Intro to Perception, part II

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Outline for today:

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

- basic neuroscience overview

from last time:

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.

Example:

What is this?

the true input to your brain!

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Example:

What is this?

the true input to your brain!

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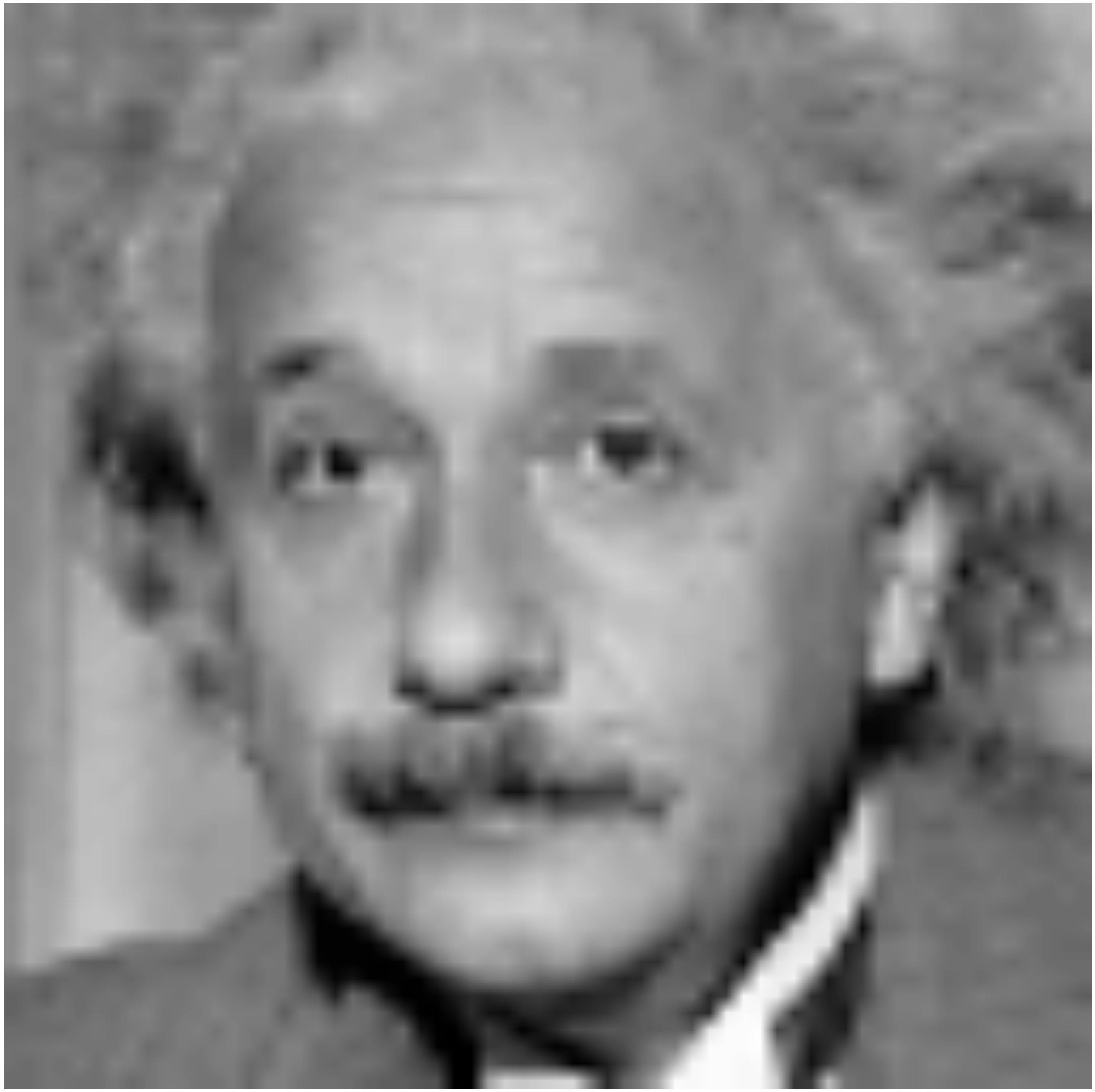
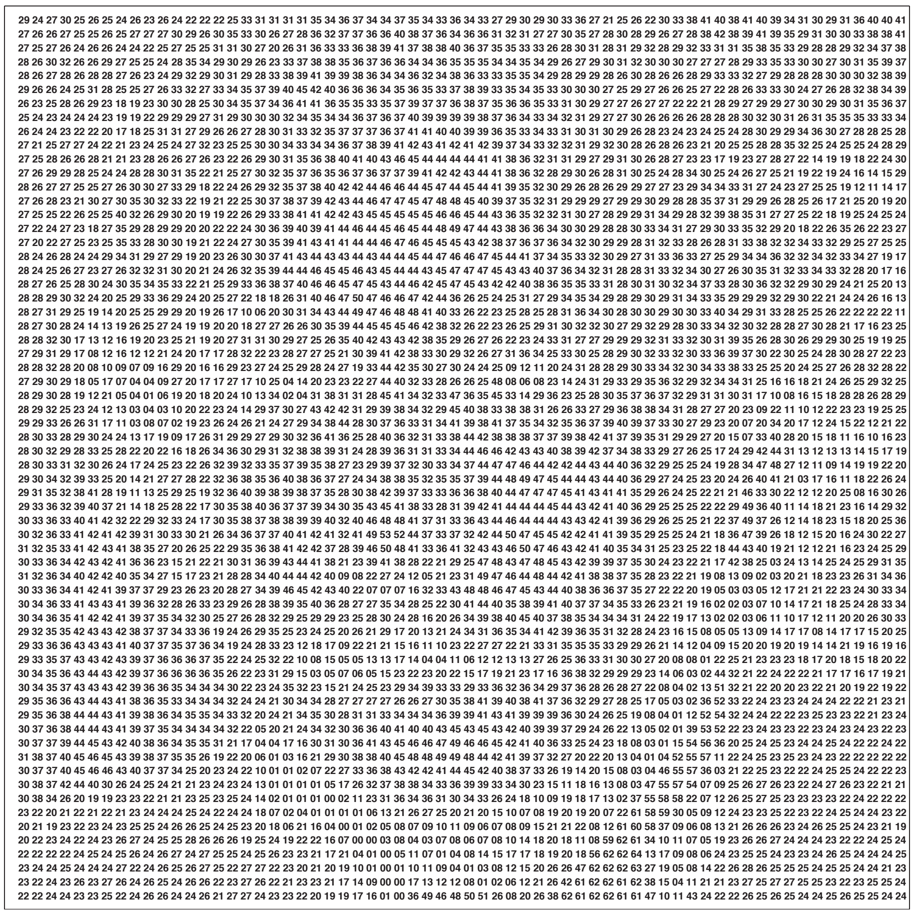


“Solving” perception would mean building an algorithm that (using just the numbers) could answer any question about the image that we can

