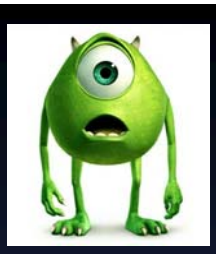
ITS 102: Visualize This!



Lecture 1: The Visual System

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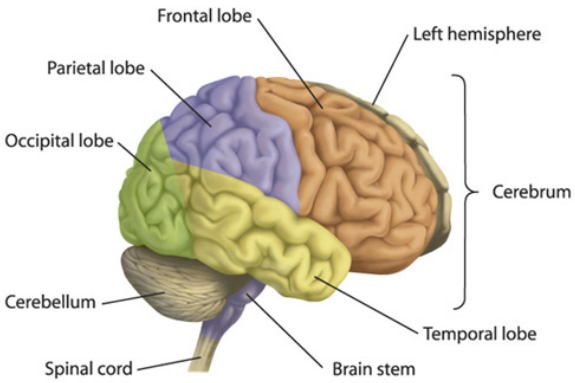
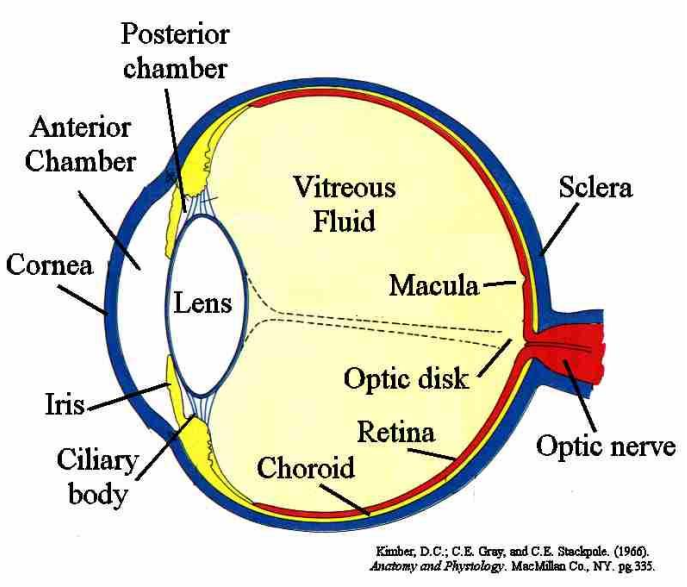
The Visual Brain

Over 50% of the human brain is dedicated to vision and visual representations,

- decoding visual information
- high-level processing of visual information
- thinking with visual metaphors



Input Device: The Eye



Kimber, D.C.; C.E. Gray, and C.E. Stackpole. (1966). *Anatomy and Physiology*. MacMillan Co., NY. pg.335.

Sensor: The Cones and Rods

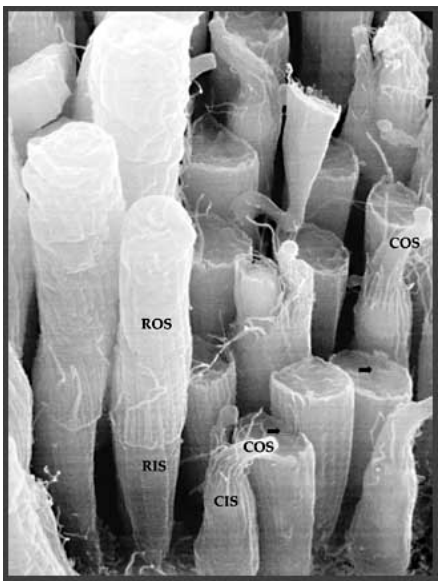
Two types of receptors on retina:
rods and *cones*

Rods:

- spread all over the retinal surface (75 - 150 million)
- low resolution, no color vision, but very sensitive to low light (*scotopic* or dim-light vision)

Cones:

- a dense array around the central portion of the retina, the fovea centralis (6 - 7 million)
- high-resolution, color vision, but require brighter light (*photopic* or bright-light vision)



