

Cognitive Construction of Space: Part II

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The Story of Epistemology So Far

- Kant claimed to had explained why arithmetic and geometry can be known *a priori* with certainty.
- He also claimed that he provided a refutation of Hume's skepticism about induction. Although the metaphysical skepticism is still there.
- Kant's idea is that the Euclidean space and time is the pure form of our intuition.
- But is that true? Can we learn about how we know where thing are using empirical methods?

The Construction of Space

How our senses and motor systems construct space?

Vision



Hearing



Touch



Body position

Movement

Balance



Outline

- ① Visual Perception
- ② Spacial Image Formation
- ③ Body Position Sensing
- ④ Neural Signals
- ⑤ **Brain Maps**
- ⑥ Sound and Brain Representations
- ⑦ Reference Frames and Navigation
- ⑧ Memory and Cognition

Figure-Ground Segregation

Rubin's Face-Vase Illusion

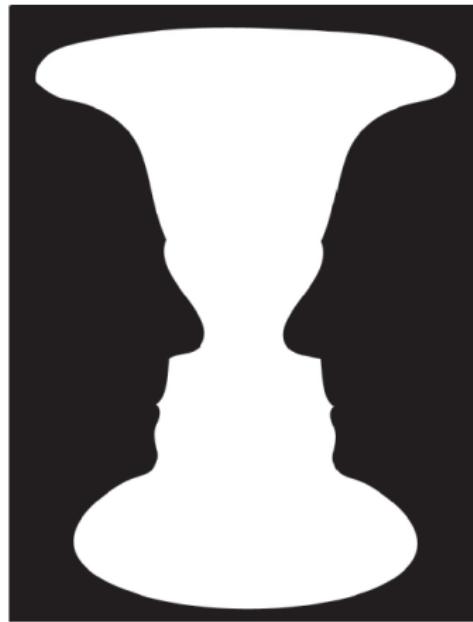
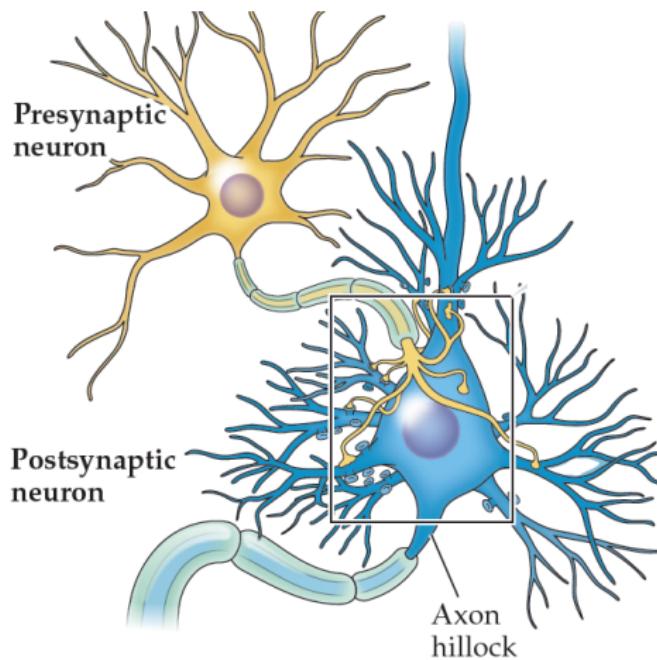


