A Pigment of Your Imagination: Understanding Visible Color

Teacher: Sana Meher (BS Neuro ‘27)

Time: 2 hours

# of Students: 40

Overview:

Do you think physics is useless? Do you think the brain is cool? Wondering why Disney villains are always green? If so, this class is for you. We will study how color originates, how humans see color and how the biological basis of color perception has led to different cultures giving colors different meanings. You will (hopefully) leave this class with an appreciation for physics, an understanding of what neuroscience entails, and the ability to examine films and other visual media through their colors.

Goals: list the main learning goals/takeaways you want your students to learn

- ★ Describe the physical causes of how light is reflected to “produce” color
    - Recall the three reasons why mirrors have their mirror ability (and why other materials do not)
- ★ Define the electromagnetic spectrum, specifically the visible spectrum
    - Observe the correlation between wavelength and color
    - Understand that color is not an inherent property of an object
- ★ Distinguish different parts of the eye, including the parts involved involved in color recognition
    - Analyze how cones respond to different wavelengths of light
    - Examine the biological bases of colorblindness
- ★ Identify regions of the brain involved in perceiving light
- ★ Compare and contrast how colors are received across different global cultures
    - Analyze the usage of color in order to send a message

Materials: list the materials required for your class

Class Outline: bullet point outline of the structure of your class, including activities and estimated length

- ★ Introductions & transition into topic (10)
    - My intro + everyone else's intro
        - Write names on stickers (hi my name is…)
    - What is everyone's favorite color? Form #1
        - Find someone else in the class who has the same favorite color as you!
    - Show graph of most popular colors across the "world"
        - Reference: https://today.yougov.com/international/articles/12335-why-blue-worlds-favorite-color?redirect_from=%2Ftopics%2Finternational%2Farticles-reports%2F2015%2F05%2F12%2Fwhy-blue-worlds-favorite-color
    - But how do we even see color in the first place? And why is there a preference for certain colors over others? Do colors have a meaning amongst humans (think emoji)
- ★ Describe the physical causes of how light is reflected to "produce" color (20 min for this and next one)
    - Light: can be thought of as a photon (think like a bouncy ball) or as a series of waves (think of when you hit the water waves are me)
    - Recall the three reasons why mirrors have their mirror ability (and why other materials do not)
        - Assuming the photon model: the molecular surface of an object affects how it reflects light. Perfectly smooth surfaces like mirrors reflect all light in the same direction while rougher surfaces like paper reflect light in different directions
            - Influenced by layers: light can pass through molecular surface, so the direction lower layers force light to bend in affects how well it reflects
        - Given the wave model: when the above happens, lots of these waves cancel out. Some waves are still there (remember waves represent light) and these waves end up as light that goes in at most two directions
        - Reflected vs refracted light
            - Reflected light: light that bounces off. More reflected light gives objects a more reflective quality (ex: mirrors)
            - transmitted aka refractive light: light that is absorbed by the material. More refraction means more transparency
                - Thought experiment: can you see through a mirror?
                - Eventually, refracted light fades off the farther it goes into the material

- Light passes via waves. Whether an object has color or is clear depends on how much light is reflected to our eyes and what kind of light it is
  - Going back to waves, we can have different kinds of wavelengths
  - Show how wave works and how energy depends on wave
  - Reference: https://www.google.com/url?q=https://www.google.com/url?q%3Dhttps://www.youtube.com/watch?v%253D1n_otIs6z6E%26sa%3DD%26source%3Ddocs%26ust%3D1708932474208643%26usg%3DAOvVaw2qWh1hPo3n-dwkRQn0LRfp&sa=D&source=docs&ust=1711429529269128&usg=AOvVaw1xFHVJHOVlqIpQ7ScHA8nA

★ Define the electromagnetic spectrum, specifically the visible spectrum
- From above Changes in EM wavelength cause different colors
  - Thus we can conclude that different colors are a result of
    - Different wavelengths of light
- Observe the correlation between wavelength and color
  - Electromagnetic spectrum (visible spectrum) and higher frequency means closer to purple
- Understand that color is not an inherent property of an object
  - Reference: https://www.pa.uky.edu/sciworks/light/preview/color4aa.htm
- But why can't we see x-rays? Or gamma rays? To be explained in the next section..