Wiring: The Visual Pathways

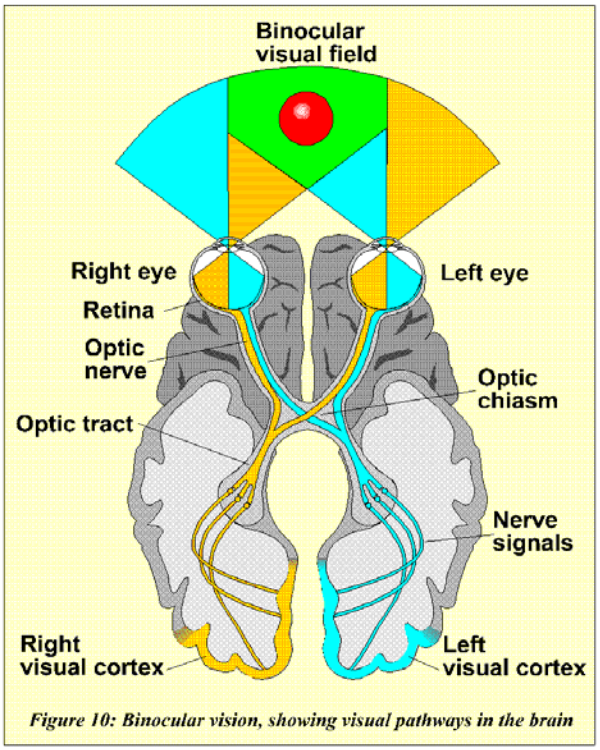
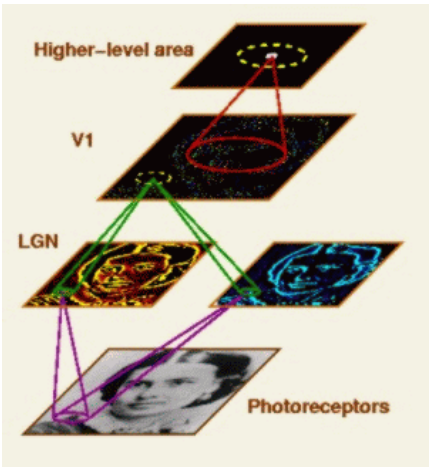


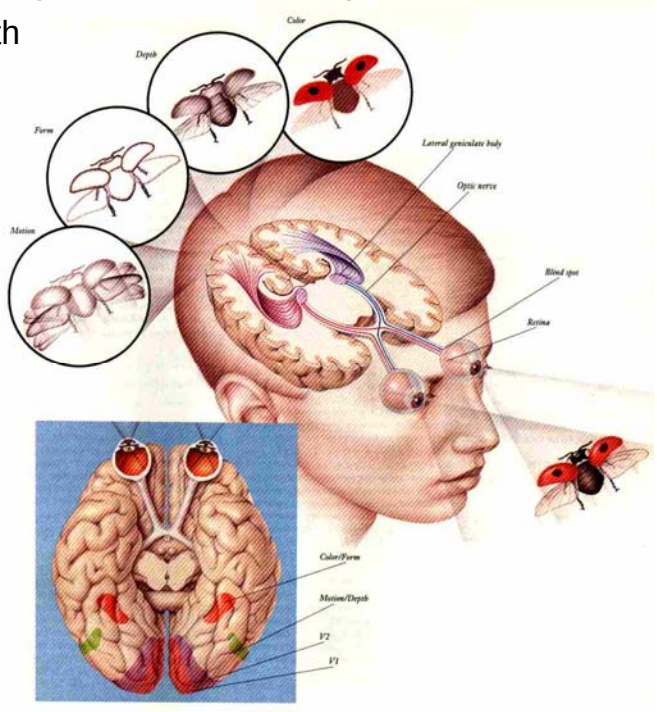
Figure 10: Binocular vision, showing visual pathways in the brain

Processing Unit: The Visual Cortex (V1, V2)

Visual cortex breaks input up into different aspects:

- color, shape, motion, depth

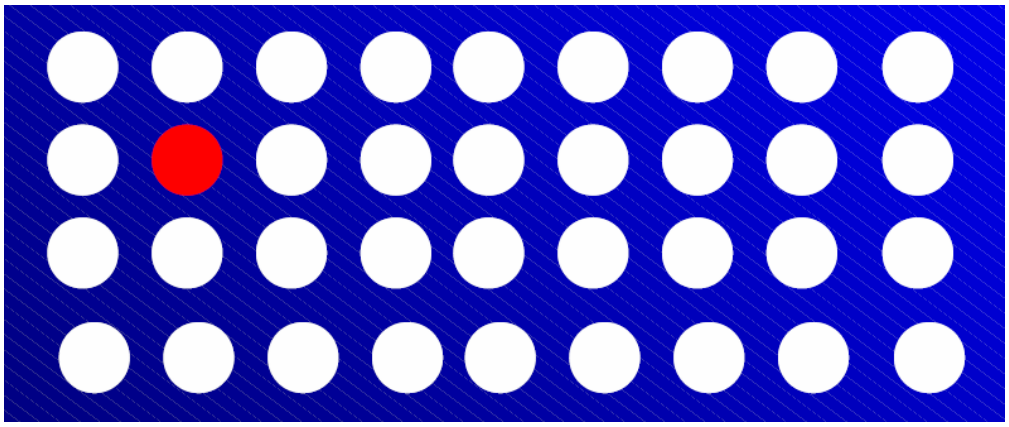




Pre-Attentive Processing

If you want it or not: some features are always detected

And fast – within 200 ms or less



Pre-Attentive Processing

Why is it so fast?

