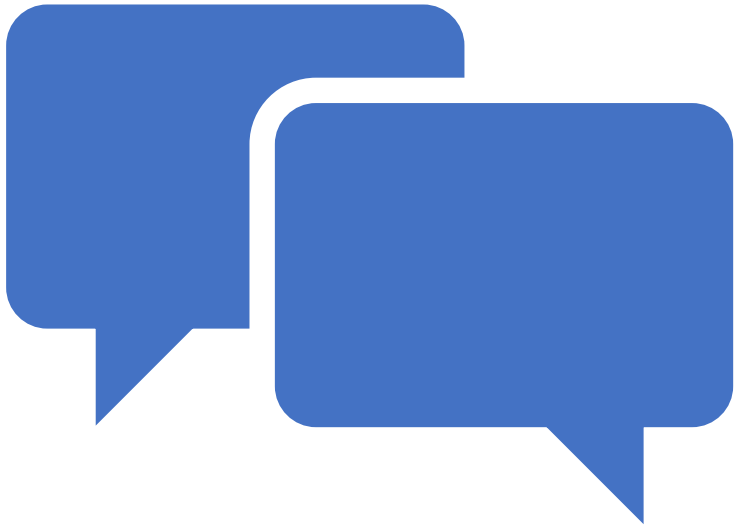
Think Again

Fall Term 2021

Class 1 - Introduction

Email and Website



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If the Human Brain Were So Simple That We Could Understand It, We Would Be So Simple That We Couldn’t

Emerson Pugh as quoted by George Pugh

Class Procedures

- Mostly presentation with periods for questions and comments approximately every 15-20 minutes
- Submit comments and questions as instructed by Moderator
- But please jump in rather than waiting if I say something that is incorrect or that you did not understand.
- I will post the slides to the website after each class and will send out an email when it has been posted.
- There will be other information on the website such as the Syllabus, Glossary, and Reference Materials.

Areas to be Covered Not Necessarily in Order

- Description of brain, primary parts, neurotransmitters, electrical currents, and networks.
- How the brain works and why
- Limitations of rational and conscious thought
- Optical and auditory illusions, why they work
- Cognitive biases, strengths that can become weaknesses
- Creating perceptions and rationalizing them
- Brain differences between liberals and conservatives
- Negative feelings, why we need them
- How we can improve our own functioning
- Healthy Brains

Physical Characteristics of the Brain

- Architecture – the parts and what they do
- Connections – how different parts work together
- Electrical – brain waves and electrical flow
- Chemical – neurotransmitters
- Networks – various parts working in concert
- Overrides – the built-in alarm system
- Communication – between the brain and other organs and glands

Myths

- Brain stops growing, developing, and changing
- We only use 5-10% of our brain
- Size matters – but is one of multiple factors affecting intelligence
- Specialized areas only, cannot be changed
- Rational thought in isolation
- Brain – mind – consciousness
- Our brains have to become weaker with age
- Much of left brain right brain claims
- Multitasking
- People have different learning styles

Primary Functions of Brain

- Recognize Patterns
- Make predictions
- Emotions are primary; rational thinking is secondary
- Architecture of the brain does not distinguish between the physical and the emotional
- Kick upstairs only when predictions generally fail

Have You Ever Tripped on a Step?

Four Level of Brain Processing

Sensory input that is largely ignored by the brain – minimal energy

Sensory input that is used at lower brain levels – low energy, large capacity

Activity at higher levels of the brain – high energy, limited capacity

Conscious awareness – extreme high energy, very limited capacity

Finite Energy Resources

Our brains, making up about 2% of our weight, use up 20% of our energy, even in the resting state.

Higher level and conscious thought are extremely energy intensive, more so than strenuous physical exercise.

We could not survive if our brains failed to avoid those levels unless absolutely necessary.

