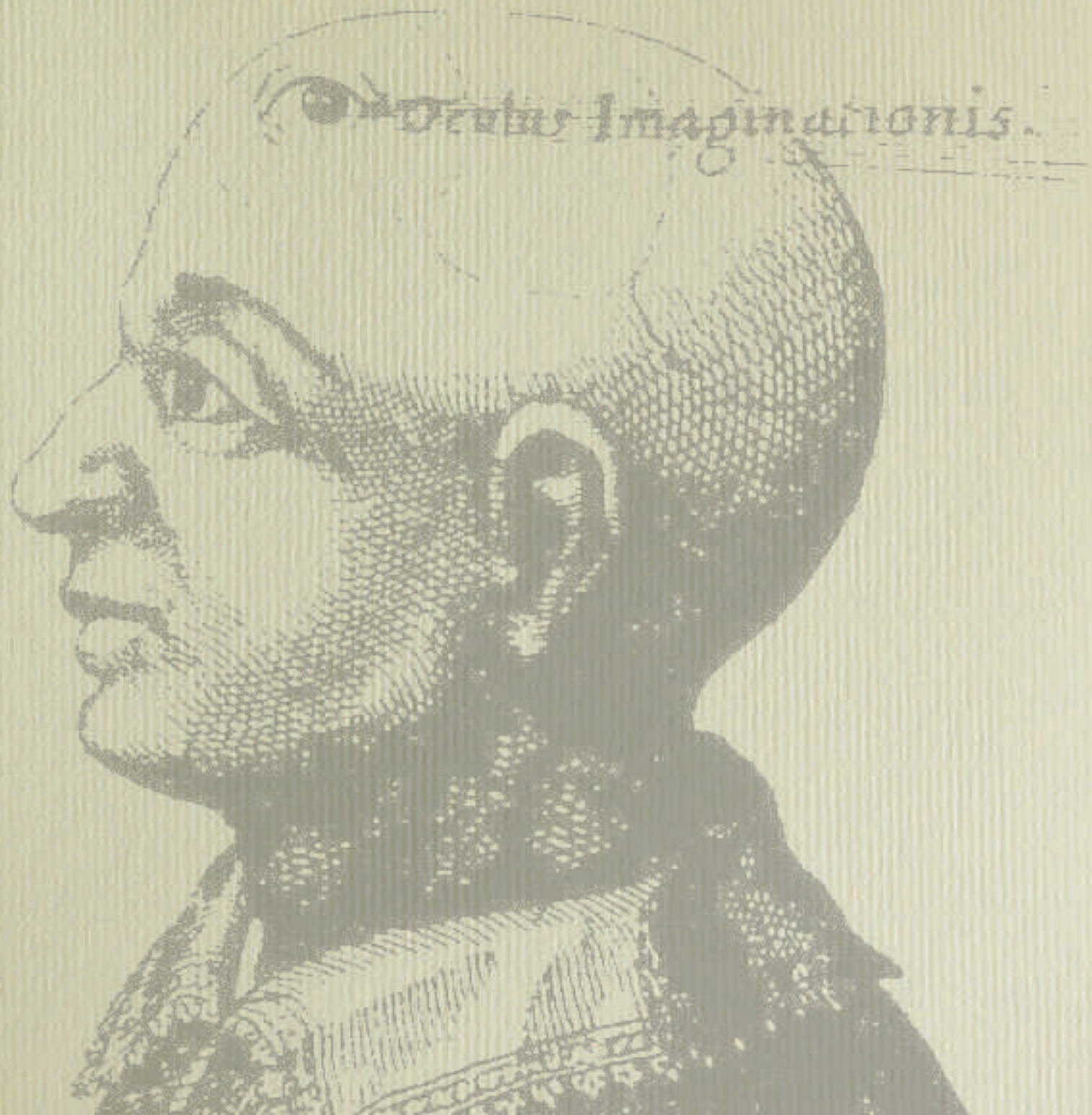
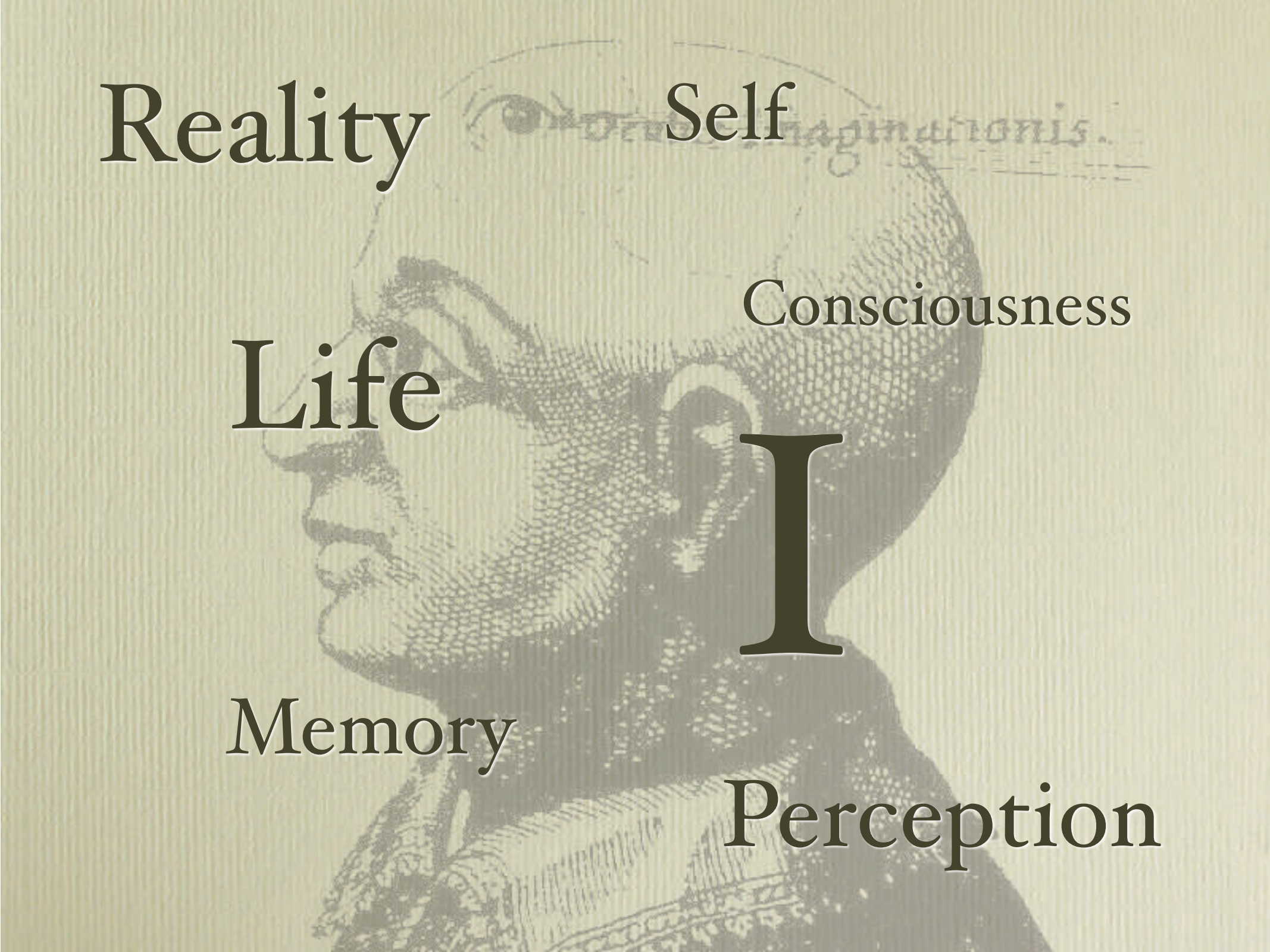
Vision and learning

Solar Eclipse Cruise
Eastern Mediterranean (or is it?), 26 March 2006


Oculus Imaginationis.


Reality
Self
Consciousness
Life
I
Memory
Perception

How do we remember?

How do we remember?

835-7663

A Quick Survey:

- Three statements
- Rate agreement
- Scale 1–5: disagree = 1, agree = 5

Seeing is believing

"Visual observations greatly help the understanding of material"

1 = disagree, 5 = agree

Visualization is important

"Memories of observations reinforce the retention of physical models"

1 = disagree, 5 = agree

1 picture = 1000 words

"Information can be transferred more quickly and more effectively visually than verbally"