Well, because 50% of the brain is dedicated to vision

Vision is a MASSIVELY parallel processor dedicated to

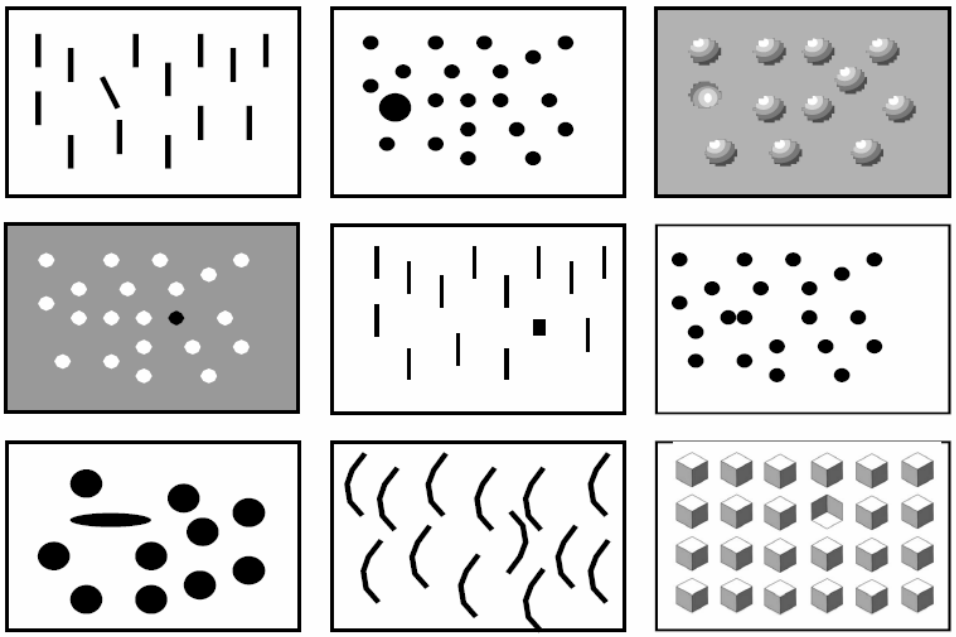
- detect
- analyze
- recognize
- reason with

visual input

Pre-Attentive Processing

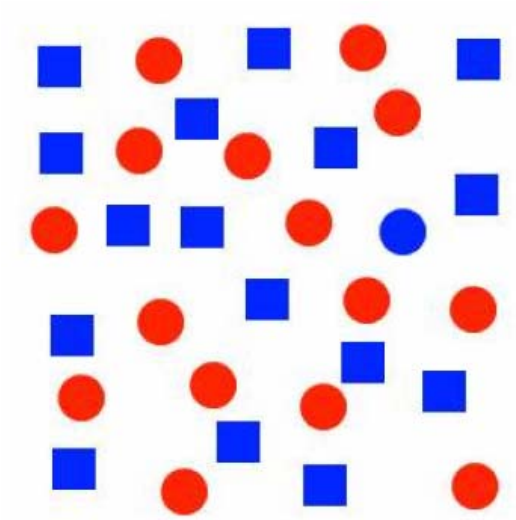
Sensitivity to differences in:

- color, orientation, size, shape, motion, shading, 3D depth, …



Pre-Attentive Processing

But there are limits: conjunctions don't work well



quick: find the blue circle

Pre-Attentive Processing

Some features/cues are stronger than others:

Pre-Attentive Processing

Words are patterns, which form strong pre-attentive feature

- this would have been different if this had been done in Arabic

There are limits, however

- let's see the next experiment

Pre-Attentive Processing

Reading 1

Aoccdrnig to a rscheearch at an Elingsh uinervtisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht frist and lsat ltteer is at the rghit pclae. The rset can be a toatl mses and you can sitll raed it wouthit porbelm. Tihs is bcuseae we do not raed ervey lteter by it slef but the wrod as a wlohe

Pre-Attentive Processing

Now, is tihs ture? Raed on….

Pre-Attentive Processing

Reading 2

Anidroccg to crad cniyrrag lcitsiugnis planoissefors at an uemannd, utisreviny in Bsitirh Cibmuloa, and crartnoy to the duoibus cmials of the ueticnd rcraeseh, a slpmie, macinahcel ioisrevnn of ianretnl cretcarahs araepps sneiciffut to csufnoe the eadyrevy oekoolnr

Pre-Attentive Processing

Reading 2

According to card carrying linguistics professionals at an unnamed, university in British Columbia, and contrary to the dubious claims of the uncited research, a slpmie, macinahcel ioisrevnn of ianretnl cretcarahs araepps sneiciffut to csufnoe the eadyrevy oekoolnr

Pre-Attentive Processing

Reading 2

According to card carrying linguistics professionals at an unnamed, university in British Columbia, and contrary to the dubious claims of the uncited research, a simple, mechanical inversion of internal characters appears sufficient to confuse the everyday onlooker

What To Learn From This

The human visual system (HSV) tolerates (visual) noise very well

- it can read the randomly garbled text very well
- machines (equipped with computer vision) are poor at this