Figure-Ground Segregation

M. C. Escher “Mosaic II”

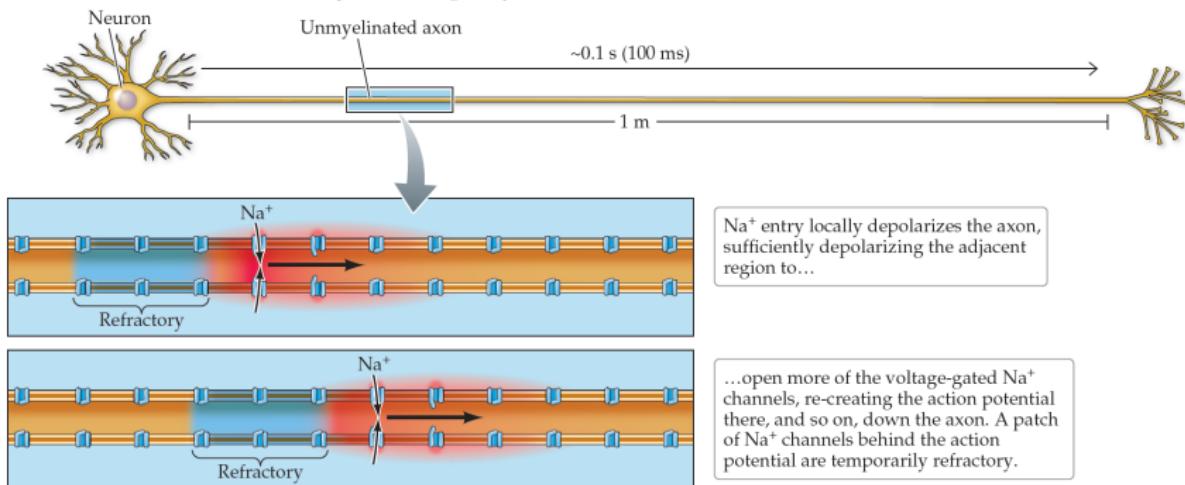


Neural Communication



Propagation of Action Potential

(A) Slow (10 m/s) conduction of action potential along unmyelinated axon

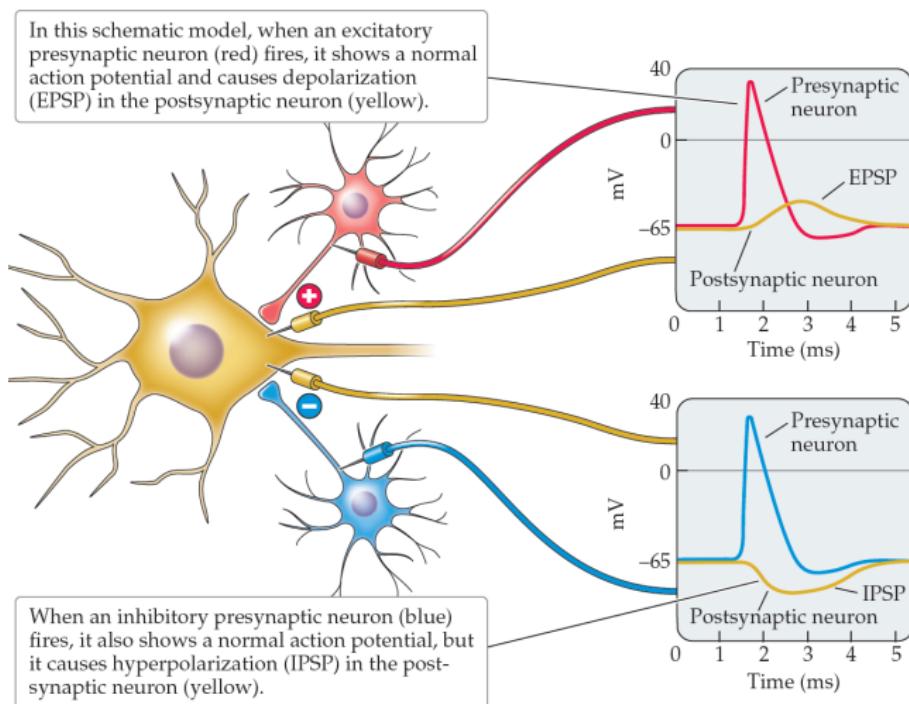


Biological Psychology, Figure 3.8

Postsynaptic Potentials

- Postsynaptic potentials are brief changes in the resting potential. 2 types:
- Excitatory postsynaptic potential: produces a small local depolarization, pushing the cell closer to threshold. This is caused by opening of Na^+ channels on the post-synaptic membrane.
- Inhibitory postsynaptic potential: produces a small hyperpolarization, pushing the cell further away from the thredshod. Caused by the influx of Cl^- into the cell. Not action potential, just the small fluctuation of input information for a neuron.