1 = disagree, 5 = agree

Instructions

1. Add your scores
2. Divide by 3 & round to nearest integer
3. Enter your result

A = 1, B = 2, ..., E=5

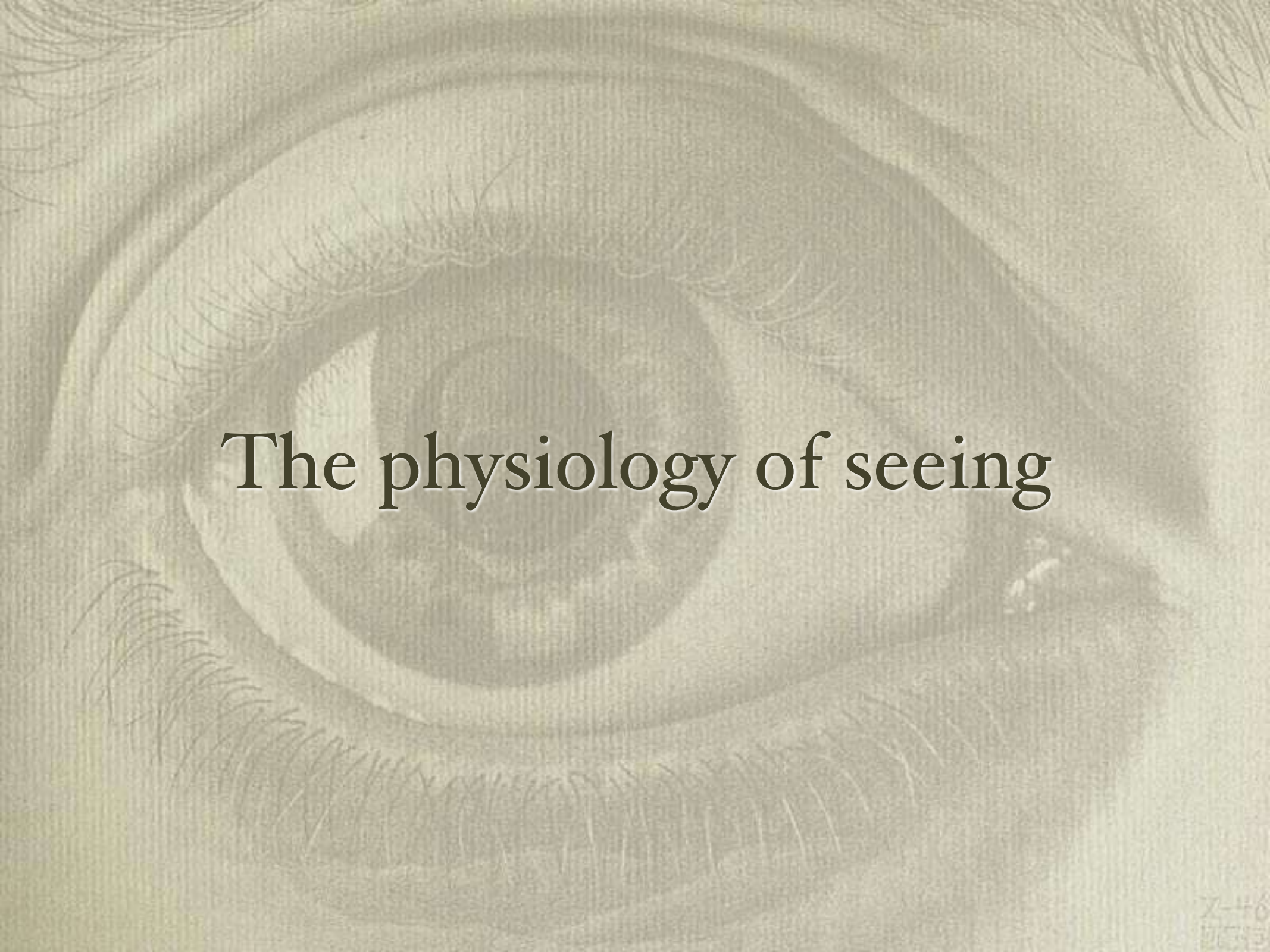
My message

There is much to learn from neurobiology and cognitive psychology

Outline

- the physiology of seeing
- cognitive issues related to seeing

The physiology of seeing

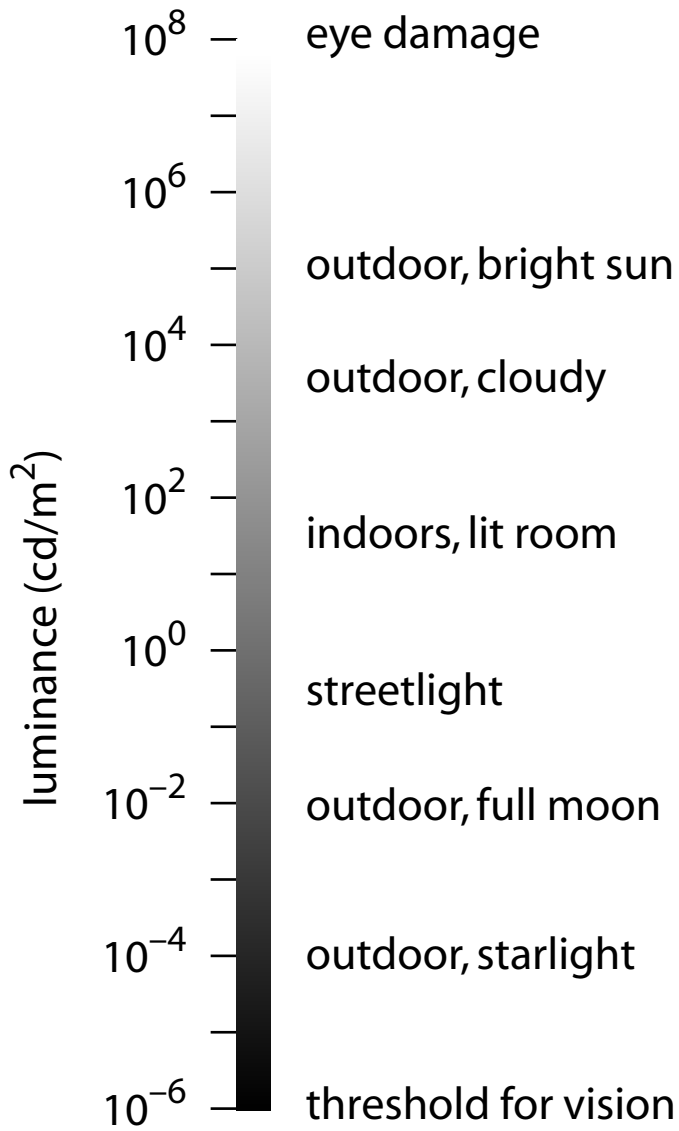


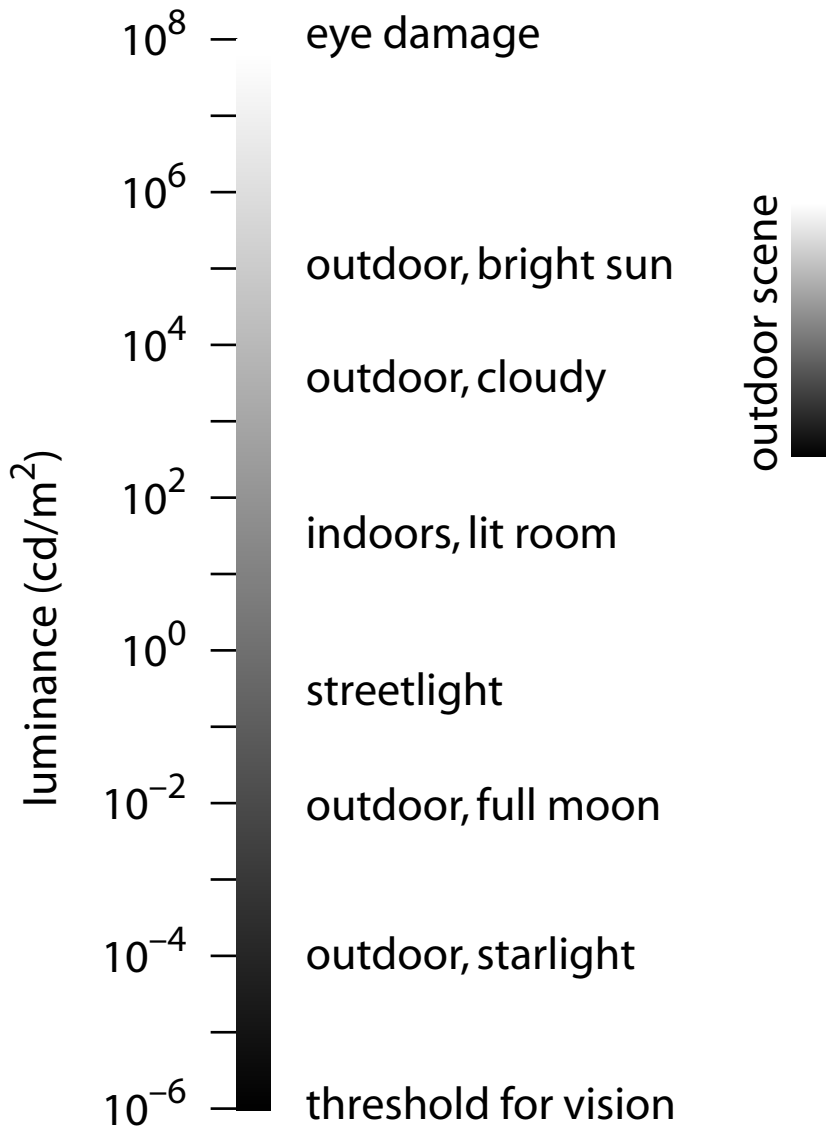
Human vision

- Small frequency range
- Huge luminance range

Luminance

- Light energy radiated/reflected
- Determined by reflectance and illumination


luminance (cd/m2)
10^8
10^6
10^4
10^2
10^0
10^−2
10^−4
10^−6
eye damage
outdoor, bright sun
outdoor, cloudy
indoors, lit room
streetlight
outdoor, full moon
outdoor, starlight
threshold for vision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outdoor, bright sun
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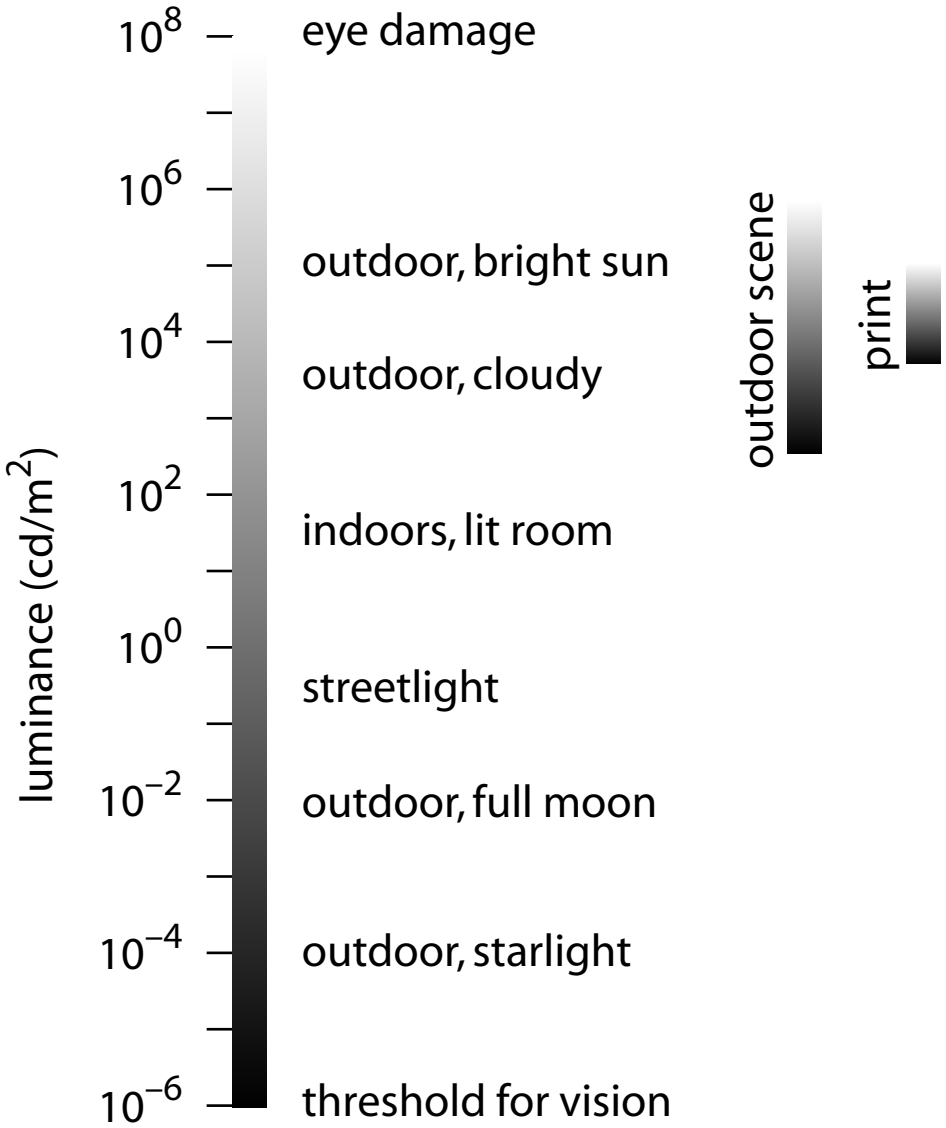
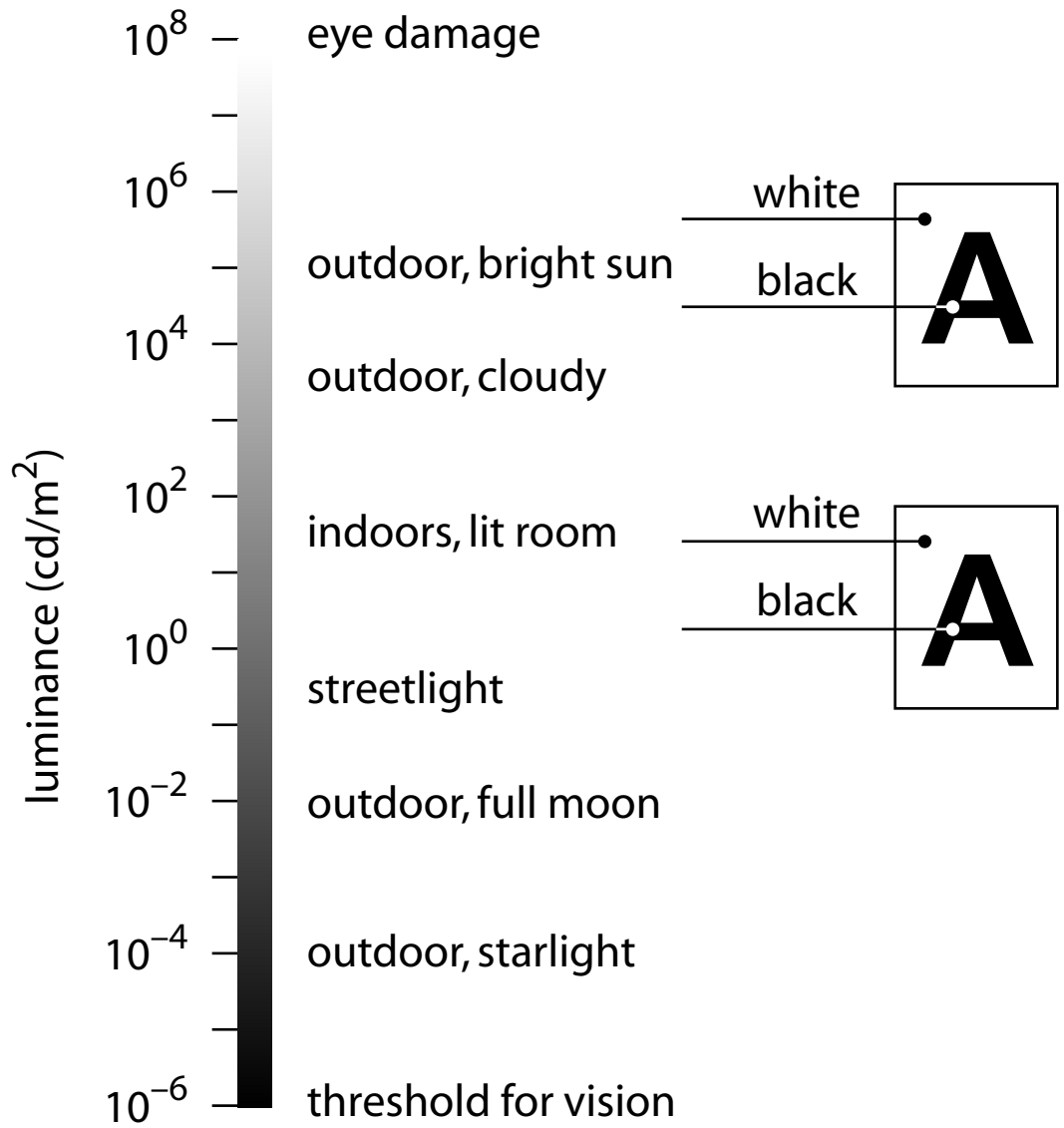
indoors, lit room
streetlight
outdoor, full moon
outdoor, starlight
threshold for vision
outdoor scene


luminance (cd/m2)
10^8
10^6
10^4
10^2
10^0
10^−2
10^−4
10^−6
eye damage
outdoor, bright sun
outdoor, cloudy
indoors, lit room
streetlight
outdoor, full moon
outdoor, starlight
threshold for vision
outdoor scene
print

What color?

A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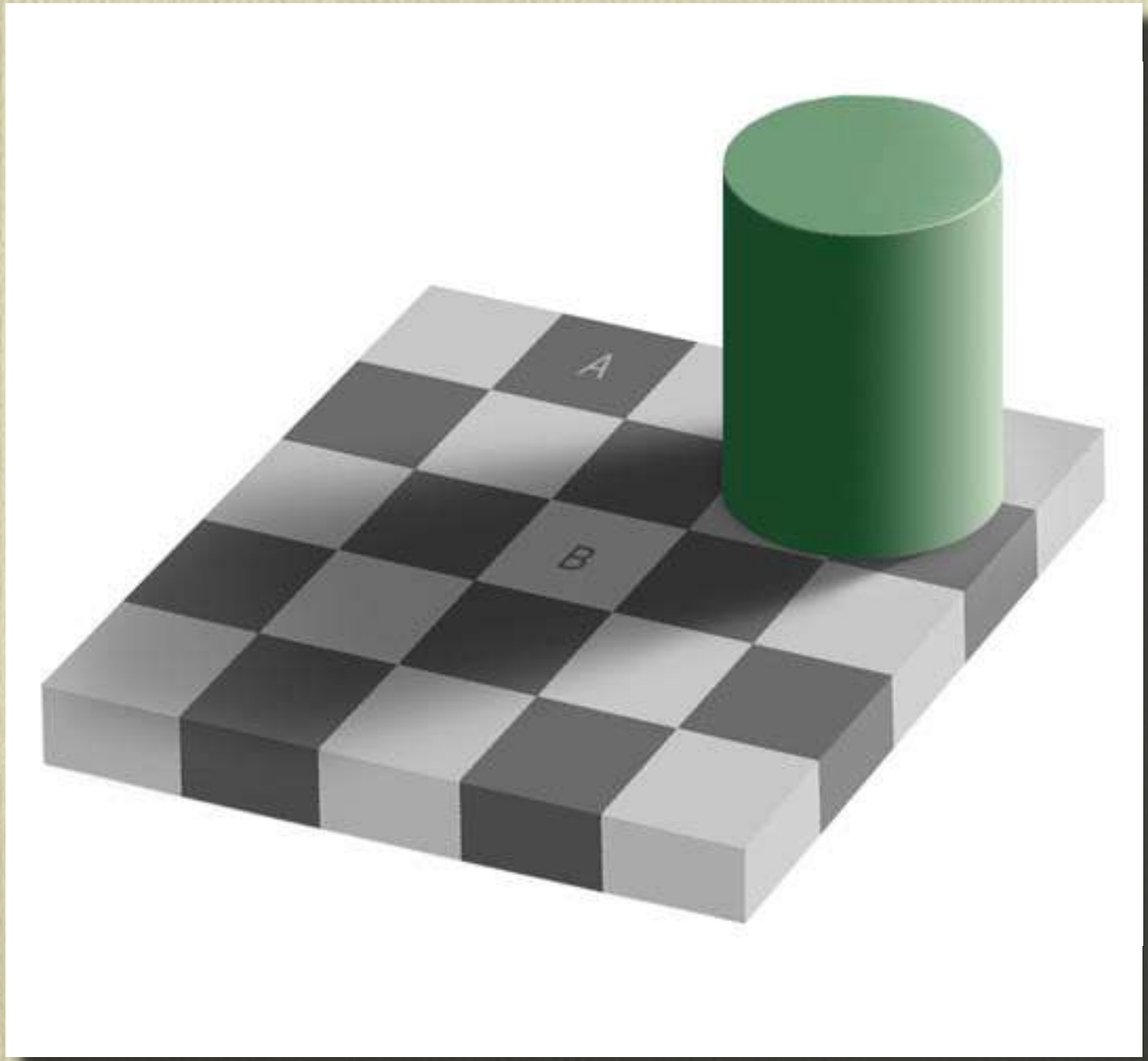
10^2
10^0
10^−2
10^−4
10^−6
eye damage
outdoor, bright sun
outdoor, cloudy
indoors, lit room
streetlight
outdoor, full moon
outdoor, starlight
threshold for vision
white
black
A
white
black
A

