Developing Critical Thinking Skills Workshop

FOR: Department of Chemistry
UNIVERSITY OF NAIROBI

Professor Kathryn Parker

March 4, 2025


Karibu
welcome

Who Am I?

B.S. Biology, M.S. Chemistry

Chemistry Professor

Environmental Scientist

Researcher

Project Manager

U.S Senate Science Fellow

Peace Corps Volunteer, Mexico

Mother of 2 Rwandan Genocide Orphans

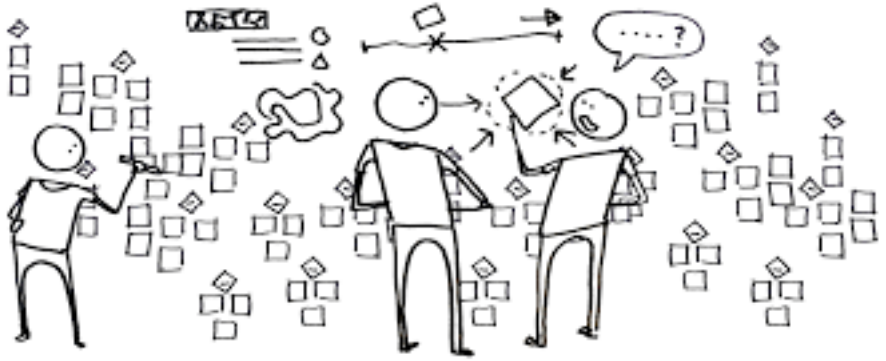
Who Are You?

Session Outline

Introductions

Critical Thinking Skills
- What is it and why is it important?
- How do we know things?
- How does the mind work?

Common Errors in Thinking-some examples
- Errors of Perception
  - Optical & Auditory Illusions
- Pattern Recognition & Cognitive Biases
  - Pareidolia
  - Data Mining
  - Causation vs. Correlation



Use of Critical Thinking Skills
- Evaluating claims in everyday life
- Further sessions/short courses?

Session questionnaire/feedback

This is an interactive session, so please be prepared to participate!

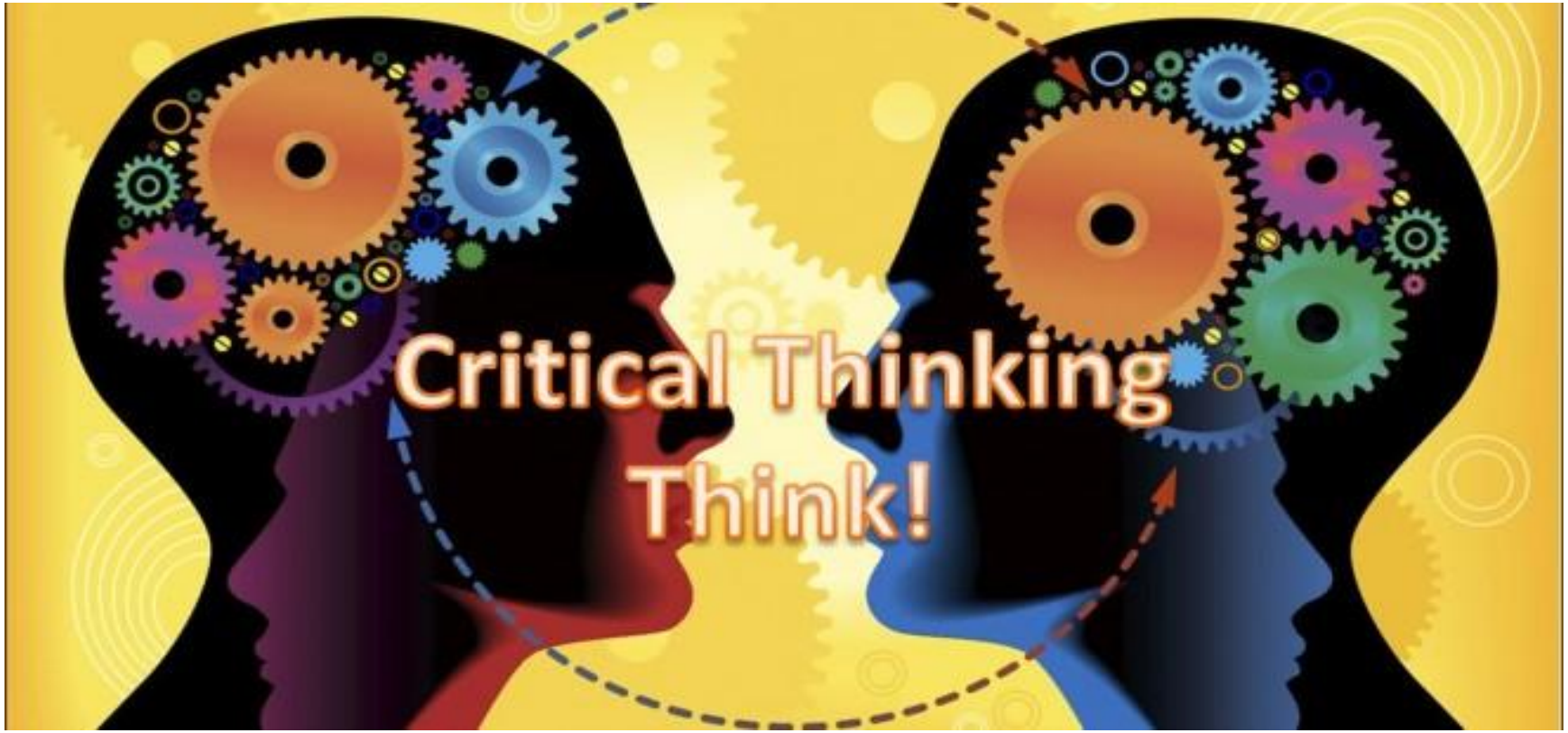
Session Goals

- Understand some fundamental critical thinking skills concepts
- Become aware of some of the limitations of our minds
- Identify ways to develop and use critical thinking skills in both your academic and in your everyday life
- Support one another in the Chemistry Department to encourage and sustain the use of critical thinking skills

Session Norms

- Phones on silent
- When speaking keep it short and on topic
- Speak one at a time and in a loud voice. Raise your hand. No side conversations.
- Participate. Respect one another. Share your views. All questions and comments are welcomed

What is Critical Thinking?



What is Thinking?

Everyone thinks *(it is our nature as humans to do so)*

However, much of our thinking is :

- Biased
- Distorted
- Partial
- Uninformed
- Often simply Prejudiced

Yet the quality of our life depends precisely on the quality of our thought!

What is Critical Thinking?

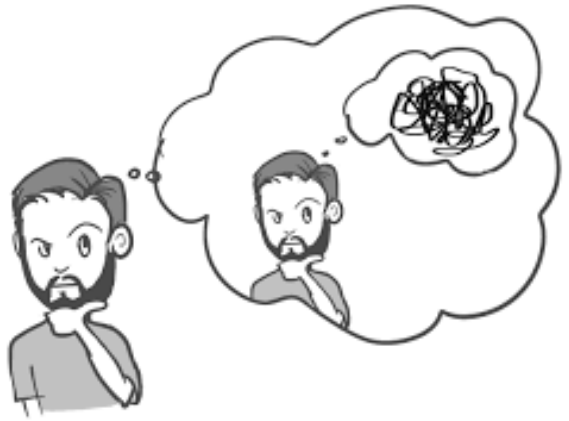
or "Thinking about Thinking"!

"Critical thinking is thinking that is clear, rational, open and based on evidence."

The principle aspects are:

- Having a skeptical and questioning attitude
- Being curious and asking questions
- Open to analyzing and evaluating your own thought processes

Thinking About Thinking



Common terms=Critical Thinking, Metacognition, Scientific Skepticism

Beliefs permeate our lives and profoundly impact our thinking

Our Brains

- We are our brains (tool for thinking)
- Have intelligence, but deceptive
- Possess logic, but not inherently logical (highly emotional)

Therefore, logic and critical thinking are learned skills!

Why is it important to think critically?

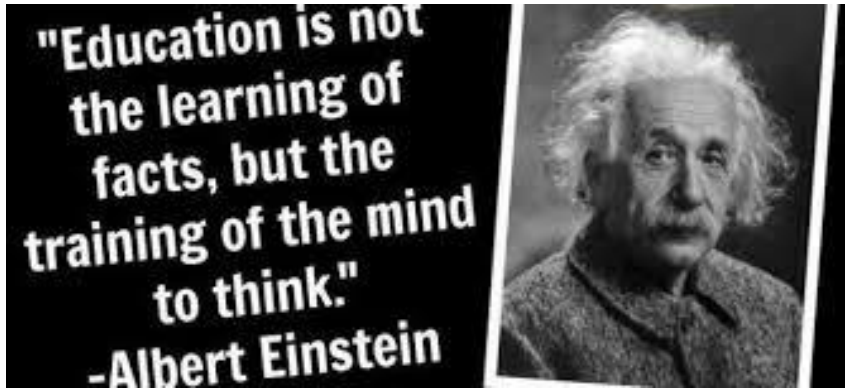
OR

Why should you care about learning to do it?

