

# Intro to Perception

(functionalism, naive realism, Weber's law)



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Princeton University

# Outline for today:

- algorithms / functionalism
  - argument from illusion
  - methods of study
  - Weber-Fechner Law
- 
- basic neuroscience overview

*from last time:*

## **Philosophical position of this course:**

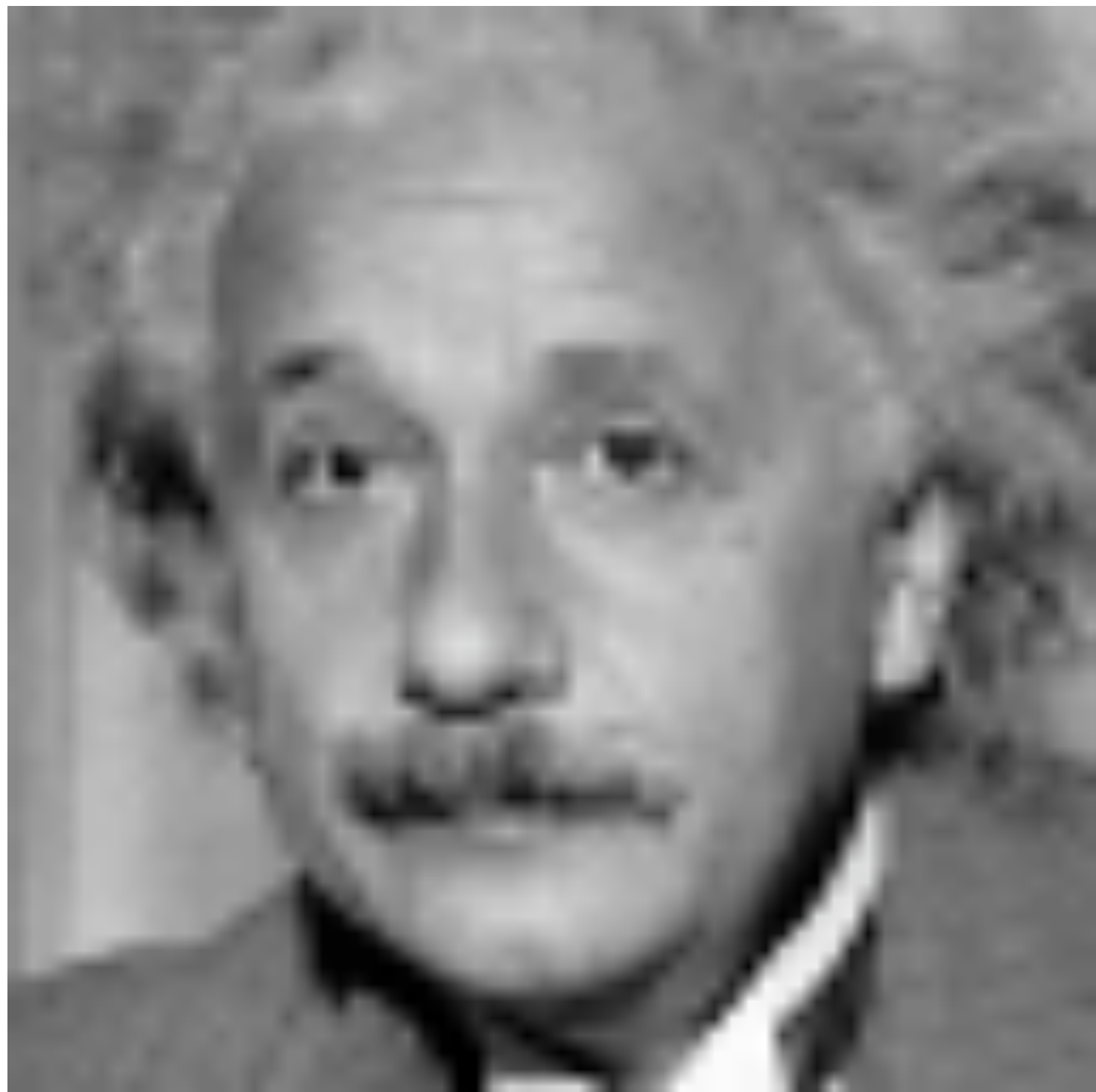
- Empiricism - knowledge from senses (obviously!)
- Materialism - only one kind of stuff (matter/energy)
- Representative Realism - indirect knowledge of world, via the senses
  
- Functionalism - understanding the “function” of the sensory systems is all that we need to know to “understand” them.

In this course, “understanding” perception means:

1. We can write down an algorithm for how a perceptual task is performed  
(i.e., we could use it to design an AI agent to perform the task)
2. Knowing where and how the algorithm is implemented in the nervous system.