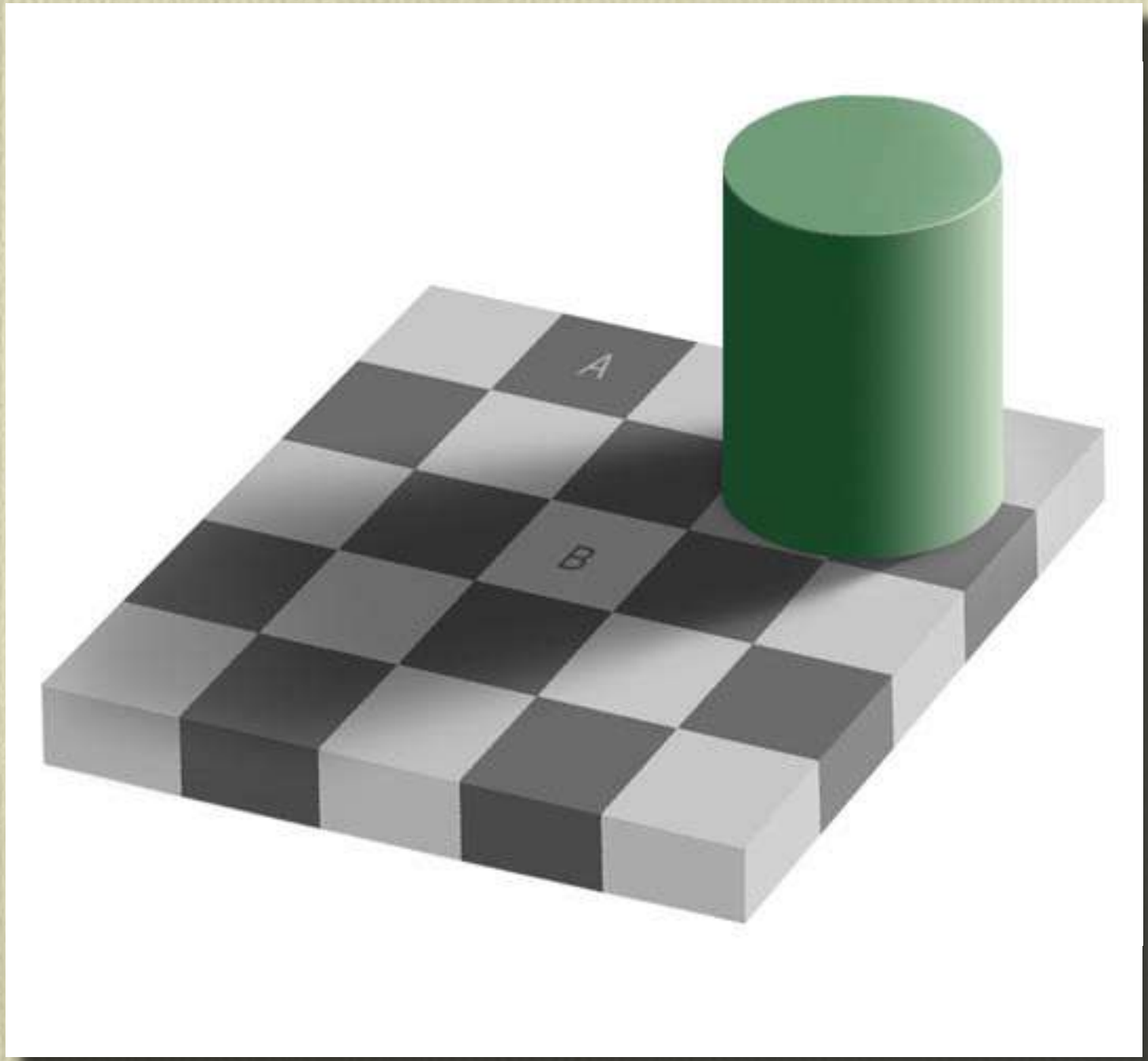
What the retina does:

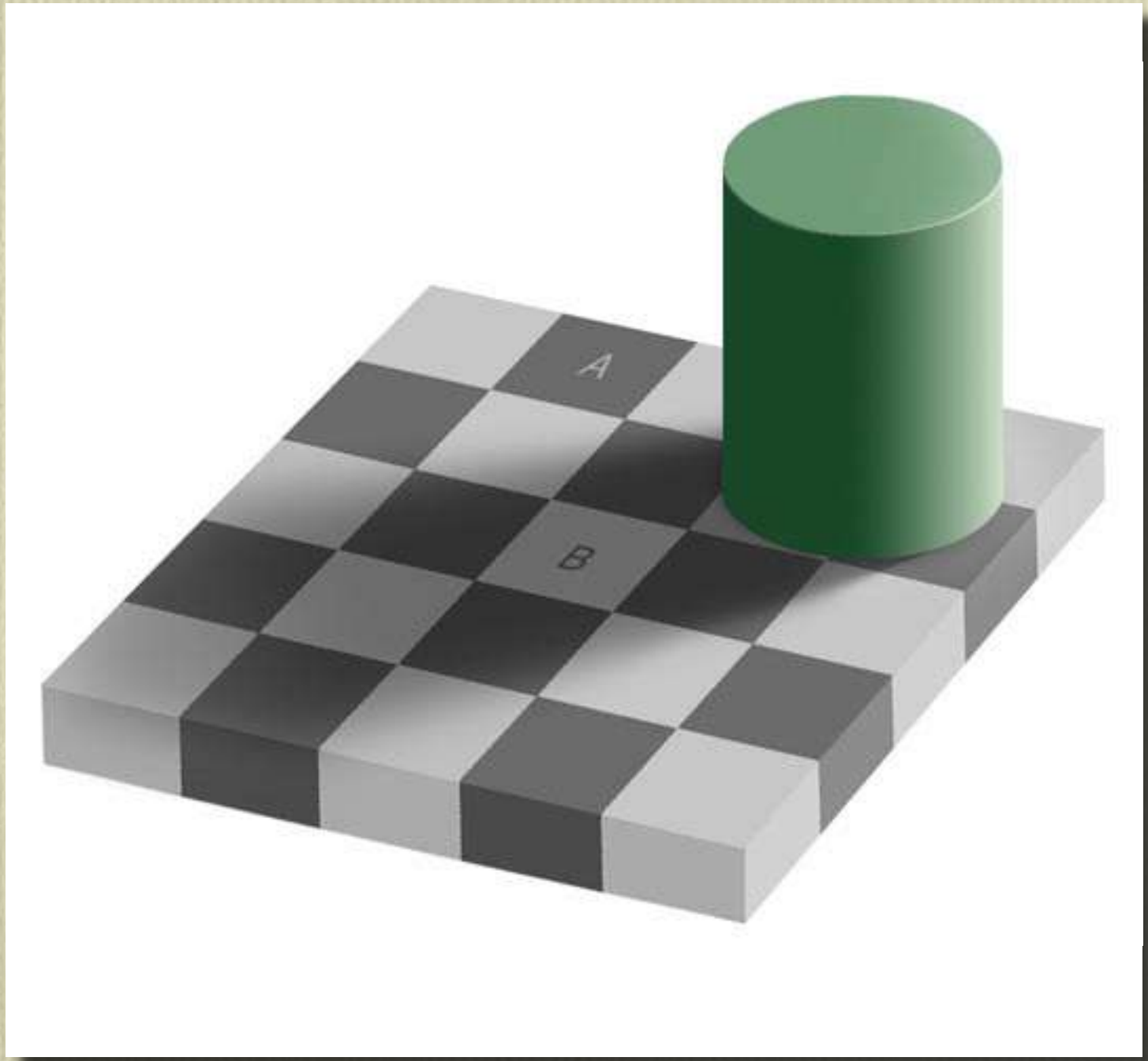
- Spatial compression
- Adjust luminance range to nerve S/N
- Extract reflectance

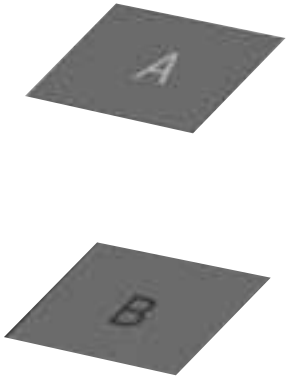

A
B

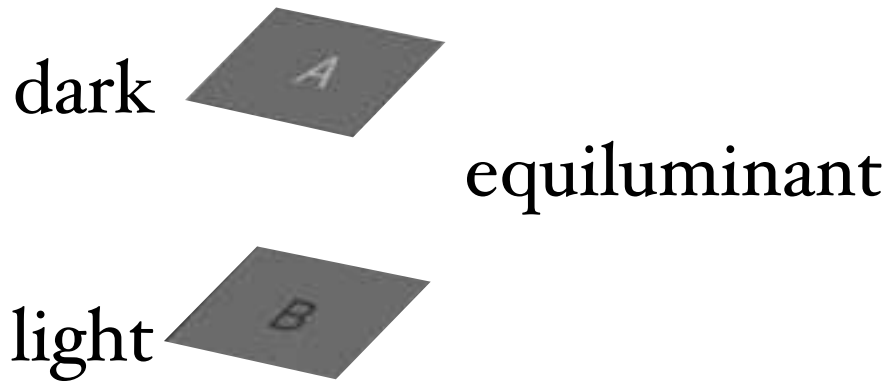
Which is darker?

A. the letter A is darker
B. the letter B is darker
C. both are the same
D. you're tricking me; just *tell* me
E. I'm confused

