S. Rinzivillo – rinzivillo@isti.cnr.it

DATA VISUALIZATION AND VISUAL ANALYTICS

Who I Am?

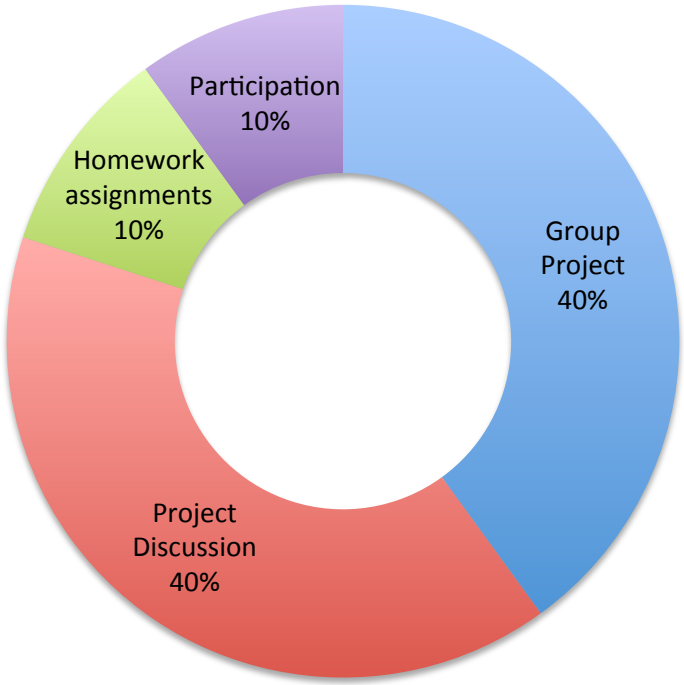
- Salvatore Rinzivillo
  - rinzivillo@isti.cnr.it
- Page course: http://didawiki.cli.di.unipi.it/
  - Visual Analytics

Schedule

- On Monday
  - 14:00 to 16:00
  - Room: ~~L1~~ N1
- On Friday
  - 14:00 to 16:00
  - Room: N1

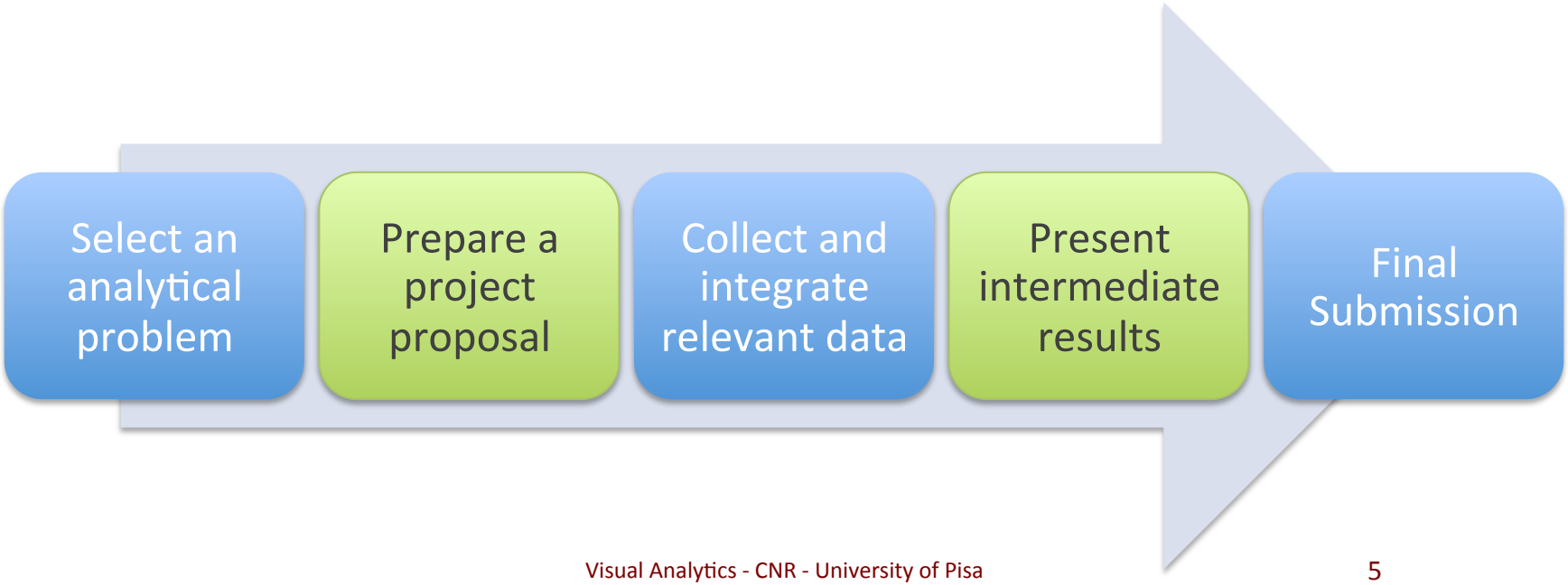
Grading

- Homework assignments (10%)
  - *In itinere* tasks and small projects
- Project (40%)
  - Up to 2 persons per group (?)
- Project discussion (40%)
- Participation (10%)



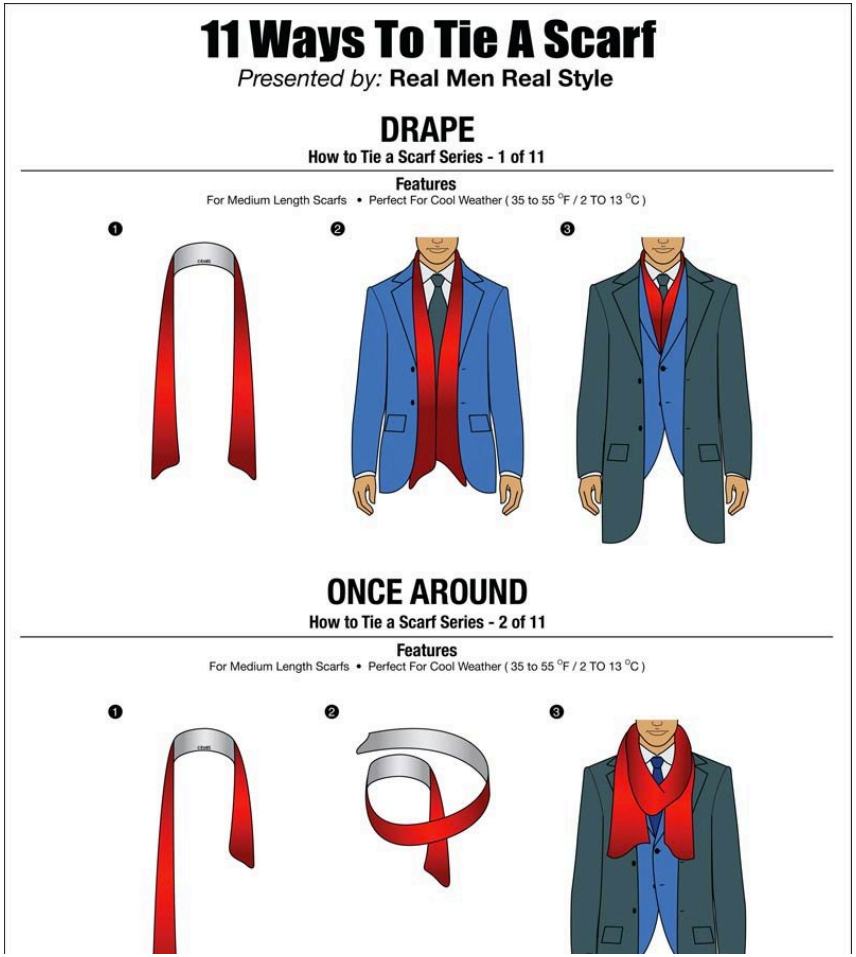
Grading Projects

- Objective: select and present a visual interface for an analytical problem



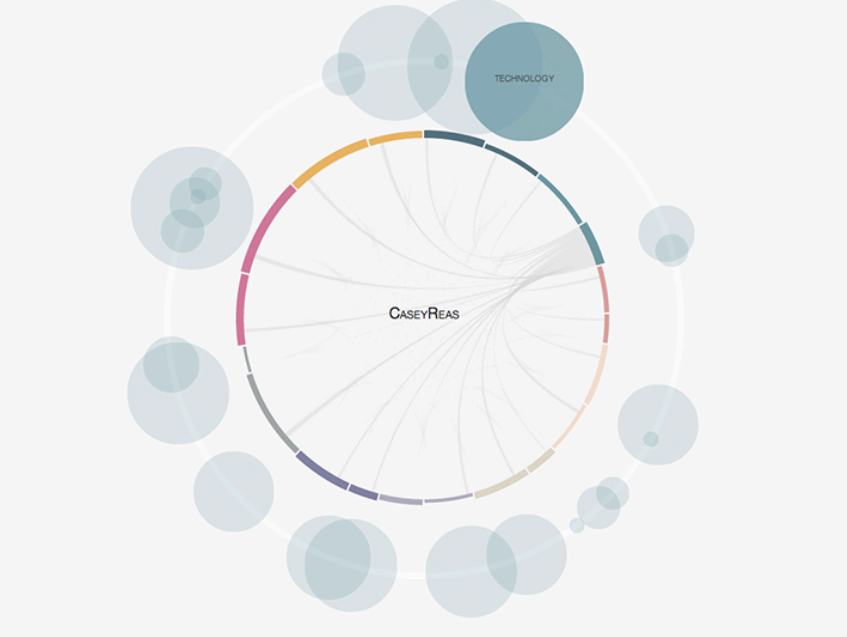
Not valid projects

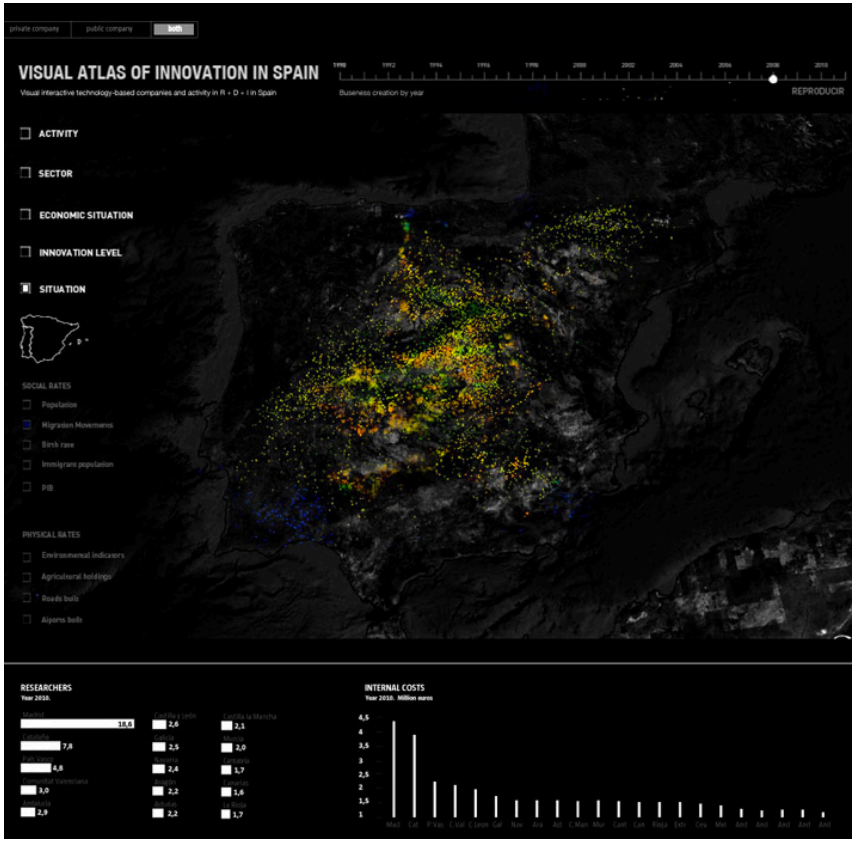




Visual appealing compositions. Not linked to data nor to an analytical process

Valid proposals



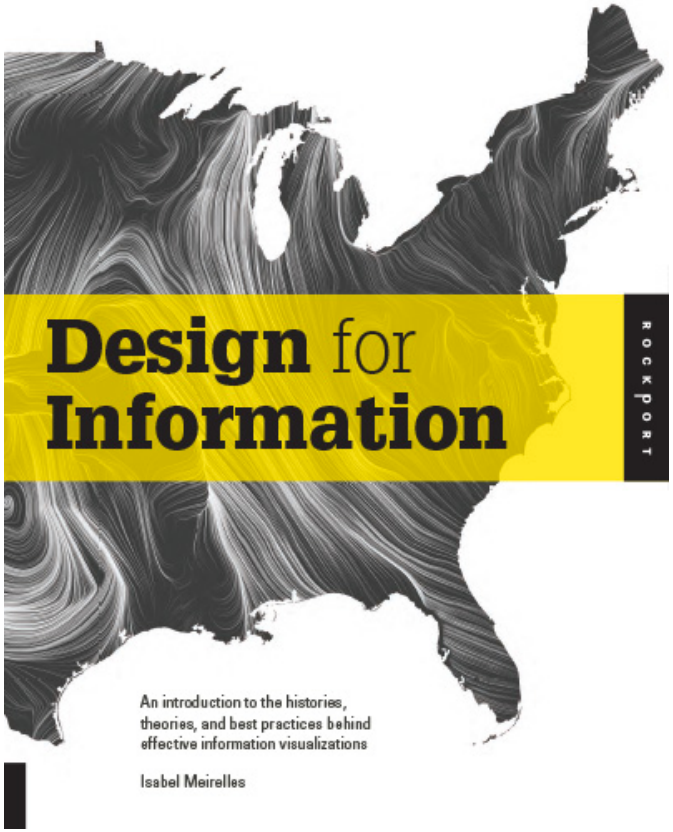


http://lab.interactivethings.com/substratum-visualization/application.html

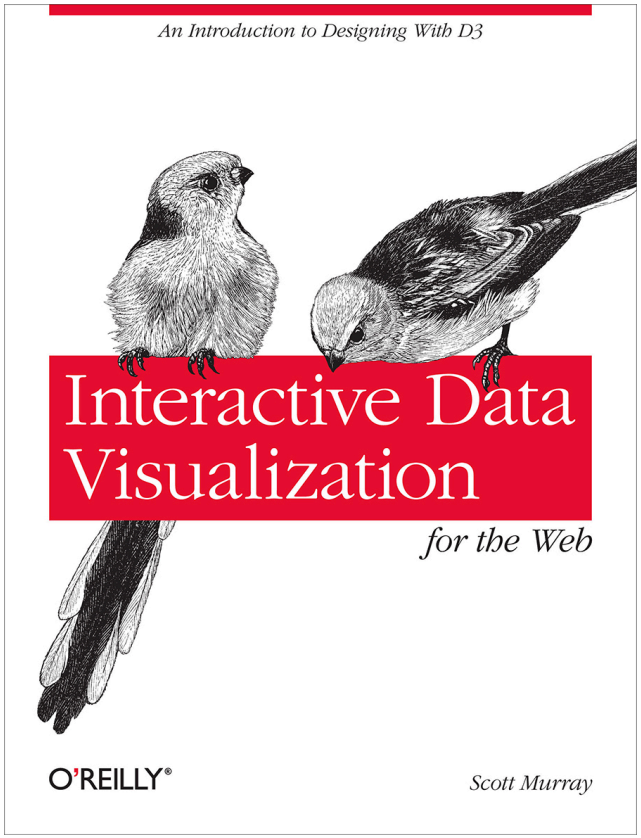
http://www.atlasvisualdeinnovacion.com/

Textbooks

Design for Information
Isabel Meirelles



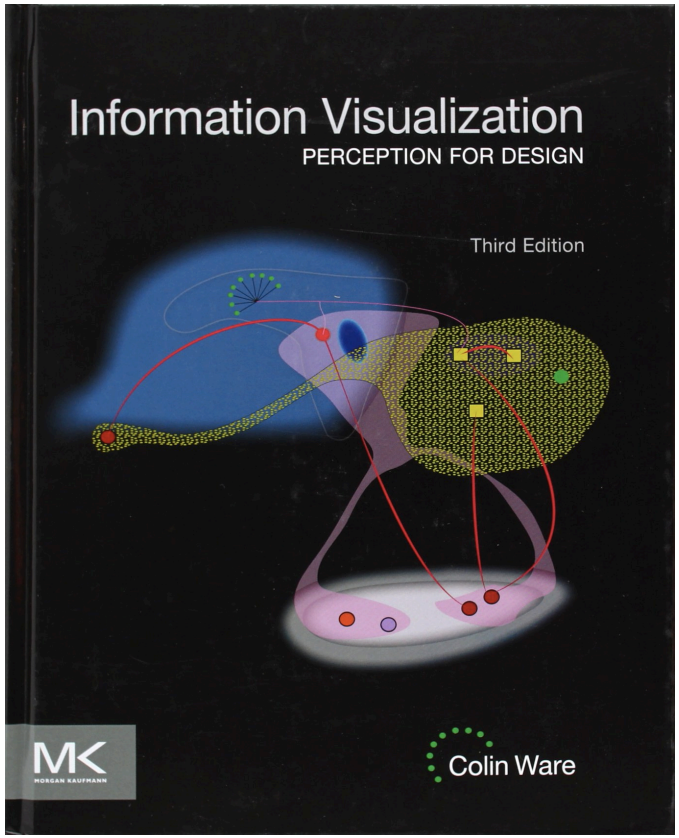
Interactive Data Visualization
Scott Murray



