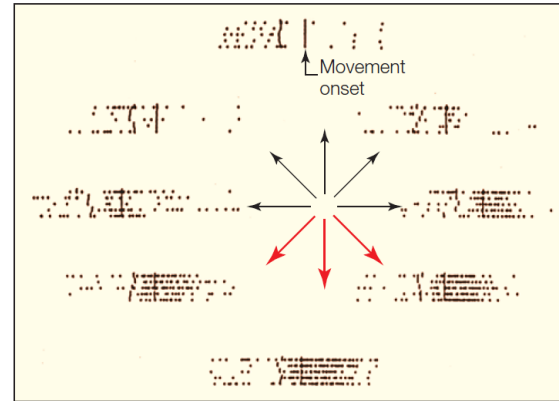
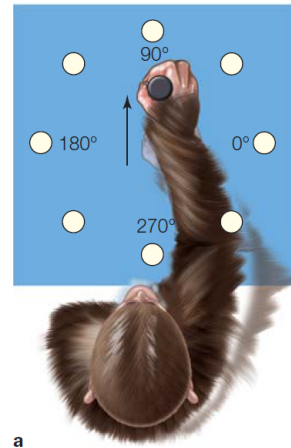


Heydt et al. (1984) Science

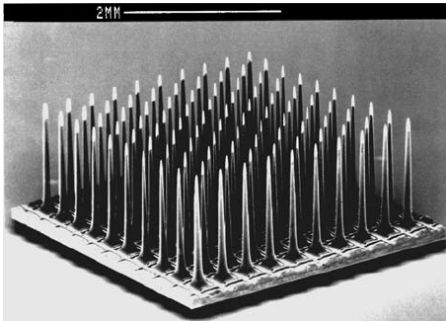
Action



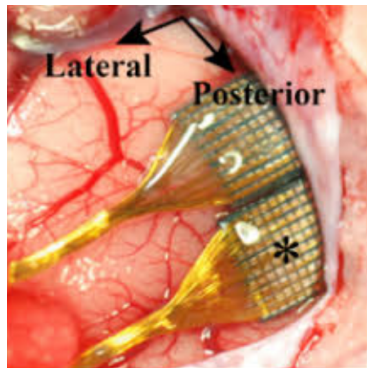
Decoding of movement



Decoding of movement



Blackrock Microsystems



Davies et al. (2012) J Neur Eng



Andrew Schwartz group

Attention

“the process by which organisms **select** a subset of available information upon which to focus for **enhanced processing** (often in a signal-to-noise-ratio sense) and integration” *Laurence M. Ward*

