浙江大学 ZHEJIANG UNIVERSITY

2019 ZJU
International Summer School on Visual Analytics

Perception & Cognition

Guodao Sun

Associate Professor
Zhejiang University of Technology
Email: guodao@zjut.edu.cn
Homepage: http://godoorsun.org

Stuart Card

"Visualization is really about external cognition, that is, how resources outside the mind can be used to boost the cognitive capabilities of the mind."

What is Visual ?

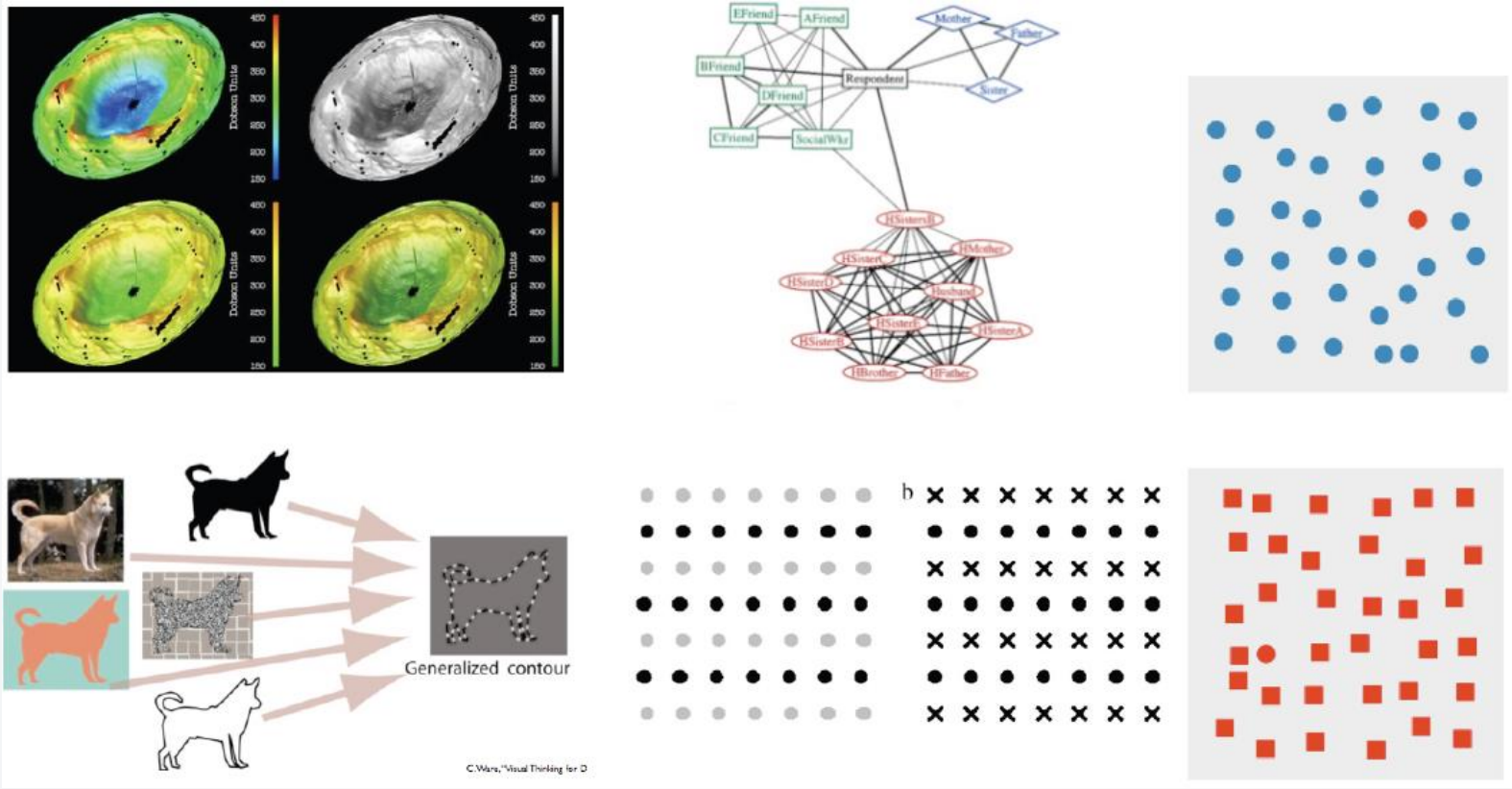
01 Perception:

about the nature of the signals coming in; what you see

02 Cognition:

about how you understand and interpret what you see

What is Visual Perception ?



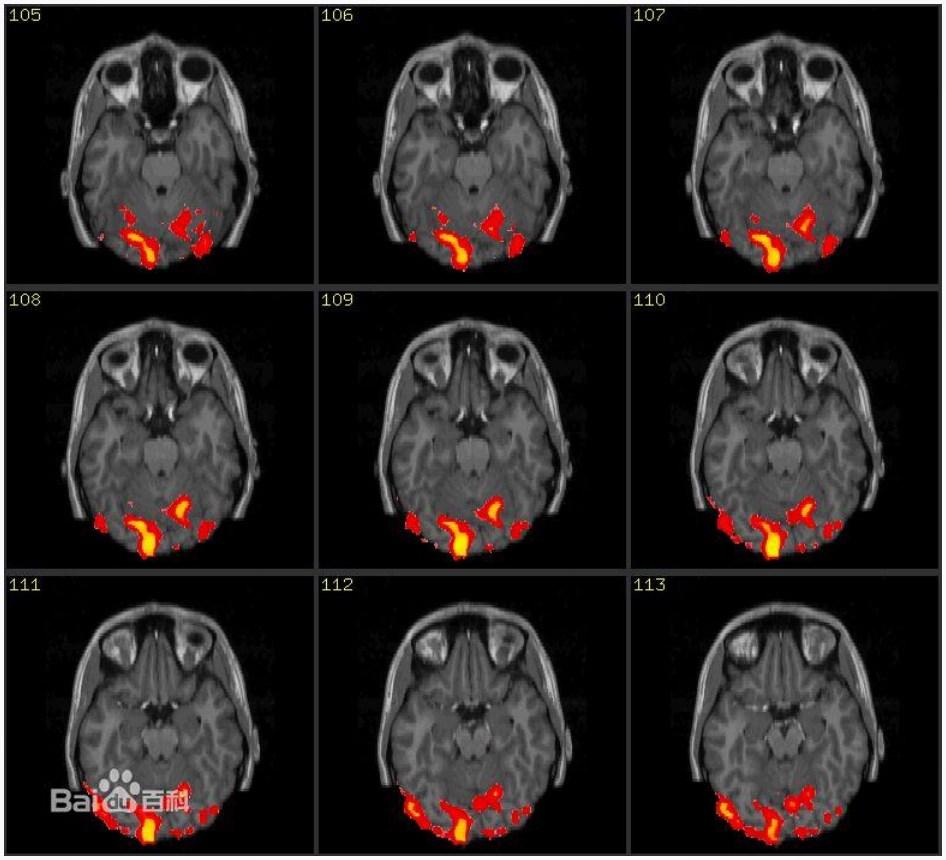
Perception is the organization, identification and interpretation of sensory information in order to represent and understand the environment.

