Systems Neuroscience

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Talk Outline

- What is “systems neuroscience”?
- Example systems
- Correlation vs causation
- techniques

What is Systems Neuroscience?

Systems Neuroscience

Wikipedia Definition: Systems neuroscience is a subdiscipline of neuroscience and systems biology that studies the function of neural circuits and systems. It is an umbrella term, encompassing a number of areas of study concerned with how nerve cells behave when connected together to form neural networks. At this level of analysis, neuroscientists study how different neural circuits analyze sensory information, form perceptions of the external world, make decisions, and execute movements.

Systems Neuroscience

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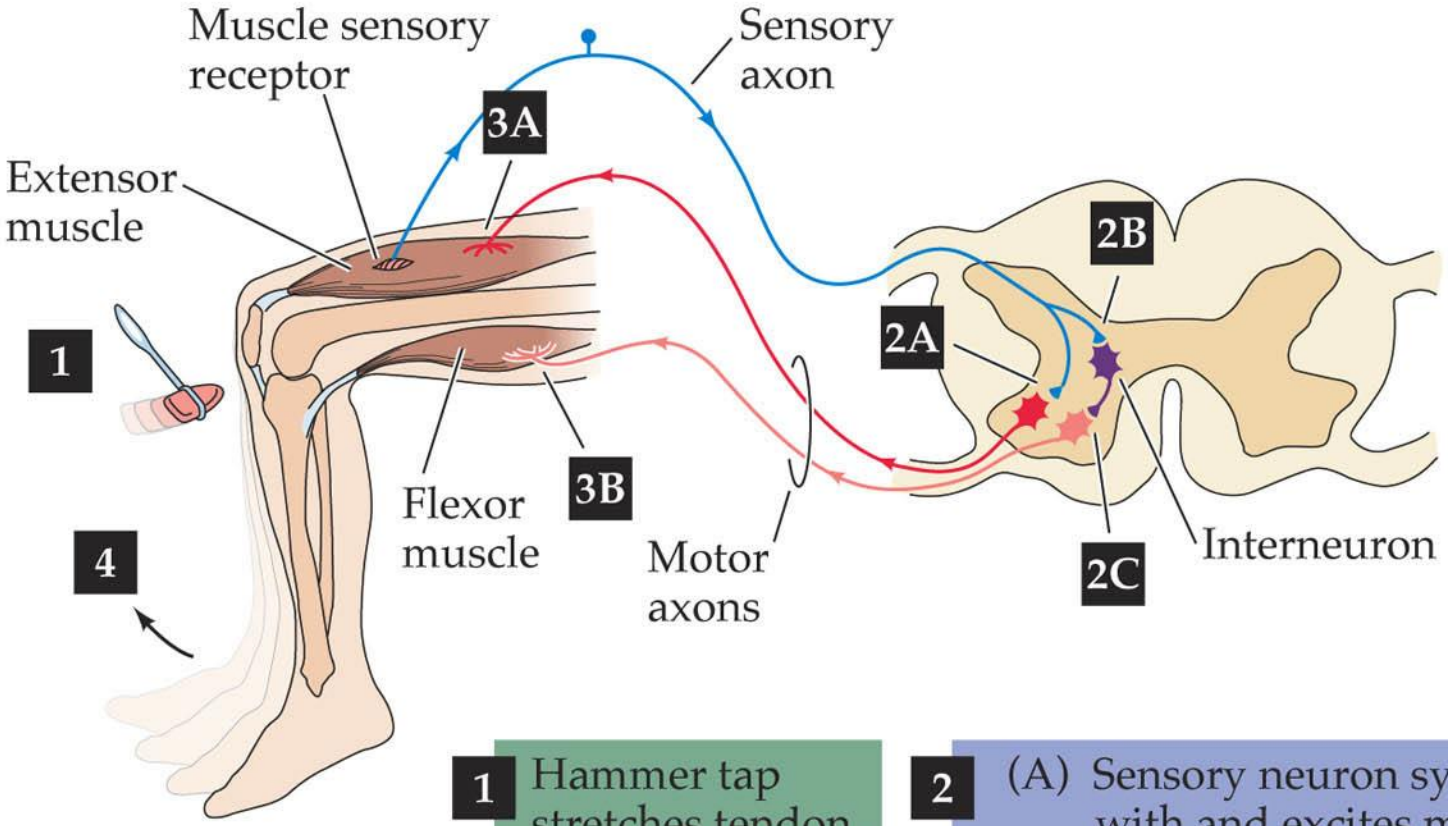
Researchers in systems neuroscience are concerned with the relation between molecular and cellular approaches to understanding brain structure and function, as well as with the study of high-level mental functions such as language, memory, and self-awareness (which are the purview of behavioral and cognitive neuroscience). Systems neuroscientists typically employ techniques for understanding networks of neurons while they function in vivo (e.g. electrophysiology (single or multi-electrode recording), in vivo imaging, fMRI, PET). ***The term is commonly used in an educational framework: a common sequence of graduate school neuroscience courses consists of cellular/molecular neuroscience for the first semester, then systems neuroscience for the second semester.***