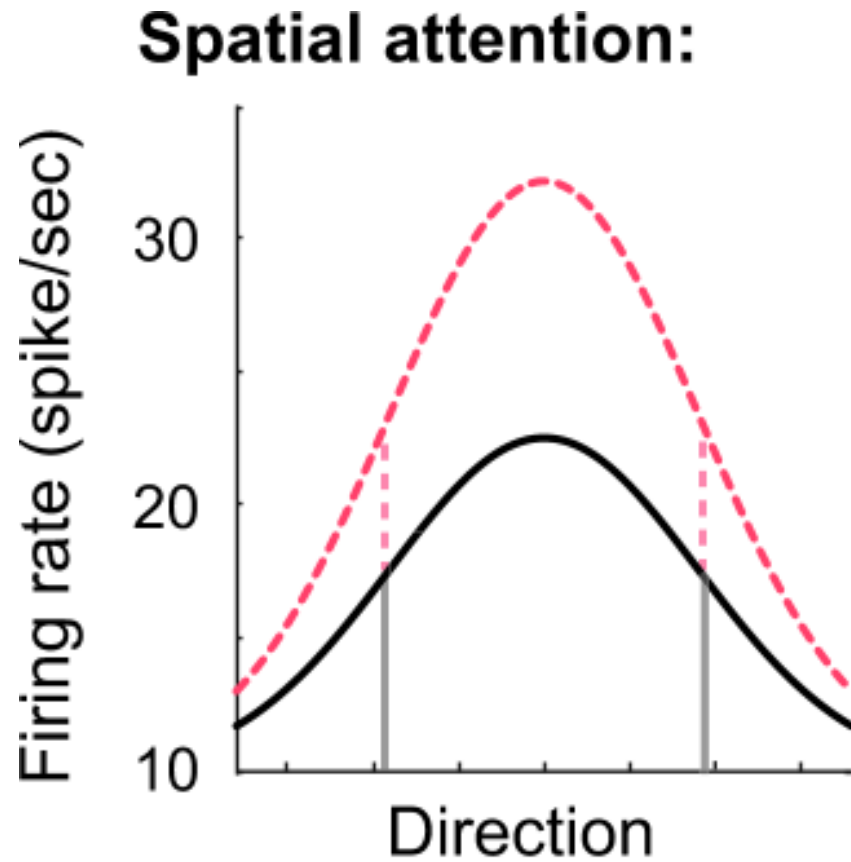
Spatial attention



Feature-based attention

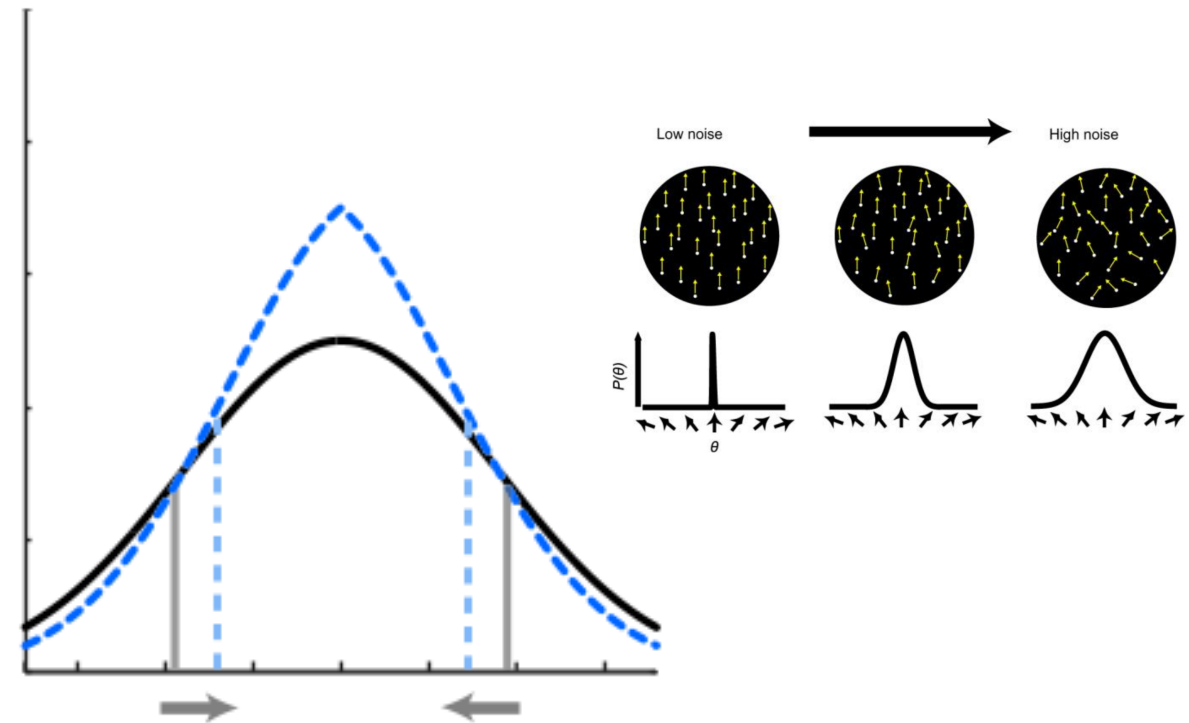


Modulation of population response



