Today

- Self-introductions
- Syllabus
- Grading
- Academic honesty
- Introduction to the course
Perception is an Illusion
(Sometimes closer to reality than others)

Checker-shadow illusion: The squares marked A and B are the same shade of gray.

Edward H. Adelson
Perception is an Illusion
(Sometimes closer to reality than others)
A Blind Spot

• Our brain makes a best guess (inductive inference) at what’s out there based on the data it gets
Hermann von Helmholtz (1821-1894)

- **Physics**:
  - conservation of energy
  - fluid dynamics
  - thermodynamics

- **Neuroscience**
  - nerve physiology
  - visual perception (depth, color, motion)
  - auditory perception
  - *perception as unconscious inference*
Helmholtz - The Facts of Perception (1878)

*Perception as Unconscious Inference*

- Our sense can be divided into distinct modalities ("circle of quality"), such as taste and sight.

- The nature of sensory experience depends on which sensory nerve, not on the physical stimulus (e.g. blow to the eye).

- Different percepts within a modality correspond to different nerves of the same modality (e.g. tones).

- Our sensations are *signs* (noisy data), not *copies*, of external objects/events, and the two need not be similar, but there should be *lawful regularity* (consistency).
Helmholtz - The Facts of Perception (1878)

*Perception as Unconscious Inference*

- Signs + lawful (statistical) regularity + learning + inductive inference ⇒ intuition about the world (outer) and self (inner)

- e.g. intuition for *space*: self motion ⇒ consistent changes in sensory experiences ⇒ spatial properties (outer intuition); those experiences unchanged by self motion are non-spatial (inner intuition); 3D sufficient for explaining the world (a surface encloses a 3D space)

- e.g. common features ⇒ a class of objects; persistent features ⇒ changes in time

- *Law of causality* ⇒ *inductive inference* ⇒ *comprehensibility*
A succeeded and P failed at: visually-guided paw placement, avoidance of a visual cliff, blink to an approaching object.
Some Questions We Will Explore

- How do prior knowledge and learned expectations combine with sensory inputs to yield perception?
- What kind of neuronal maps and activities underlie sensory processing?
- What is the neural code? Is it shared across different functions and modalities?
- Are the different sensory modalities vastly different/modular or do act as an integrate whole?
- Which aspects of neural processing are innate? Which are plastic as a function of experience?
Gross Anatomy of Sensory Systems

(1) FRONTAL LOBE
  - frontal eye field
  - prefrontal area
  - Broca's area (in left hemisphere)

(2) PARIETAL LOBE
  - sensorimotor area

(3) TEMPORAL LOBE
  - auditory association (in left hemisphere)

(4) OCCIPITAL LOBE
  - Wernicke's area
  - visual association

vision

audition
Introduction to the Visual System

Sagittal view

Eye

cornea $\Rightarrow$ lens $\Rightarrow$ retina

Thalamus

gateway to the cortex
(- olfaction)

Dorsal stream
“where” pathway

Primary visual cortex
V1, Broadman area 17

Ventral stream
“what” pathway
The Eye and the Retina

- Light is focused by the **cornea** and the **lens** onto the retina
- Retinal image is **inverted**, the brain later corrects for it
- **Retina** is a thin layer of neural tissue containing photoreceptors
- **Photoreceptors** transduce light into neural signals
- Retina send visual inputs into the brain via **optic nerve fibers**
Introduction to the Visual System

Horizontal view
Photoreceptors: Rods and Cones

- **Rods**: highly sensitive (few photons needed for activation)
- **Cones**: color sensitive (3 types corresponding to 3 wavelengths)

Why is night vision colorless?
Photoreceptors: Rods and Cones

Fovea

Periphery

(A) Fovea

(B) Periphery

Diagram showing the distribution of rods and cones in the eye.
Cones and Color Perception

Electromagnetic spectrum

Three types of cones

THE VISIBLE SPECTRUM - Wavelength in Nanometers

Normalized sensitivity

Wavelength (nm)
Color: Hue, Saturation, & Lightness

**Mean** corresponds to **Hue**
- same area
- different mean
- same shape

**Variance** corresponds to **Saturation**
- same area
- same mean
- different shape

**Area** corresponds to **Lightness**
- different area
- same mean
- same shape

ADJUSTMENTS
- **Hue/Saturation**
  - **Hue:** 0
  - **Saturation:** 0
  - **Lightness:** 0
Information Flow in the Retina
Neuron: Communication Unit
Action Potential

Diagram showing the propagation of an action potential in a neuron, with labels for closed and open channels, direction of propagation, and states of the cell body (resting, active, and resting and temporarily unable to fire).
Neuronal Communication

1. Action potential arrives
2. Vesicle fuses with plasma membrane
3. Neurotransmitter is released into synaptic cleft
4. Neurotransmitter binds to receptor
5. Ion channel opens
6. Ion channel closes
Action Potential

- A certain **threshold**-level input must be achieved in order to produce a spike.
- Spikes are **all-or-none**, discrete, stereotyped events.
- **Refractory period**: after a neuron has fired an action potential, it cannot fire another until some time has passed.
- The **firing rate** of the neuron (e.g., spikes per second) represents information about stimulus (input) intensity by each neuron.
- Response **latency** (precise timing) may also encode information.
Retinal Ganglion Cell (RGC)

ON-center/OFF-surround  OFF-center/ON-surround
Visual Field Representation in the Cortex
Presentation Schedule

Each student presents two times, in teams of two
45-min presentation, 30-min discussion

Week 1: Vision (Retina)
Week 2: Vision (LGN & V1) (Nate, Akshay)
Week 3: Visual attention (Sara, Nate)
Week 4: Multistable percept & decision-making (Cassie, Joyce)
Week 5: Audition (Akshay, Jasmine, Patrick)
Week 6: Olfaction & somatosensation (Jasmine, Joyce, Jocelyn)
Week 7: Vestibular system (Cassie, Alfred, Patrick)
Week 8: Multimodal integration (Sara, Alfred, Jocelyn)
Week 9: Perceptual learning
Week 10: Final in-class assignment