Cognition

In science, cognition is a group of mental processes that includes:

- attention
- memory
- producing and understanding language
- solving problems
- making decisions

Recovering Visual Cognition using fMRI



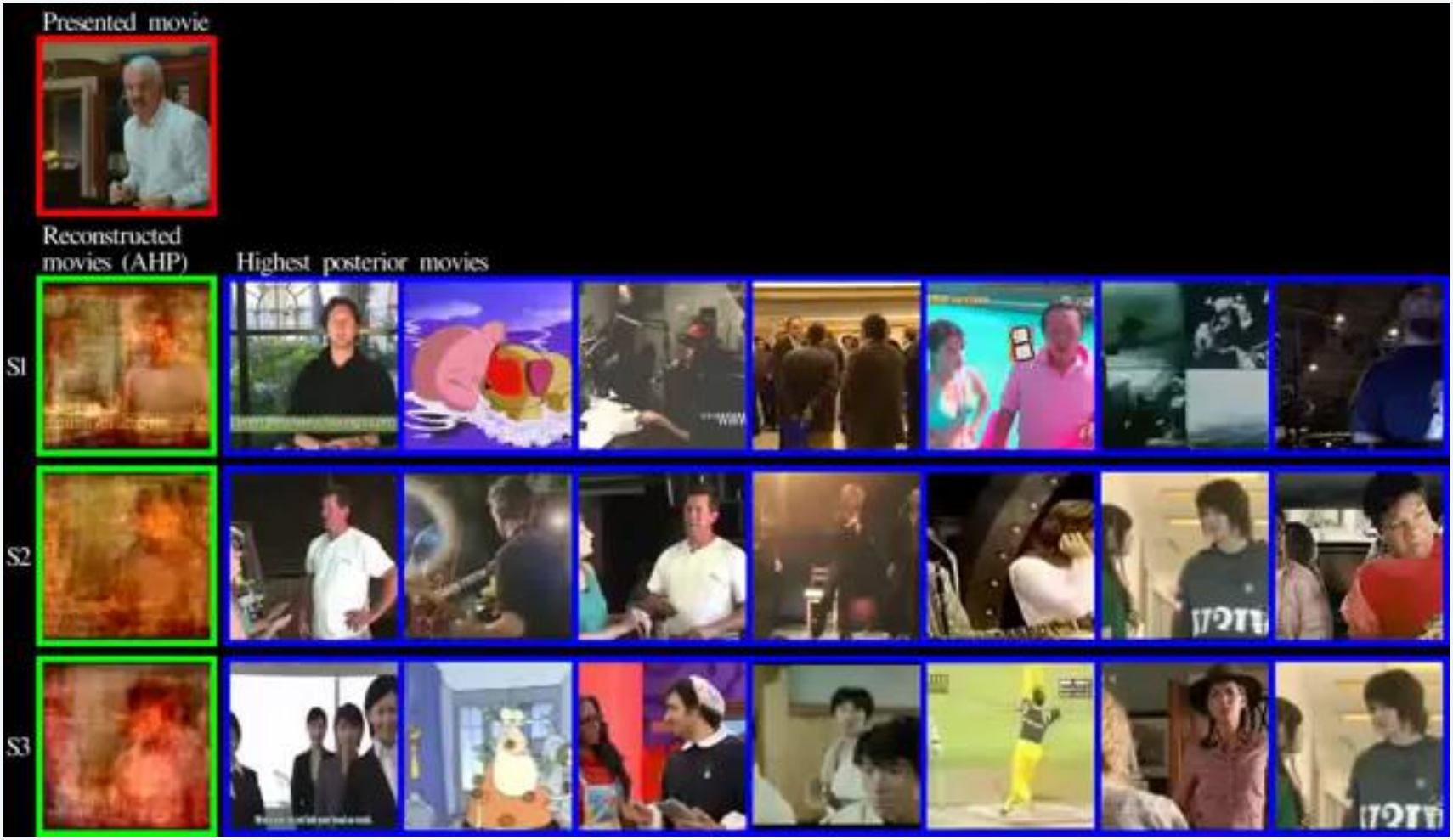
fMRI, functional magnetic resonance imaging