Please raise your hand and suggest some answers

Some reasons why critical thinking is important

- Better understand ourselves and others *(& not be slaves to our emotions or biases)*
- Avoid self-deception or being deceived by others
- Make the best use of our minds: improve our capacity to think rationally as intelligent human beings and explore alternative choices/possibilities
- Empower ourselves to better navigate our complex world



How do you know things exist?
How do you know things, in general?
How do thoughts/ideas get into our minds?

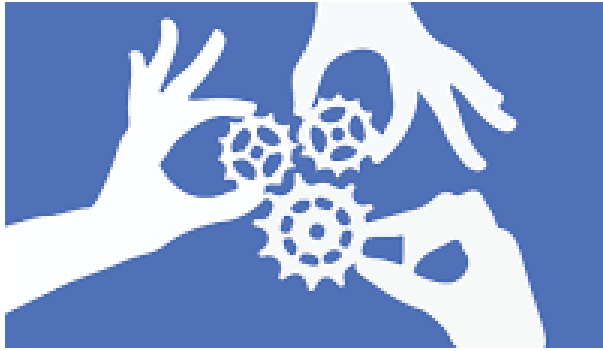
Turn to your neighbor and together come up some ideas

Ways of Knowing

"Received" wisdom

- Parents & Family
- Culture/Society
- Religion
- Media (television, radio, etc.)
- Written word (Books, newspapers, internet!)

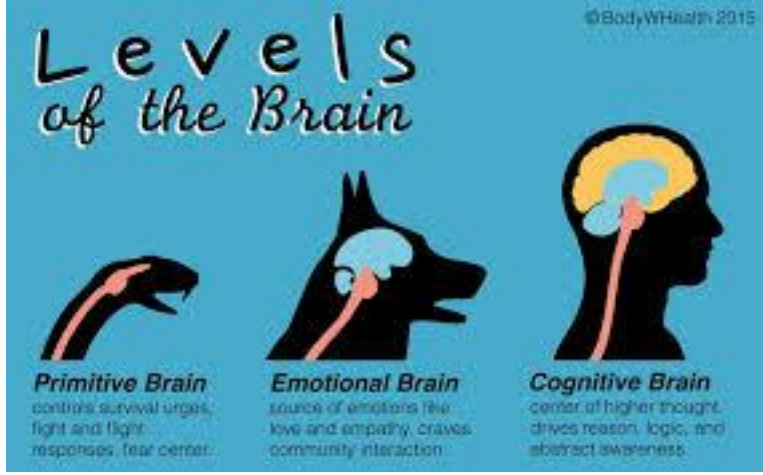
Received Knowledge vs. Experiential Knowledge



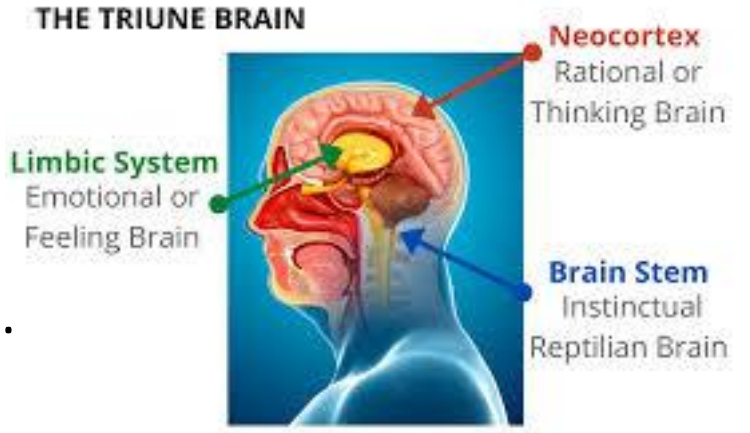
- **Received knowledge** **is often beliefs that have been handed down over generations and can sometimes be erroneous.**
  - **Can you think of a belief that you or your community once thought was "true" but now you know is not?**
- **Experiential knowledge** **(relying on your own senses) can also be problematic.**
  - **Let's look at how our brain works and some examples of it frailties …**

Neuroscience of Belief

Why do we believe what we believe?

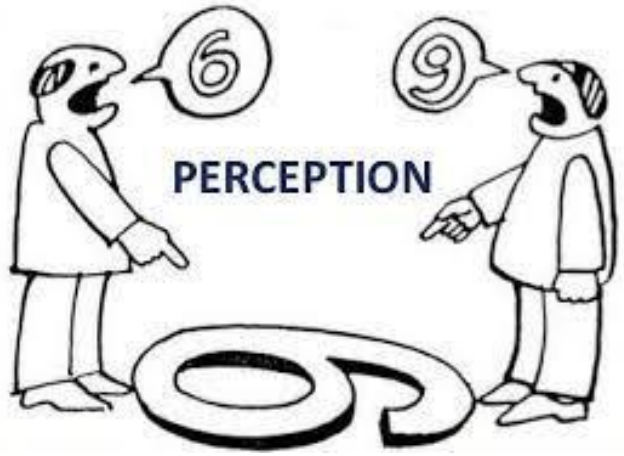


- Our brains are “belief machines”
- We are slaves to our emotions
- Our brain contains more primitive brains
- What motivates us?
  - Desire for: control, simplicity, sense of purpose, justice, etc.
  - Intensely social animals (self-esteem/ego)
  - Tendency for pattern recognition *(more later)*
  - Sense of essence or spiritual force



Therefore, it is difficult to change behavior by making rational arguments, because we are driven by emotions-but we can learn!

Experiential Knowledge & Perception



- Perception is a construct—something happening inside our brains
- Each individual sensory stream is interpreted and modified: different streams are combined, compared, and altered based on that comparison
- We attend to a very small subset of sensory information, which we weave into a complete story by adding confabulating pieces as needed, ending in a story that is largely fiction
- This constructed reality often results in arguments due to an irrational faith in the fidelity of our perceptions

If we understand the limits of our perceptions, we will not overly rely

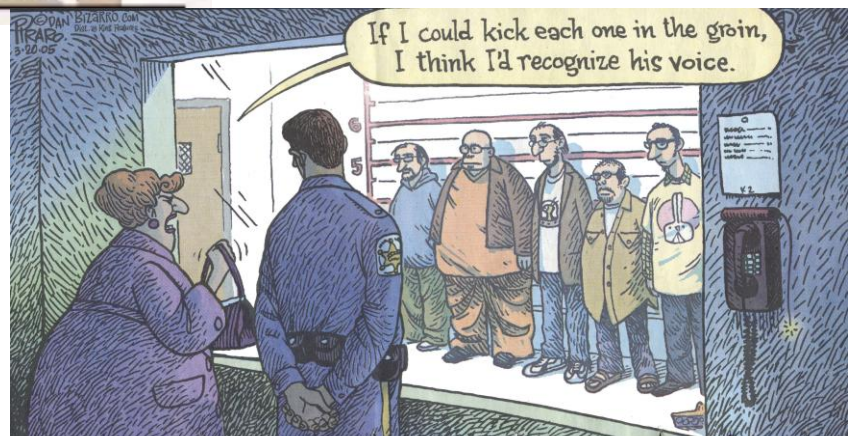
Errors of Perception
(relying on our senses)

- Believing is seeing
- Brains are NOT a passive recording machine
- Actively construct “reality” *(eg: optical & auditory illusions)*
- Make assumptions and then process & fill in information

Therefore, perception is a construct!

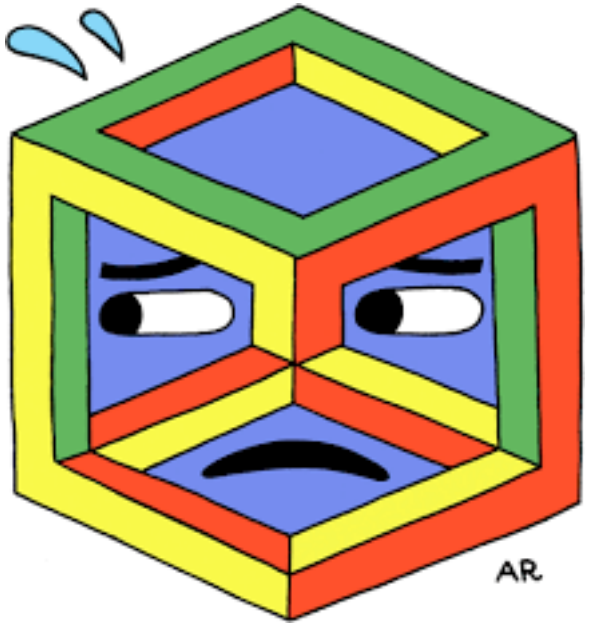
Some Examples

- Brain synchronizes visual and auditory events *(temporal synchronization)*
- Filtering of sensory information *(inattentional and change blindness)*
- Multi-tasking: Brain can't do it!
- Eye witness testimony: Notoriously unreliable!