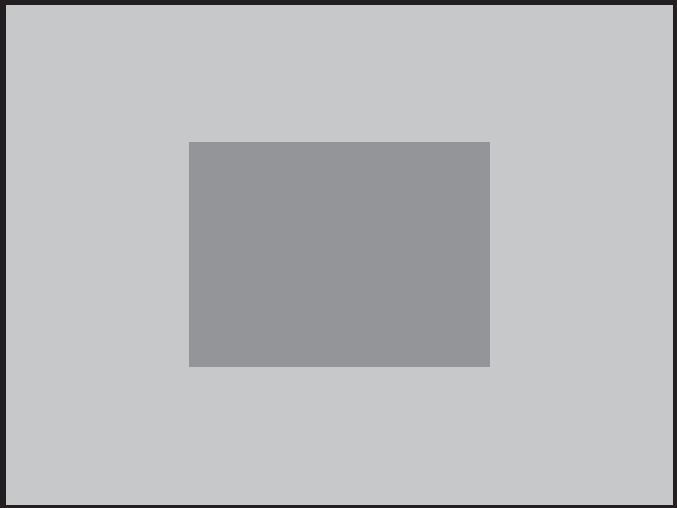

A
B

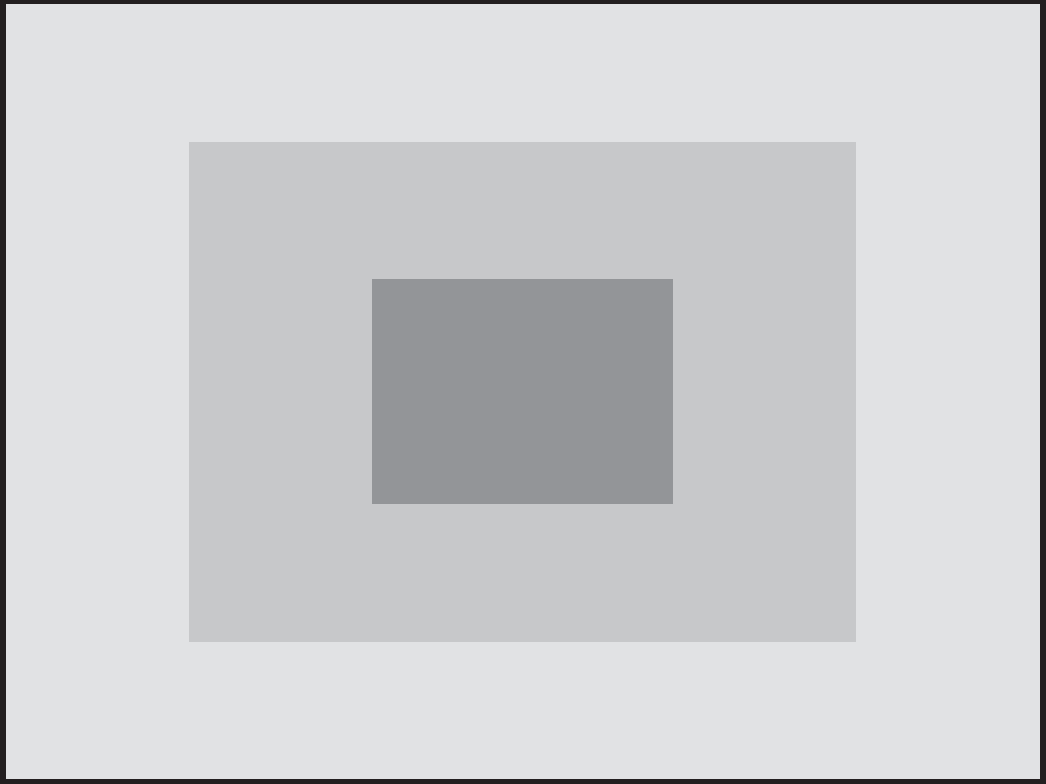

A
B

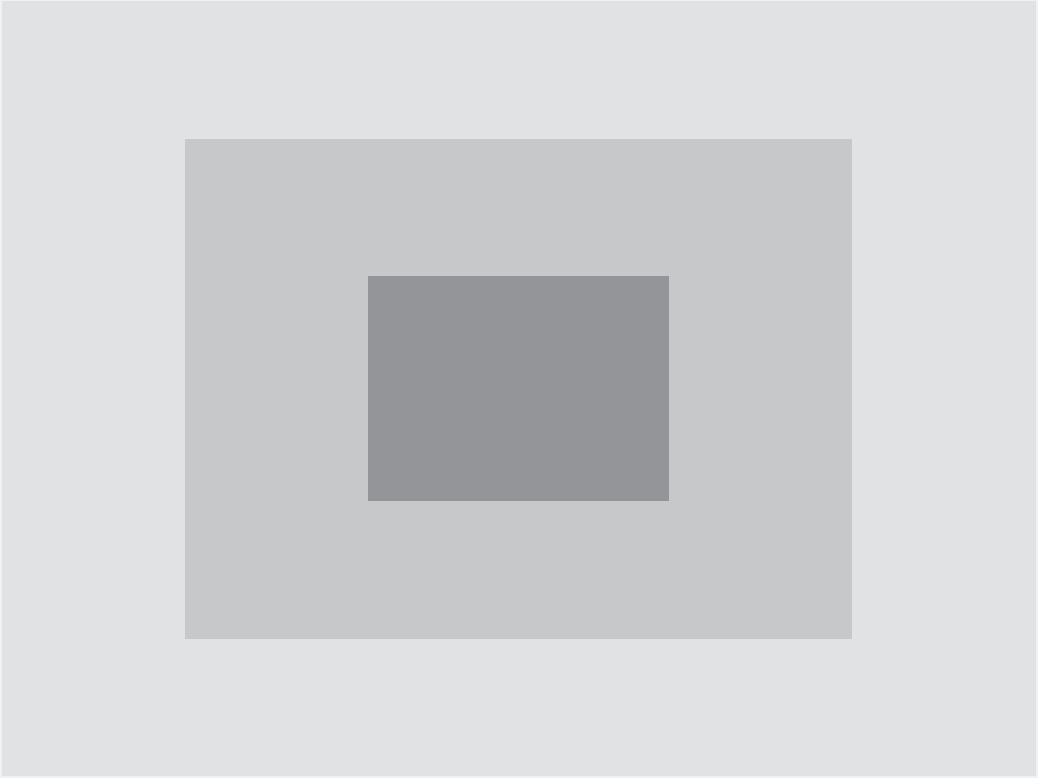

A
B



luminance = illumination + reflectance





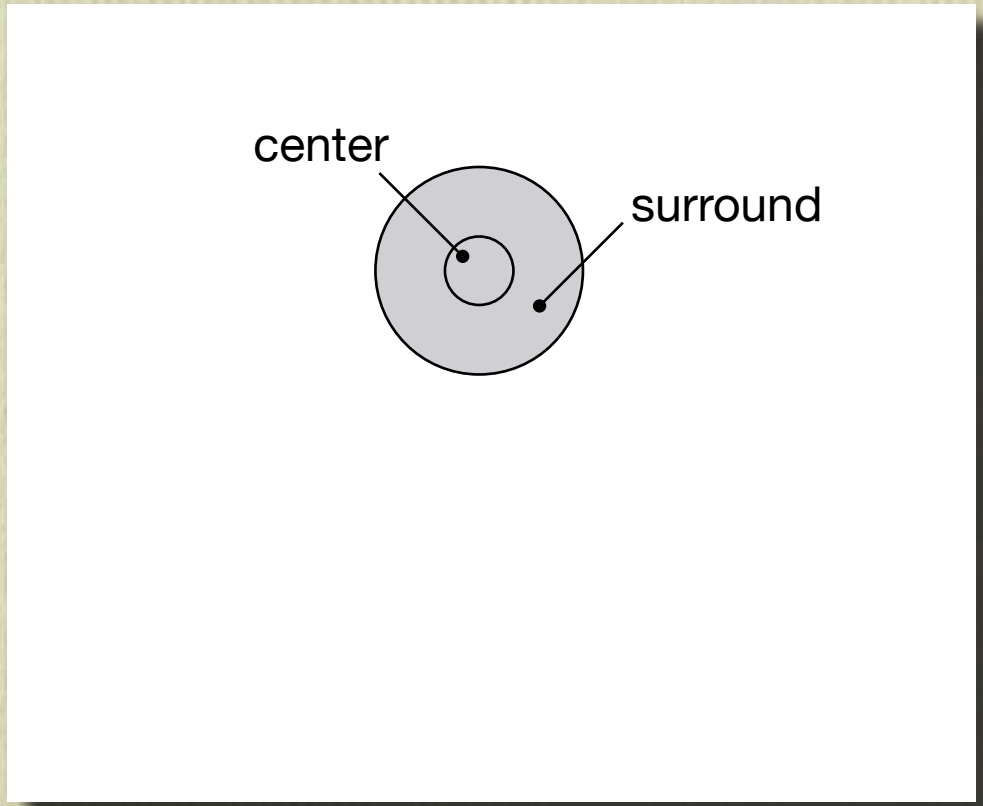


Retinal cell organization

- 10^8 receptors (rods and cones)
- 10^6 ganglion cells

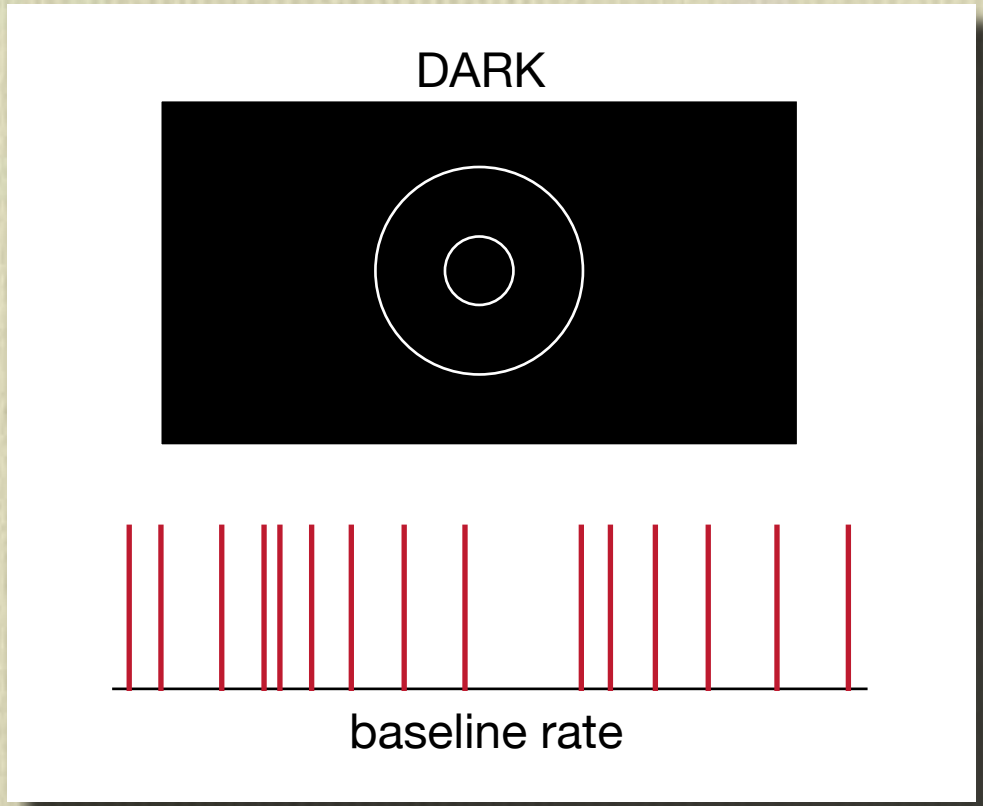
Each ganglion cell has a receptive field containing about 100 receptors

