VISION:

Sensation:

- Refers to detection.
- **Detection:** the stimulation of nerves and transmission of their signals.
- You have physical stimuli that arrive at the peripheral receptors.
- They are then converted into sensations, which allows for the transmission of electrical signals to various parts of the brain.
- Physical stimuli for vision are the light hitting the retina that is related to audition and changes in air pressure forming waves.
- These physical stimuli arrive at our peripheral sense receptors.
- Sensations involve taking physical stimuli and converting them into something the brain can read (electrical signals).
- The process of sensation is the detection of **transduction.**

Perception:

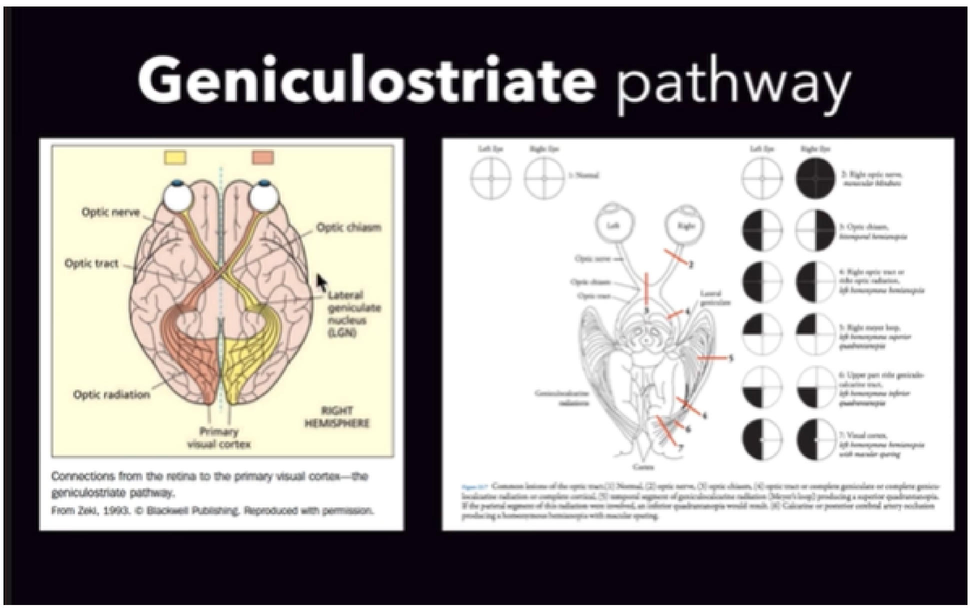
- The perception system is always making assumptions.
- **Top-down processing:** Using models, ideas, and expectations to interpret sensory information
- **Bottom-up processing:** Taking sensory information and then assembling and integrating it.
- Understand the interpretation of those signals to build a representation of the world.
- It takes these signals and combines them with our brain to create a vivid picture of our environments.
- **Perception is very hard:**
    - A computer AI miss categorizes an image of a kid looking at drums to a kid looking at a panda.
    - Adversarial images are images that are categorically miscategorized by neural networks (even really advanced vision networks).

- Connectionist networks and neural networks are more or less like a black box, so we don't know what's happening.

- We know though if something goes wrong at the output layer because you have a miscategorization that the computer vision AI thinks it's a giant panda.

- A lot of computation goes to human vision and it's very difficult to reproduce the process on a computer.

What happens after the information leaves the eye?:



- Information goes to a variety of different places in the brain.

- **Geniculostriate pathway:**
    - It is responsible for conscious vision.
    - It is one stream of information that leaves the eye and gets processed back here in the primary visual cortex.
    - It is also responsible for conscious vision.
    - The right and left sides of the visual fields are processed in different brain hemispheres.
    - Objects on the right of the face are termed the right visual field falling on the left side of the **retina** both eyes.

- It then projects back to the left lateral chin and eventually to the left side of the primary visual cortex.

- Light will hit the left on both sides of the **retina**.

- Then information leaves the optic nerve and crosses over something called the **optic tract.**

- It puts the information from the left visual field and the right visual field is going to separate it.

- Your right visual field is going to be on the left side of your brain.

- It goes through the optic tract that goes through the **lateral geniculate nucleus.**

- It then radiates down through the optic radiations, which then end up to the primary visual cortex.

- There are 2 **lateral geniculate nuclei.**

- One is on the left and right sides of your brain.

- The left **lateral geniculate nucleus** is going to process information from your right visual field.

- The right **lateral geniculate nucleus** is going to process information from your left visual field.