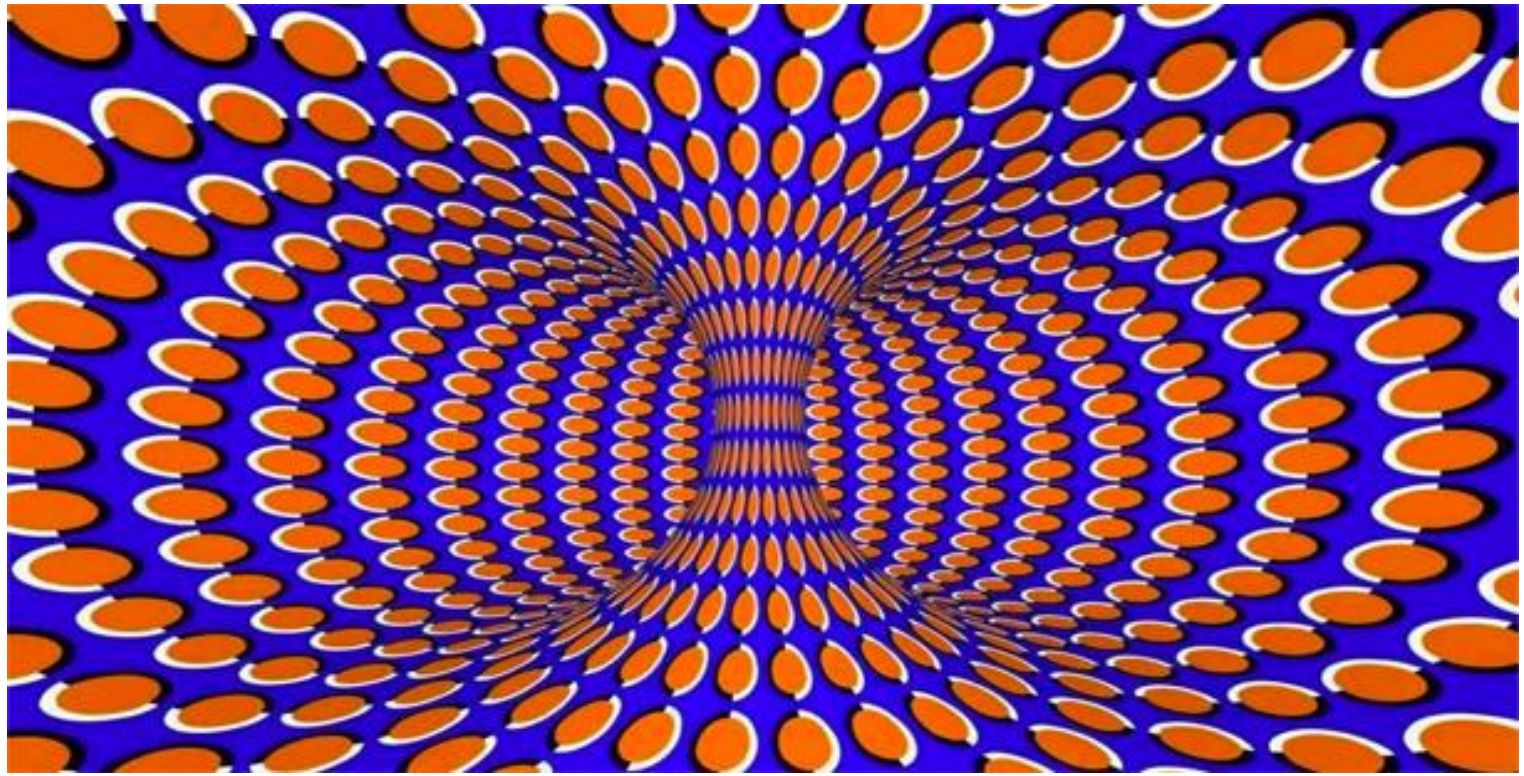


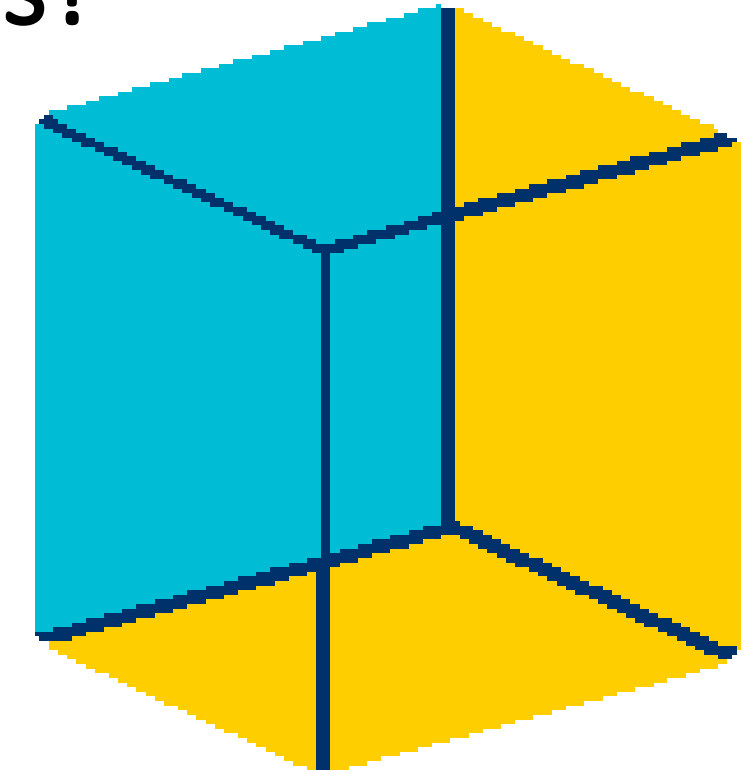
Optical Illusions

Be skeptical about what you think you're seeing!

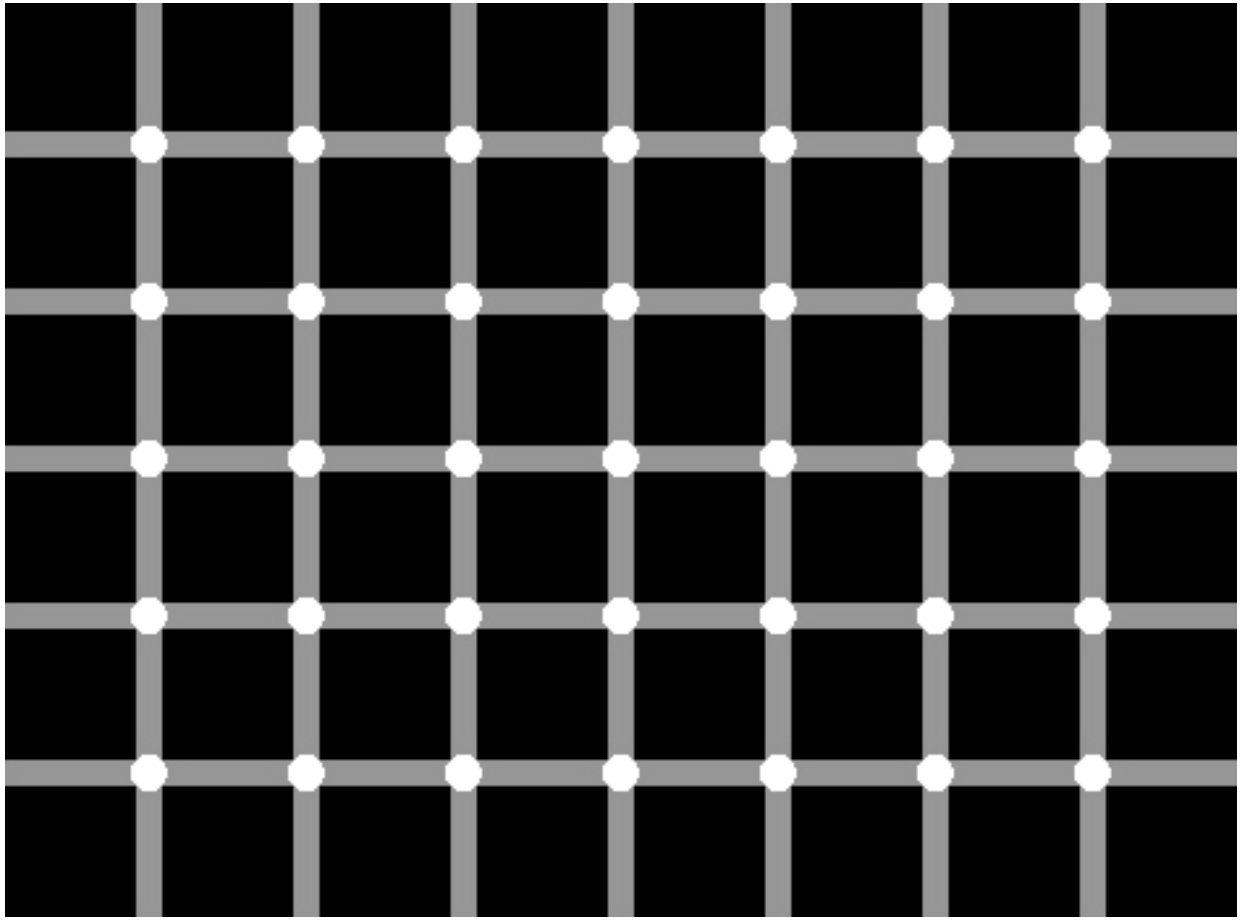


How many dimensions are these figures?