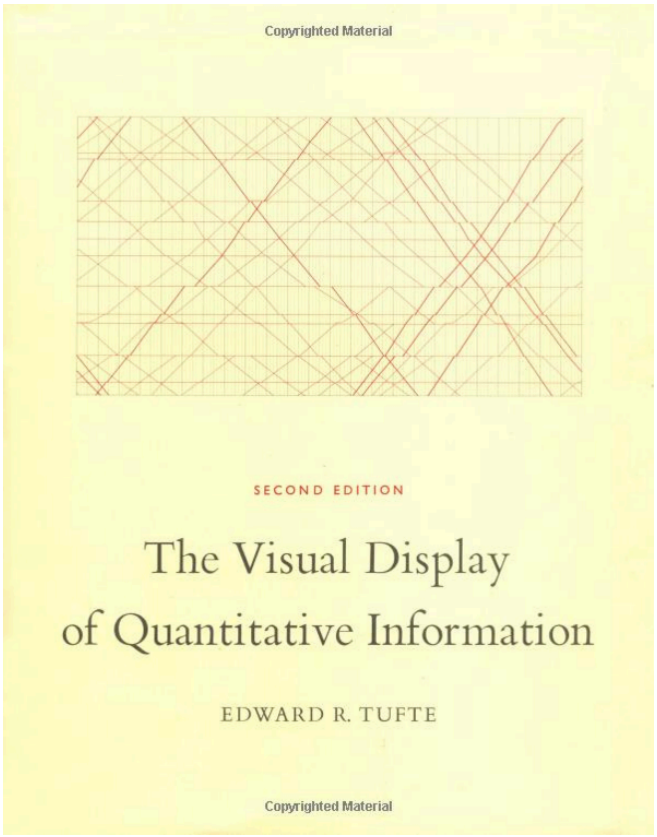
http://alignedleft.com/tutorials

Interesting Readings

Information Visualization
Colin Ware



The Visual Display of Visual Information
Edward R. Tufte

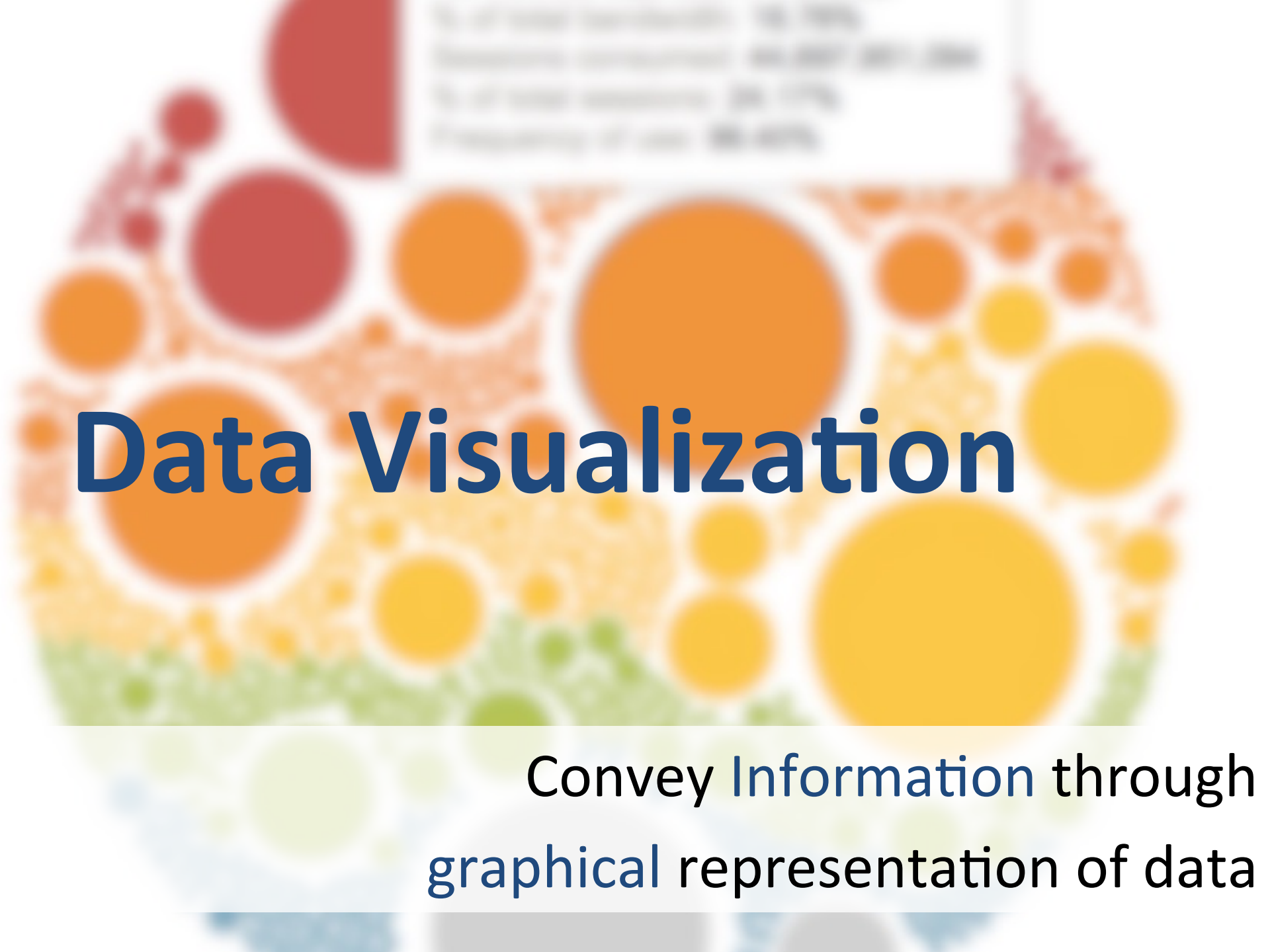


DATA VISUALIZATION AND VISUAL ANALYTICS

INTRODUCTION

VA - Crash course

- Effective Visual Representation
  - Vision System
  - Visual Variables
- Toolbox – D3.js
  - Basics
  - Charts
  - Advanced Visualization
- Scientific Visualization
  - Plotting
  - Geography
- Storytelling



Data Visualization

Convey Information through graphical representation of data

Motivations

- Data everywhere
- No value for raw data
  - Need to extract valuable information
- Information overload:
  - Irrelevant for current task
  - Processed in an inappropriate way
  - Presented in an inappropriate way

Visualization Goal

- Record Information
  - Sketches, photographs, ECG,…
- Analyze data to support decisions (exploration)
  - Create and verify hypotheses
  - Identify Patterns
  - Identify Outliers
- Communicate (explanation)
  - Share or highlight insights on data
  - Persuade

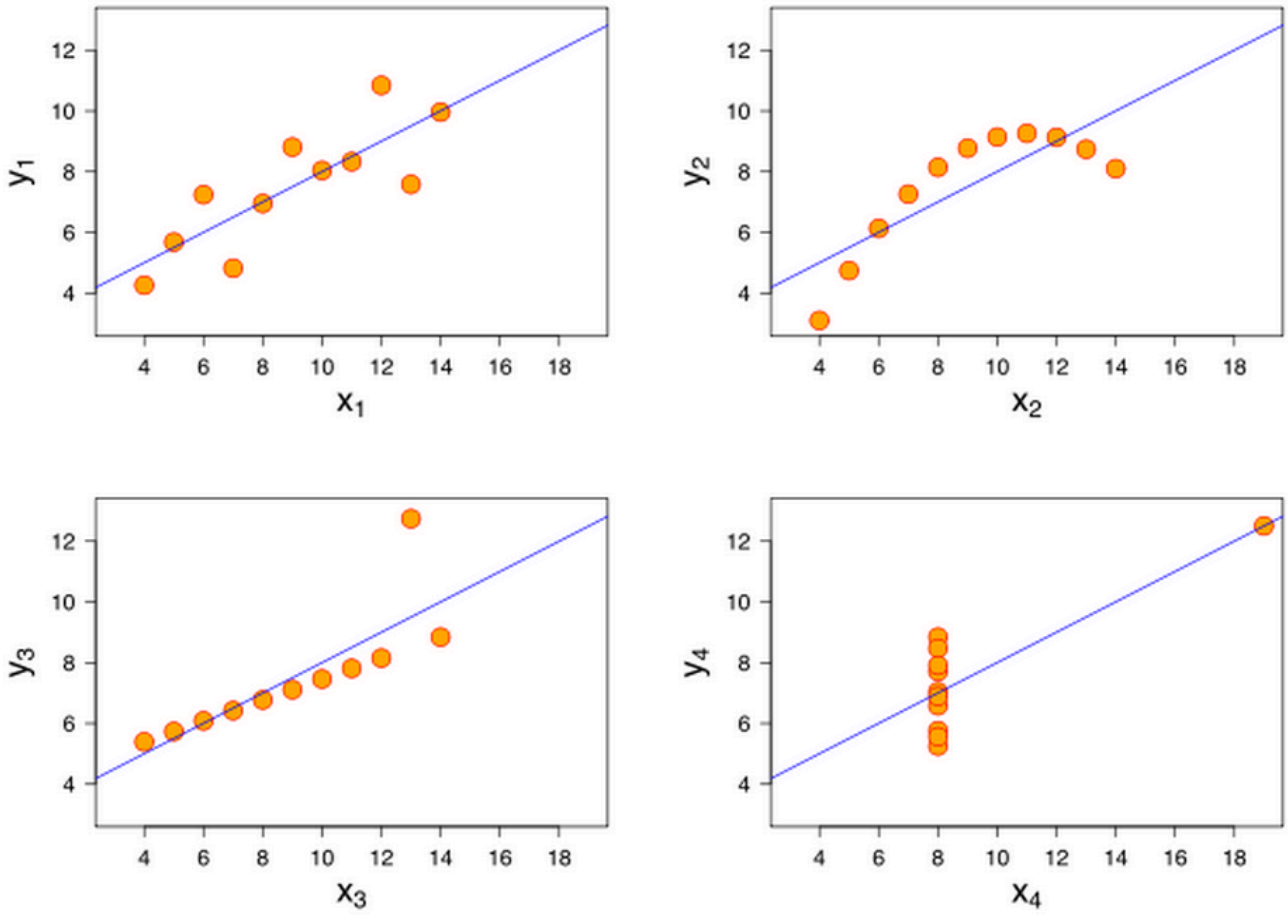
Analyze: Anscombe's quartet - datasets

Data Set A		*Data Set B*		*Data Set C*		*Data Set D*	
X	**Y**	**X**	**Y**	**X**	**Y**	**X**	**Y**
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89

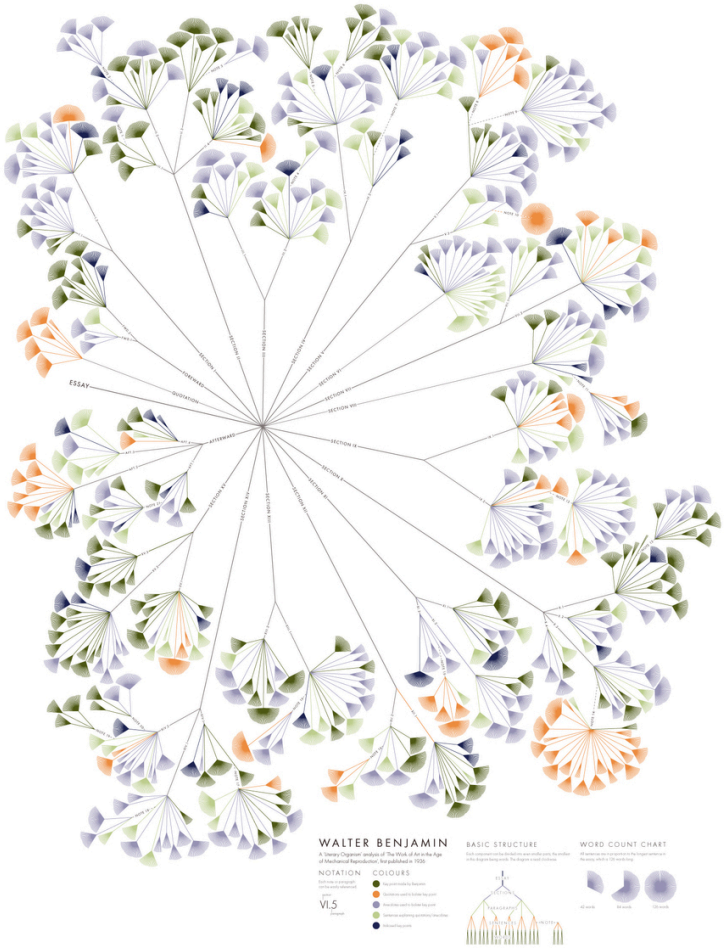
Analyze: Anscombe's quartet - properties

Property	Value
Mean of x in each case	9 (exact)
Sample variance of x in each case	11 (exact)
Mean of y in each case	7.50 (to 2 decimal places)
Sample variance of y in each case	4.122 or 4.127 (to 3 decimal places)
Correlation between x and y in each case	0.816 (to 3 decimal places)
Linear regression line in each case	$y = 3.00 + 0.500x$ (to 2 and 3 decimal places, respectively)

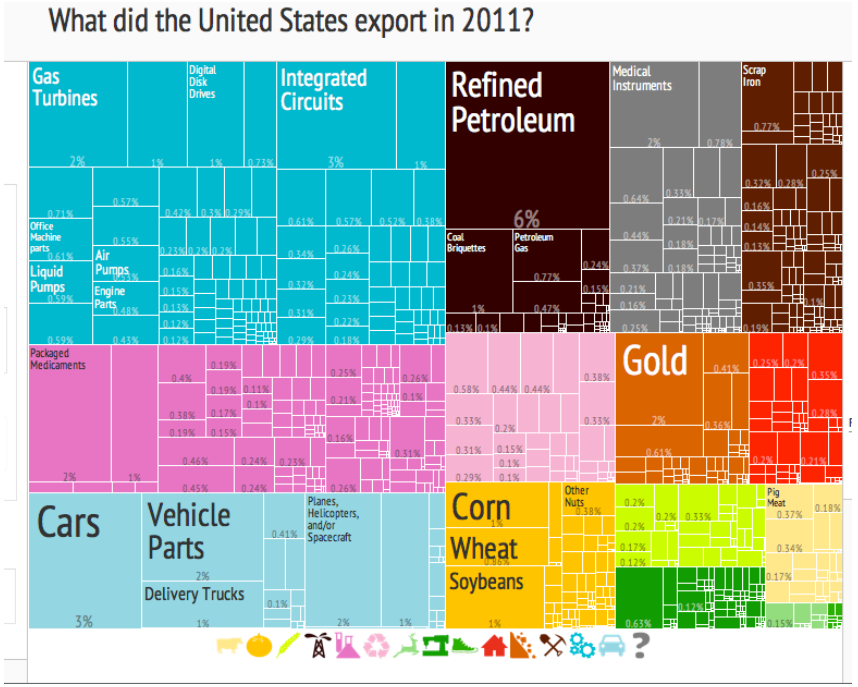
Analyze: Anscombe's quartet – graphics



Communicate: Hierachical Structures

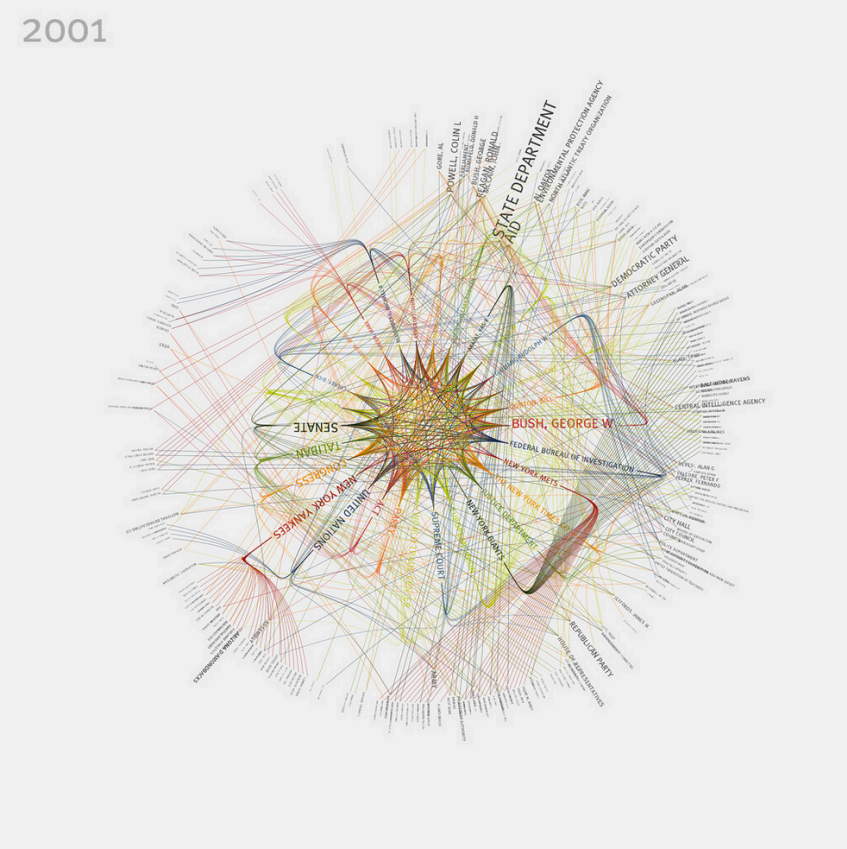


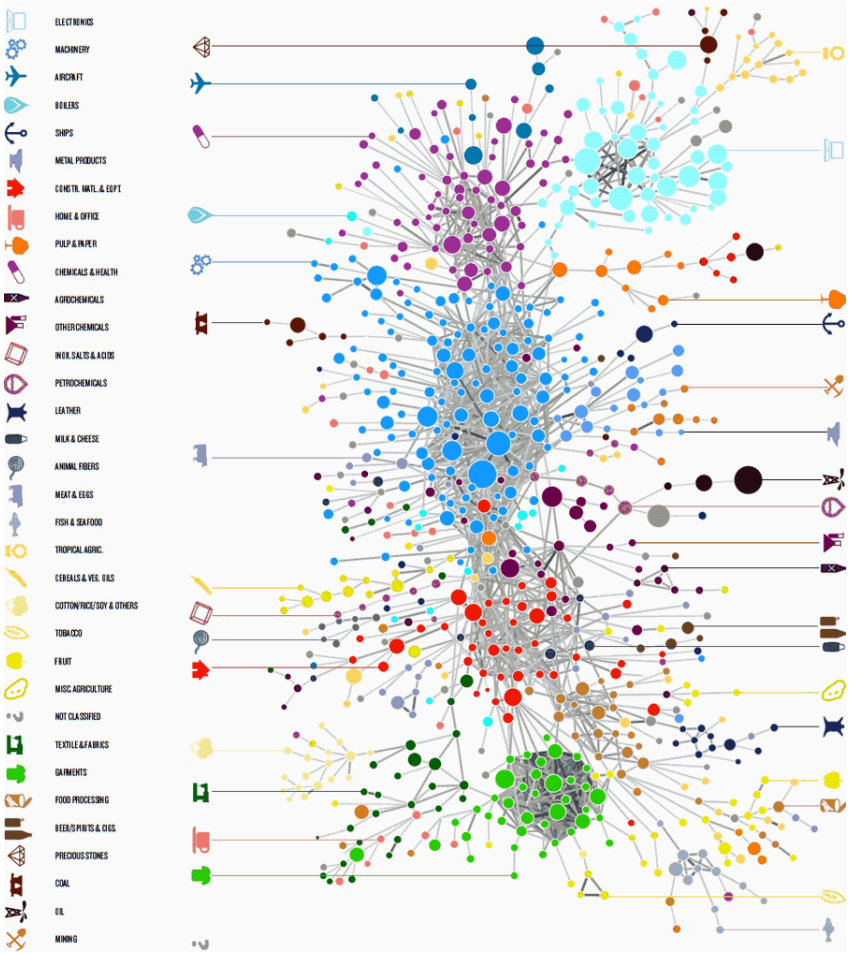
http://www.stefanieposavec.co.uk/entangled-word-bank/