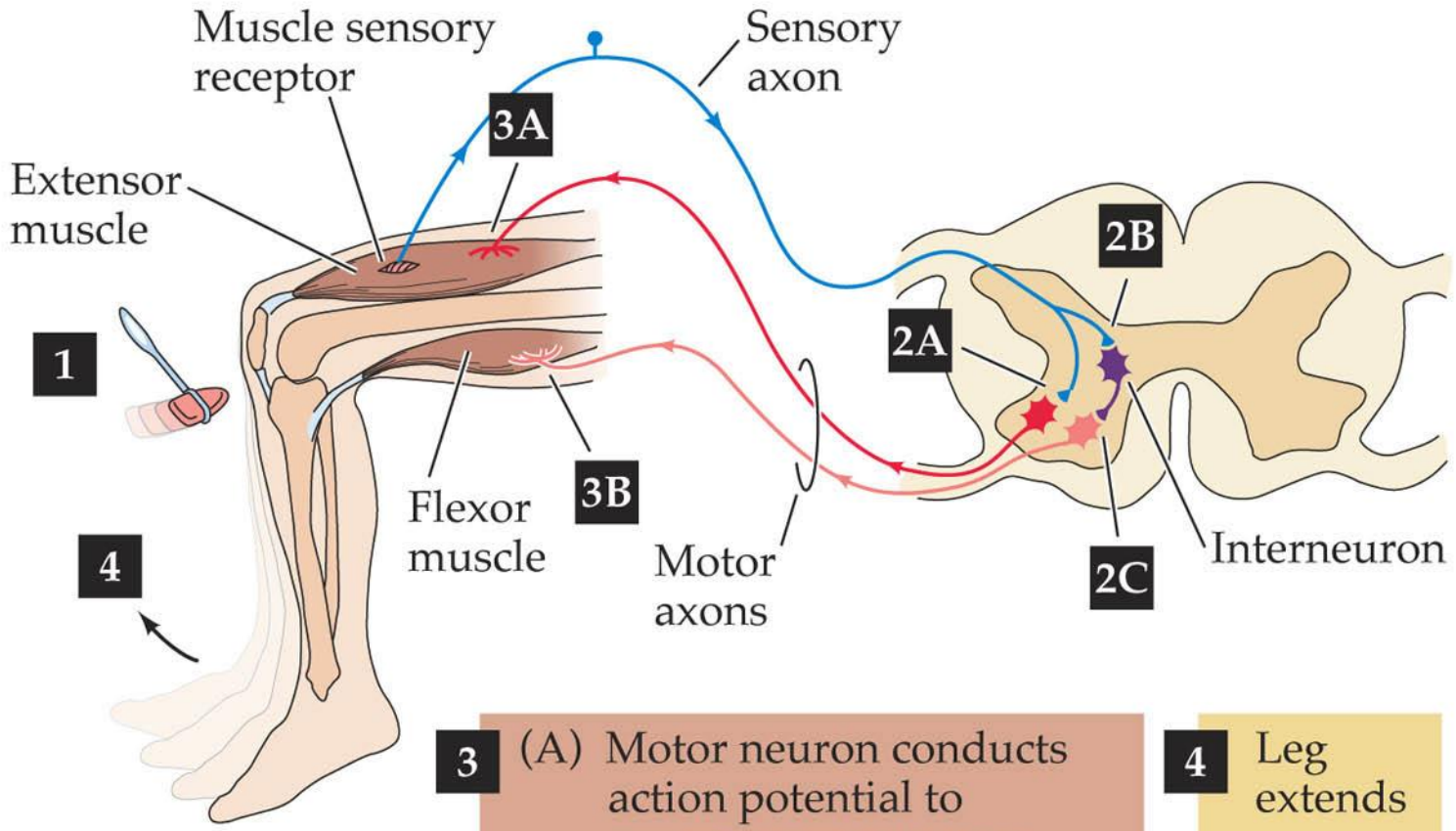


1 Hammer tap stretches tendon, which, in turn, stretches sensory receptors in leg extensor muscle

2 (A) Sensory neuron synapses with and excites motor neuron in the spinal cord

(B) Sensory neuron also excites spinal interneuron

(C) Interneuron synapse inhibits motor neuron to flexor muscles

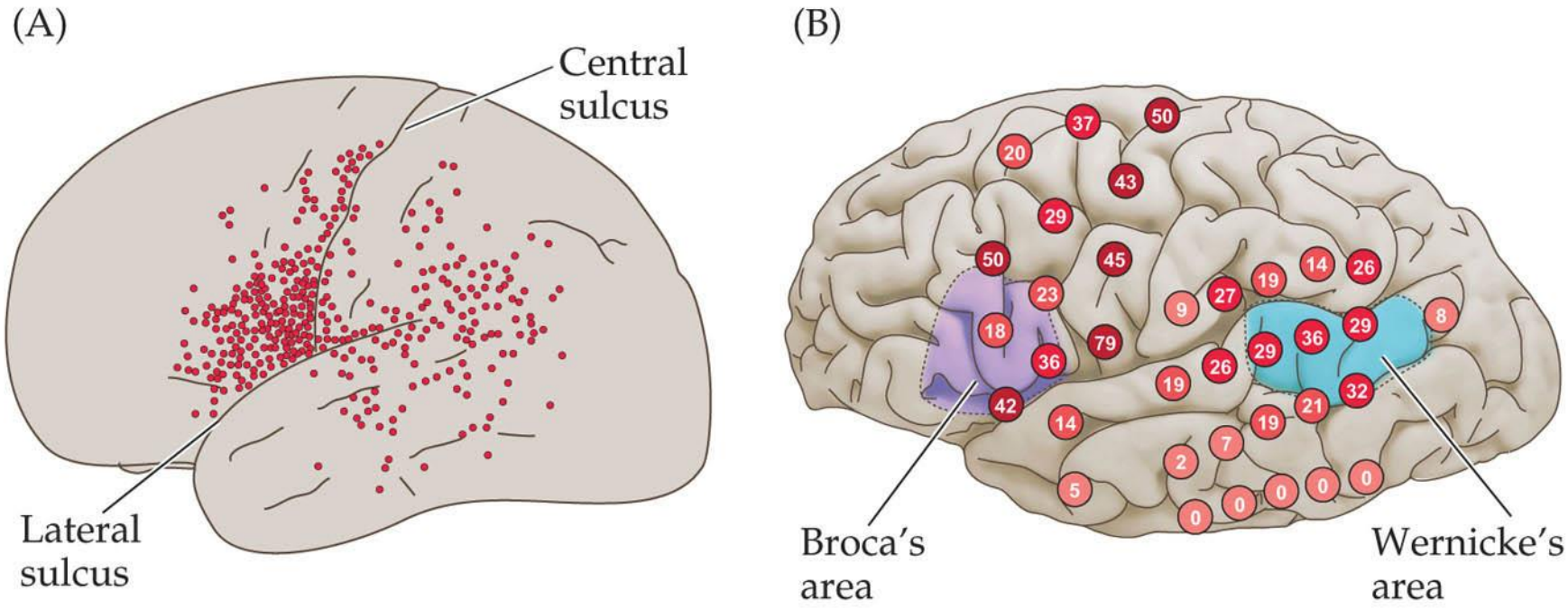


3 (A) Motor neuron conducts action potential to synapses on extensor muscle fibers, causing contraction

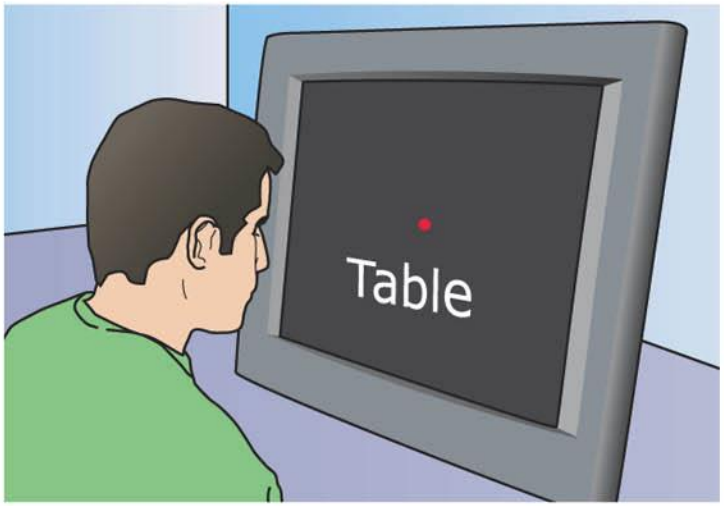
(B) Flexor muscle relaxes because the activity of its motor neurons has been inhibited