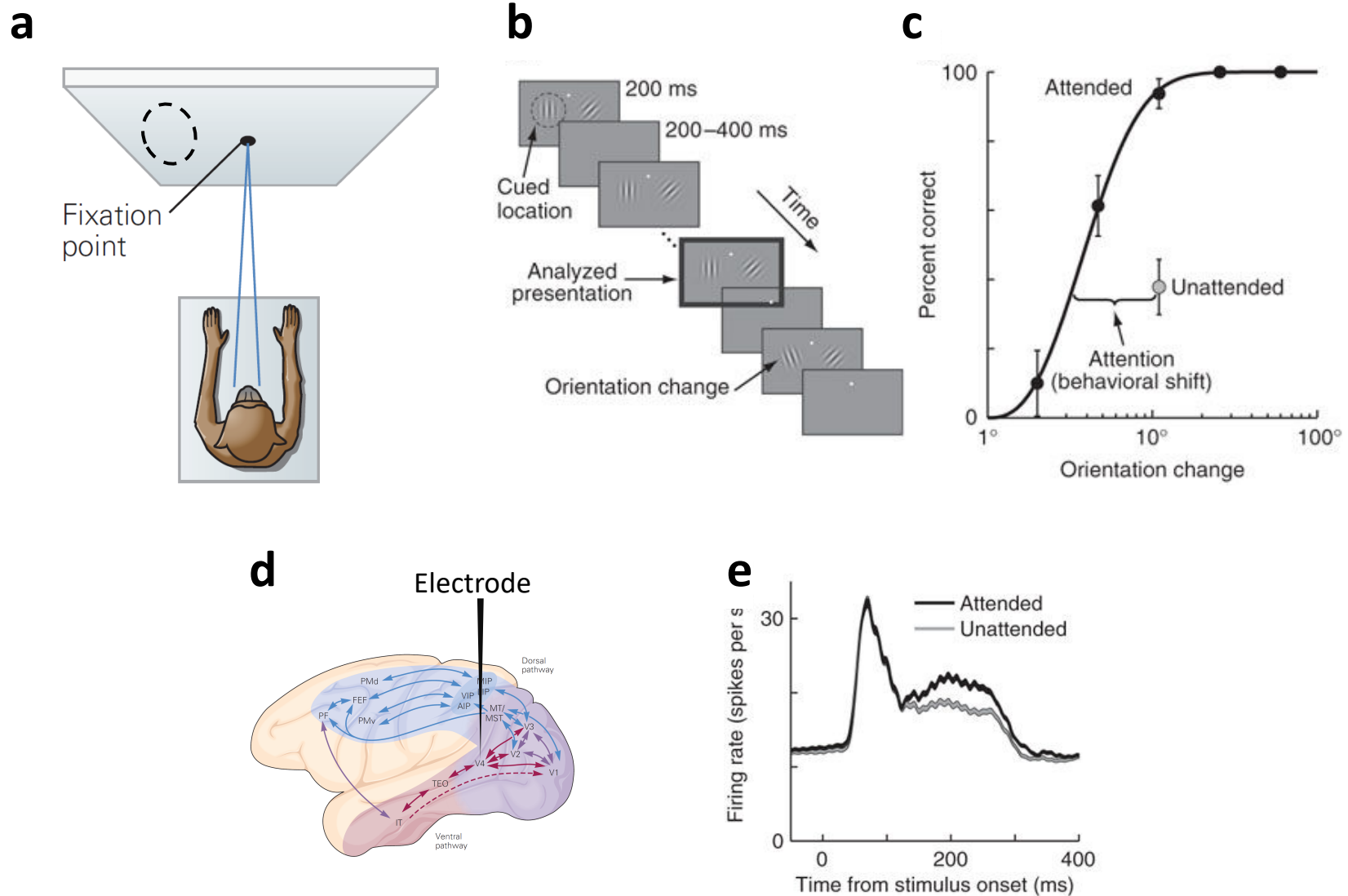
Increase in firing rate

Feature-based attention:

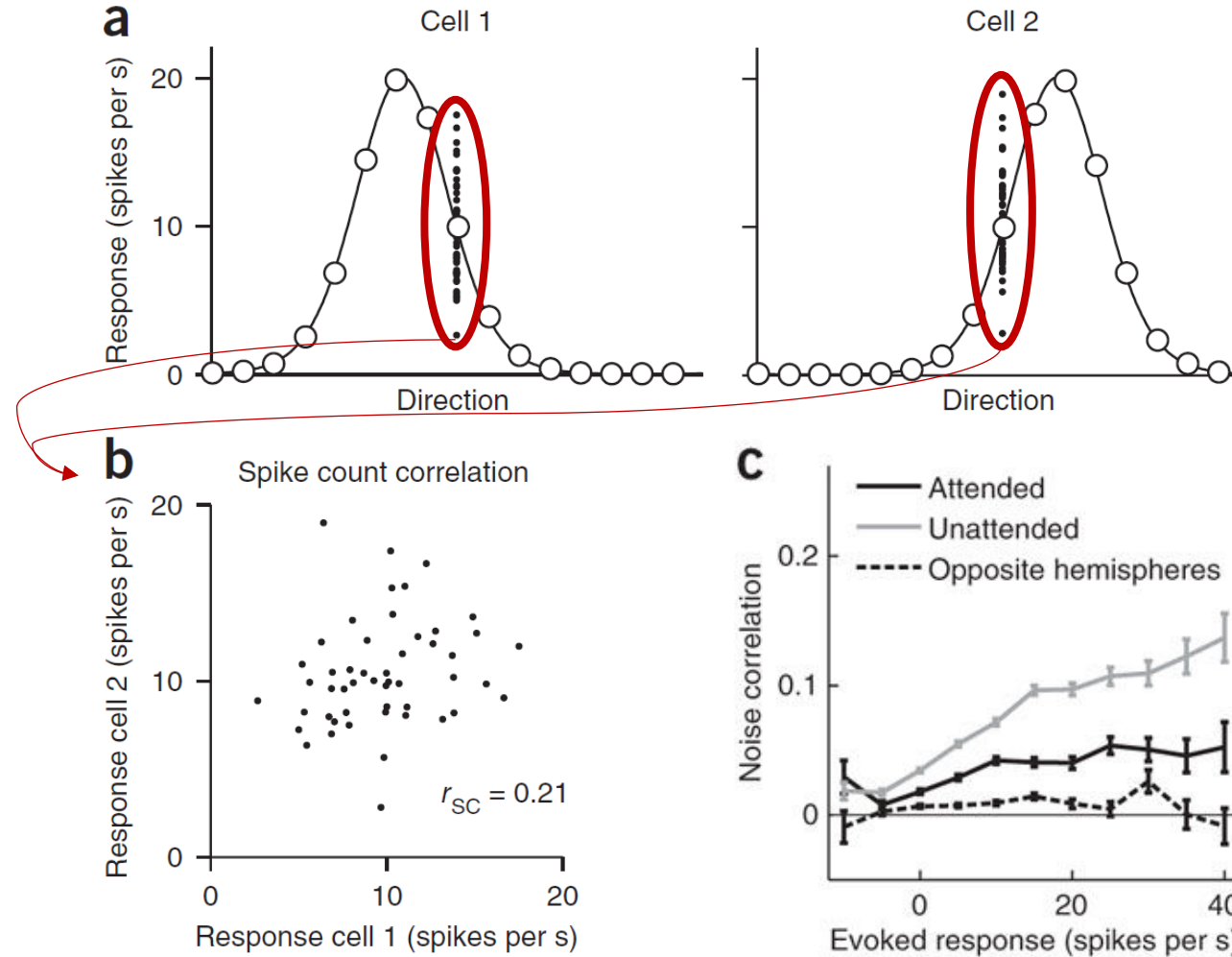


Increase in firing rate +
sharpening of response
(tuning)