Retinal cell organization

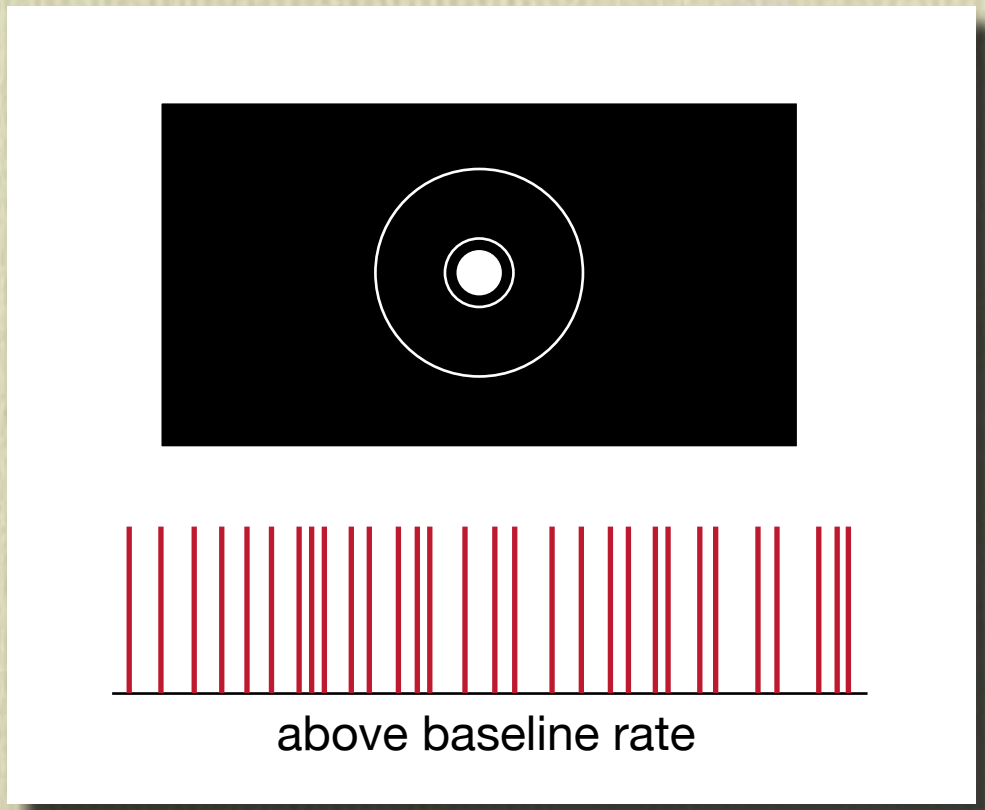


Receptive field divided into two regions

Retinal cell response

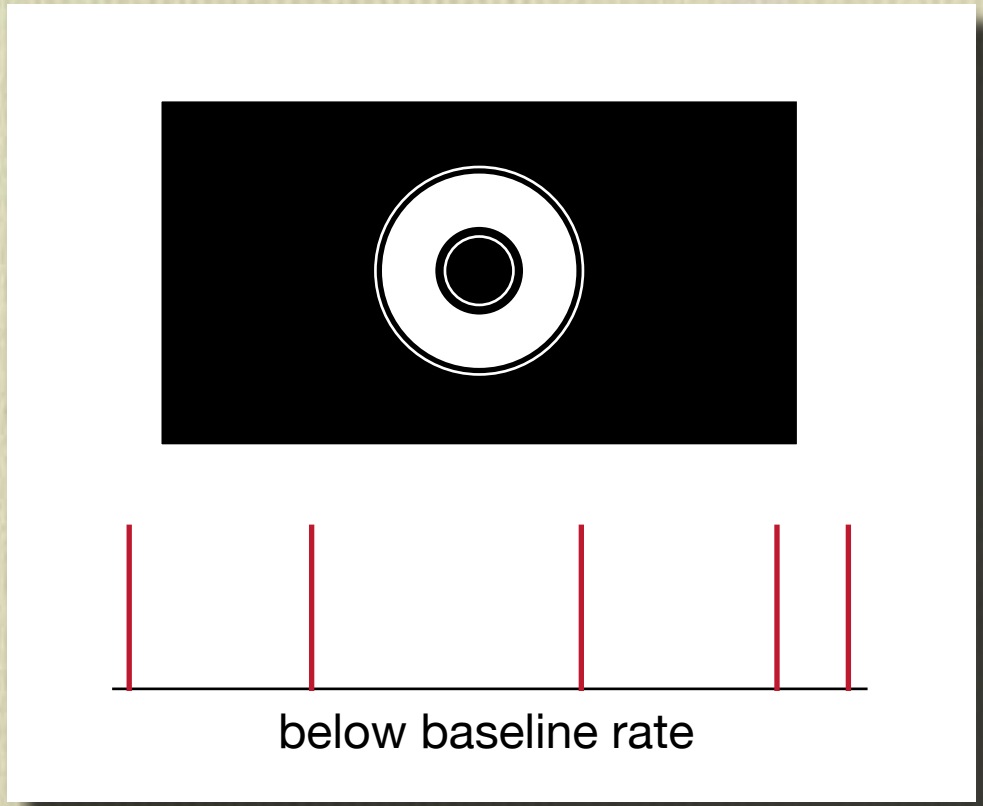


Retinal cell response



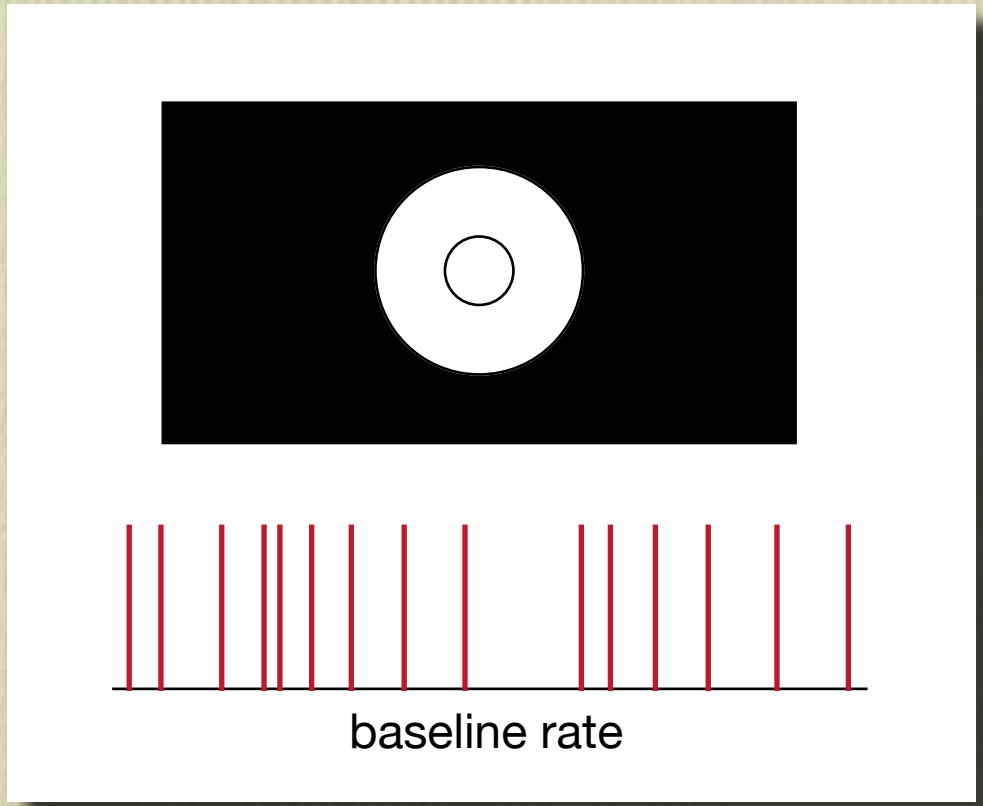
Center excites

Retinal cell response



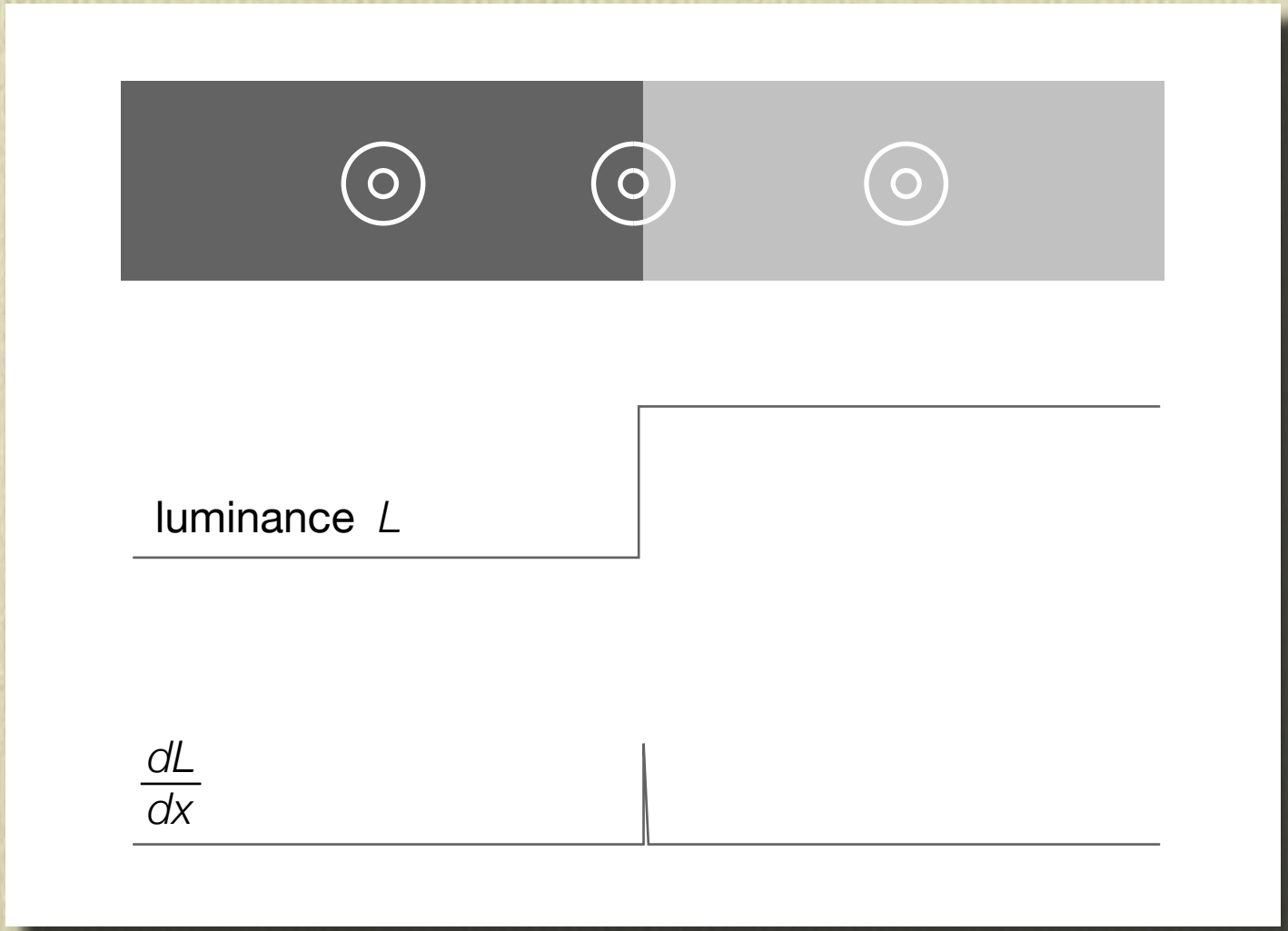
Surround inhibits

Retinal cell response

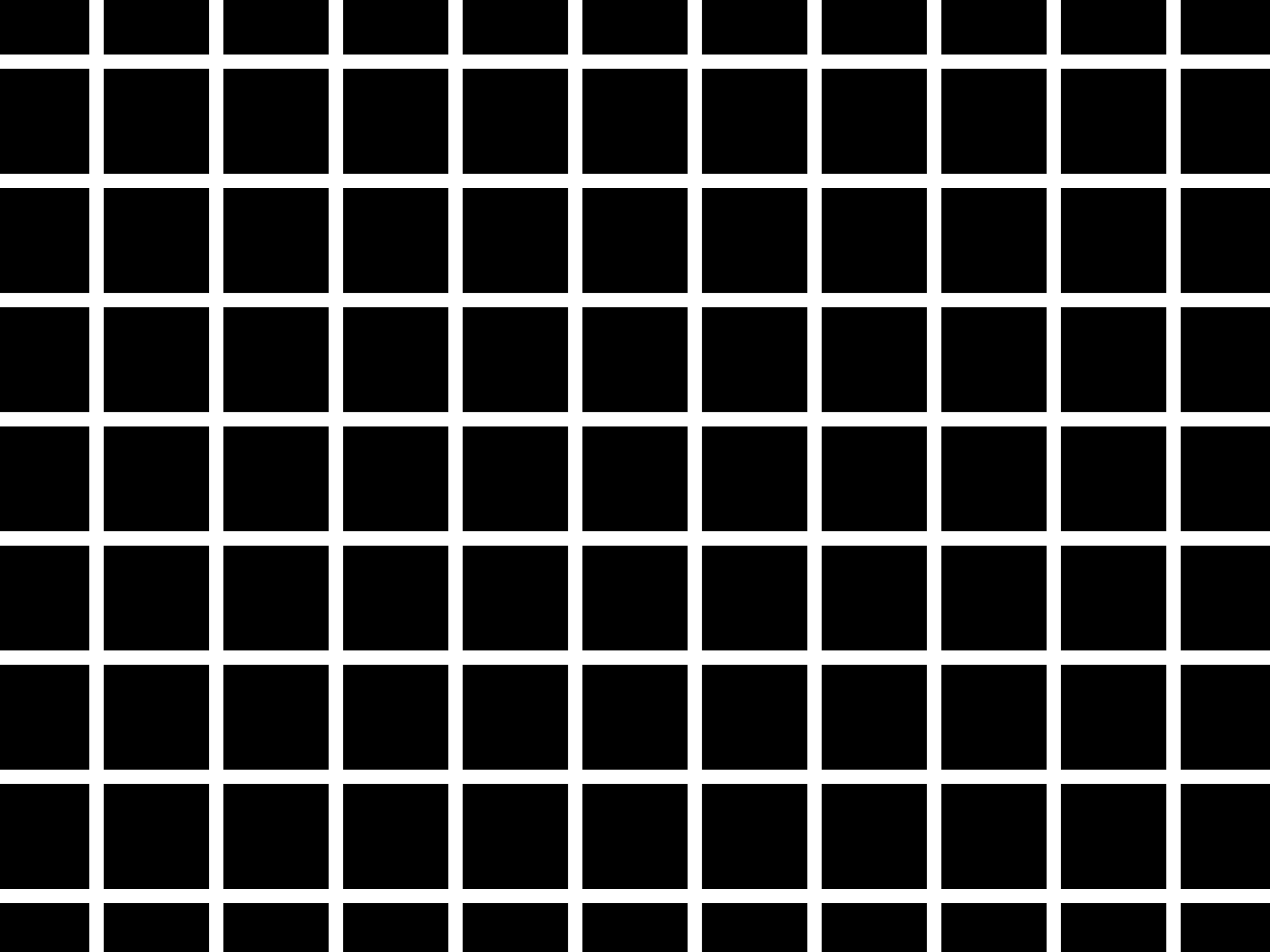


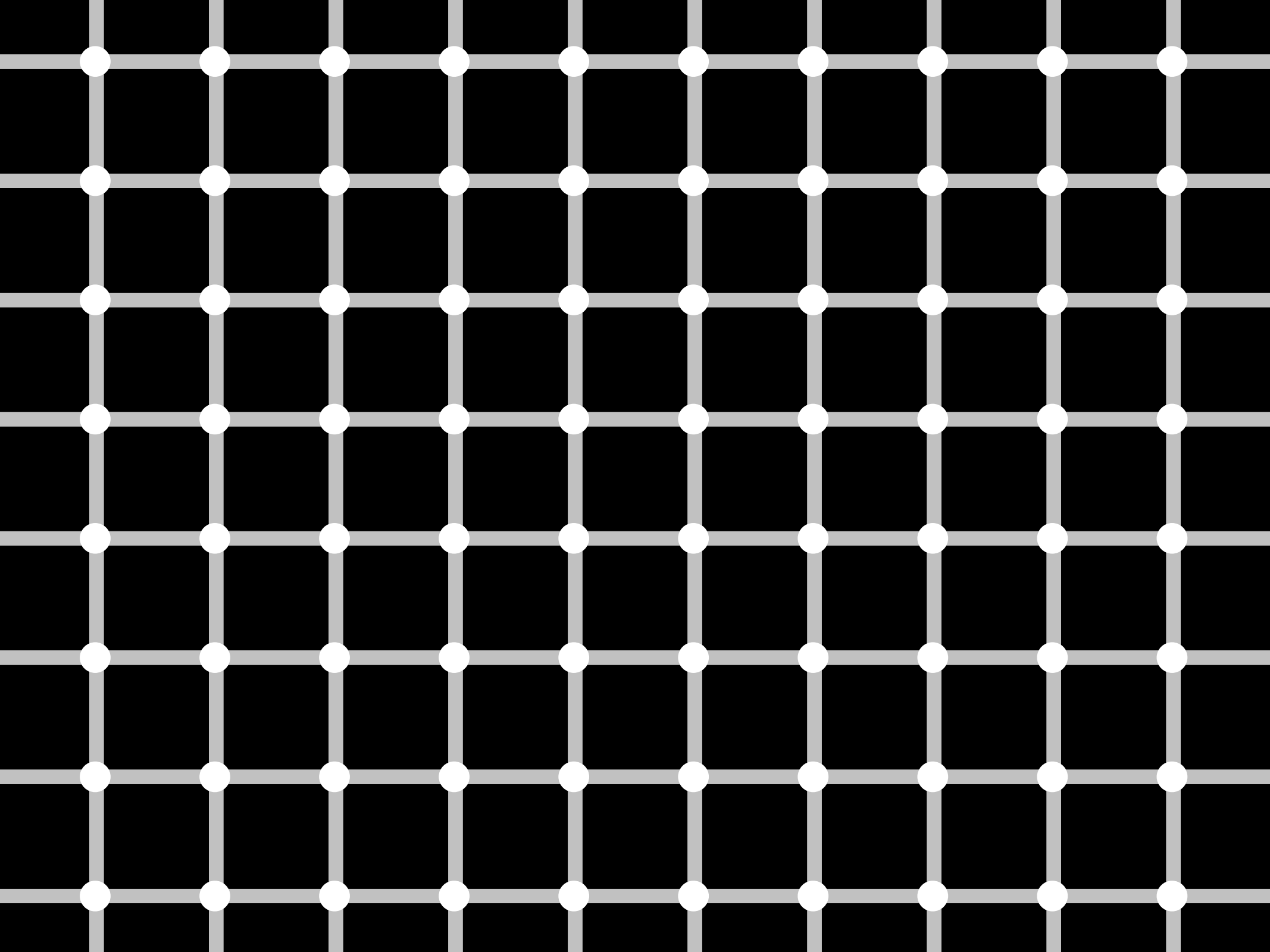
Full illumination same as no illumination