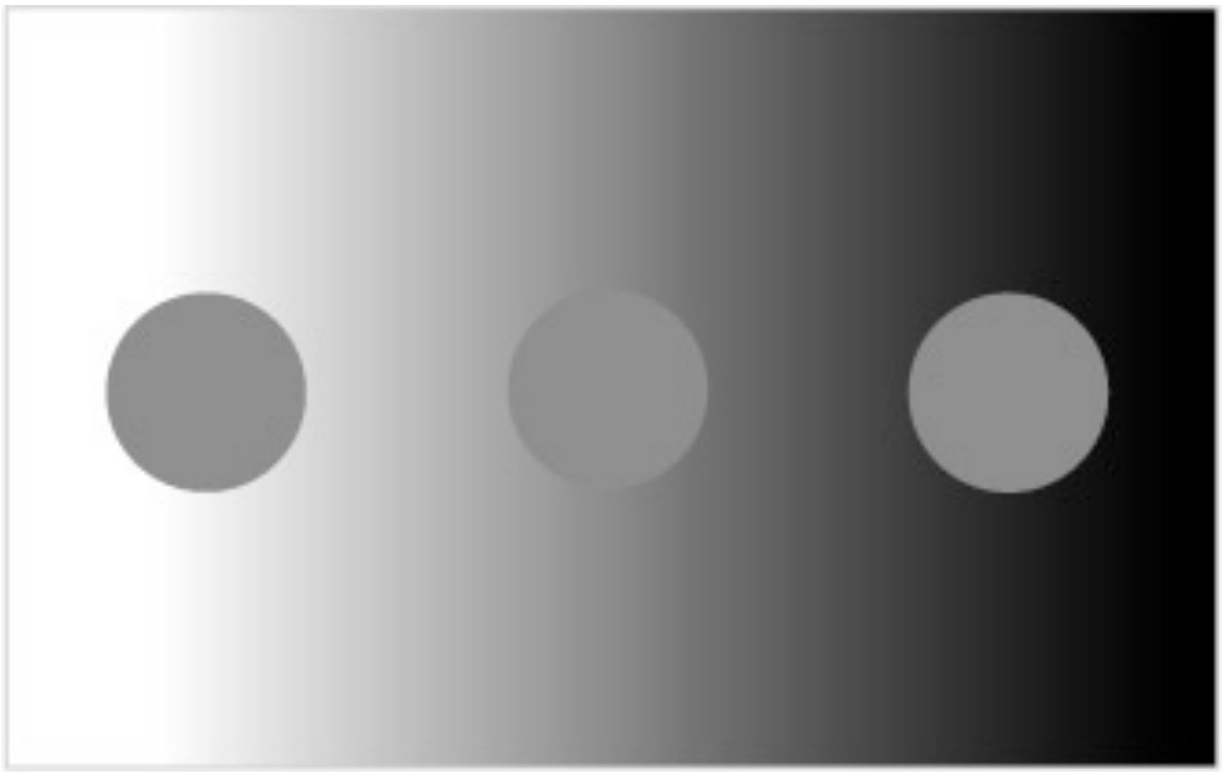


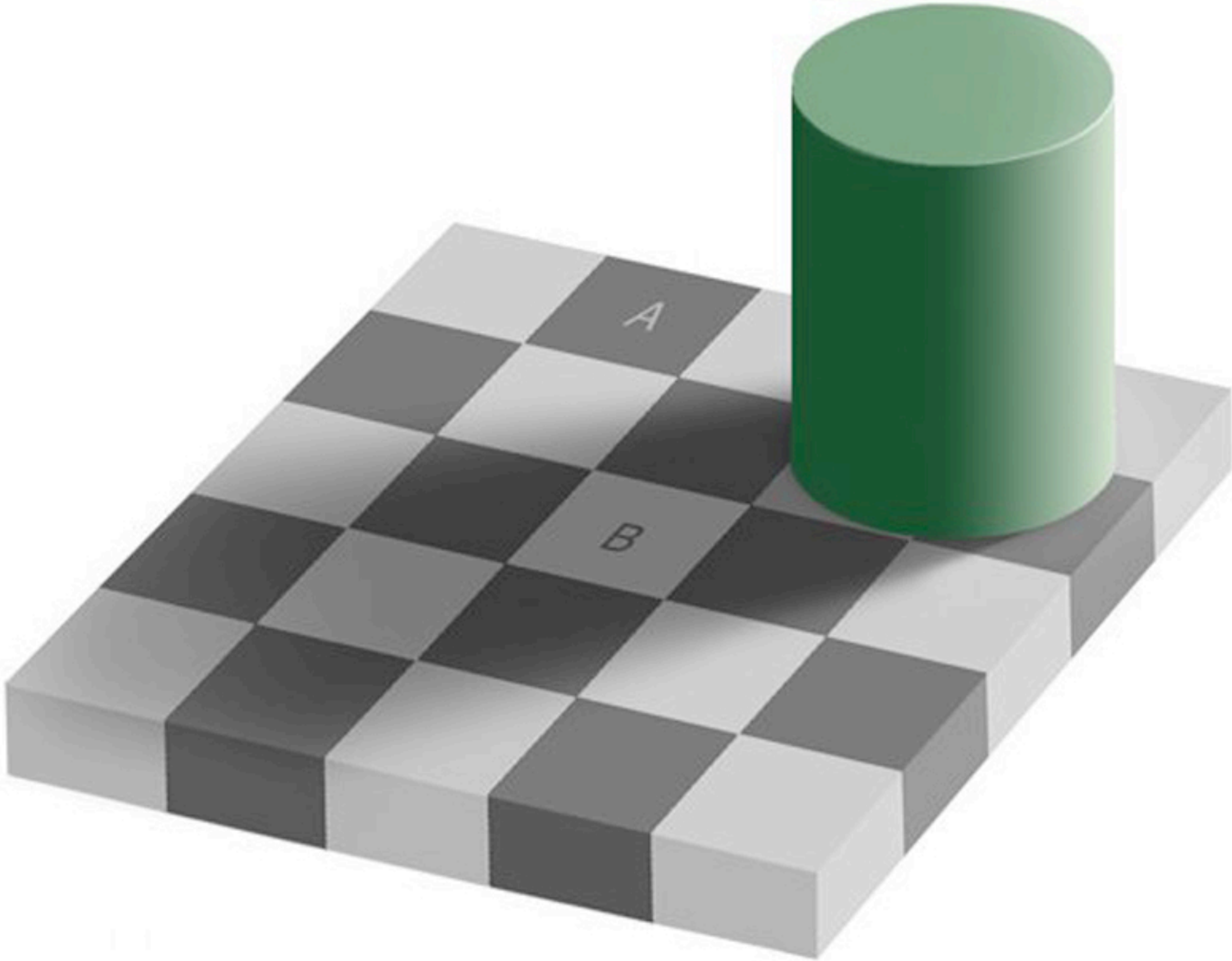
- who is this?
- what’s his facial expression?
- what is he wearing?

Next:

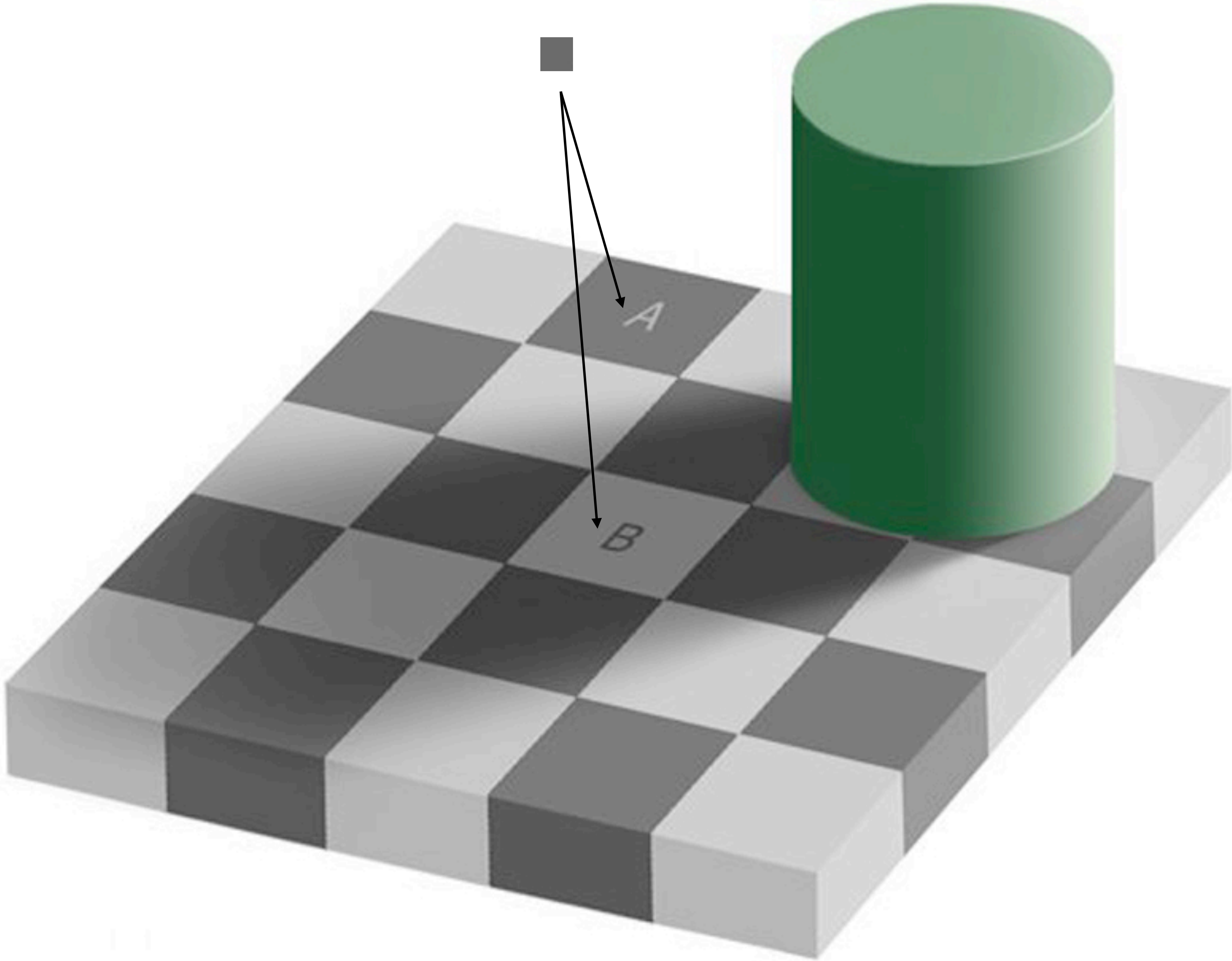
“why naive realism is wrong”