Recovering Visual Cognition using fMRI

Presented clip

Clip reconstructed from brain activity

Recovering Visual Cognition using fMRI



Outline

① Visual Perception

② Cognition

③ Shape

④ Color

⑤ Toolkits

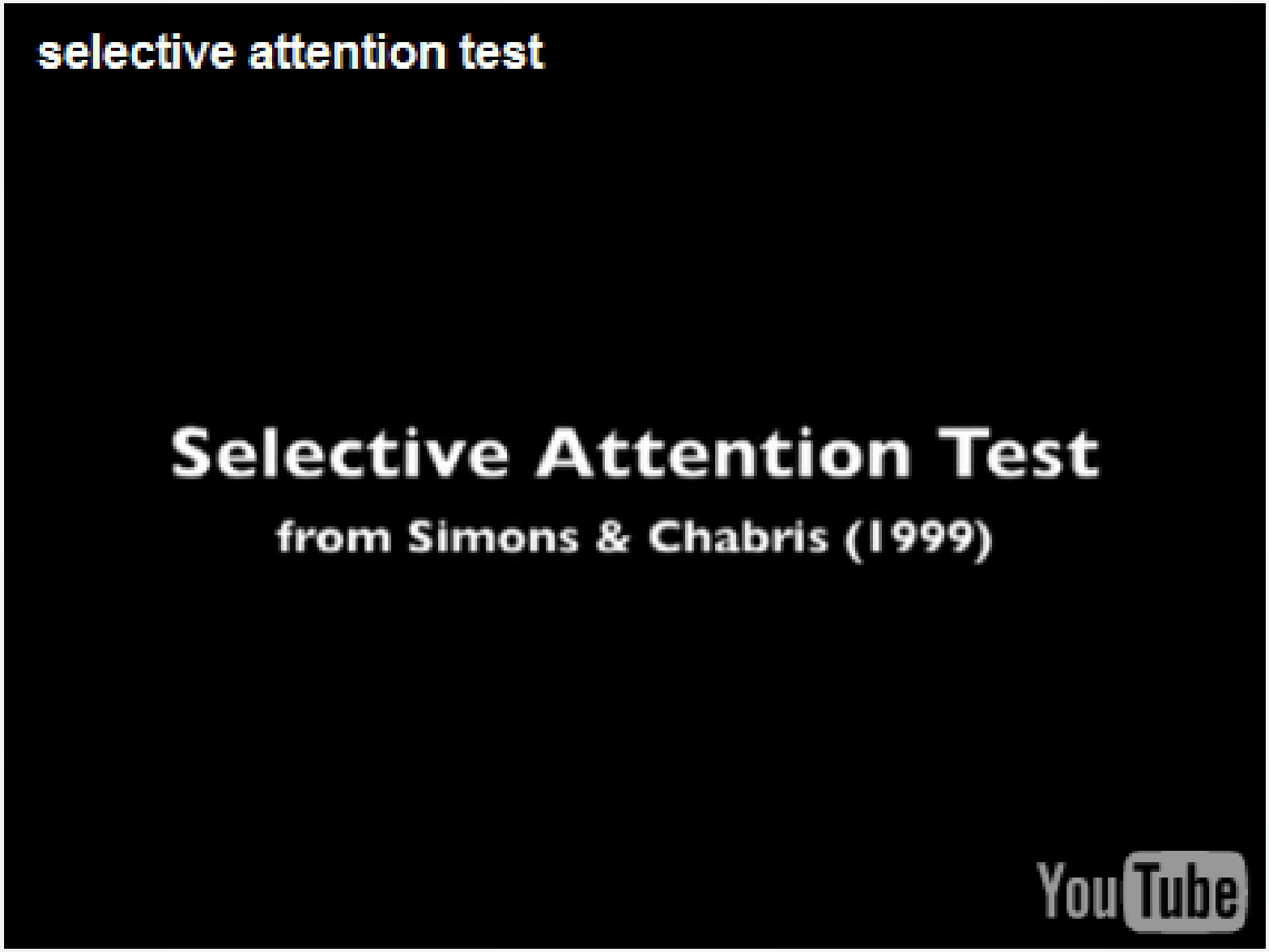
Task1

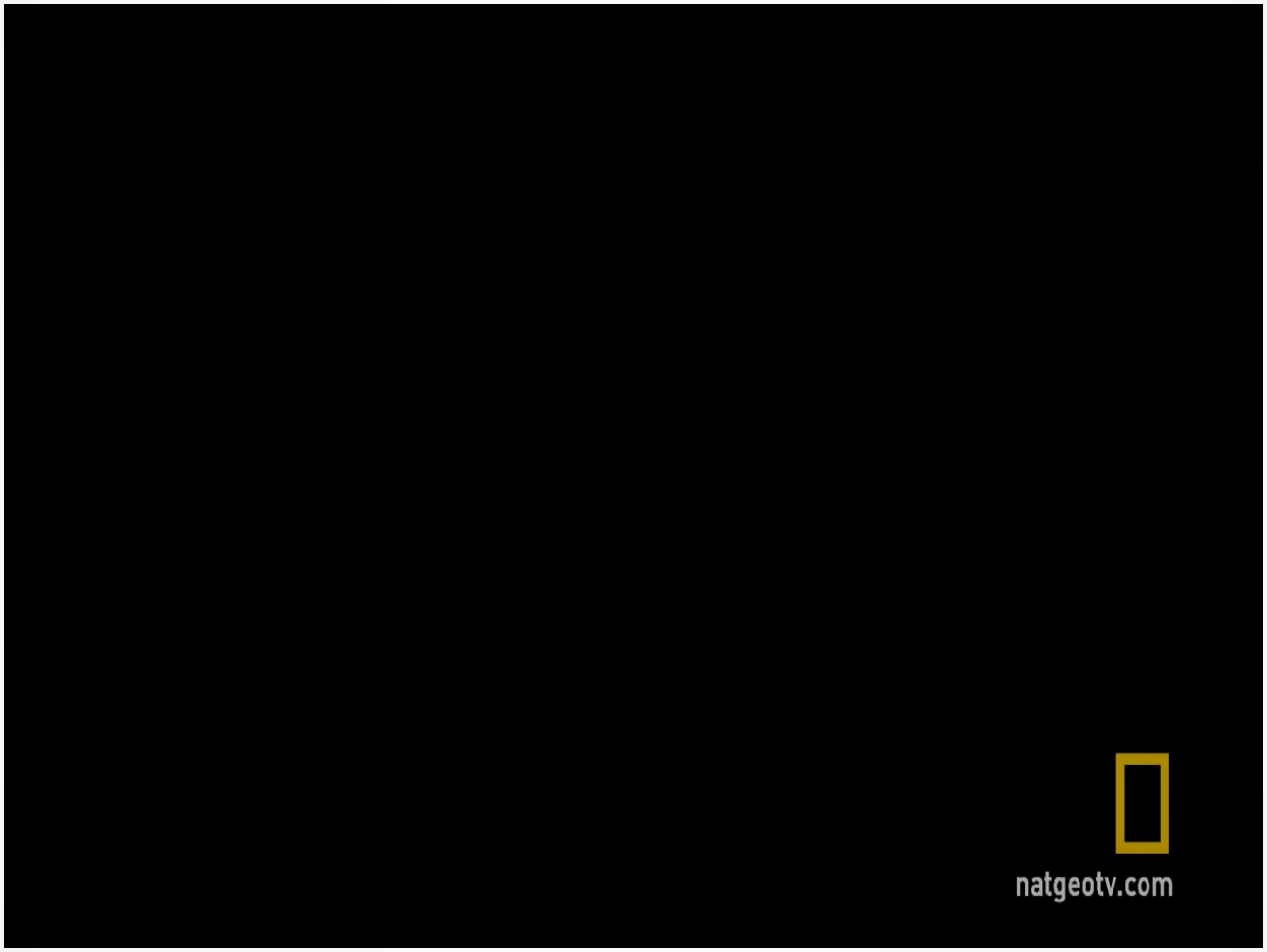
01 This example requires sustained attention and concentration

02 3 players in white and 3 players in black passing a different basketball to each other

03 Count the total number of times people wearing white are passing the ball

04 Do not count passes by the players in black





Fact

Memory plays an important role in human cognition, but working memory is extremely limited.