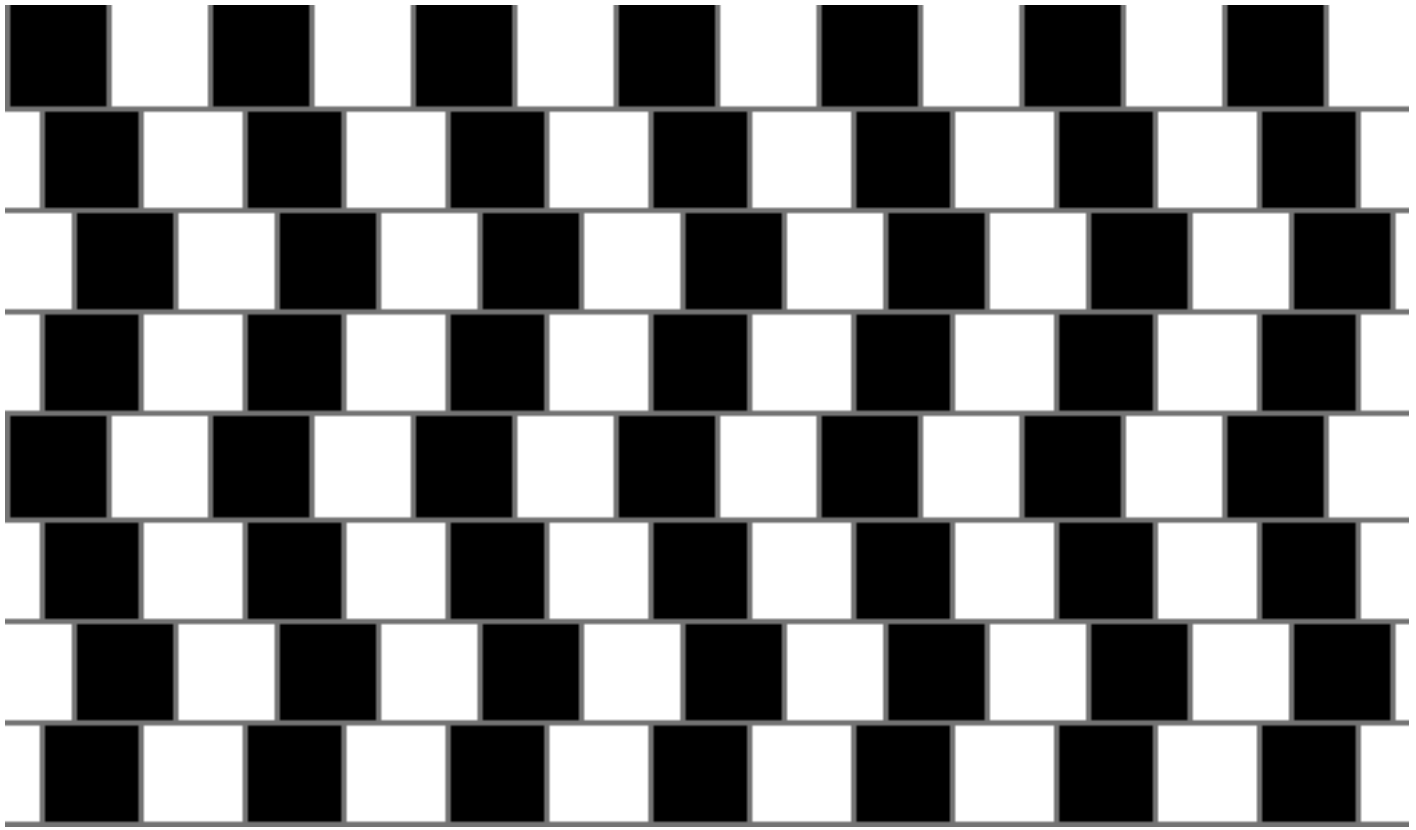




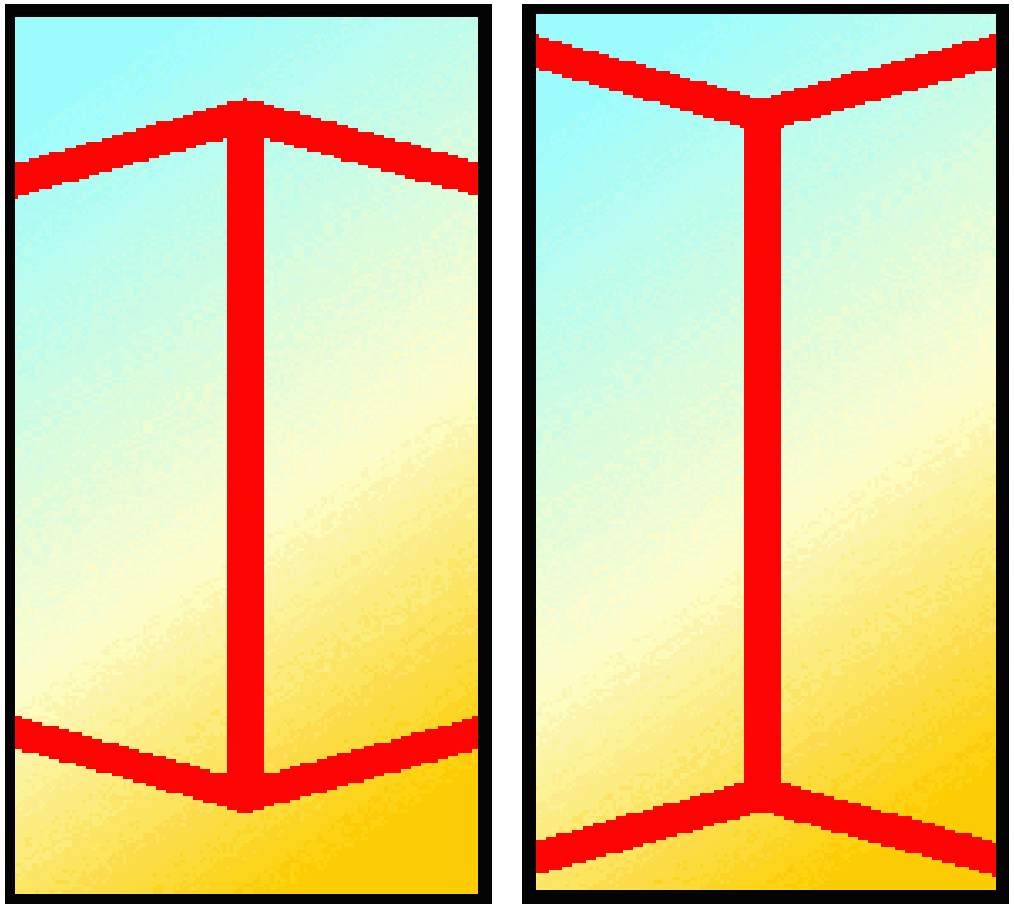
What color are the dots?



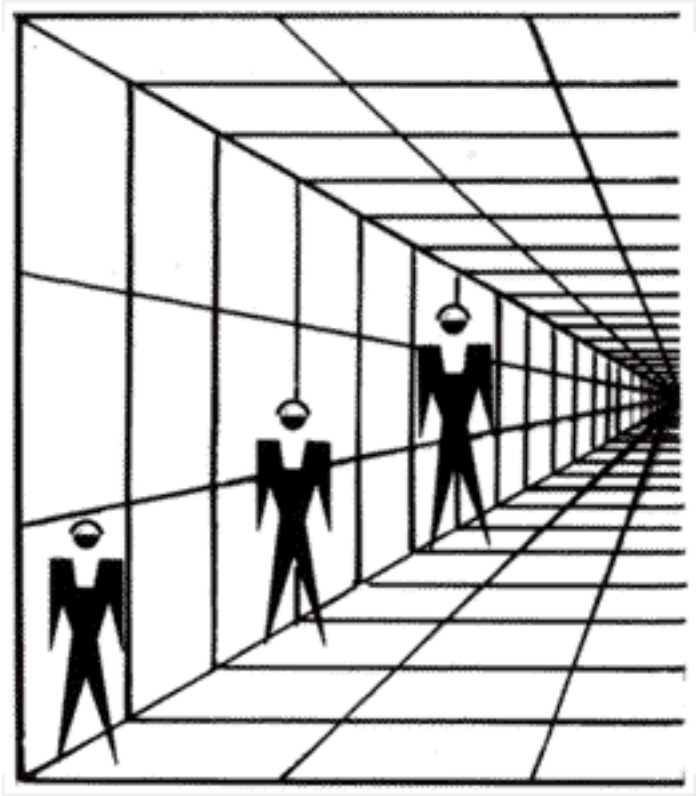
Are the horizontal lines straight or curved?