Lightness illusion

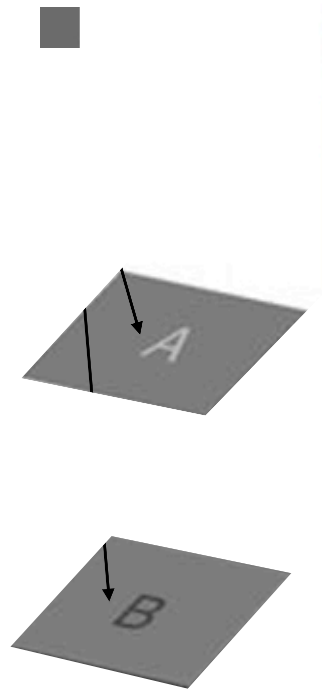



A
B

Comparison patch



Comparison patch

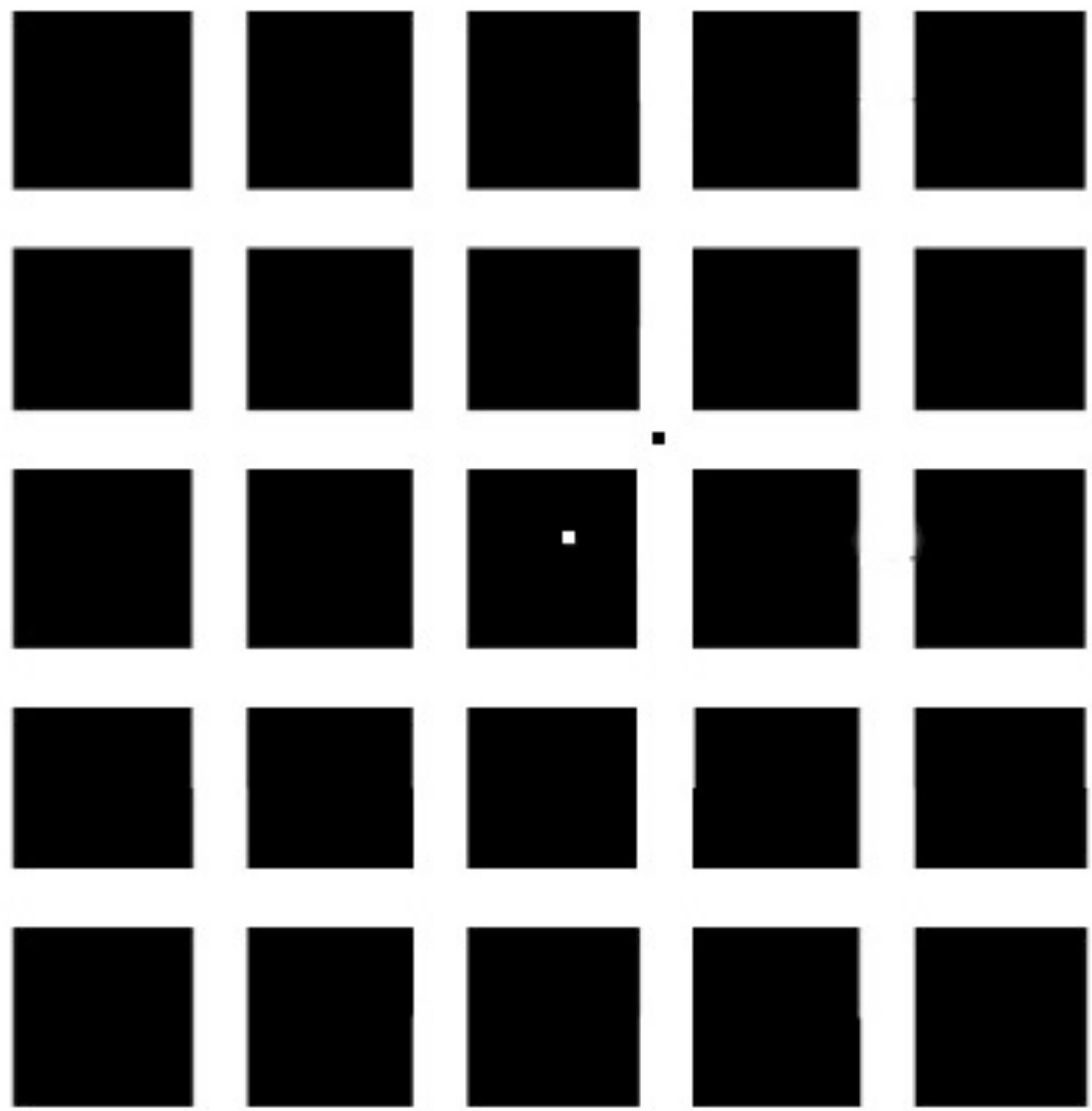


“Argument from Illusion”

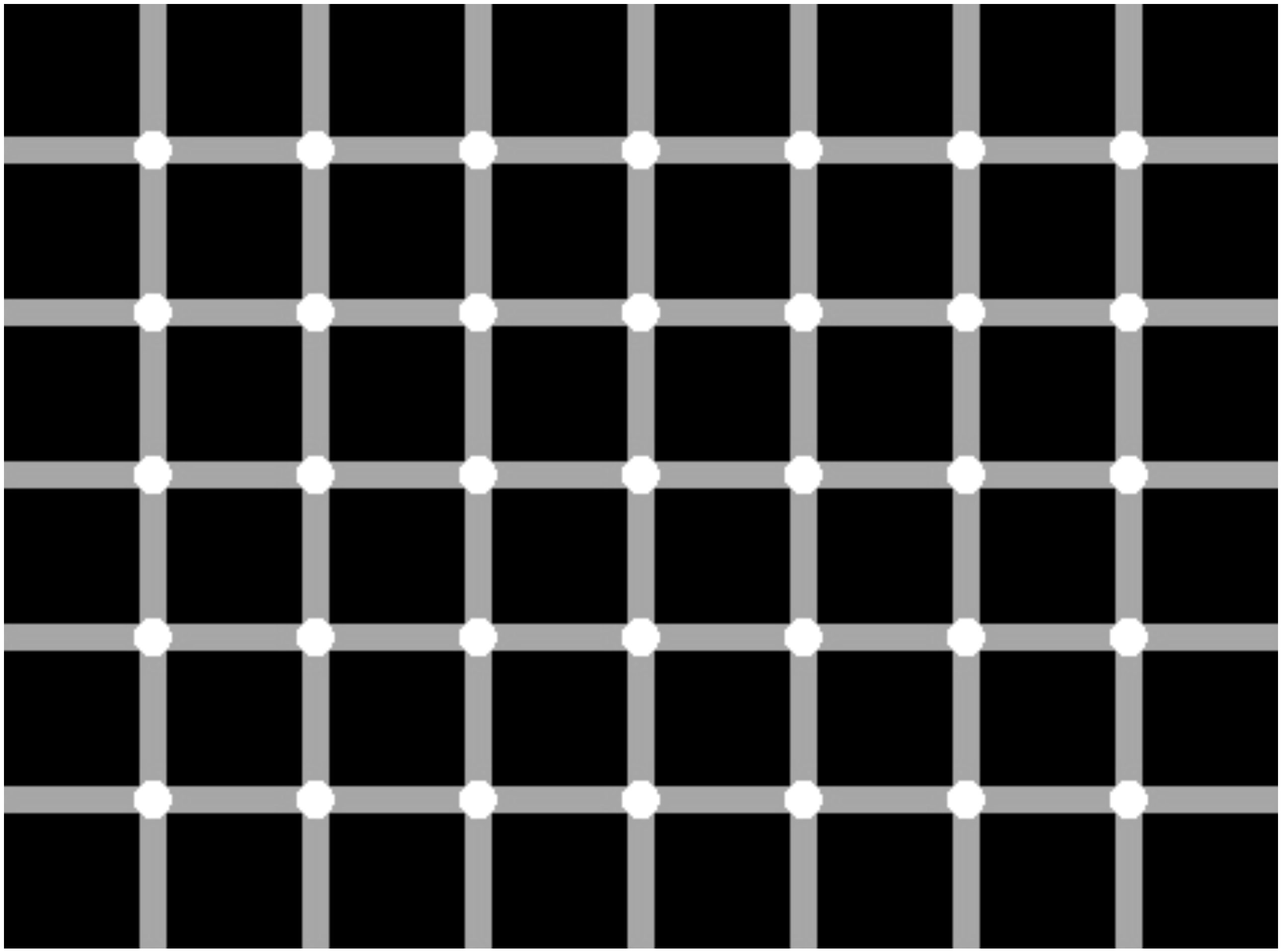
- The fact that we are sometimes mistaken in our sensory perceptions indicates that we do not directly perceive the world
- (Naive realism is false!)