Postsynaptic Potentials

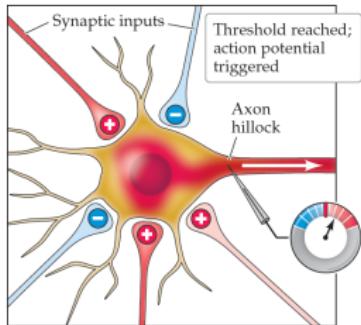


Postsynaptic Potentials

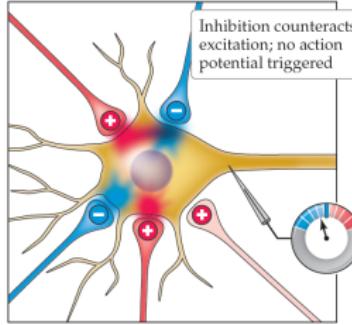
- Neurons perform information processing to integrate synaptic inputs.
- A postsynaptic neuron will fire an action potential if a depolarization that exceeds threshold reaches its axon hillock.
- Discovered by another Nobel Winner: Charles Sherrington (1932 Nobel Prize)

Postsynaptic Potentials

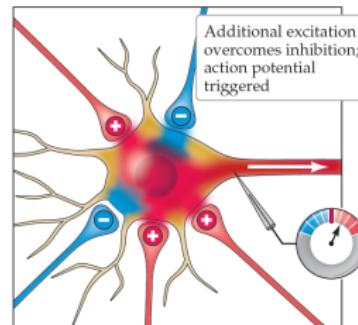
(A) Excitatory inputs cause the cell to fire



(B) Inhibition also plays a role



(C) The cell integrates excitation and inhibition



Biological Psychology, Figure 3.10

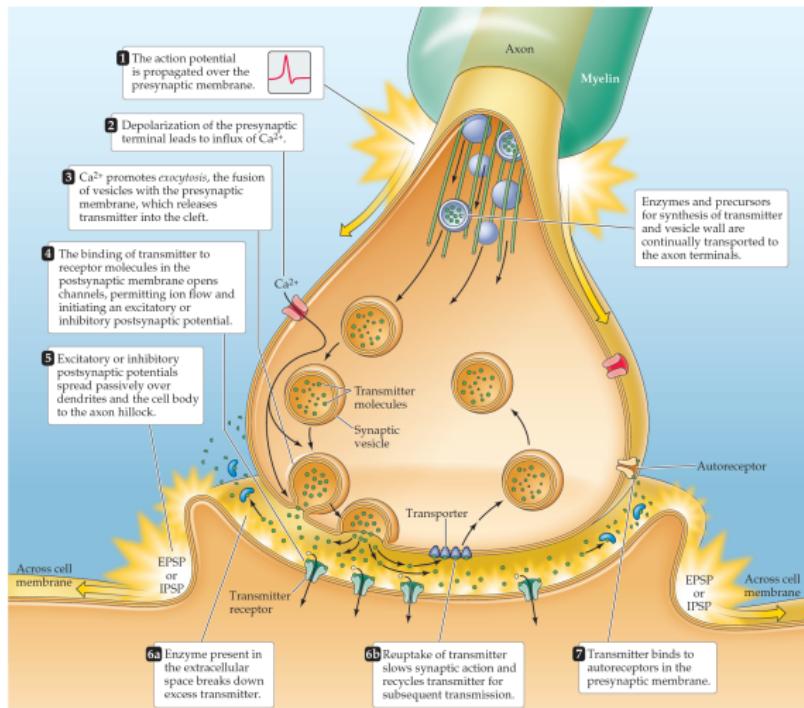
The Sequence of Transmission

- ① Action potential travels down the axon to the axon terminal.
- ② Voltage-gated calcium channels open and calcium ions (Ca^{2+}) enter.
- ③ Ca^{2+} entry causes synaptic vesicles to fuse with membrane and release transmitter into the cleft.
- ④ Transmitter molecules cross the cleft to bind to special receptor molecules in the postsynaptic membrane, leading to the opening of ion channels in the postsynaptic membrane.

The Sequence of Transmission

- ⑤ This ion flow creates a local EPSP or IPSP in the postsynaptic neuron.
- ⑥ Synaptic transmitter is either (a) inactivated (degraded) by enzymes or (b) removed from the synaptic cleft by transporters, so the transmission is brief and accurately reflects the activity of the presynaptic cell.
- ⑦ Synaptic transmitter may also activate presynaptic autoreceptors, regulating future transmitter release.