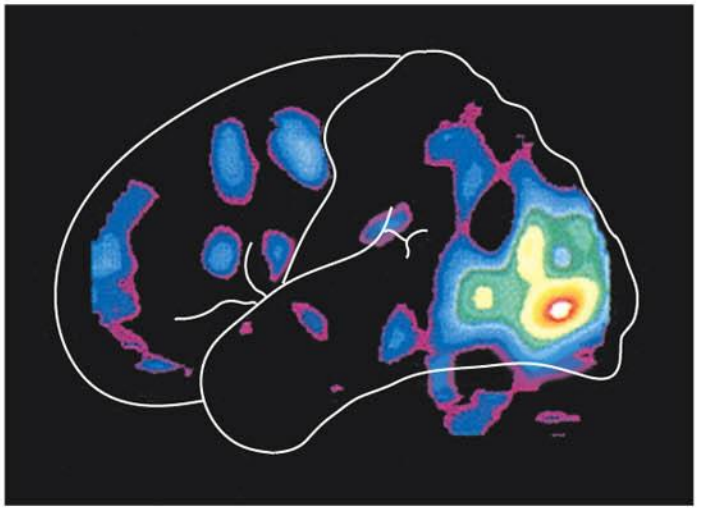
4 Leg extends

Variability in Localization of Cortical Speech Areas

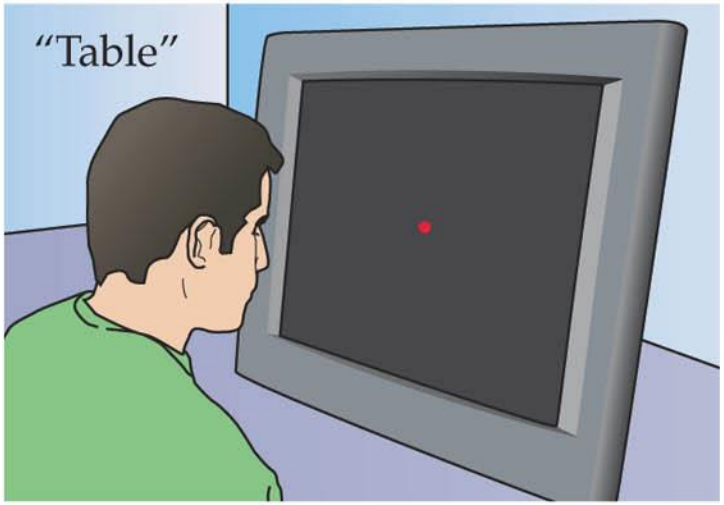


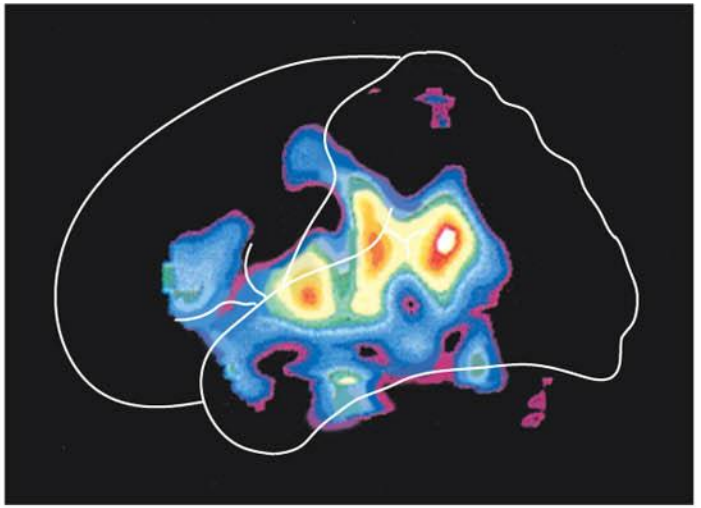
Passively viewing words



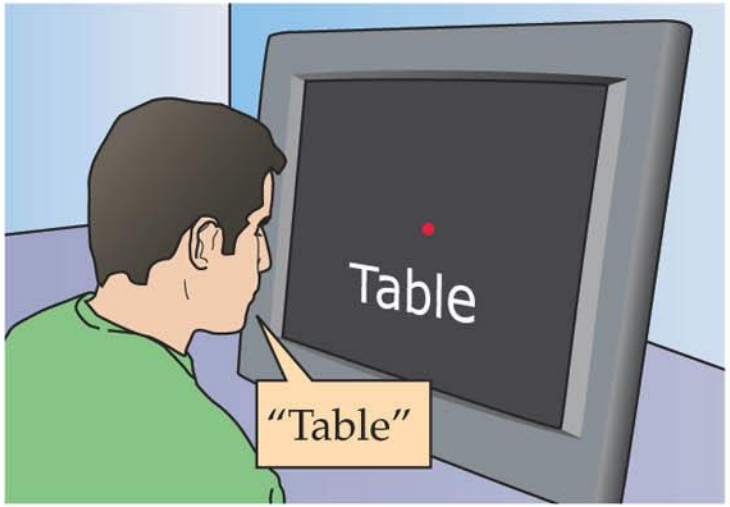


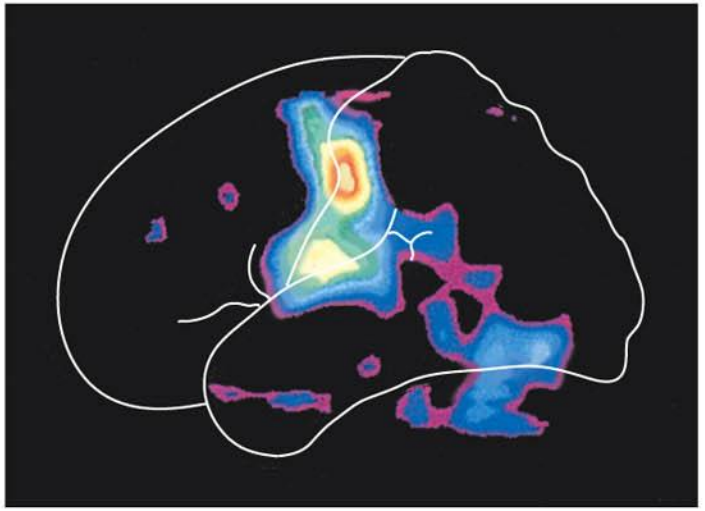
Listening to words



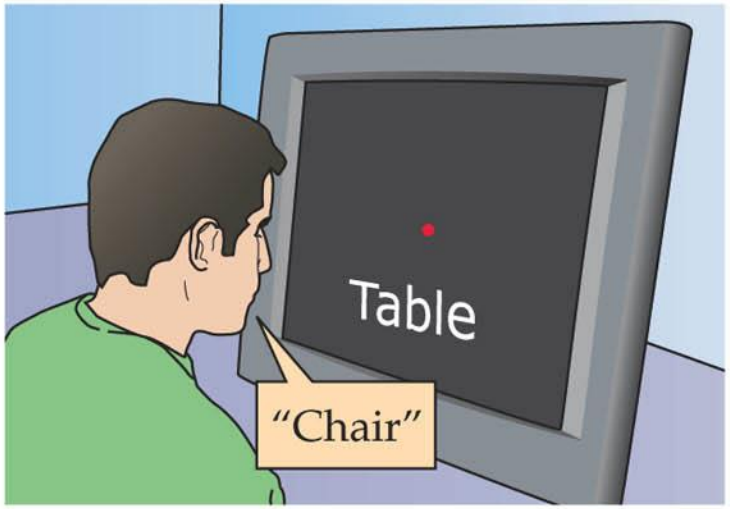


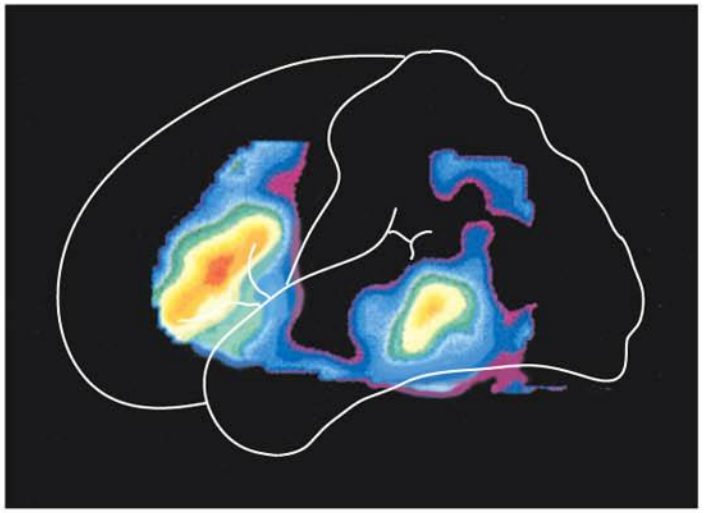
Speaking words





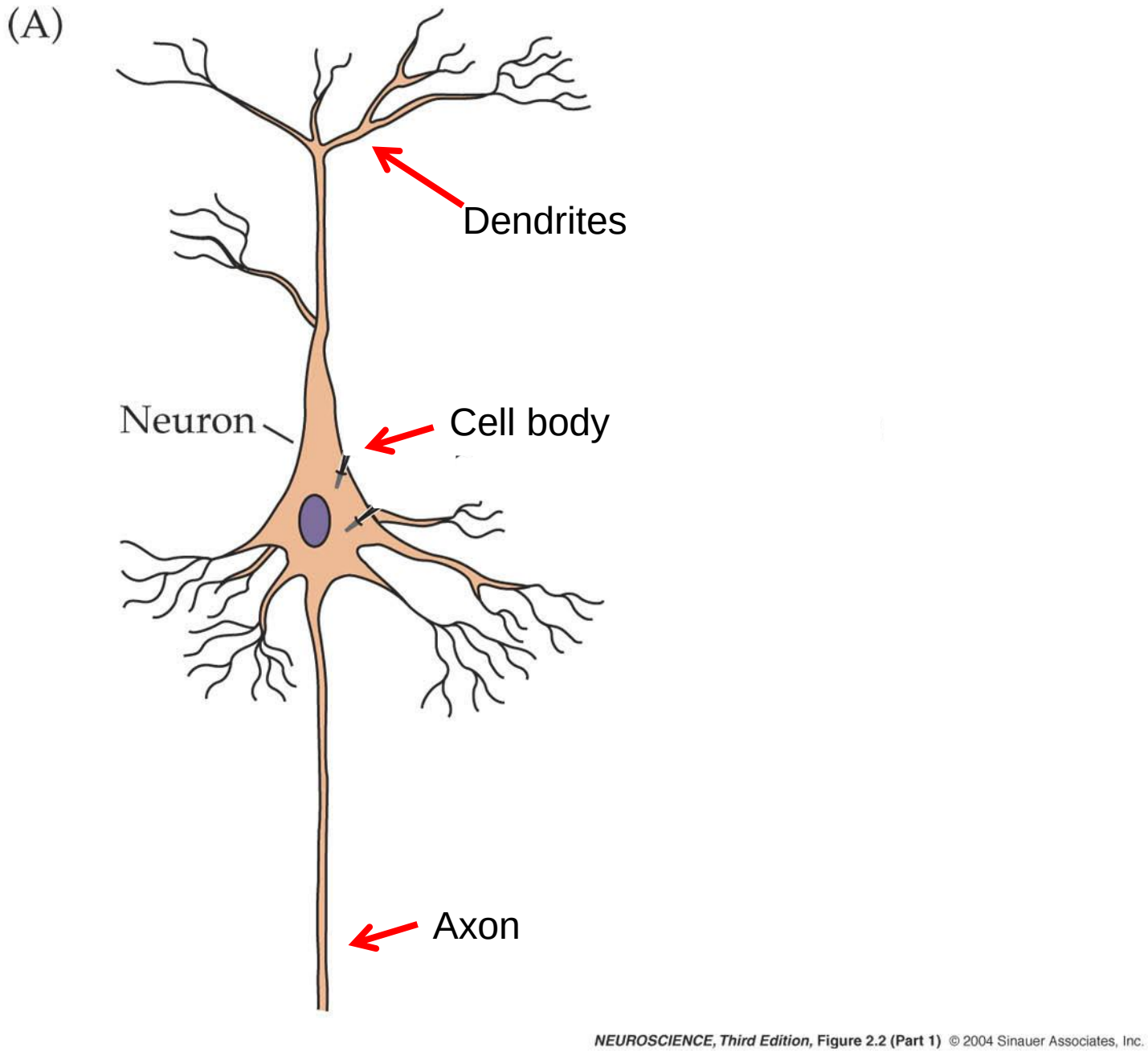
Generating word associations





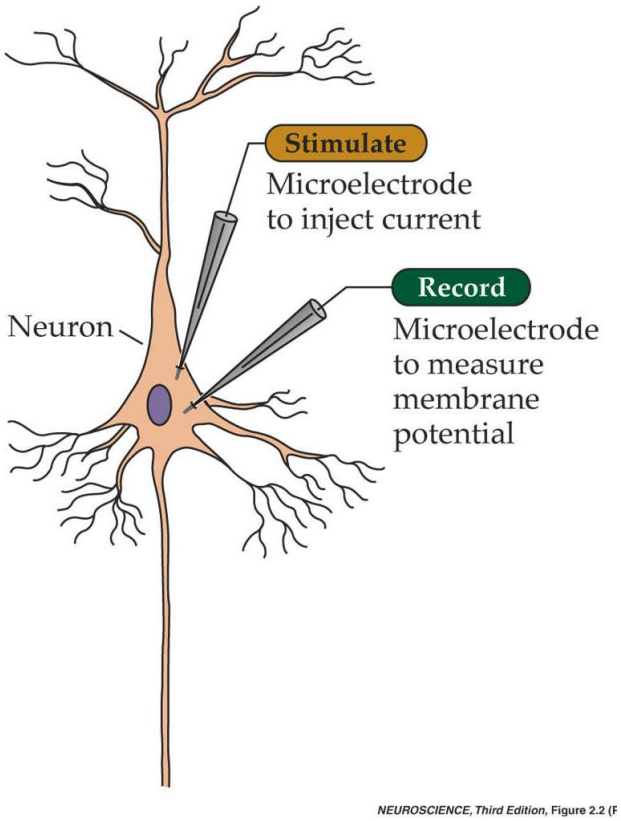
Techniques to measure neural activity