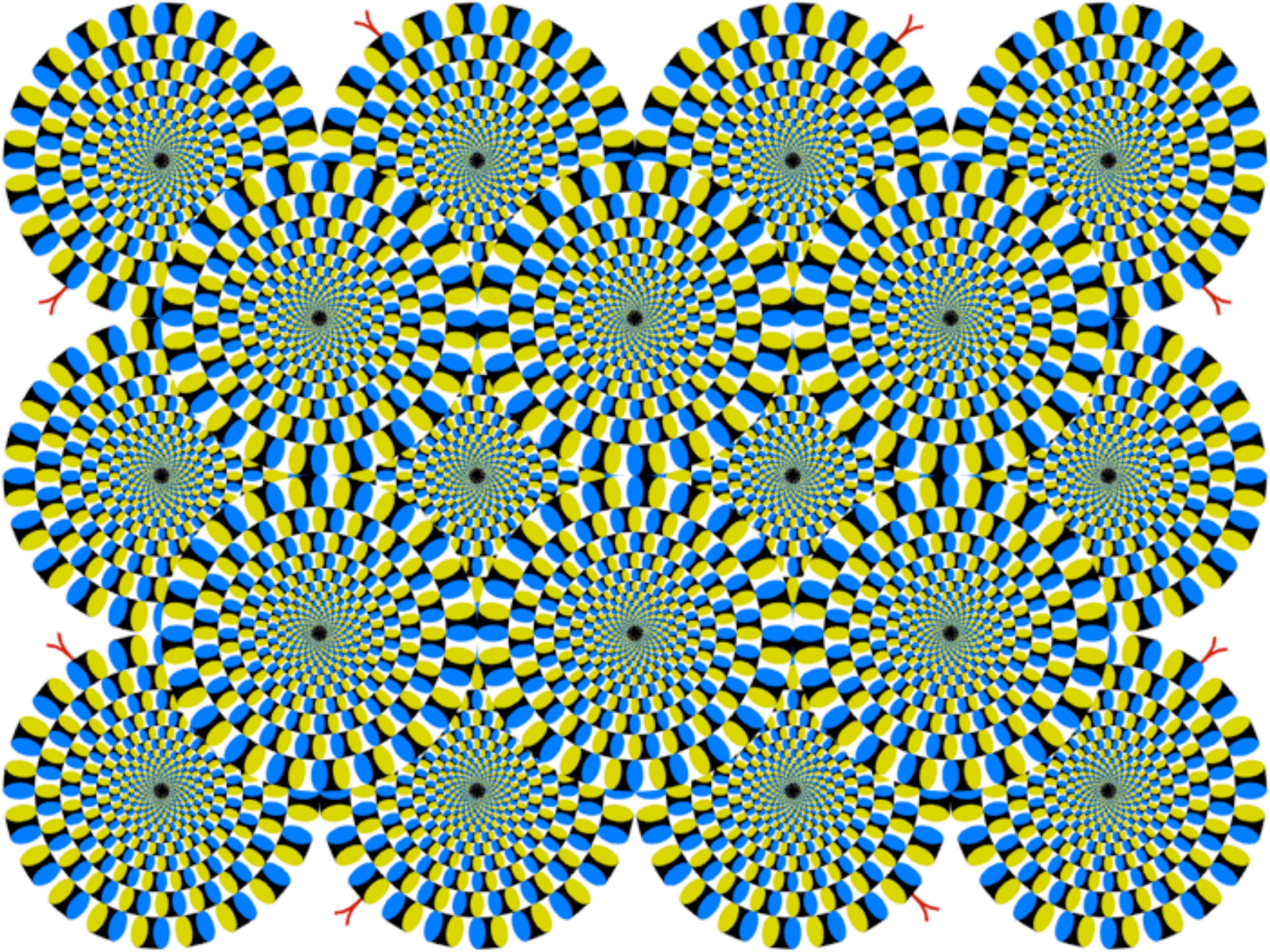
A.J. Ayer – British Philosopher 1910–1989