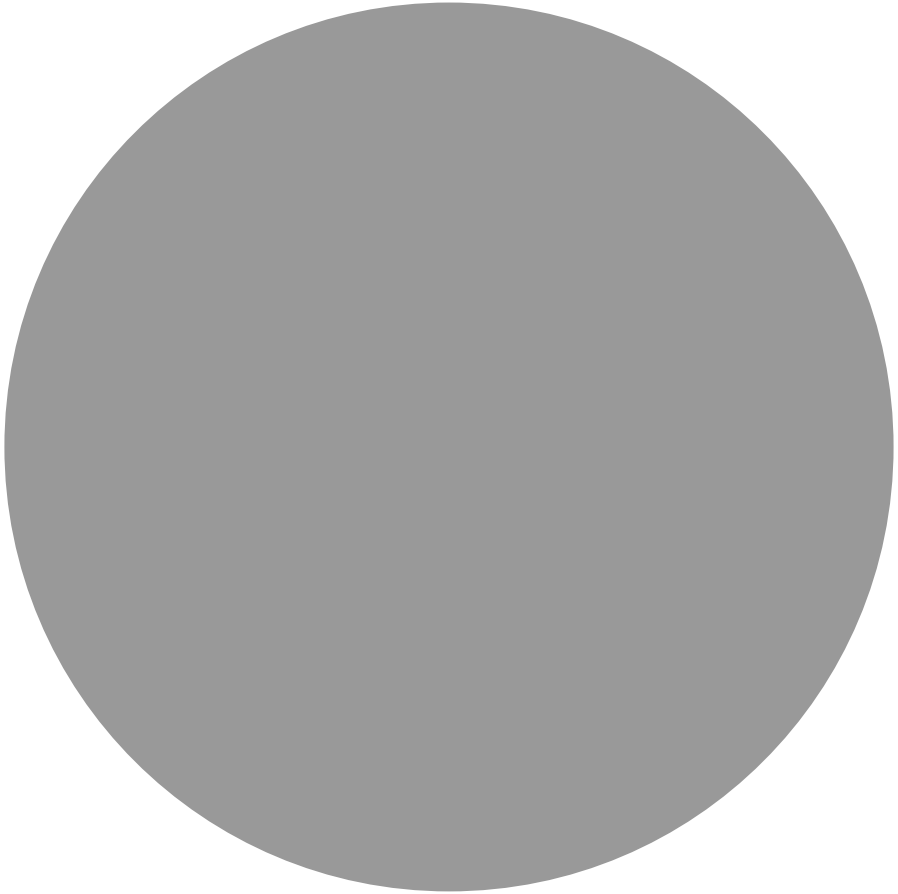
Center-surround antagonism

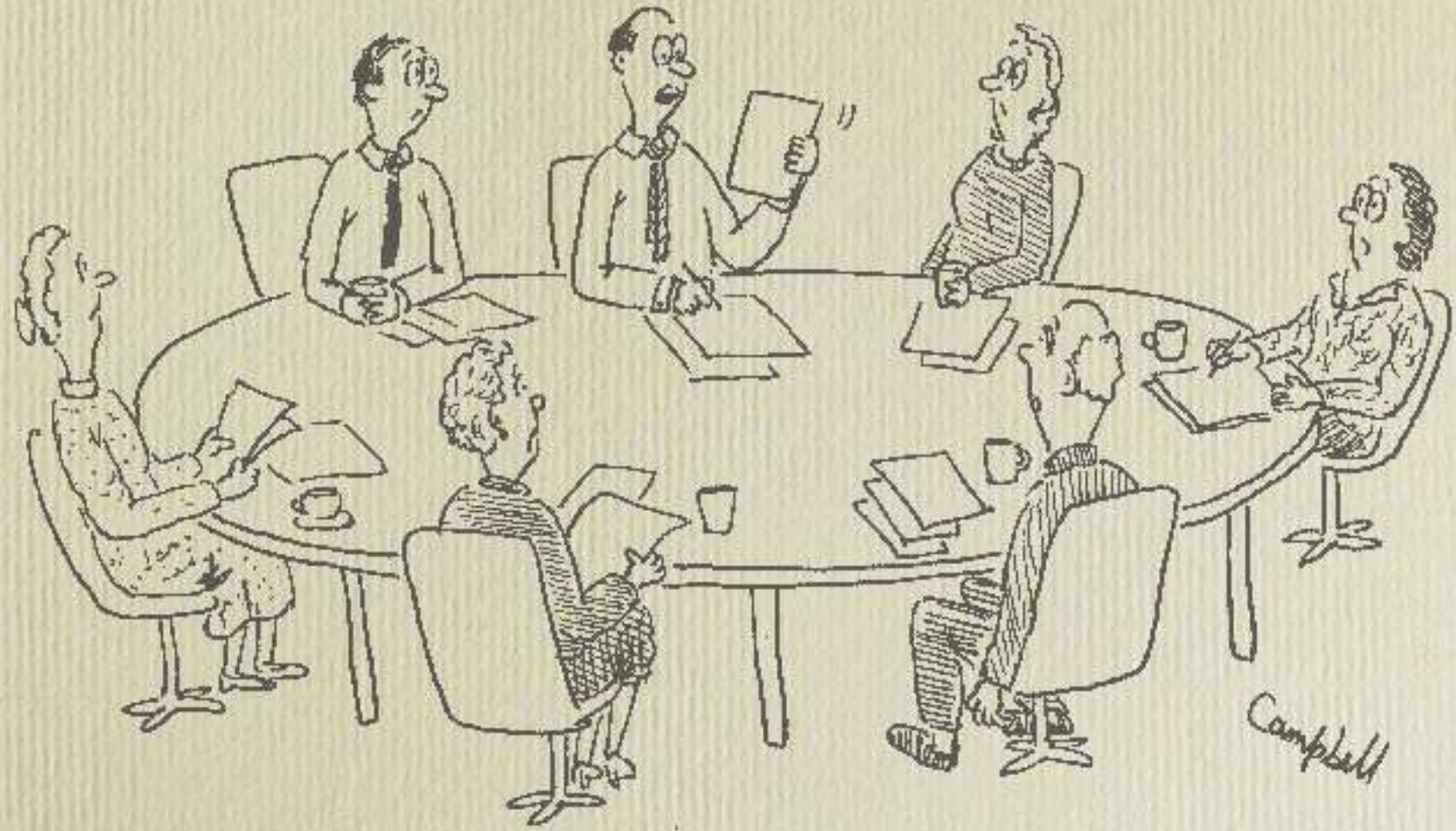


cells respond to *differences* in intensity

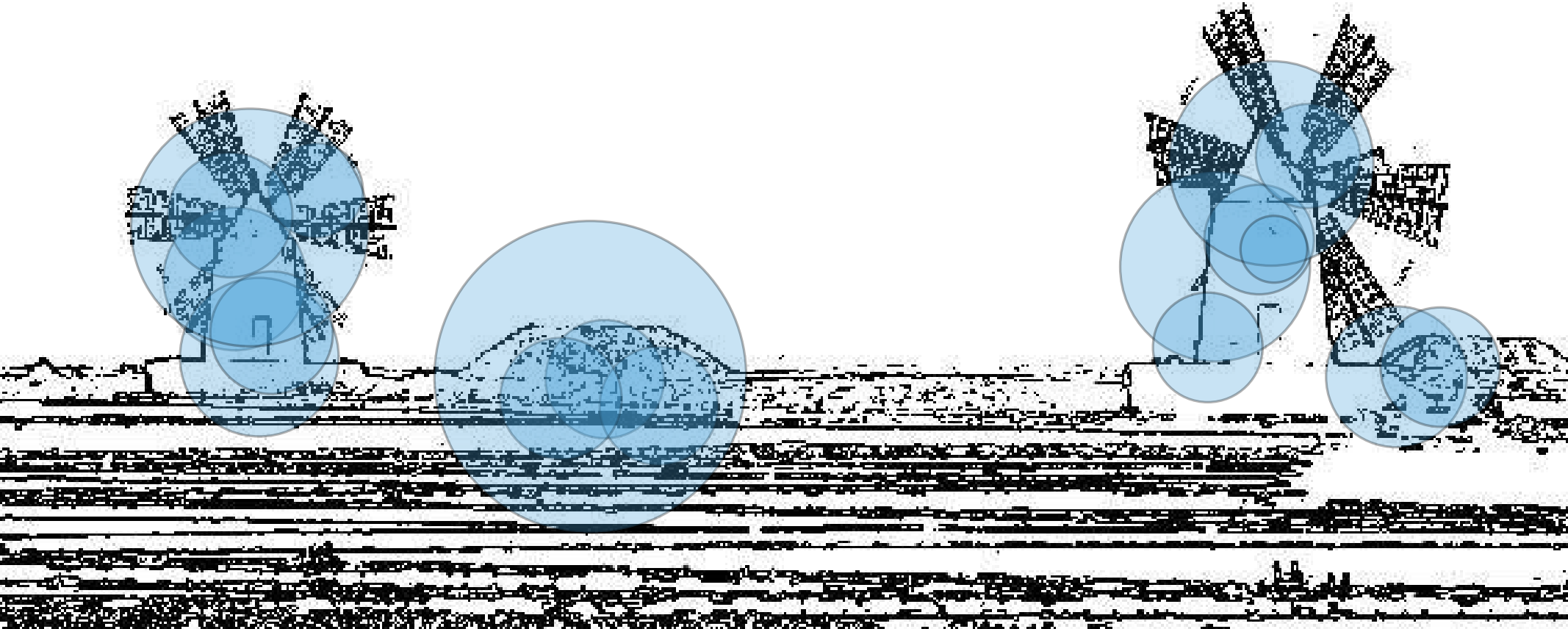







Campbell


Crayola
Crayola
Crayola
Sophie

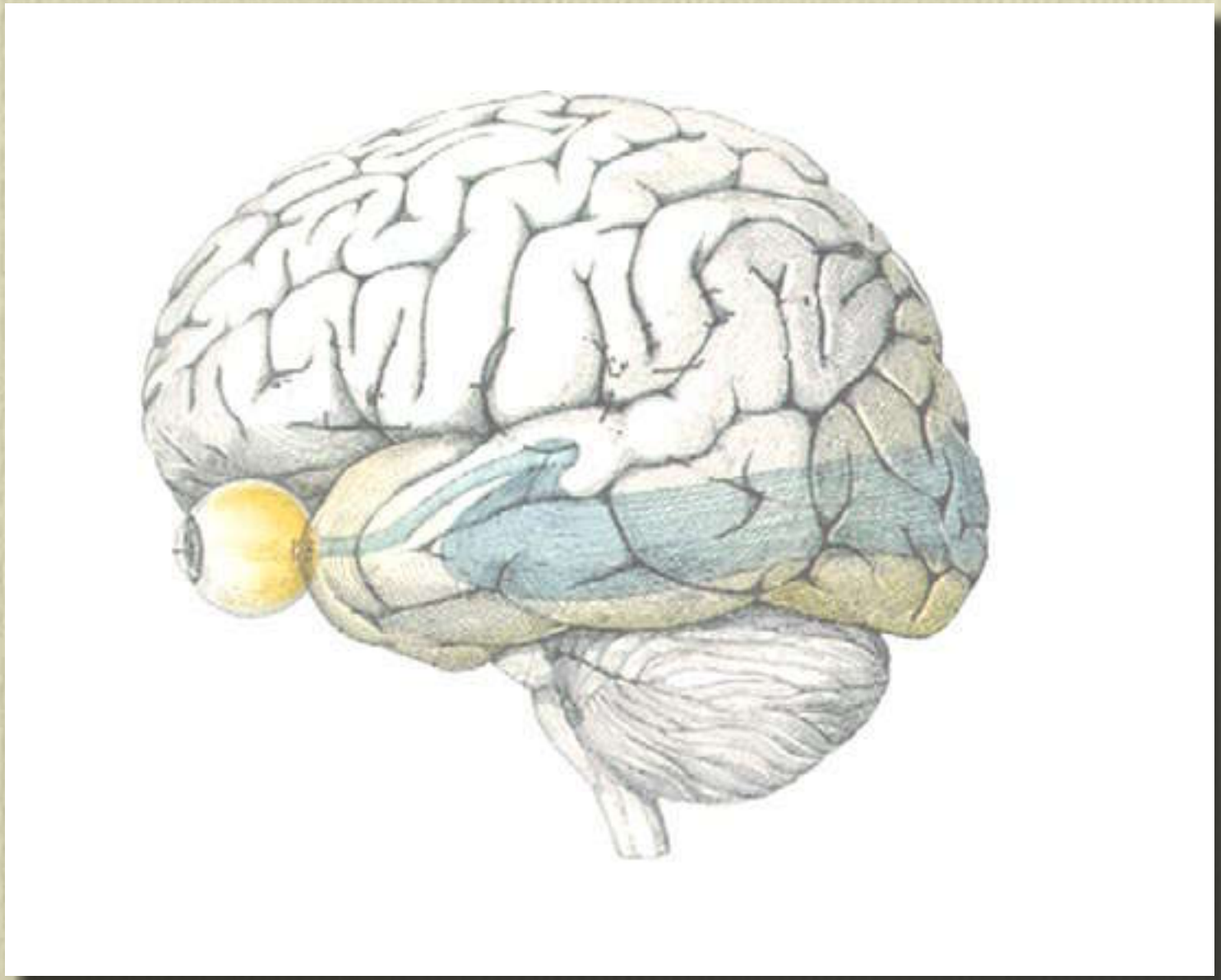


Processing of visual information

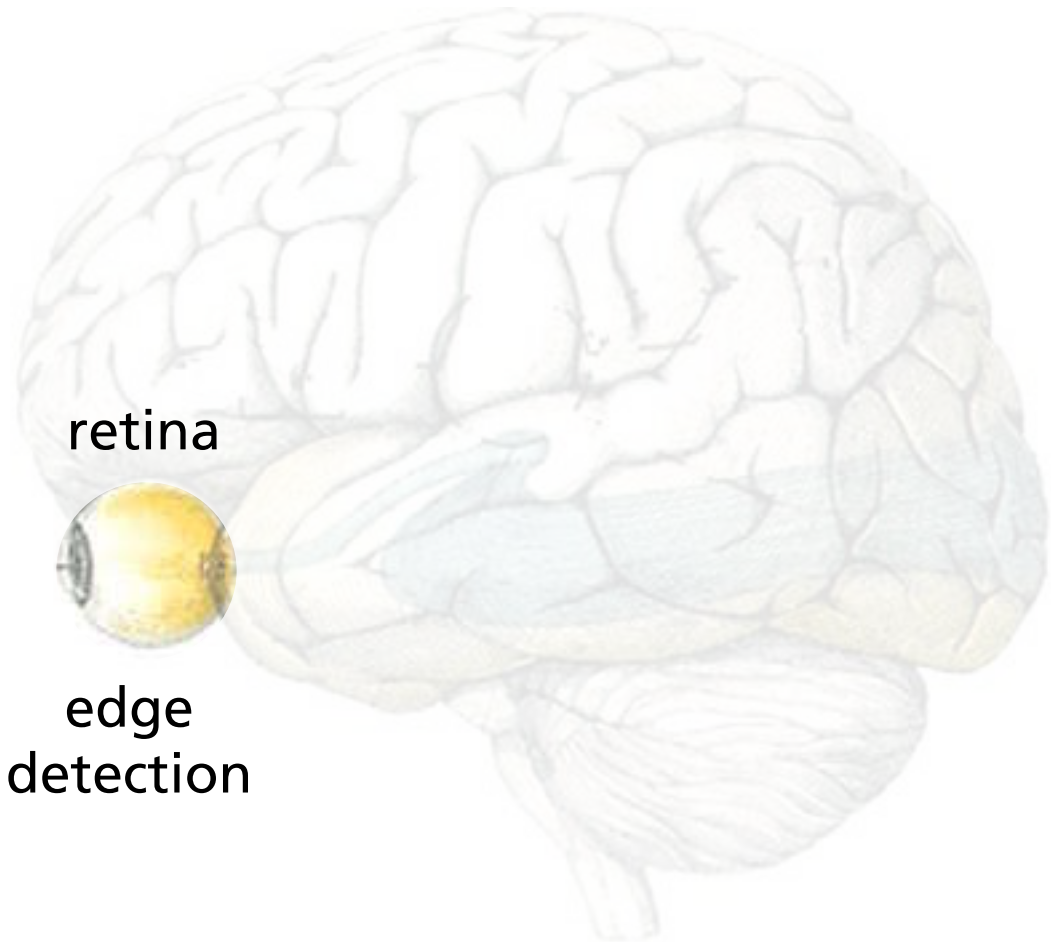
- 10^6 retinal ganglion cells
- 100 impulses/s
- that's about 10 MB/s!