- Intracellular recording
- Extracellular recording
- Multi-electrode arrays
- Imaging: functional Magnetic Resonance Imaging (fMRI)
- Imaging: Positron Emission Tomography (PET)
- optogenetics



NEUROSCIENCE, Third Edition, **Figure 2.2 (Part 1)**

Intracellular recording reveals subthreshold even



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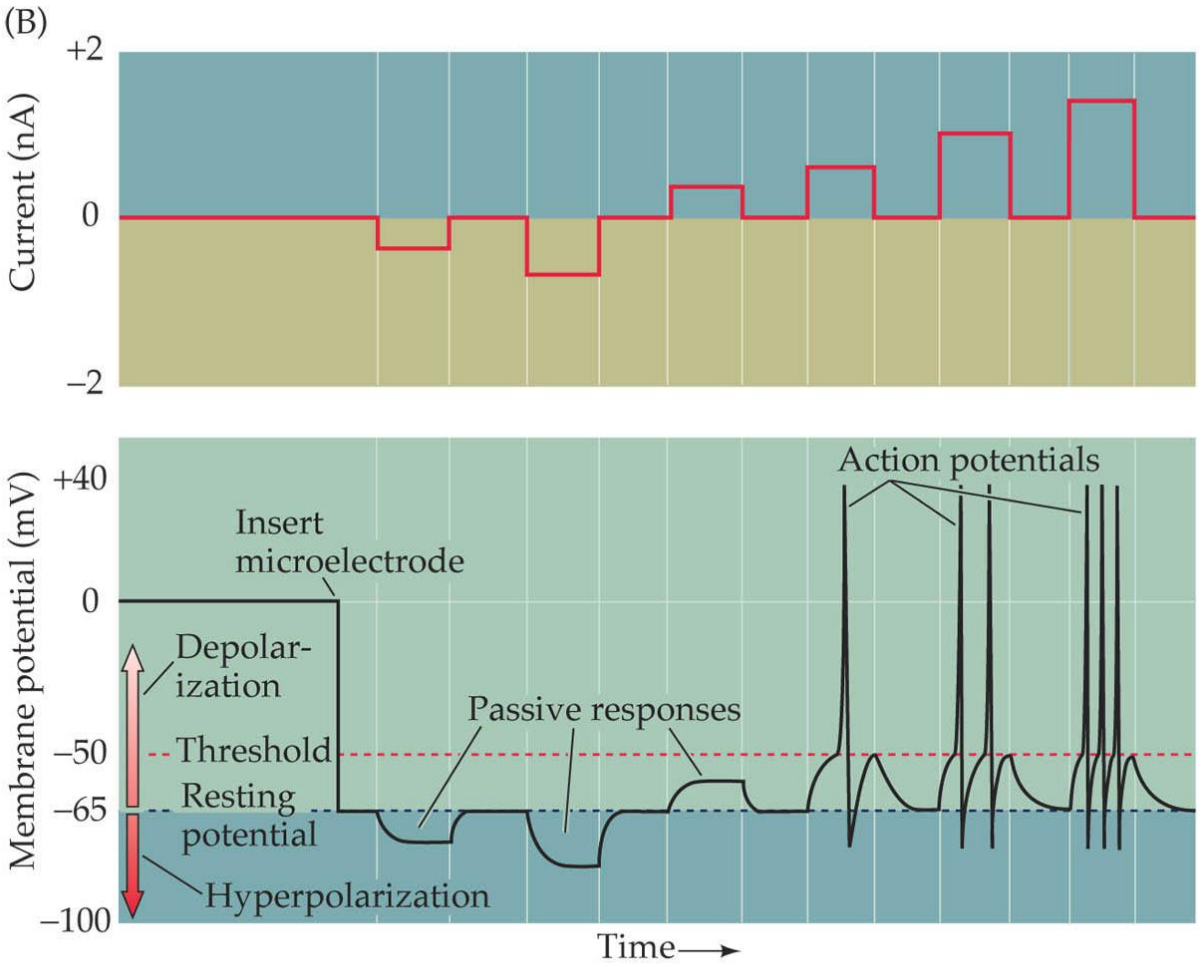

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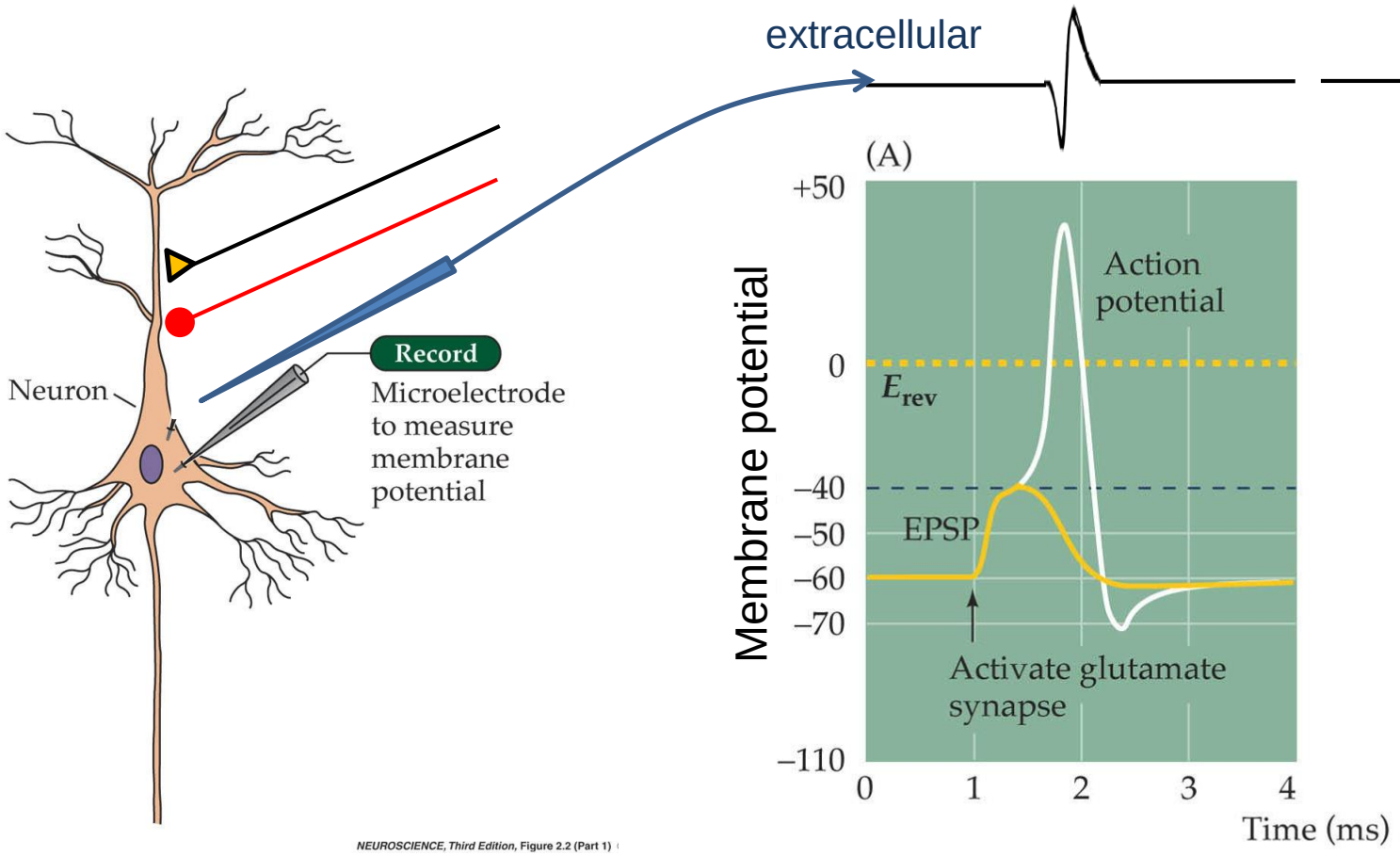
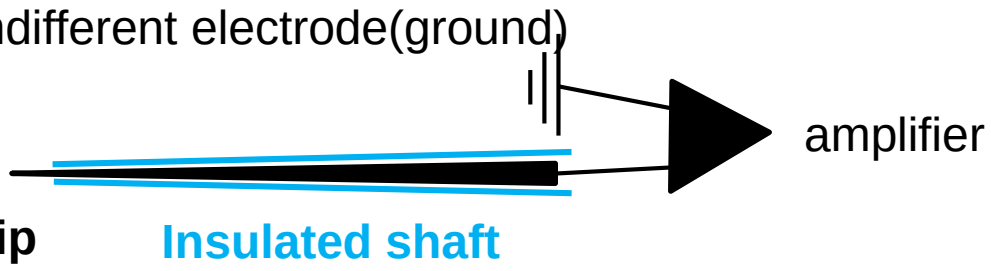
Extracellular recording misses subthreshold events