Visualization must serve as an external aid
to augment working memory

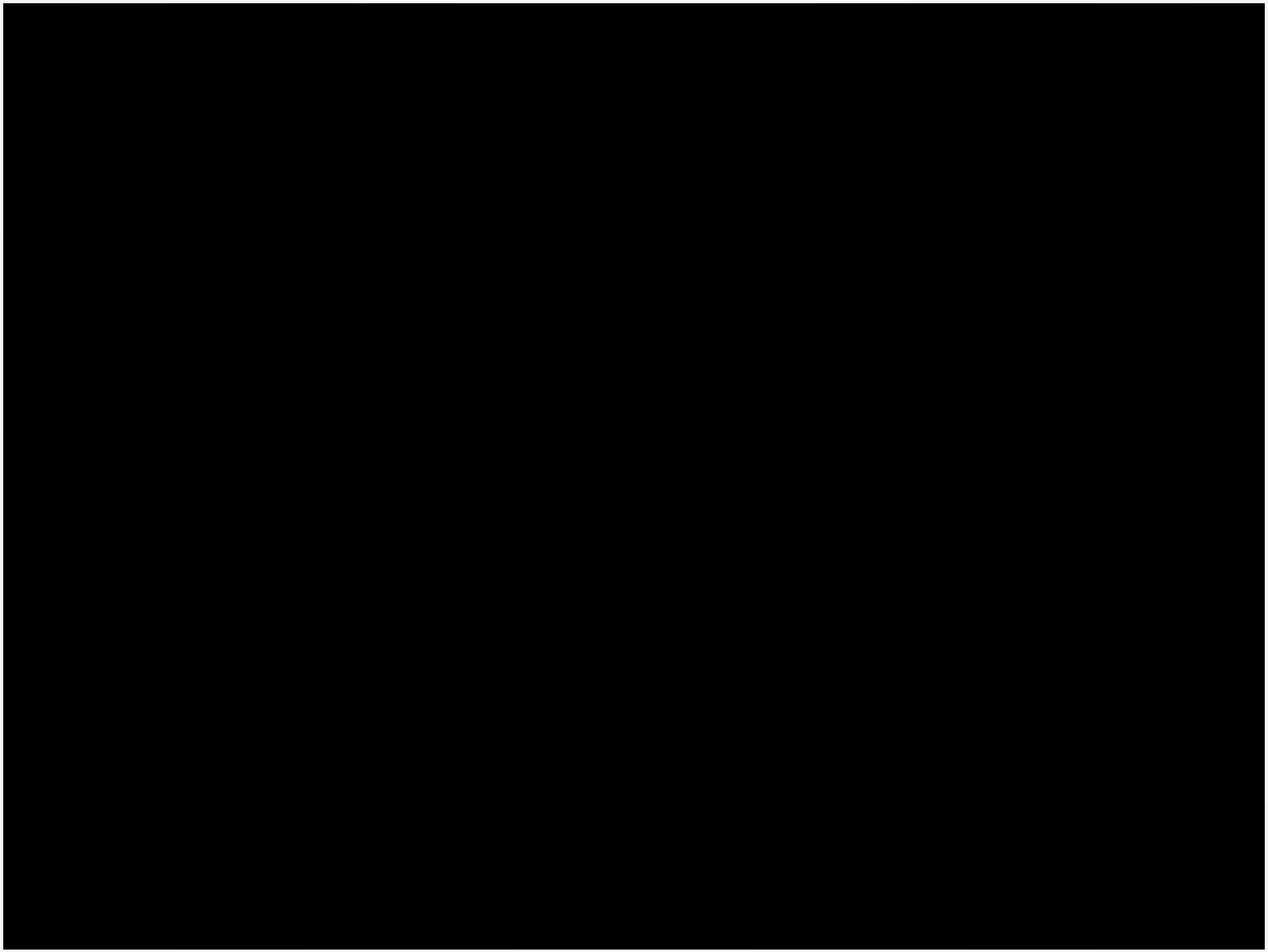
Animated Transitions in Statistical Data Graphics

Task2

01 Find the one thing in the image that is changing

02 Raise your hand once you detect the change

03 Remain quiet while others continue to look



Visual Cognition Lab, UIUC

Change Blindness

Ron Rensink 2002

Fact

To see an object change, it is necessary to attend to it.