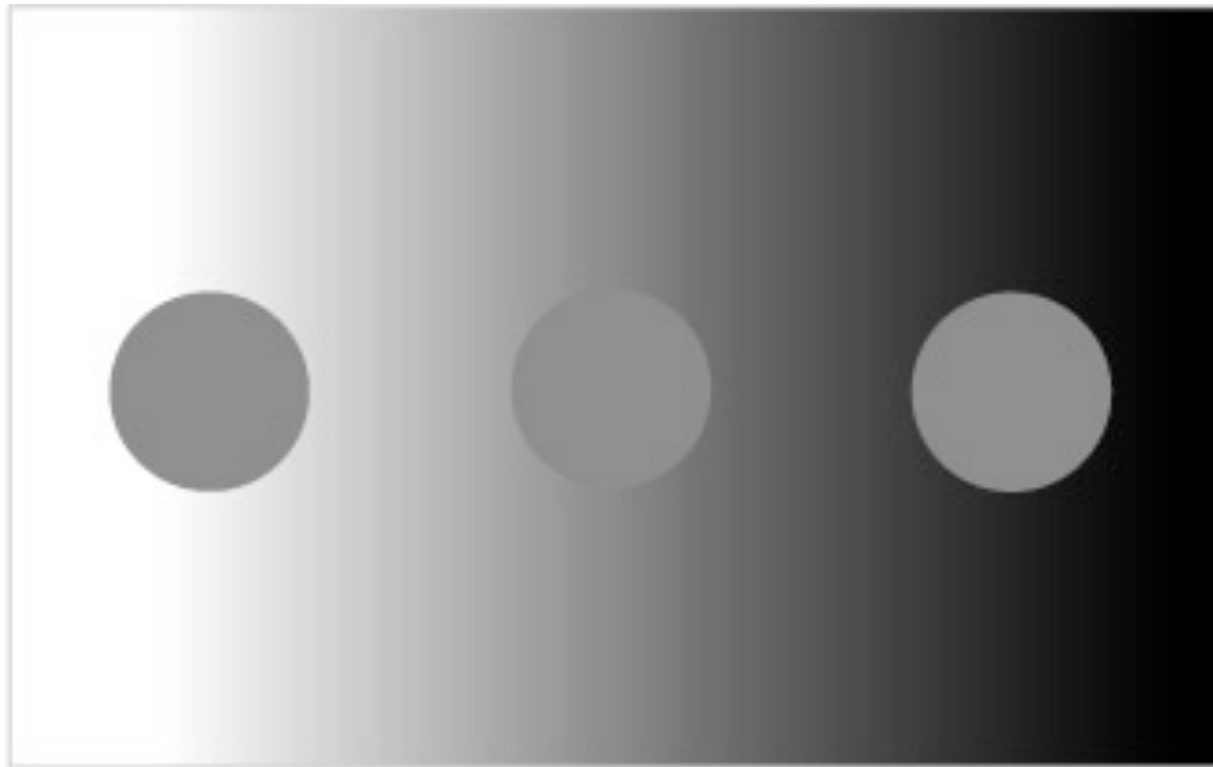


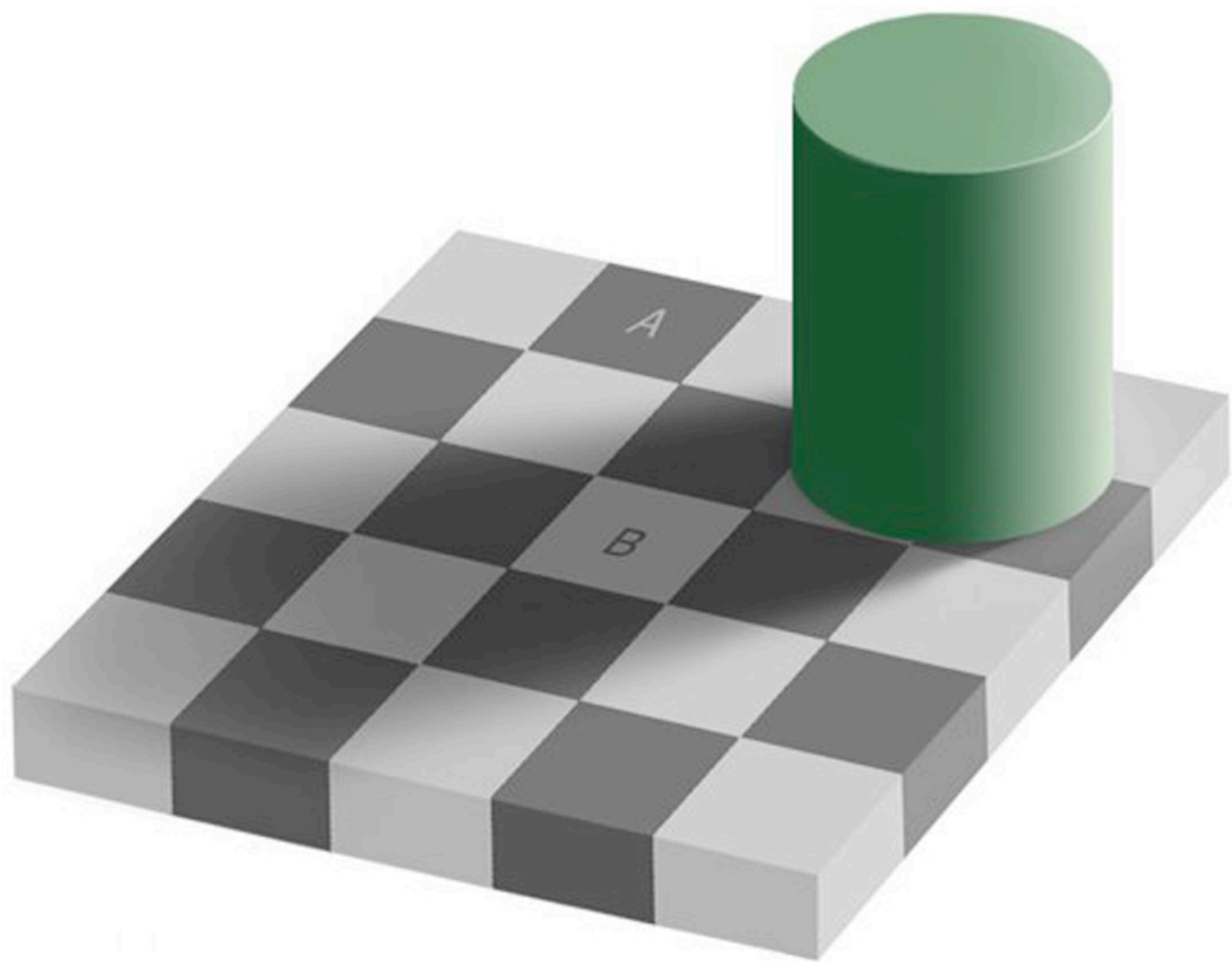


Next:

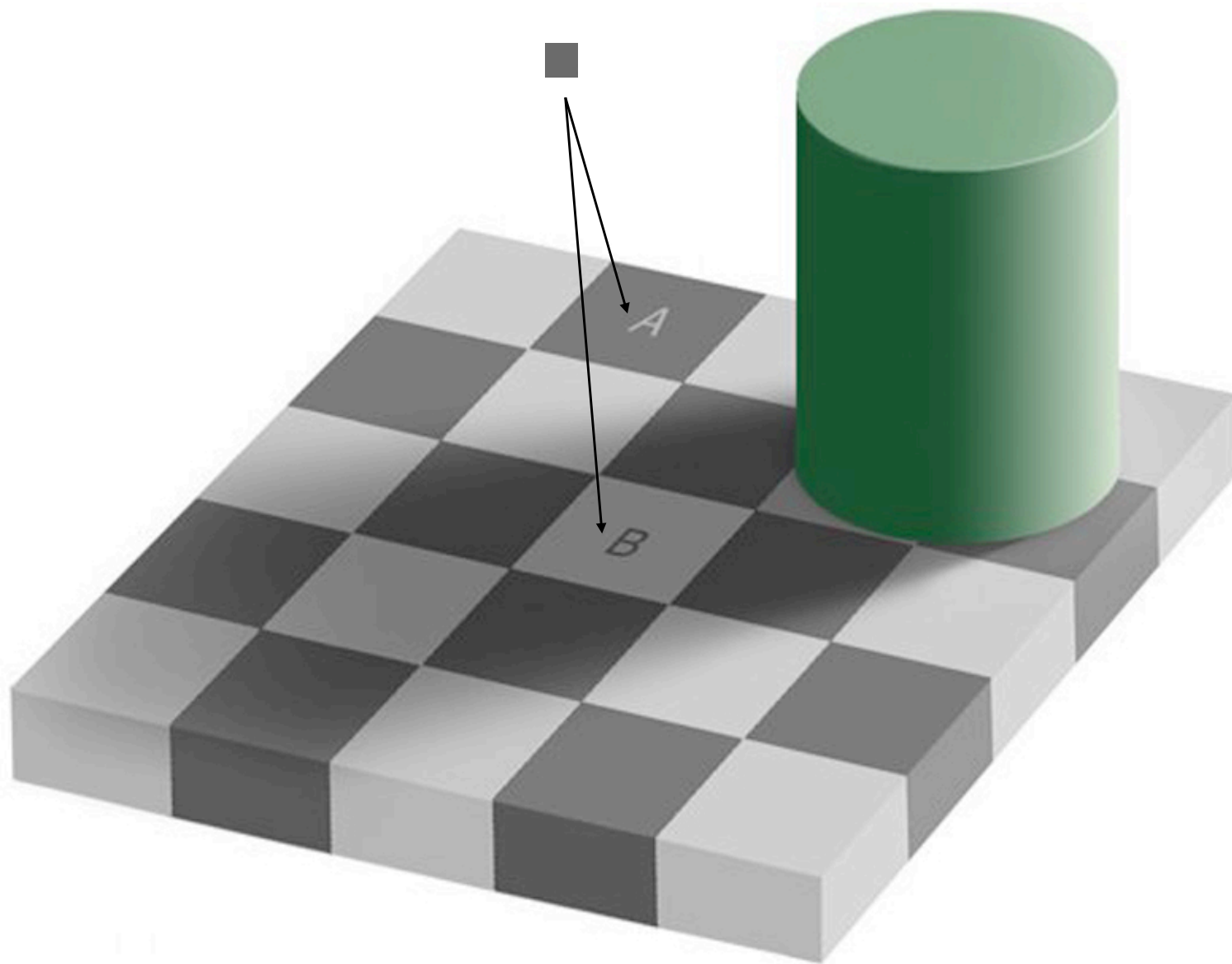
“why naive realism is  
wrong”