http://atlas.media.mit.edu/

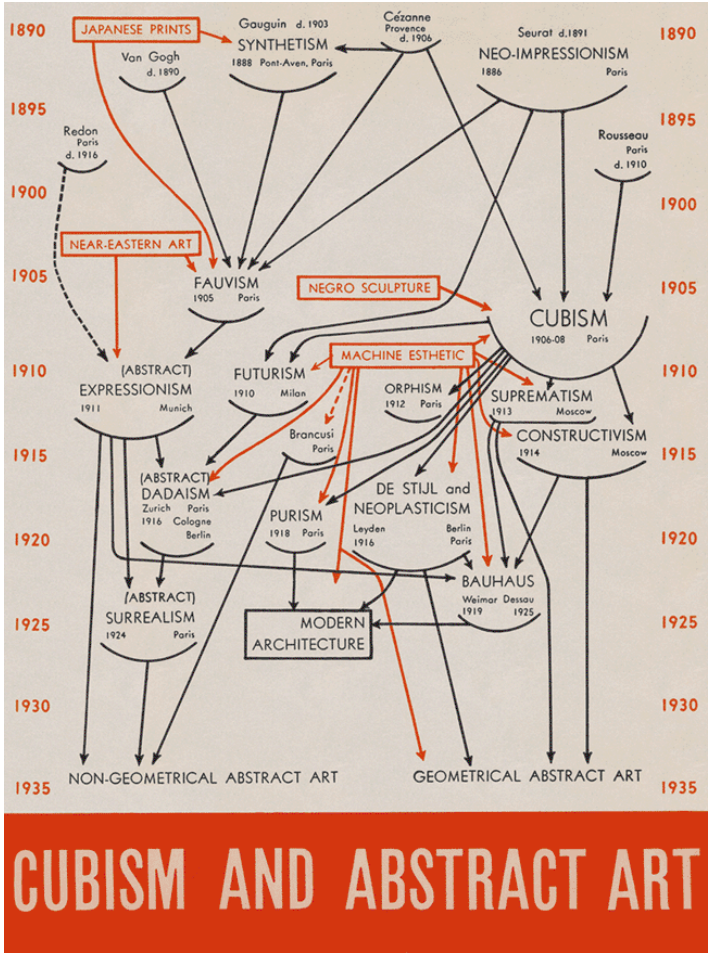
Communicate: Networks



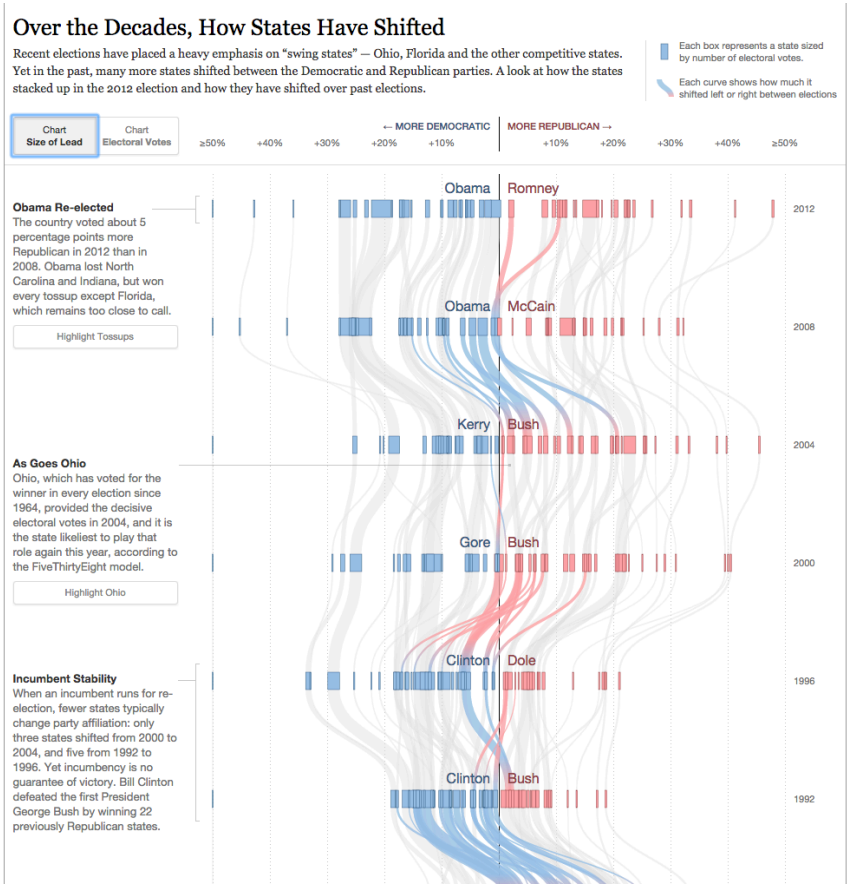


https://www.flickr.com/photos/blprnt/sets/72157614008027965/ http://atlas.media.mit.edu/

Communicate: Temporal Structures

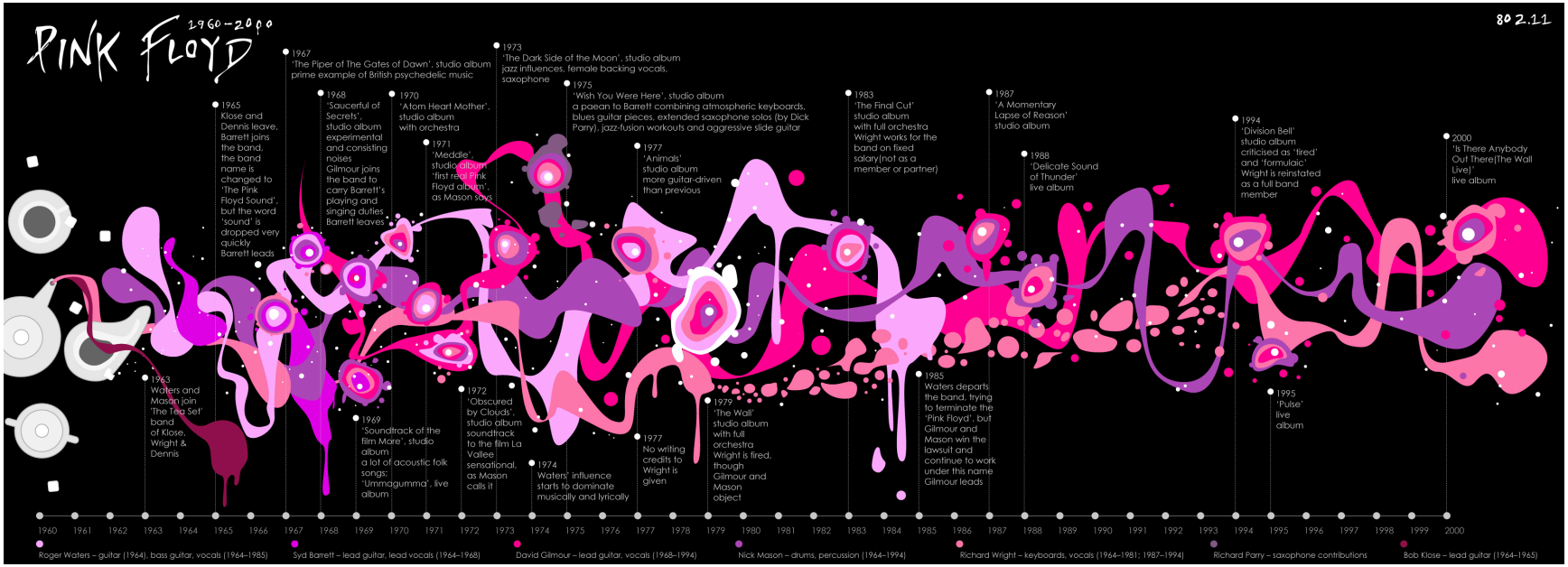


Cubism And Abstract Art (Alfred H. Barr 1936)



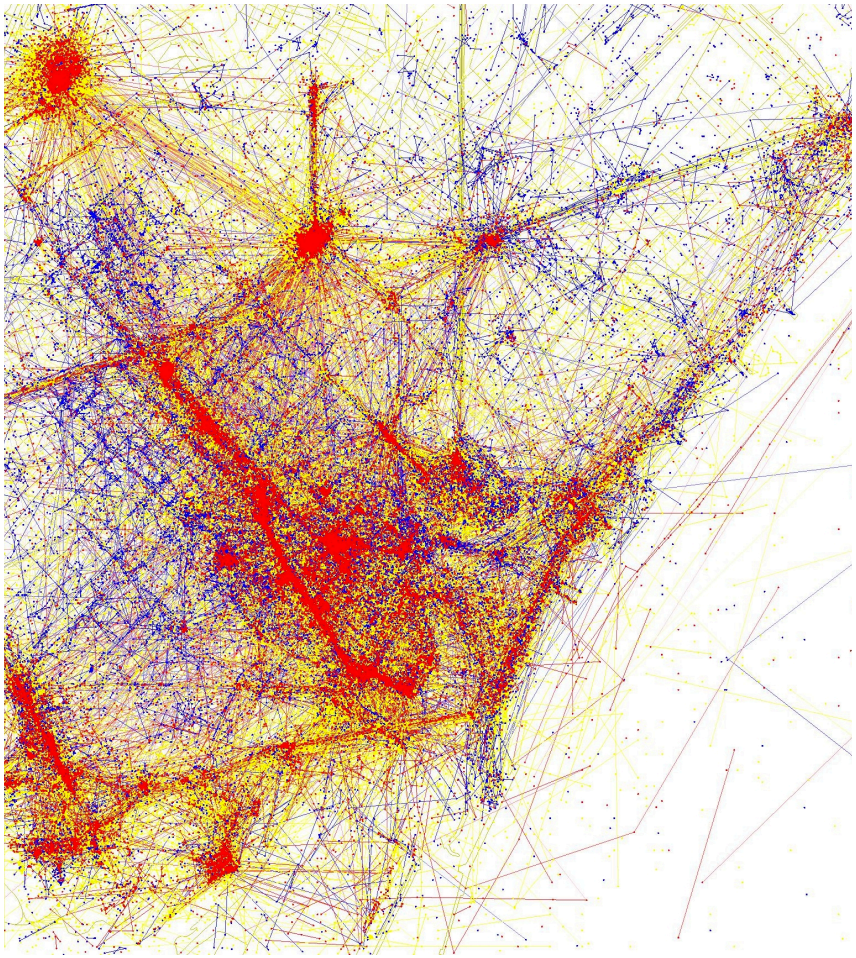
http://www.nytimes.com/interactive/2012/10/15/us/politics/swing-history.html

Communicate: Temporal Structures

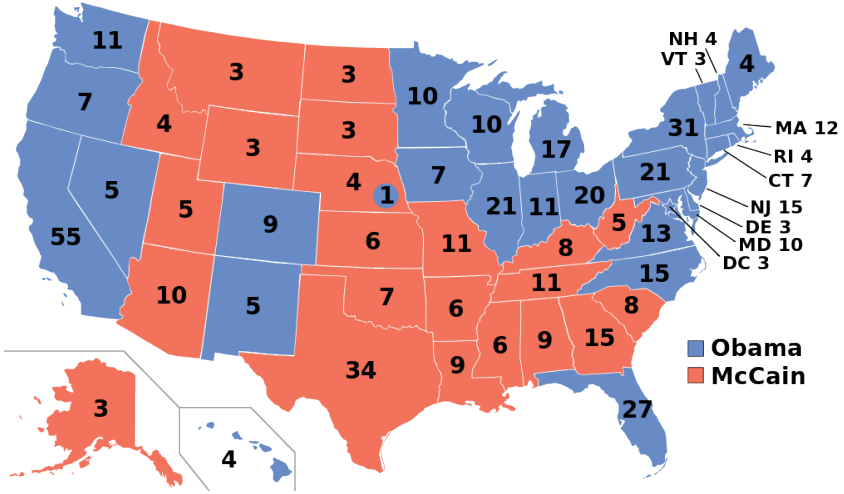


http://www.80211.cc/

Communicate: Maps

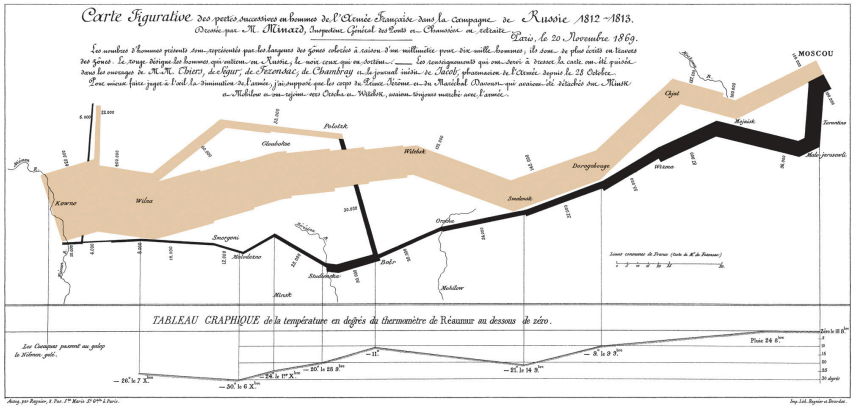


https://www.flickr.com/photos/walkingsf/sets/72157624209158632/

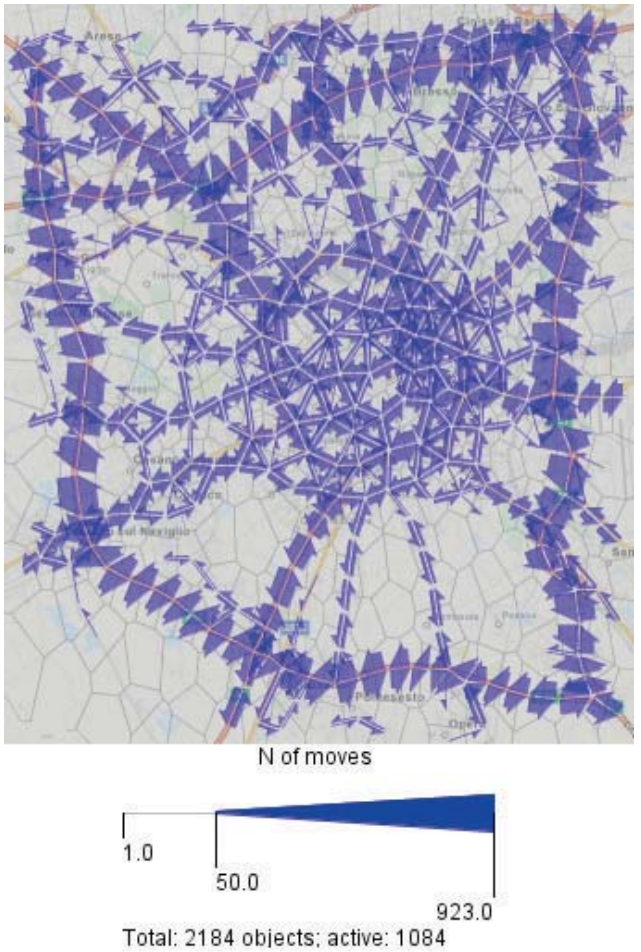


"ElectoralCollege2008" by Gage - Own work. Licensed under Public Domain via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:ElectoralCollege2008.svg#mediaviewer/File:ElectoralCollege2008.svg

Communicate: Spatio-Temporal data
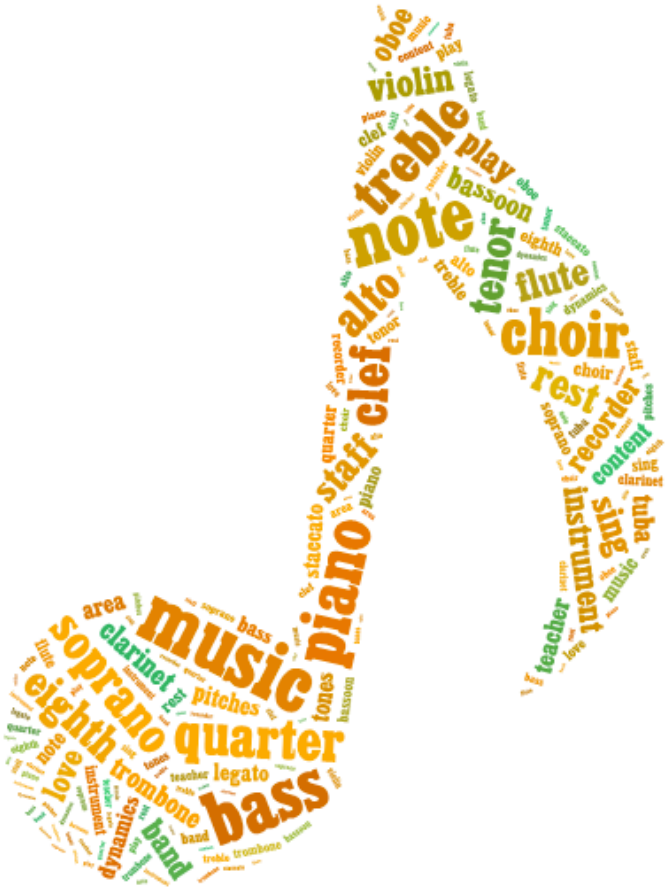


"Minard" by Charles Minard (1781-1870) - see upload log. Licensed under Public Domain via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Minard.png#mediaviewer/File:Minard.png



Visual Analytics of Movement.
G. Andrienko, N. Andrienko, P. Bak, D. Keim, S. Wrobel
Springer, 2013