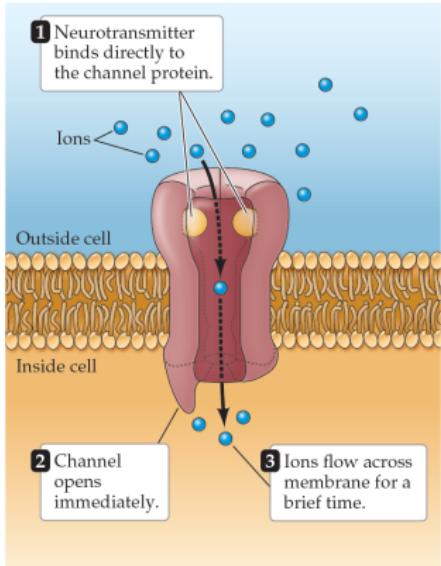
The Key Figure



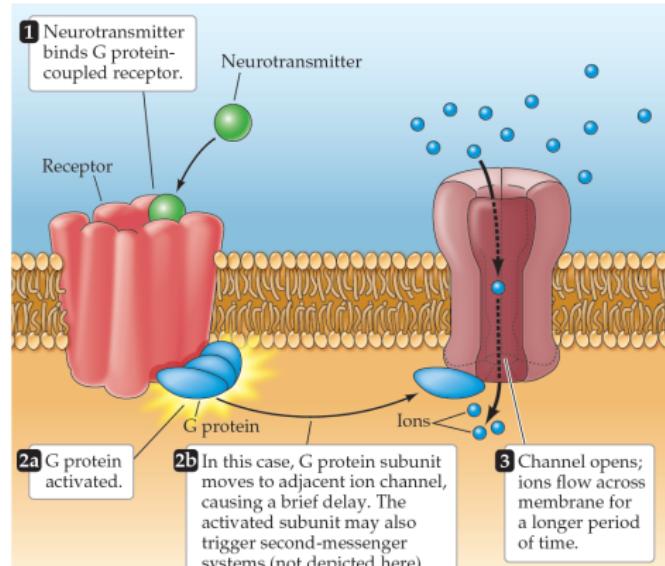
Biological Psychology, Figure 3.12

Receptors

(A) Ionotropic receptor (ligand-gated ion channel; fast)



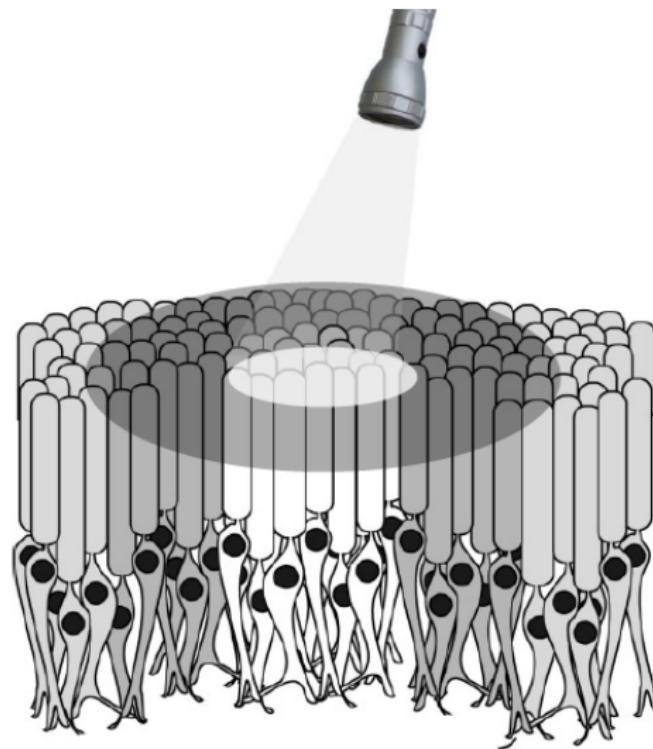
(B) Metabotropic receptor (G protein-coupled receptor; slow)