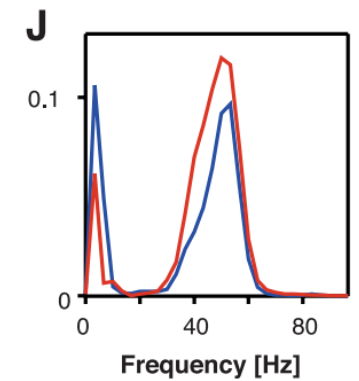
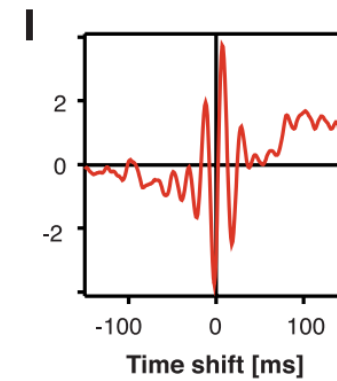
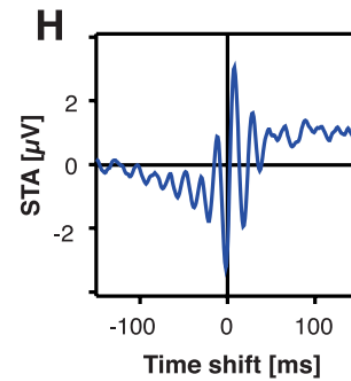
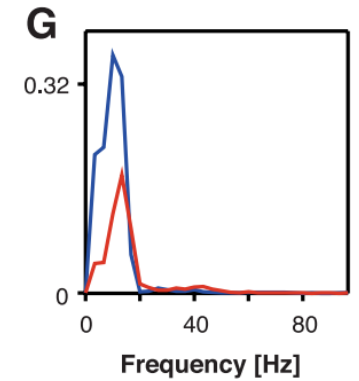
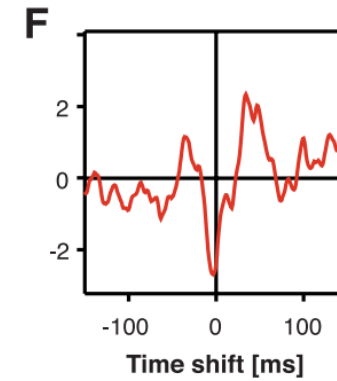
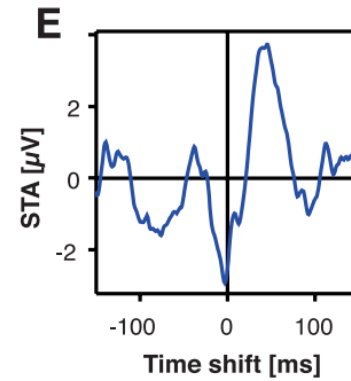
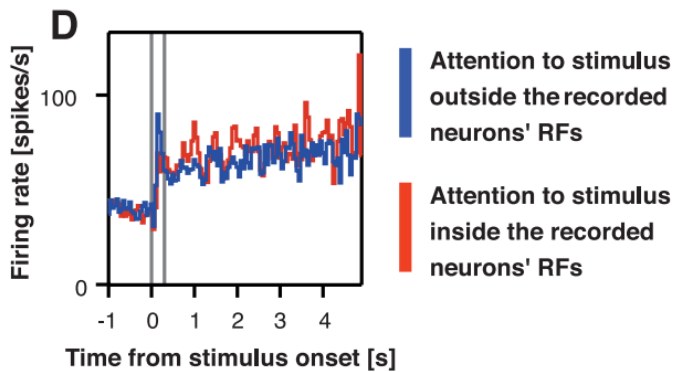
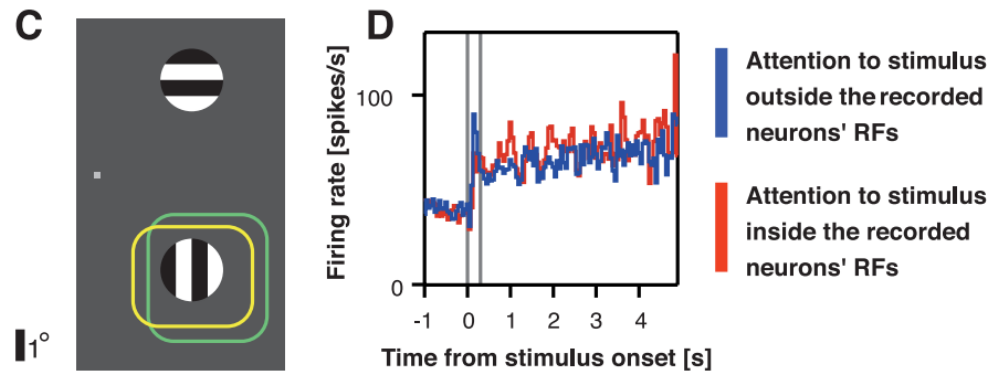
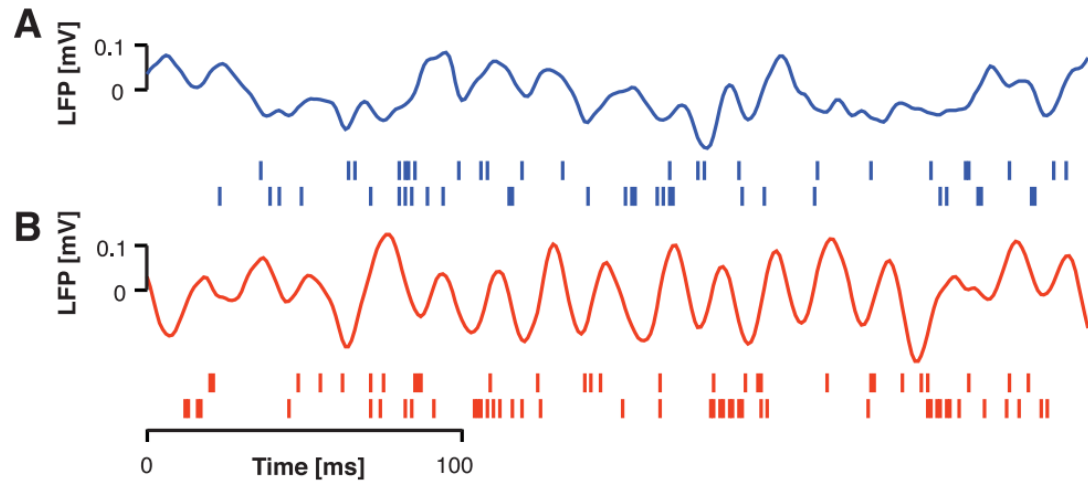
Visual spatial attention enhances firing rate in V4