Communicate: Text

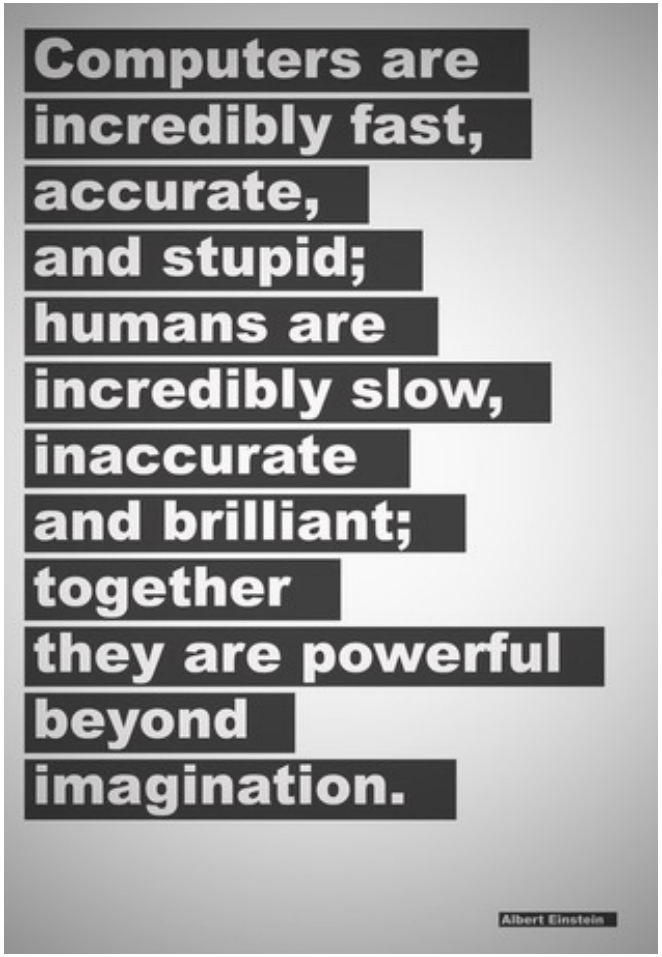




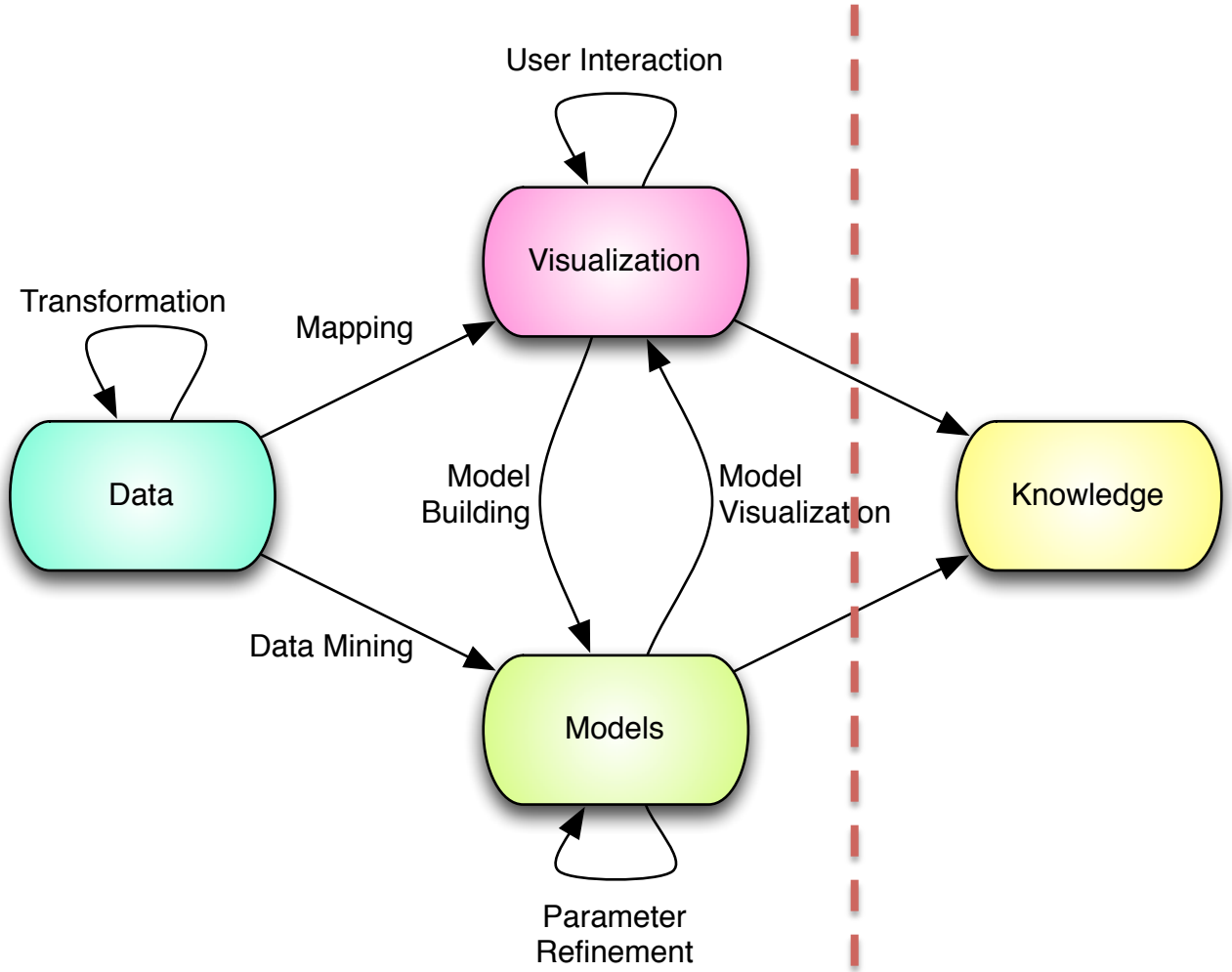
http://benfry.com/writing/archives/529

Visualization and Visual Analytics

- Make data and information processing transparent
- Combine strengths of humans and computers

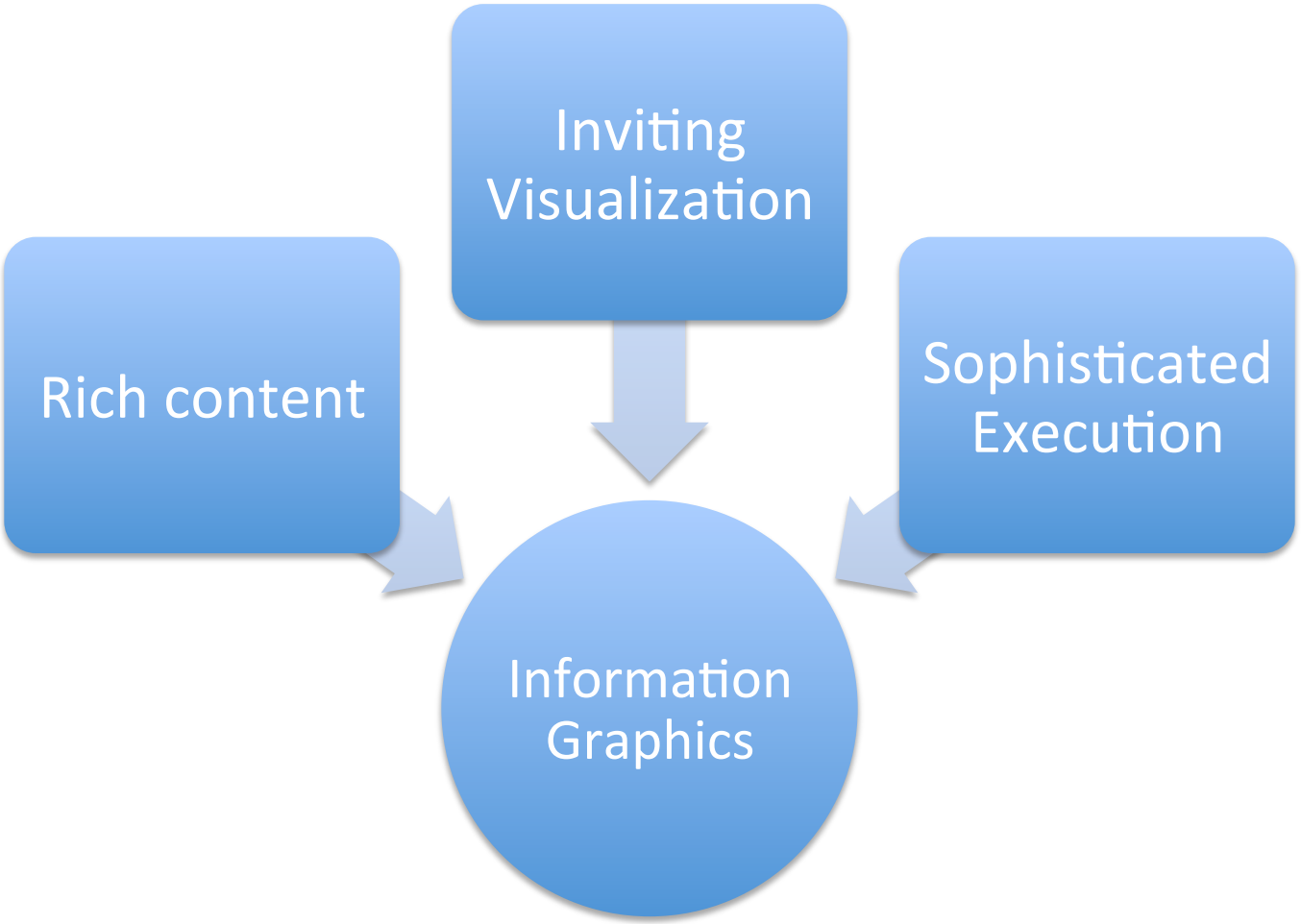


Visual Analytical Process



Adapted from:
Mastering the Information Age
Keim, Kohlhammer, Ellis, Mansmann

Elements of Good Visualization



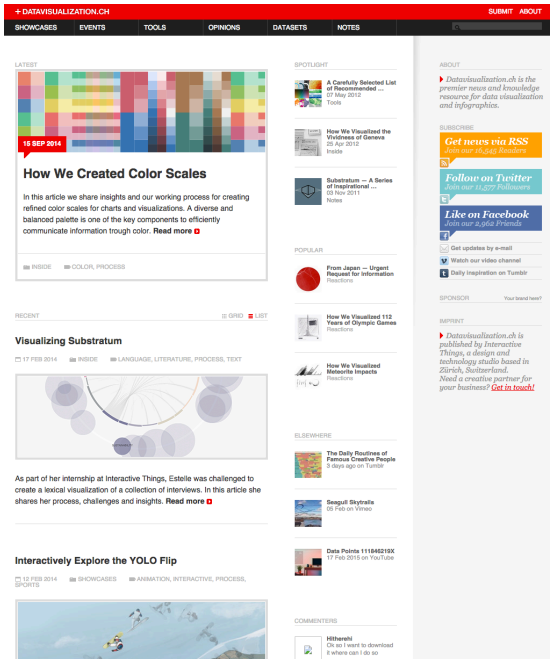
Importance of valid data



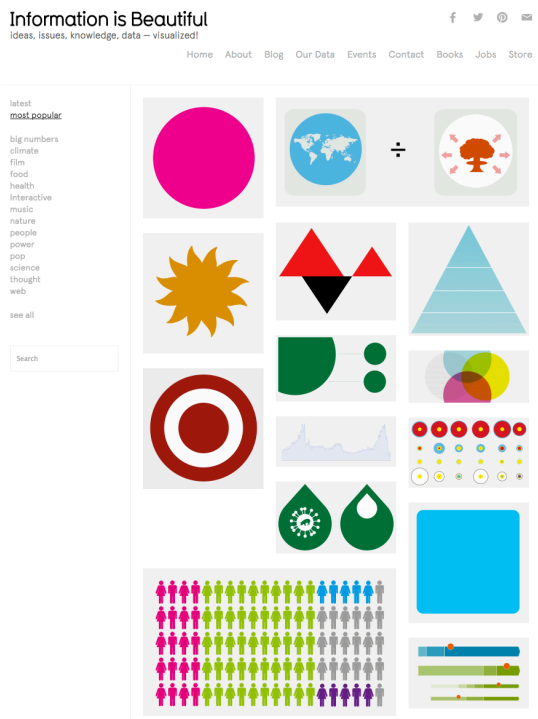
Other Resources

Observe how others resolved design problems

datavisualization.ch



informationisbeautiful.net

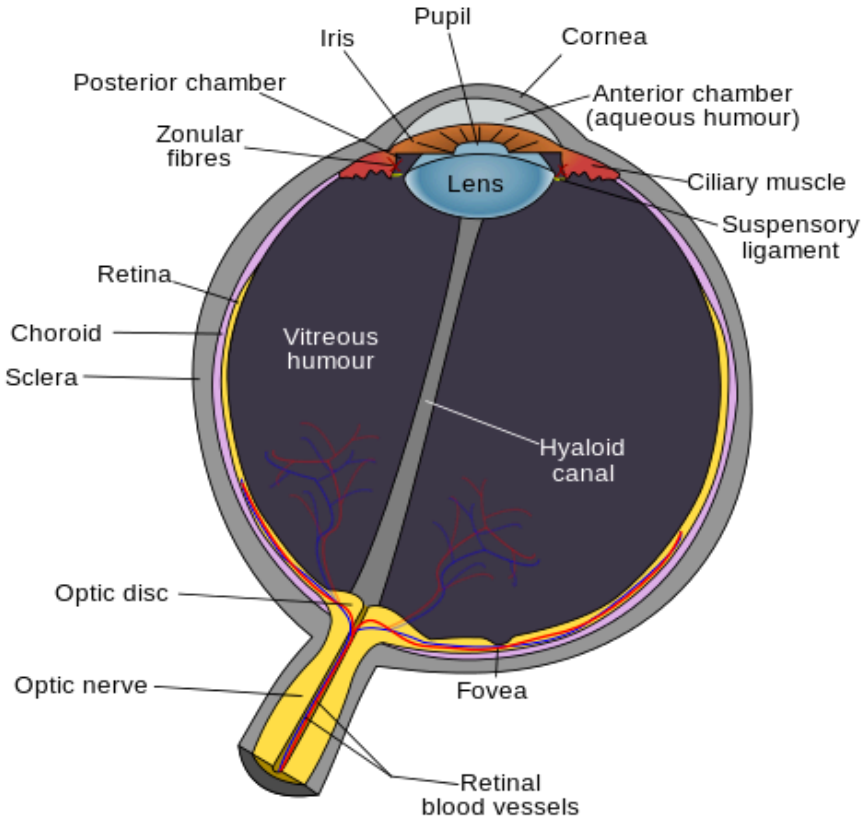


infosthetics.com



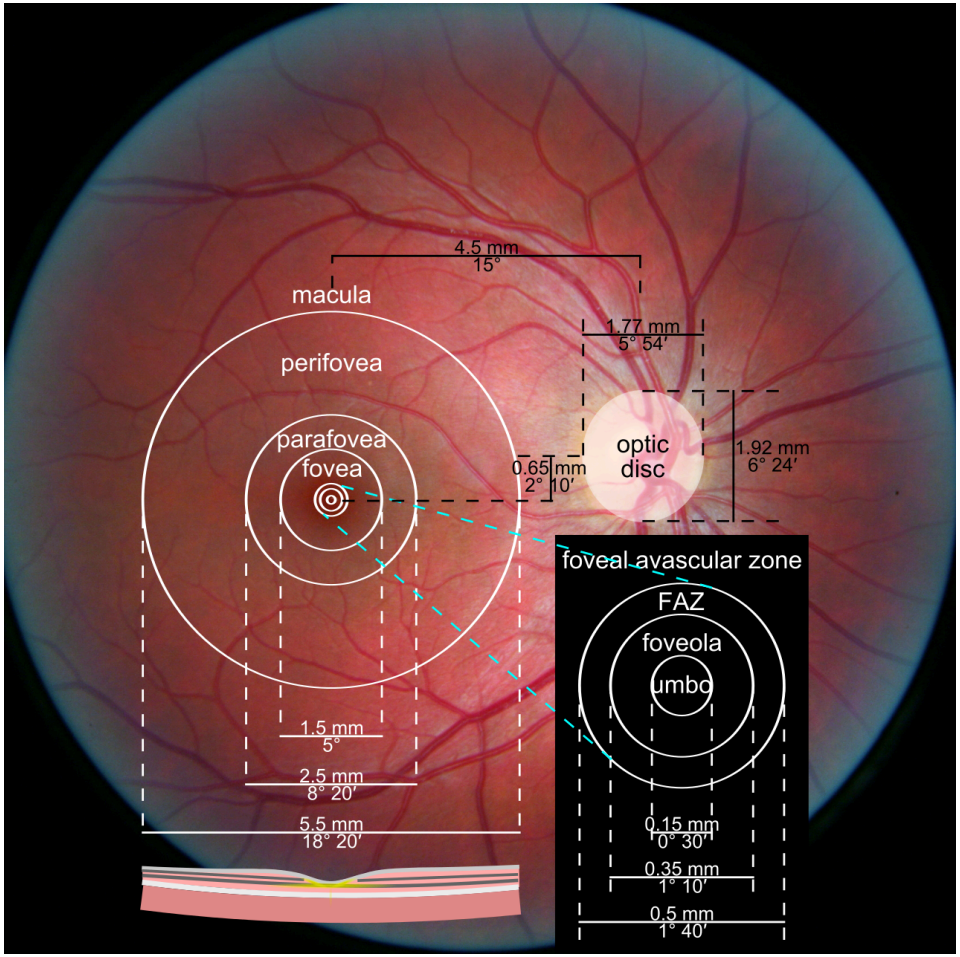
VISION AND PERCEPTION

Human Eye



"Schematic diagram of the human eye en" by Rhcastilhos - Schematic_diagram_of_the_human_eye_with_English_annotations.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

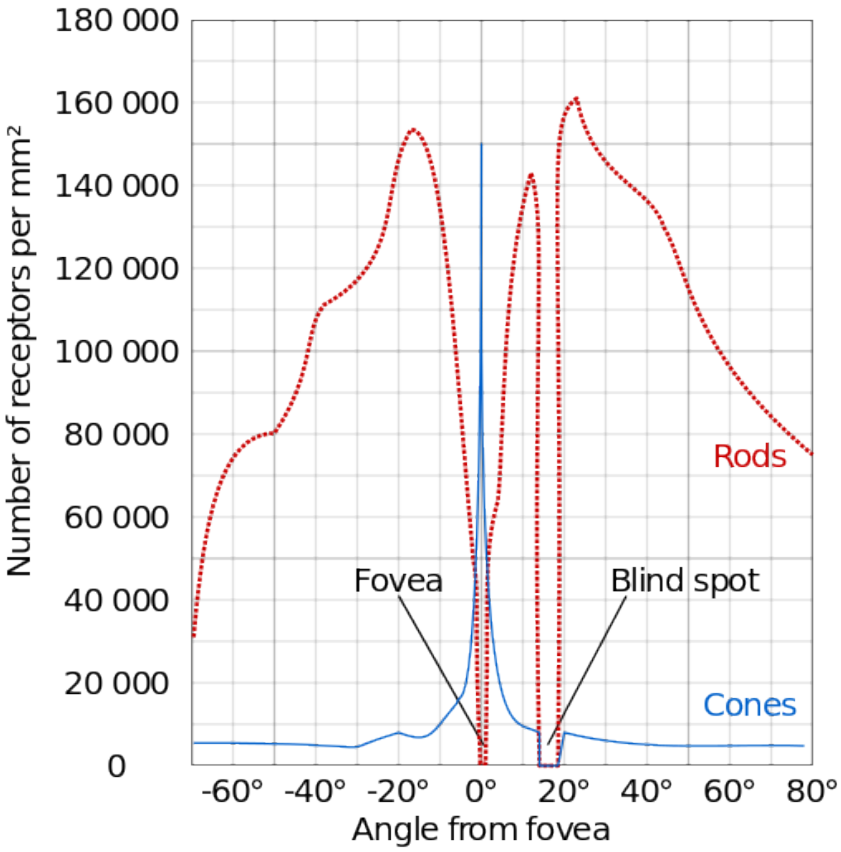
Macula and Fovea



"Macula" by Photograph: Danny Hope from Brighton & Hove, UK - File:Righ_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