Hermann-Hering Illusion



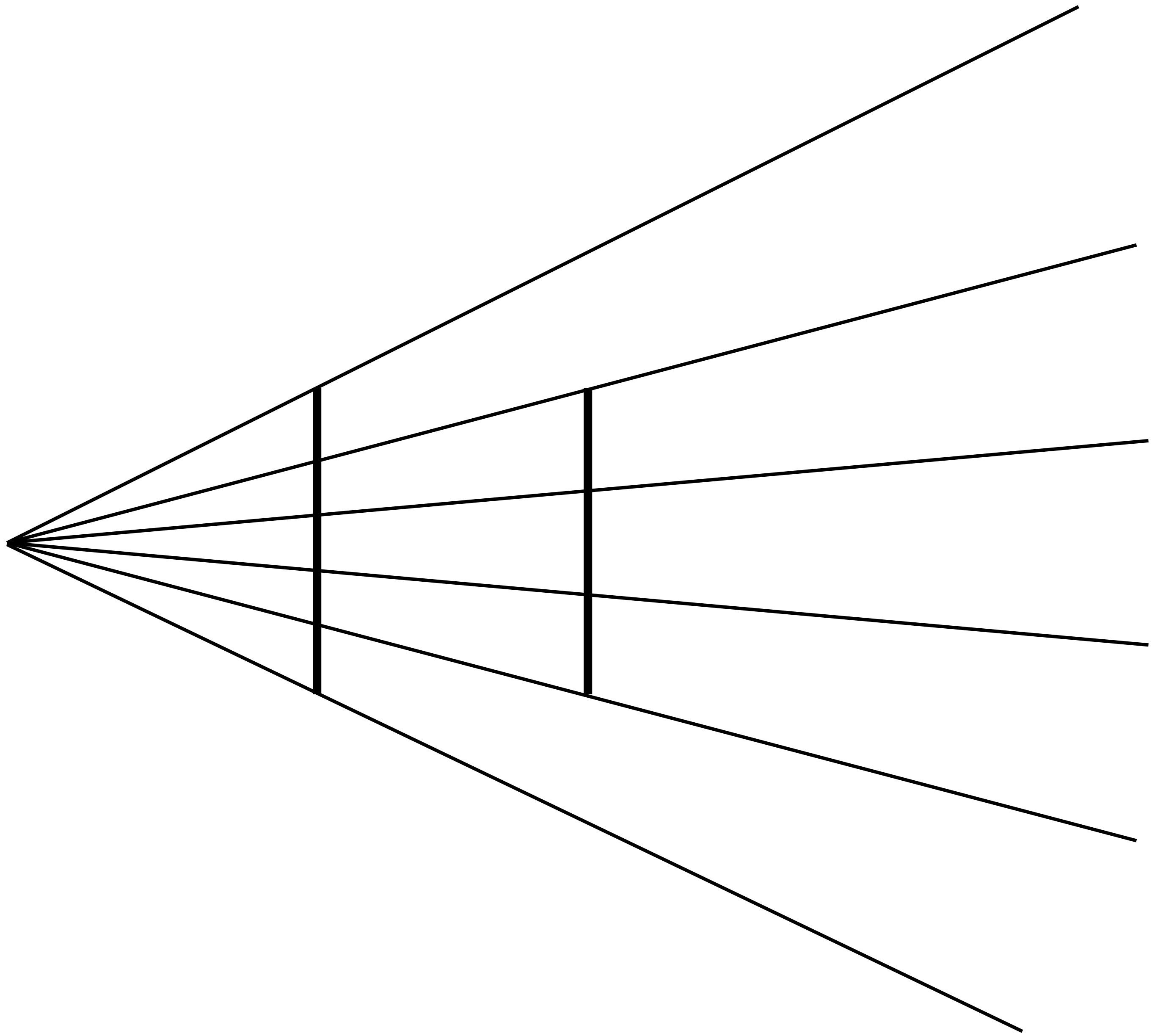
Hermann variant



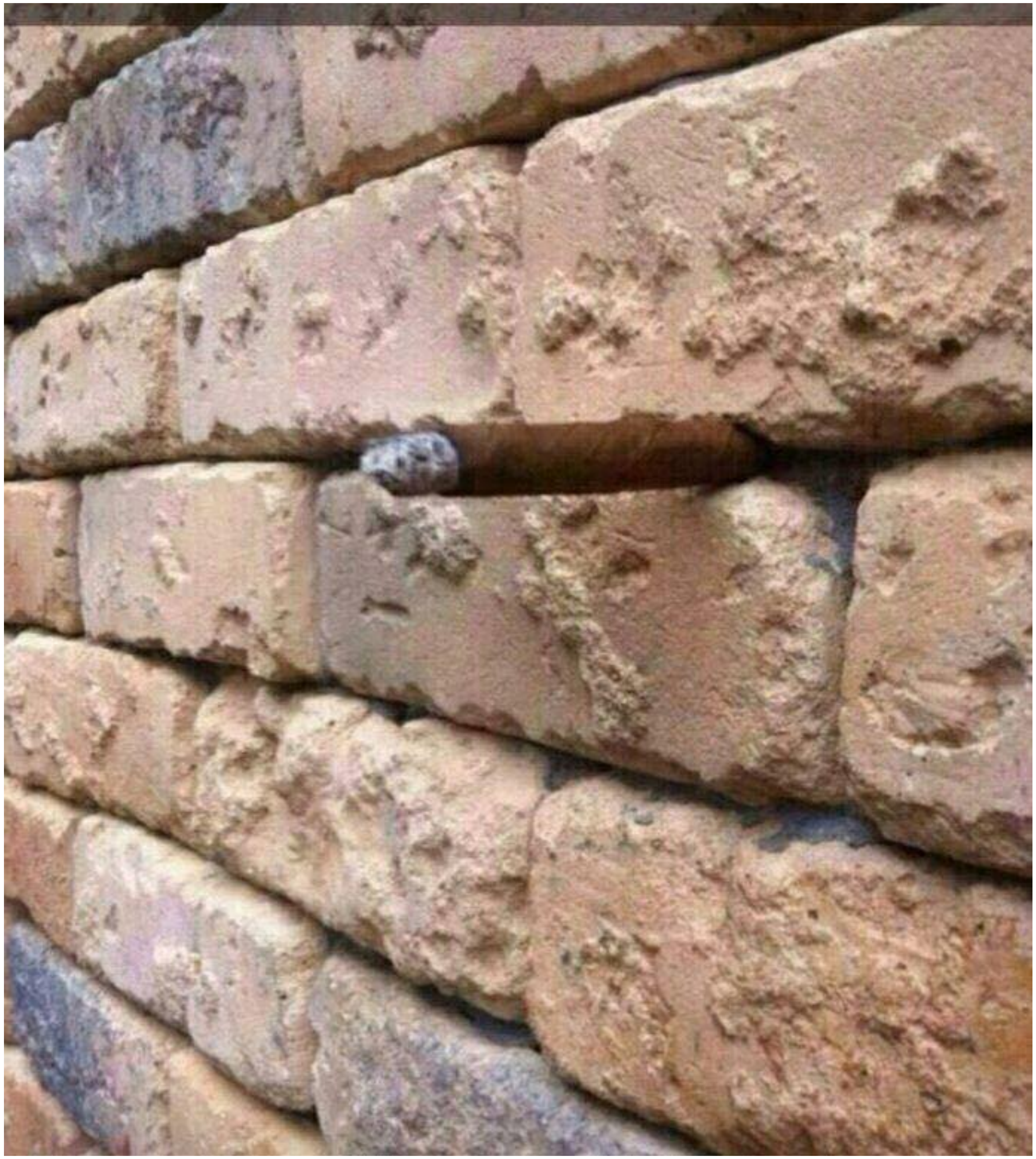


Eye movements

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



Context is important!



Top-down information (eg, memory) is important 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

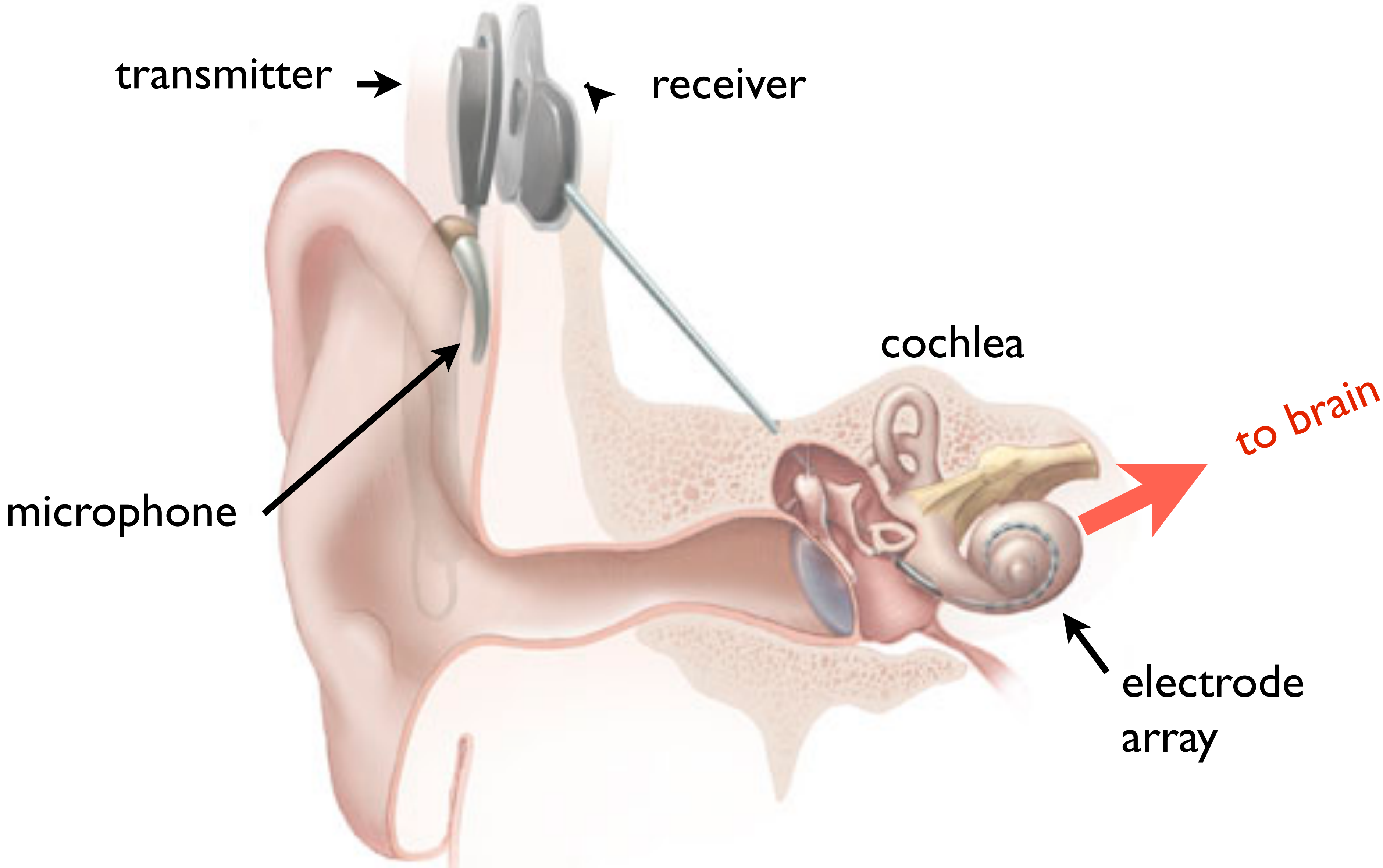
- Brain sometimes comes up with interesting percepts in response to conflicting sensory cues

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 strength*: scientific rigor
- *main weakness*: use of impoverished stimuli that are rarely if ever encountered in nature

Neurophysiology

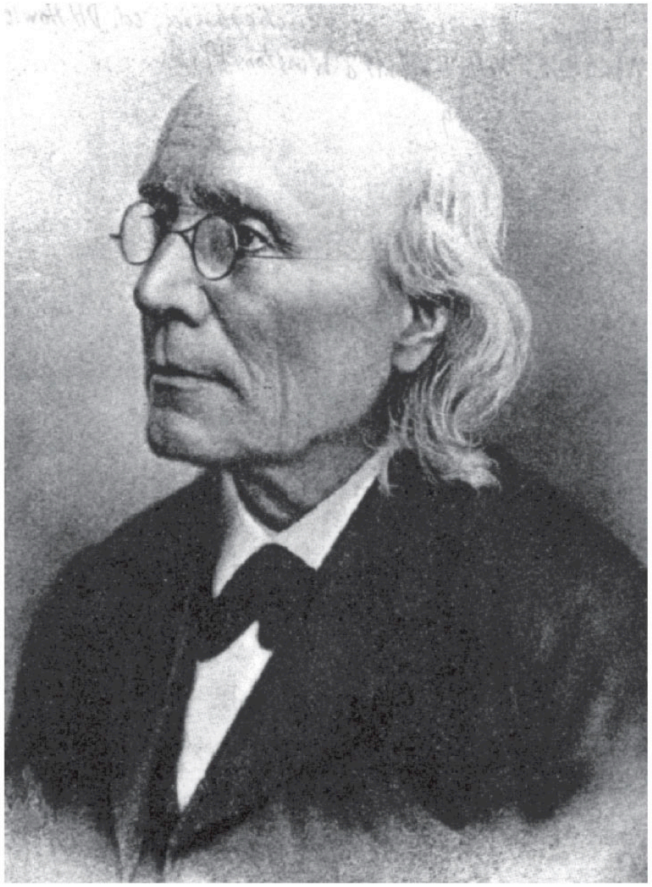
- use of carefully controlled laboratory stimuli (like psychophysics)
- measures the response of neurons or groups of neurons at various locations in the perceptual system
- sometimes not meaningfully connected to behavior / perception