# Lightness illusion

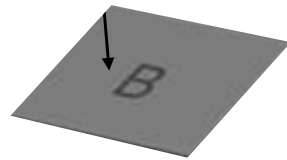
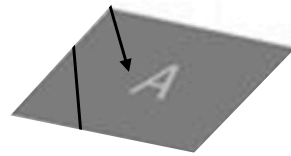




Comparison patch



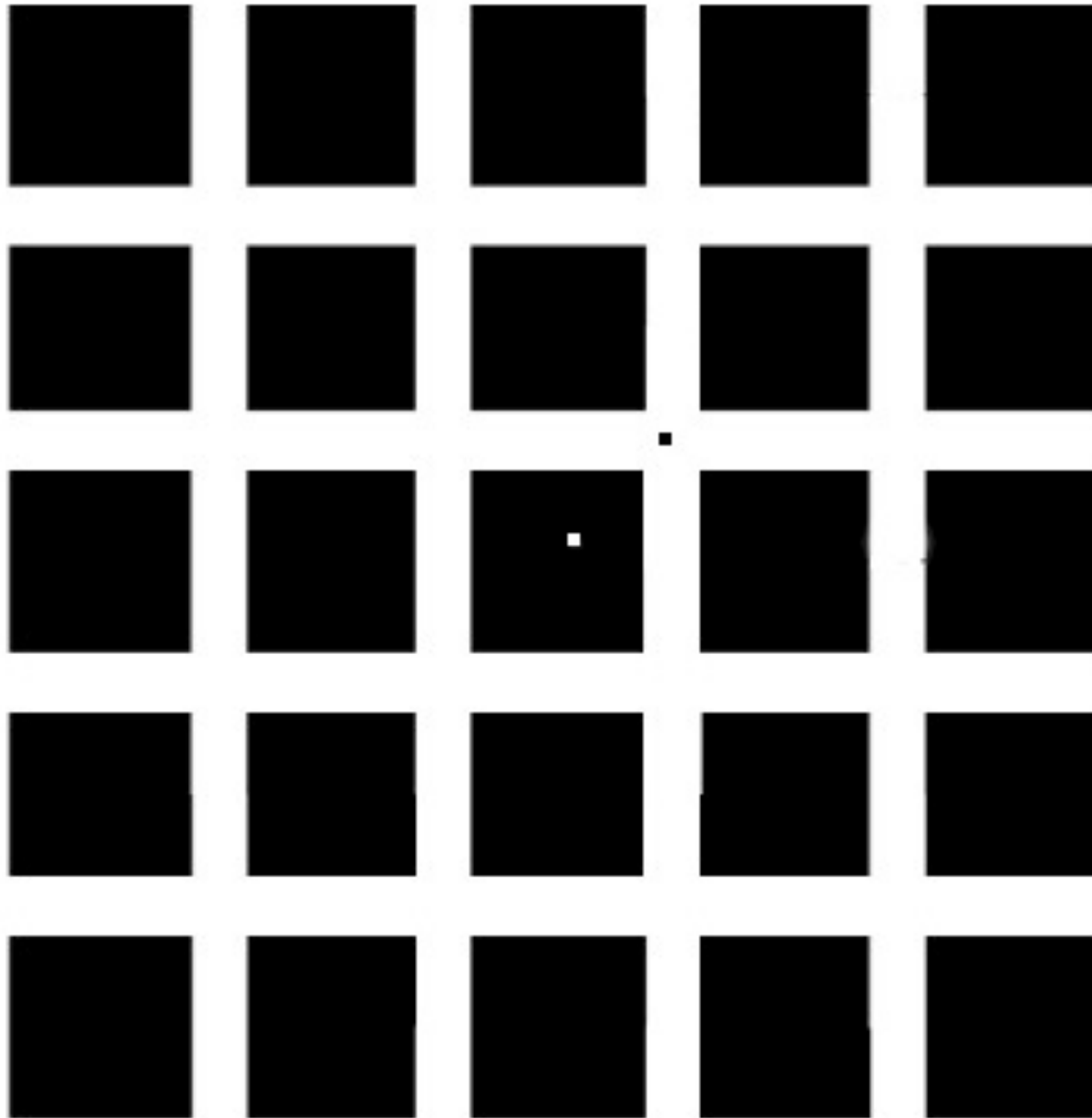
# Comparison patch



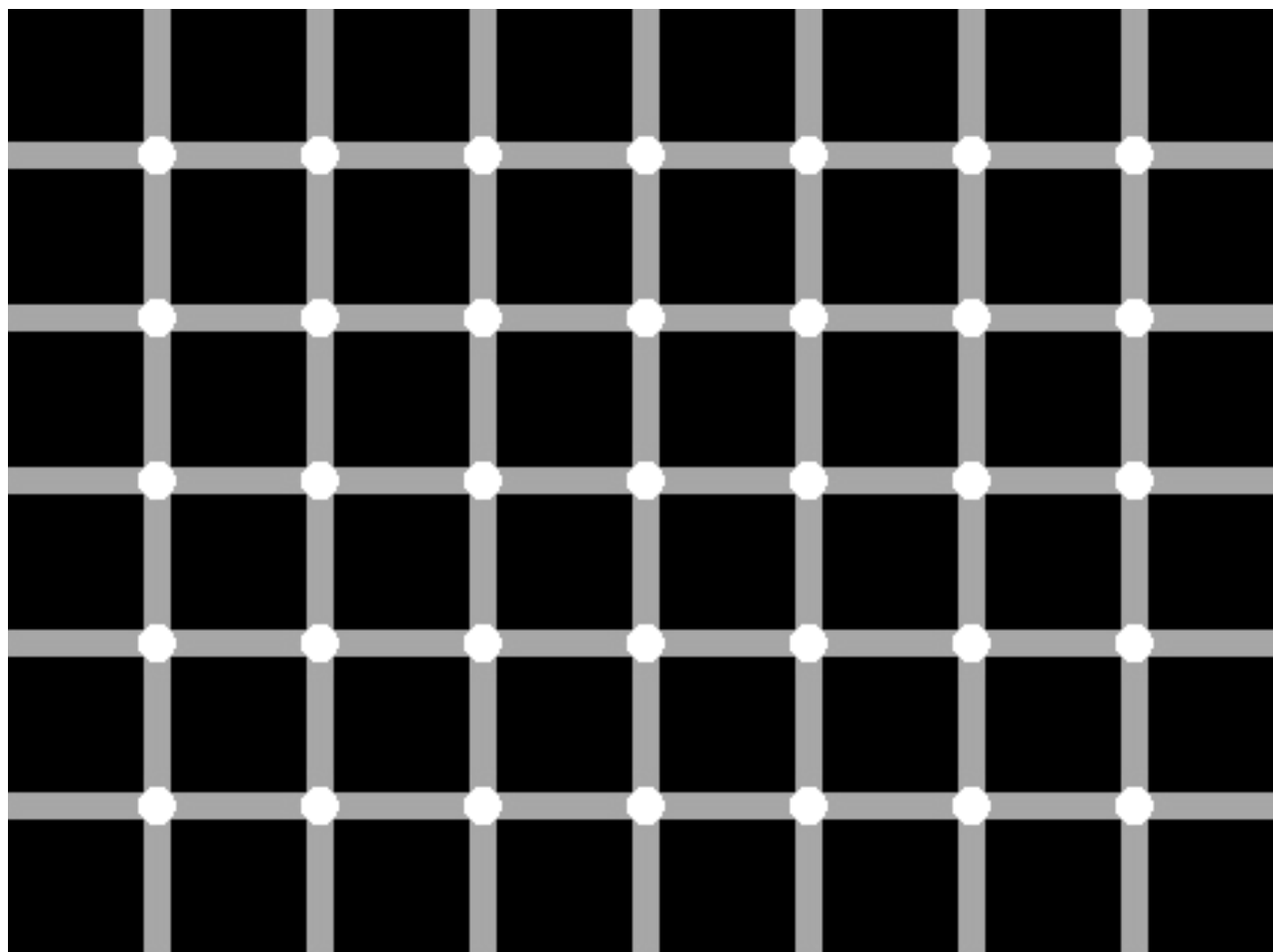
# “Argument from Illusion”