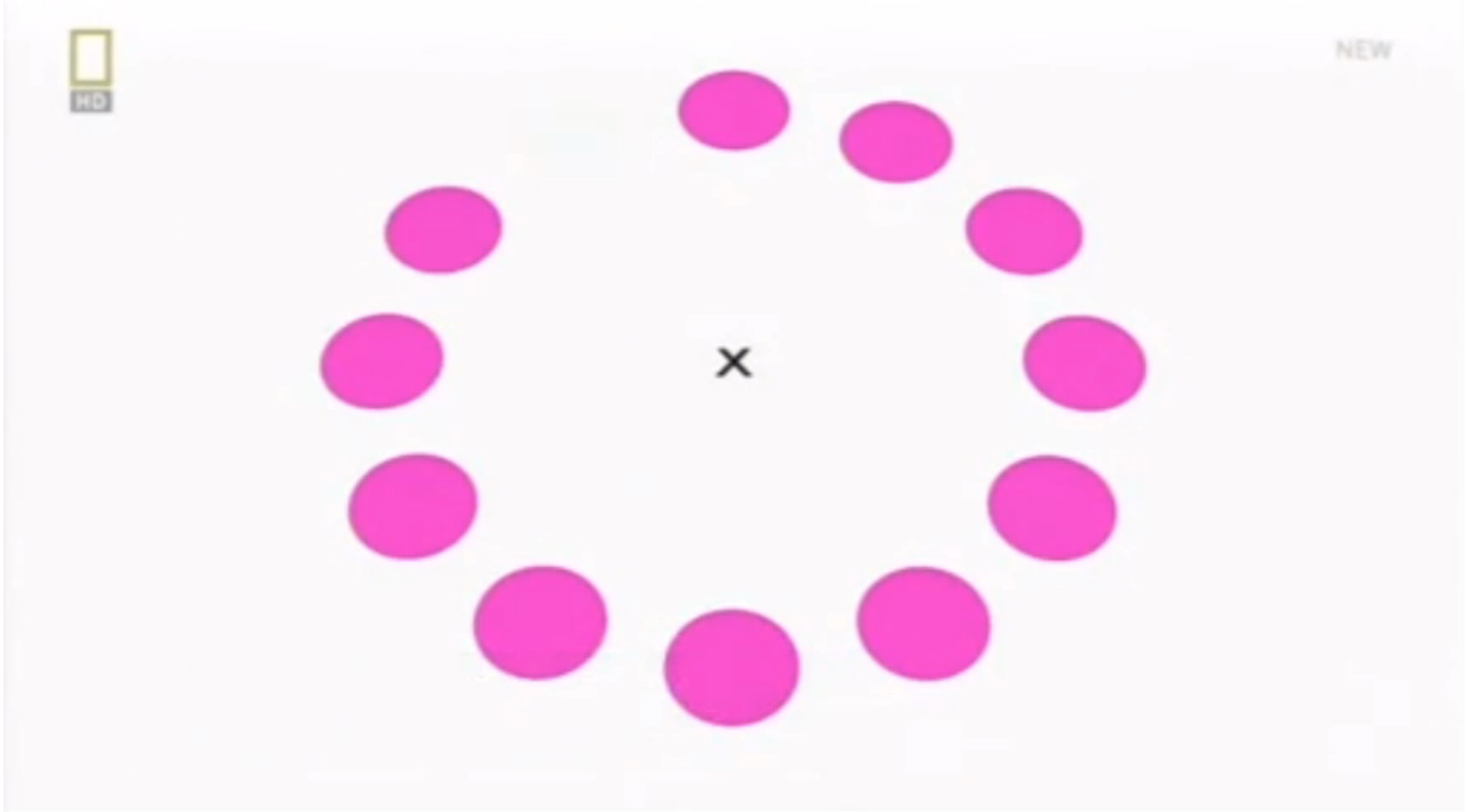
Photo Receptor Cells

- 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

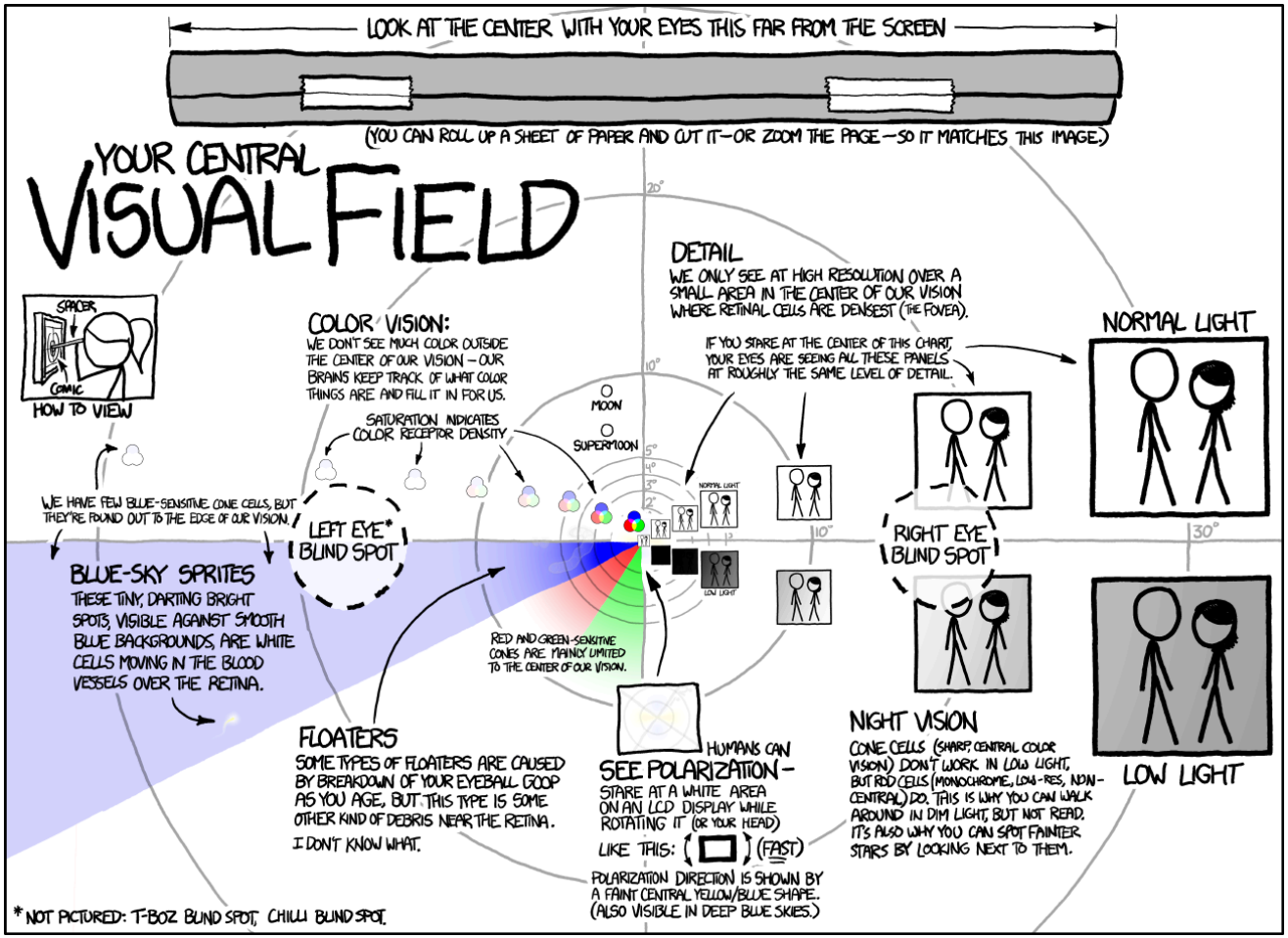


"Human photoreceptor distribution" by Cmglee - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Human_photoreceptor_distribution.svg#mediaviewer/File:Human_photoreceptor_distribution.svg

Peripheral Vision Test – Game #1

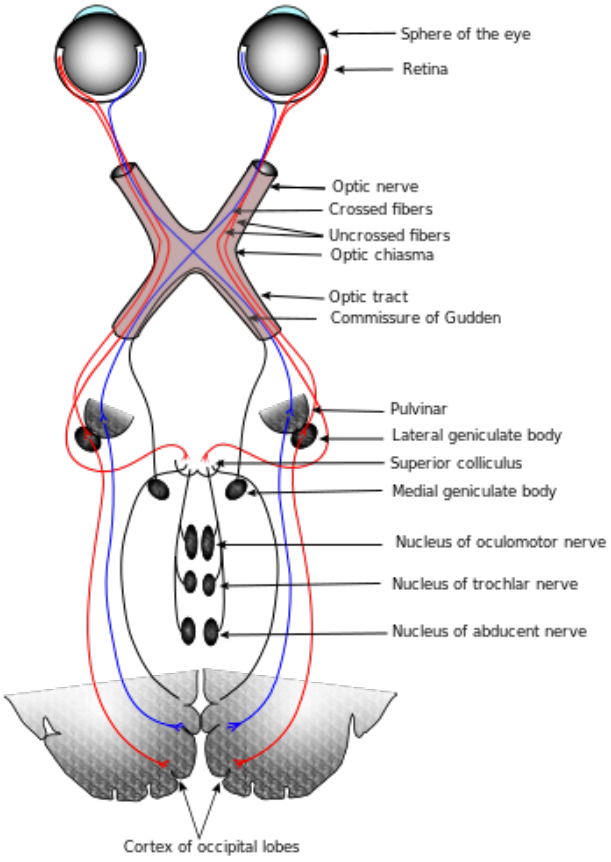


Vision Resolution

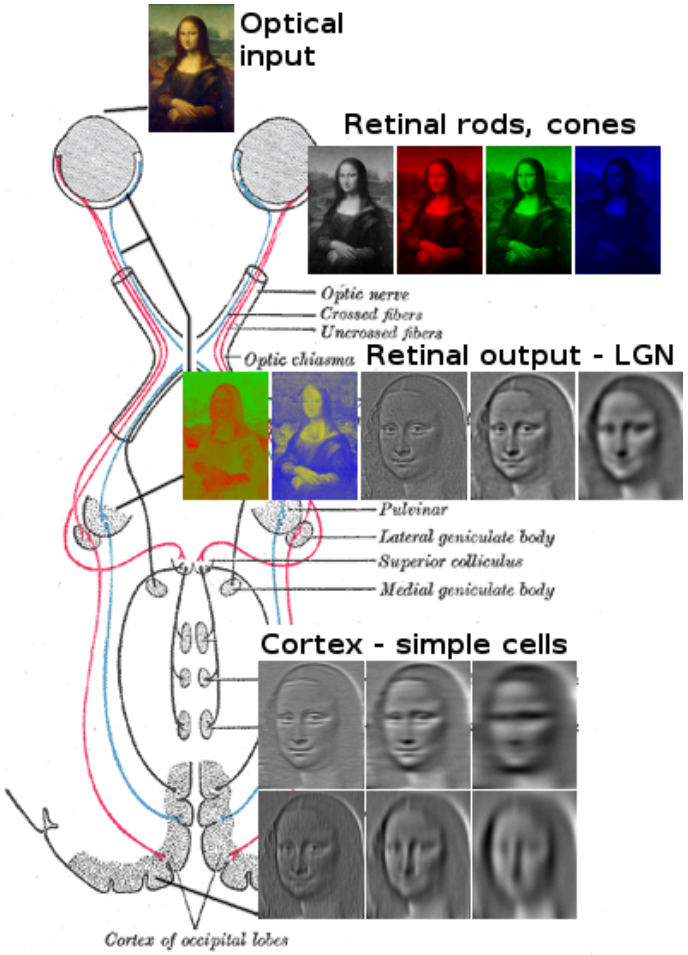


http://xkcd.com/1080/

Visual System



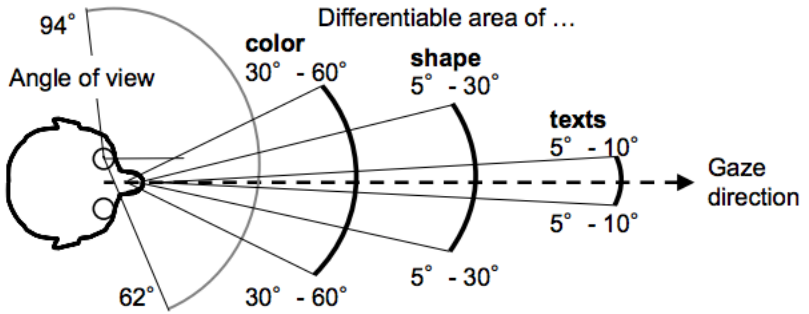
"Gray722-svg" by KDS444 - https://commons.wikimedia.org/wiki/File:Gray722.png. Licensed under Public Domain via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Gray722-svg.svg#/media/File:Gray722-svg.svg



"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

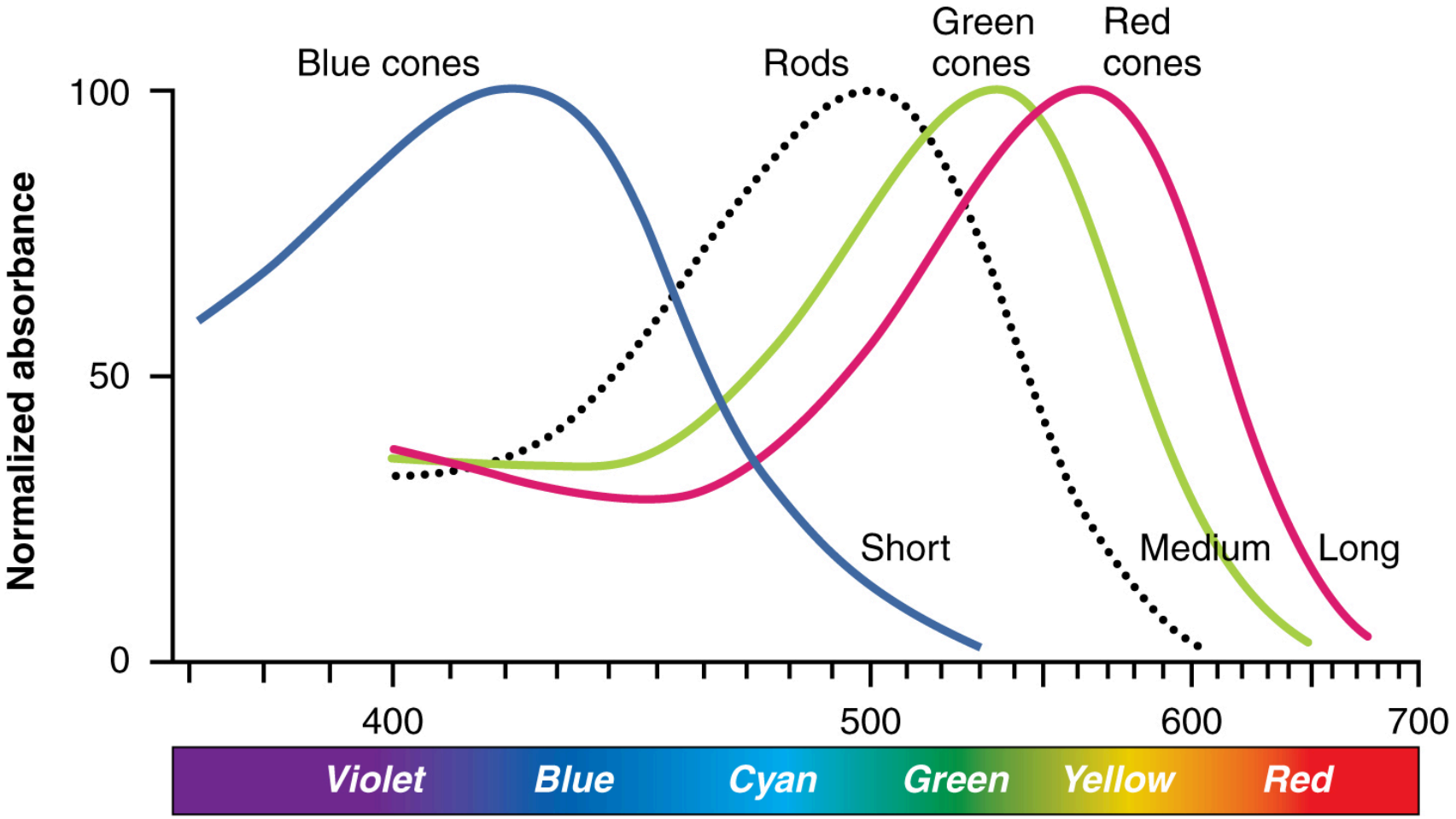
Vision Resolution

- 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)

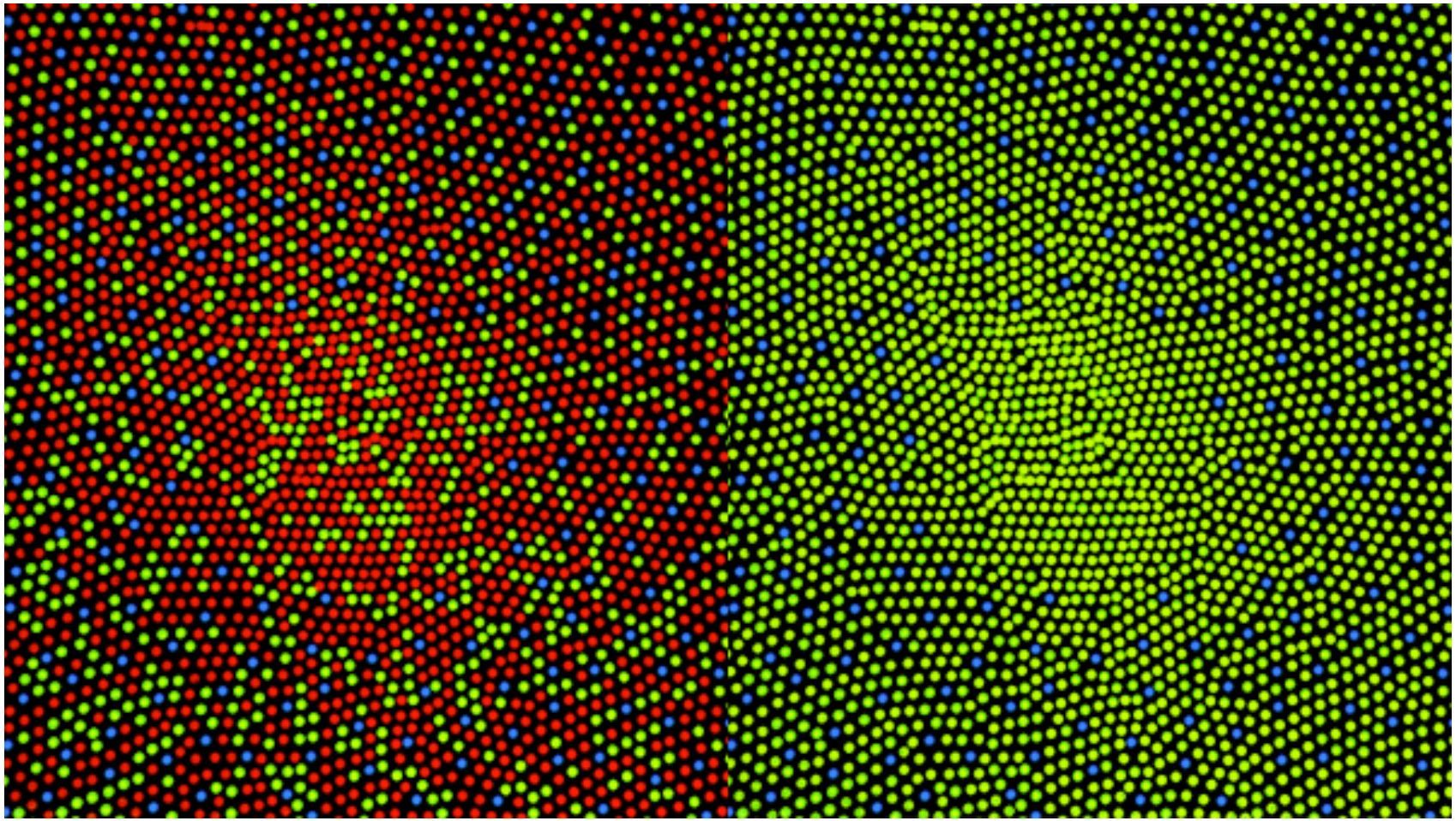
Photo Receptor Cells



"1416 Color Sensitivity" by OpenStax College - Anatomy & Physiology, Connexions Web site. http://cnx.org/content/col11496/1.6/, Jun 19, 2013.. Licensed under CC BY 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:1416_Color_Sensitivity.jpg#mediaviewer/File:1416_Color_Sensitivity.jpg

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? – Game #2

THE GOBBLING GLUTTONS

ONCE UPON A TIME, WALDO EMBARKED UPON A FANTASTIC JOURNEY. FIRST, AMONG A THRONG OF GOBBLING GLUTTONS, HE MET WIZARD WHITEBEARD, WHO COMMANDED HIM TO FIND A SCROLL AND THEN TO FIND ANOTHER AT EVERY STAGE OF HIS JOURNEY. FOR WHEN HE HAD FOUND 12 SCROLLS, HE WOULD UNDERSTAND THE TRUTH ABOUT HIMSELF.