- This right-left-visual-field-organization of the **geniculostriate pathway** is an example of something called **lateralization of brain function.**

  V1: Primary visual cortex
  V2: Responsible for visual memory
  V3: Responsible for color.
  V4: Responsible for color and the color constancy effect.
  V5: responsible for motion .

  This is the pathway to be able to populate your conscious experience with a rich representation of the world.

Perceptual System:

Color Constancy:

- An object's color doesn't change when light does.
- Our perceptual system takes in lighting and color cues when looking at an object's color.
- If something is in a shadow, your perceptual system is going to be brighter than they actually are.
- Perception is trying to accommodate an object's color in different lighting.
- Color can be a darker thing in high light conditions.
- Color can also be a brighter thing in low light conditions.
- It is underdetermined and we don't know exactly what color we are looking at.
- The perceptual system is able to make assumptions and fill in some of the gaps and preserve **Color Constancy.**
- You also get color constancy effects if you change the tints of something.

- The perceptual system can also assume that objects are a whole even if parts of them are covered or gone.
- It marks assumptions about color constancy, continuity, and depth.
- **Perceptual System Assumption of Depth:**
    - It relates to something called size constancy scaling.
    - The perceptual system is taking depth cues into account.
    - The **retina** does not allow for much in terms of depth cues.
    - The perceptual system is then trying to build in assumptions to see how far things are to scale them appropriately.
    - It's making things bigger or smaller depending on the distance of an object.

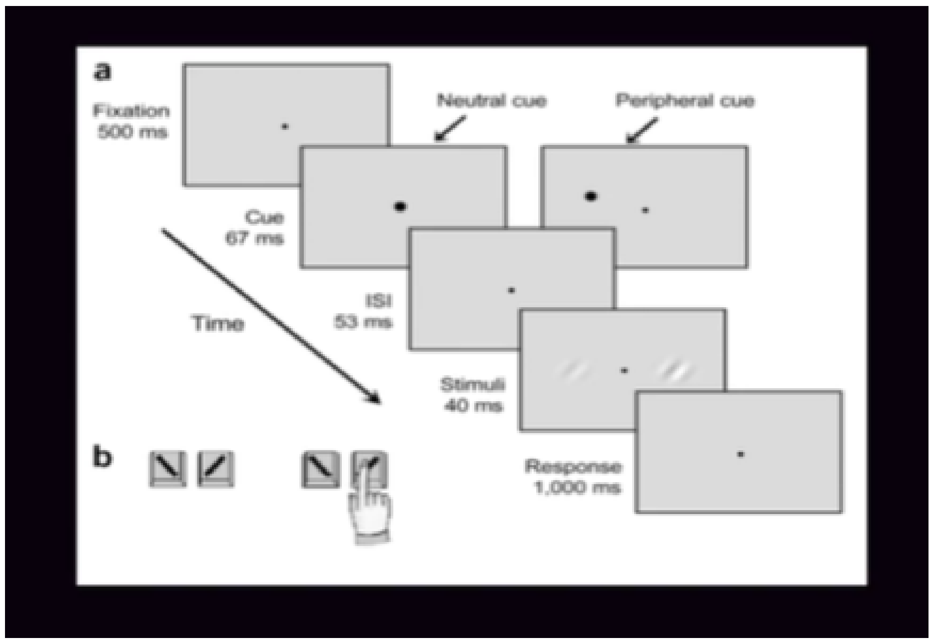
- Perception relies on the attention of how you choose to focus your gaze or mental focus to build a representation of our world.

- Attention helps to disambiguate and figure out what parts of a scene to pay attention to.

- Attention seems to fundamentally change what perception processing looks like.

Studies on Attention:

Carrasco, Ling & Read (2004):



- Subjects were told to report the orientation of the Gabor patch, which is something that has different contrast levels.

- They are trying to see how attention is affecting subjects' perception of contrast.

- If they make subjects attend to something, will that make them see the Gabor patch as higher in contrast?

- They were testing something called **exogenous attention (indirect attention).**

- There is also something called **endogenous attention (direct attention).**

- Subjects would fixate their eyes on the dots.

- The peripheral cue was supposed to draw their indirect attention to the left or right.

- Attention seems to be conferring degrees on contrast on the patches and it confers different degrees.

- Also known as “sensory modalities”

- **Vision:**
    - The things that you see.

- **Olfaction & Gustation:**
    - Your sense of smell and taste.

- **Thermosensation:**
    - The sensation of temperature.

- **Audition:**
    - Things you hear.