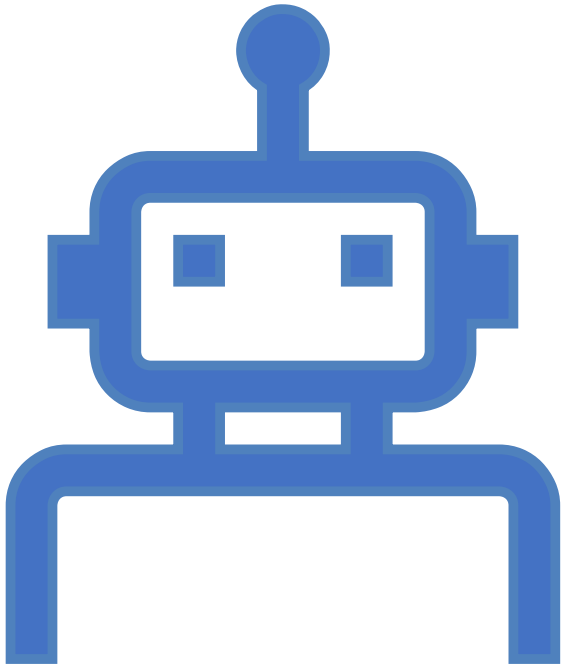
Limitations of Conscious Awareness

- We assume conscious awareness to be the same as reality but the connection is quite attenuated and often non-existent.
- Our brains pick up an infinitesimally small percentage of what exists in the material world.
- An infinitesimally small percentage of what our brains perceive move to higher level processing.
- An infinitesimally small percentage of higher-level processing enters conscious awareness.
- The majority of conscious awareness comes from learning and survival mechanisms unrelated to actual sensory input.

Numbers Beyond Human Comprehension

- Over thousands of years of evolution, we have only had to deal with small numbers, animals to hunt, plants to forage, family members. We had no reason to comprehend large numbers.
- 86-120 Billion Neurons
- Approximately equal number of glial cells
- 100 trillion to 1 quadrillion connections – 1000 to 10,000 times estimated stars
- 30 Trillion Human Cells in average person
- 40 Trillion Bacteria in Digestive Tract
- 380 Trillion Viruses in the Microbiome

Thought Experiment
Design a Human Brain



- Our brains process 11 million bits of information per second.
- Our conscious minds process at most 40-50 bits per second but at that rate, we would die of exhaustion in a few minutes.
- If the brain simply ran everything it processed to our conscious mind, we would die of old age before processing 2 minutes worth of input.
- How would you design the brain to process information?
- Evolution has developed a process of synthesizing input and drawing conclusions while bringing only necessary conclusions to our conscious minds.