IN EVERY PICTURE FIND WALDO, WOOF (BUT ALL YOU CAN SEE IS HIS TAIL), WENDA, WIZARD WHITEBEARD, ODLAW, AND THE SCROLL. THEN FIND WALDO'S KEY, WOOF'S BONE (IN THIS SCENE IT'S THE BONE THAT'S NEAREST TO HIS TAIL), WENDA'S CAMERA, AND ODLAW'S BINOCULARS.

THERE ARE ALSO 25 WALDO-WATCHERS, EACH OF WHOM APPEARS ONLY ONCE SOMEWHERE IN THE FOLLOWING 12 PICTURES. AND ONE MORE THING! CAN YOU FIND ANOTHER CHARACTER, NOT SHOWN BELOW, WHO APPEARS ONCE IN EVERY PICTURE EXCEPT THE LAST?



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 linera

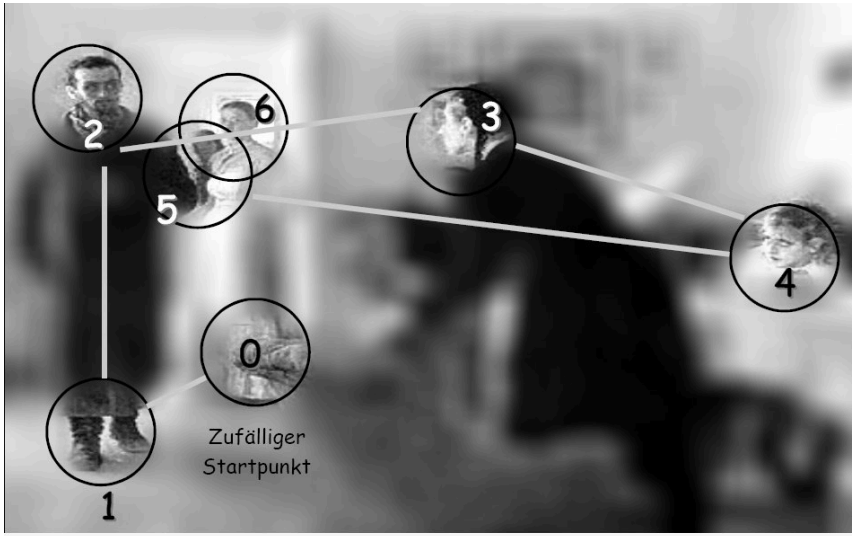


Bild 11: Foveale Ergänzung durch die ersten 6 Fixationen (nach Daten von *Yarbus,1967*)

"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

Eye Tracking for Design



Top-Down Attention



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

Perception and Cognition



VS

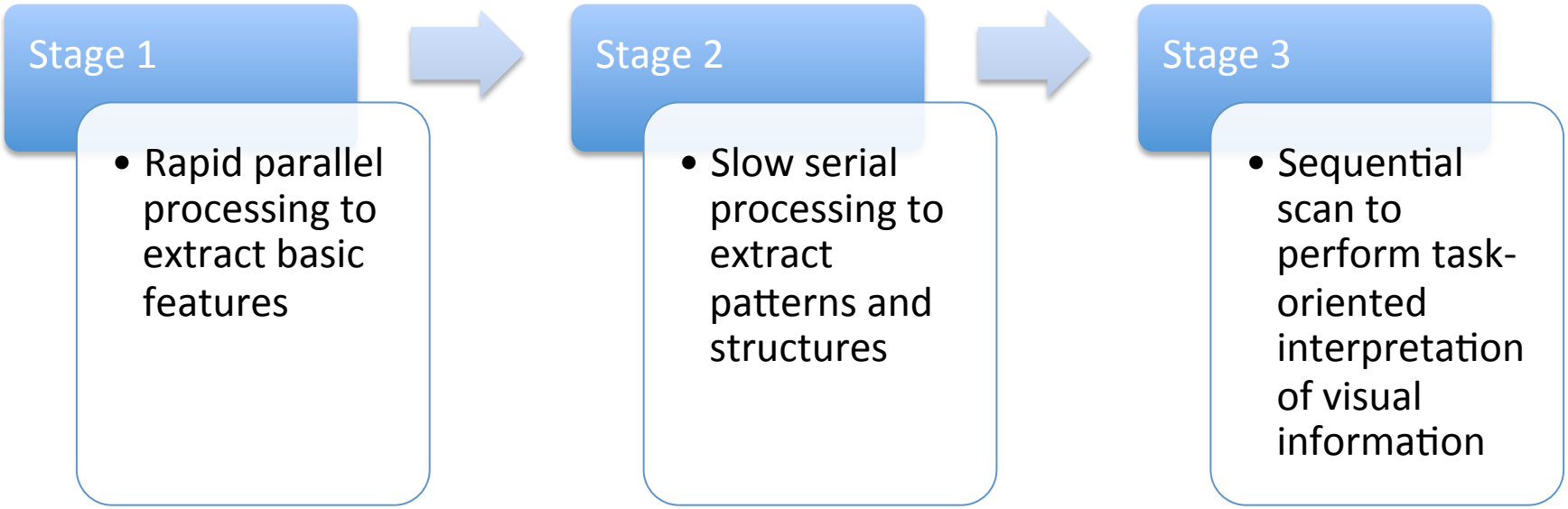


Game #4 – How many 3s?

125896516876513216894321 3
546347965432132035496841 3
206879841718452952928714 9
217495317819529392654683 1
354651650989855468498298 4

How many “3”?

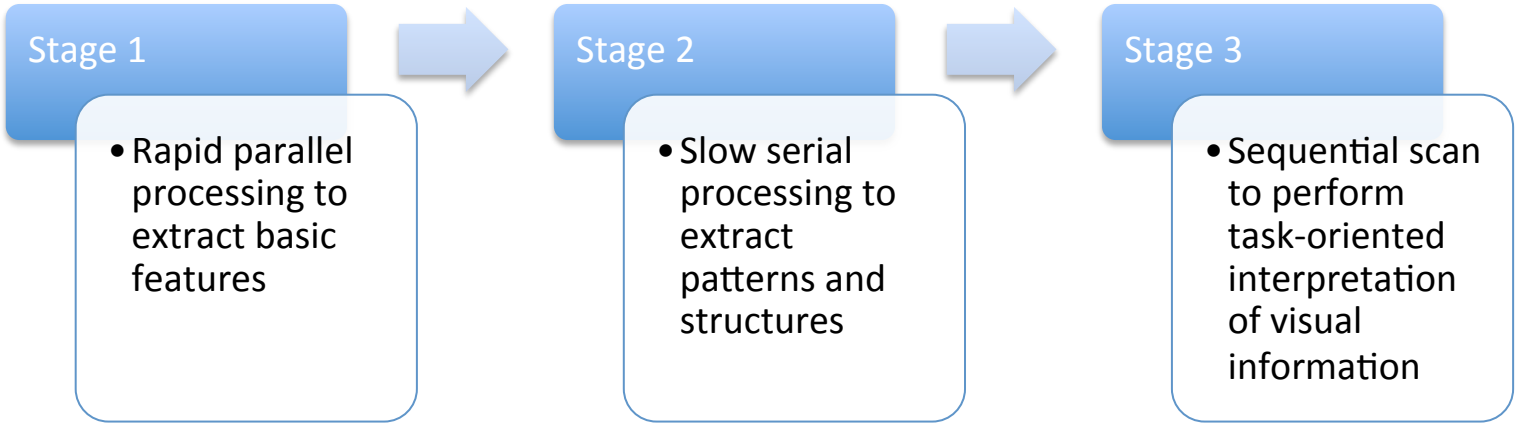
Perception and Cognition



Ware Colin. Information Visualization, third edition. 2004

Visual Perception

- Early visual processing takes places without our conscious intervention
- Graphs that convey information at this level allow the observer to be more efficient in decoding



Visual Cognition

- At second stage, the observer is required to consciously analyze the image/scene
- At this level, the observer can perform higher level reasoning
  - This object is larger than the other one
  - This street slope is lower than the previous

Timer

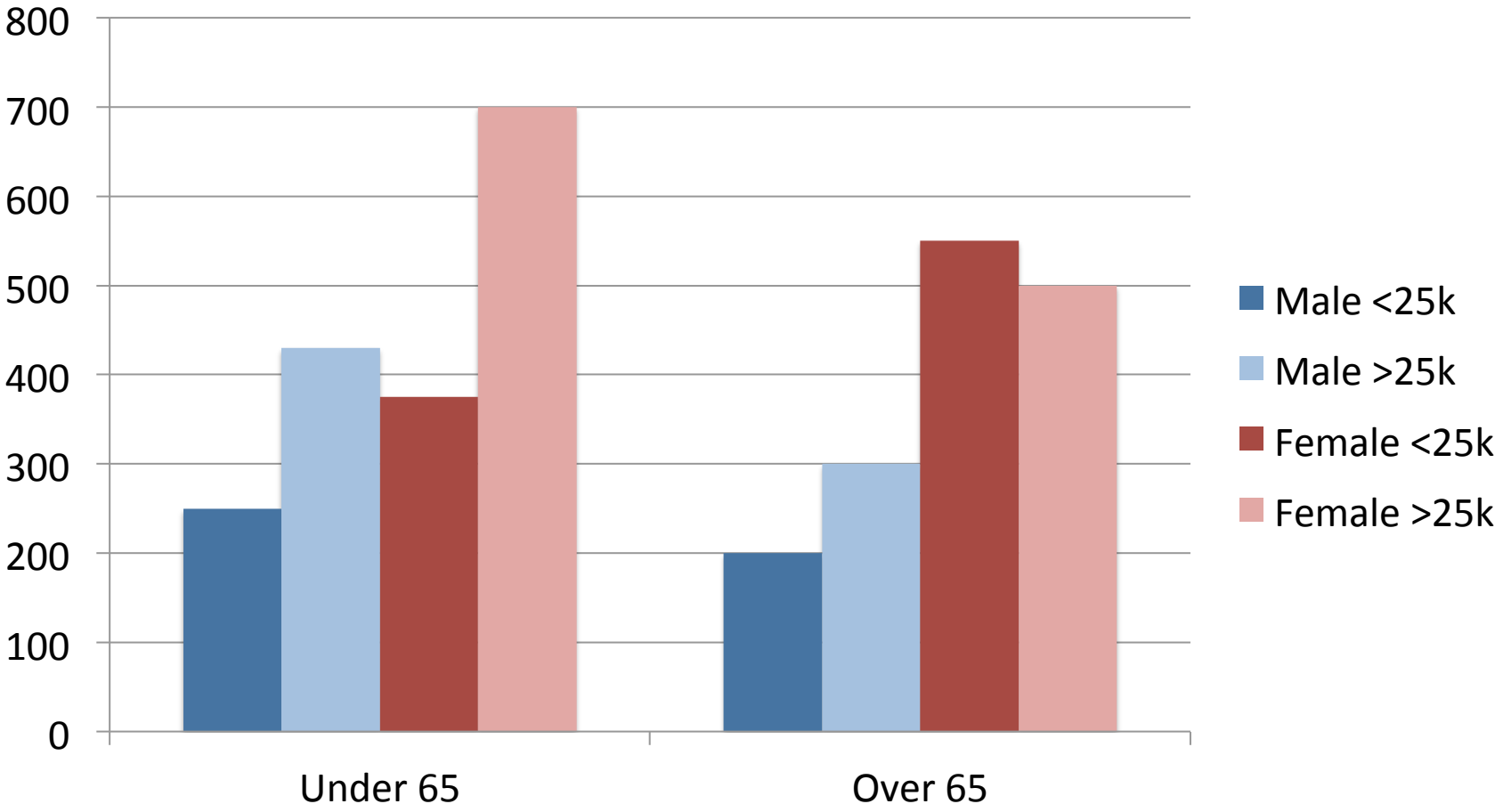
GAME #5 – CHOLESTEROL, AGE, AND GENDER

Game #5 – Cholesterol, Age, and Gender

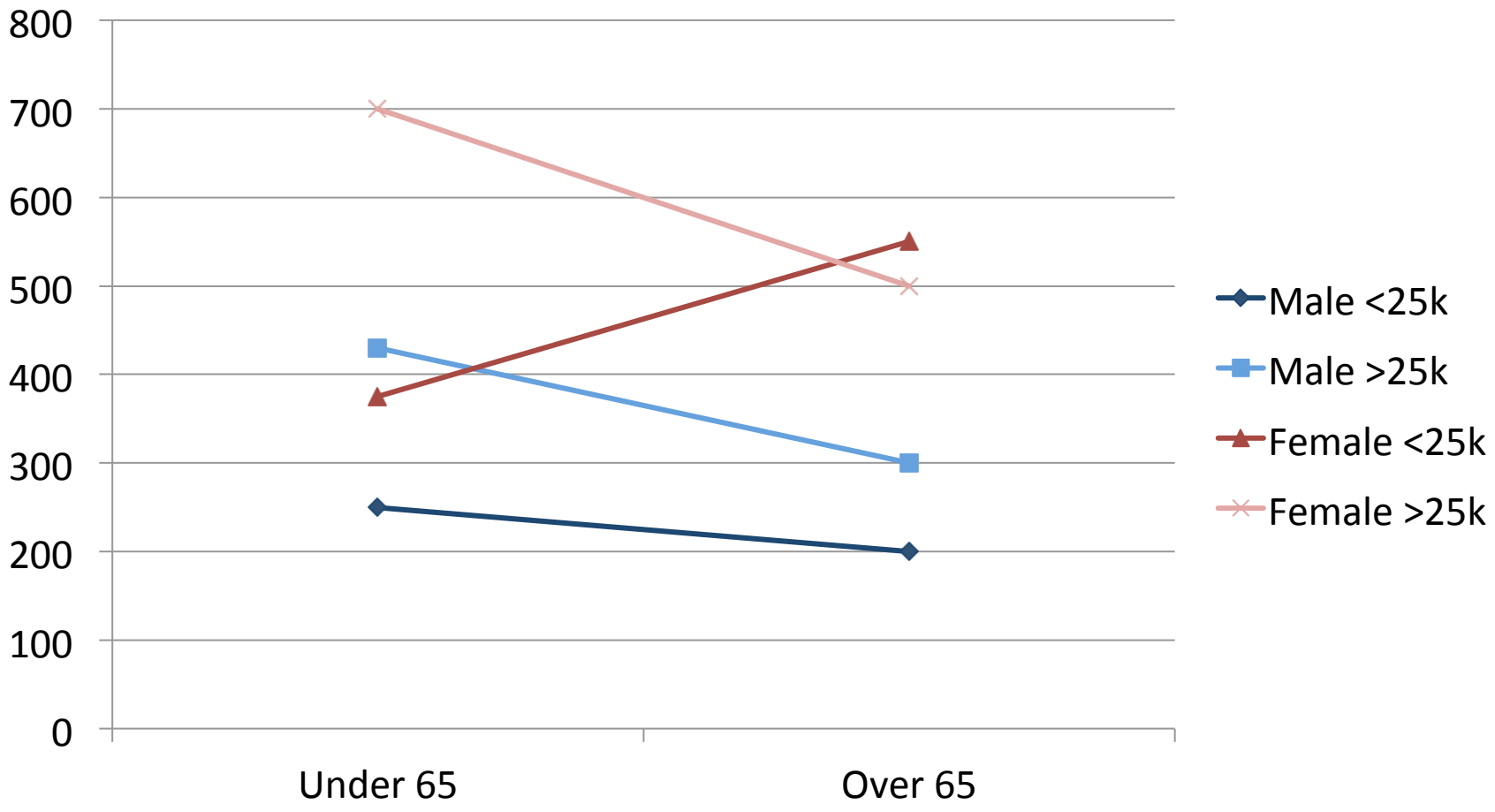
Which relation between gender or income level groups?

	Males		Females	
Income Group	**Under 65**	**65 and Over**	**Under 65**	**65 and Over**
0 – 24,999$	250	200	375	550
25,000$ +	430	300	700	500

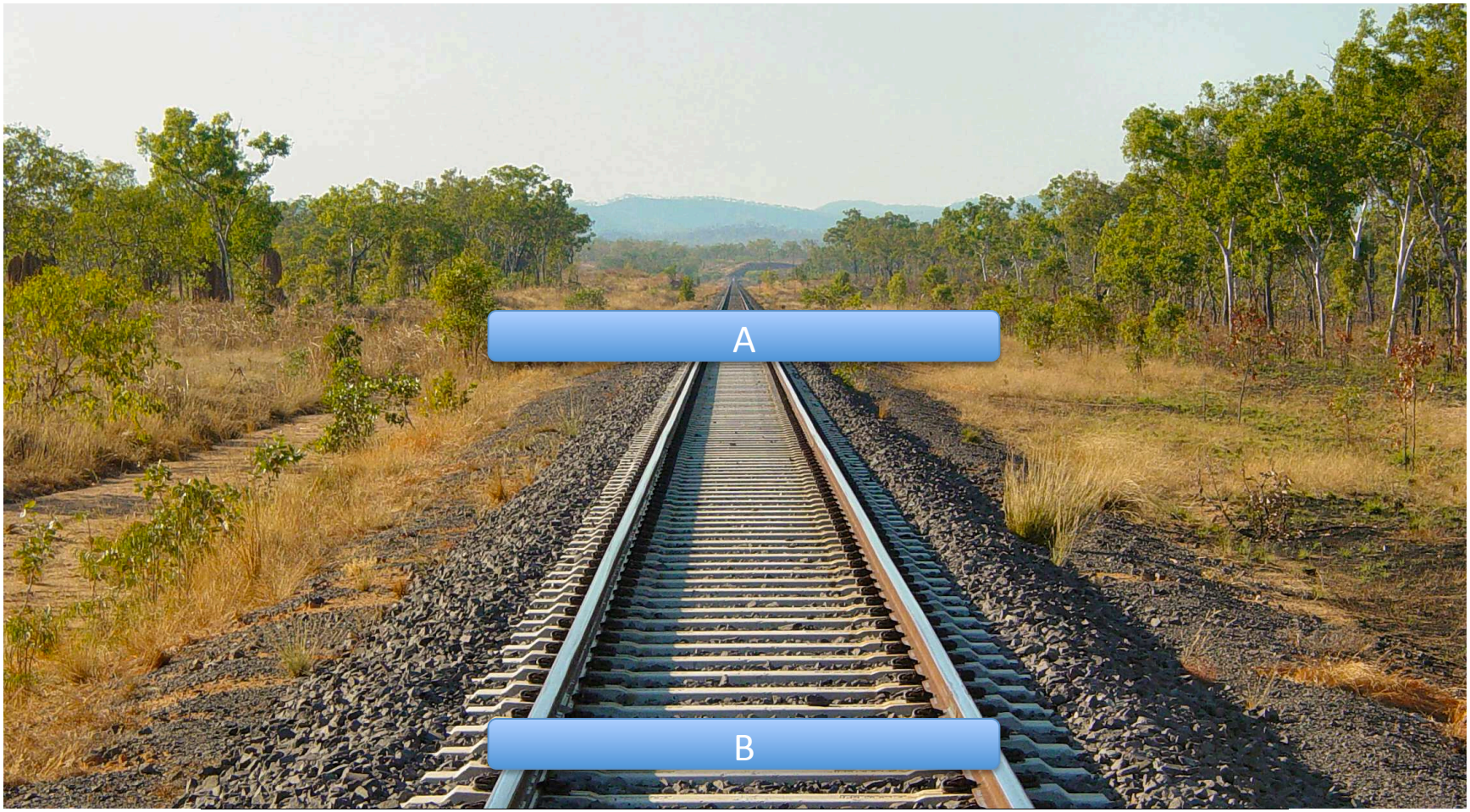
Game #5 – Visual Solution (2)



