

Visual Analytics

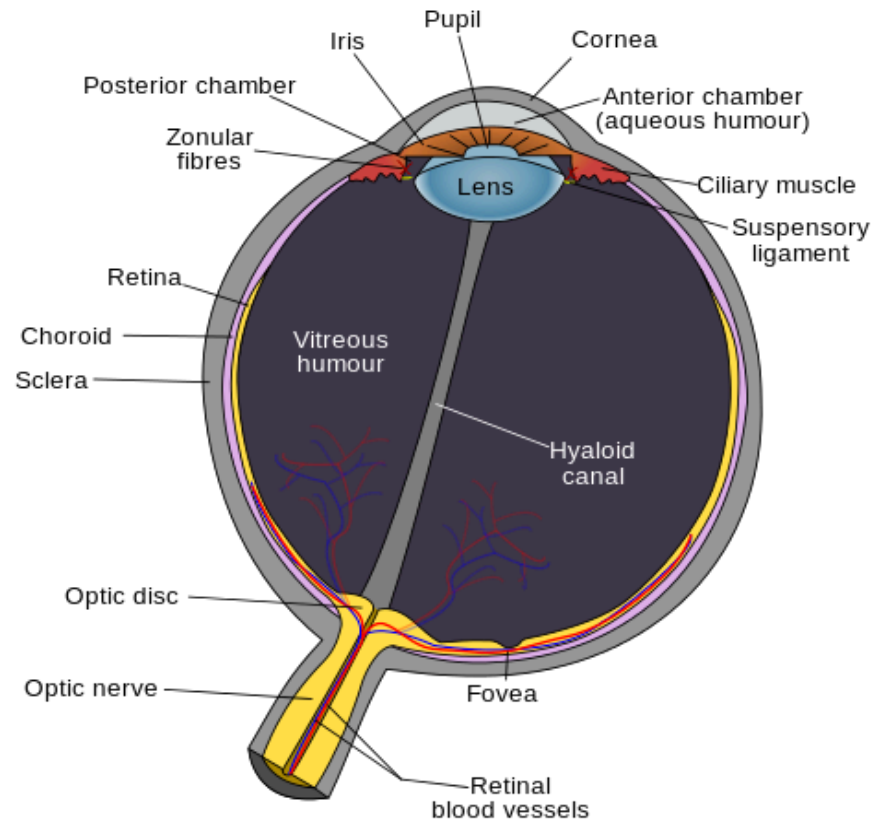
Vision and Perception

S. Rinzivillo

16 March 2015

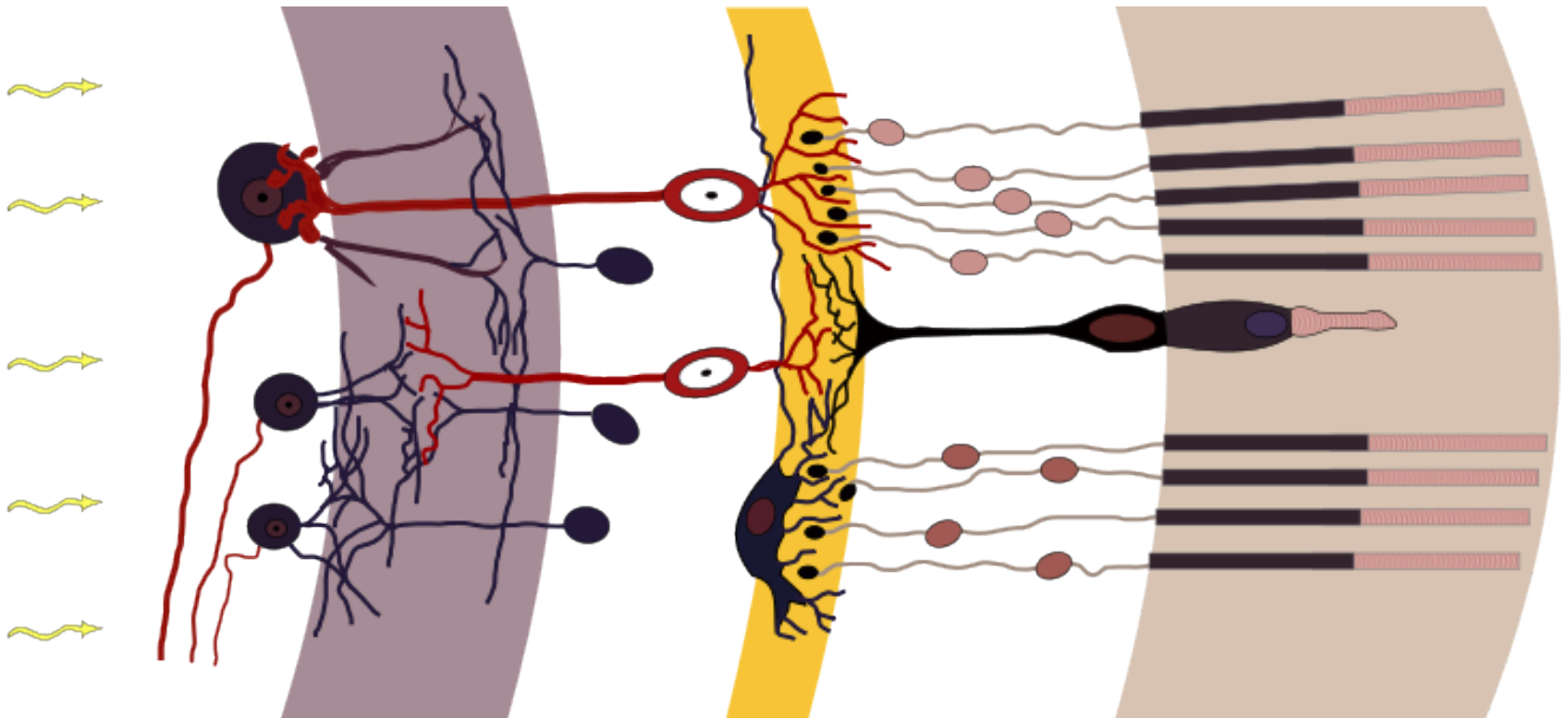
HUMAN VISION

Human Eye



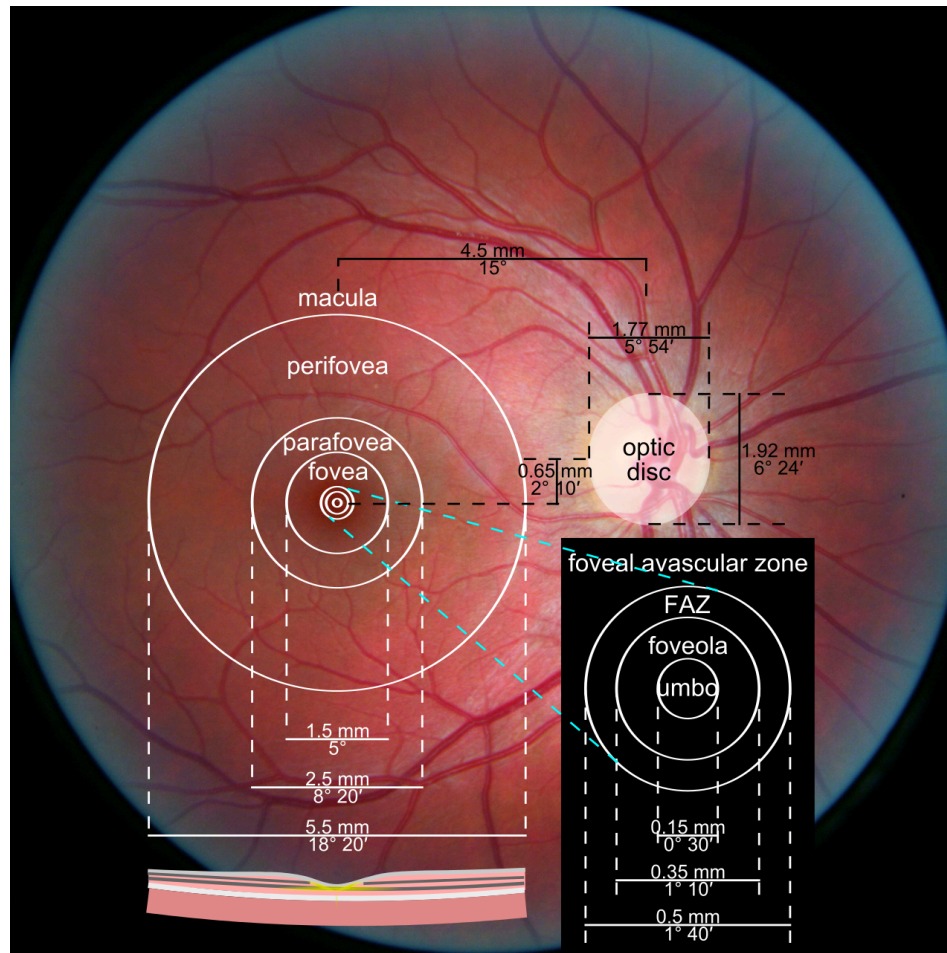
"Schematic diagram of the human eye en" by Rhcastilhos - [Schematic_diagram_of_the_human_eye_with_English_annotations.svg](http://commons.wikimedia.org/wiki/File:Schematic_diagram_of_the_human_eye_en.svg). Licensed under Public Domain via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Schematic_diagram_of_the_human_eye_en.svg#mediaviewer/File:Schematic_diagram_of_the_human_eye_en.svg

Retina



"Retina-diagram" by Fig_retine.png: Cajal derivative work Fig retine bended.png: Anka Friedrich (talk) derivative work: vectorisation by chris 論 - Fig_retine.png Fig retine bended.png. Licensed under CC BY-SA 3.0 via Wikimedia Commons - <http://commons.wikimedia.org/wiki/File:Retina-diagram.svg#mediaviewer/File:Retina-diagram.svg>

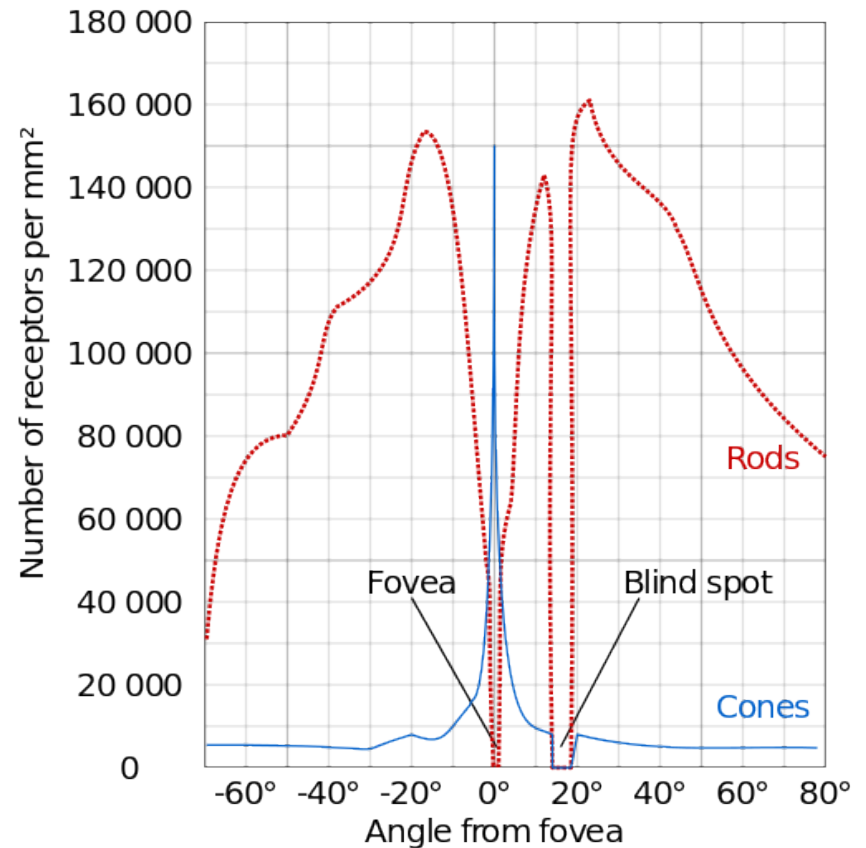
Macula and Fovea



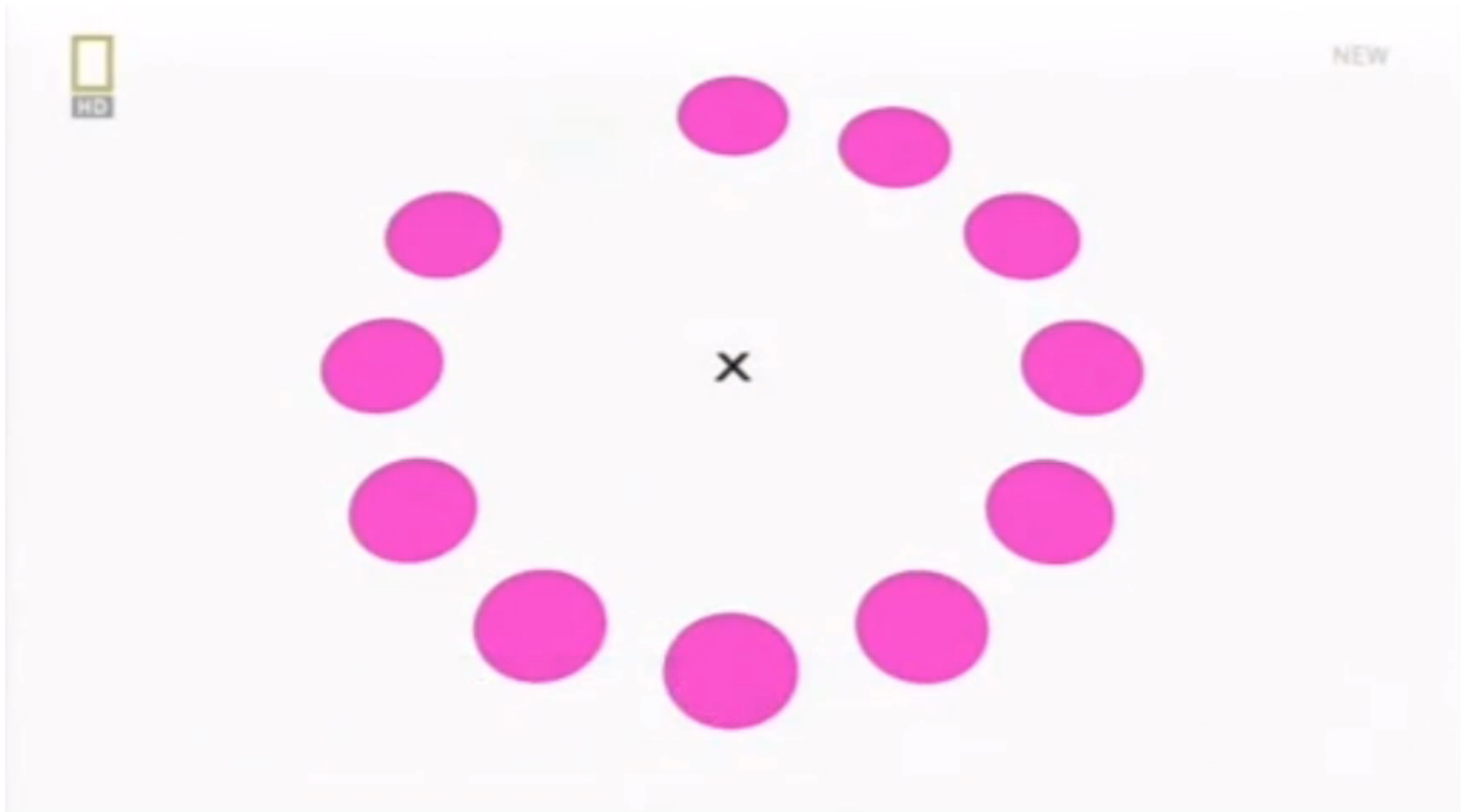
"Macula" by Photograph: Danny Hope from Brighton & Hove, UK -
File:Right_eye_retina.jpg (which come from My Right Eye). Licensed under CC BY
2.0 via Wikimedia Commons - [http://commons.wikimedia.org/wiki/
File:Macula.svg#mediaviewer/File:Macula.svg](http://commons.wikimedia.org/wiki/File:Macula.svg#mediaviewer/File:Macula.svg)