Humans have only limited computational capacity

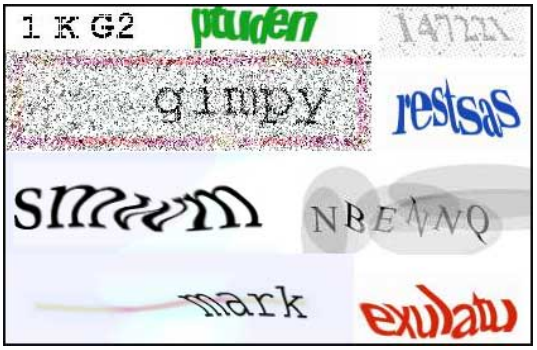
- hard to execute a fixed rule to decipher text
- especially once the text gets longer (7±2 rule of working memory)
- this is where computers excel

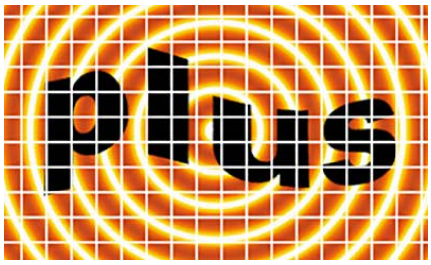
The fact that computers deal poorly with noisy patterns is exploited in CAPTCHA

- **CAPTCHA: C**ompletely **A**utomated **P**ublic **T**uring Test to tell **C**omputers and **H**umans **A**part
- used to ensure that an actual human is interacting with a system
- some examples:
  - creating a new gmail or yahoo account (prevent spammer accounts)
  - submitting files, data, email

CAPTCHA

CAPTCHA: noisy and vastly distorted patterns that are difficult to recognize by machines





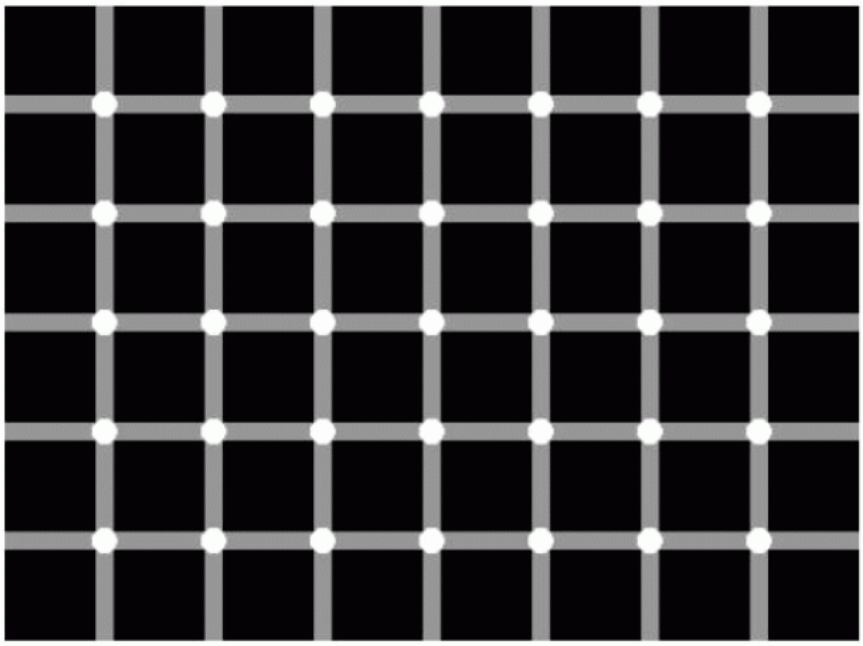
CAPTCHA

But computer vision algorithms have become more sophisticated at CAPTCHA *character* recognition

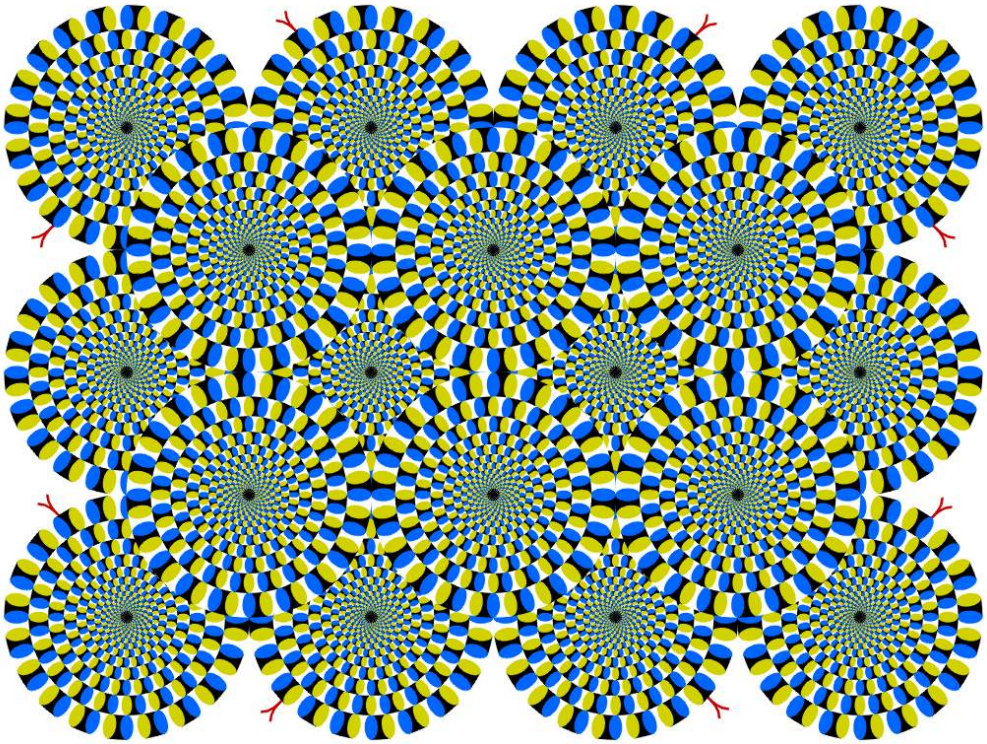
- the latest approach is *object* recognition