Attention improves performance by reducing noise correlations



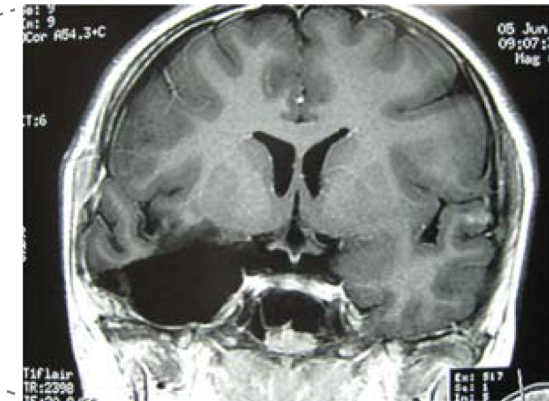
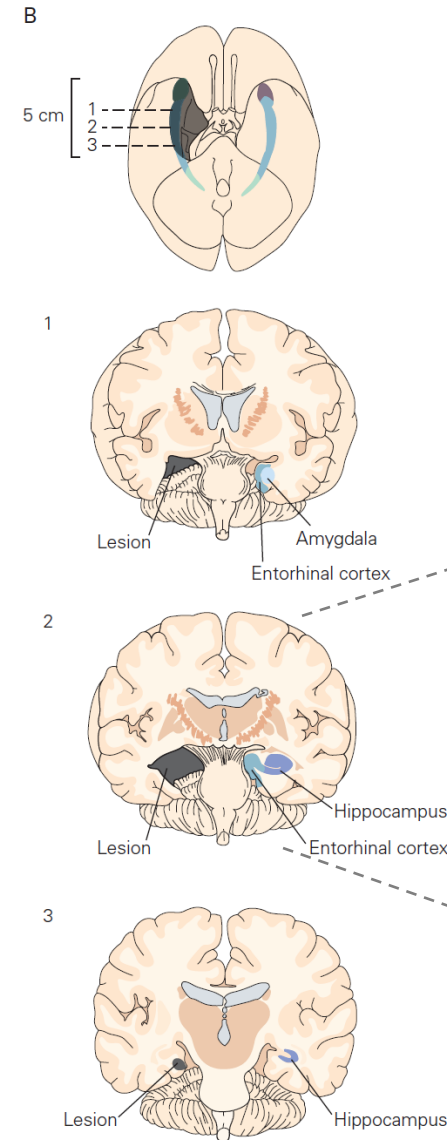
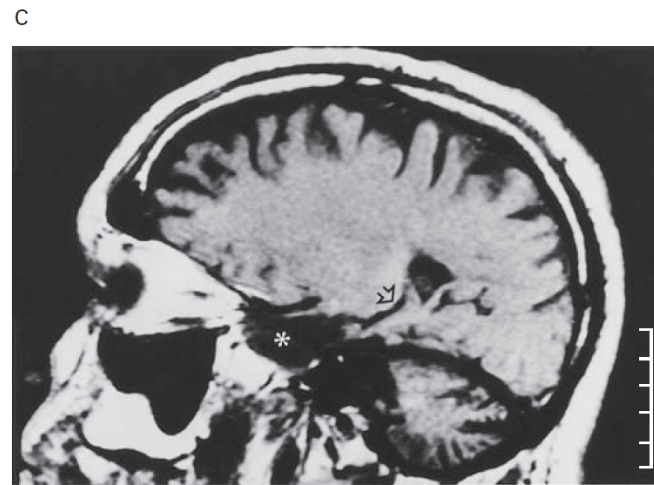
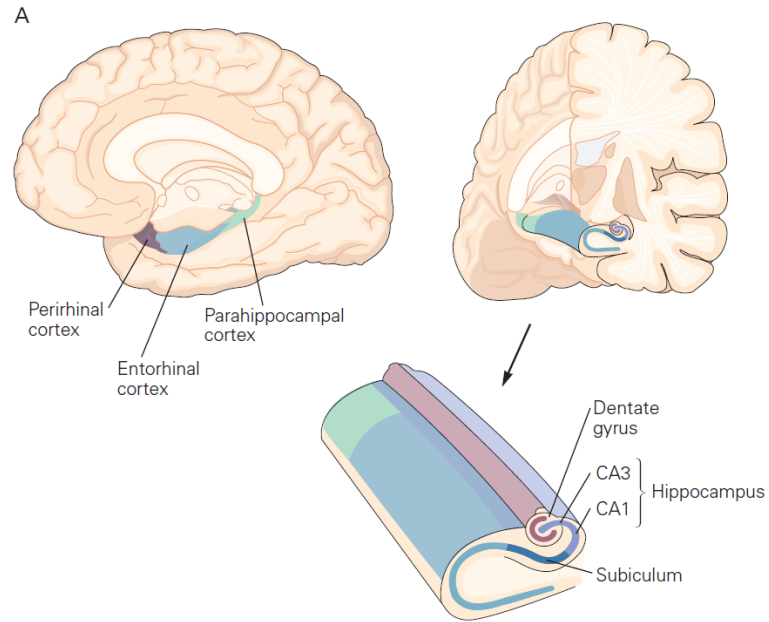
Selective visual attention modulates oscillatory neuronal synchronization