Photo Receptor Cells

- Two types of light sensitive cells
 - Rod Cells (~120M)
 - Provide low-light vision
 - Peripheral vision
 - Almost no role in color vision
 - Cone cells (~6M)
 - Provide normal vision
 - Three sub-types of cells
 - Sensitivity to different light wavelengths
 - Used for colored vision



Peripheral Vision Test

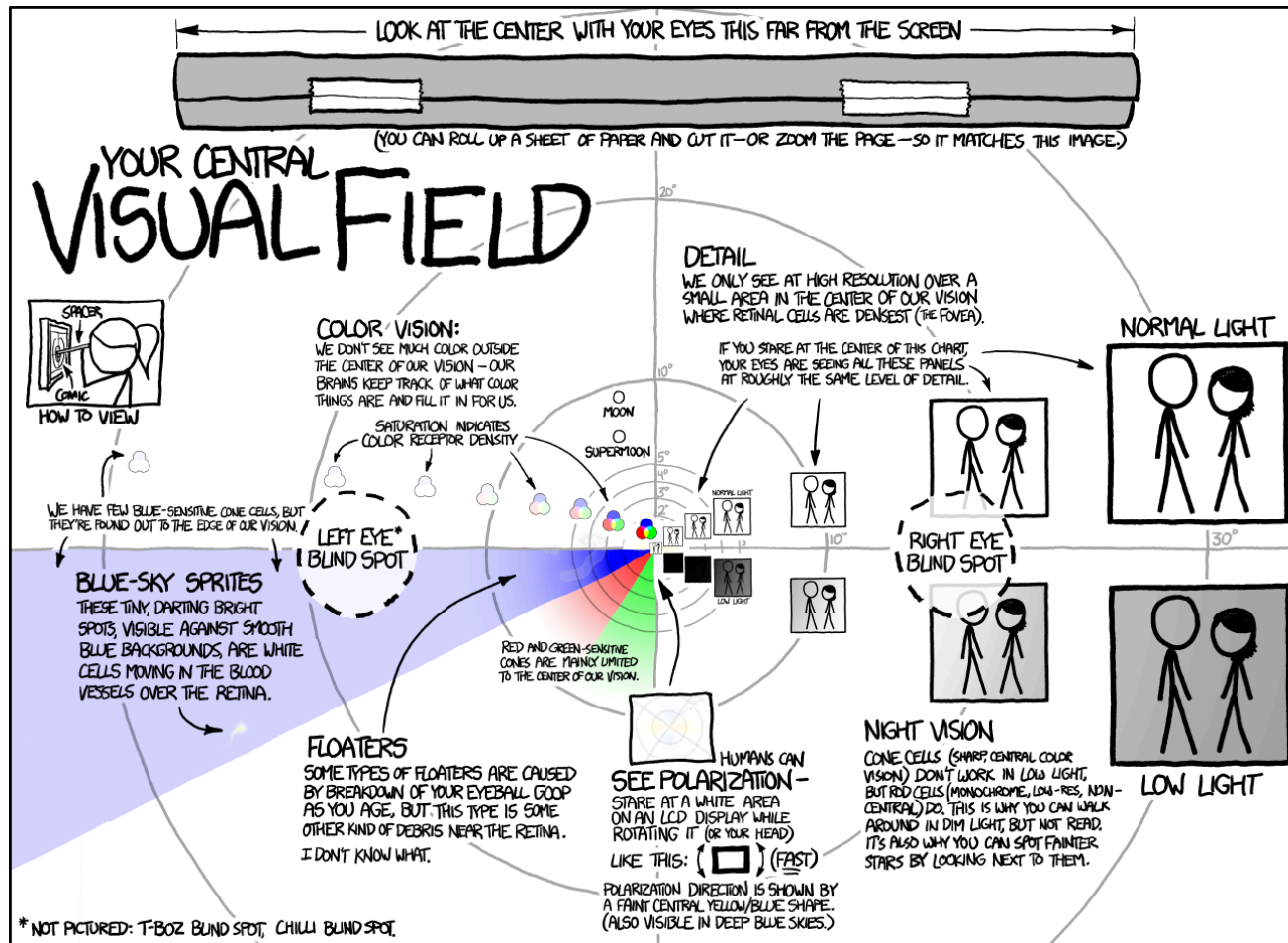


Blind Spot

- There are no receptors where optic nerve meets the retina
- This is a **blind spot**
- Brains merges information from both eyes to reconstruct missing parts
- Find your blind spot
 - Draw a cross (right) and a dot (left) on a paper (around 8cm distant)
 - Close your right eye
 - Look at the cross
 - Move the page until the dot disappears

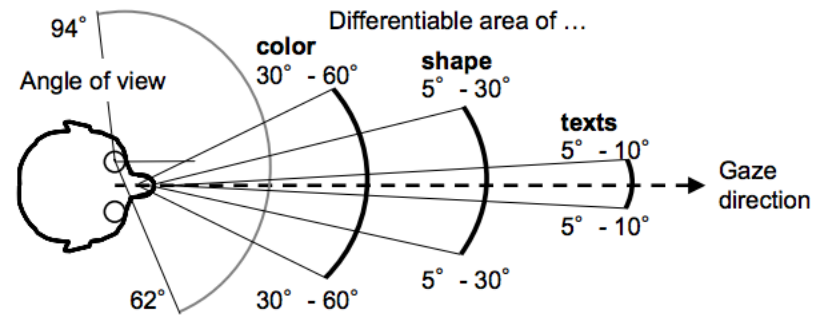


Vision Resolution



Vision Resolution

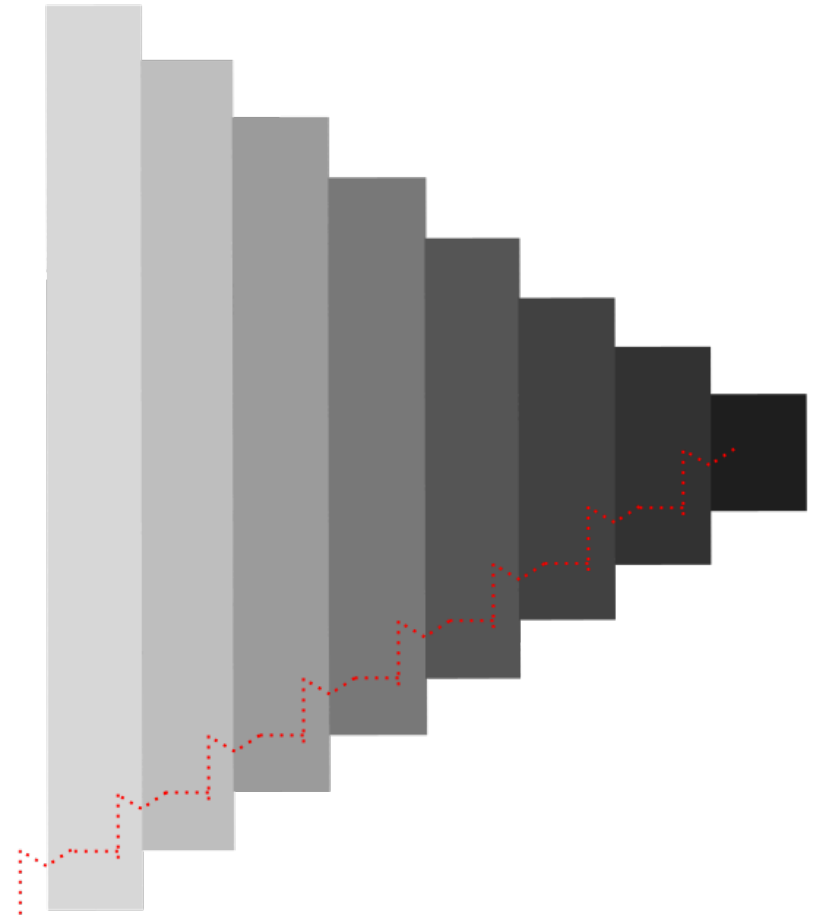
- Fovea yields the highest resolution (normal light)
- Fovea occupies around 15° of visual field
- Highest resolution is provided by *fovea centralis* (around 1°)



Komatsubara, A. Human error, Maruzen co. Ltd. 2008. (In japanese)

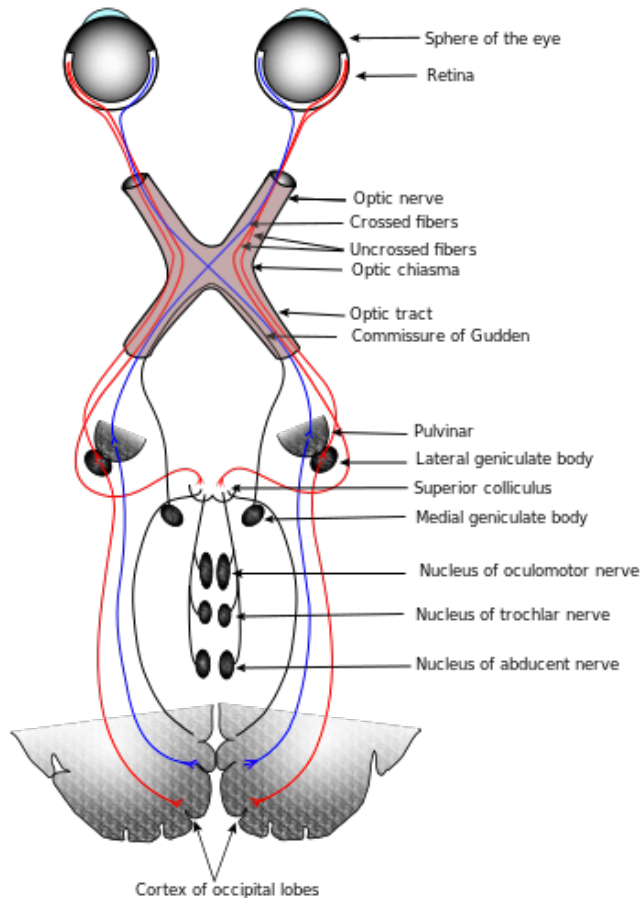
Mach Banding

- Lateral Inhibition: a positive outcome in one element induces a negative outcome in its neighbours
- Some initial processing is done in horizontal cells in the eyes
- Mach Banding shows this phenomenon



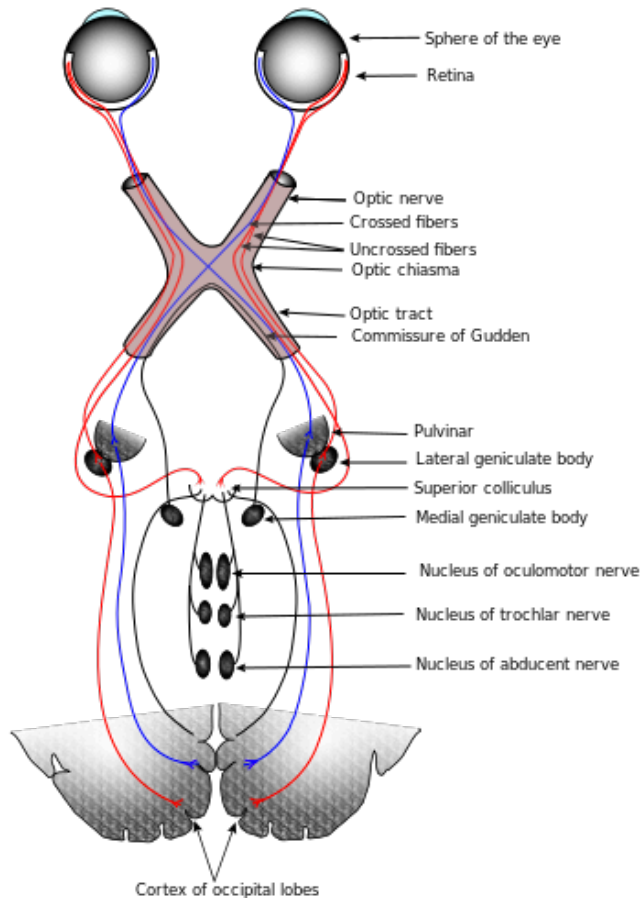
"Mach band90" di Mach_band.svg: DancingPhilosopherderivative work: DancingPhilosopher (talk) - Mach_band.svg. Con licenza Pubblico dominio tramite Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Mach_band90.svg#/media/File:Mach_band90.svg

Visual System



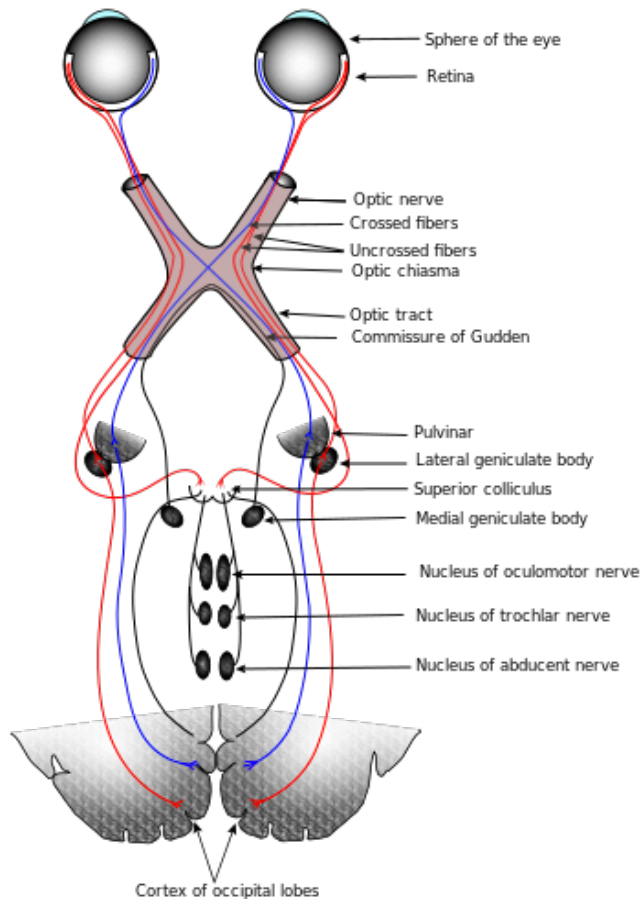
- Signals are transmitted from the retina to the optic nerve
- 1M nerve fibres and 125M receptors
- Around 1000 rods carried on the same nerve fibre
- From central fovea each receptor is connected to two nerve cells