Pre-Attentive Processing

Count the black dots!

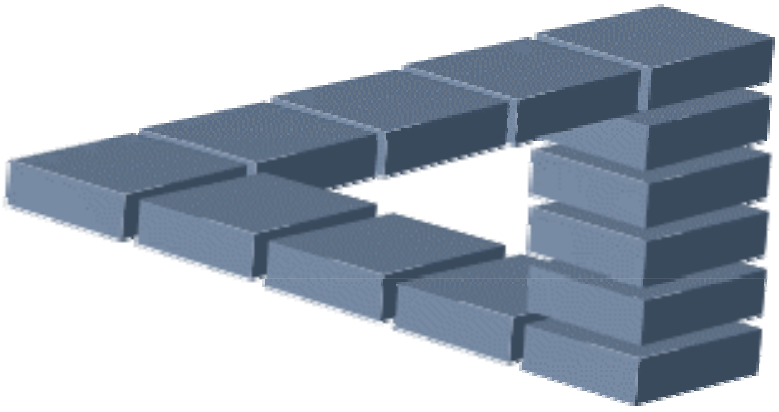


Pre-Attentive Processing

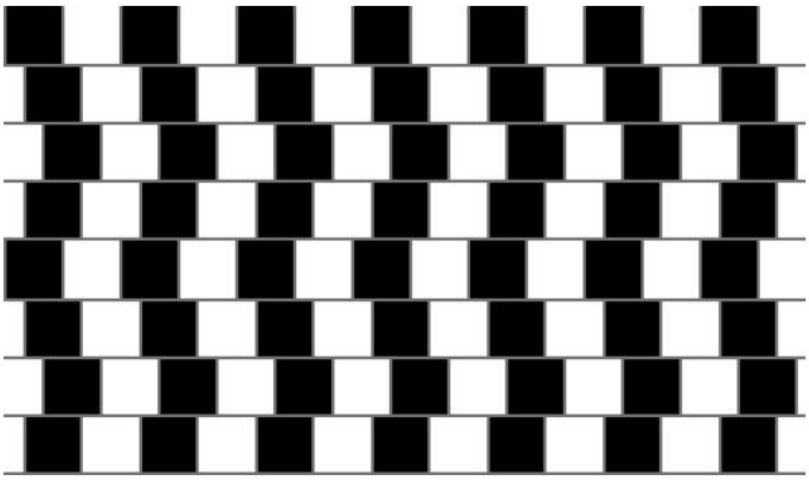


More Optical Illusions

Optical Illusions

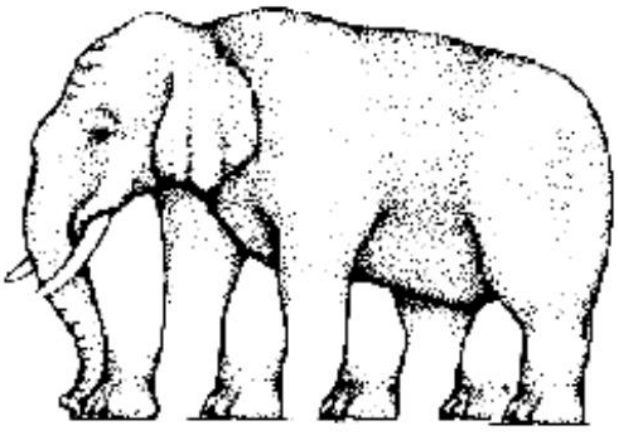


Optical Illusions



Are the horizontal lines parallel or do they slope?