Make changes visible in visualizations
to reduce the cognitive load

Constancy

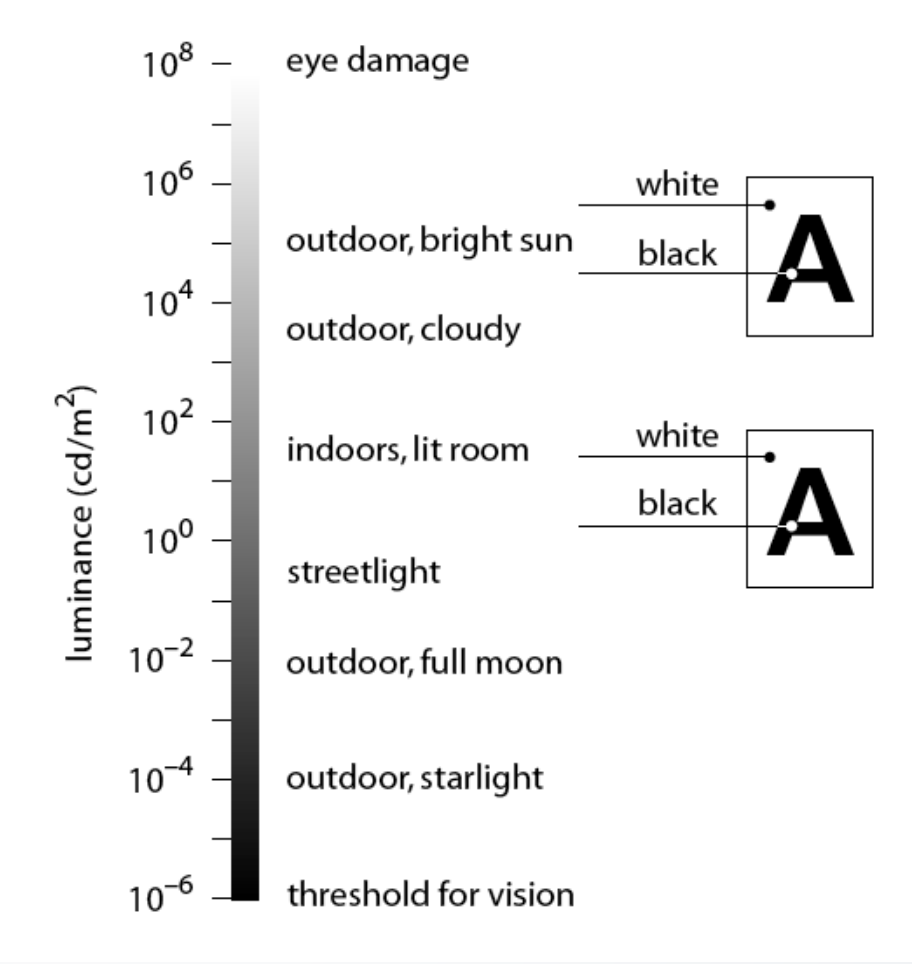
- Objects change in our eyes constantly as we or they move….but we are able to maintain content perception
- Shape Constancy
- Size Constancy
- Lightness Constancy
- Orientation constancy
- Distance constancy
- Location constancy

Lightness Constancy

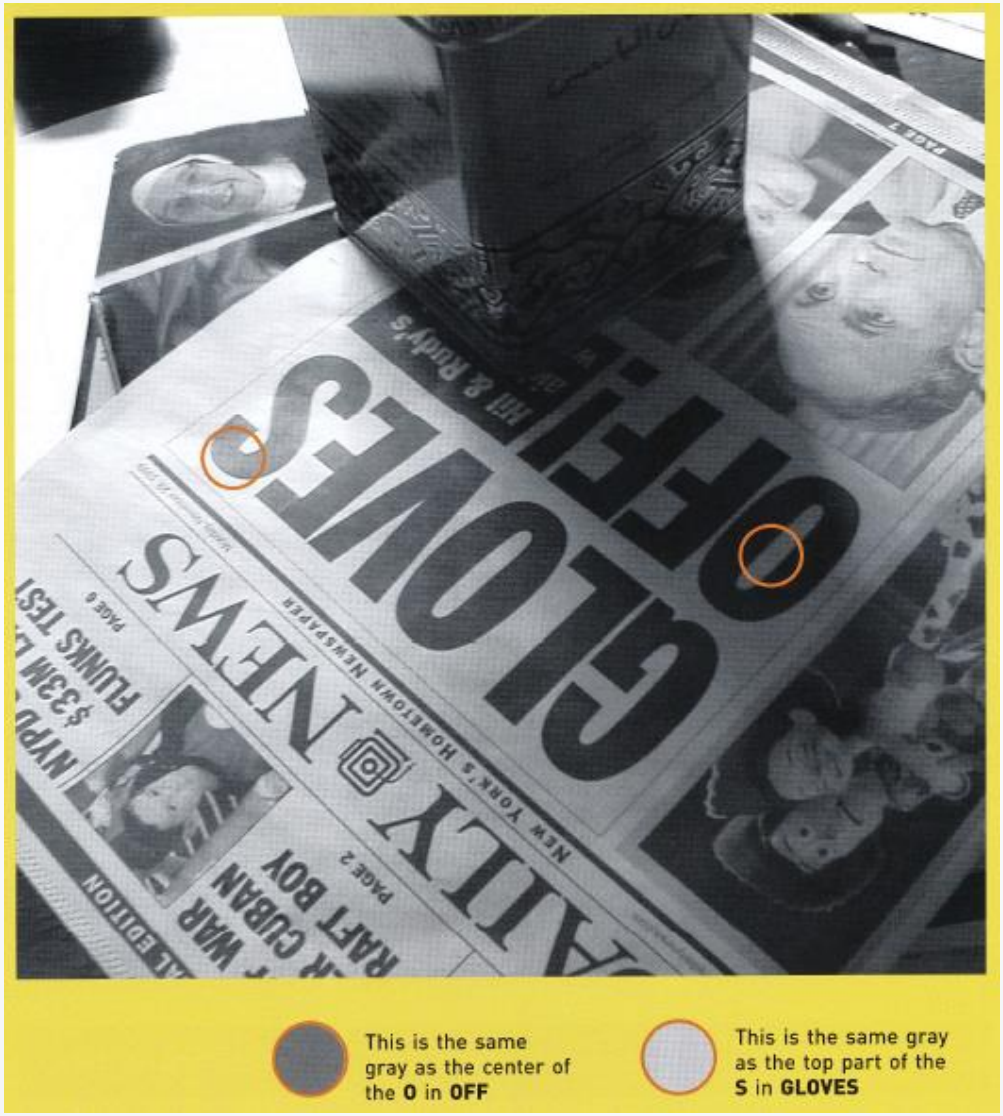
Video Source: https://www.youtube.com/watch?v=TVUrHf2kcUM

Lightness Constancy

- Light levels can vary by six orders of magnitude.
- Our visual system deals with that by responding to relative differences.