Visual System



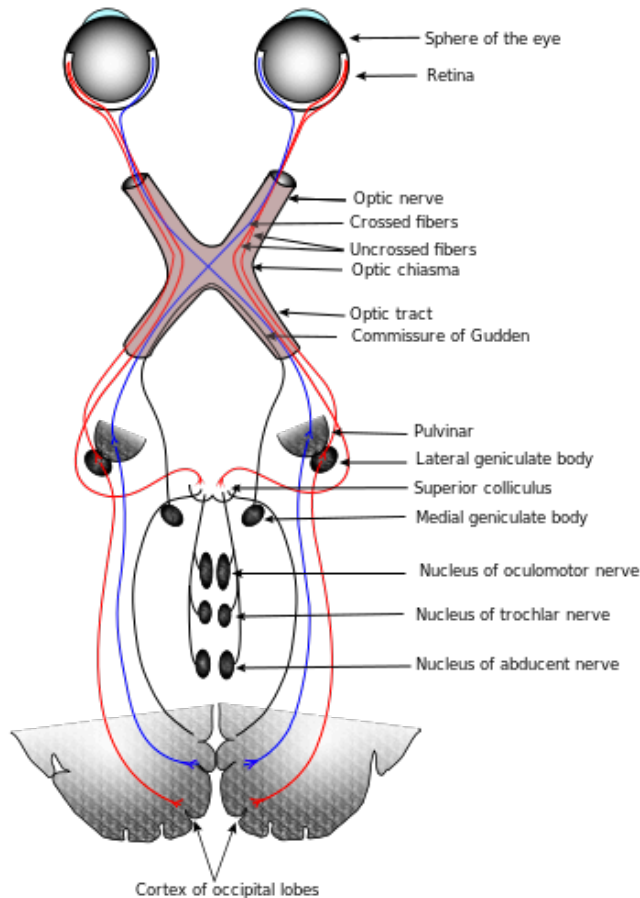
- Optic nerves from the eyes converge to Optic Chiasm
- Signals from both eyes are mixed at this point
- Filling of blind-spot gaps
- Estimation of depth

Visual System



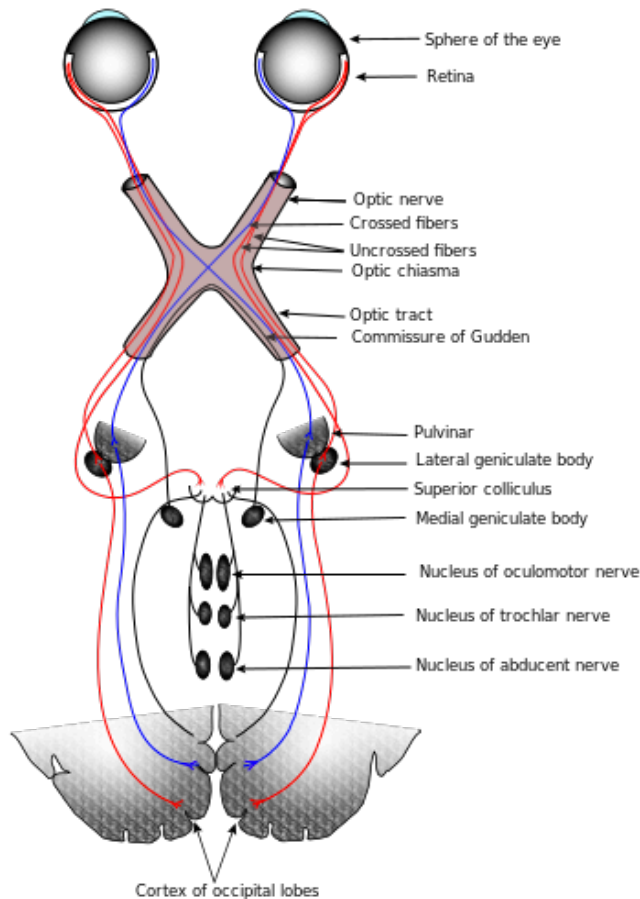
- Lateral Geniculate Body serves as a relay to dispatch signals to visual cortex
- Actually, some information is received back from the cortex

Visual System

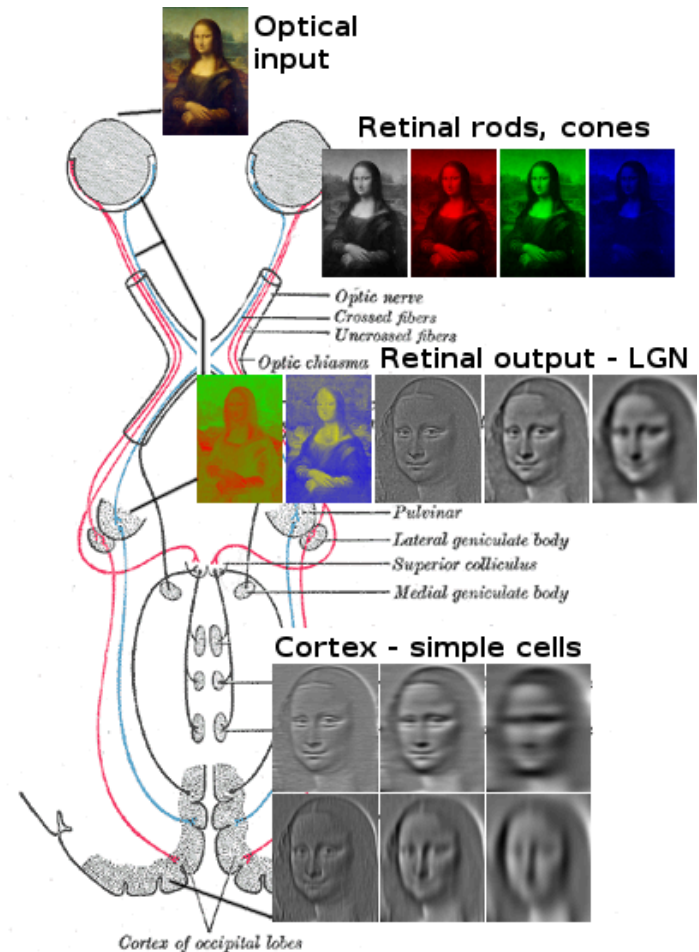


- Visual Cortex process signals and extract basic visual information
 - Detection of particular orientation
 - Shape detection
 - Ad-hoc processed are performed with higher and higher level of details

Visual System



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"Lisa analysis" by Clock - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Lisa_analysis.png#/media/File:Lisa_analysis.png

Photo Receptor Cells

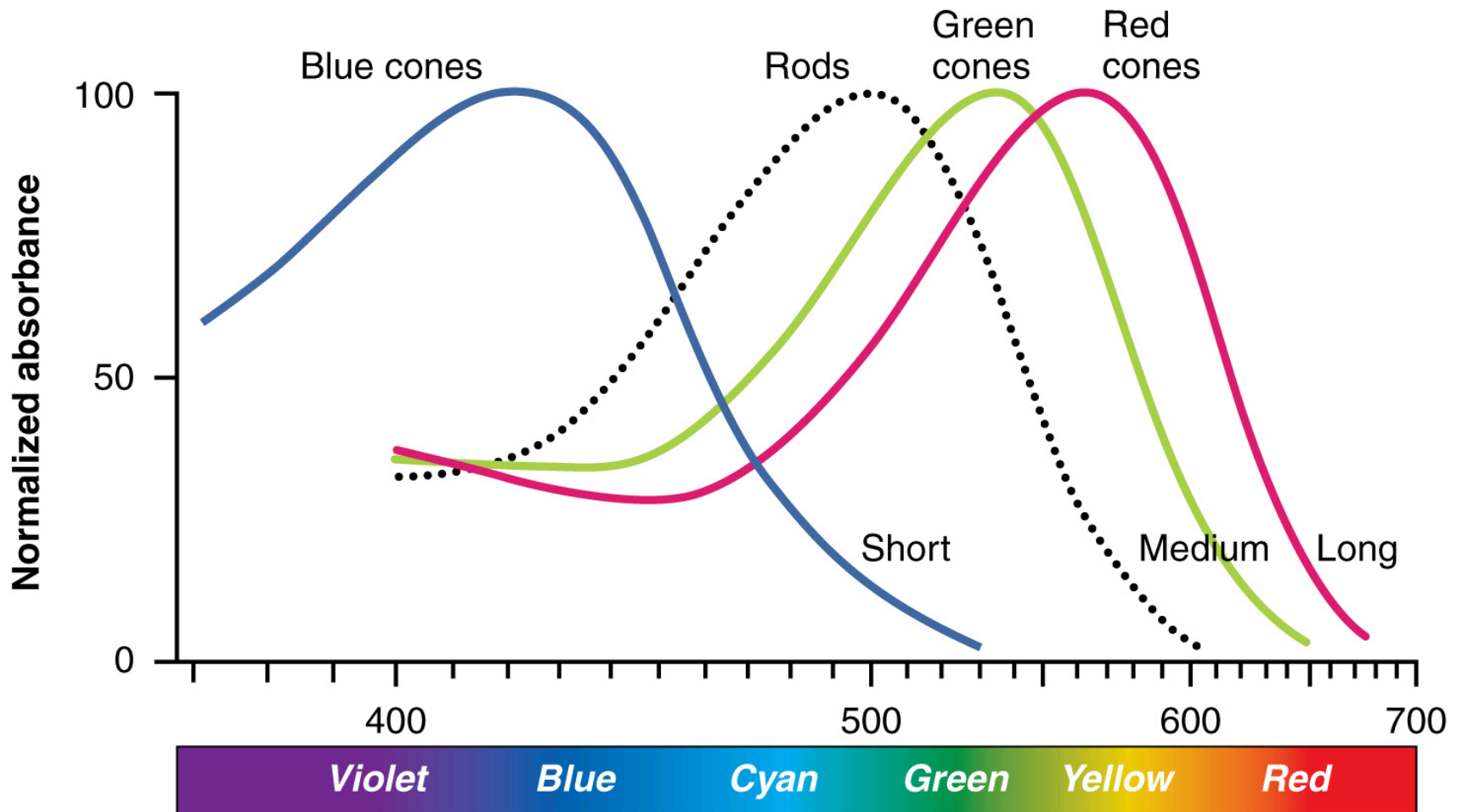
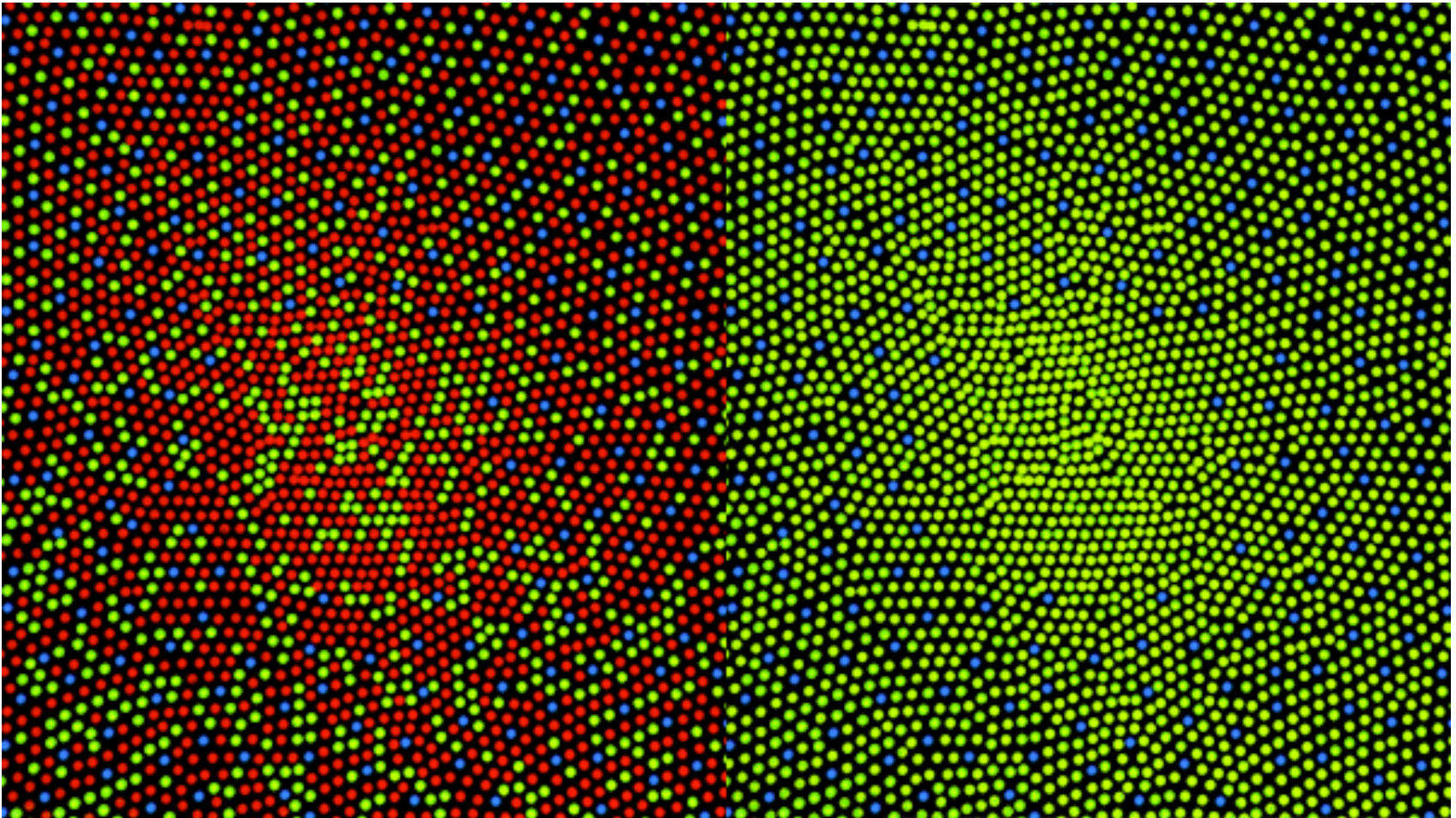