- **Equilibrioception:**
    - Your sensation of balance.

- **Somatosensation:**
    - Sensation of touch.

- **Proprioception:**
    - Perception and sensation of movement and the body position.

- **Nociception:**
    - Sensation of harm.
    - The sensation of bodily harm or potential harmful stimuli produces the feeling of pain.
    - It is processed by special sensory nervous system cells called gnosis receptors.

TRANSDUCTION:
- The conversion of a signal from one form to another.

- The physical stimuli that arrive at the peripheral receptors (depending on what sense modality you are in).

- Where that information is converted into an electrical signal that can be processed in the brain.

- **Example of Transduction from the Audition modality:**
    - Sound signals are converted into electrical signals.

    - It has to convert changes in air pressure.

    - Electrical signals then have to process it into the brain.

    - It allows us to build up conscious level auditory representations of our environment.

    - It all starts with this conversion of the sound signal to the electrical signal.

THE LATERAL GENICULATE NUCLEUS:
- It contains six layers in total.

- Each eye has 3 layers.

- It is also part of the **thalamus** (it is composed of different nuclei that serve a role ranging from relaying sensory and motor signals. It also regulates consciousness and alertness).

  It contains 3 different types of cells:
    - The upper 4 are the **Parvo Cells**: Responsive to details in color.

    - The lower 2 are the **Magno Cells**: Responsive to movement.
    - In between are the **Konio Cells**: They are more general.

- Different parts of the **LGN** are supposed to represent different parts of space.

- It also represents different parts of the **retina** where the light is hitting the **retina**.

- Each **LGN** is responsible for processing things that happen in its opposite visual field.

- The information goes through the optic regions and then the **Primary Visual Cortex.**

PRIMARY VISUAL CORTEX:
- Neurons are transforming the information that gets translated through the **LGN.**

- It transforms it into basic code that enables various kinds of information processing to be extracted at later stages.

- It is being extracted to eventually be built up to visual representations of the world.

It extracts bais information:

- Edges
- Orientations
- Wavelengths of light

Later processing stages use basic info to extract information:

- Shape
- Color
- Movement
- Perception

A famous example of research on the visual cortex:

- It comes from Hubel and Wiesel.

- They were doing single-cell recordings(recording the activity of one neuron) on cats

- They were trying to figure out what the neuron was responsive to any kind of stimulus.

- Neurons in the primary visual cortex have responses to particular orientations.

- Neurons in the primary cortex are responsible for different sorts of stimulus orientations.

CELL TYPES IN V1 (visual area):

- **Simple Cells:**
  - Combine responses of several **LGN** cells.
  - Responds to different orientations.
  - If you change the angle, the orientation response will go away.

- **Complex Cells:**
  - Combine responses of **simple cells.**
  - Responds to orientation and movement.
  - They also have a **receptive field**, which is the part of the visual space they're responding to.

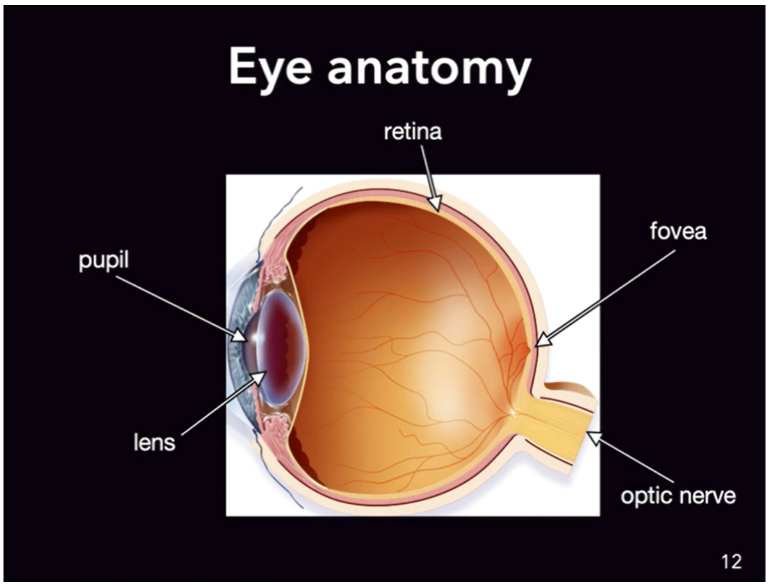
- **Hypercomplex Cells (outside V1):**
  - Combine the responses of several **complex cells.**
  - Responds to orientation, movement, and length.

- These are the building blocks to eventually get a higher-level object representation.