Lightness Constancy



Simultaneous Contrast

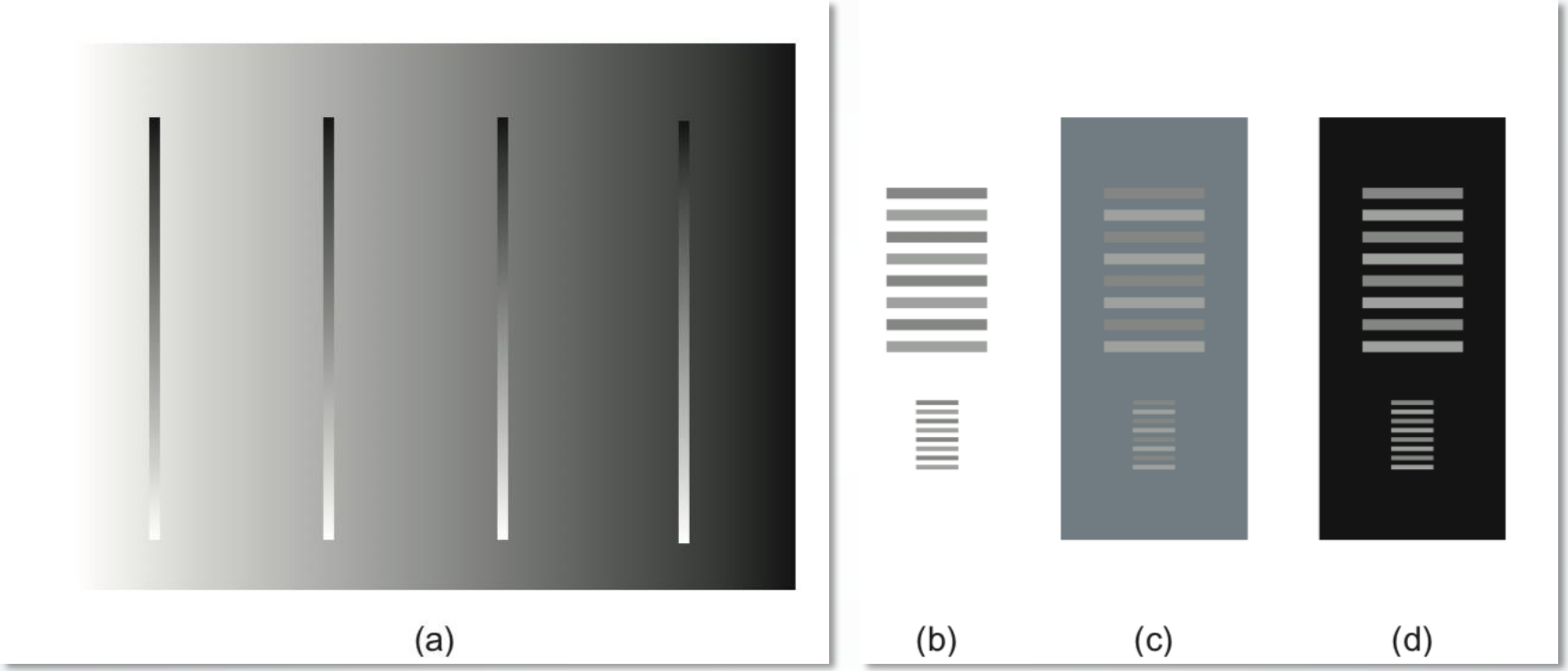
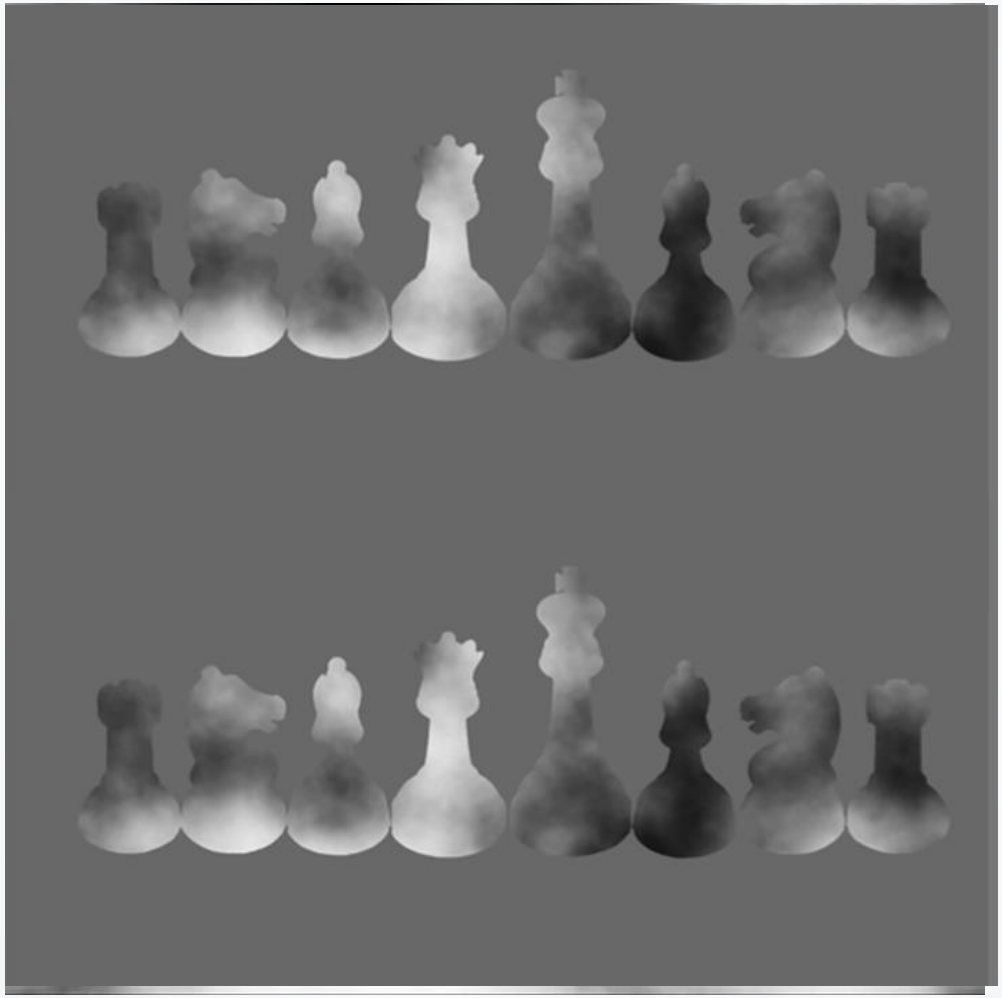


