VISION:

- **The Proximal Stimulus in the sense-data:**
    - It is inherently ambiguous and consistent with many interpretations.
    - This is “unconscious inference” (Helmholtz 1867).
- The goal of perception is to infer the properties of the world (the distal stimulus) based on the evidence in the proximal stimulus, plus other knowledge.
- Hopefully, this yields a vertical (true) representation.
- Each 2D stimulus is consistent with an infinite number of 3D objects (distal stimuli).
- Generally, every stimulus is consistent with an infinite number of interpretations (scene models).
- The brain knows the X and Y of a cube/object in a plane, but won’t know the depth.
    - Depth is very ambiguous.
- The Z dimension of objects is being guessed by our brains.
- Z dimensions can be misleading depending on what angles you are looking at an object.
- **What You See:**
    - Intuitively you simply see “the world.”
    - That is, you are subjectively aware of the actual physical scene in front of you, simply because you can see it.
    - This idea is sometimes called **naive Realism.**
    - The sense data (**proximal stimulus**) is the only thing the brain has “direct” access to.
        - This has led to a misconception that what you actually “see” is the **image** (the proximal stimulus).
        - A model of the world, **a mental representation**, has to be inferred from the sense data.
        - **You don’t see the sense data itself.**
    - **Color:**
        - People will perceive colors differently according to the brain.

- Color has nothing to do with an object and color is something that the light receptors in your brain process.

- **The Famous Dress:**
  - People perceive the dress as different colors due to the luminosity and how the brain process it.

- **Top-down vs. Bottom-up:**
  - Knowledge, Expectations → Perception ← Sensory data.

  - Perception is always a mix of knowledge, expectations, and sensory data is what creates your perception of the world.

  - Top-down influences can change what you see.

  - **But conscious knowledge usually doesn't:**
    - Visual illusions are mostly **unaffected** by what you "know" (illusions).

      - Perception is **informationally encapsulated.**

      - It is "walled-off" from consciously acquired knowledge.

- **Lightness Perception:**
  - **Lightness perception** refers to the way the brain estimates the reflectance of a surface, i.e. the percent of the light it reflects.

  - More reflective surfaces (e.g. 90%) are perceived as white, less reflective (10%) as black, and intermediate ones (50%) as gray.

  - Color is a separate matter.

  - The proximal stimulus contains information about only how much light there is at a particular point, not what percent of light was reflected.

  - But this also depends on the illumination, which you don't know.

  - So how does the brain infer reflectance?

  - Illumination and reflectance can be conflated in images.

  - **So how do we solve it?**
    - The brain solves this problem and many other perception problems by tacitly **making assumptions.**

        - Assume a **common illuminant** over the entire scene:
            - All surfaces are then relative to each other.

            - Note that this assumption is often violated (e,g, spotlights)

        - Assum the brightest surface is white:
            - All other surfaces are interpreted relative to it.

- **Constancies:**
    - Constancy is an apparent invariance of some prosperity of the **distal stimulus.**

    - Despite its enormous variation in the corresponding property in the **proximal stimulus.**

    - You have constancies because your brain is **successful** at estimating the distal property.

    - **Shape constancy:**
        - The apparent shape remains constant despite changes in the 3D pose.

    - **Lightness constancy:**
        - Apparent surface reflectance remains constant despite changes in illumination.

    - **Color Constancy:**
        - Apparent surface color remains constant despite changes in illumination color.

    - **A failure of size constancy:**
        - Apparent physical size remains constant despite enormous changes in retinal size as distance changes.

            - Size estimates depend on distance estimates.

- **The Retina and Photoceptors:**
    - **Three types of cones:**
        - Short-wavelength
        - Medium-wavelength
        - Long-wavelength

    - **Rods:** Just 1 type, but more sensitive, and faster response.

- Rods can't tell the dfiferent between different colors while cones can tell the difference between colors.

- Rods are more sensitive to light than cones.

- Cones are not as sensitive for light but can tell the difference of colors.

- **Fovea:**
  - The central area of the retina with a high density of photoreceptors, so high resolution, mostly cones.

  - The fovea is what you point a something when you "look at it."

COLOR:

- Newton (1704) found that light is composed of light of different wavelengths.

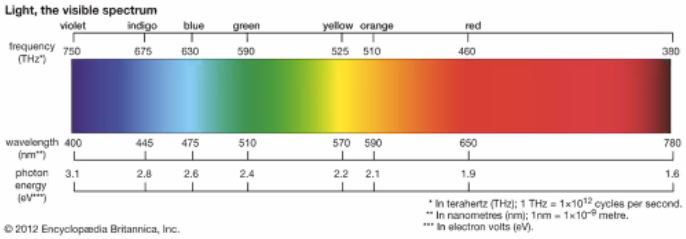
- Different colored protons would go different ways, which is known as a rainbow.

- Depending on color blindness, people can experience "blue" as a different color.

- Color is just wavelengths.

- This is the physical idea of color: a spectrum of wavelengths.