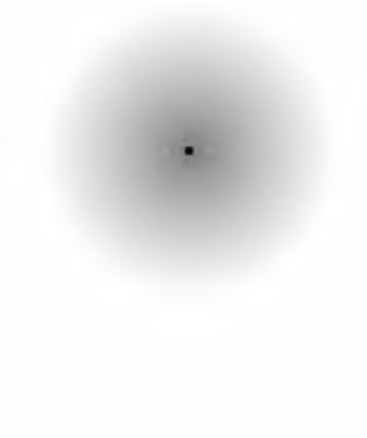
Optical Illusions



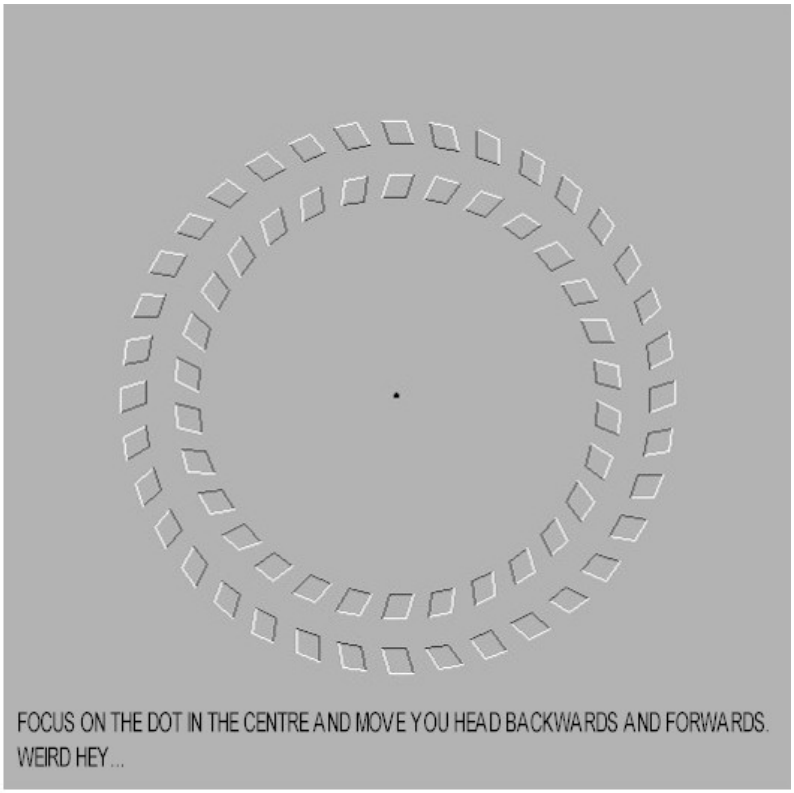
How many legs does this elephant have?

Optical Illusions

Keep staring at the black dot. After a while the gray haze around it will appear to shrink.



Optical Illusions



Optical Illusions

Follow the instructions:
1) Relax and concentrate on the 4 small dots in the middle of the picture for about. 30-40 secs.
2) Then, take a look at a wall near you (any smooth, single coloured surface)
3) You will see a circle of light developing
4) Start blinking your eyes a couple of times and you will see a figure emerging…
5) What do you see? Moreover, who do you see?

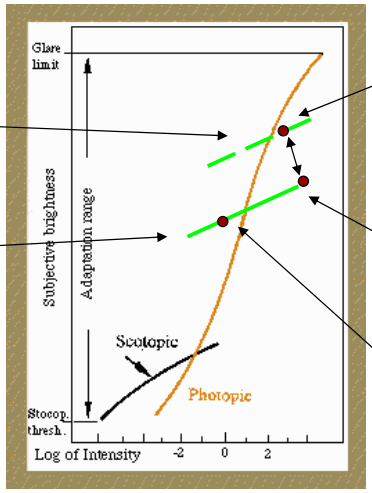
Explanation

While the retina can perceive a high range of intensities, it cannot handle all simultaneously

- at any given time, each region adapts to a small intensity range determined by the local intensity
- that is why you have to wait a while when you step from a bright into a dark room (say, a dark movie theater from a brightly lit lobby)

after moving the eye: eventually adapted range

current adapted range

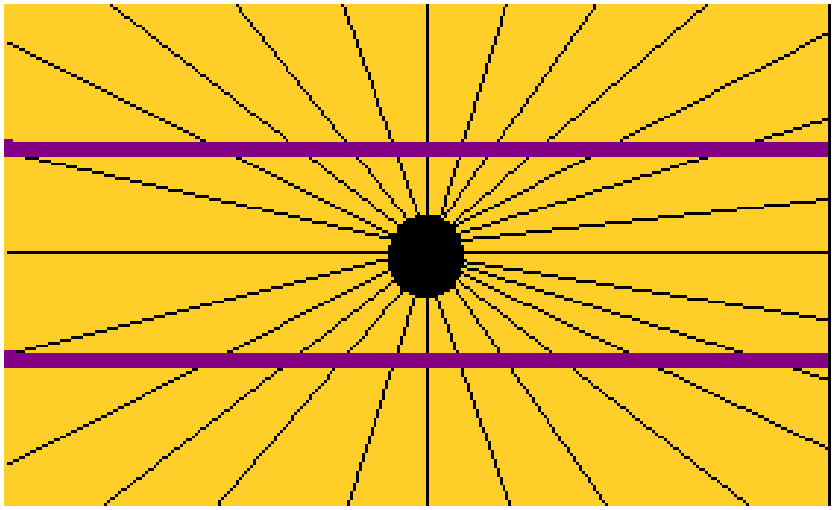


eventually the bright area intensity is unsaturated, matches neighborhood (which was already adapted here before)