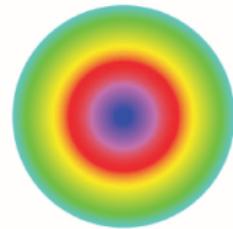
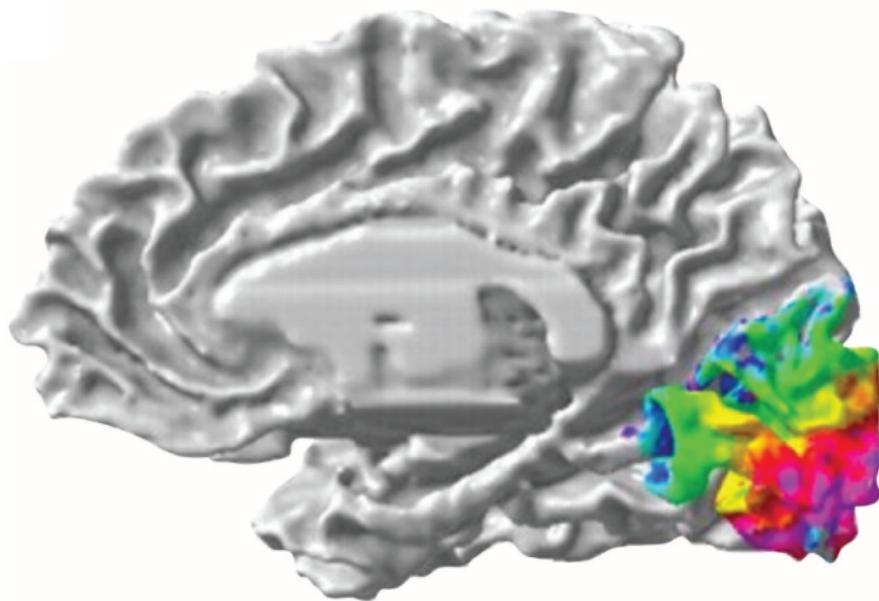
Biological Psychology, Figure 3.16

Center Surround Organization

Hubel and Wiesel Video

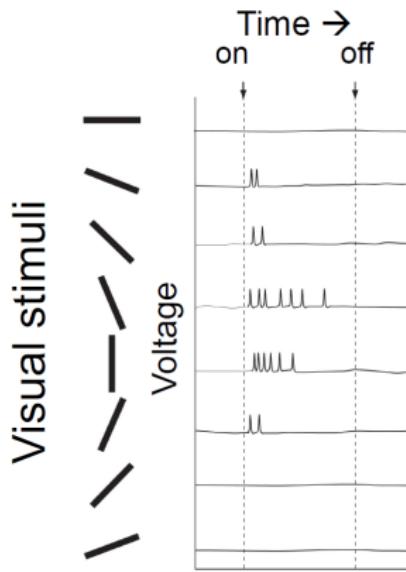


Retinotopic Maps

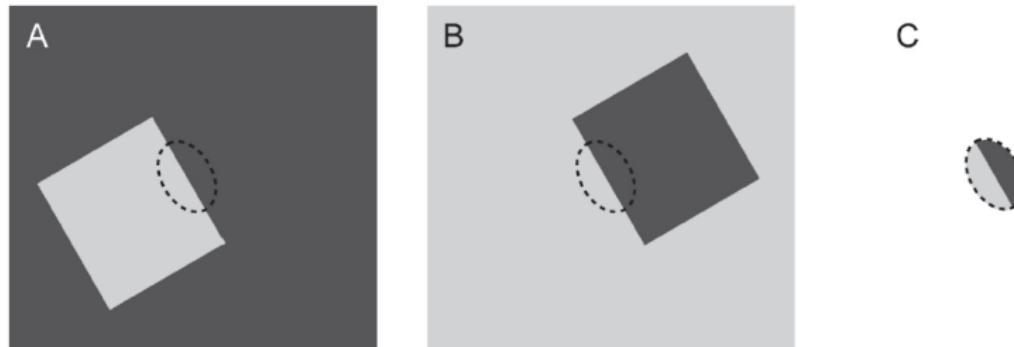


Orientation Selectivity

Hubel and Wiesel Video



Border Ownership Selectivity



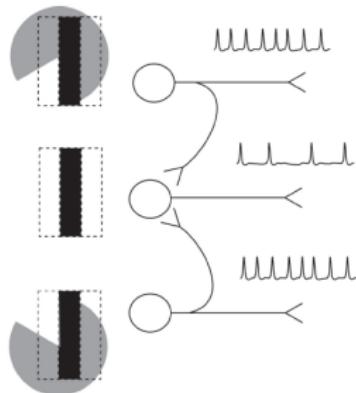
Zhou, H., H. S. Friedman and R. Von Der Heydt
(2000). J. Neurosci. 20(17): 6594-6611.