Reporting to the CEO

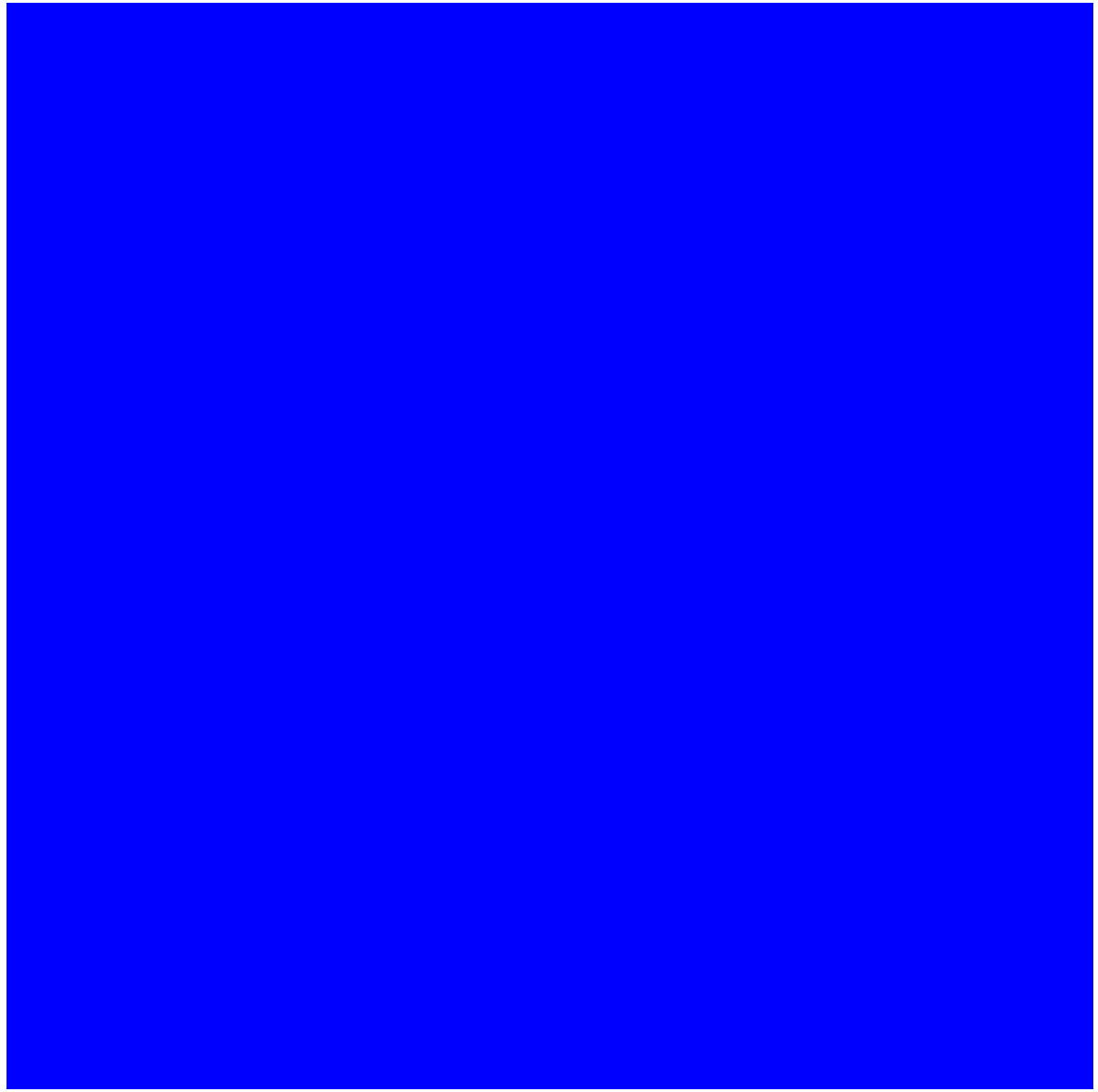
- Company has 2000 employees with 10 Division Chiefs who report to the CEO at weekly meetings.
- Division Chiefs only know what those below them have reported to them.
- If those reporting to DC told everything they knew, that first meeting would extend past retirement.
- If the DC's told CEO everything they knew, that first meeting would extend past the careers of 20 consecutive CEO's.
- So at their meeting they report conclusions based on their past experiences and understanding of what it means and what is important.
- Primarily any pending crises or needs to make critical decisions.
- Now imagine there are 100 billion employees.

