Cognitive Construction of Space: Part II

Renjie Yang

Capital Normal University
Department of Philosophy

April 2020

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"

Light is Electromagnetic Radiation

Figure-Ground Segregation

- Plato (428-348 BCE): Extramission
- Democritus (460-370 BCE): Intromission
- How do particles convey information such as size?
- Why can many observers see the same thing at once?

https://www.bilibili.com/video/BV1gE411578j?from=search&seid=3717589972584344301

Neural Communication

Propagation of Action Potential

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

Biological Psychology, Figure 3.9

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

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. Ca2+ entry causes synaptic vesicles 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. membrane.

The Key Figure

Biological Psychology, Figure 3.12

Receptors

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

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 (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.

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

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"