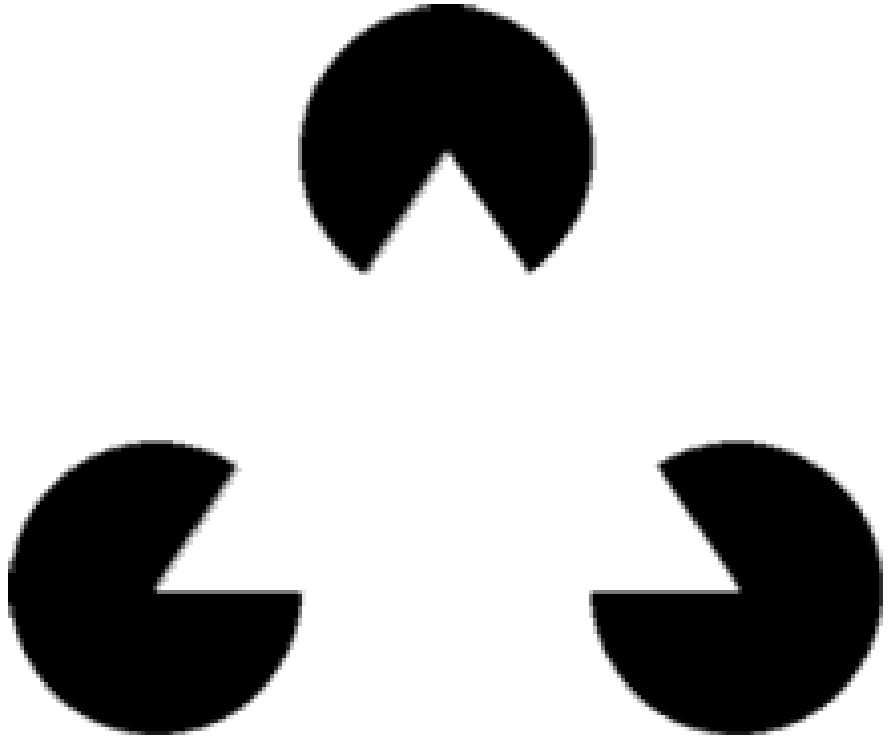
Are the vertical lines the same length or different?

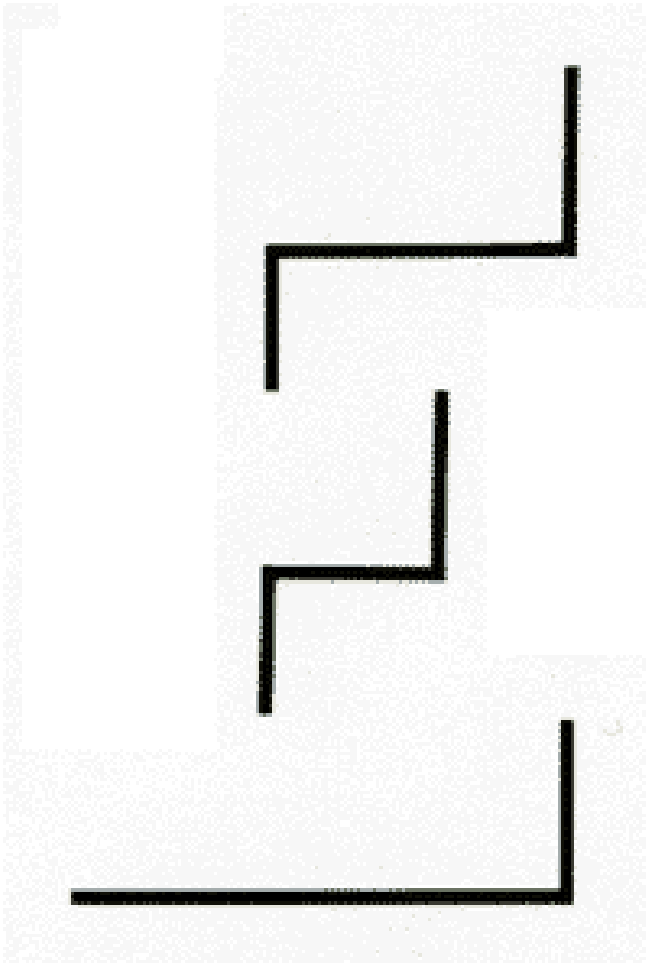


Are the figures the same size or different sizes?



What do you see?

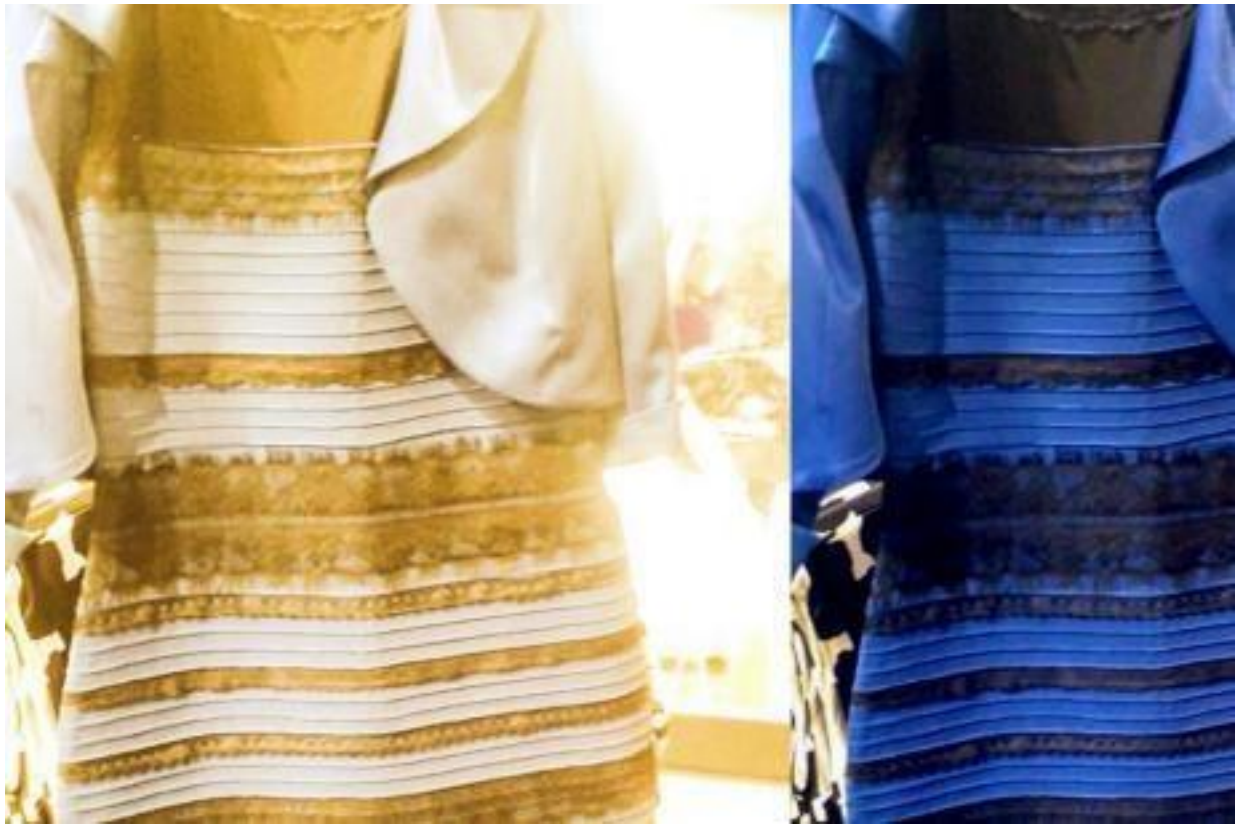




The Dress

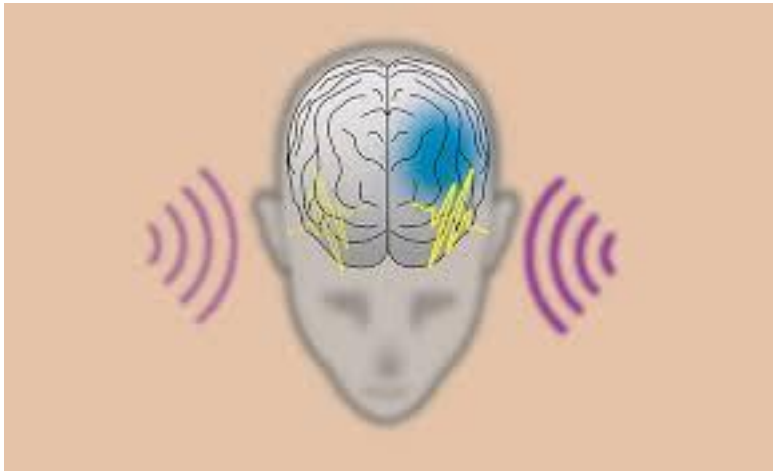
Blue and Black OR White & Gold?