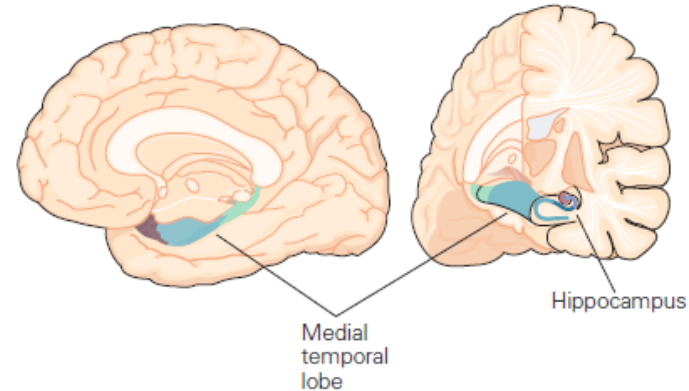
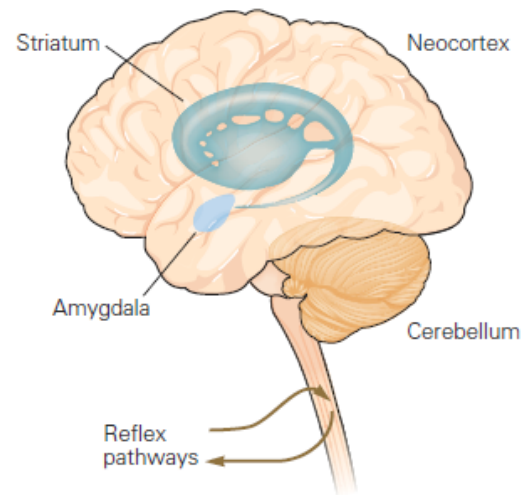
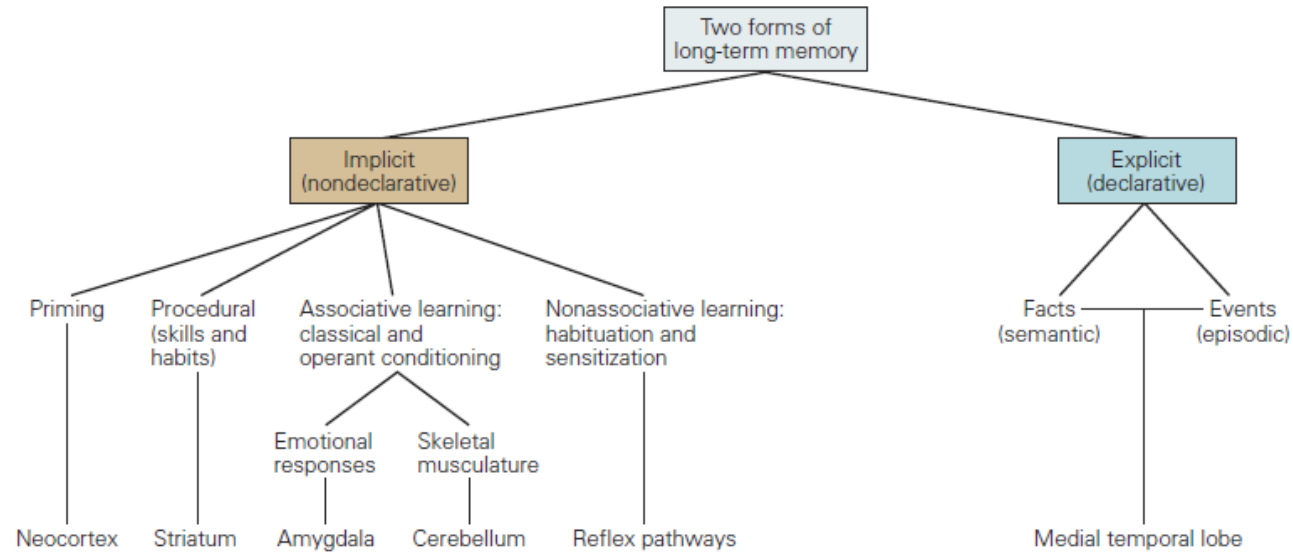
Long-term memory



Henry Molaison
(H.M.)

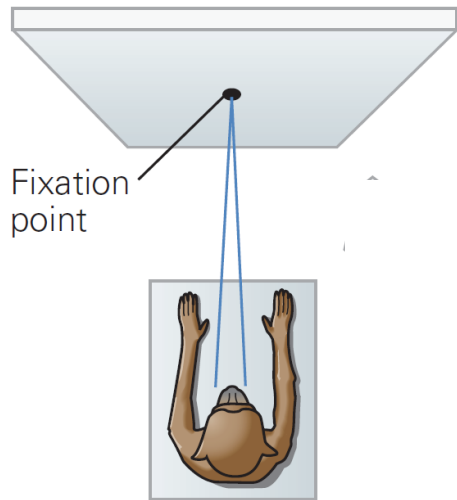
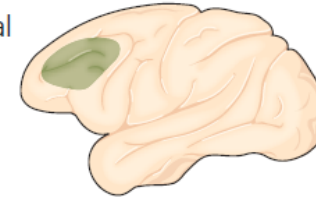