Game #5 – Visual Solution



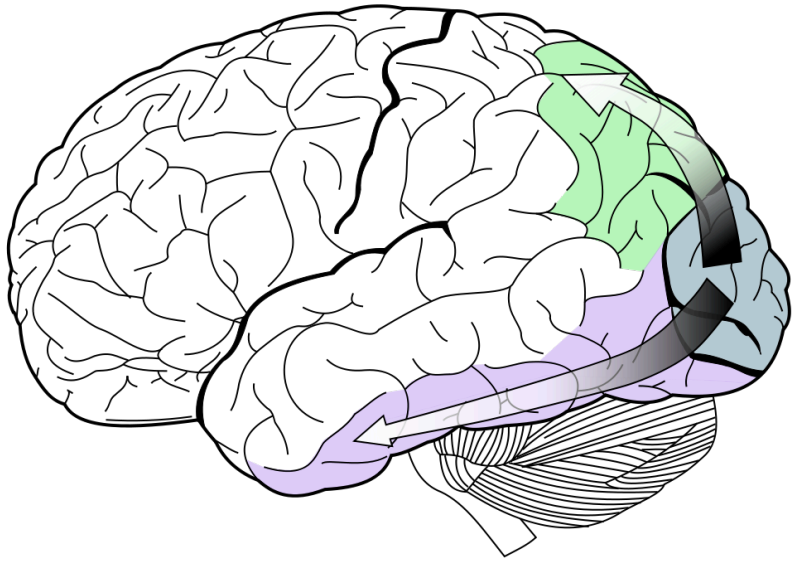
Game #6 – Length comparison



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

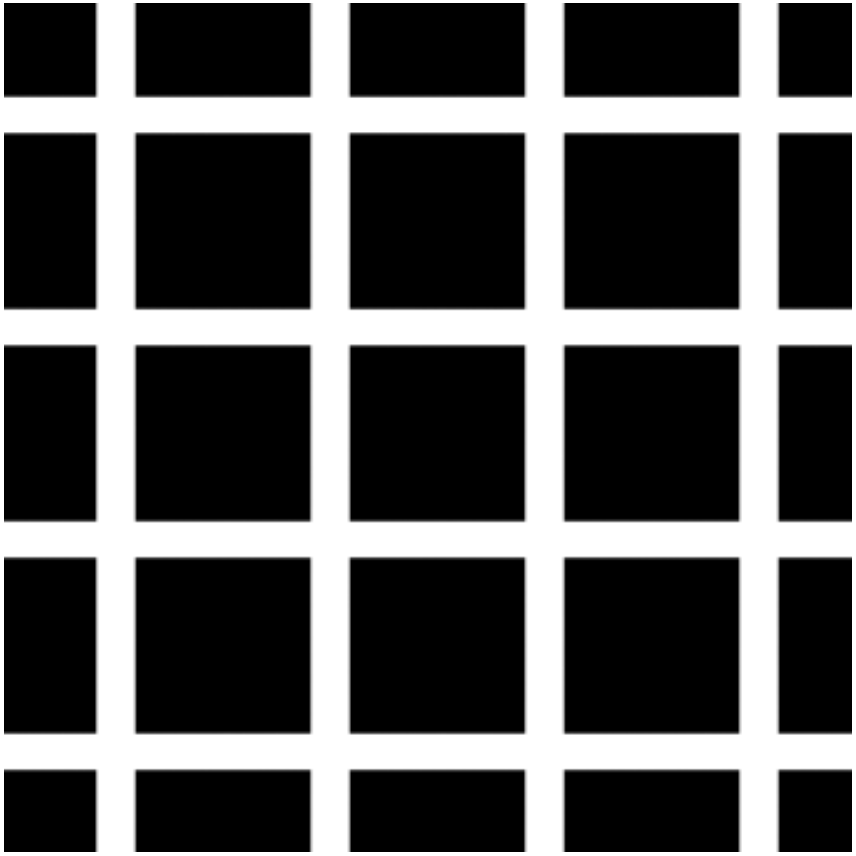


"Ventral-dorsal streams" by Selket - I (Selket) made this from Image:Gray728.svg. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Ventral-dorsal_streams.svg#/media/File:Ventral-dorsal_streams.svg

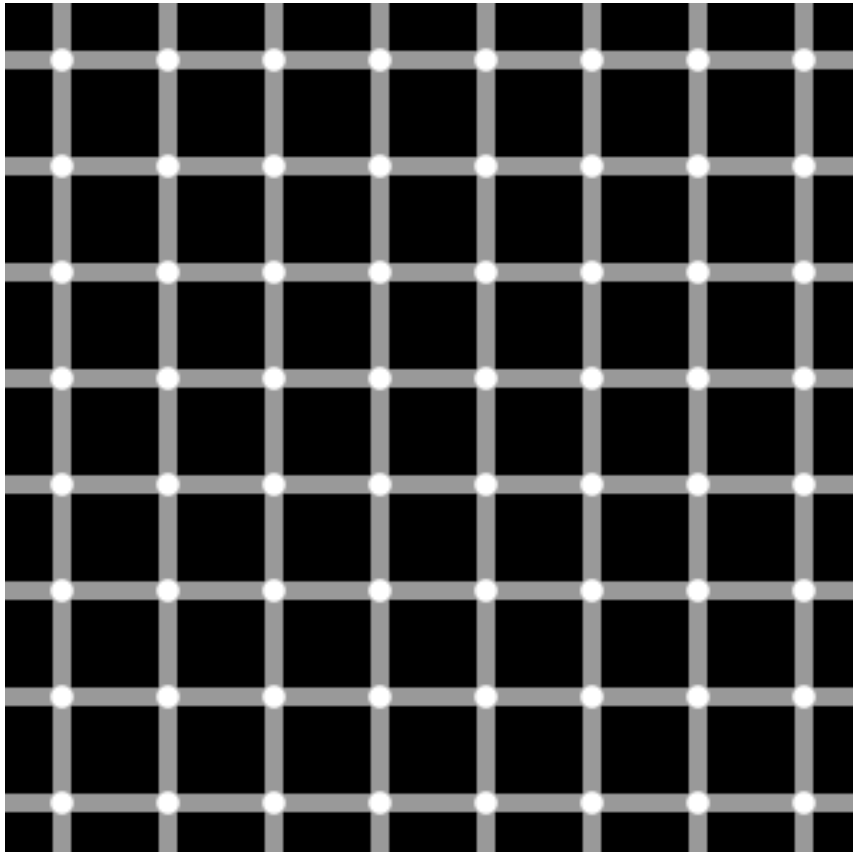
Visual Illusions

- Perceived images differ from measurable reality
  - Optical Illusions
  - Physiolagical illusions (Mach Bands)
  - Cognitive illusions
    - Arise by unconsciuos inferences based on assumptions about real world

Physiological Grid Illusion

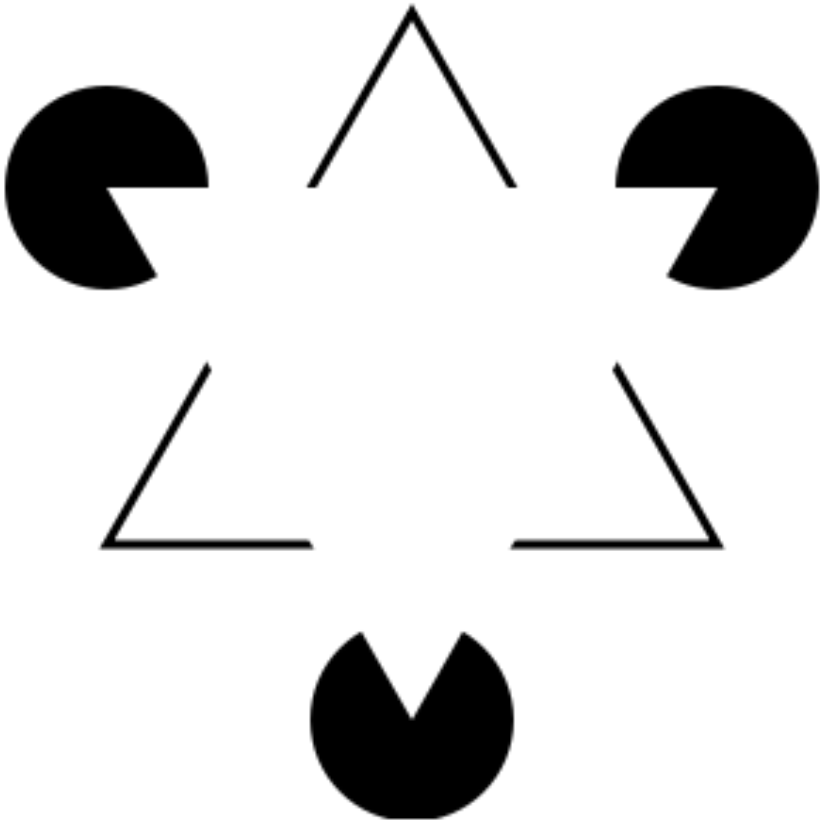


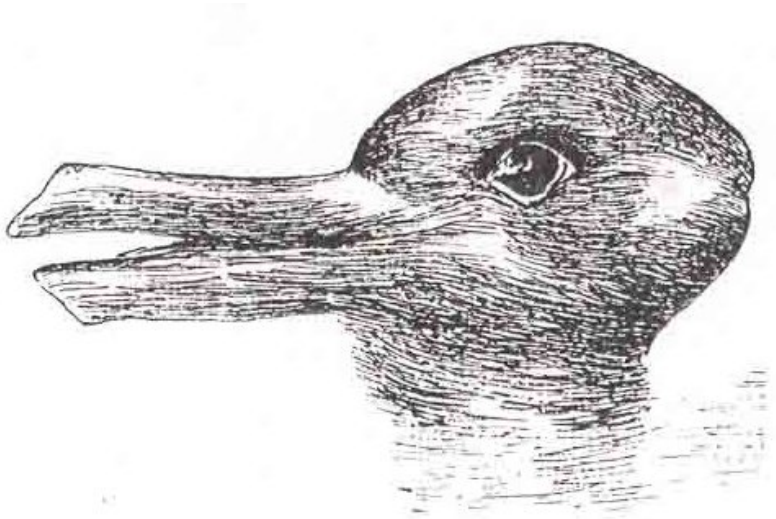
"HermannGrid" by en:User:Famousdog - http://en.wikipedia.org/wiki/File:HermannGrid.gif. Licensed under Public Domain via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:HermannGrid.gif#/media/File:HermannGrid.gif



"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



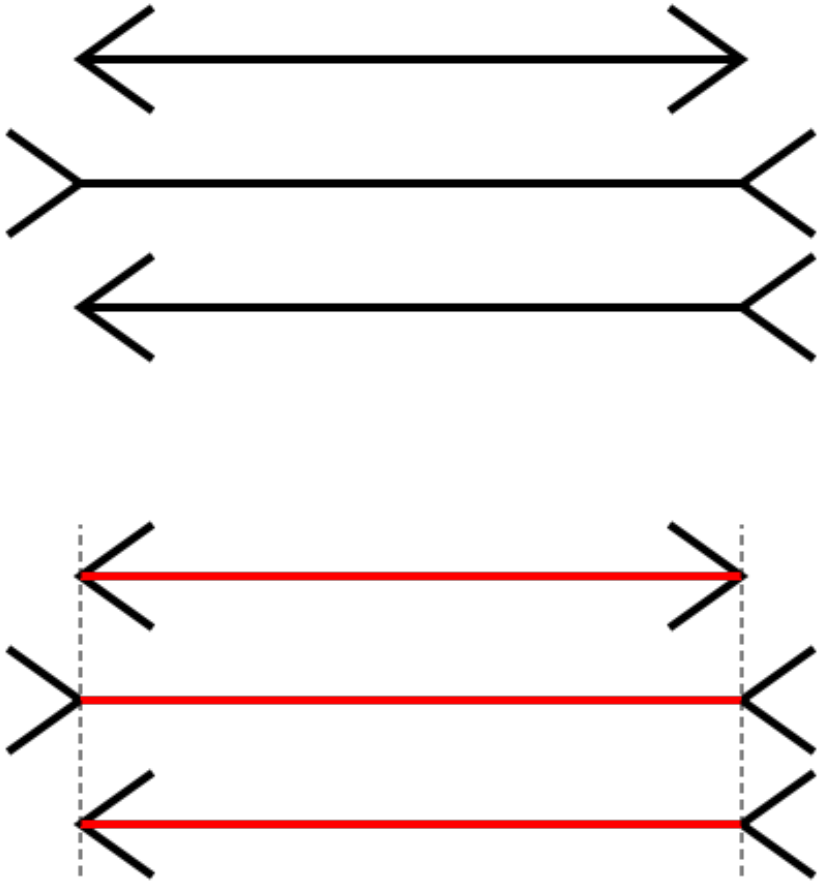


"Kanizsa triangle" by Fibonacci - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Kanizsa_triangle.svg#/media/File:Kanizsa_triangle.svg

"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

Lengths Distortion

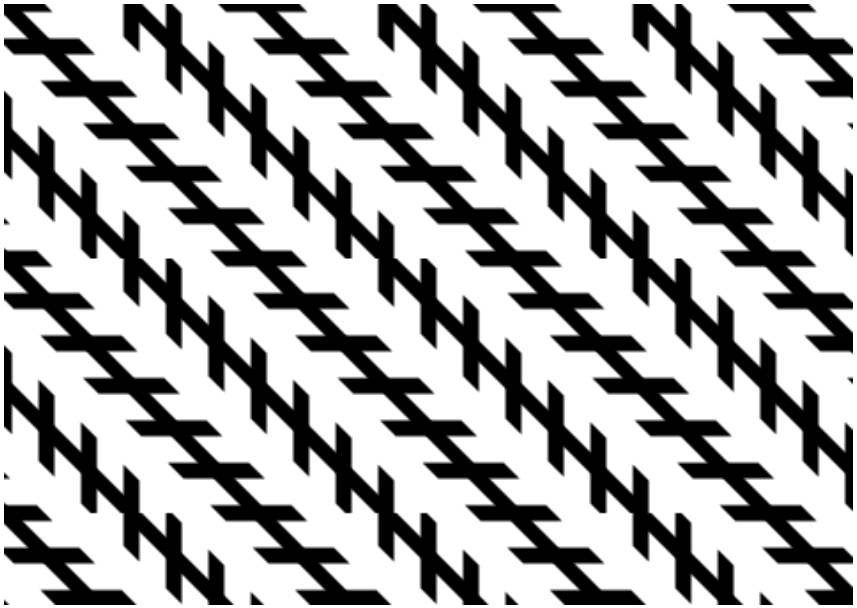
Müller-Lyer illusion



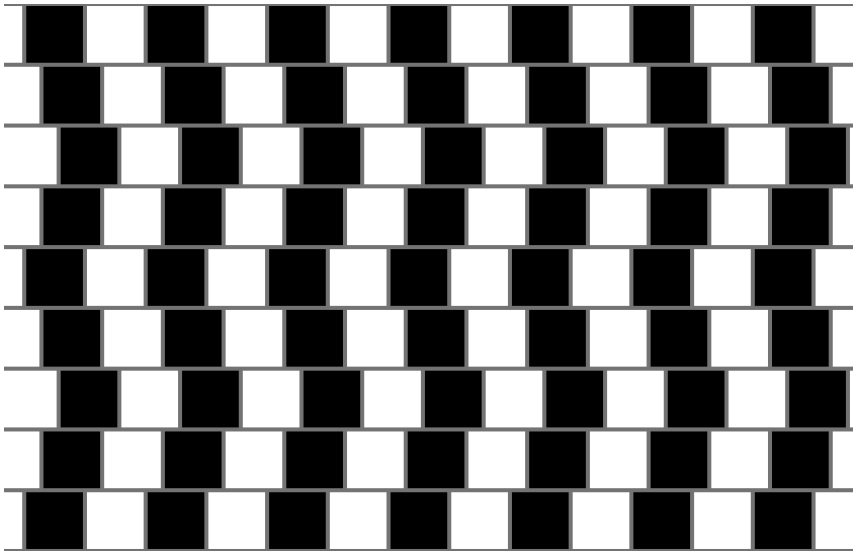
"Müller-Lyer illusion" by Fibonacci - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:M%C3%BCller-Lyer_illusion.svg#/media/File:M%C3%BCller-Lyer_illusion.svg

Orientation Illusion

Zöllner illusion

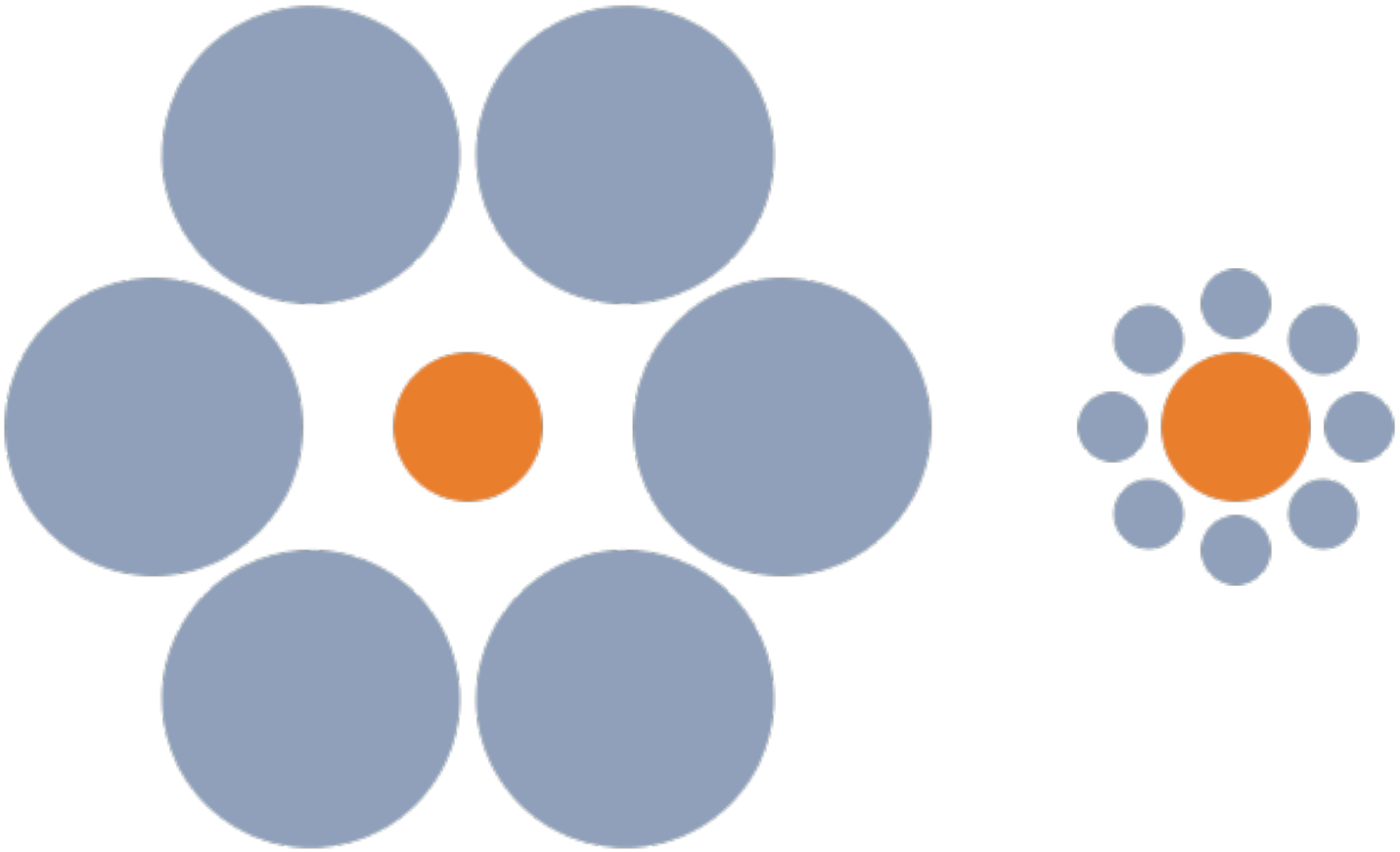


"Zollner illusion" by Fibonacci - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Zollner_illusion.svg#/media/File:Zollner_illusion.svg