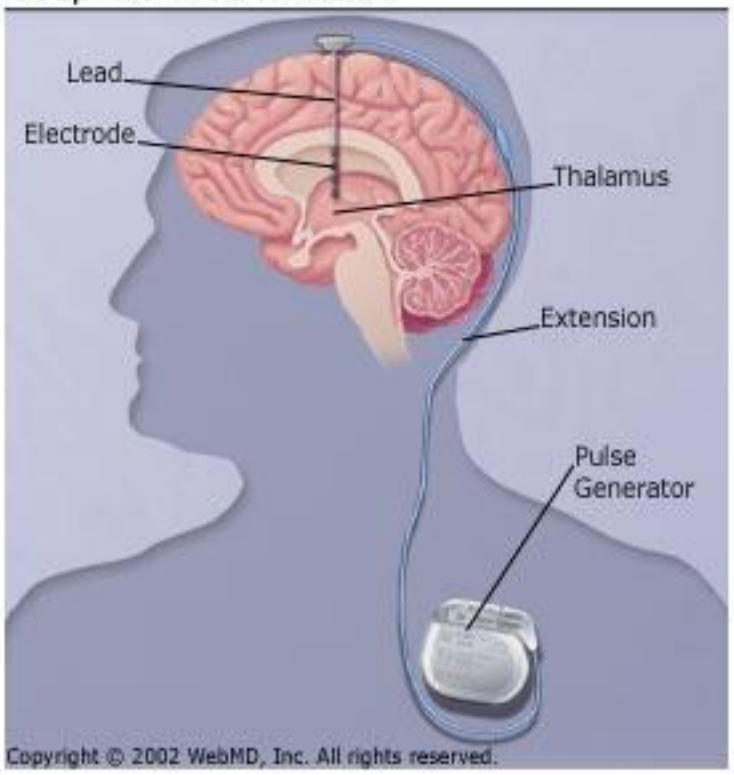
NEUROSCIENCE, Third Edition, Figure 2.2 (Part 1)

NEUROSCIENCE, Third Edition, Figure 5.19 (Part 1) © 2004 Sinauer Associates, Inc.

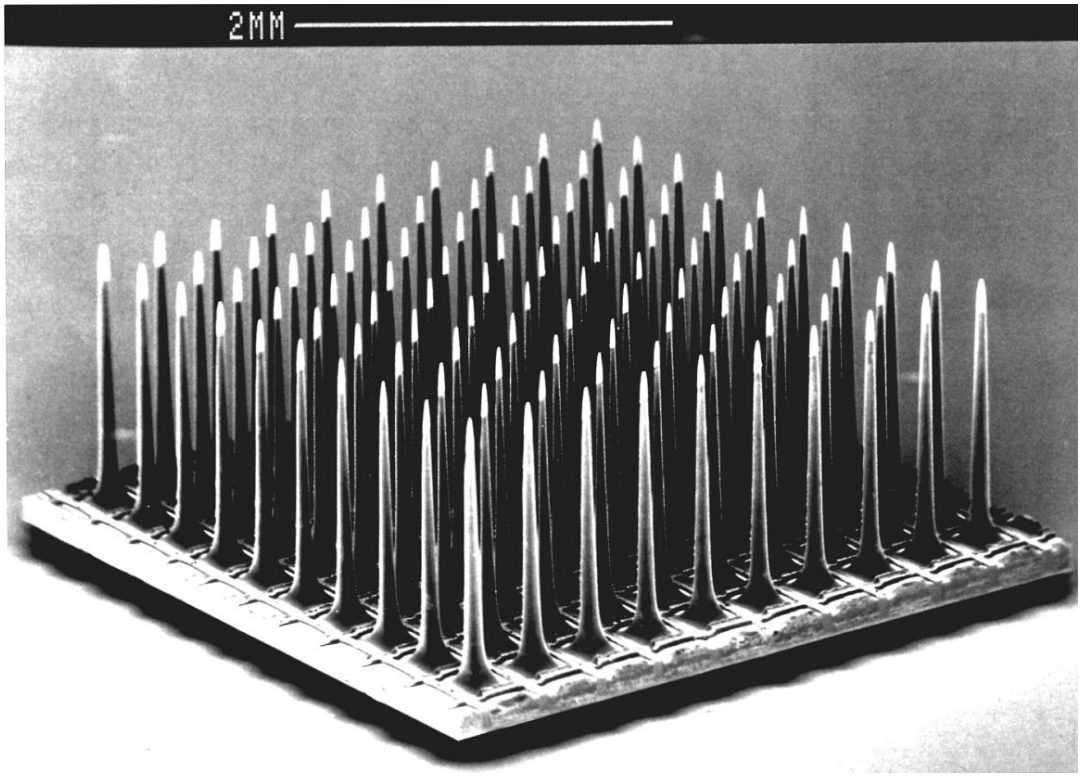
Microelectrodes are used to record extracellularly



Deep Brain Stimulation



Utah array (10 x 10 array of electrode)