Types of long-term memory

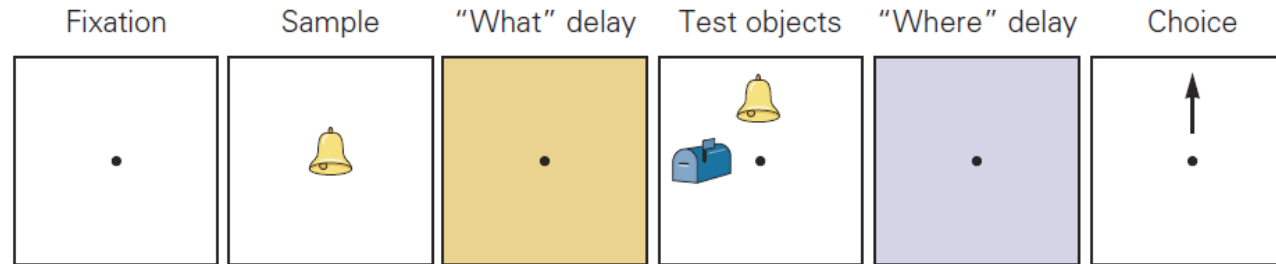


Short-term memory

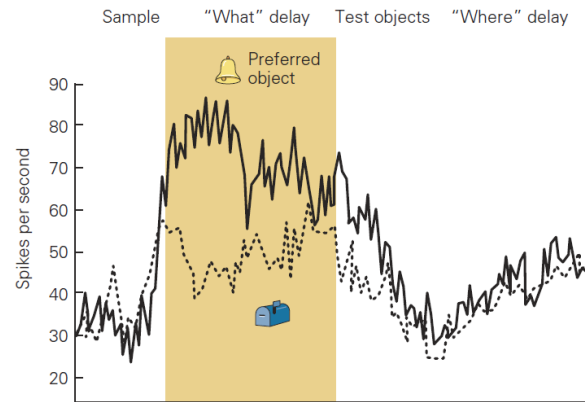
Dorsolateral
prefrontal
cortex



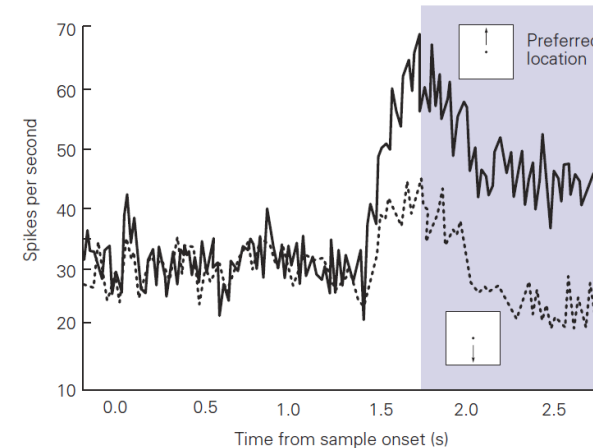
Fixation
point



Object-selective neuron

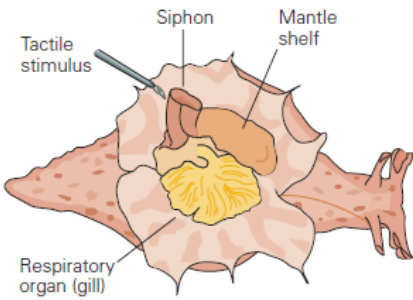


Location-selective neuron

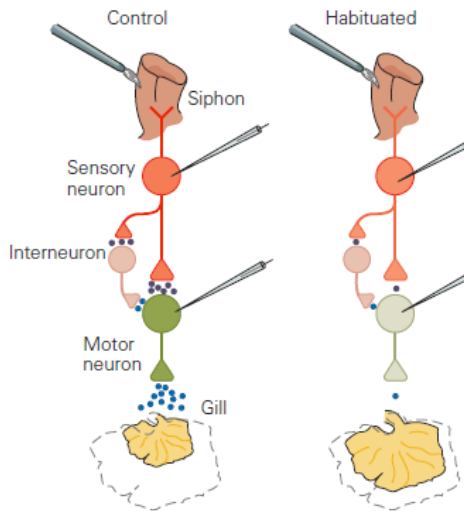


Learning: habituation & sensitization

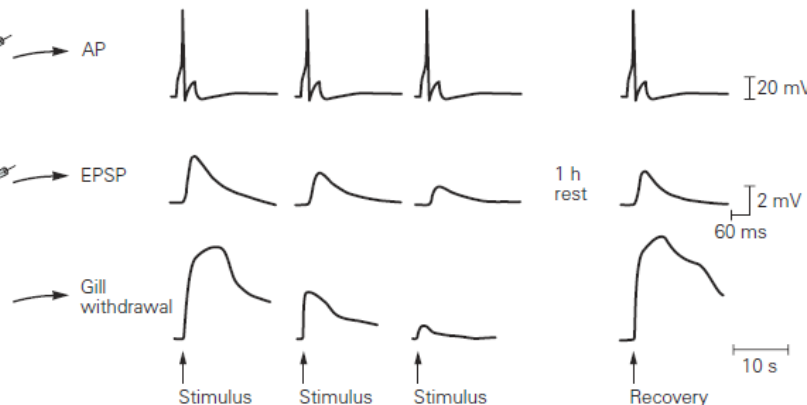
A Experimental setup



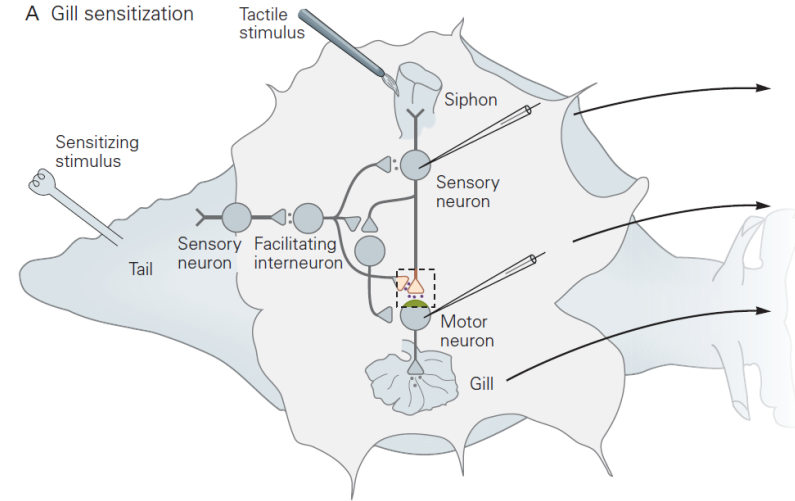
B Gill-withdrawal reflex circuit



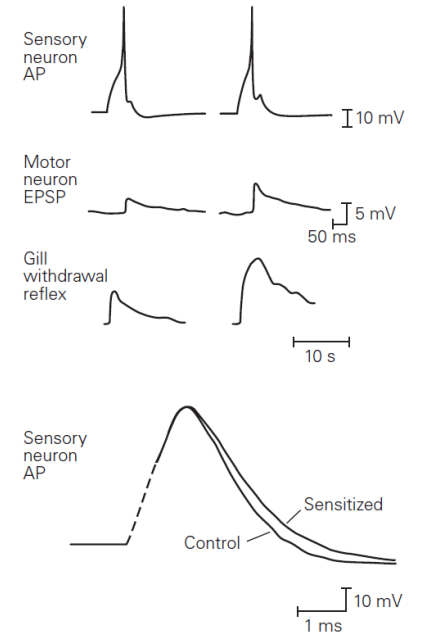
Habituation



A Gill sensitization



Sensitization



Synaptic enhancement:
increase of readily