Ultraviolet<-



->Infrared

- **Psychological Colors:**
  - Goethe (1810) noticed that the perception of color has properties that cannot be explained by wavelength.

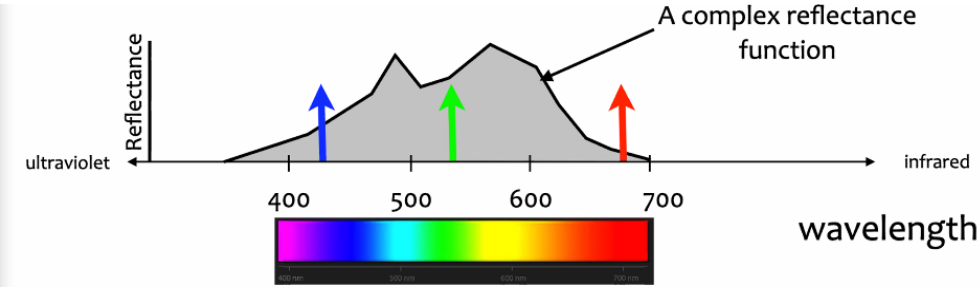
  - Later scientists concluded that these include:
    - Trichromacy

    - Human color percepts have three degrees of freedom, now called hue, value, and saturation (RGB).

    - This is why TVs can make "all" colors by using three-component wave lengths such as RGB.

- **Opponency:** Some colors are opposite of each other.

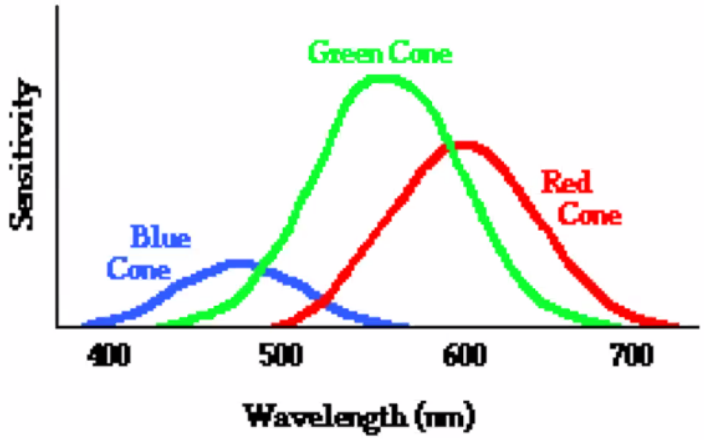
- **The Reflectance function:**



  - Real surfaces reflect characteristic distributions of wavelength
    - Just like lightness is really the proportion of light reflected.

  - What is the relative response of the 3 cone types?

  - The brain infers the reflectance function from the ratio of responses of the 3 types of cones (RBG).



- **Metamers:**
  - Since you are only sensitive to the ratio of cone responses, colors with the same **ratio** of the cone responses **will look the same.**
    - These are called metamers.

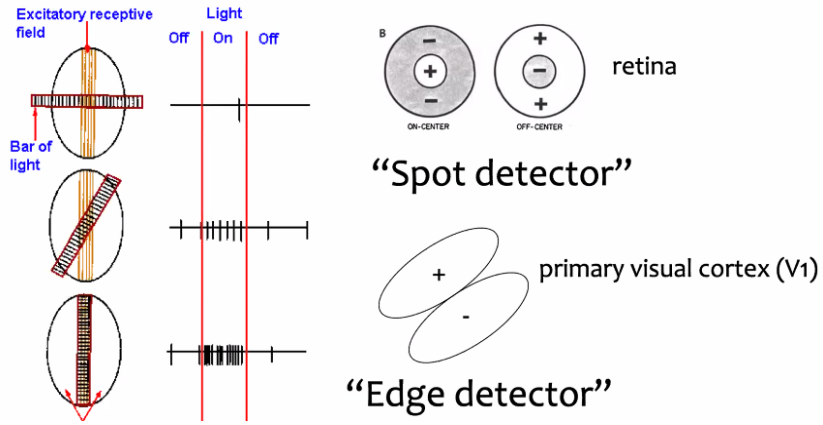
  - TVs and computer screens are full of examples.

  - If you stare at a certain color for a while, the neurons in your brain exhaust themselves where the color will change.

- **Colorblindness:**
    - If your cones do not work, you will be insensitive to color differences (achromatopsia).
    - If you have only two kinds of cones (e.g. Protanopia, Deuteranopia), you will be insensitive to some color differences.
    - People with two working cones types have a 2-dimensional color space instead of a 3-dimensional one.
    - Some people have 4 cone types and thus are sensitive to color distinctions that most people can't detect.

RECEPTIVE FIELDS:

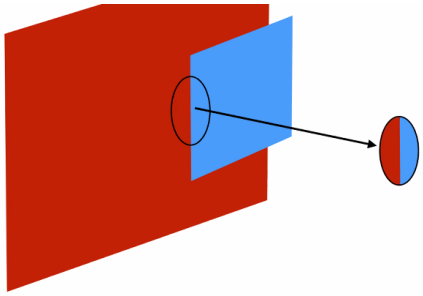
- Lateral inhibition = competition between neighboring areas.