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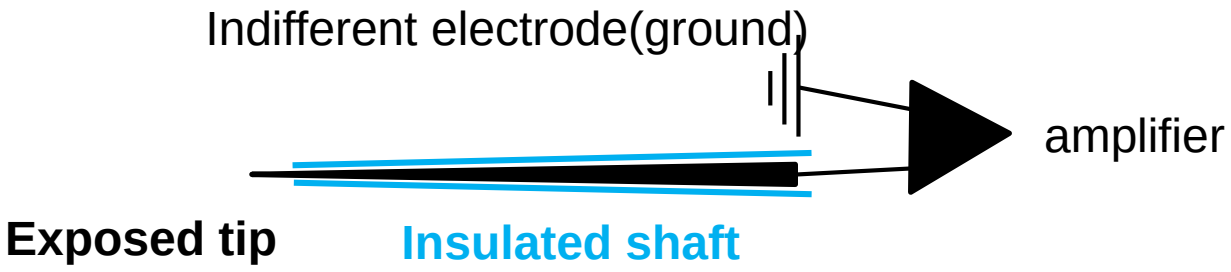
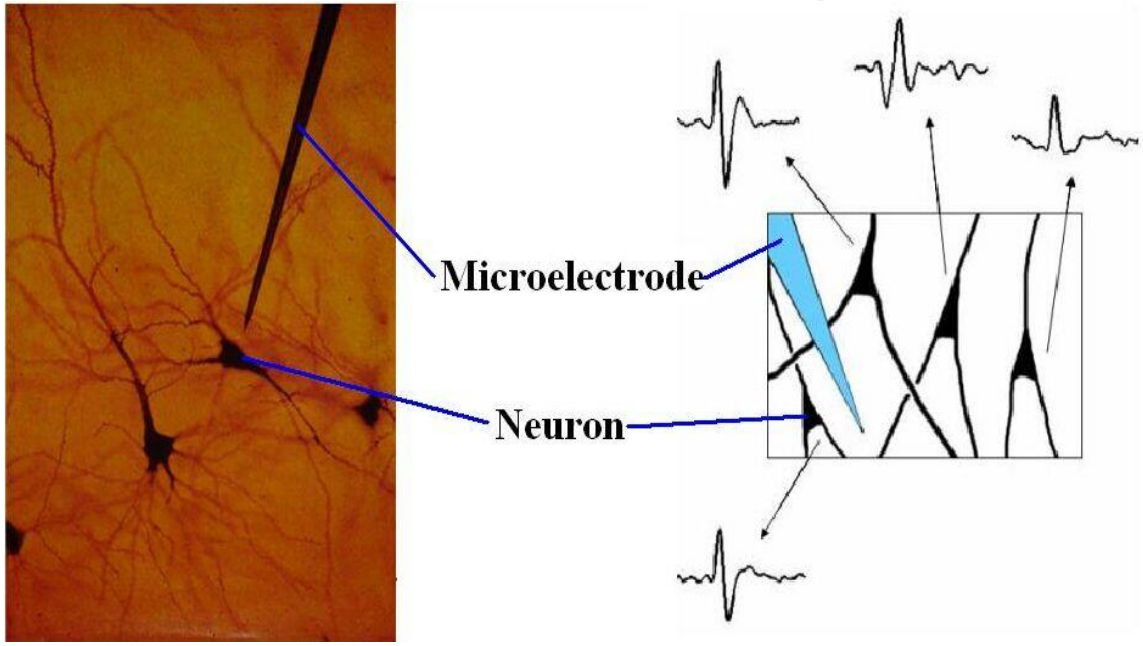
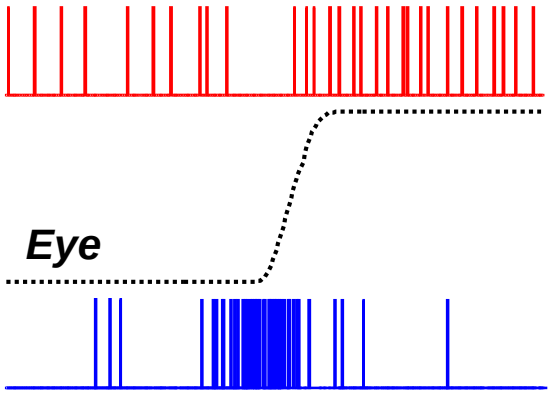