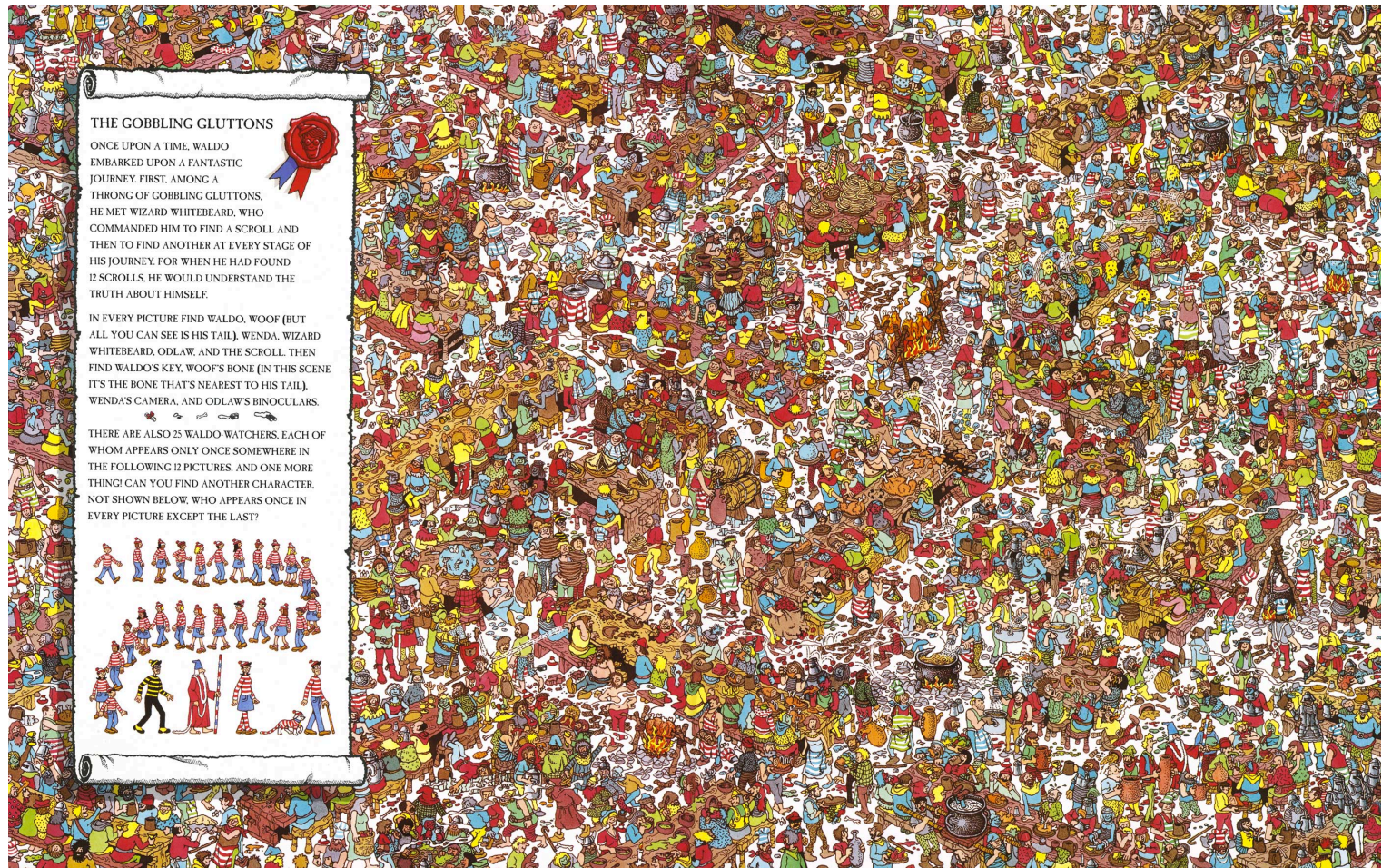
Photo Receptor Cells

Distribution of cone cells in the fovea of an individual with normal color vision (left), and a color blind retina.



"ConeMosaics" by Mark Fairchild. Licensed under CC BY-SA 3.0 via Wikimedia Commons - <http://commons.wikimedia.org/wiki/File:ConeMosaics.jpg#mediaviewer/File:ConeMosaics.jpg>

Where is Waldo?



High Resolution Vision

- HiRes vision is limited to a narrow angle of field vision
- Eyes move to scan an object in order to expose the image on the fovea
- The movement of eyes is not regular or linear

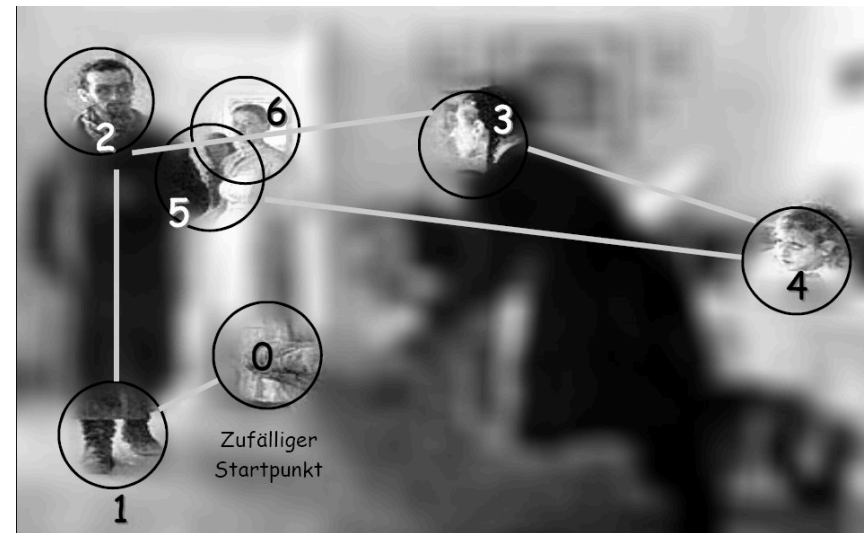


Bild 11: Foveale Ergänzung durch die ersten 6 Fixationen (nach Daten von Yarbus, 1967)

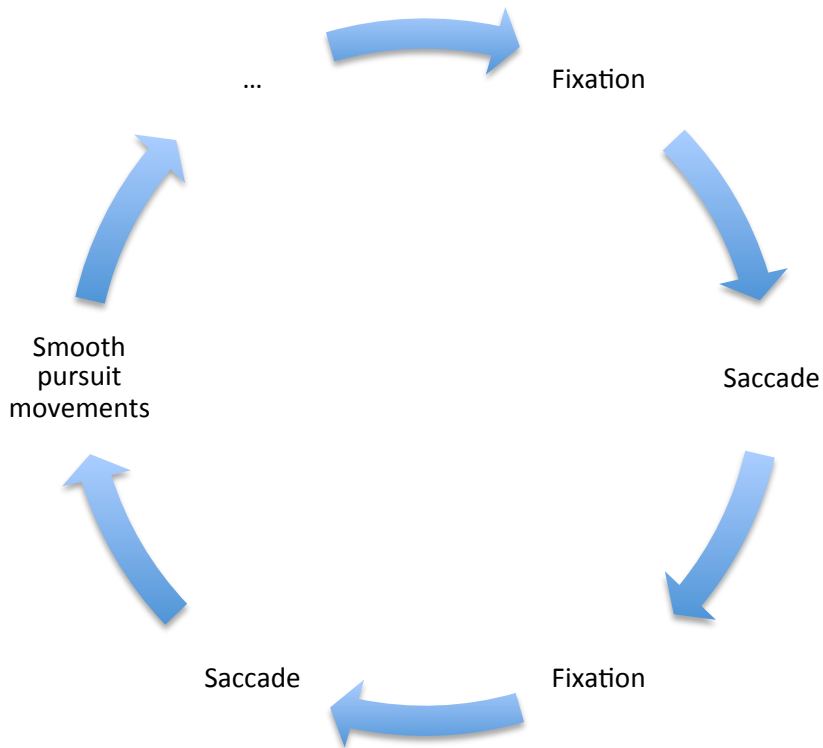
"Vision 2 secondes" by Hans-Werner Hunziker. Licensed under CC BY 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Vision_2_secondes.jpg#/media/File:Vision_2_secondes.jpg

WHAT CATCHES OUR ATTENTION?

Attention and Focus

- **Attention** is the mental process to focus on something or someone with high relevance
- Concentration on a subset of available visible information
- Based on a limited processing resources
- **Top-down attention** (endogenous attention)
 - Intentional allocation of focus to an item or a location
 - E.g. where is waldo? game
- **Bottom-up attention** (exogeneous attention)
 - Attention redirection to react on an external stimulus
 - E.g. a sudden loud noise near you

Eye Movements

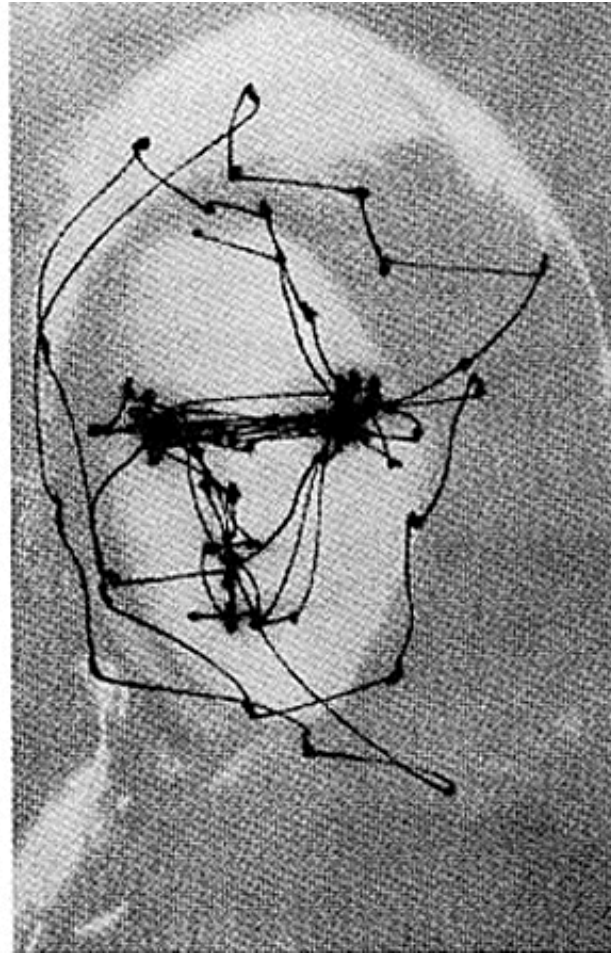


- Fixation: eye focuses on a single point
- Saccade: motion from a fixation point to the next one
- Smooth Pursuit: eyes follows a moving object

Eye Movement

- Experiments by I. L. Yarbus
- General setup
 - Present an image to a subject
 - The subject may or not have a task to perform
 - Record the movements of the eyes
- First experiments in Russia between 40s and 50s

Examining a face



Context and Face Recognition



The Unexpected Visitors



<http://www.cabinetmagazine.org/issues/30/archibald.php>

T1: Examine the picture



T2: How wealthy is the family?



T3: Estimate ages of persons



T4: what the family was doing before the visitor?



Eye Tracking for Design



Top-Down Attention



<http://channel.nationalgeographic.com/brain-games/videos/brain-games-pay-attention/>

Three Dimensional Vision

- Brain reconstructs depth perception by many cues on the visual images
 - Perspective
 - Relative size
 - Occlusion
 - Parallax
 - Shadows

Shadows game

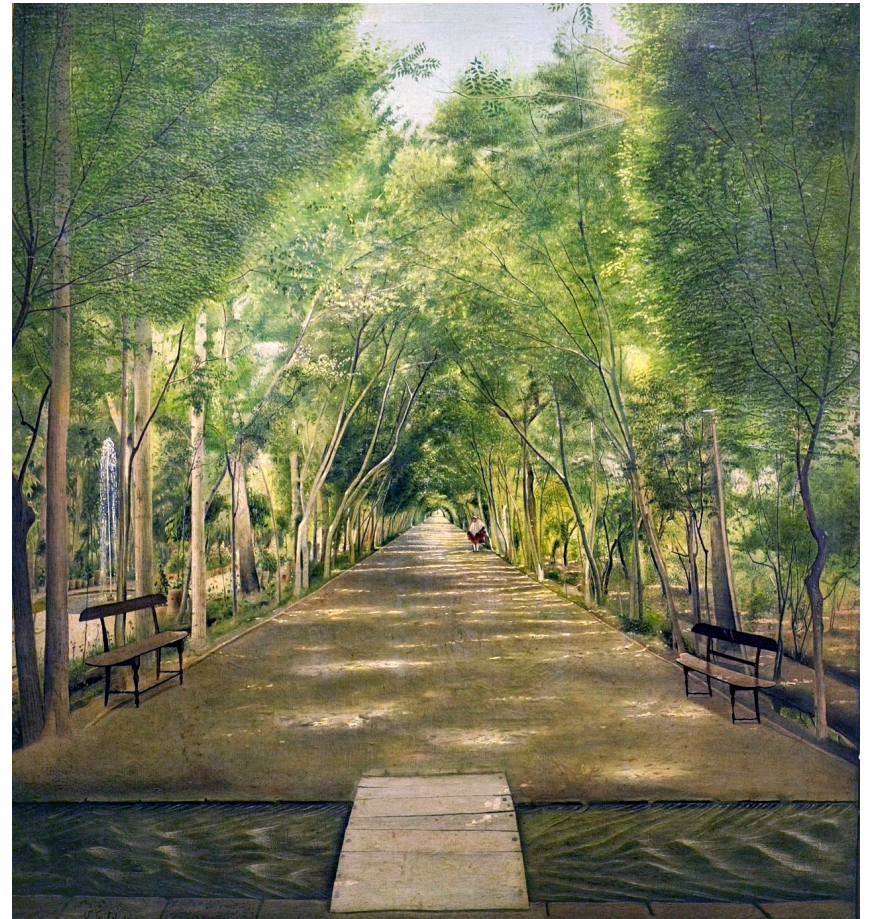


Ball game



Perspective

- Linear Perspective
 - Distant objects are perceived smaller
 - Parallel lines converge to a common point
- Aerial Perspective
 - Appearance of an object is modified by atmosphere
 - Distant objects loose contrast