- The fact that we are sometimes mistaken in our sensory perceptions indicates that we do not directly perceive the world
- (thus Naive realism is false!)

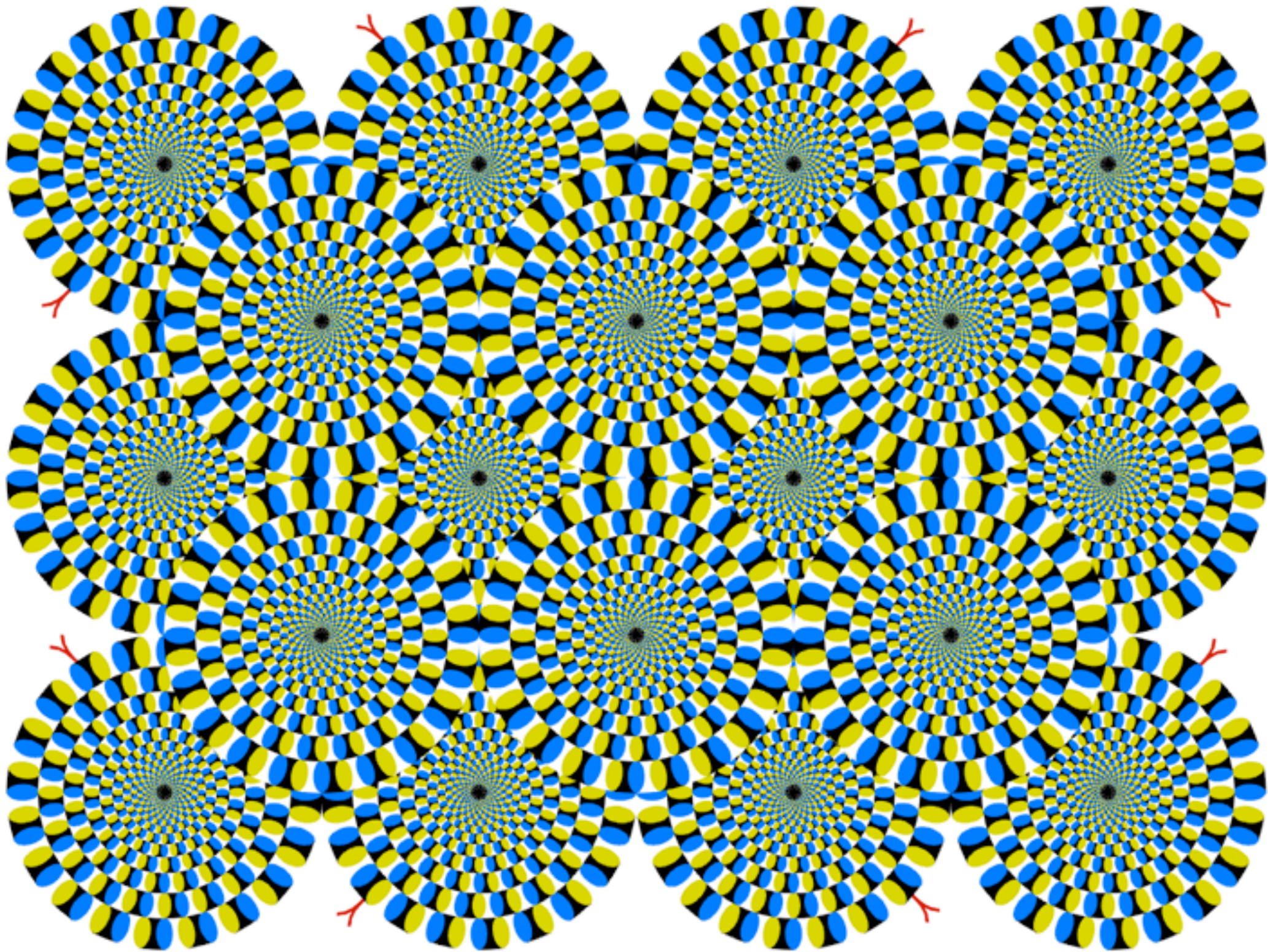
# Hermann-Hering Illusion



# Hermann variant







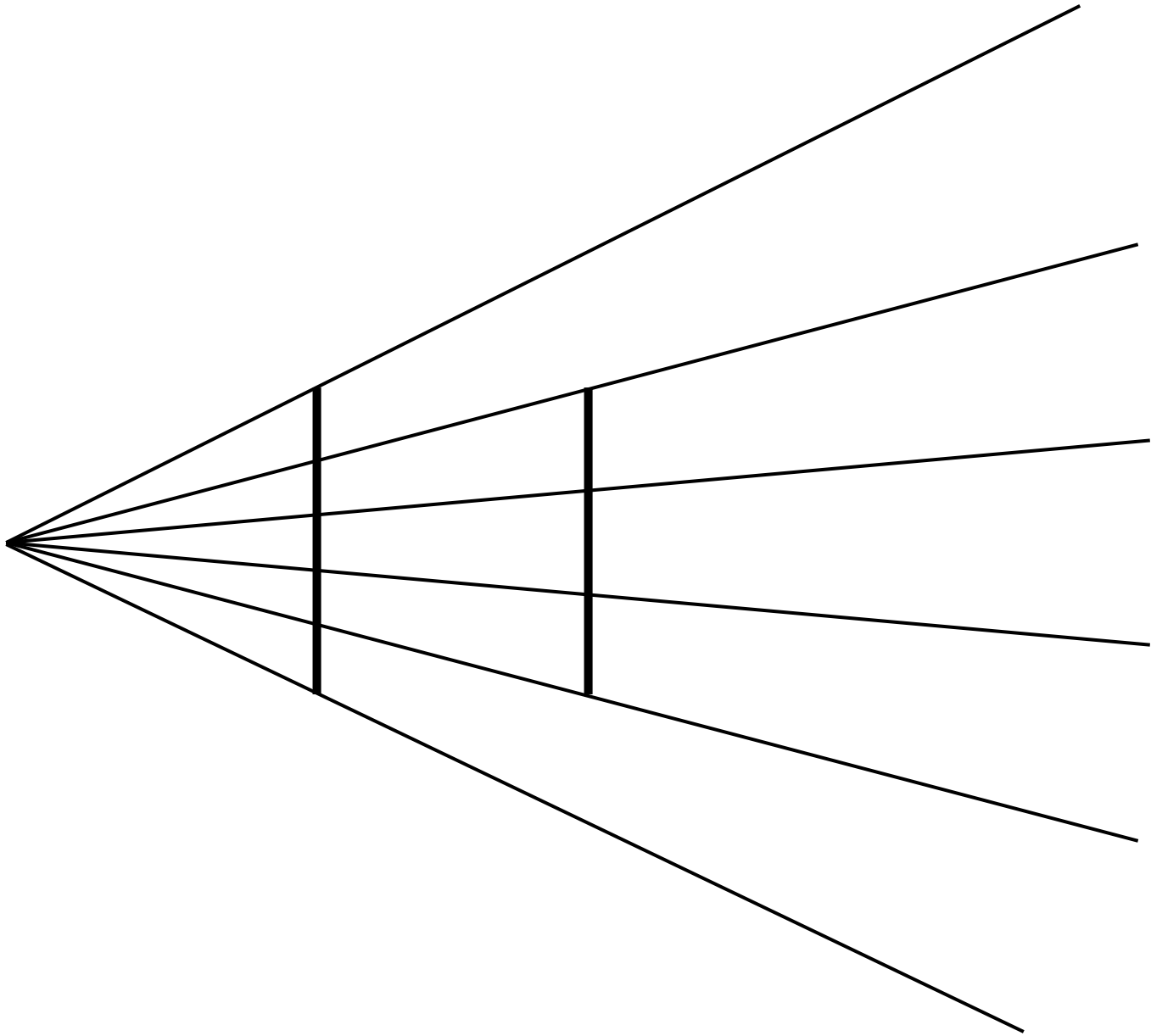