Microelectrode in neuropil

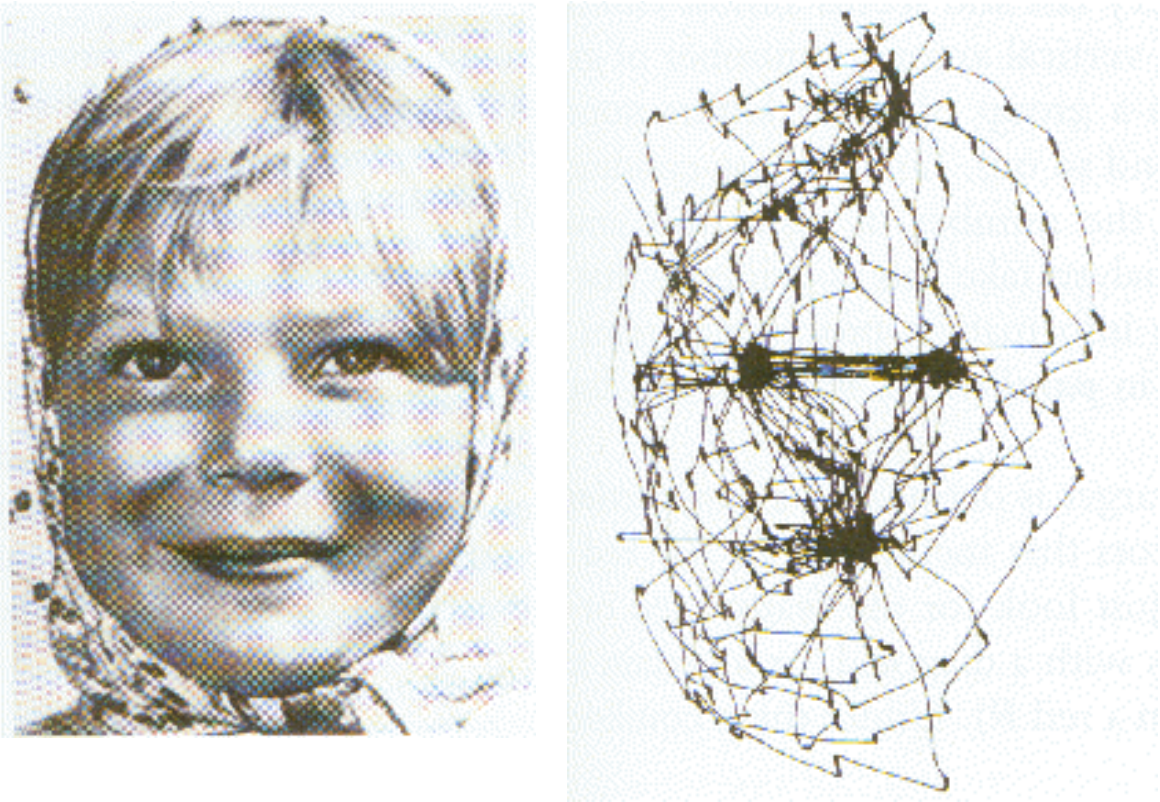


Correlate to behaviour



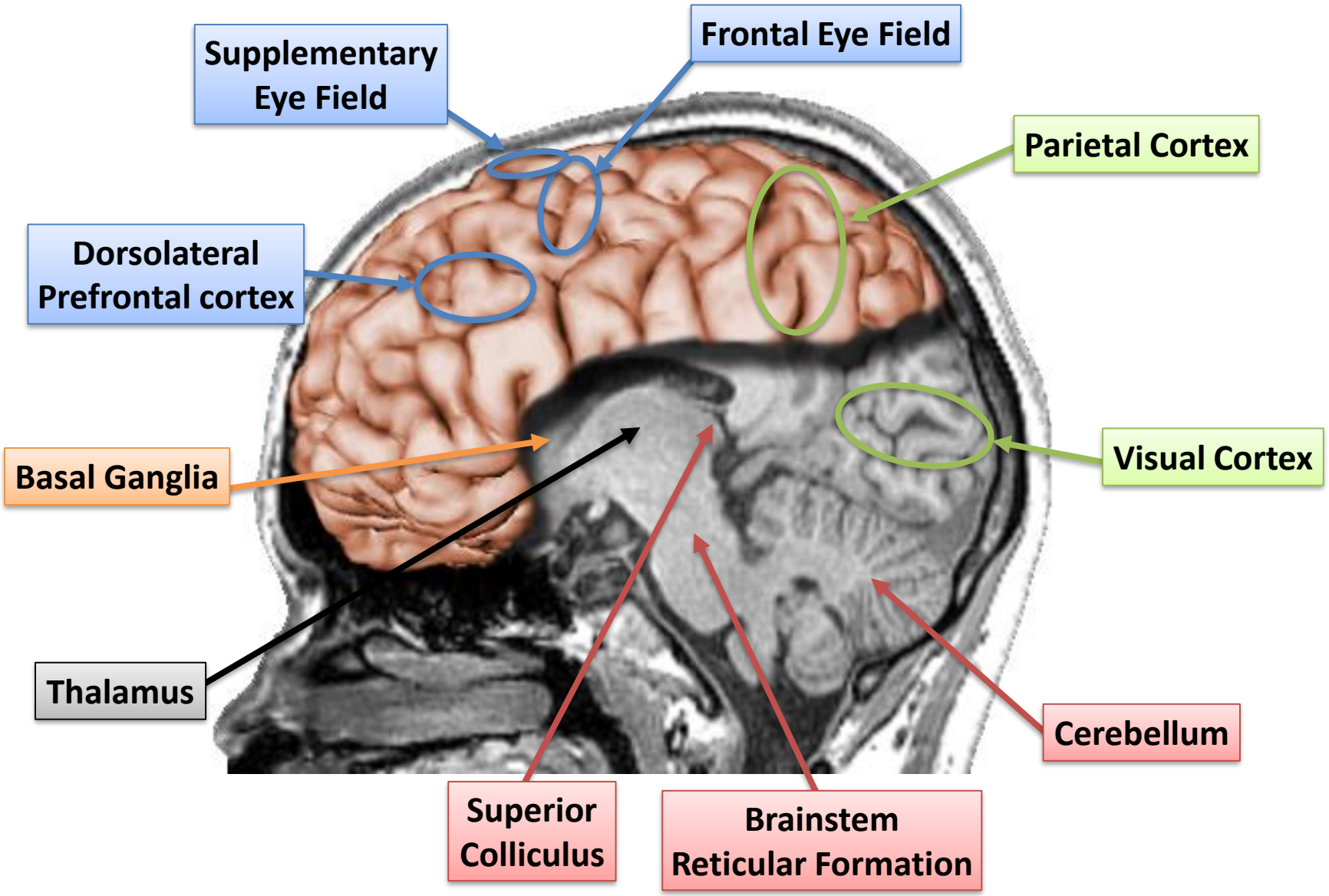
Saccade-Fixation Behaviour

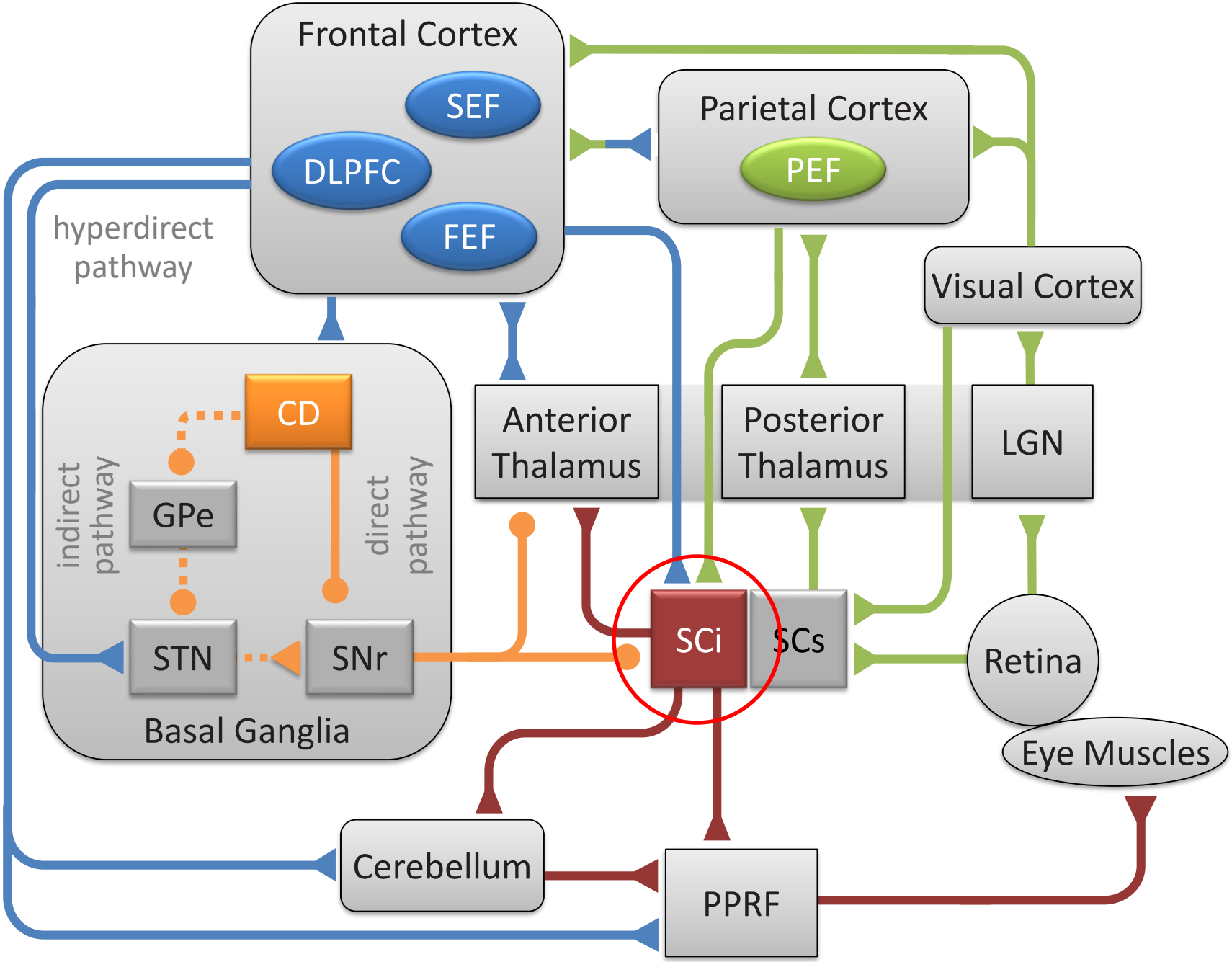
Saccades allow us to scan the visual field and intermittently focus our *attention* on the parts of the scene that convey the most *significant information*.



Yarbus 1967

Multiple Brain Areas Involved in Controlling Saccadic Eye Movements

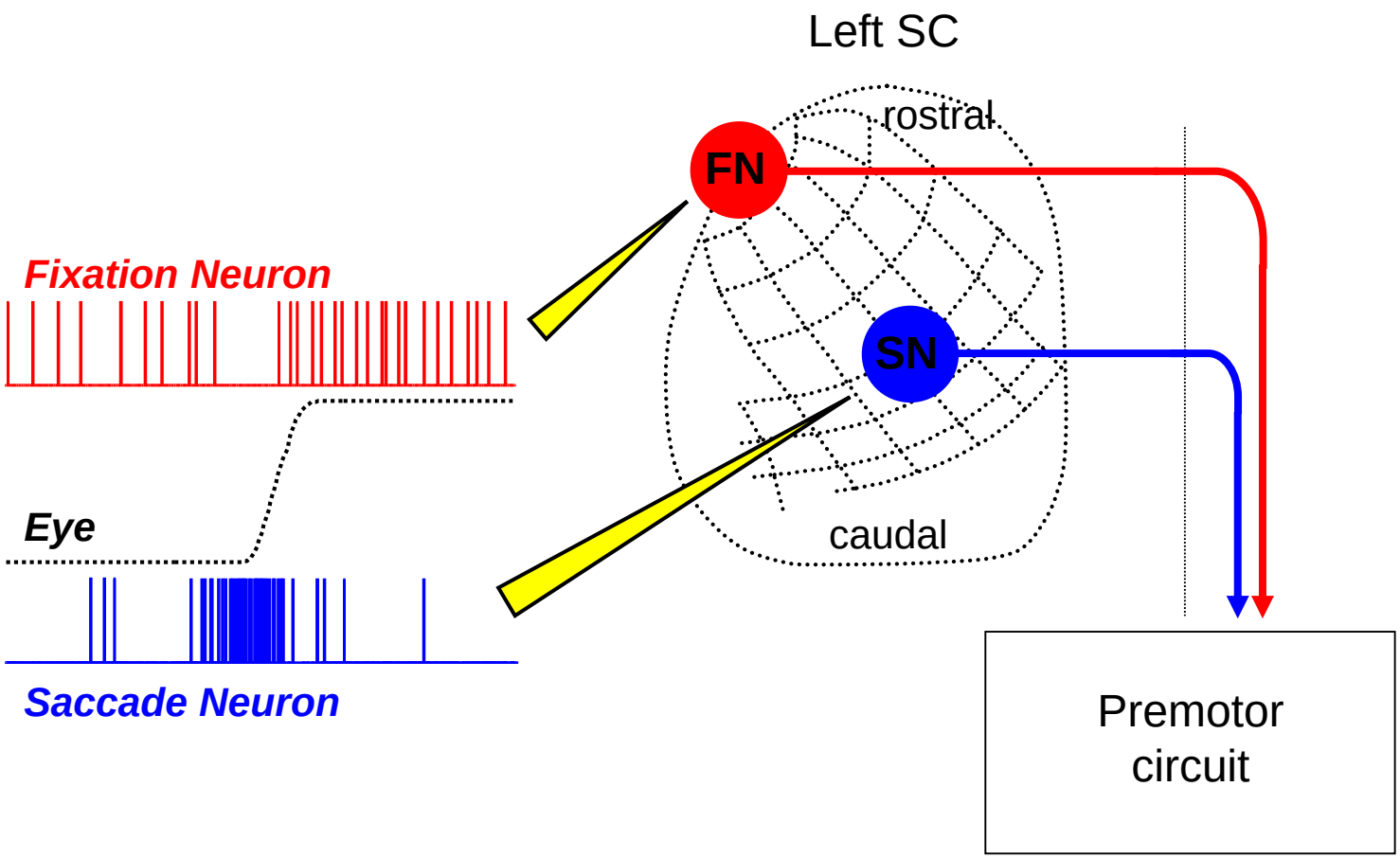




Munoz, Armstrong & Coe 2007

A Saccade Map in the Superior Colliculus:

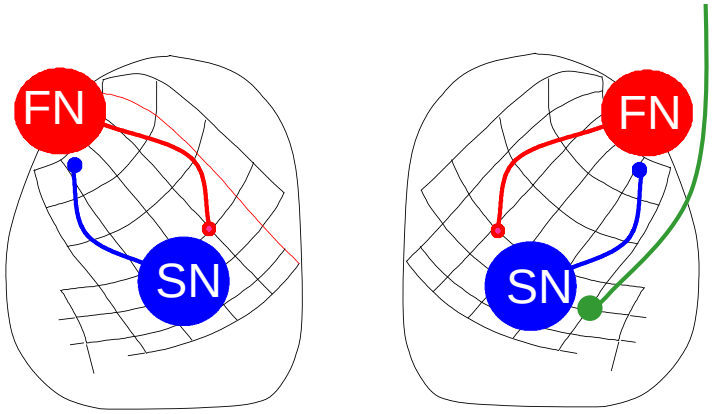
Contains **Fixation** and **Saccade** Neurons



Rodgers et al. 2006 J Neurophysiol 95: 3502

How to Establish Causation?