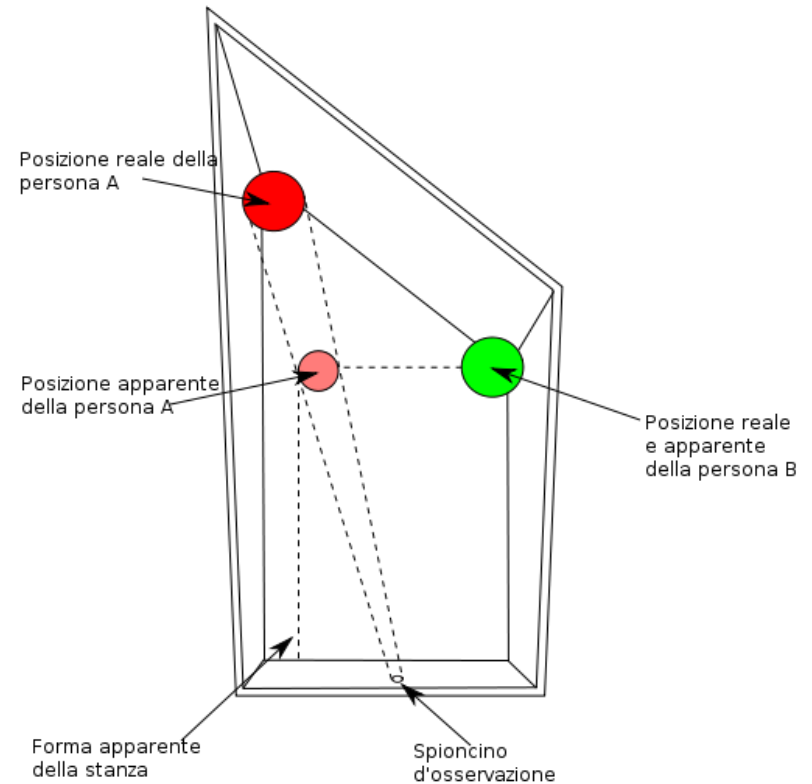


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Perspective



Ames Room



"Ames room forced perspective" di mosso - optical Illusion. Con licenza CC BY 2.0 tramite Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Ames_room_forced_perspective.jpg#/media/File:Ames_room_forced_perspective.jpg

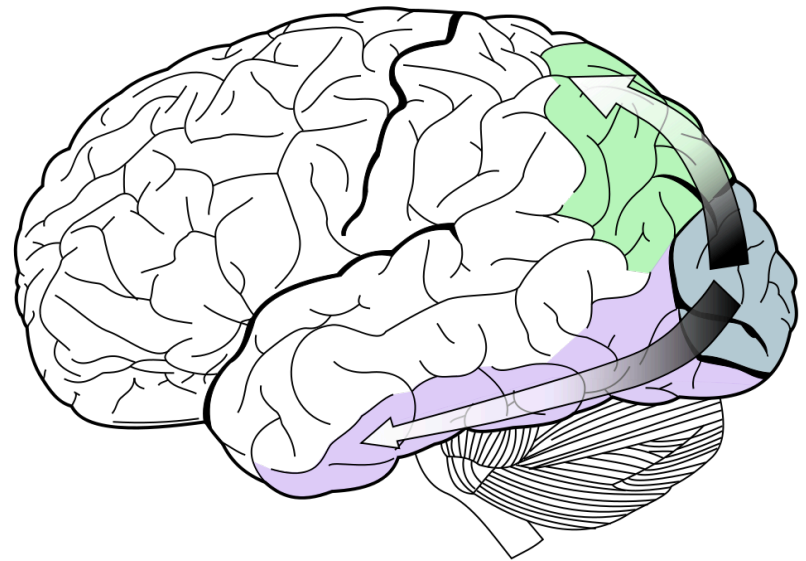
"Ames room-it" di Ames_room.svg: Alex valavanisderivative work: Carnby (talk) - Ames_room.svg. Con licenza Pubblico dominio tramite Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Ames_room-it.svg#/media/File:Ames_room-it.svg

PERCEPTION

Perception

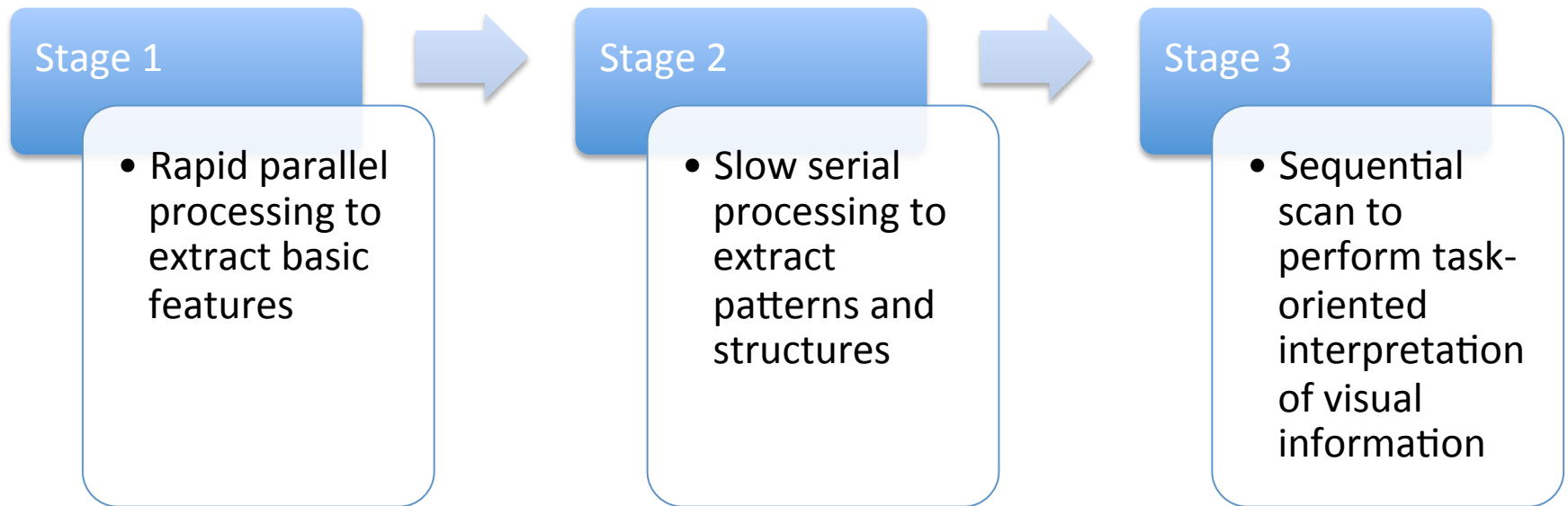
- Perception: the way in which something is regarded, understood, or interpreted (Oxford Dictionary)
- Electrical signals from vision system are interpreted and organized by the brain
- Two-stream hypothesis:
 - Ventral Stream
 - Dorsal Stream

The dorsal stream (green) and ventral stream (purple) are shown. They originate from a common source in the visual cortex



"Ventral-dorsal streams" by Selket - I (Selket) made this from Image:Gray728.svg. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Ventral-dorsal_streams.svg#/media/File:Ventral-dorsal_streams.svg

Perception and Cognition



Perception and Cognition

1258965168765132168943213
5463479654321320354968413
2068798417184529529287149
2174953178195293926546831
3546516509898554684982984

How many “3”?

1258965168765132168943213
5463479654321320354968413
2068798417184529529287149
2174953178195293926546831
3546516509898554684982984

1258965168765132168943213
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Visual Illusions

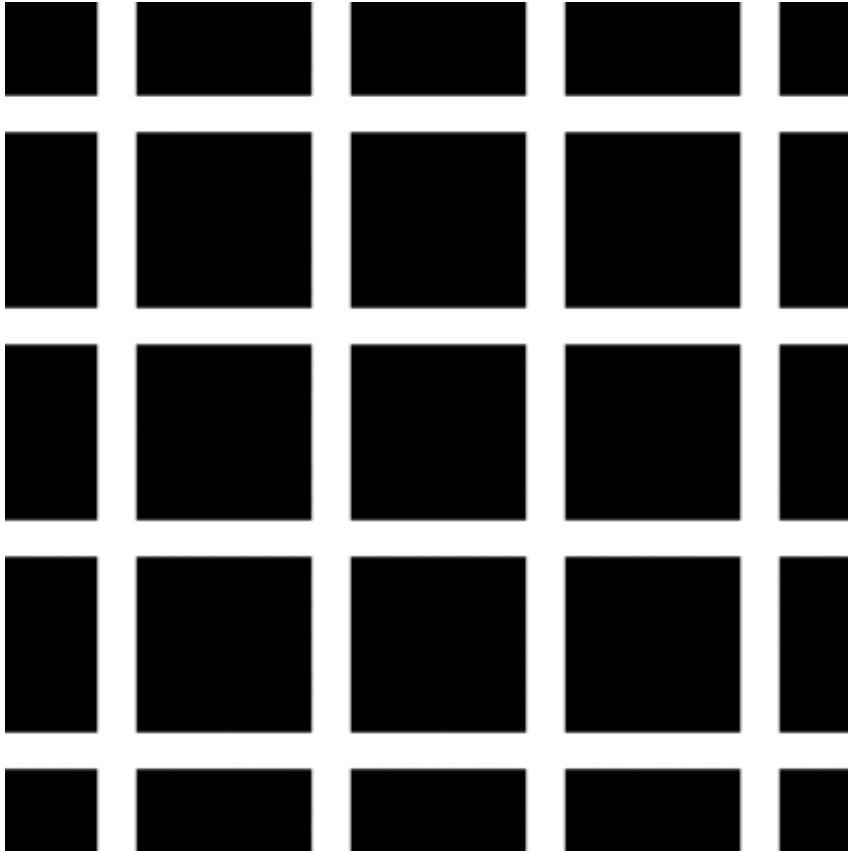
- Visually perceived images differs from measurable reality
 - Optical Illusions
 - Physiological illusions (Mach Bands)
 - Cognitive illusions
 - Arise by unconsciuous inferences based on assumptions about real world

Optical Illusions

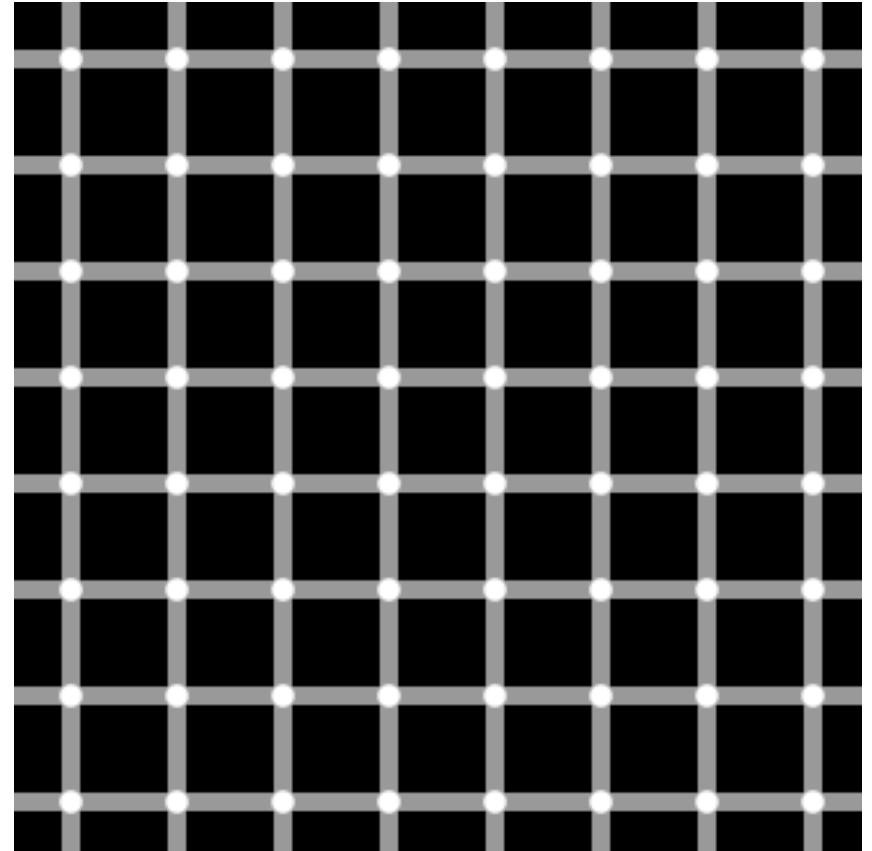


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Physiological Grid Illusion

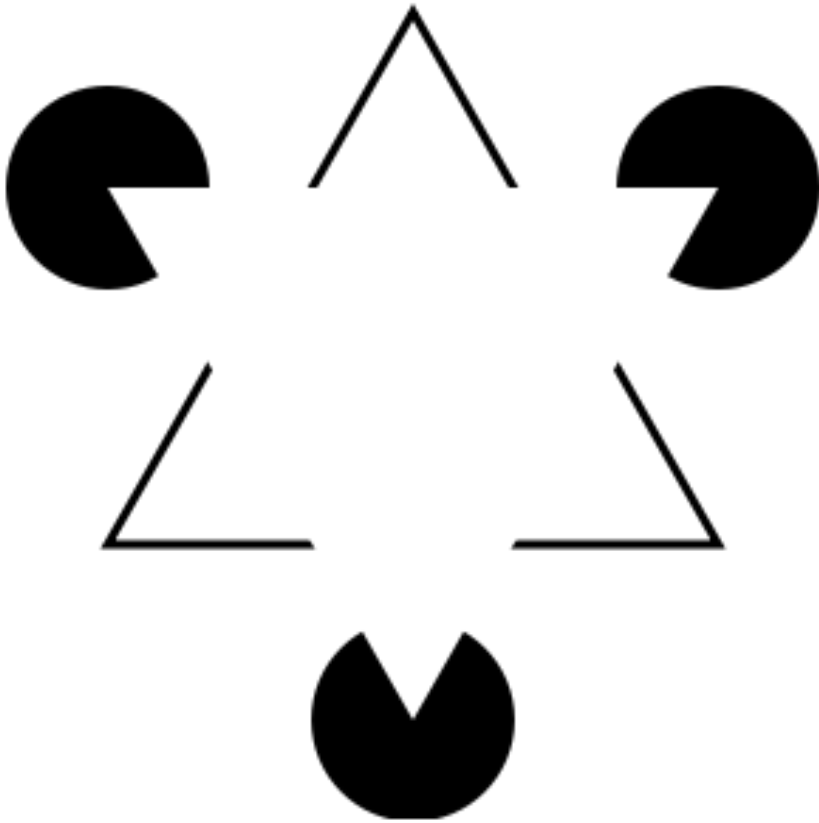


"HermannGrid" by en>User:Famousdog - <http://en.wikipedia.org/wiki/File:HermannGrid.gif>. Licensed under Public Domain via Wikimedia Commons - <http://commons.wikimedia.org/wiki/File:HermannGrid.gif#/media/File:HermannGrid.gif>

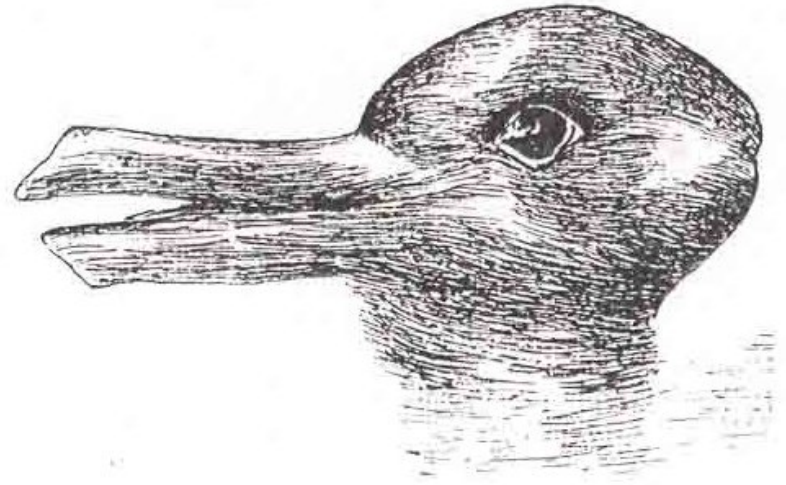


"Grid illusion" by User:Tó campos1 - Own work. Licensed under Public Domain via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Grid_illusion.svg#/media/File:Grid_illusion.svg