- Edge detectors are everywhere.
- Every orientation x, every position x, and every size x.
- **Perceptual Grouping:**
    - Perceptual grouping is the organization of the raw elements of visual images into larger units, like contours, surfaces, and objects.
    - **Gestalt Perceptual Organization:**
        - The Gestalt psychologists (Germany, 1920s) emphasized the "whole" (Gestalt).
        - "The whole is different from the sum of its parts."
        - This led to how the visual image is perceptually organized.

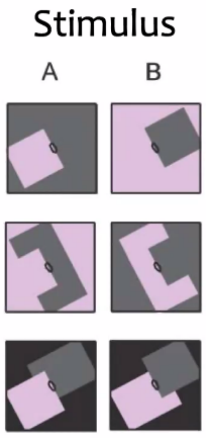
- **Figure and Ground:**
  - Each boundary separates one region that is closer (figure) and another that is farther (ground).

- **Border Ownership:**
  - The figural (blue) side of the boundary “owns” the boundary.



- Cells in Visual Area 2 (V2) are sensitive to Figure/Ground.

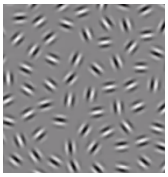
- It's as if they can only see that tiny red and blue region shown.



More Gestalt Principles:

- Principle of proximity.
- Principle of similarity.
- Principle of common fate.
- Principle of good continuation.
- Pragnanz.

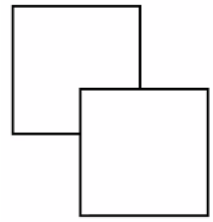
- **=Good Continuation:**
  - Contour integration
  - Elongated contours are created by communication among adjacent receptive fields.



- **Pragnanz:**
  - Preer the simplest or most coherent interpretation.
  - Good organization.

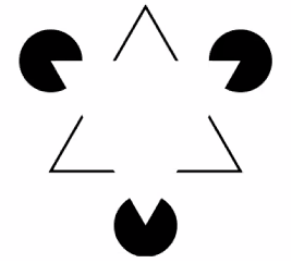
- Edges in a visual field make the most sense if organized in a certain way.

- **Perceptual Completion:**
  - **Amodal completion**:



  - One object is perceived as “completing” behind the other but is not literally seen.

  - **Subjective Contours:**



    - One object is perceived as in front of another, including the visible constructed boundaries.

SHAPE AND SHAPE PERCEPTION:

- **Example: Chair:**
  - Chairs can come in many different shapes, sizes, and designs.
  - Shapes with the same label (“chair”) differ enormously.

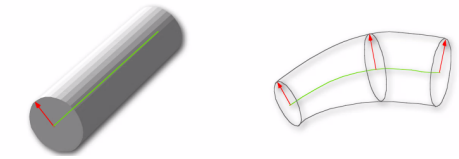
- Viewpoints can change appearances can change radically.

- **Canonic View:** A viewpoint from which an object is readily recognizable.

- Axial and part-based representations are critical.

- Axial representations are recognized as “pipe cleaners” and can still be used to identify objects.

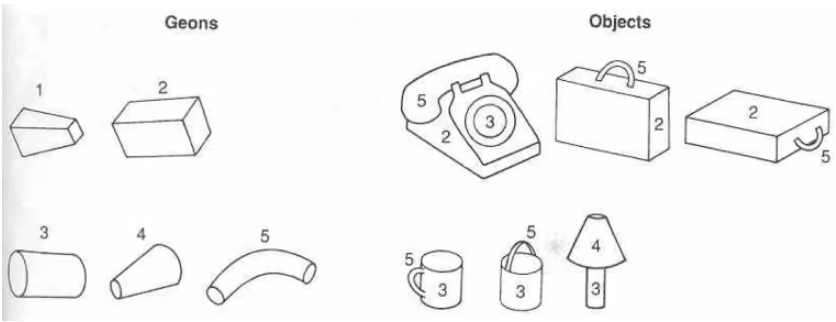
- **Generalized Cylinders:**



  - Each cylinder has different angles and scales.

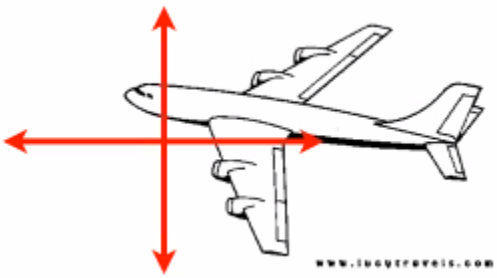
- **Recognition By Components:**
  - Geons (“geometric ions”).

  - They are individual part types that are combined in various ways to form unique 3D object models.



- **How does the brain achieve shape constancy?:**
  - **Viewer-Centered coordinate system:**
    - Implies viewpoint dependence.

  - **Object-Centered coordinate system.**
    - Implies viewpoint independence.



(The tail is to the right of the wings)

(The tail is at the rear of the body)