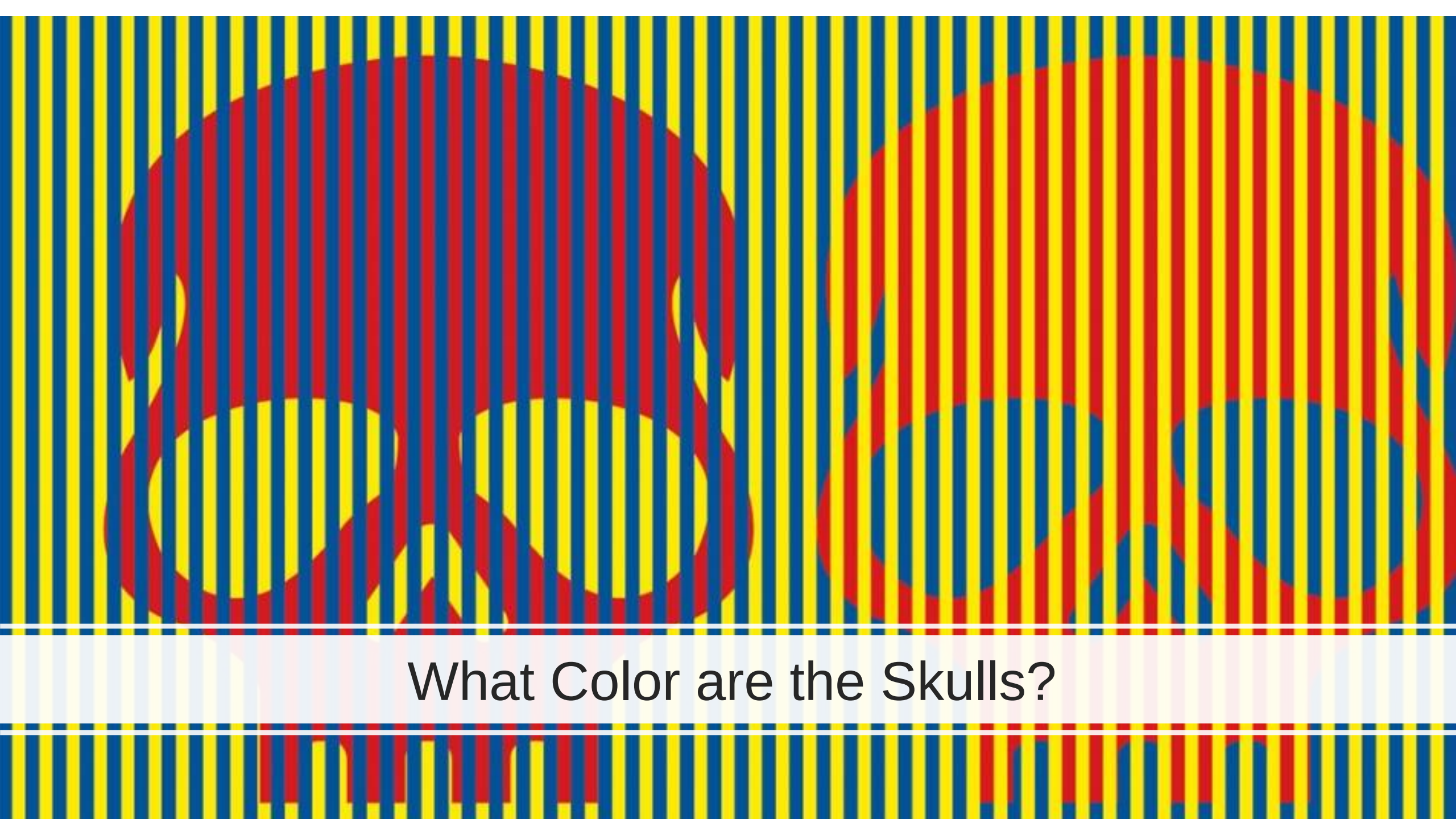
Purpose of the Brain
(recap)

- Organisms evolve primarily to improve odds of survival and secondarily to procreate (perpetuate the species).
- Procreation is secondary since you can survive individually without procreating but cannot procreate without surviving.
- Accurately reflecting external reality would be both inefficient and a threat to survival.
- Primarily, our brains identify patterns and make predictions.
- Our awareness is limited to the prediction which is only adjusted if it fails to work over the long haul.