Which did you see?

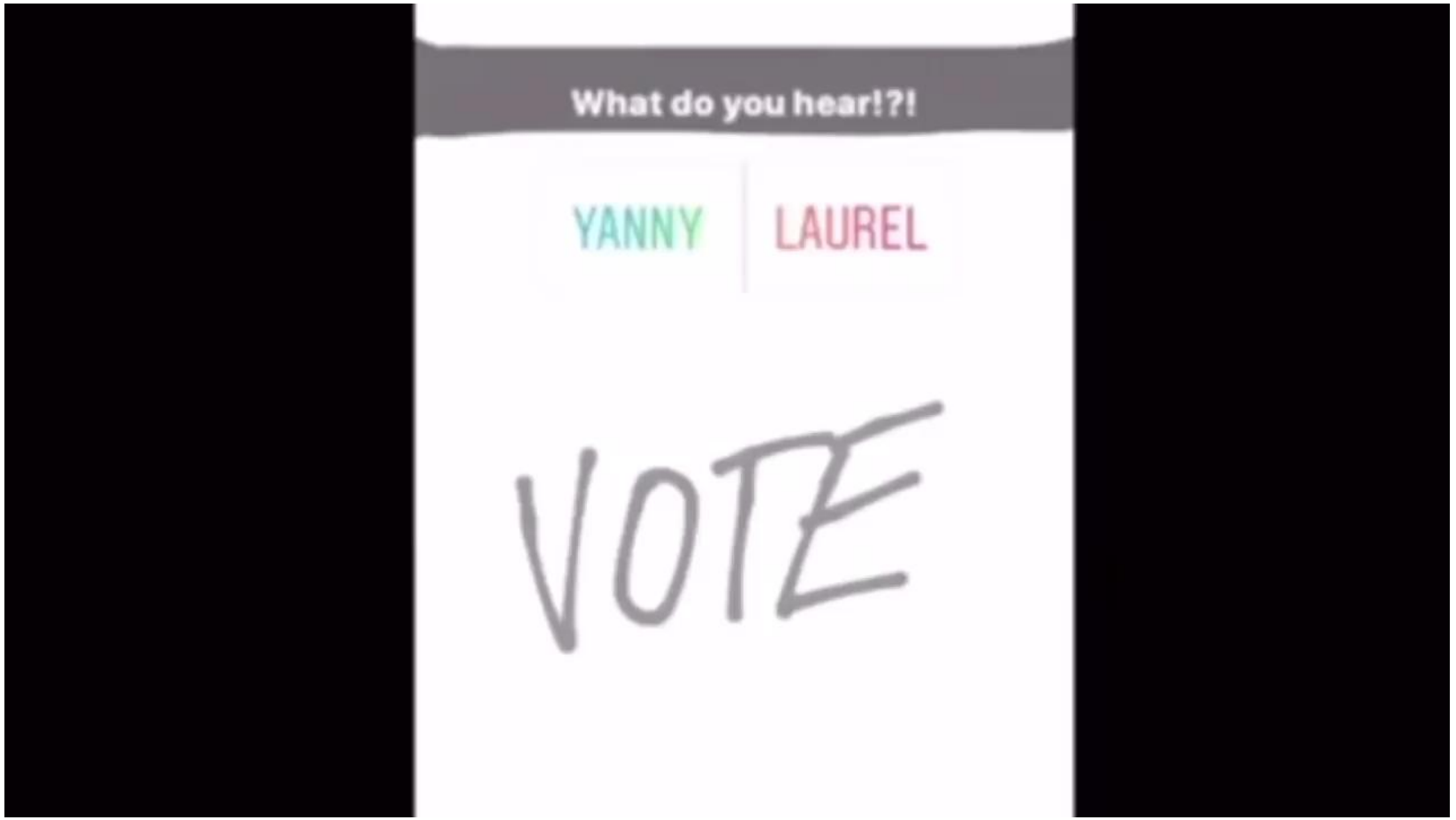


Auditory Illusions

Be skeptical about what you think you're hearing!



How many of you hear YANNY and how many of you hear LAUREL?



Finding Meaning in Patterns

Our brains are massive parallel processers and rely on pattern recognition

- *Ability to make connections between different ideas, visual patterns, words, event and objects.*
- *Allow us to make abstract connections and think creatively.*
- *Are wired to assign meaning and emotions to things.*

Pattern recognition

- *Is filtered through a module of our brain that undertakes reality testing (less during dreaming)*
- *Psychosis is a lack of reality testing*

Pattern Recognition
seeing what's not there

Pattern recognition is both a cognitive strength, and a weakness *(seeing patterns that do not exist)*

We constantly recognize illusory patterns

- *Pareidolia**
- *data mining**
- *hyperactive agency detection*
- *superstitious thinking (imbue emotions into patters)*

**we'll discuss some specific examples*

Critical thinking skills allow us to transcend our evolved tendency to detect patterns and agency, sorting out what is real from what appears to be real

Pareidolia

Brain seeks patterns to fit the stimuli

- *Visual pareidolia is the tendency to see a pattern in randomness*
- *Once you see a pattern in random stimuli, difficult to stop seeing it*
- *We imbue emotions into patterns*

Human face-most familiar pattern we impose (visual cortex dedicated to seeing faces)

- *Evolutionarily important to be able to recognize others*
- *Average human can recognize over 10,000 different faces*

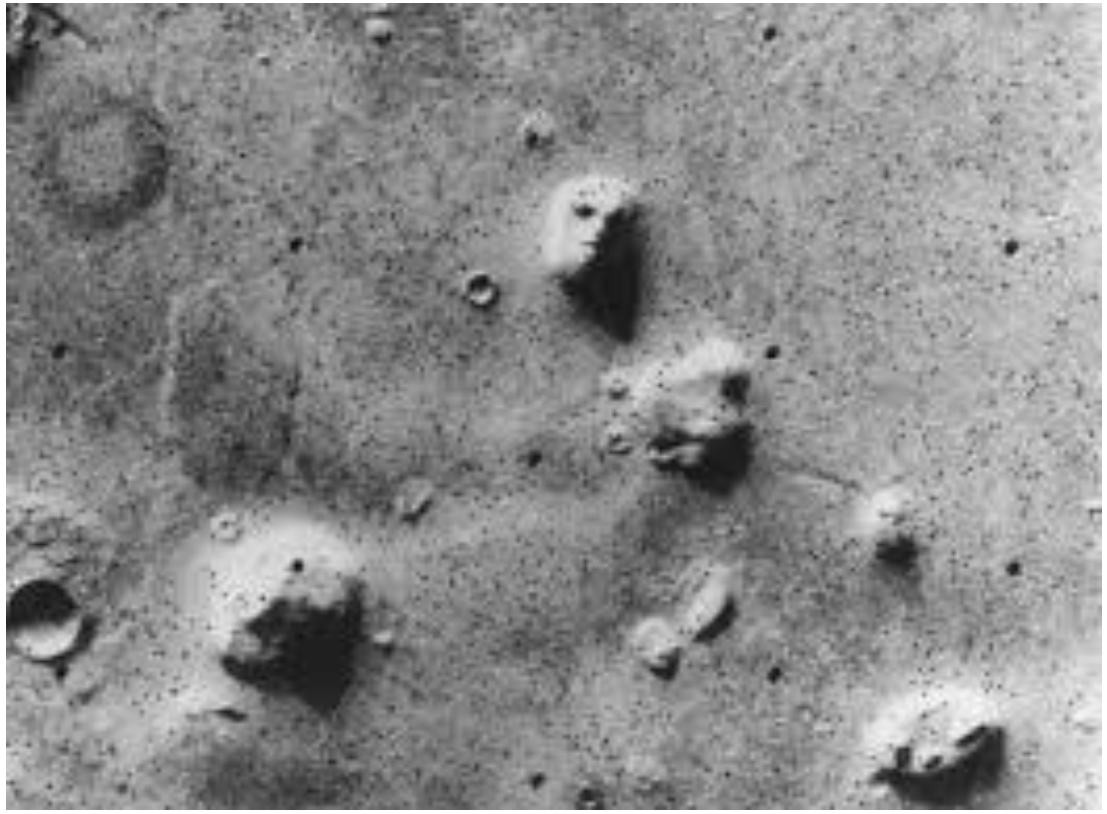
What do you see?

What do you see?