Paradox Ambiguos Illusions



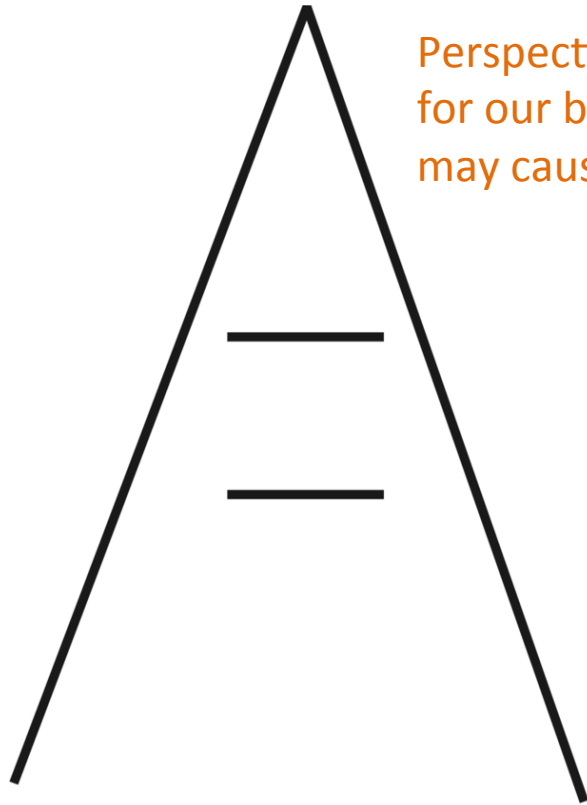
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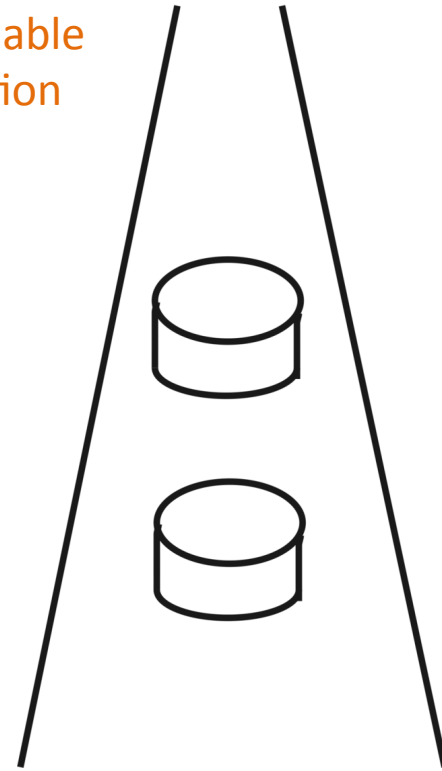
"Duck-Rabbit illusion". Licensed under Public Domain via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Duck-Rabbit_illusion.jpg#/media/File:Duck-Rabbit_illusion.jpg

Depth Perspective Illusions

Ponzo Illusion

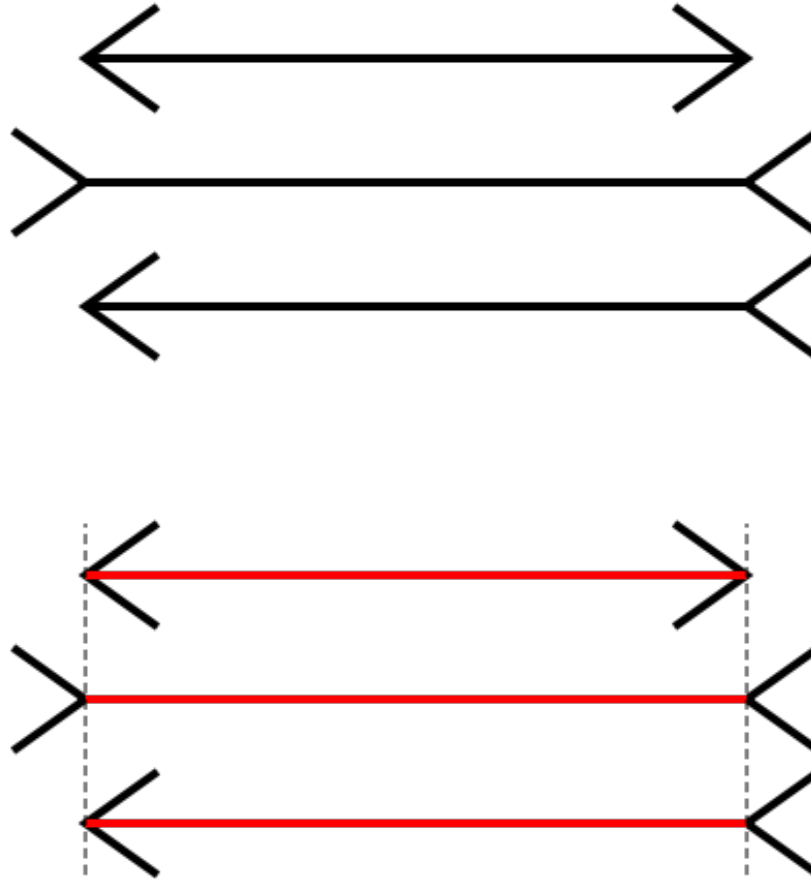


Perspective is highly dependable
for our brain: misinterpretation
may cause strong distortions



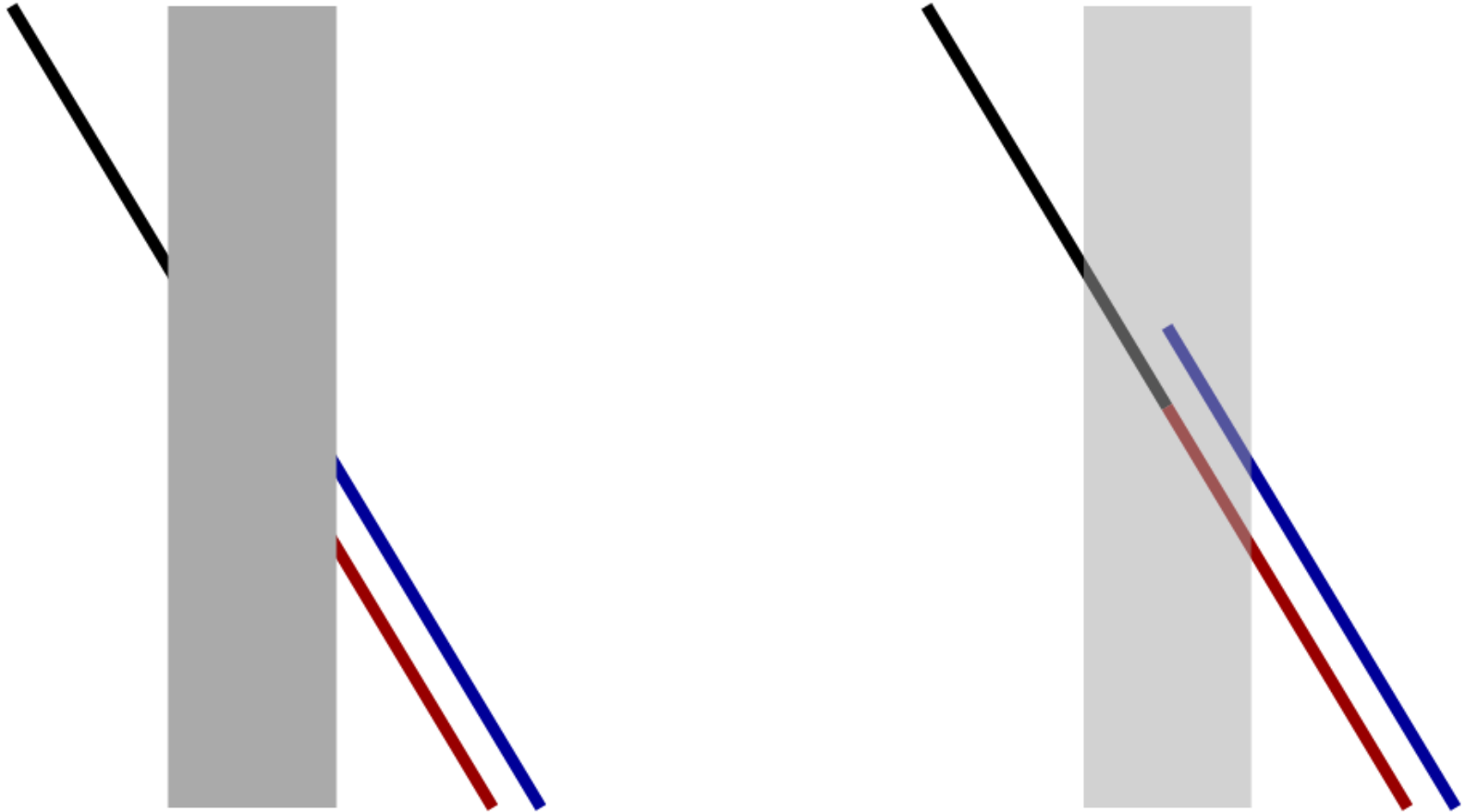
Lengths Distortion

Müller-Lyer illusion



Position Illusion

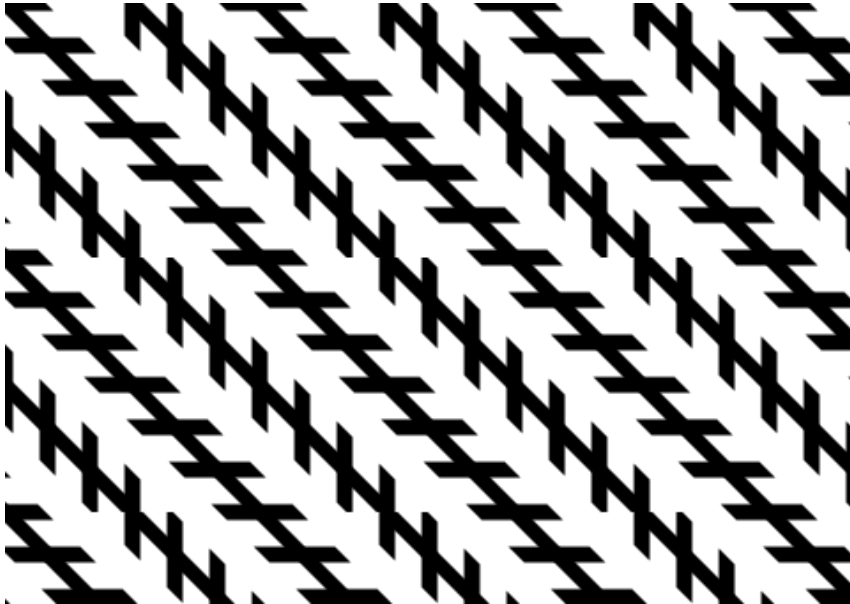
Poggendorff illusion



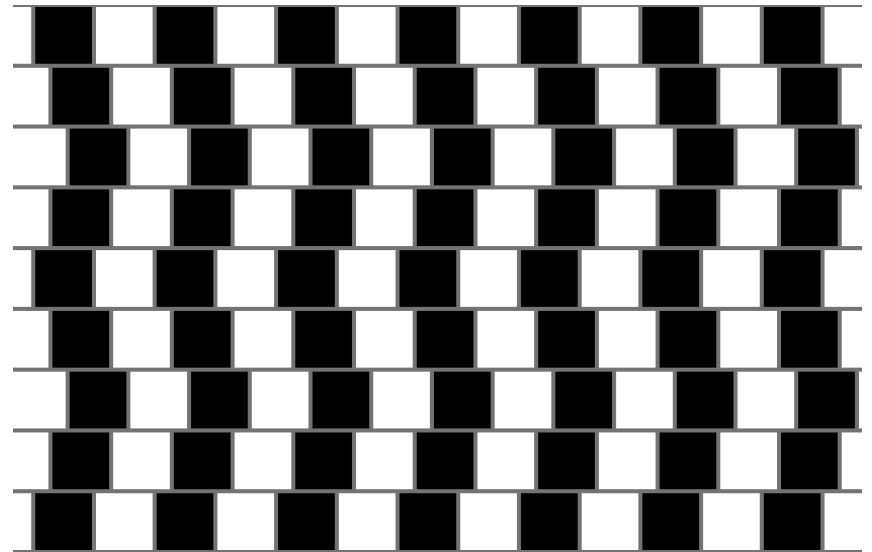
"Poggendorff illusion" by Fibonacci. - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Poggendorff_illusion.svg#/media/File:Poggendorff_illusion.svg

Orientation Illusion

Zöllner illusion

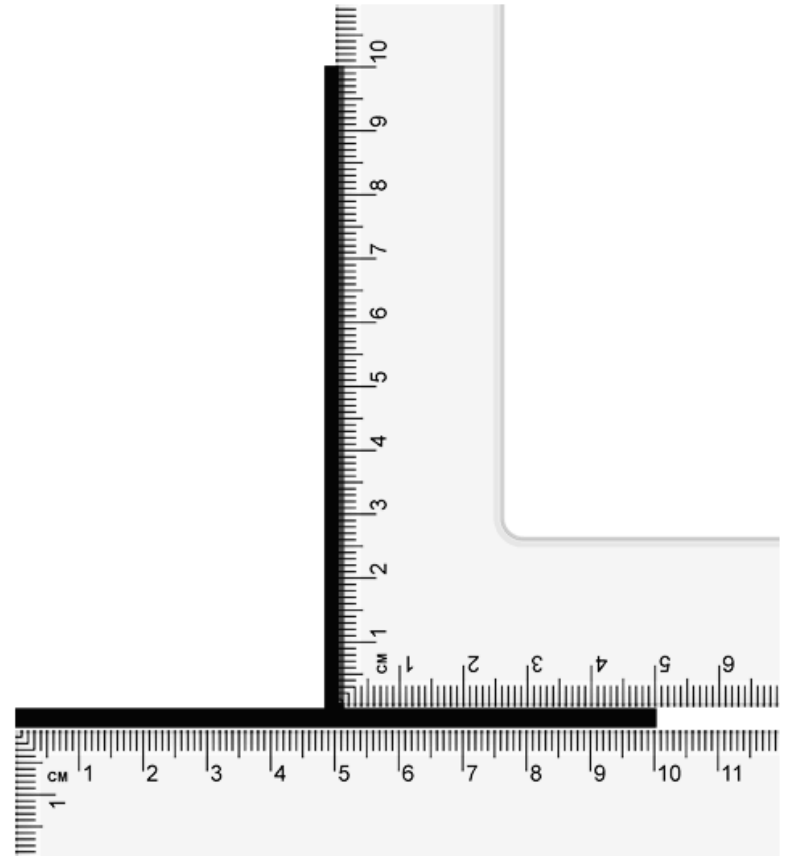
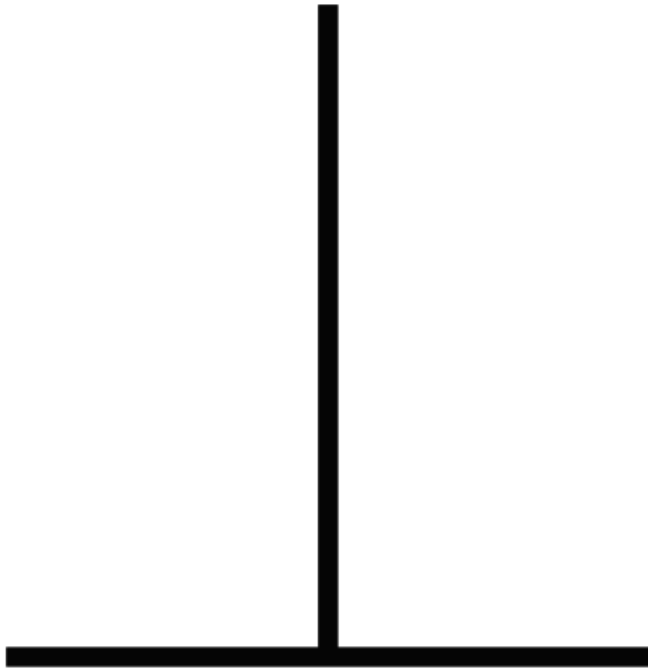


