260-2017-11-27-vision-II

2017-11-27 08:19:19

Traveling at Warp 1

https://vimeo.com/117815404

Today's topics

- Wrap-up on vision
- Biological basis of learning & memory
- Blog post 3/papers due **today**

Coming up...

- Quiz 4, review Exam 3 on Fri
- In-class lab next Mon
- Review for Exam 4 next Wed
- Exam 4, Mon 12/11, 12:20-2:10 pm in 302 Boucke

From eye to brain



© 2001 Sinauer Associates, Inc.

From eye to brain

- Retinal ganglion cells
- 2nd/II cranial (optic) nerve
 - Optic chiasm

of thalamus (90% of

projections)

•

From eye to brain

- Hypothalamus
 - Suprachiasmatic n.
- Superior colliculus & brainstem

LGN



LGN

- 6 layers + intralaminar zone
 - Parvocellular (small cells): chromatic
 - Magnocellular (big cells): achromatic
 - Koniocellular (chromatic short wavelength?)
- Retinotopic map of opposite visual field

From LGN to V1



© 2001 Sinauer Associates, Inc.

From LGN to V1

• Via optic radiations

•

in occipital lobe

Human V1



http://www.scholarpedia.org/w/images/3/3a/03-Human-V1.png

Measuring retinotopy in V1



(Dougherty et al. 2003)

Retinotopy in V1

- Fovea overrepresented
 - Analogous to somatosensation
 - High acuity in fovea vs. lower outside it
- Upper visual field/lower (ventral) V1 and



- 6 laminae (layers)
 - Input: Layer 4
 - ~80% is from other cortical areas!
 - Output:
 - Layers 2-3 (to cortex)
 - Layer 5 (to brainstem)
 - Layer 6 (to LGN)

- Columns
 - Orientation/angle
 - Spatial frequency

Orientation/angle tuning



https://foundationsofvision.stanford.edu/wp-content/uploads/2012/02/dir.selective.png

From center-surround receptive fields to line detection



Spatial frequency tuning



(Panichello, Cheung, and Bar 2013)

- Columns
 - Color/wavelength
 - Eye of origin,

Ocular dominance columns



Ocular dominance signals retinal disparity

Cloudy with a Chance of Meatballs 3D Snippet (yt3d:enable=true)	

http://www.scholarpedia.org/w/images/9/99/11-Hubel-Wiesel-model.png

Beyond V1



© 2001 Sinauer Associates, Inc.

Beyond V1

•

•

- Larger, more complex receptive fields
 - (where/how)
 - Toward parietal lobe
 - (what)
 - Toward temporal lobe

What is vision for?

- What is it? (form perception)
- Where is it? (space perception)
- How do I get from here to there (action control)
- What time (or time of year) is it?

Comparing sensory systems

- Functional segregation/specificity
- Topographic maps
- Variable resolution

Learning and memory

Memory capacity of the human brain?

- 1e11 neurons
- 1e3 synapses/neuron
- 1e14 synapses or 1.25e13 bytes
- 1e9 gigabyte, 1e12 terabyte, 1e15 petabyte

http://www.scientificamerican.com/article.cfm? id=what-is-the-memory-capacity

What is learning and memory anyway?

- Learning
 - ?
- Memory
 - ?

How do you known when you've

- Learned?
- Remembered?

What is learning and memory anyway?

- Learning
 - Change in perception, thought, behavior, emotion over time
- Memory
 - Information derived from past experience that influences current behavior

How computer memory ≠ biological memory

- Stored in sequences of binary digits (bits): {0,1}
- Stored by address: "011000" stored in "1110000"
- Single characters, images, sounds, data stored as sequences of bits.
- Volatile vs. non-volatile
- Computers have separate memory stores; brains store info everywhere

Biological basis of L&M?

- Changes in patterns of neural activity
- Changes in patterns of connectivity
 - New synapses
 - Changes in synaptic strength (+/-)

How do synapses change strength?

Donald Hebb's Insight

(Hebb, 1949, p. 62)

(Lowell & Singer,

1992, p. 211).

'Hebbian' learning via NMDA receptor

receptor (NMDAR)

'Coincidence' detector

•

- Sending cell has released NT
- Receiving cell is/has been recently active

'Hebbian' learning

- · Chemically-gated AND
 - Ligand- (glutamate/aspartate + glycine) gated
 - Sending cell active
- Voltage-gated
 - *Zn*⁺⁺ or *Mg*⁺⁺ ion 'plug' removed under depolarization
 - Na^+ & Ca^{++} influx; K^+ outflux
 - Receiving cell responds

NMDA receptor figure

Activated NMDAR



https://upload.wikimedia.org/wikipedia/commons/thumb/0/00/Activated_NMDAR.svg/220px-Activated_NMDAR.svg.png

NMDA receptors contribute to associative learning

- Associate (link)
 - Concept A -> Concept B
 - Neuron A -> Neuron B

Donald

Donald

- Trump
- Duck
- Draper

NMDA clinical significance

•

(Alzheimer's Disease treatment) blocks NMDAR

- Controls over-activation and *Ca*⁺⁺ excitotoxicity?
- Implicated in effects of (PCP)
 - Link to glu hypothesis of schizophrenia?

NMDA clinical significance

- is NMDA receptor antagonist
- anesthesia, sedation pain relief
- possible short-term relief for depression
- Analgesic effects of nitrous oxide (laughing gas; NO)
- Ethanol inhibits (Ron et al., 2011)

Next time...

- Long-term potentiation/depression
- Disorders of learning & memory

References

Dougherty, R. F., V. M. Koch, A. A. Brewer, B. Fischer, J. Modersitzki, and B. A. Wandell. 2003. "Visual Field Representations and Locations of Visual Areas V1/2/3 in Human Visual Cortex." 3 (10): 1– 1. doi:10.1167/3.10.1.

Panichello, Matthew F., Olivia S. Cheung, and Moshe Bar. 2013. "Predictive Feedback and Conscious Visual Experience." 3: 620. doi:10.3389/fpsyg.2012.00620.