after moving the eye: new bright area saturates intensity perception

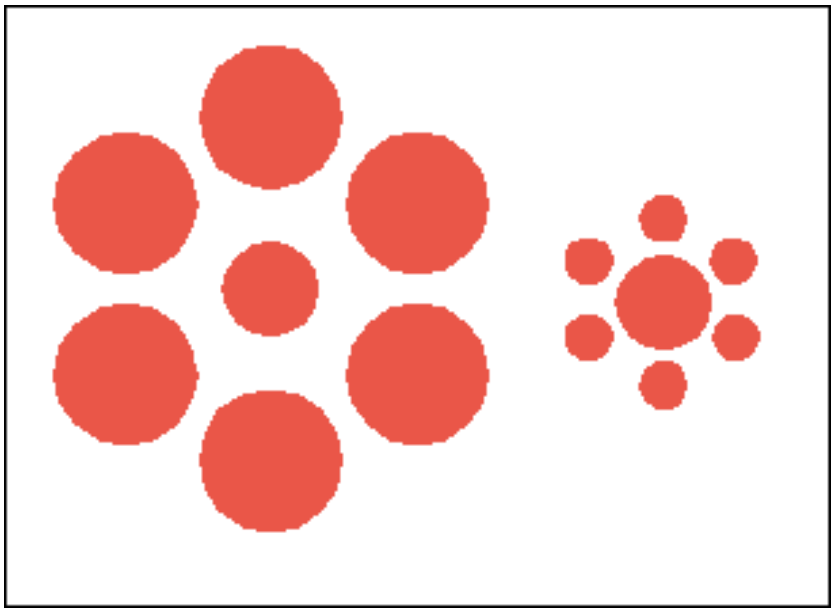
current dark area in picture falls here

Optical Illusions



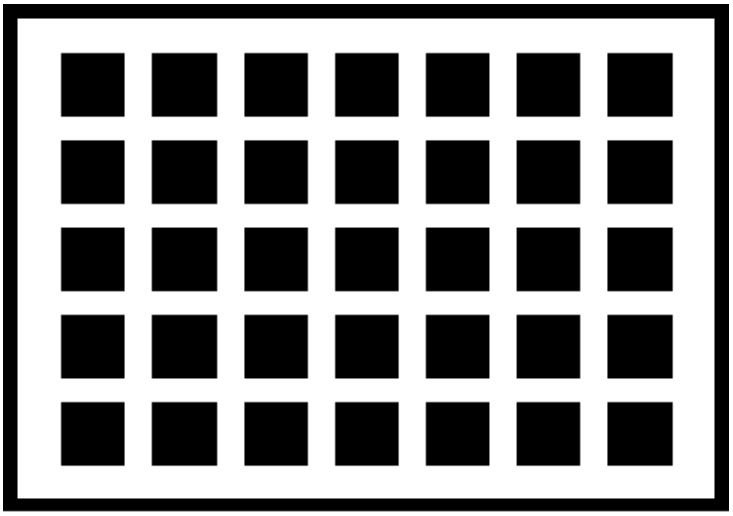
Are the purple lines straight or bent?

Optical Illusions



Which circle in the middle is bigger?

Optical Illusions



Do you see gray areas in between the squares?
Now where did they come from?

Optical Illusions

You should see a man's face and also a word...
Hint: Try tilting your head to the right, the world begins with 'L'