- This is the recipe for the visual system progressing towards more complexity.

- **V1** is retinotopically organized and builds up representation using the 3 cell types.

MODALITY OF VISION:



- **The Pupil:**
    - A hole located in the center of the iris that allows light to come back and strike the retina.
    - **Constricts and Dilates:** Part of **"adaption".**
    - When it constricts, it does not let in a lot of light.
    - It will only do this when you are in front of a lot of light.
    - When your pupil dilates when you're in low light situations.
    - The pupil will get bigger, so more light can hit the back of the retina.
    - Both processes are **automatic.**

- **The Lens:**
    - The lens focuses the light then the retina is going to be made up of different kinds of photoreceptor cells.
    - It can change the shape of light.
    - It can either flatten or curve.
    - If it flattens light, it helps you see things from farther away.
    - If it curves light, then you can see things closer.

- The process where the lens changes the shape of light is called **accommodation.**
- As you get older, you're not able to flatten and curve light as efficiently.
- You also develop **cataracts** when you're older.
- **Cataract:** A cloudy area that develops in the lens and makes it harder for light to pass through the lens to the back of the retina.

- **The Retina:**
  - Able to detect light and **transduce** it into a format then is able to be interpreted by the brain.
  - **Photoreceptor Cells:** Reacts to light.
  - It's made up of many layers of photoreceptor cells that react to different kinds of light.

- **The Fovea:**
  - Part of the Retina.
  - **Also known as the "pit":** You don't have layers of ganglion cells and bipolar cells.
  - The part where you have the best visual **acuity** (lots of tightly packed cones, which is a photoreceptor).
  - These photoreceptor cells are responsive and better in light conditions rather than dark conditions.
  - It can also distinguish colors.
  - There are no rods in the **fovea**.
  - Fovea only consisted of cones cells.

- **The Optic Nerve:**
  - The back of the eye.
  - Transmits information from the retina to the brain
  - Half of the fibers are responsible for carrying information from the **fovea**.
  - Is a blind spot on the "outside" of each eye.
  - You have a gap in your vision because you can't have photoreceptors in that space.
  - It's a gap where there are no photoreceptors and the optic nerve leaves the back of our eye.
  - Our brain is very clever and fills in the gap missing.

- The eye is an amazing transducer.

- It is able to transduce information coming in the form of light that hits the back of the retina.

- It creates electrical impulses that allow the brain to interpret what's happening.

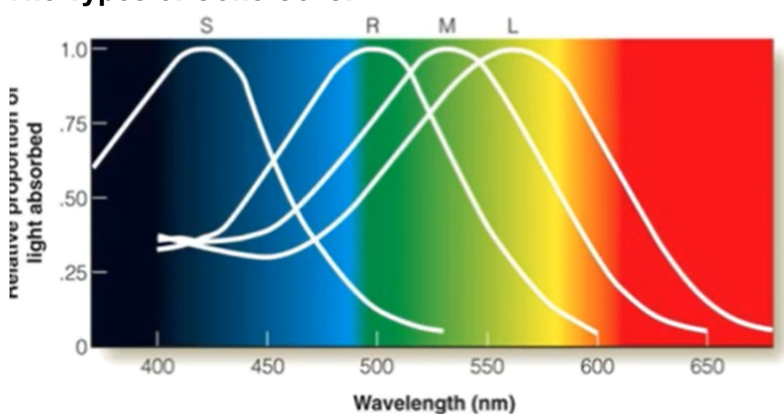
PHOTORECEPTOR CELLS:

- **Acuity:** Lots of tightly packed cones, which is a photoreceptor.

- **Rod Cells:**
    - Better in the dark.
    - Can't distinguish colors.
    - Has lower **acuity.**
    - The rods are in the periphery.
    - They only provide **monochromatic** information.
    - They have a **photopigment** known as **rhodopsin**.
    - Rhodopsin is sensitive at different light levels.
    - Rhodopsin is very responsive to low light levels.
    - It can bleach a photobleach if you have too much light.
    - It can help you see in the dark well.

- **Cone Cells:**
    - Better in the light.
    - Can distinguish colors.
    - Has higher **acuity.**
    - Our cones are packed in the middle where the fovea is.

    - **The Types of Cone Cells:**



        - The 3 types below are sensitive to different wavelengths:
            - Short
            - Medium
            - Long

        - Cones contain one of 3 **photopigments** that are called **iodopsins.**

        - Those **photopigments** are responsible to light different wavelengths, which correspond to different colors.