# Eye movements

- we aren't aware of them, but they are essential for vision
- if you stabilize the eye, you become blind within several seconds

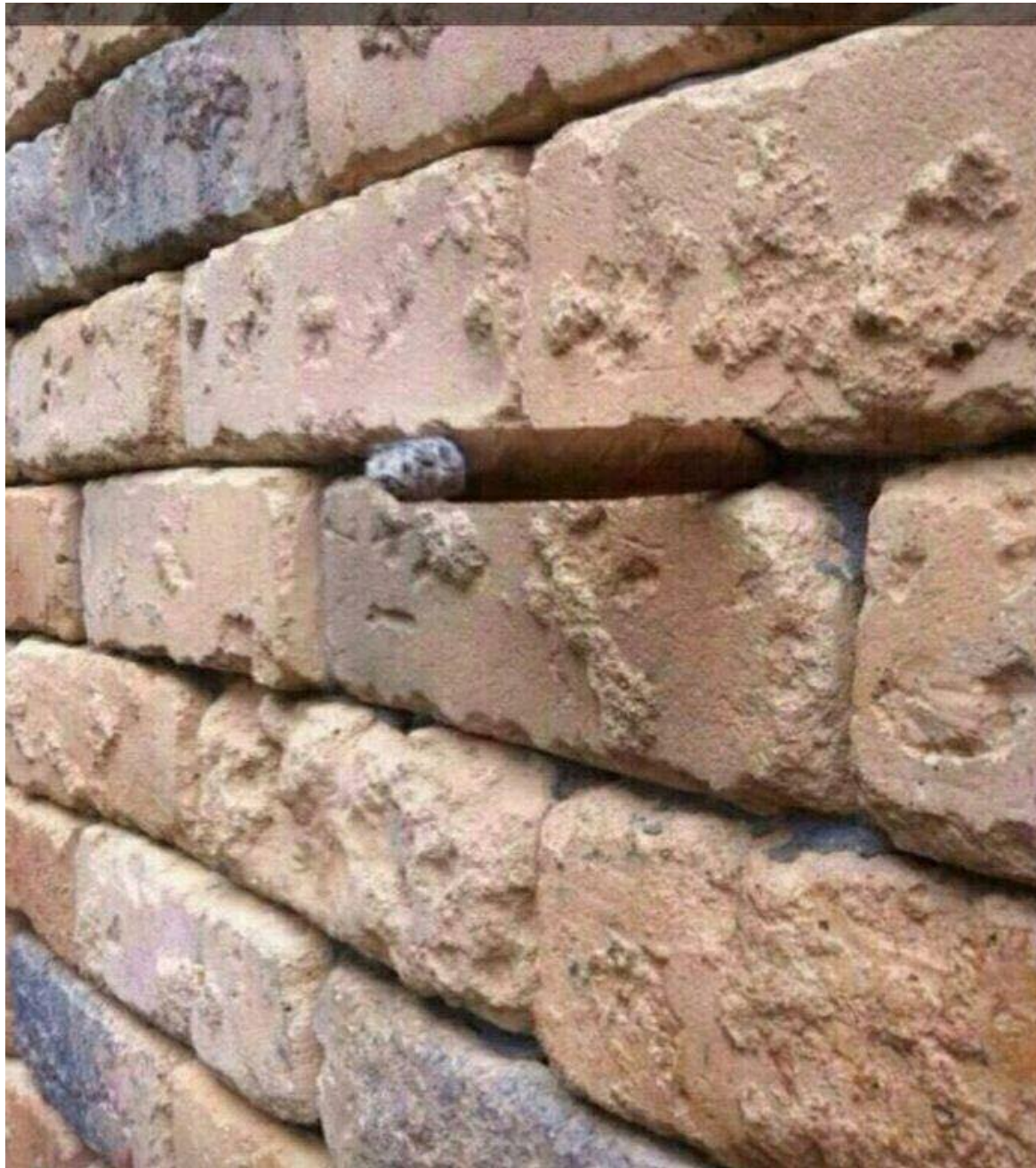
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Context is important!





Top-down information (eg, memory) is also critical for perception!