How do we *do* it?

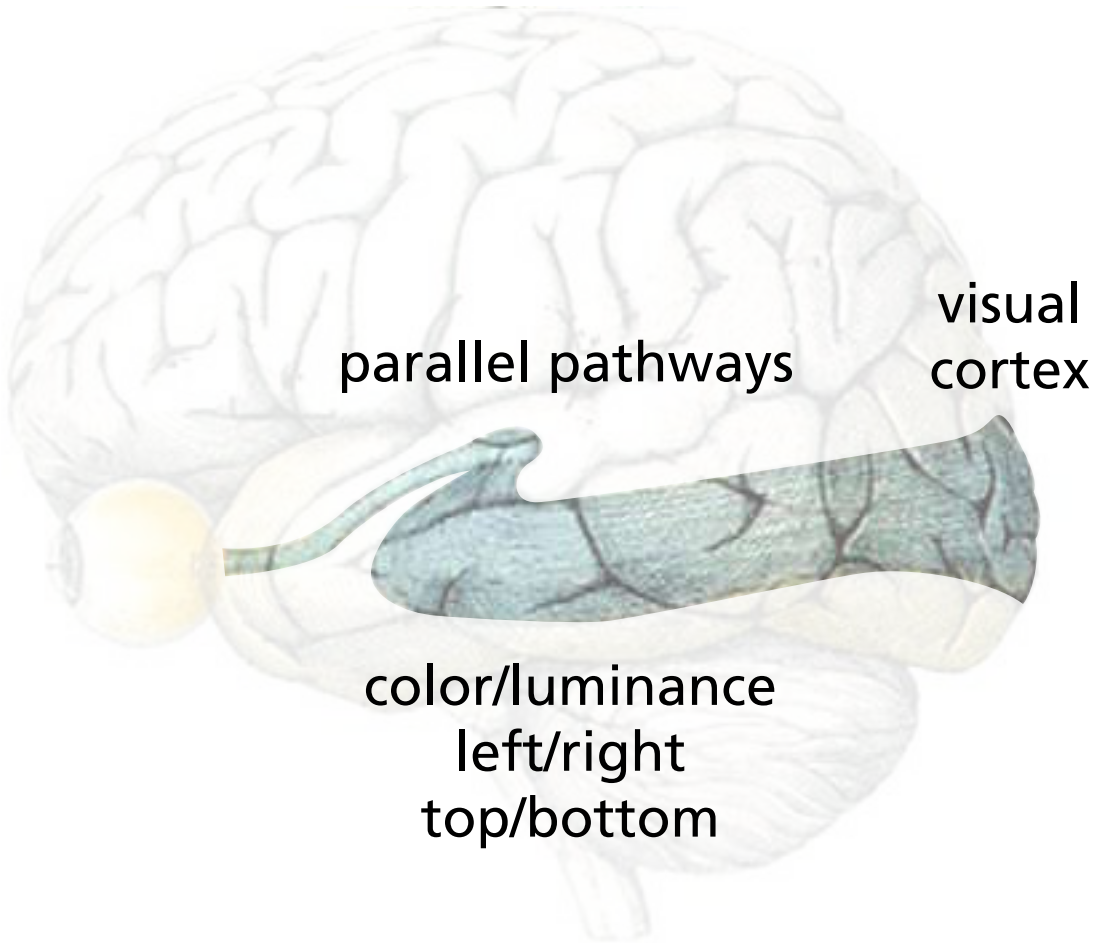
Visual pathways



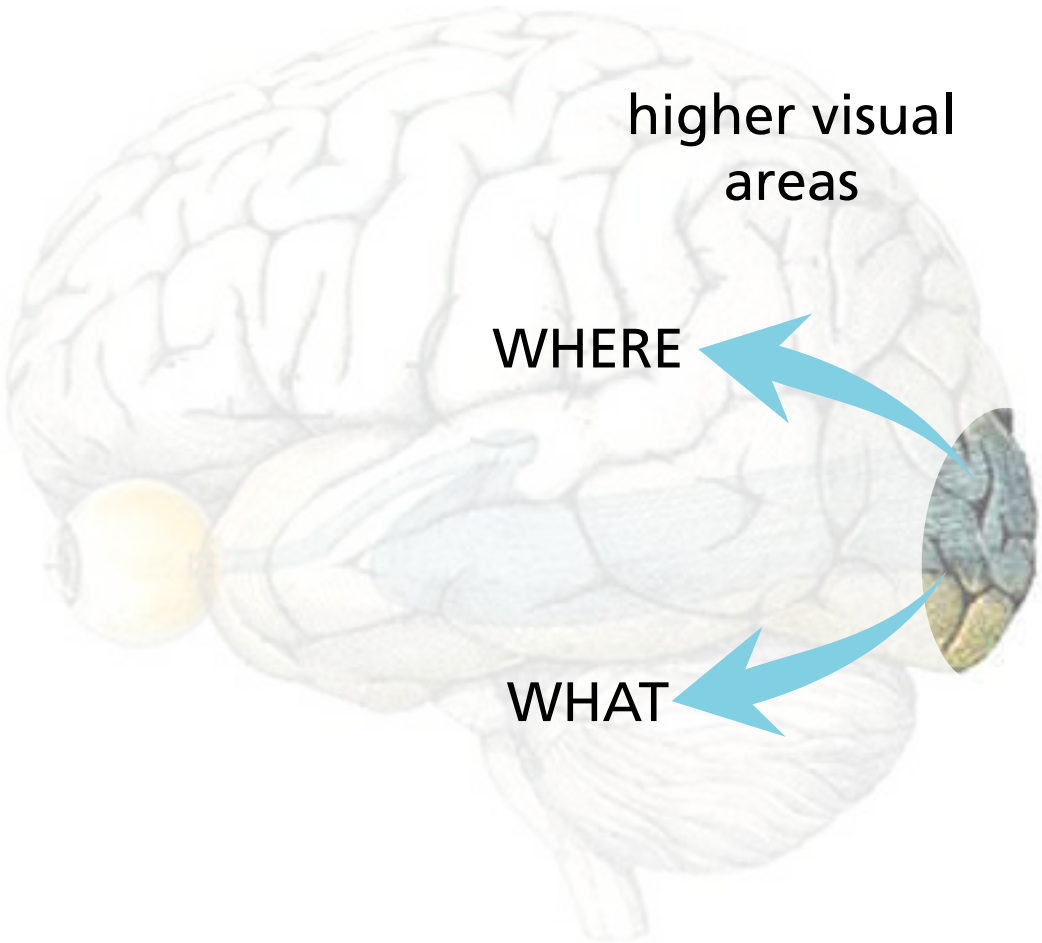
Visual pathways



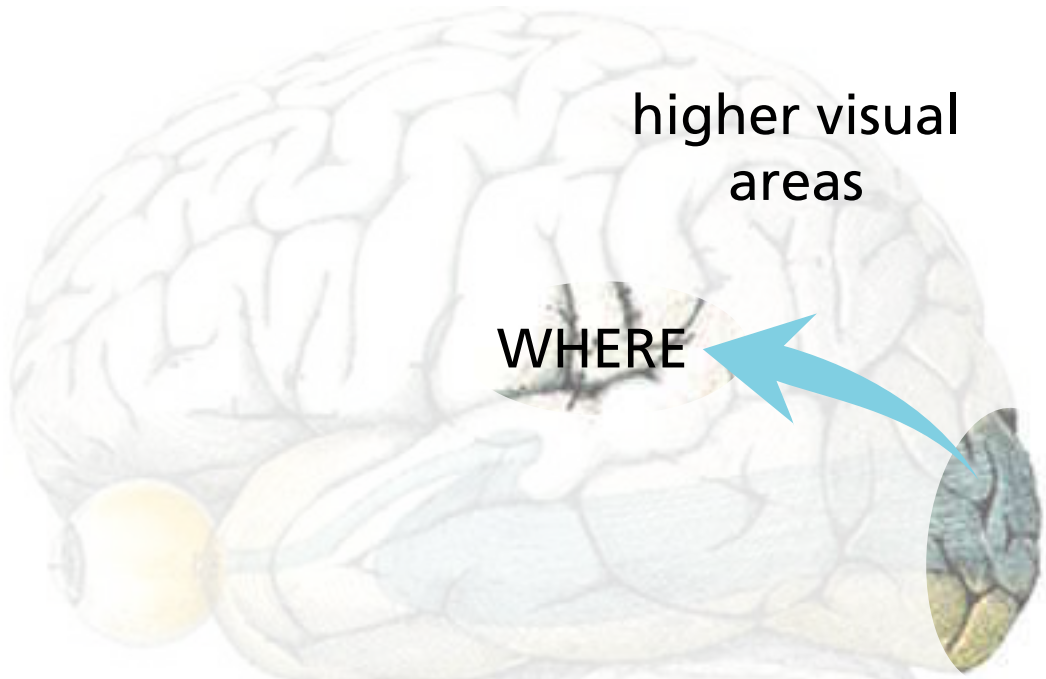
Visual pathways



Visual pathways

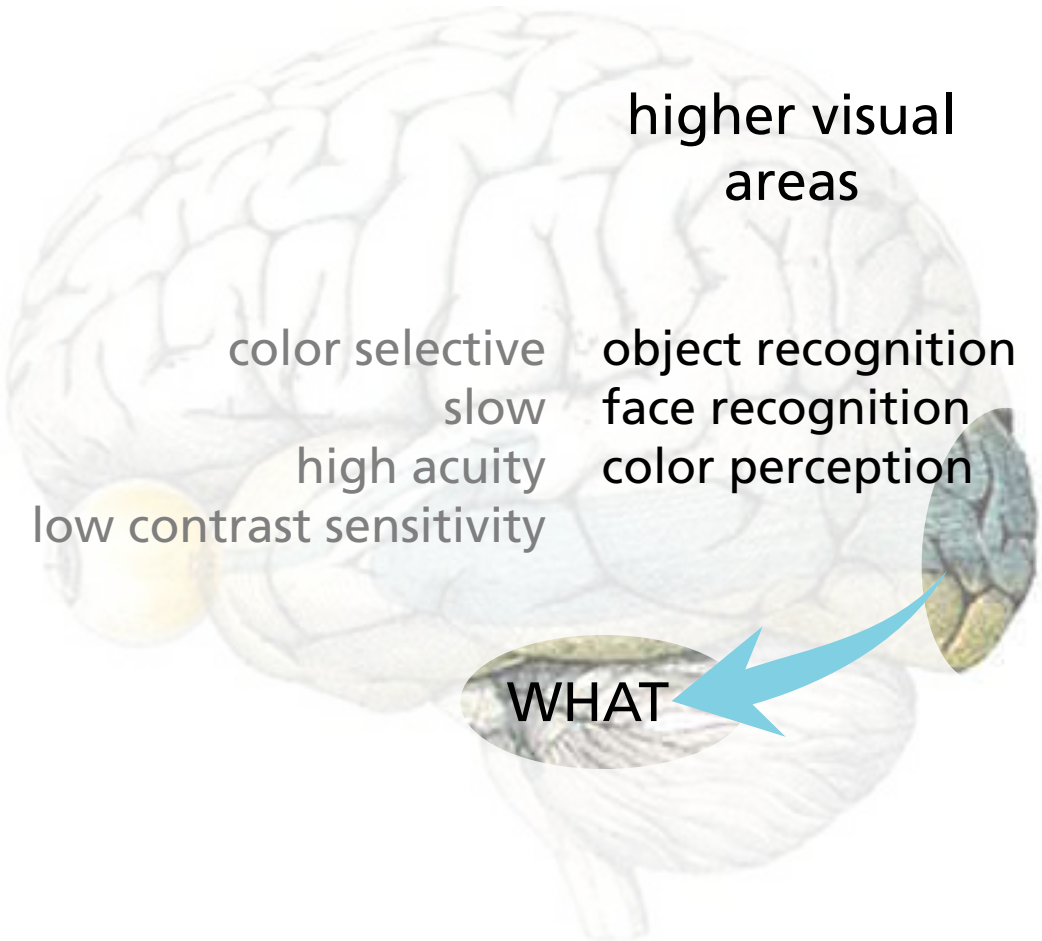


Visual pathways



color blind	motion perception
fast	depth perception
low acuity	spatial organization
high contrast sensitivity	figure/ground segregation