★ Distinguish different parts of the eye, including the parts involved involved in color recognition
- Analyze how cones respond to different wavelengths of light
  - 3 diff cones that process 3 different types of wavelengths
  - Combo of cone receptions → colors (there is another video from the ref above that explains this)
    - Bc of the way this works, Magenta is a made up color
    - Cones can only measure certain wavelengths. Wavelengths that are outside the range biologically possible for humans are simply “invisible” to our eyes.
      - Differs between species. That's why other organisms can see UV light
      - Reference: https://blog.zoo.org/2012/01/ultra-awesome-ultraviolet-eyesight-in.html
- Examine the genetic and biological bases of colorblindness
  - Colorblindness = cones aren't that great at detecting different wavelengths (i.e., red green)
    - Can be corrected with certain glasses

        - Show Ishihara test for colorblindness
- ★ Identify regions of the brain involved in perceiving light
    - Optic nerve connecting eyeball to rest of brain
    - Goes through optic chiasma
        - Chiasma = x
        - Show khanacademy video: https://www.khanacademy.org/science/health-and-medicine/nervous-system-and-sensory-infor/sight-vision/v/visual-field-processing
    - Then to thalamus
        - Thalamus is relay station for sense
    - Occipital lobe = primary visual areas
        - Show photo
        - Involved in determining which color is which
        - So we have established that biologically, the eye and the brain of ONE human can see a certain range of colors. So what happens when we have a society (or multiple) with multiple humans all seeing the same color?????? (next session)
- ★ Compare and contrast how colors are received across different global cultures (10)
    - Analyze the usage of color in order to send a message
        - Color and the natural world
            - Blue = sky, ocean (calm), natural greens = nature, yellow= sun (across all colors) orange = orange (was named for the fruit)
            - More on color and language if there is time :)
    - Colors in relation to each other (this part is going to be a bit tricky to understand)
        - Same color == same “thing”
        - Different color == different “thing”
        - Ex: bollywood song “Hawa hawa” 0:45 start at from Youtube video
            - Difference in hero’s outfit vs background dancers
    - Ex: West vs East
        - In eastern countries (i.e., China, India) red is seen as a color to be worn at festivals and most notably, weddings
        - In western countries (i.e., the US) red is seen as a color to NOT wear at a wedding!!!
        - Same issue = brides wear same color => solidarity within culture BUT not necessarily between
    - Ex: in religion
        - Good figure (Jesus, Allah, truth in Buddhism) = white or light
        - bad figure = black
        - Reference: https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.20

19.00206/full&sa=D&source=docs&ust=1711429529269503&usg=AOvVaw0BVDYl18TnT6J0_4V9HTaG

- More US specific examples
  - UCLA vs USC
    - Ucla = blue. Usc = red. American colors: white, red, and blue. Considering ucla and usc are the biggest schools on the west, is it a coincidence that their colors are representative of american colors as well as “opposing “ on the flag?
    - Other EXAMPLES: stanford v berkeley, harvard v yale
    - In fact, blue and red are the most common college colors
    - reference: reddit lol– https://www.reddit.com/r/CFB/comments/2ao4hm/the_colors_of_college_football/&sa=D&source=docs&ust=1711429529269787&usg=AOvVaw06wkfsW_KcQCXbyrtbZuYU
  - Disney villains
    - Are either all green or all purple
    - Why? Bc purple is rare and thus eye catching due to unnaturalness, just like neon villain green
    - Other examples: the grinch, the joker, thanos

★ Conclusion (10-15)

- Summarize everything learned
- 10 minutes for college/course Q&A and or fill out exit survey