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



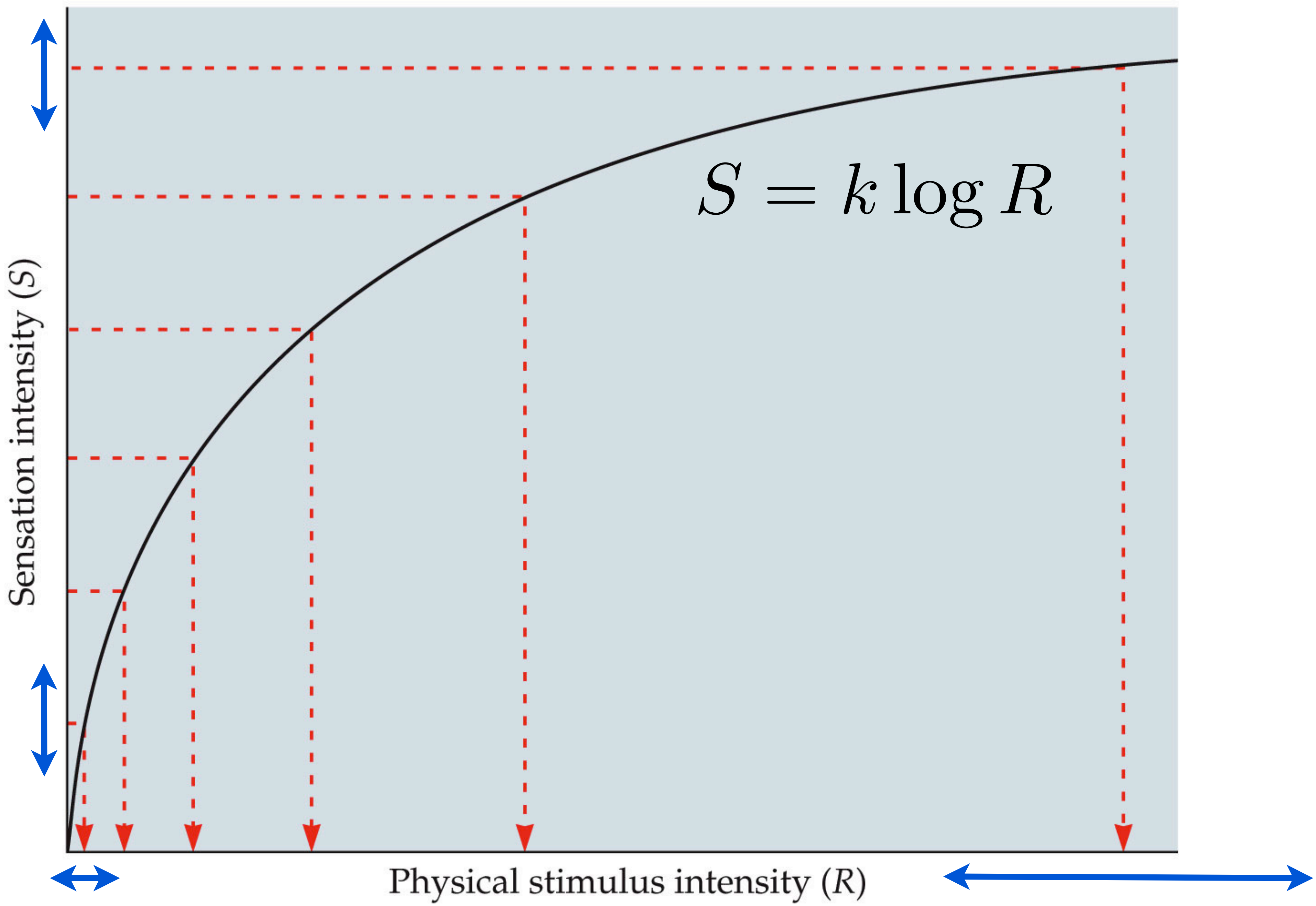
psychophysics

mind

matter

- scientific theory of the relationship between mind and matter

Fechner's law



The Dawn of Psychophysics

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

is just as detectable as

0.2 pound change in a 4 pound weight $\frac{0.2}{4} = .05$

Ernst Weber (1795–1878)

Weber Fraction

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

change in stimulus ⟶ dR

stimulus intensity ⟶ R

$$\frac{dR}{R}$$

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

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

Just-Noticeable Difference (JND)

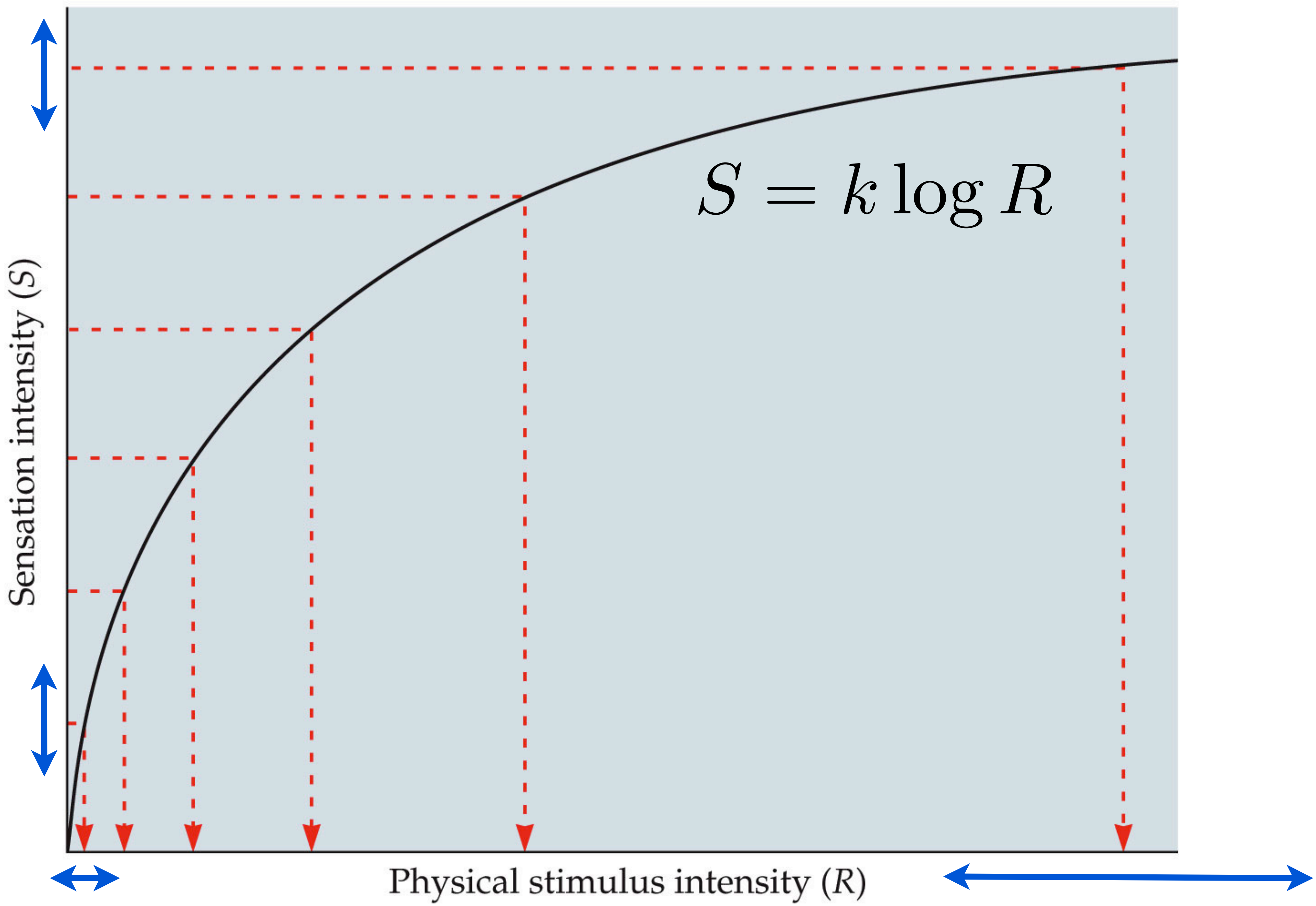
• smallest magnitude change that can be detected

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

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

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

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 stimulus intensity (dR)

↑ change in percept intensity (dS)