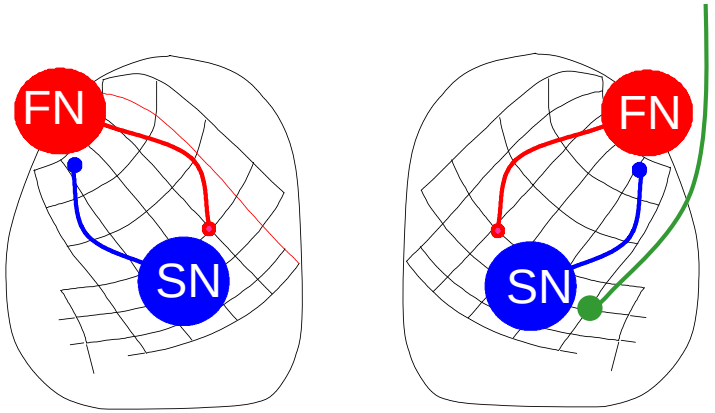
Hypothesis



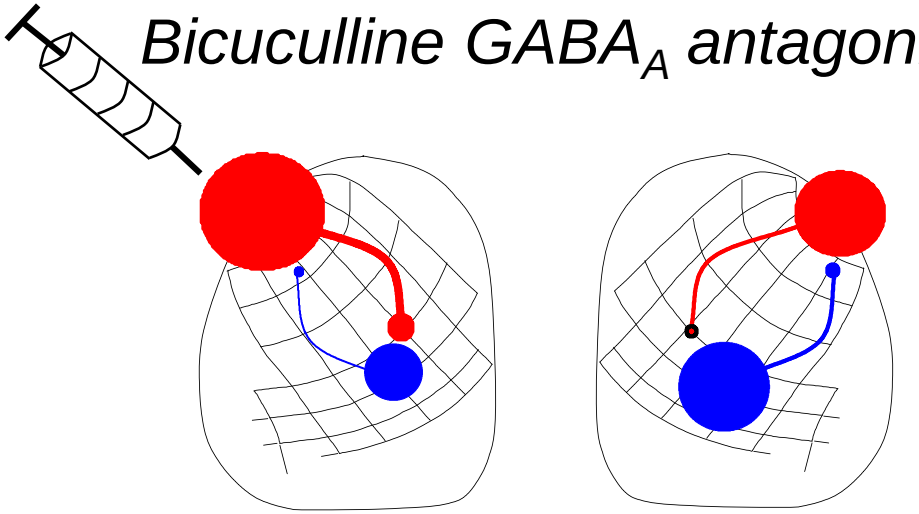
Microstimulation has problems because we cannot differentiate between activation of local SC processes or activation of fibers of passage

Pharmacological Manipulation of Fixation Signal

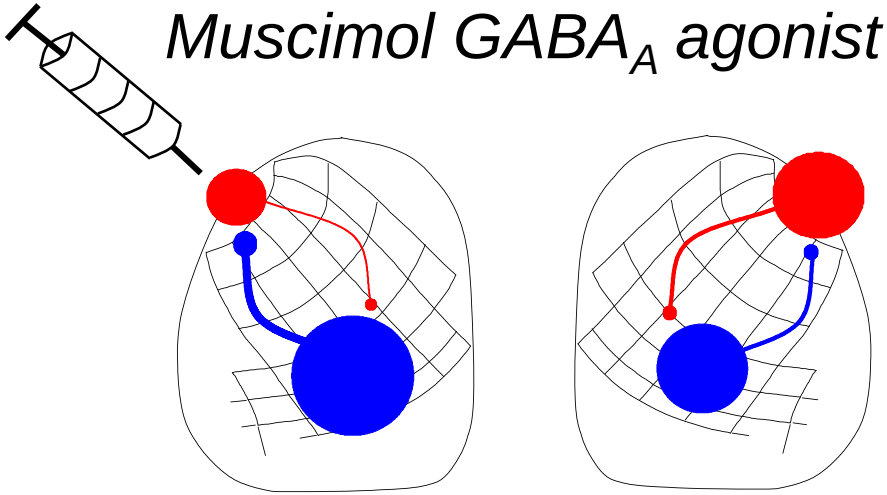
Hypothesis



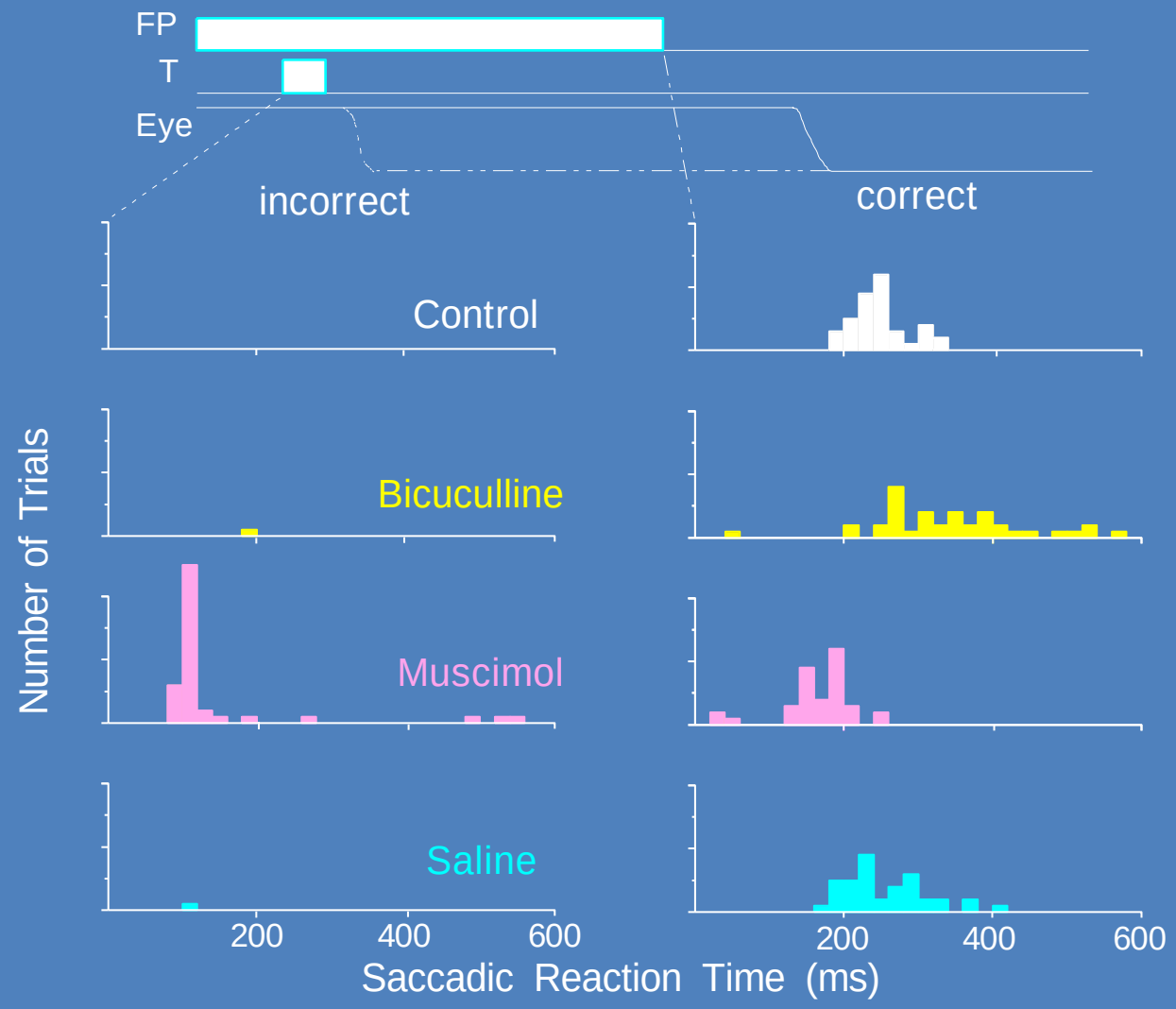
Bicuculline $GABA_A$ antagonist



Muscimol $GABA_A$ agonist



Memory-Guided Saccade Task



Gap Saccade Task