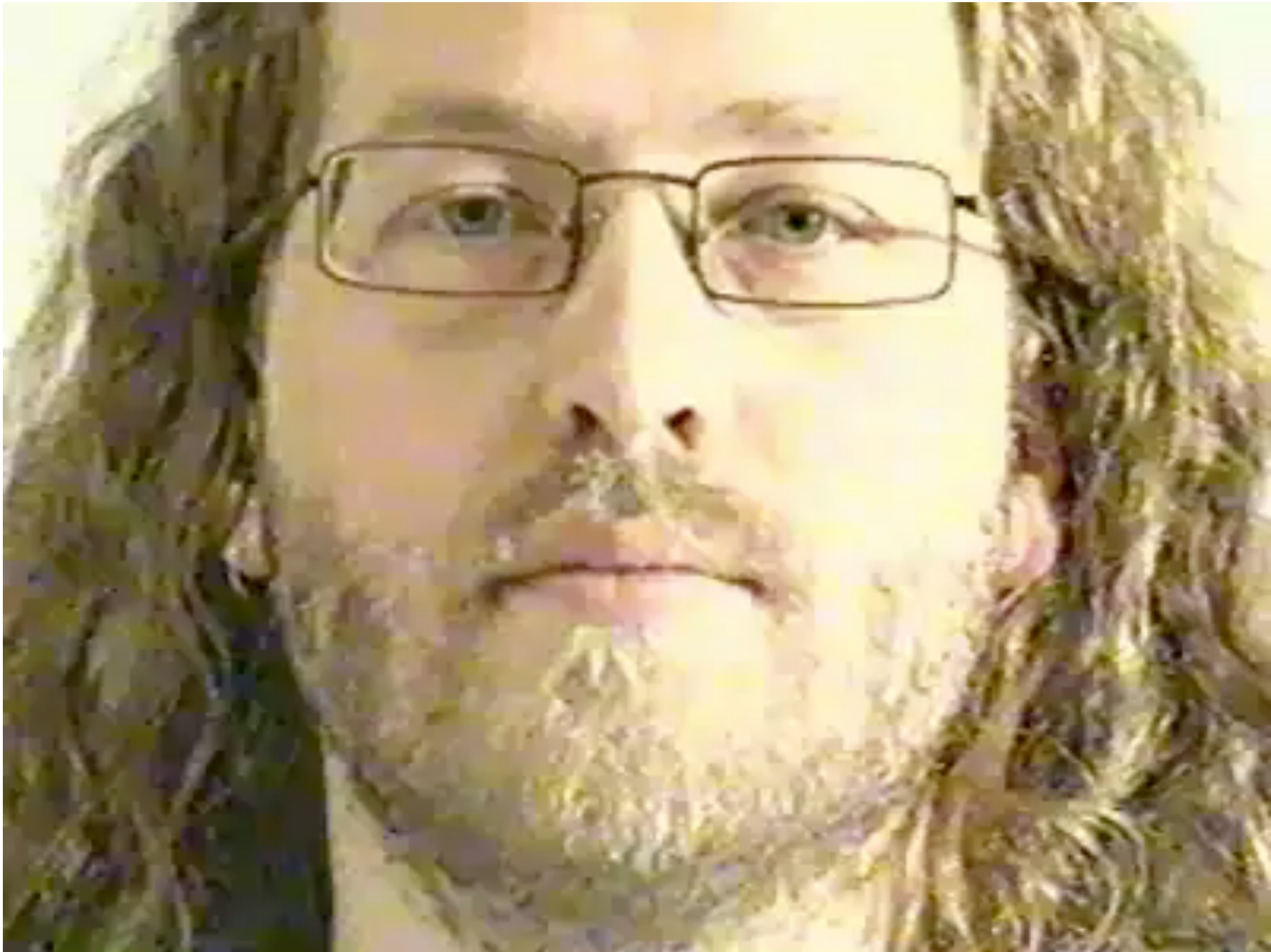


YOUR **BRAIN** HAS POWER TO CHANGE  
THE DIRECTION OF THIS TRAIN.



JUST **THINK** AND THIS TRAIN RUNS IN OPPOSITE DIRECTION.

# McGurk Effect





# Illusions from conflicting information

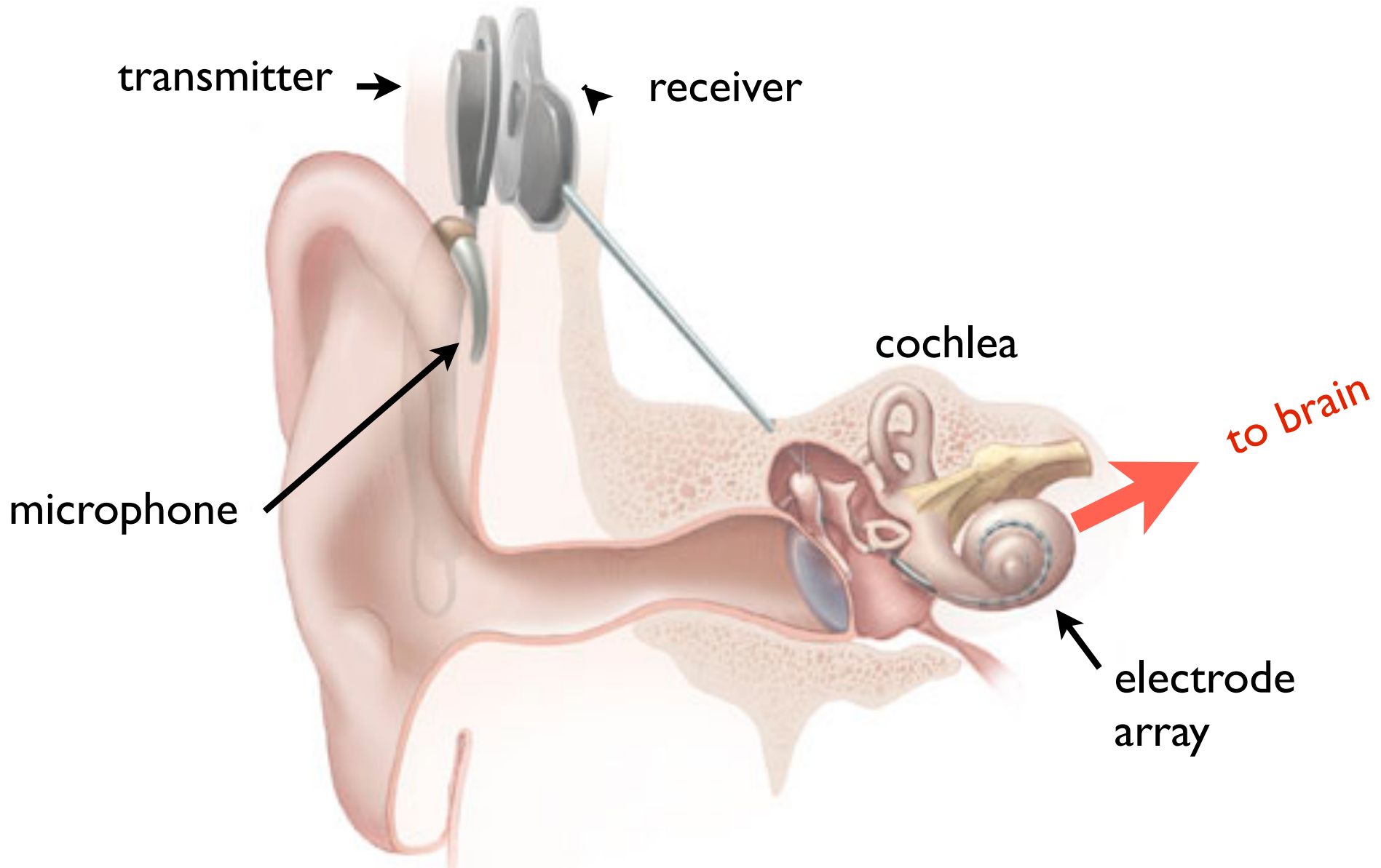
- Brain sometimes comes up with entirely new percepts in response to conflicting sensory cues

# Algorithms for perception

- if we truly understand perceptual mechanisms, we can replace neural processing with computer processing

# Cochlear implants

(using a “different computer” to encode auditory signals)



# conclusions:

- perceptual representations are not always accurate (naive realism is wrong)
- we can understand why the world looks the way they does by studying the algorithms/ computations used to generate percepts
- if we understand the computation, we can replace neural circuits with computer chips!