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

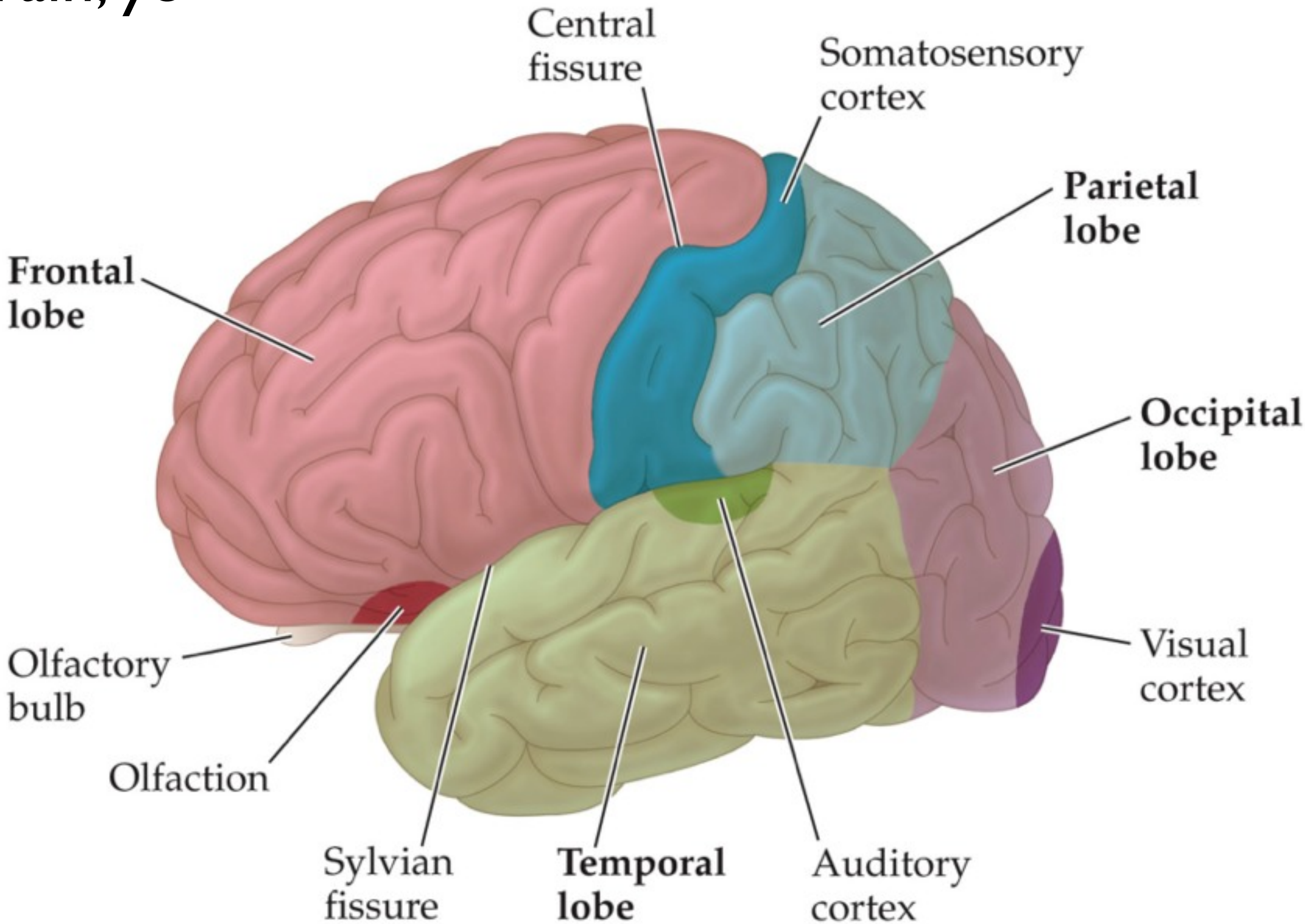
(so, it's really the same law!)

Weber-Fechner Law

my rating: this is very deep + important!

Brief Neuroscience Intro:

the brain, yo

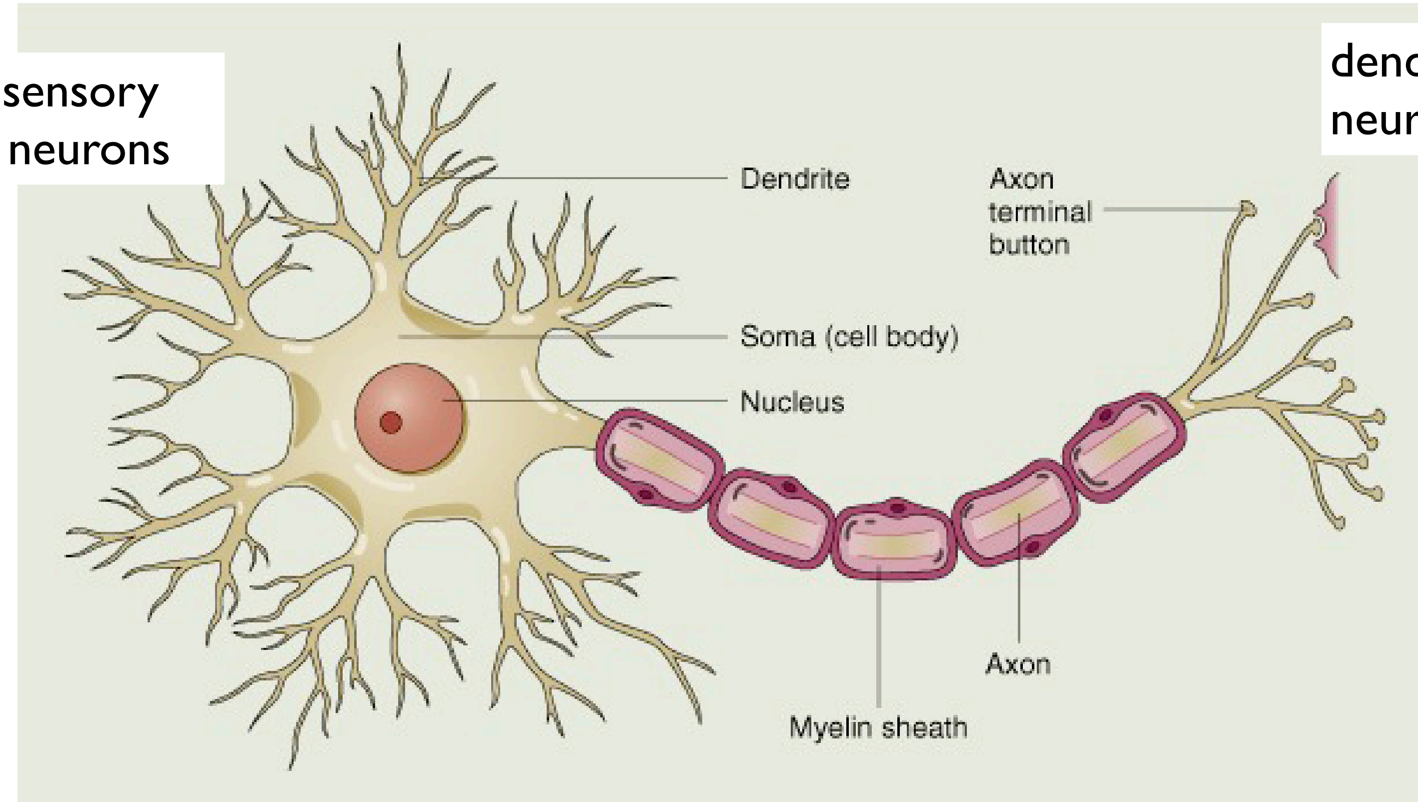


Central
fissure
Somatosensory
cortex
Parietal
lobe
Frontal
lobe
Occipital
lobe
Visual
cortex
Olfactory
bulb
Olfaction
Sylvian
fissure
Temporal
lobe
Auditory
cortex