“Michael Jackson’s Ghost Spotted on car hood”

“New Mexico Man Finds Jesus’s Face in a Tortilla”

“Viking 1 Spacecraft captures human face on Mars”

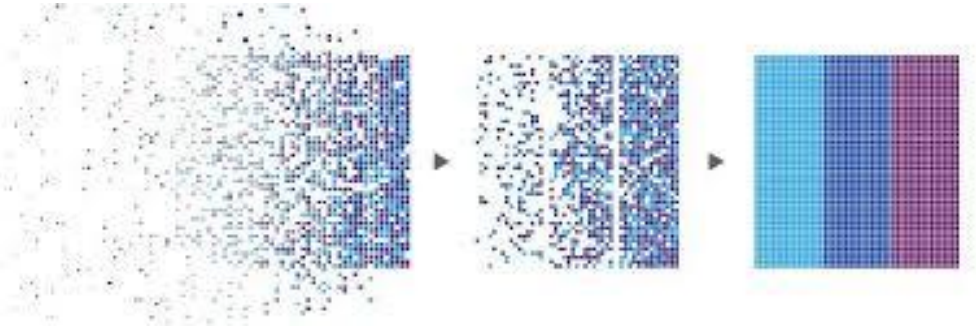


Our Constructed Reality

Summary:

- Our perceived reality is an illusion constructed by our brains
- Our perceptions are filtered and constructed
- Our brains assign patterns to what we perceive and then assign meaning to them

Practicing executive control over our more primitive parts of our brains is a learned skill. This is why we need logic and critical thinking skills to help us to carefully and reliably sift through the myriad potential patterns that we see.



Data Mining

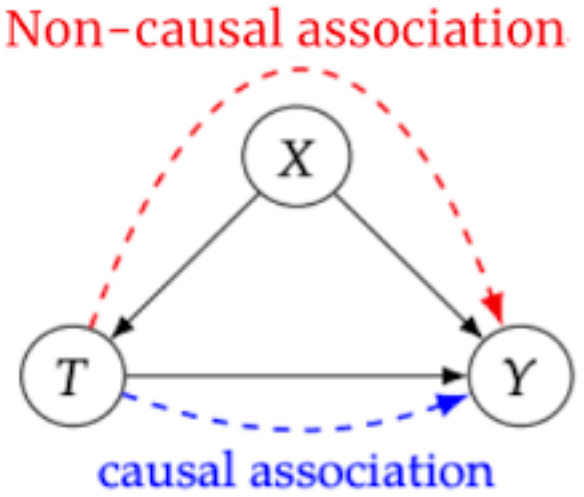
Analyzing large amounts of data looking for random patterns that occur by chance

- Scientists use it to generate hypothesis *(but **not** to confirm an idea)*
- Since our brains are highly suggestable to finding patterns, they must be tested against independent data sets
- Astrology is an example of using data mining and false pattern recognition
- Anecdotes are a way of subconscious data mining and are subject to confirmation biases, memory effects, and other cognitive biases.

Data Mining

Drawing Causal Relationships

- A flawed conclusion in data mining, specifically in scientific applications, can occur when researchers misinterpret patterns or correlations in the data,
- This leads to incorrect conclusions about the underlying phenomenon.
- A common example is drawing causal relationships from observational data without proper experimentation.



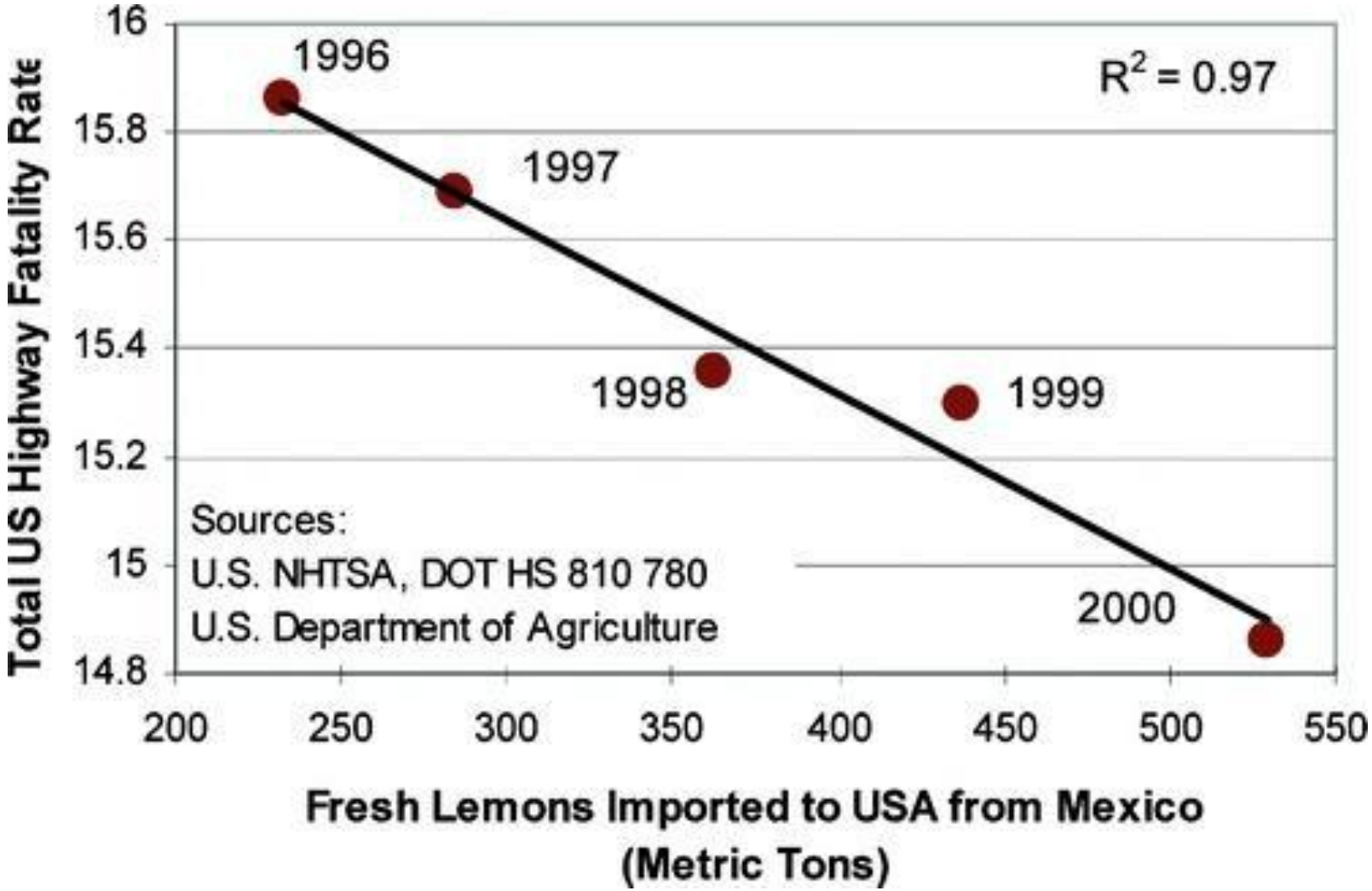
A Common Error in Thinking
Causation vs. Correlation

The two are often confused but the distinction is important in critical thinking

A correlation is a relationship between two quantities that when one changes, the other does also.

Example: If we compare the total U.S. highway fatality rate to the metric tons of fresh lemons imported from Mexico, we observe a very strong correlation ($R^2 = 0.97$).