Visual pathways



visualization
visualization
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visualization

Some points to keep in mind

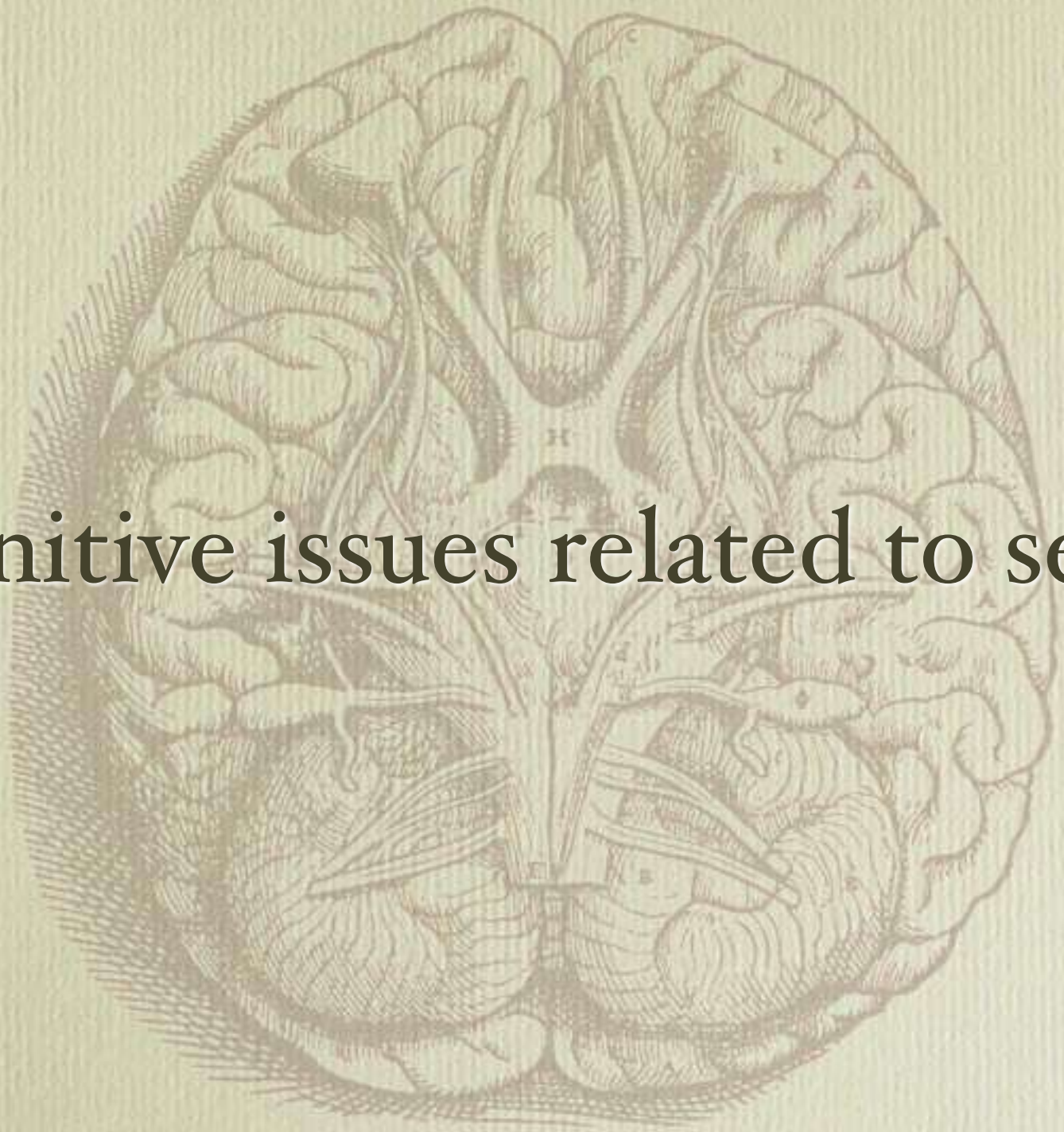
Luminance:

- depth
- motion

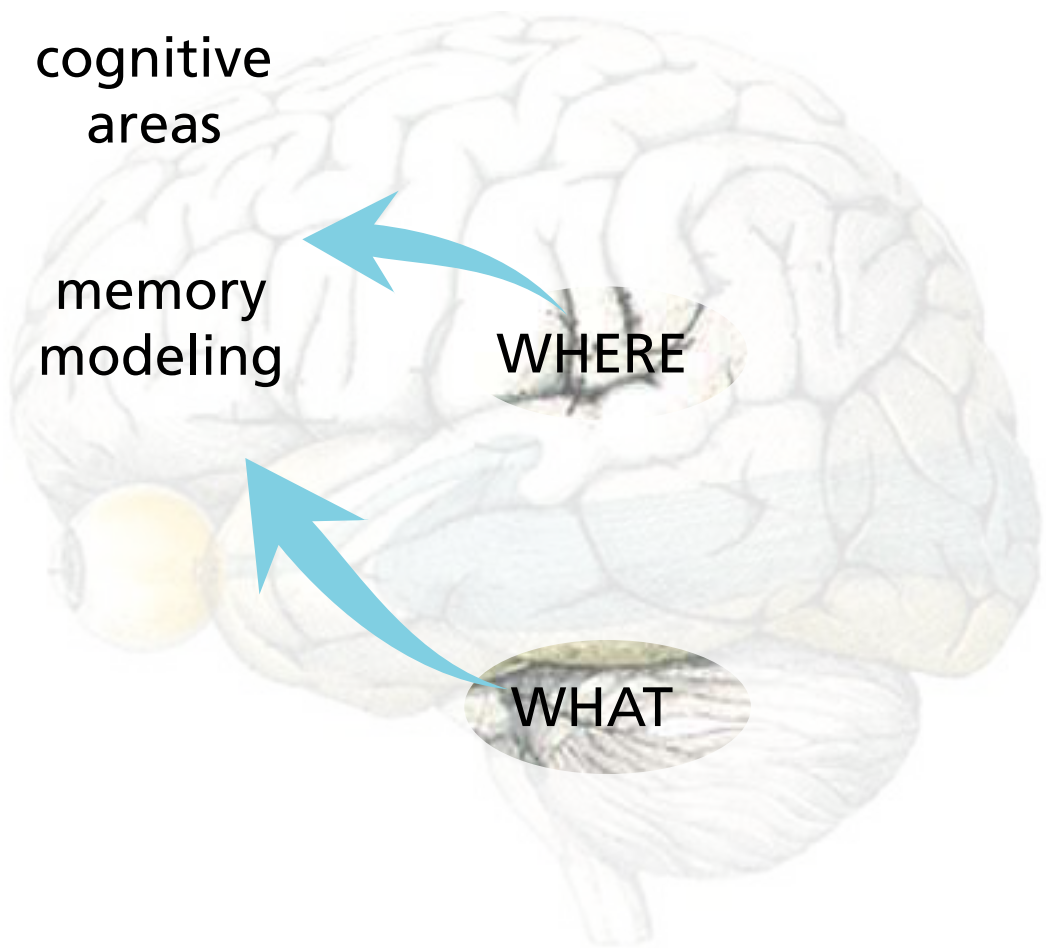
Color:

- form
- function

Cognitive issues related to seeing



Visual pathways

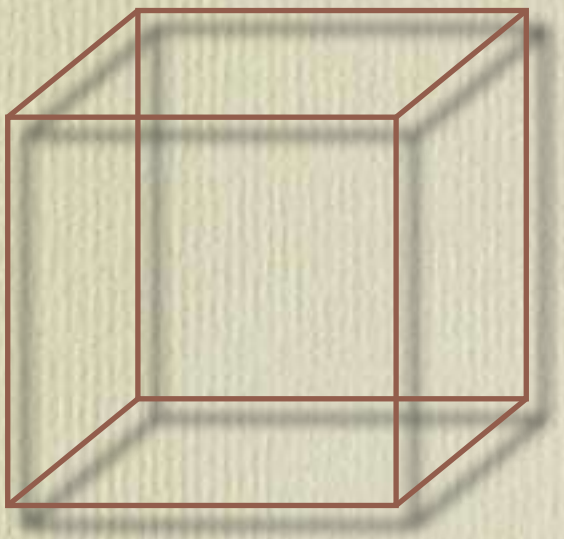


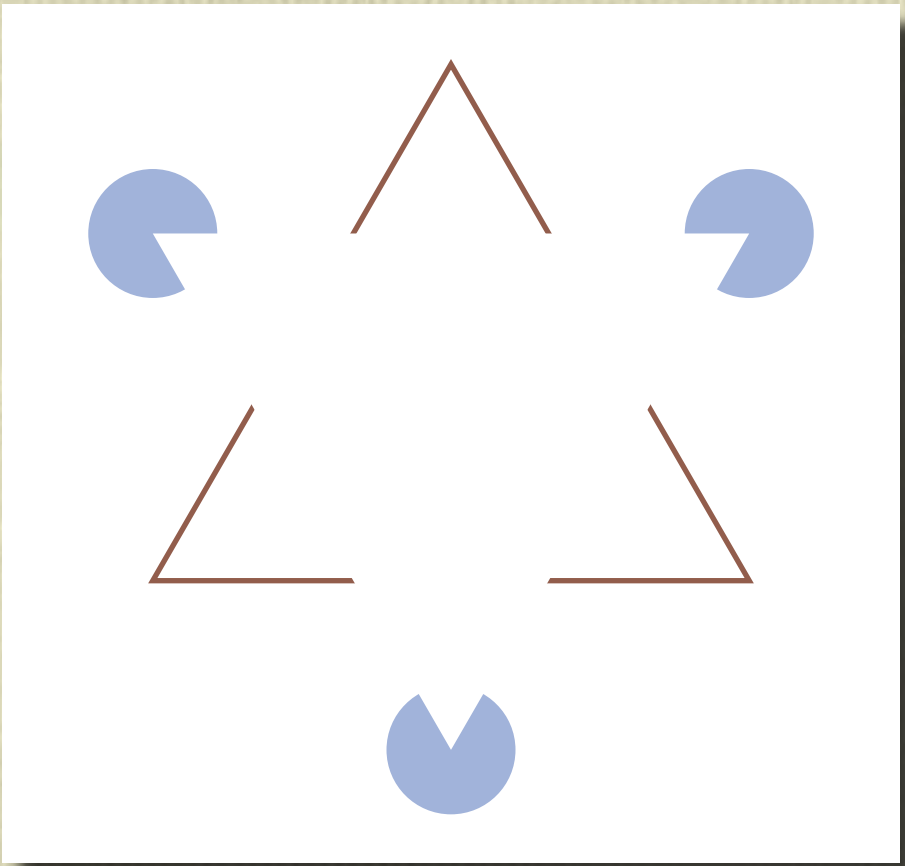
Mental models

of behavior, events, workings are essential to

- understand our experiences
- predict outcomes of our actions
- handle unexpected occurences

Mental models affect what we see



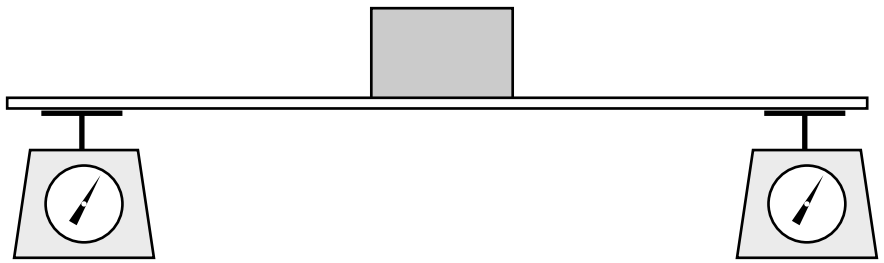


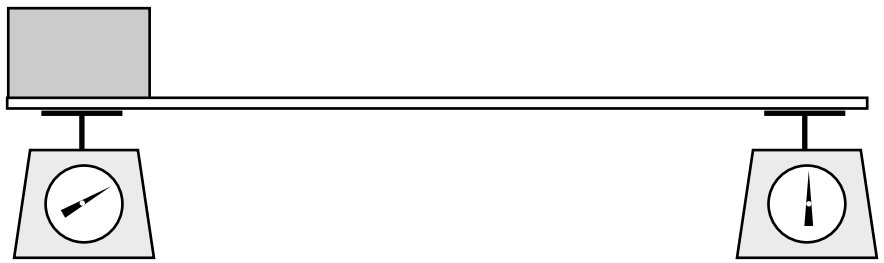
Mental tasks can prevent us from seeing

Number of passes?

A. 13 or less
B. 14
C. 15
D. 16
E. 17 or more

Mental models override visual memory





Common misconception

Plank evens out the load,
so scale reading doesn't change

Can we correct this misconception
by showing the demonstration to students?

Presenting ineffective

"As demonstrated in lecture both scales will read 10 N regardless of where the center of mass is located. The platform and the metal block form one unit that is being measured, so the scales show two evenly distributed readings, no matter where the metal block is placed along the platform."

Remember?

A. 835 6773
B. 835 7336
C. 853 7336
D. 835 7663
E. 853 6773

Remember?

A. 835 6773
B. 835 7336
C. 853 7336
D. 835 7663
E. 853 6773

Facts *vs.* models

835-7663

TEL-ROOF

Observation can *reinforce* misconception!

Must provide opportunity to revise model

How?

- Predict outcome before observation
- Record observation
- Reconcile prediction with observation

Points to keep in mind

- Mental models affect what we see
- Mental tasks can prevent us from seeing
- Mental models override visual memory

Some things for you to ponder

- My reality is not your reality
- What you see depends on what you believe
- We store models, not facts

Acknowledgments

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Dr. Veronica McCauley
Dr. Wolfgang Rueckner
Prof. Daniel Simons (Cornell)

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