Kanizsa Triangle: Illusory Contours

a

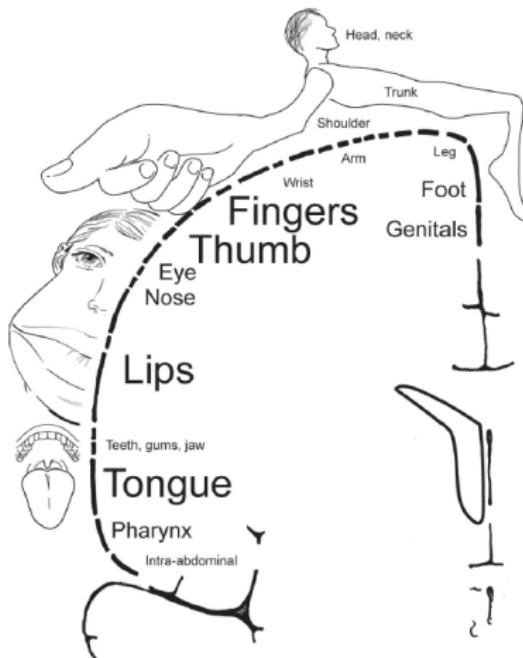


b

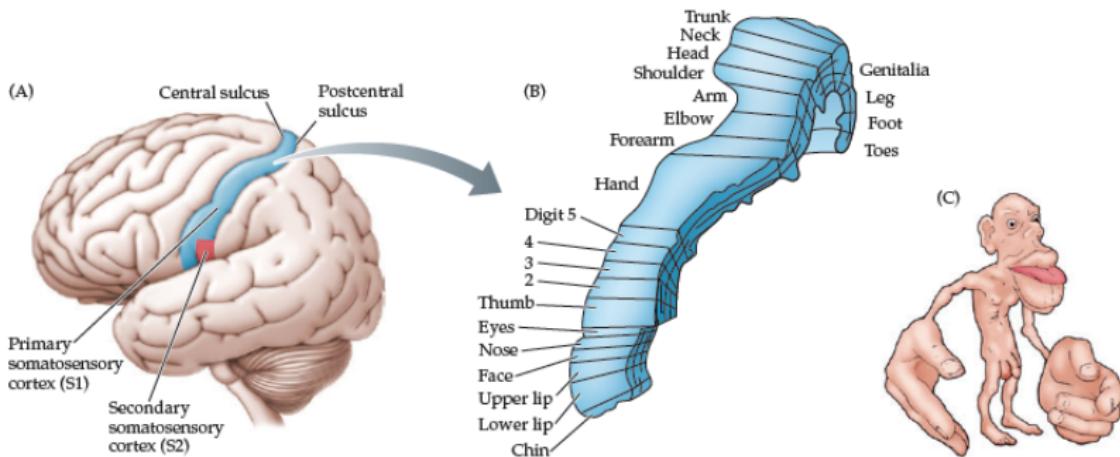


Phantom Limb and Body Map

Amputees feel like missing limb is still present



The Body Map



8.10 REPRESENTATION OF THE BODY SURFACE IN SOMATOSENSORY CORTEX

CORTEX (A) The locations of primary (S1) somatosensory cortex on the lateral surface of the parietal cortex. Secondary somatosensory cortex (S2) is much smaller than S1. (B) The order and size of cortical representations of different regions of skin. Note that information from the various parts of the hand and fingers takes up much more room than does information from the shoulder. (C) The *homunculus* (literally, "little man") depicts the body surface with each area drawn in proportion to the size of its representation in the primary somatosensory cortex.

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We will talk about these sections in the next lecture.

Reference

- Jennifer M. Groh. (2014) *Making Space: How the Brain Knows Where Things Are*, Harvard University Press.
- S. Marc Breedlove, Neil V. Watson. (2016) *Behavioral Neuroscience*, 8th edition. Sinauer Associates, Inc. Publishers.
- Wikimedia Commons <https://commons.wikimedia.org/>
- Jennifer M. Groh's Slides on "Brain and Space"