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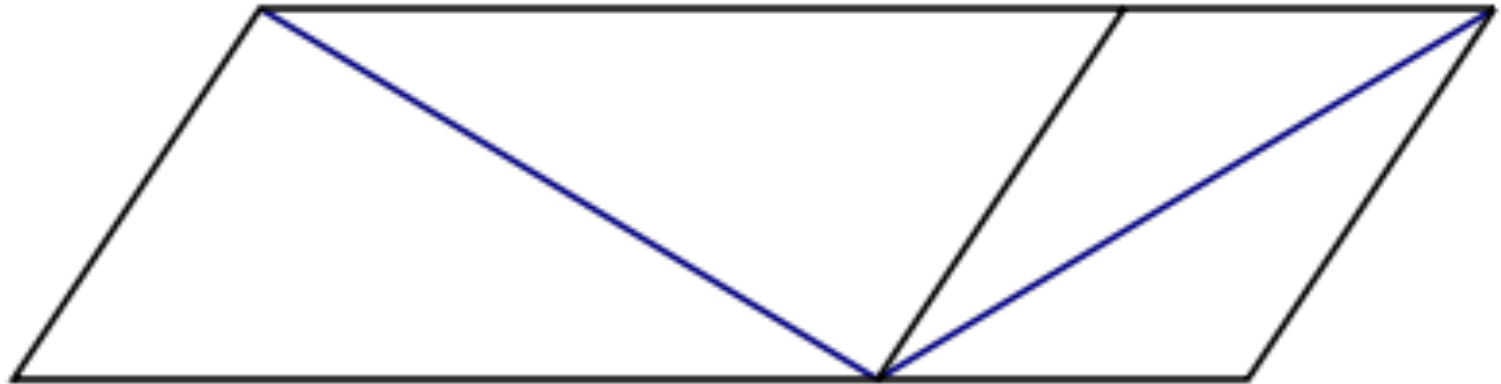
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Vertical-horizontal Illusion



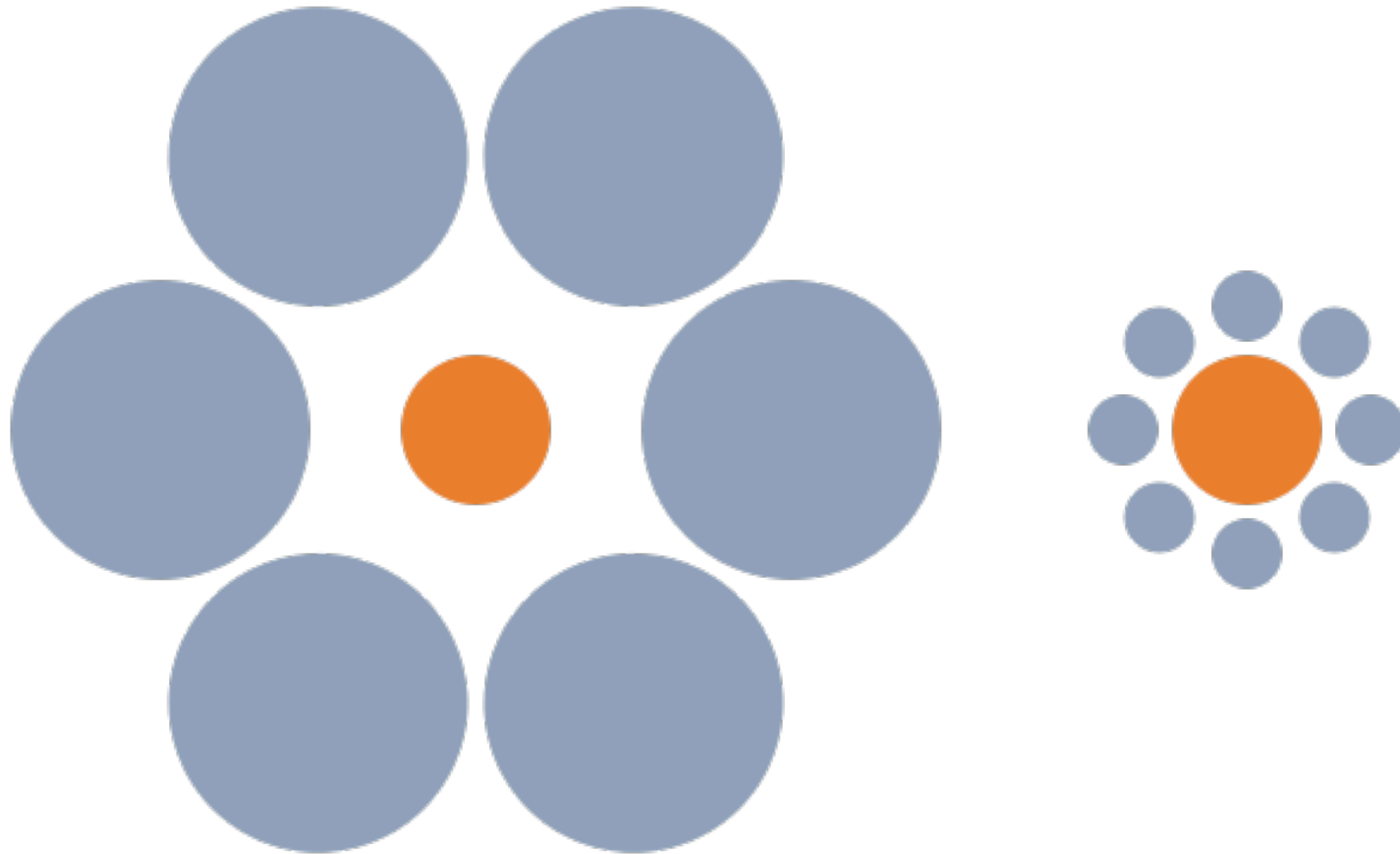
"Vertical–horizontal illusion" by S-kay - Own work. Licensed under Public Domain via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Vertical%E2%80%93horizontal_illusion.png#/media/File:Vertical%E2%80%93horizontal_illusion.png

Sander Illusion

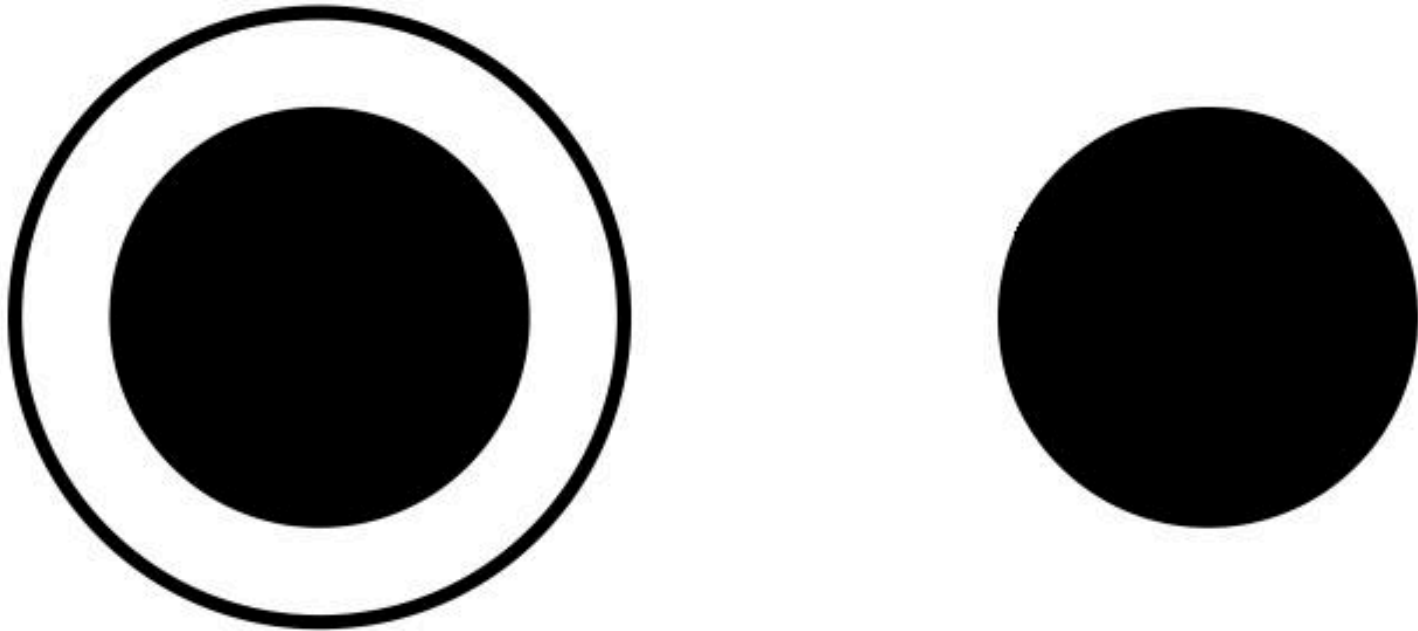


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Ebbinghaus Illusion

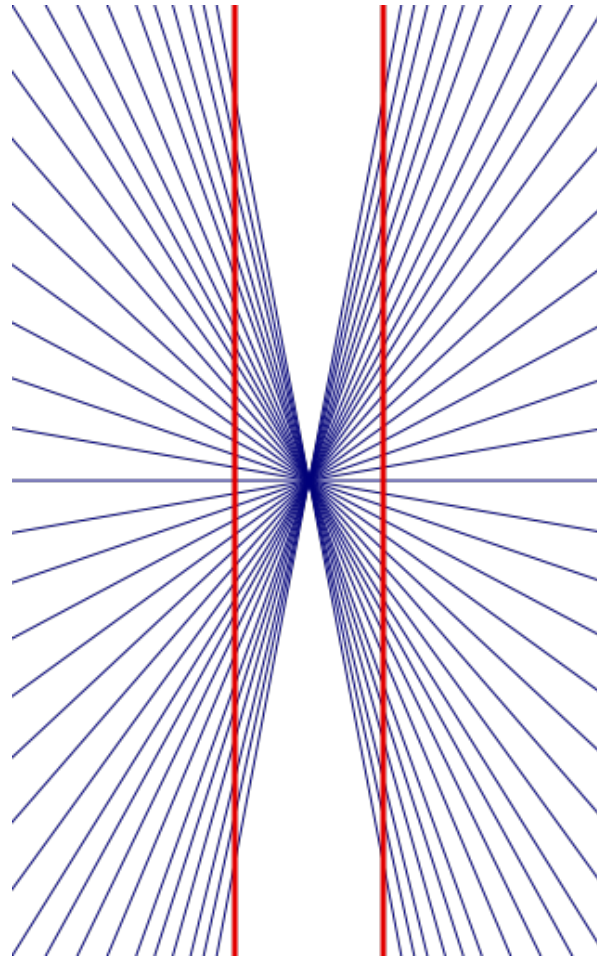


Delboeuf Illusion



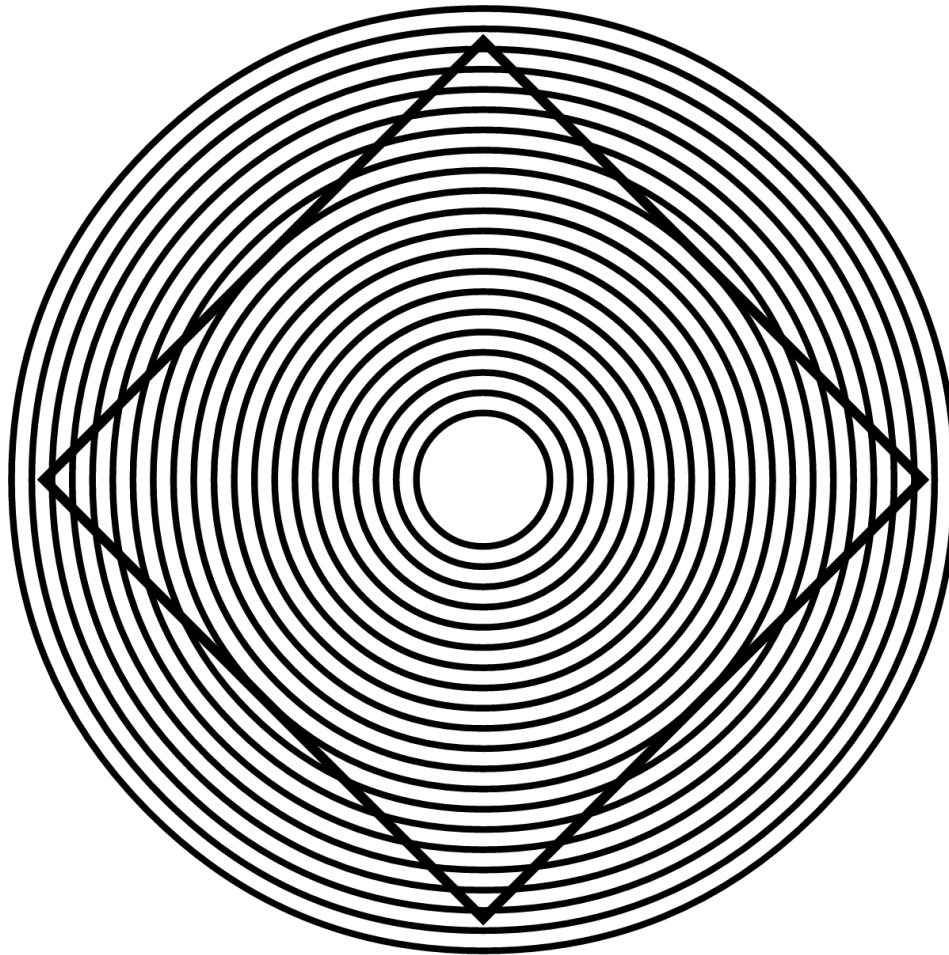
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Hering Illusion