# Methods of Study / Scientific Approaches

- Ecological ('phenomenological', 'naturalistic')
- Psychophysical
- Neurophysiological
- Modeling / Reverse Engineering

# The Ecological Approach

- “observe and draw some conclusions”
- use of rich, naturalistic stimuli
- emphasized the environment in which the system evolved, developed, and lives.
- main strength: the appreciation of the evolutionary constraints and full richness of sensory behaviors
- main weakness: lack of scientific rigor in stimulus control and self-report data (which can be unreliable).

# Psychophysics

- use of carefully controlled laboratory stimuli
- carefully measured quantitative data
- main strengths: scientific rigor, non-invasive
- main weakness: use of impoverished stimuli that are rarely if ever encountered in nature

# Neurophysiology

- use of carefully controlled laboratory stimuli (like psychophysics)
- measures the response of neurons or groups of neurons at various locations in the perceptual system
- sometimes not meaningfully connected to behavior / perception

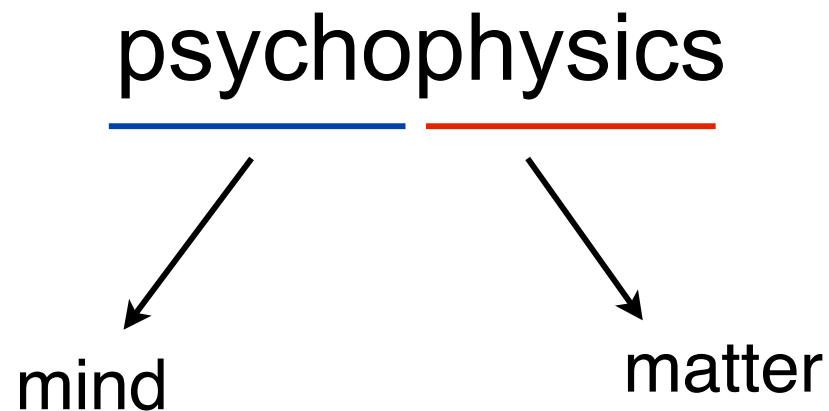
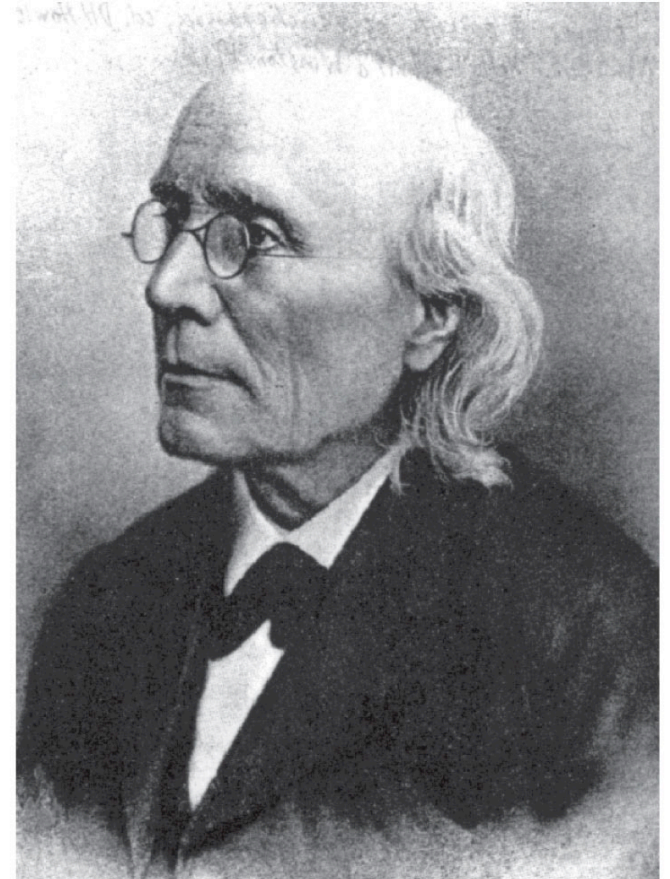


# Mathematical Modeling / Reverse Engineering

- develop quantitative theories or computer simulations to predict behavior or neural function, or
- construct artificial systems (e.g. robots) that perform like human perceptual systems