Correlation

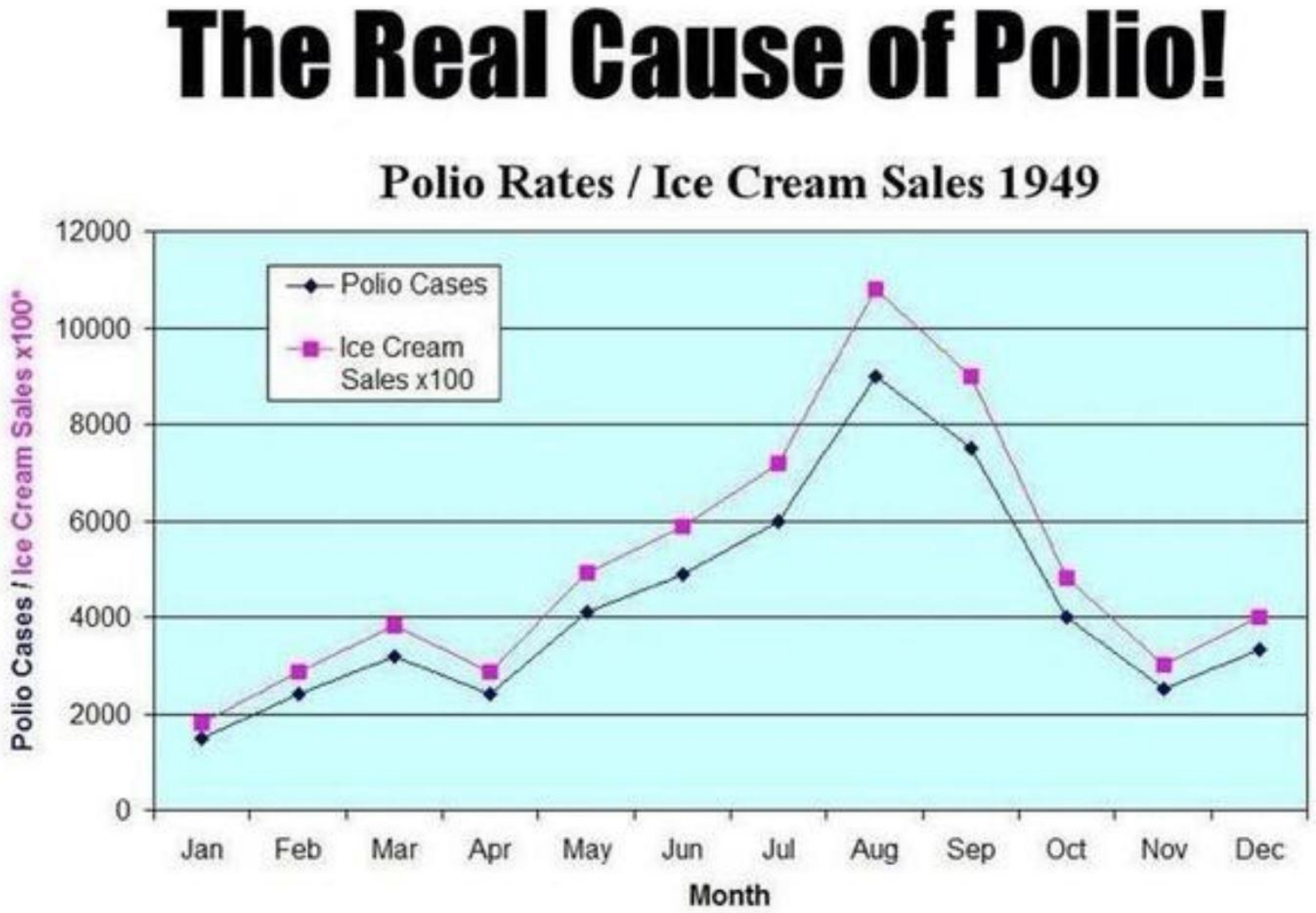


Causation vs. Correlation

Causation is the act or process of causing or producing an effect. A causal relationship between two things exists; one occurs <u>because</u> of the other.

- Logically, for one event to cause another, it must occur first in time, but just because one event occurs first does not mean it caused the second event.

The Hidden Risk of AI and Big Data



Causation vs. Correlation Examples

Here are some actual correlations. Discuss with your neighbor possible alternative explanations (causes) for the correlation instead of the stated causation.

Example 1: Sleeping with one's shoes on is strongly correlated with waking up with a headache. Therefore, sleeping with one's shoes on causes headache.

Example 2: Young children who sleep with the light on are much more likely to develop myopia (nearsightedness) in later life. Therefore, sleeping with the light on causes myopia.

Example 3: Since the 1950s, both the atmospheric CO_2 level and obesity levels have increased sharply. Hence, atmospheric CO_2 causes obesity.

Causation vs. Correlation Explanations

Example 1: Sleeping with shoes and waking up with a headache. A more plausible explanation is that both are caused by a third factor, in this case going to bed drunk, which thereby gives rise to a correlation. So the conclusion is false.

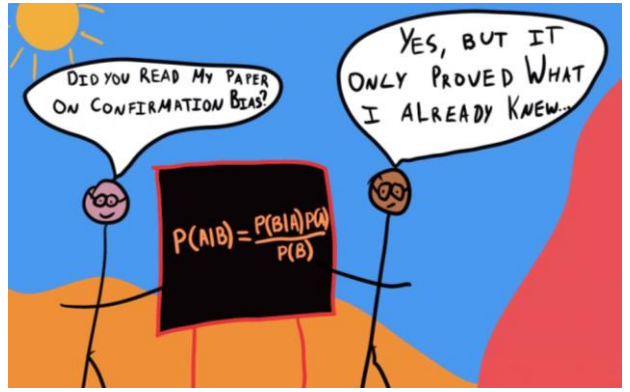
Example 2: Children who sleep with the light on and myopia. This resulted from a scientific study, but later studies found that infants sleeping with the light on did not cause the development of myopia rather it found a strong link between parental myopia and the development of child myopia, noting that myopic parents were more likely to leave a light on in their children's bedroom. In this case, the cause of both conditions is parental myopia.

Example 3: CO_2 levels and obesity. Richer populations tend to eat more food and consume more energy

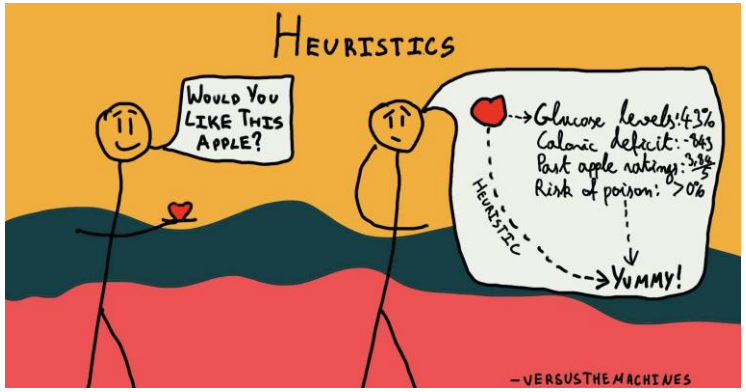
Common Cognitive Biases

In addition to correlation vs. causation, there are many other cognitive biases which distort our perception of information and can lead to irrational decisions and inaccurate conclusions.

Here are just a few of many:



Confirmation Bias-our tendency to notice, focus on, and give greater credence to evidence that fits with our existing beliefs.



Heuristics (mental shortcuts)-our minds use simple rules to arrive at a conclusion in a "fast-and-frugal"

Bandwagon effect-our habit of adopting certain behaviors or beliefs because many other people do the same (peer pressure)

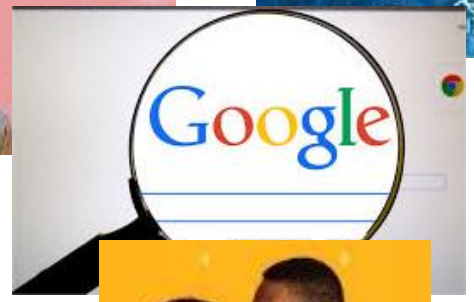
Hindsight Bias-our tendency to look back at an unpredictable event and think it was easily predictable.

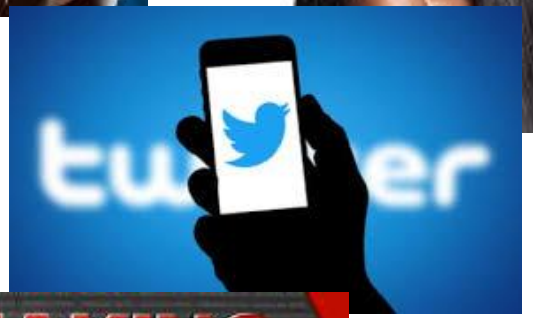
Validity of Claims

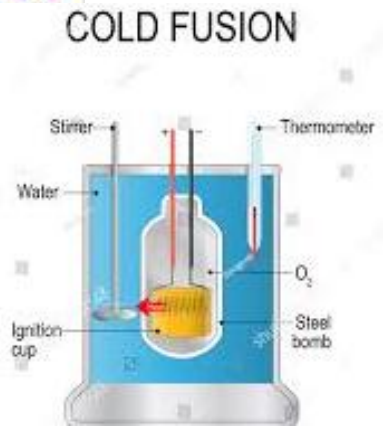
Using critical thinking skills in your everyday lives

Given the enormous amount of information we are bombarded with everyday (and our inherent biases & misperceptions), how do we evaluate the validity or "truth" of the claims we hear ("received wisdom")?

- **Product advertising**
- **Media/Internet**
- **Friends/Family/Culture**
- **Scientific claims/research results**







Reminder: thinking critically involves being curious, asking questions, being aware of our own misperceptions, and being a skeptic

It is a learned skill

How to Evaluate Claims

Some Skeptical Questions to Ask

1. Are the sources of information reliable?
2. Is there well-controlled and reproducible experimental evidence to support the claim?
3. Is there independent confirmation of the facts/claims?
4. Is the evidence to support the claim mostly anecdotal (heresay)?
5. Is there an over reliance on surveys or filtering of the data?
6. Is the claim irrefutable (cannot be falsified or testable)?
7. Does the claim attempt to “explain the unexplainable”, appealing to mysteries, myths, or long-dead theories?
8. Does it go against current/established scientific knowledge/understanding?

Session Goals

Did we meet these?

- Understand some fundamental critical thinking skills concepts
- Become aware of some of the limitations of our minds
- Identify ways to develop and use critical thinking skills in both your academic and in your everyday life
- Support one another in the Chemistry Department to encourage and sustain the use of critical thinking skills

This was a very short session for a very big topic. If you are interested in exploring critical thinking skills further, I may be offering some short courses in the future.

Please fill out the session questionnaire to help me plan for these short courses.

Thank you for your attendance and participation!