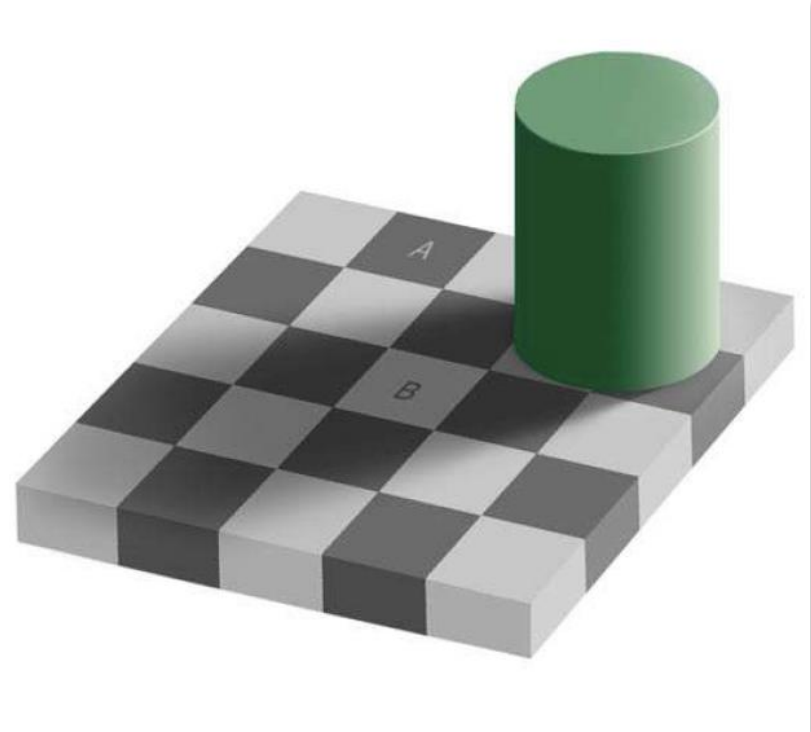
Figure 3.20 (a) All the gray strips are the same. Perceived differences between gray-scale values are enhanced where the values are close to the background gray value, an effect known as crispening. (b, c, d) The differences in the grays of the gray lattice are more evident (c) than with either the white (b) or the black (d) backgrounds, another example of crispening.

Simultaneous Contrast



相对性&绝对性

感知系统基于相对判断，而非绝对判断(Weber’ s Law)



A和B哪一个更亮？

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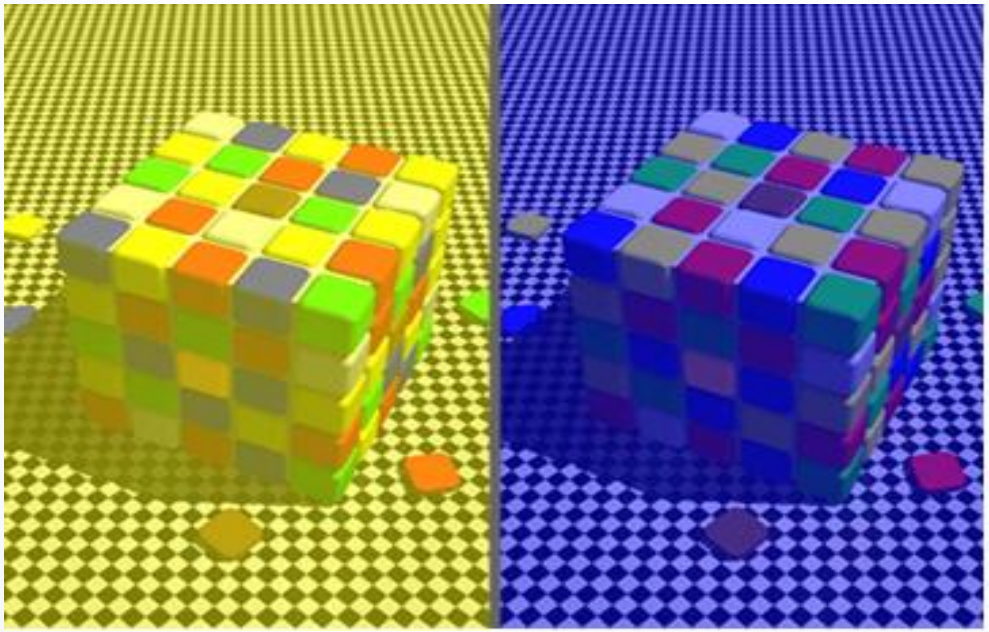

颜色？

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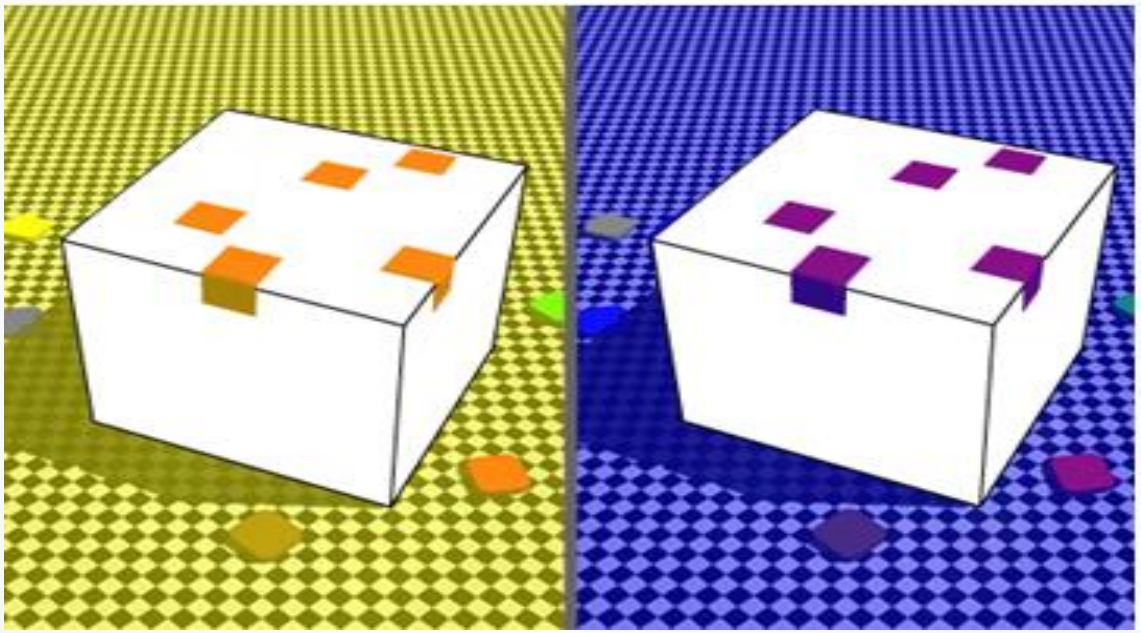