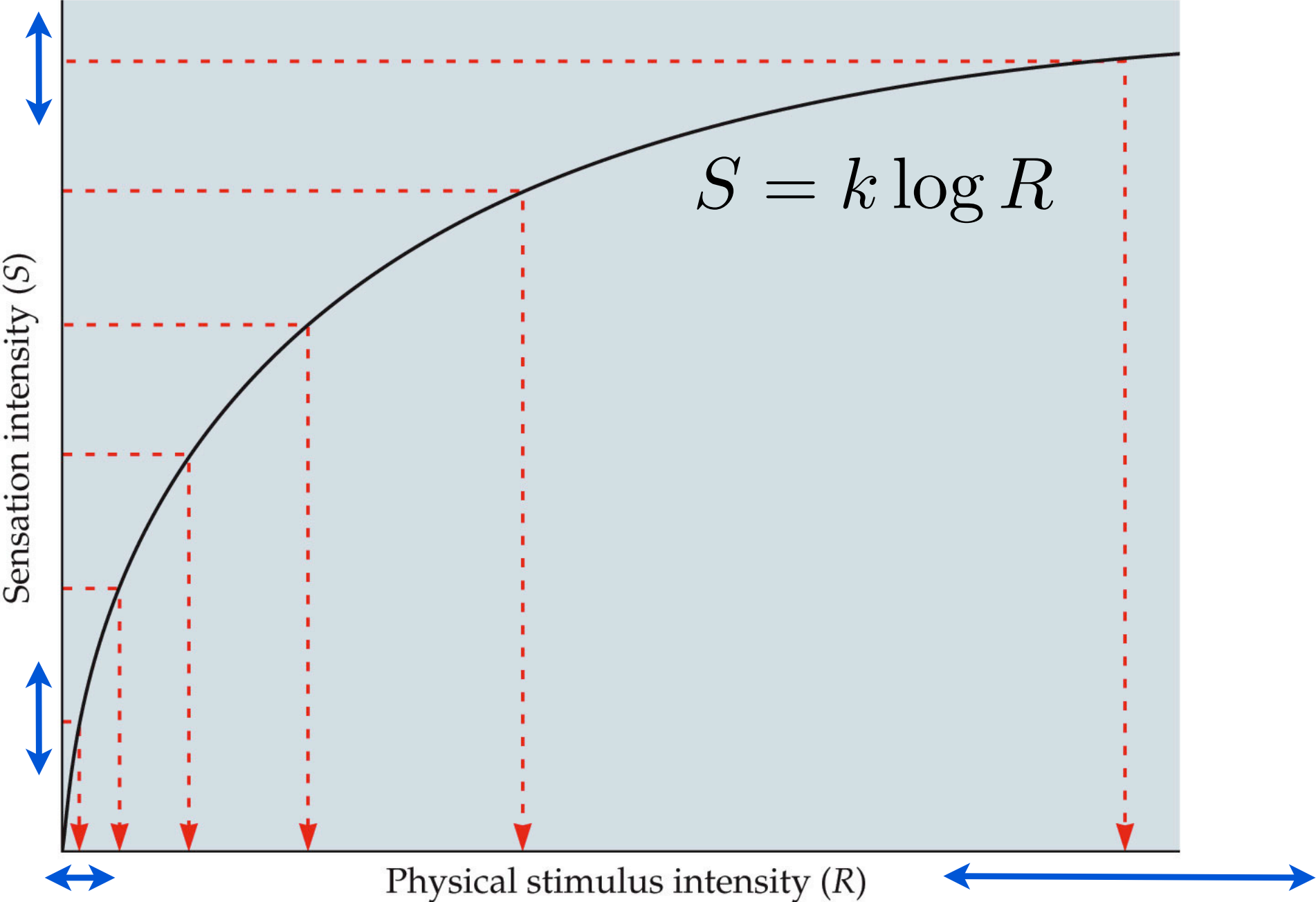
# The Dawn of Psychophysics

Gustav Fechner (1801–1887) often considered founder of experimental psychology



- scientific theory of the relationship between mind and matter

# Fechner's law



Ernst Weber (1795–1878)

## “Weber’s Law”

- law about how stimulus intensity relates to detectability of stimulus changes
- As stimulus intensity increases, magnitude of change must increase proportionately to remain noticeable



### Example:

1 pound change in a 20 pound weight

is just as detectable as

0.2 pound change in a 4 pound weight

$$\frac{1}{20} = .05$$

$$\frac{0.2}{4} = .05$$

Ernst Weber (1795–1878)

## Weber Fraction

- ratio of change magnitude to stimulus magnitude that is required for detecting the change

$$\begin{array}{l} \text{change in stimulus} \longrightarrow dR \\ \text{stimulus intensity} \longrightarrow R \end{array}$$



$$\frac{1}{20} = .05$$

$$\frac{0.2}{4} = .05$$

Q: what's the smallest change in a 100 pound weight could you detect?

Ernst Weber (1795–1878)

## Weber Fraction

- ratio of change magnitude to stimulus magnitude that is required for detecting the change

## Just-Noticeable Difference (JND)

- smallest magnitude change that can be detected



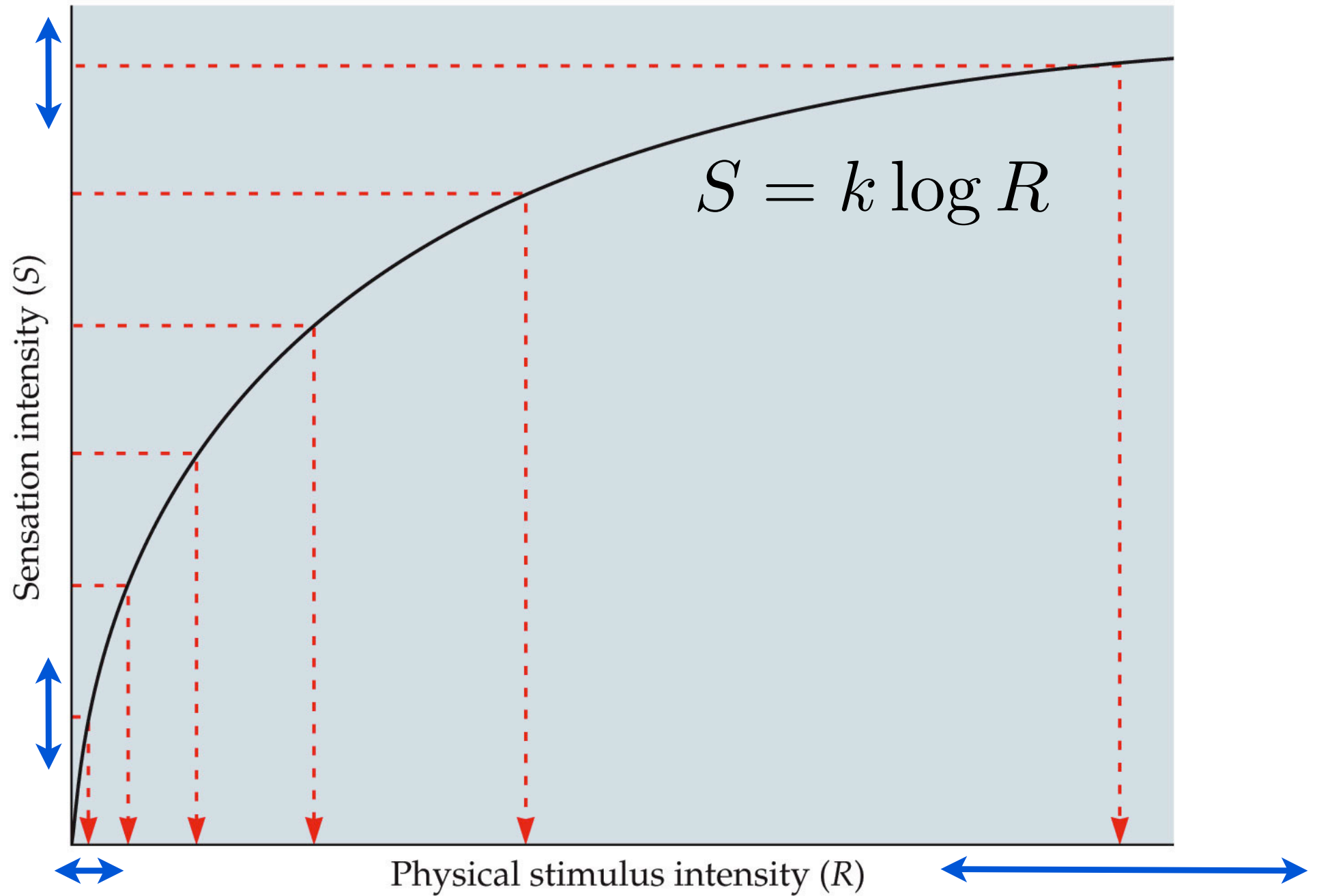
$$\frac{1}{20} = .05$$

$$\frac{0.2}{4} = .05$$

Q: what's the smallest change in a 100 pound weight could you detect?



Look at Fechner's law again:



Fechner's law:

$$S = k \log R$$

↑  
percept  
intensity

↑  
stimulus  
intensity

differentiate both sides

Weber's law:

$$dS = k \frac{dR}{R}$$

↑  
change in percept  
intensity

← change in  
stimulus  
intensity

So detectability (“how much the percept changes”) is determined by the ratio of stimulus change  $dR$  to stimulus intensity  $R$ .

(so, it's really the same law!)



# Weber-Fechner Law

my rating: this is very deep + important!