releasable vesicles

Synaptic depression:
depletion of readily
releasable vesicles

Synaptic plasticity

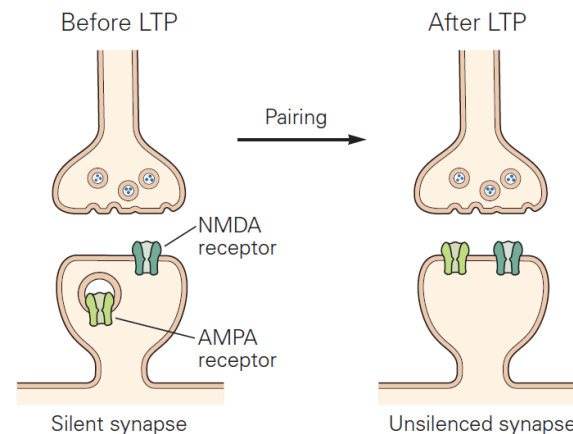
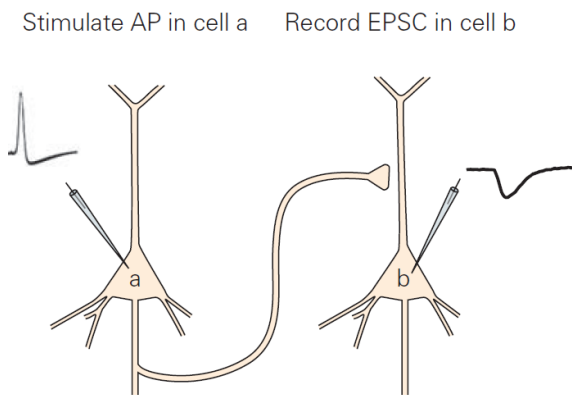
Short-term plasticity

Synaptic enhancement: increase of readily releasable vesicles

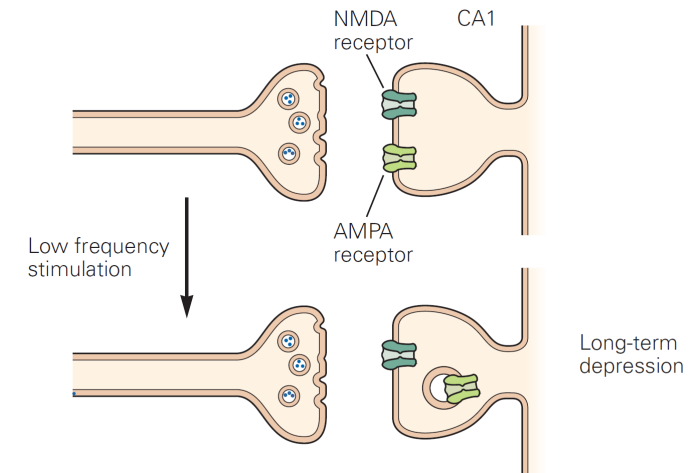
Synaptic depression: depletion of readily releasable vesicles

Long-term plasticity

Long-term potentiation (LTP):



Long-term depression (LTD):



Core cognitive processes

- ~~Perception~~
- ~~Action~~
- ~~Attention~~
- ~~Learning & Memory~~
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Thanks!

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