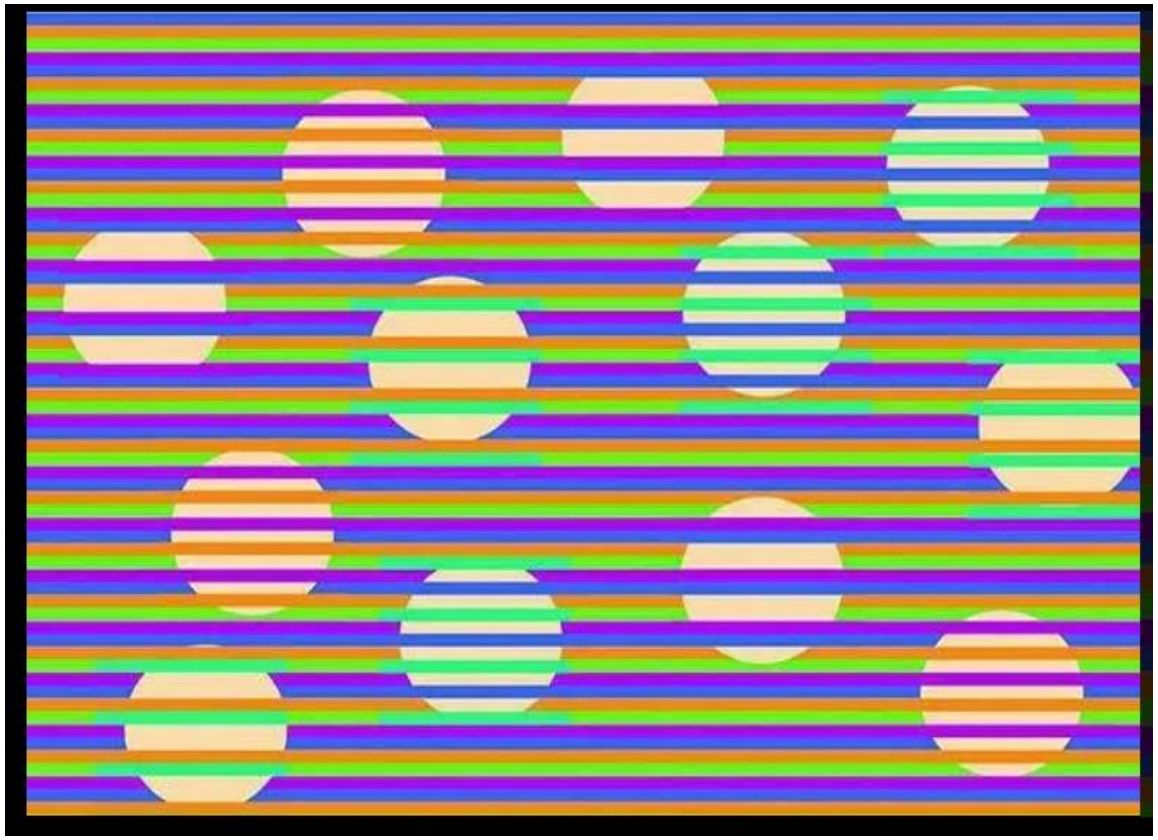
What Color is This?

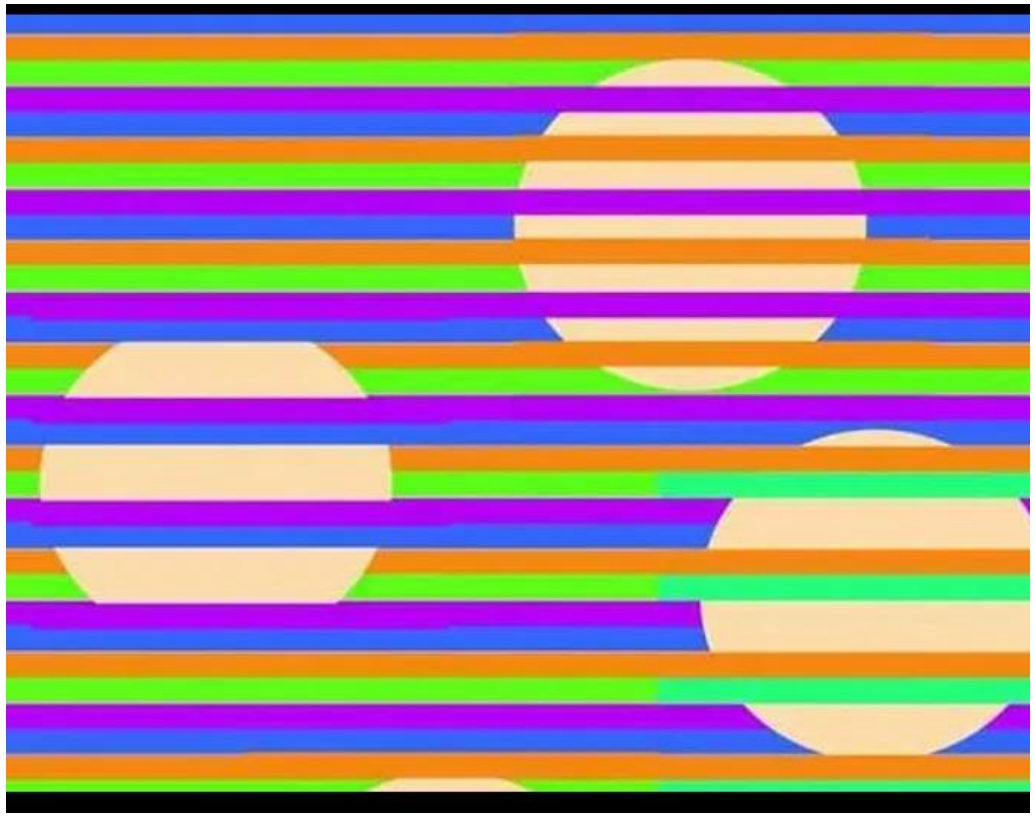
What Color is This?