        - Having cones that are responsive to short, medium, and long wavelengths allows us to see colors.

- Cones contain **idopsins** making them sensitive to different color wavelengths.

- In the **Periphery,** you have a high density of rods.

- In the **Fovea**, you have a high density of cones.

- Night vision is better in the **Periphery.**

- **Bipolar in Ganglion Cells:**
  - Changes in your photoreceptor cells are passed into the layer of bipolar cells.
  - Groups of bipolar cells connect to pass up to the ganglion cells.
  - Those pass out the optic nerves.
  - Connections between bipolar cells are facilitated by **horizontal emigrant cells.**
  - This is how information leaves the **Retina.**
  - In the **Fovea,** you don't have this layer of bipolar and ganglion cells.

Why The Retina is "Inverted":

- Light does not go straight to the photoreceptor cells.
- Light goes to another layer of cells and is only in the **fovea** where you don't have light having to pass through other layers.
- This is why there is a lot of acuity in the **fovea.**
- The **retina** seems to work backward from an engineering perspective.
- The **retina** is inverted because light passes through layers of cells before reaching the rod and cones.
- It has to do with how our eyes evolved from amphibian eyes.

FACE BLINDNESS:

- **Prosopagnosia:** Inability to see faces and recognize them well.

- It can be acquired by accident or congenital (from birth).

- Some people have very good face perception and can remember faces from like 20 years ago.

- 2% of the population can't recognize faces.

- Face blindness is an example of intact sensation, but impaired perception.

- There is nothing wrong with your sensory apparatus and nothing wrong with the eye.

- Light is still hitting the back of the **retina** and it gets transmitted because of the **optic nerve.**

- It then goes back in the primary visual cortex and builds up complexity from the simple, hyper, and complex cells.

- It will make it to your face recognition area, but you will have a deficit in that region.

- That's what is causing face blindness.

- If you see an inverted face, there is a lot less **FFA** activation.

- People with face blindness see faces inverted essentially, so that's why it's hard for them to recognize them due to the lack of **FFA** activation.

- People will process faces like objects which explains their inability to see and recognize faces well.

- Faces are processed by different mechanics in the brain because people with face blindness can recognize scenes and objects.

CAPGRAS VS PROSOPAGNOSIA:

Prosopganis: is where you can't recognize faces, emotion without recognition:

- They have something called a galvanic skin response, which tracks electrical activity across the skin.

- Damage to the fusiform gyrus.

- Researchers use this to track emotional reactions because the skin has a response to when someone is excited.

- There is no recognition, but they are still getting elevated skin conductance responses when they see people they know.

- There is some signal that is leaving the visual cortex that does not get all the way to the **FFA** areas.

Capgras Syndrome: Recognition without emotion.

- You think everything is an imposter.

- A person or a thing you remember is replaced by an imposter.
- People don't get the skin conductance response elevation when they see people they know.

- It translates to anything you have emotional connections to.

- You have difficulty accepting that the person who they appear to be is so even though it is that person you are thinking about.

- They don't get the emotional response to seeing friends or family and think they are imposters.

- It's not a perceptual deficit in the brain.

- It's a deficit on what you do with the perception to make judgments when looking at a person.

- The **geniculostriate pathway** is the foundation for conscious vision.

NONCONSCIOUS PROCESSING: BLINDSIGHT:

- Occurs when there's damage to the brain's visual cortex.

- No conscious vision.

- They are blind on the left side of the visual field.

- They don't have conscious access to information in the blind hemisphere.

- There is something in their brain that has that information because they can correctly guess the detection of motion, light, and color.

- They are able to detect motion and location.

- Conscious vision is disrupted whereas unconscious vision is intact.

- The other pathways besides the **geniculostriate pathway** is responsible for the unconscious vision pathways.

- **The geniculostriate pathway** is the most powerful pathway for vision, but there are other pathways too for vision.

THE MULTIPLE PATHWAYS LEAVING FROM THE RETINA:

- **LGN:**
  - Contains **Magno**, **Parvo**, and **Konio** cells.
  - The **Konio** cells go to the **extrastriate pathway,** which is responsible for motion processing.
  - The **Magno** and the **Parvo** and **Konio** cells go to the primary visual cortex.
- **Superior Colliculus & Inferior Pulvinar:**
  - Oriented stimuli and initiates automatic body and eye movements.
- **Suprachiasmatic nucleus (SCN):**
  - Part of the **hypothalamus.**
  - Provides information about day and night
  - Used to configure your bodily clock.
- These routes are faster than the **V1** route.