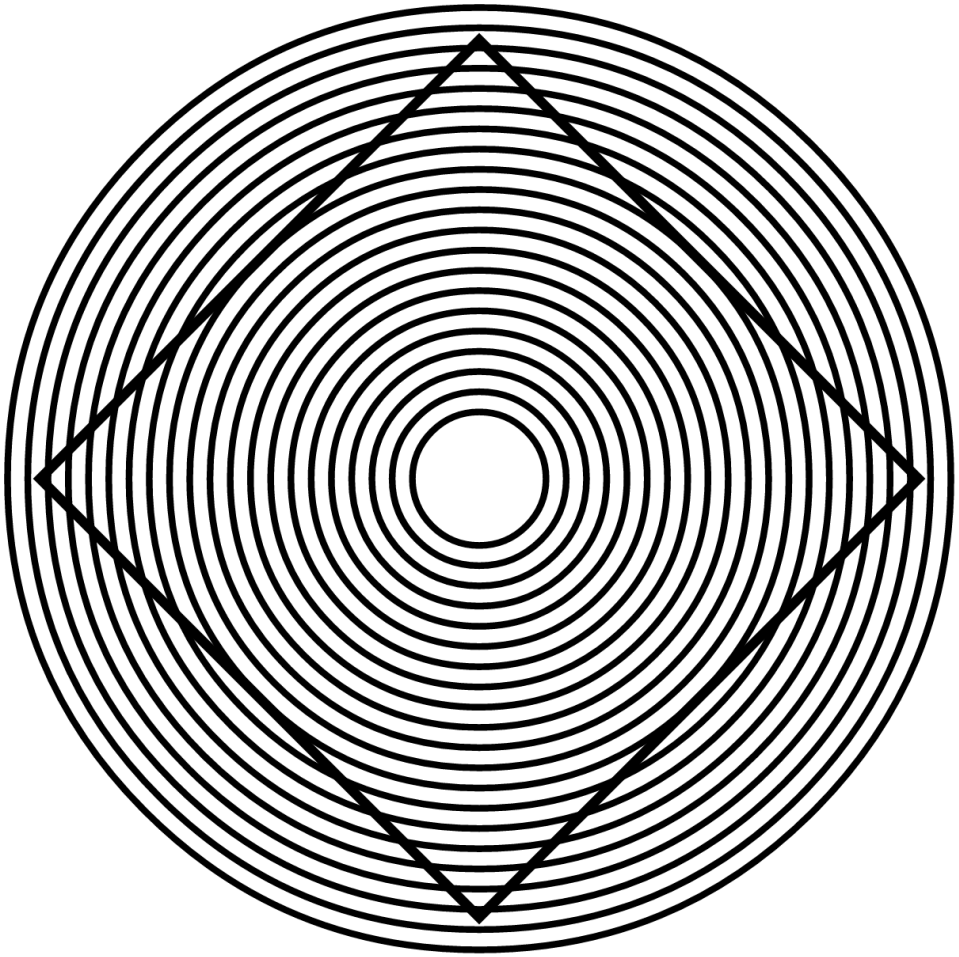
"Café wall" by Fibonacci - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Caf%C3%A9_wall.svg#/media/File:Caf%C3%A9_wall.svg

Ebbinghaus Illusion



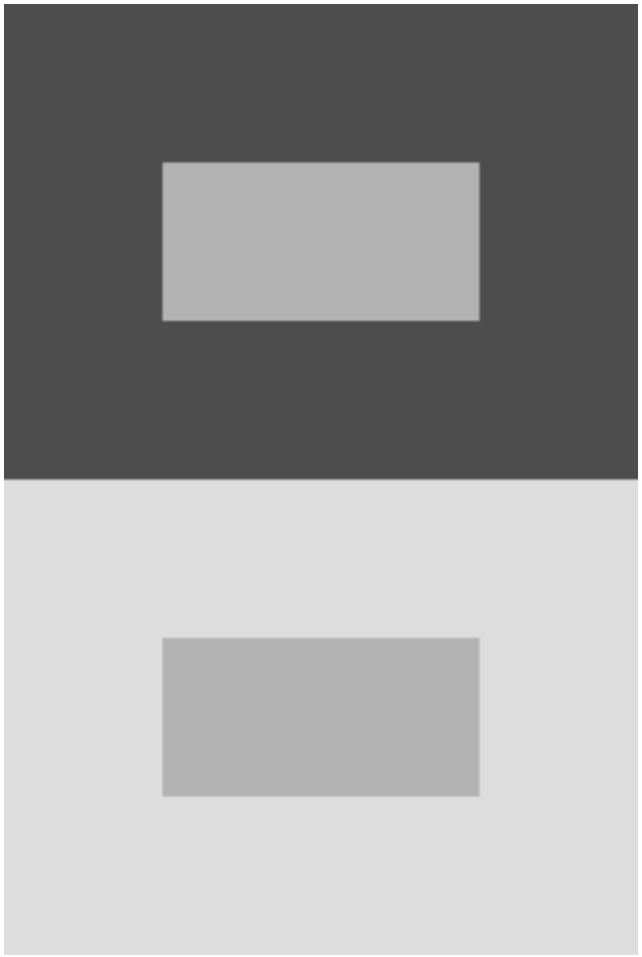
"Mond-vergleich". Licensed under Public Domain via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Mond-vergleich.svg#/media/File:Mond-vergleich.svg

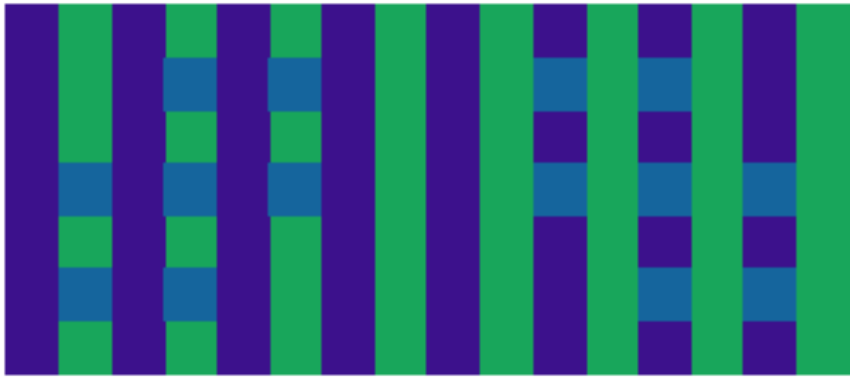
Ehrenstein Illusion



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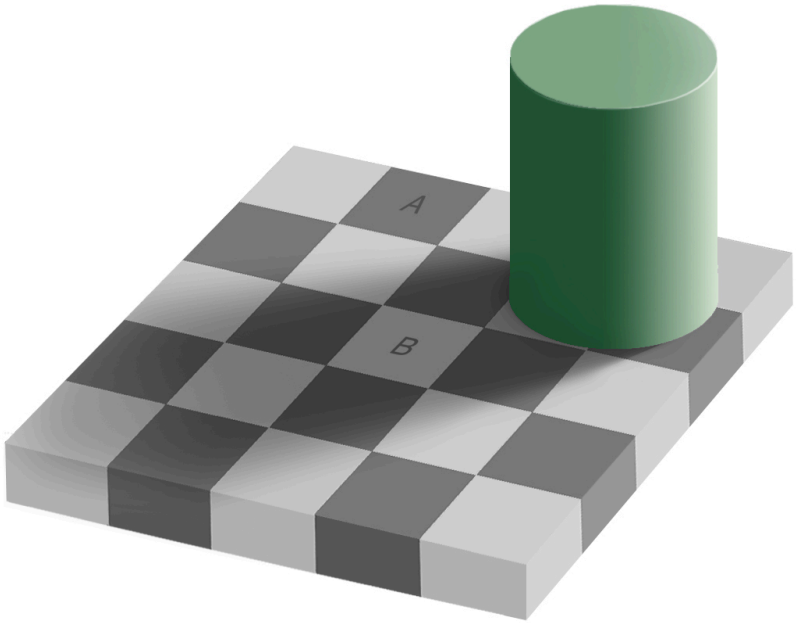
Simultaneous Contrast

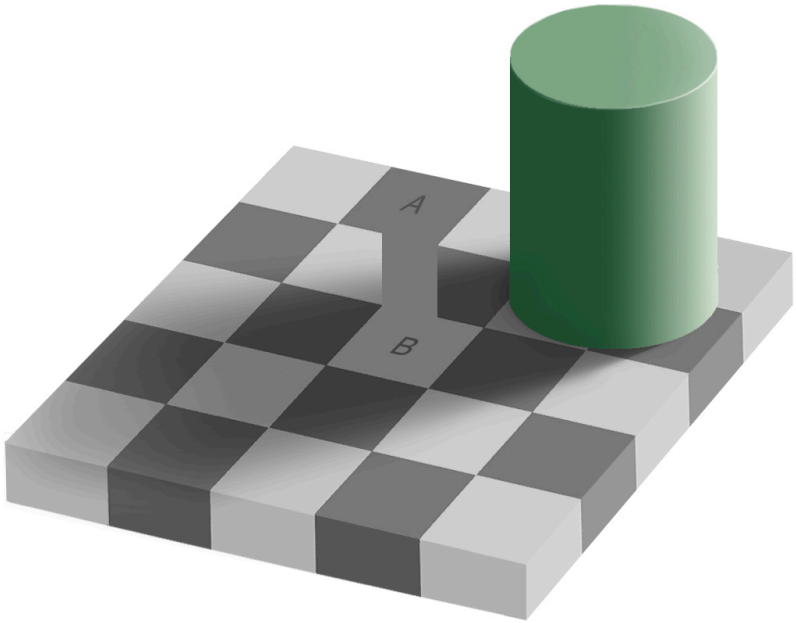




"Simultaneous Contrast" by K. P. Miyapuram - Licensed under Public Domain via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Simultaneous_Contrast.svg#/media/File:Simultaneous_Contrast.svg

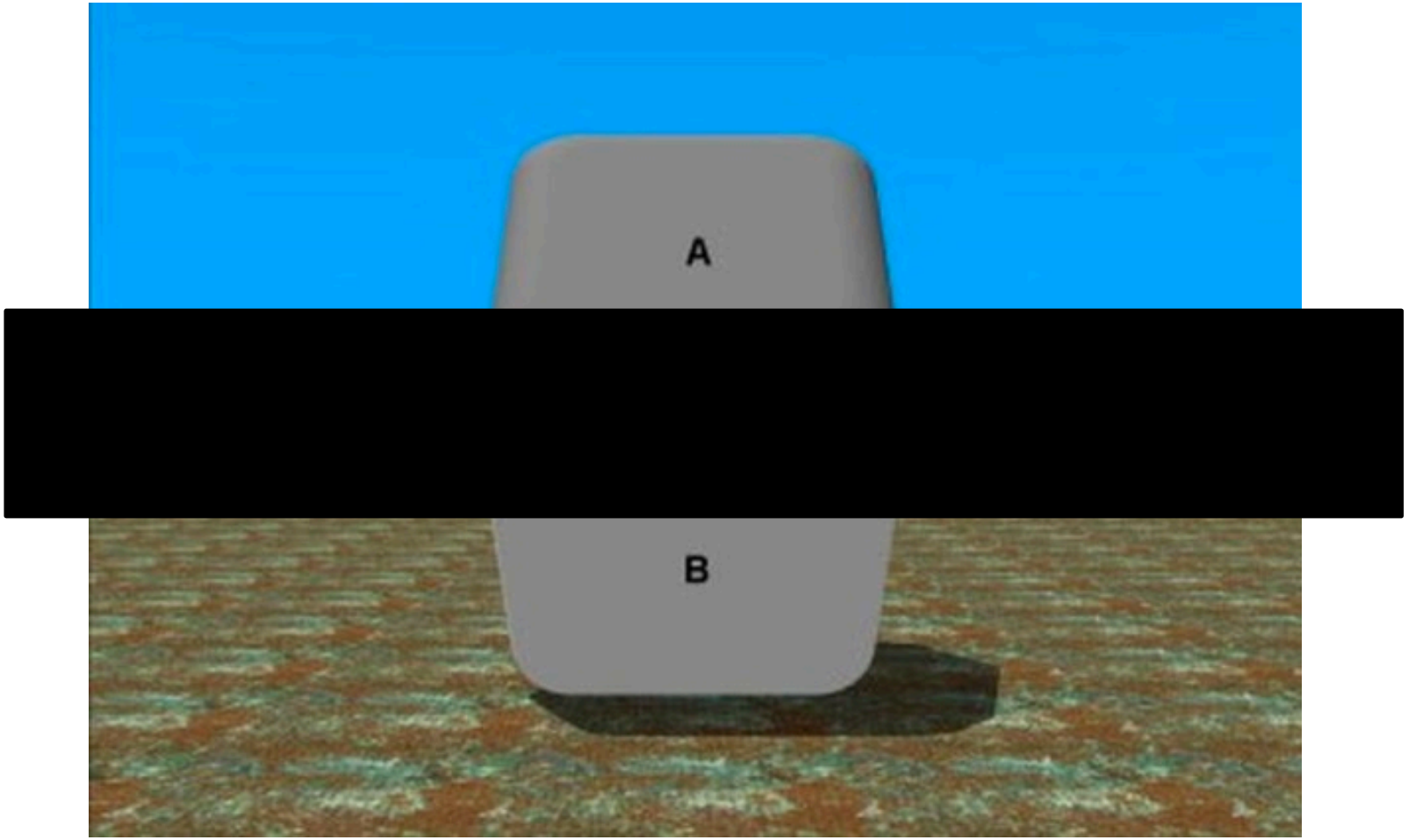
Adelson's Illusion



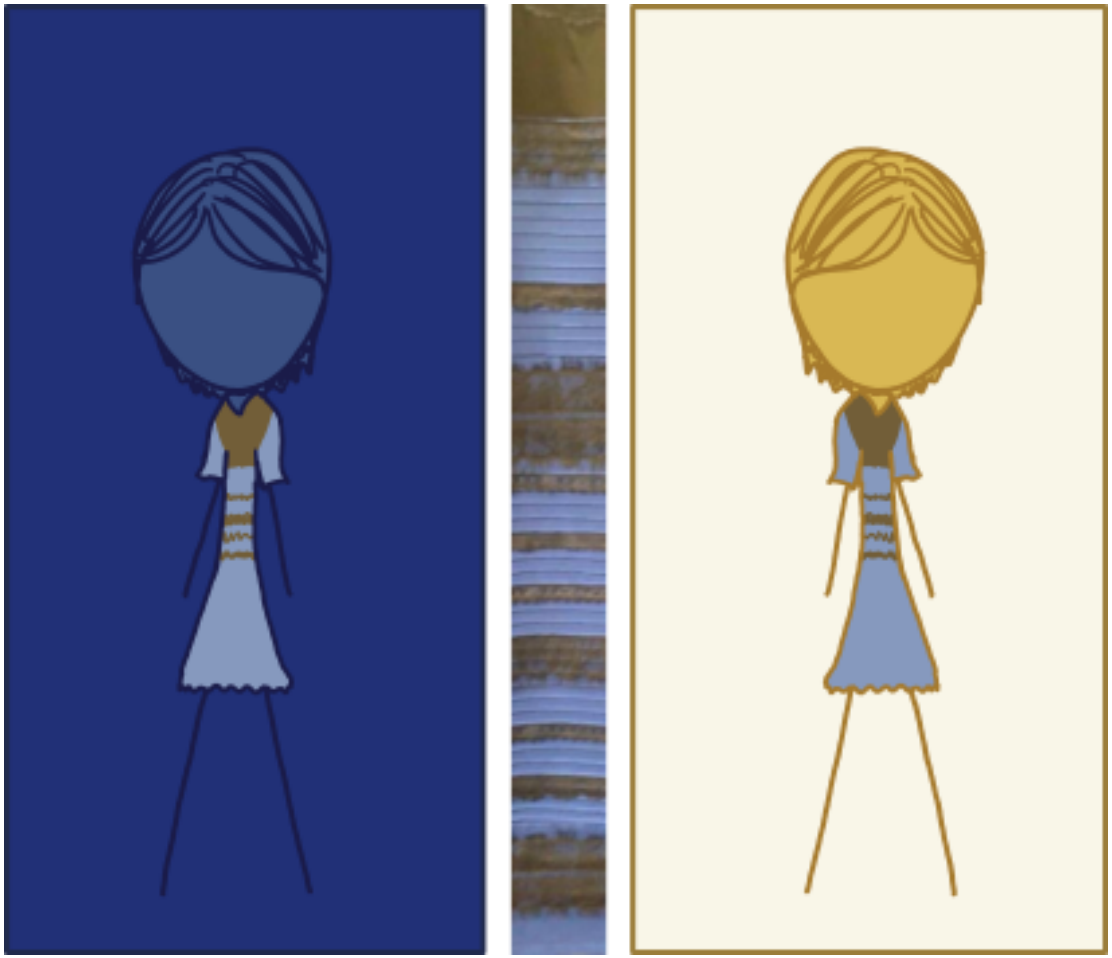


"Grey square optical illusion" by Original by Edward H. Adelson, this file by Gustavb - File created by Adrian Pingstone, based on the original created by Edward H. Adelson. Licensed under Copyrighted free use via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Grey_square_optical_illusion.PNG#/media/File:Grey_square_optical_illusion.PNG

Context



Dress Color



Takeaway Messages

- Limiations of human vision system
- Exploits message brodcast at early stage of perception: preattemptive perception
- Avoid possible causes of biases