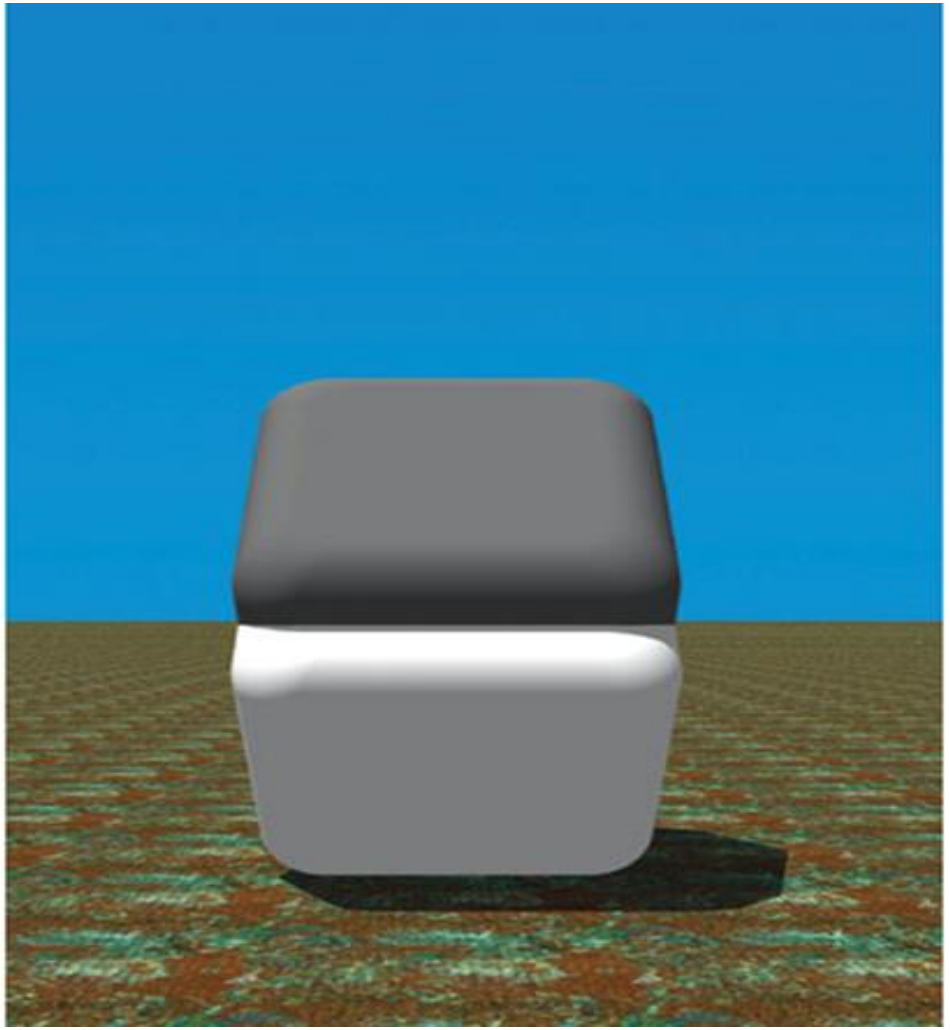

What Color are the Skulls?