Optical Illusions: Sidewalk Art

Julian Beever

Optical Illusions: Sidewalk Art

Julian Beever

Optical Illusions: Sidewalk Art

Julian Beever

Optical Illusions: Sidewalk Art

Julian Beever

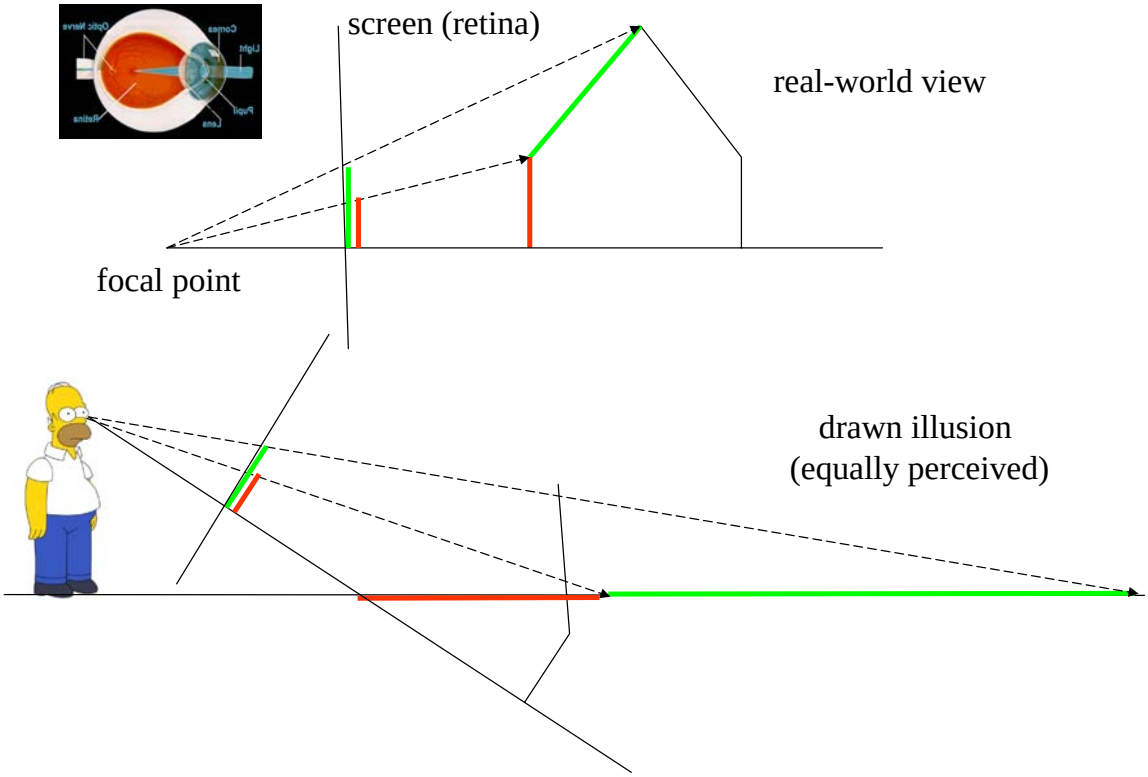
Optical Illusions: Sidewalk Art

Julian Beever

Optical Illusions: Sidewalk Art

Julian Beever

Explanation



What did you see?

Figure 1

Mind-Sets

A man or a woman?

Figure 2

Impressions resist change.

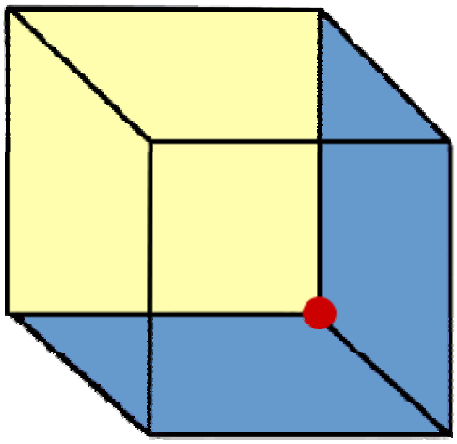
Test of Persistence of Established Images

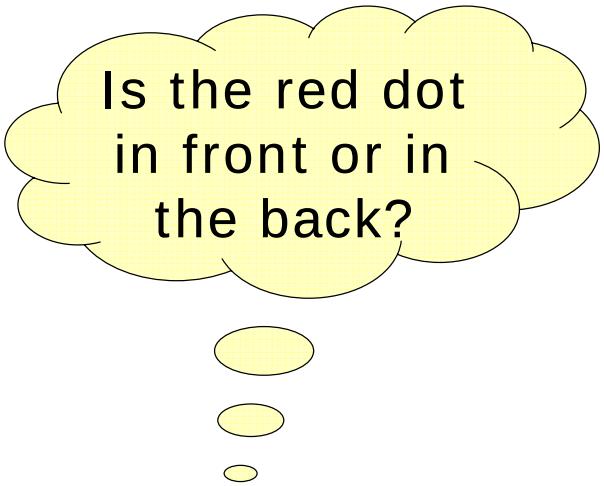
Young lady or old lady?

Figure 3

It is difficult to look at the same information from different perspectives.

Test of Persistence of Established Images





The Power of the Visional System

So the human visual system (HSV) is not perfect, but it's extremely powerful

Vision is an integral part of life

Vision is the gateway to higher-level regions of the brain

Exploit this fast and powerful processor for

- complex data analyses, creative tasks, communicating ideas

→ The science of visualization

This Course

A historical note, and the do's and the dont's of visualization

More on perception and neuroscience

How to present information visually: some examples

Some insight into color

Computer graphics: how to make stuff look 3D on a flat screen

And why are graphics boards so fast?

Photorealistic vs. non-photorealistic: illustrative visualization

Borrowing visuals from the real world: textures, images

Simulating the real world: fire, smoke, water

Visualization in the medical field: visual medicine

Visualization in science: turn numbers into visuals