neuron

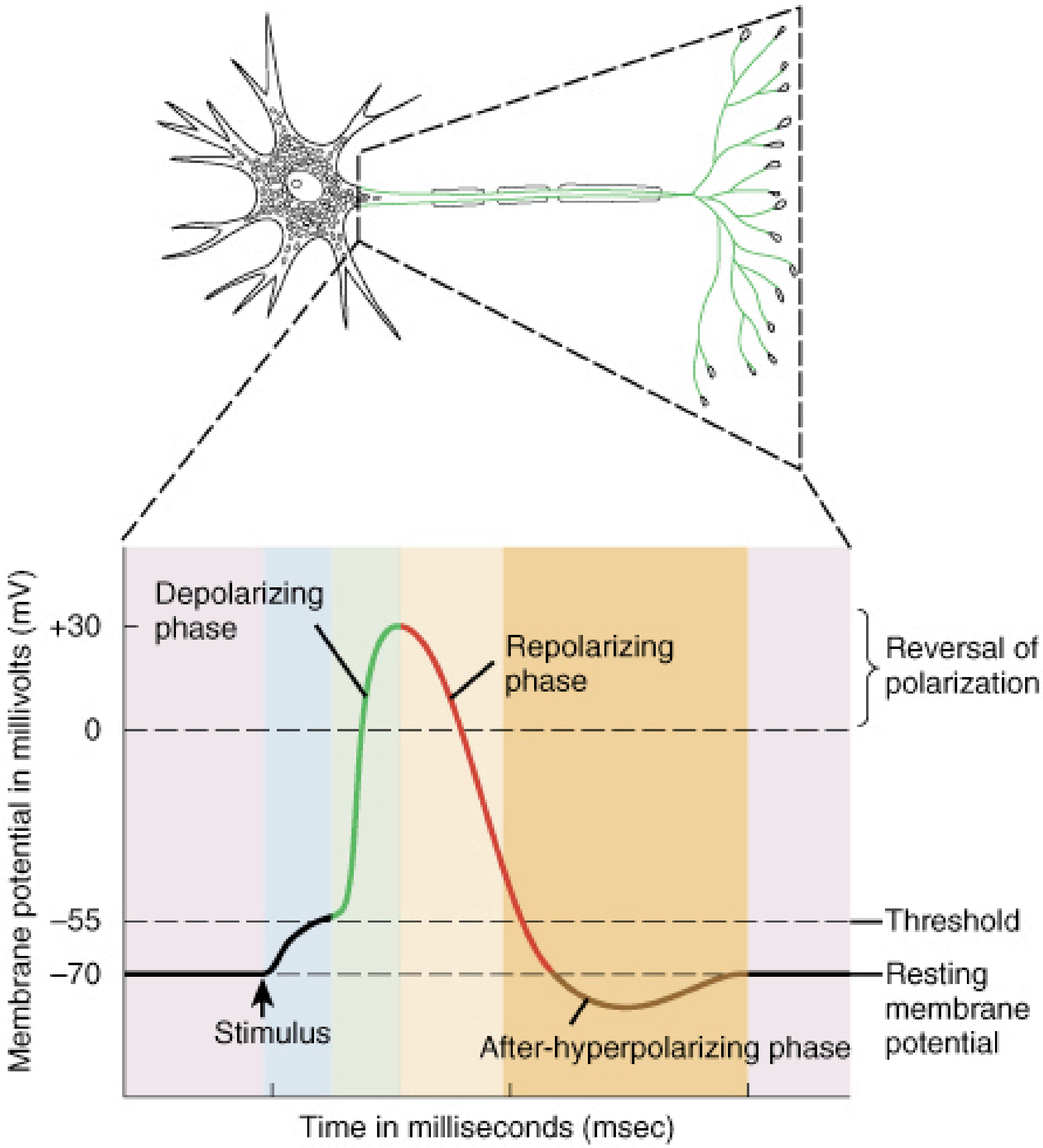
axons of sensory receptor neurons

dendrites of target neurons



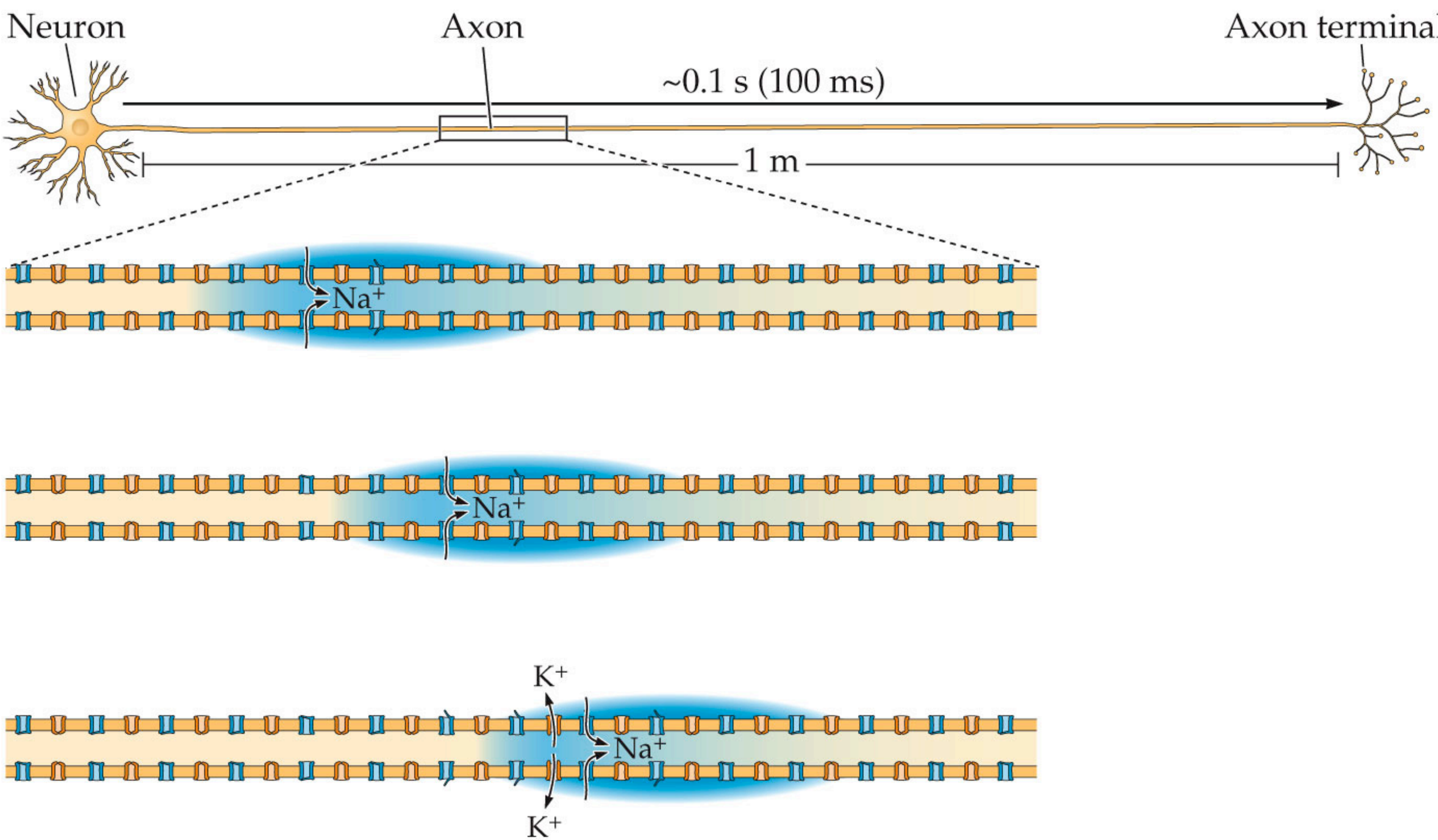
- membrane is *polarized*: voltage difference between inside and outside (neuron is like a battery)

Spikes - currency of the nervous system

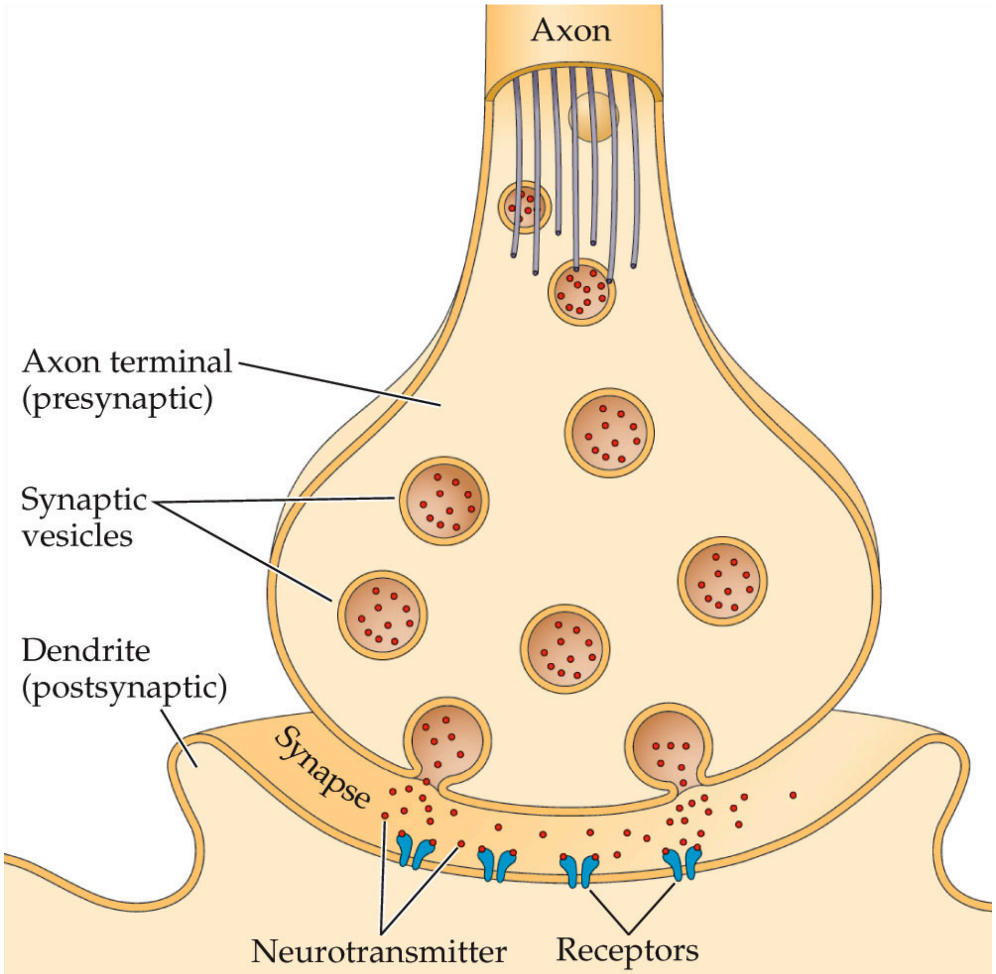


- channels open
- current flows in
- membrane becomes *depolarized*

spike propagation



synapse



- action potential triggers release of vesicles
- transmitter molecules bind to receptor
- post-synaptic electrical signal

measuring neural activity

- Invasive methods
  - electrophysiology (electrodes)
  - imaging (voltage sensitive dyes)

- non-invasive methods
  - fMRI (functional magnetic resonance imaging)
  - EEG (electroencephalography)
  - MEG (magnetoencephalography)