Same Pictures, second one a closeup





Cornsweet Illusion



Color Does not Exist in Nature

- Our optic system detects only photons, particles that travel in waves.
- Photons are electromagnetic charges and have no color.
- Our eyes have approximately 120 million rods and 6 million cones.
- **Rods** are responsible for vision at low light levels. They do not mediate color vision. You can see from the numbers which is more critical to survival.
- **Cones** are active at higher light levels (photopic vision), are capable of color vision. There are 3 types of cones, the short-wavelength sensitive cones (S-cones), middle-wavelength sensitive cones (M-cones), and long-wavelength sensitive cones (L-cones). We see them as red, green, and blue.
- Our cones detect the wavelength and create the illusion of color to allow us to distinguish between wavelengths.
- Our brains take the input, run it through rods and cones, determine whether there is immediate threat, incorporate what we have previously learned, and create the image that would be most useful to us.

Do You Know What This Is?

How About Its Color?

Detecting Shape and Color of a Table

- Billions of photons hit the object every second, from natural and artificial sources, with some absorbed and others bouncing off in all directions.
- The surface absorbs certain wavelengths and reflects other.
- Hundreds of millions of photons, hit our retinas every second, with the wavelengths limited to those that the surface did not absorb.
- In less than a tenth of a second, our brains determine color based on the unabsorbed wavelength photons and size and shape based on the angles of reflection.
- Based on past experience our brains process millions of data points and project the mental picture of shape, size, color, texture, distance, and motion.

Ratio of Rods and Cones

- Notice 20 times as many rods as cones. Detection in dim light more critical to survival than distinguishing between wave lengths.
- We do not see color at night even though the wavelengths of photons hitting our retinas are the same as they are during the day. Again, prioritizes what is more important when fewer photons available.
- Of the colors we do see, more ‘green’ wavelength detectors than other colors.
- Natural surroundings like most plants do not absorb ‘green’ wavelengths and so reflect them creating the image of green.
- Distinguishing objects in natural surrounding most critical to survival.

Electromagnetic Radiation (EM)

- Categorized by wave length, frequency, or photon energy.
- Wavelength inversely proportional to frequency. Photon energy directly proportional to frequency. Therefore, can use any measurement for comparison.
- Not all electromagnetic waves have been identified but probably range in wave length from Planck length to the size of the universe. (More about Planck later)
- At best our optical sensors can detect .0035% of the electromagnetic spectrum – referred to as visible light

Visible Light Wavelength

- Known electromagnetic waves run from gamma rays as low as a picometer in length (one millionth of a nanometer) to radio waves over 100 million meters in length.
- A nanometer is one billionth of a meter.
- Visible spectrum runs 380 to 740 nanometers.

Why We See the Wavelengths We Do

- Human vision limited to what we perceive as Red to Violet
  - Infrared/ultraviolet not visible to human eye
- Based on temperature of the sun since what we historically needed to see was reflected sunlight.
- Majority of cones are M-Length since that detects what we see as green and perception in forest environments was most critical to survival. Plants do not absorb green, which is why they appear green to us. We get the leftovers.
- Materials absorb components of sunlight and reflect the rest. The cones analyze what is reflected to create what we call color.

Other Senses

- Other senses similarly limited – compare smell, vision, hearing, touch to other animals
- We have at least two other senses that we are always aware of but rarely think about:
  - Proprioception – awareness of our bodies in time and space
  - Kinesthesia – sense of motion of muscles, bones, and tendons
- Some we can develop (echo location), others are beyond our architecture
- It appears that our brains pick up magnetism (magnetoreception) at a subconscious level. Article
- ESP has been scientifically proven to exist but hard to define or control and usually occurring at weak levels.

Optical Illusions as an Introduction

- Tend to be universal based on brain structure (limited exceptions, e.g. schizophrenia)
- More complicated concepts such as cognitive biases, involve exponentially more interactions.
- If we realize what we perceive directly through our senses is not designed to reflect reality accurately, it opens the door to accepting our limitations in other areas.

Which Man is Bigger?

The McGurk Effect

Video

Why McGurk Effect Occurs

- Dominance of visual over auditory
- Past experience
- Confusion can be time consuming, energy intensive, and even dangerous
- Greatest likelihood of being correct

Anil Seth

Video

What Did You Hear?

- What did you hear the first time?
- What did you hear after the phrase was read?
- What Changed?
- Certainly not the sound.