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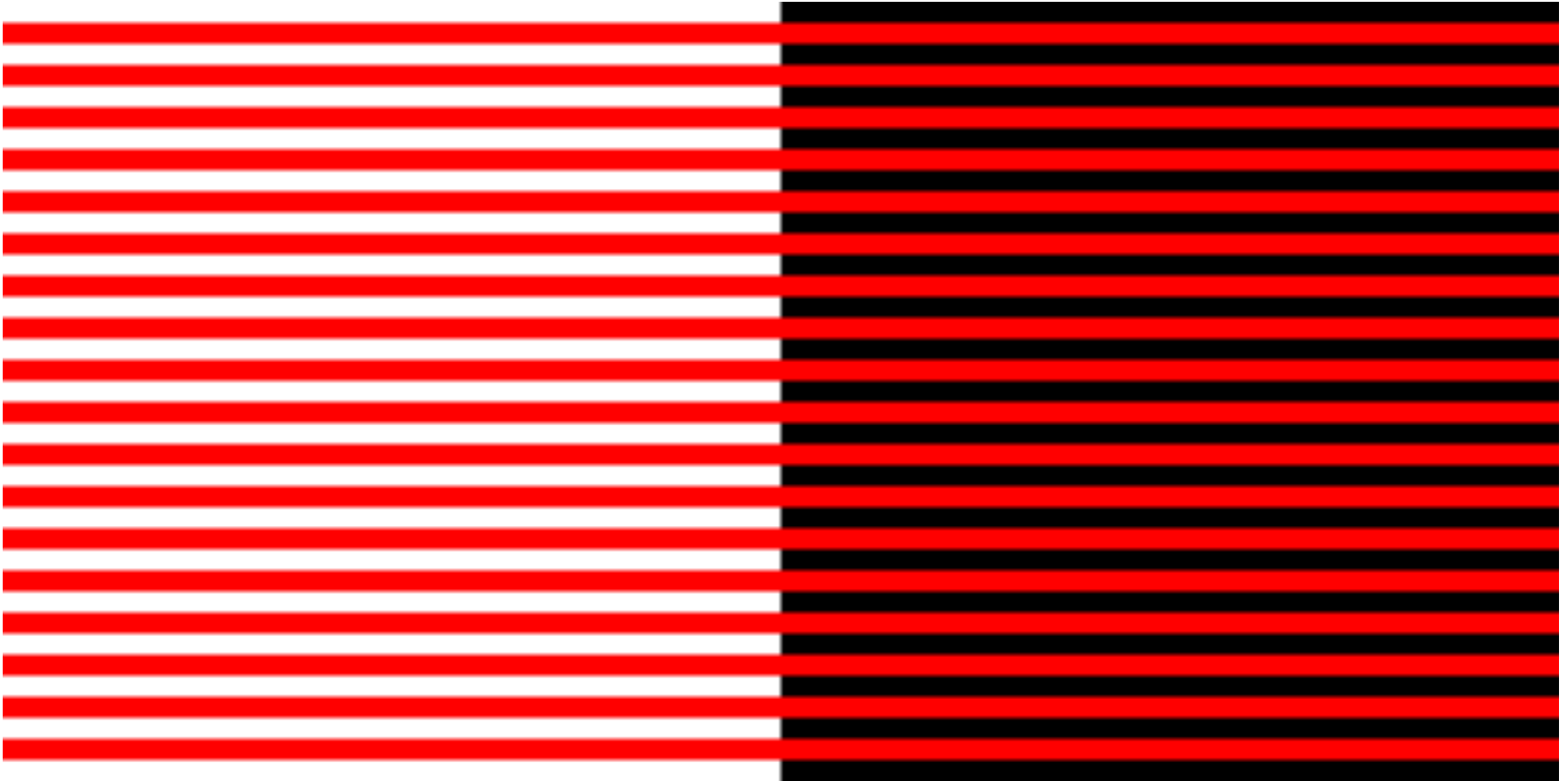
Ehrenstein Illusion



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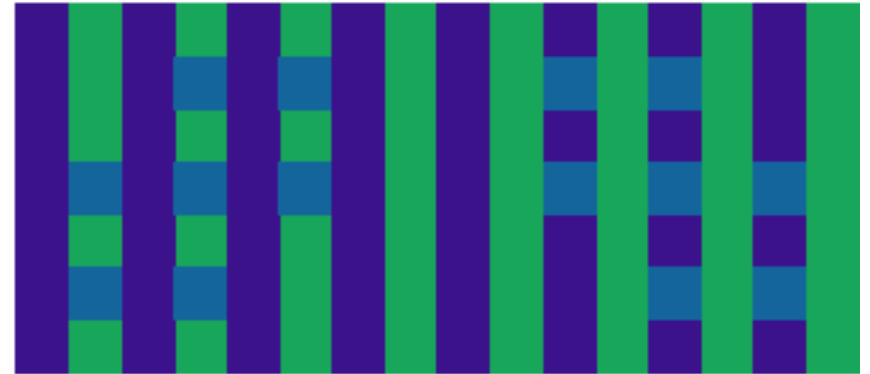
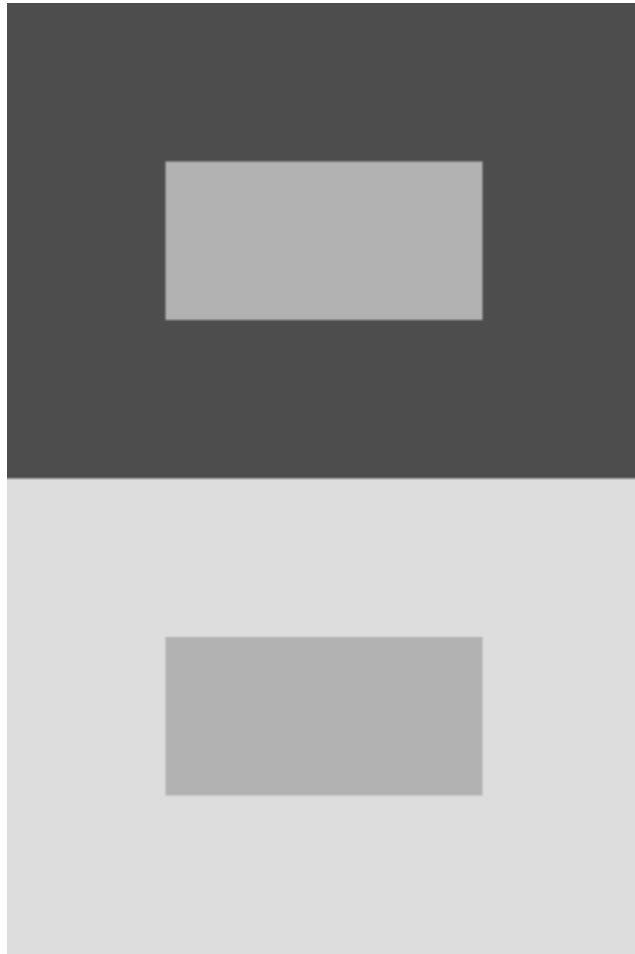
COLOR DISTORTION

Bezold Effect



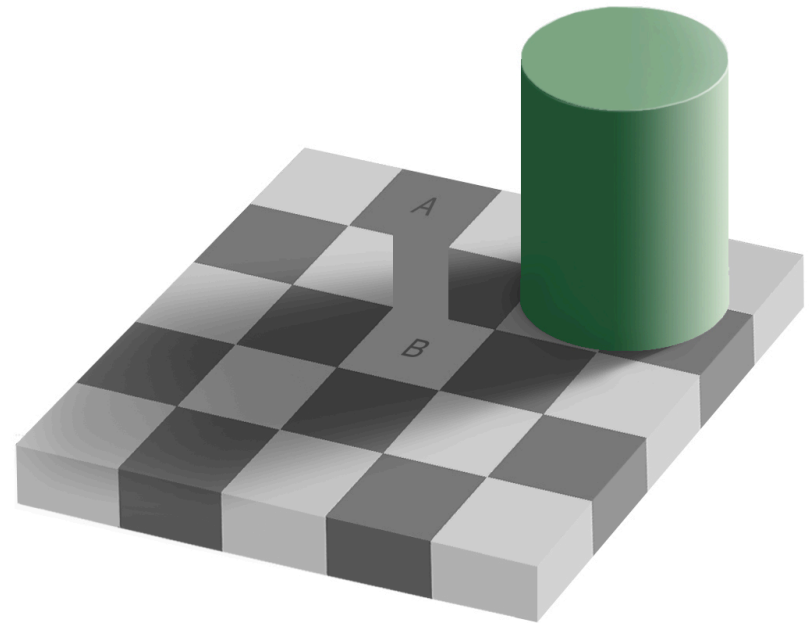
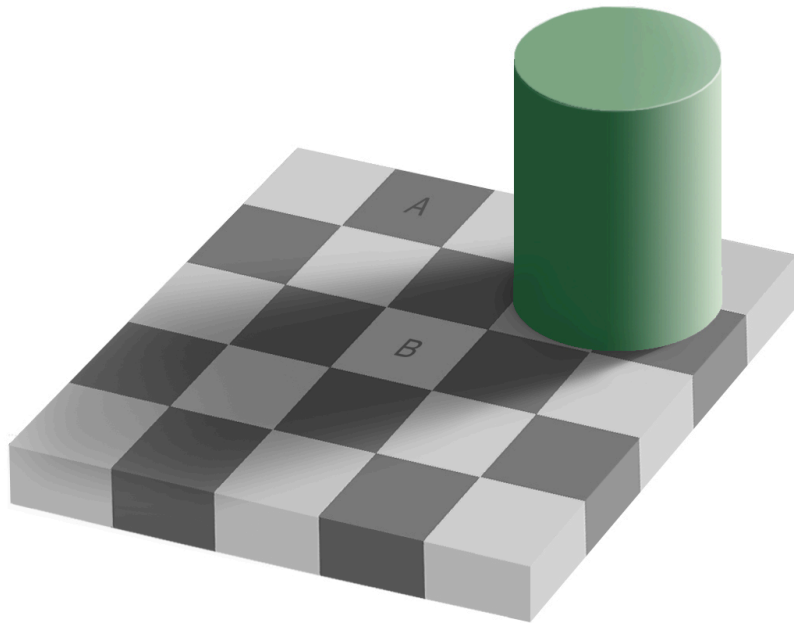
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Simultaneous Contrast



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Adelson's Illusion

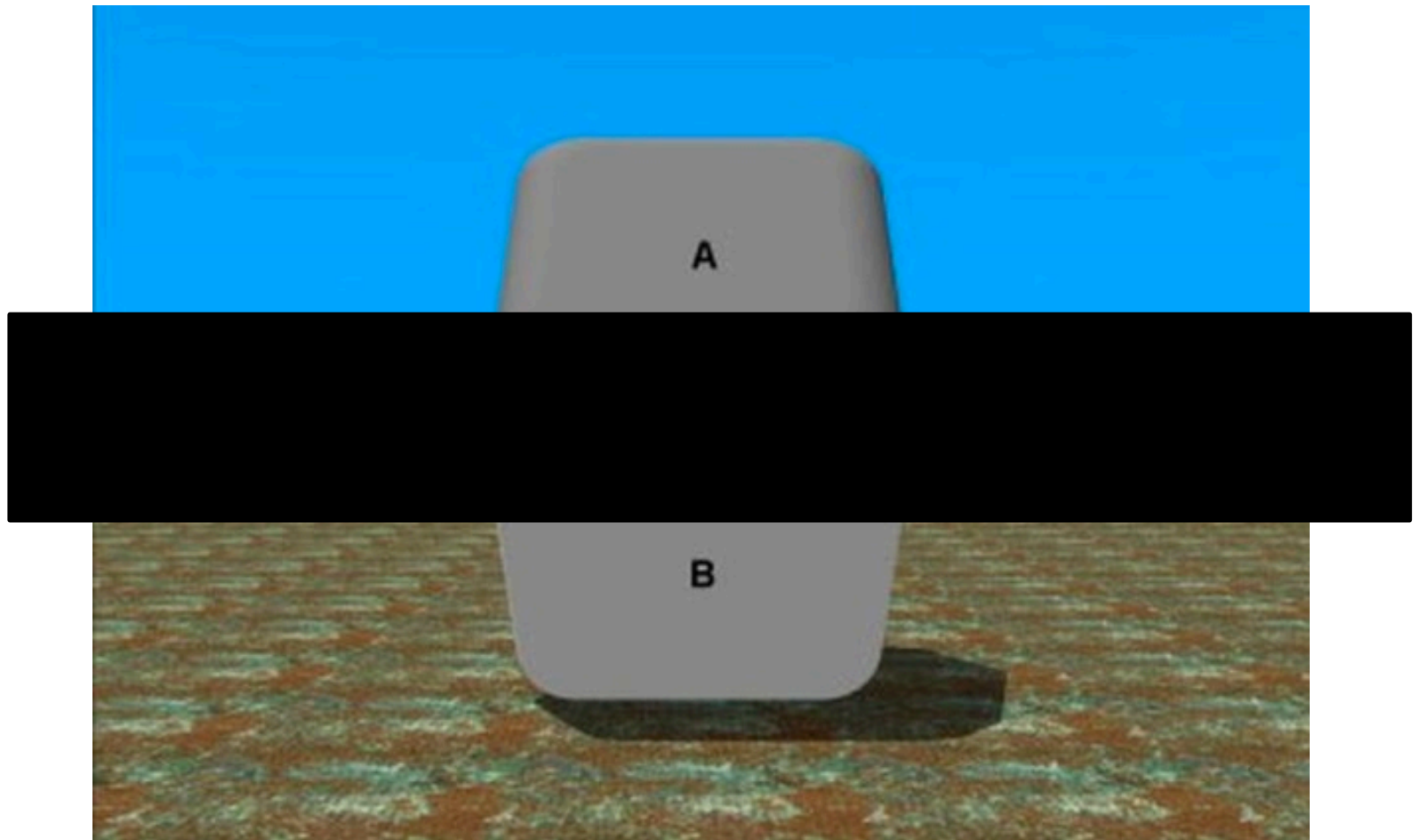


"Grey square optical illusion" by Original by Edward H. Adelson, this file by Gustavb - File created by Adrian Pingstone, based on the original created by Edward H. Adelson. Licensed under Copyrighted free use via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Grey_square_optical_illusion.PNG#/media/File:Grey_square_optical_illusion.PNG

Color perception



Context



Dress Color