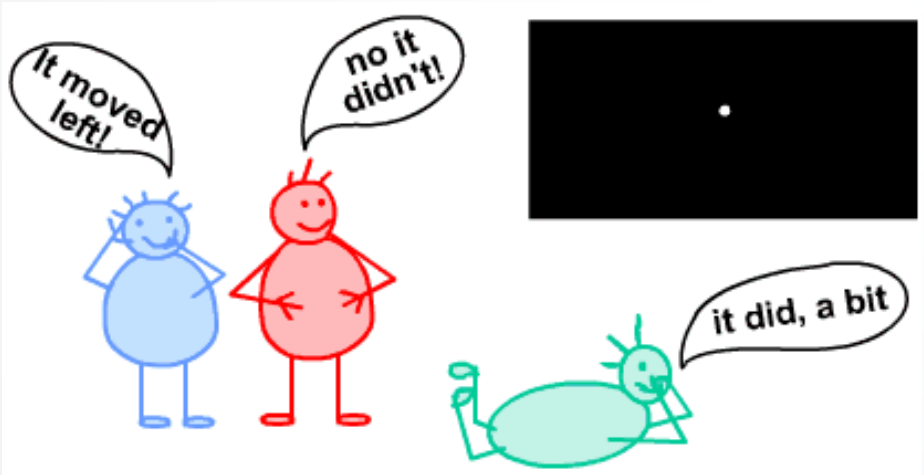
颜色？

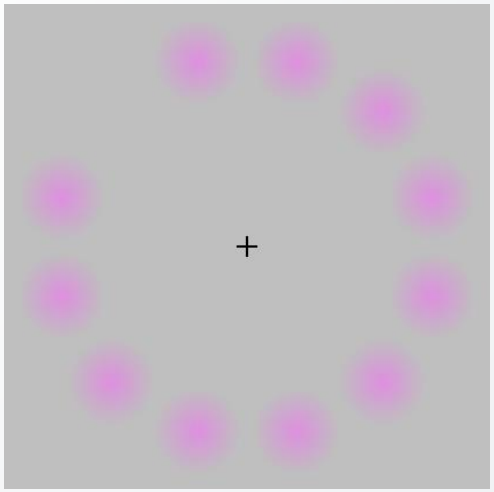
Perceived Shape

Are the two circles in the center of the same sizes?

Perceived Motion

- Stroboscopic Effect (flip book effect)
- Phi phenomenon
- Autokinetic Effect (if people stare at a white spotlight in a dark room, it appears to move.)





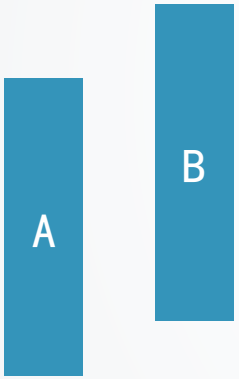
Fact

Our visual system sees differences, not absolute values, and is attracted to edges.

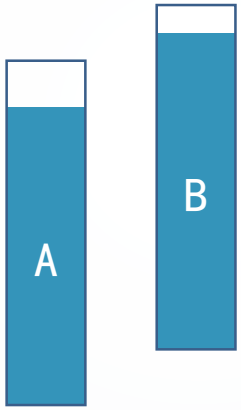
Use high contrast between objects that should be distinguishable

相对性&绝对性

感知系统基于相对判断，而非绝对判断(Weber’ s Law)



无线框
未对齐



有线框
未对齐

无线框

A和B那一个更高？

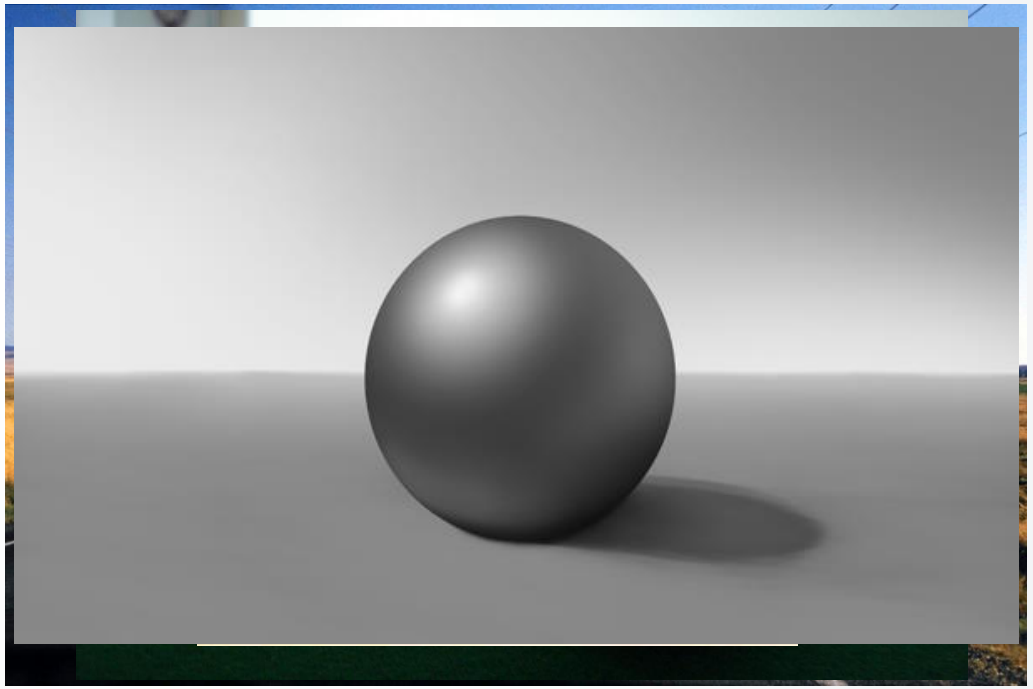
Depth Perception

Monocular depth cues – cues that provide depth information with one eye closed.

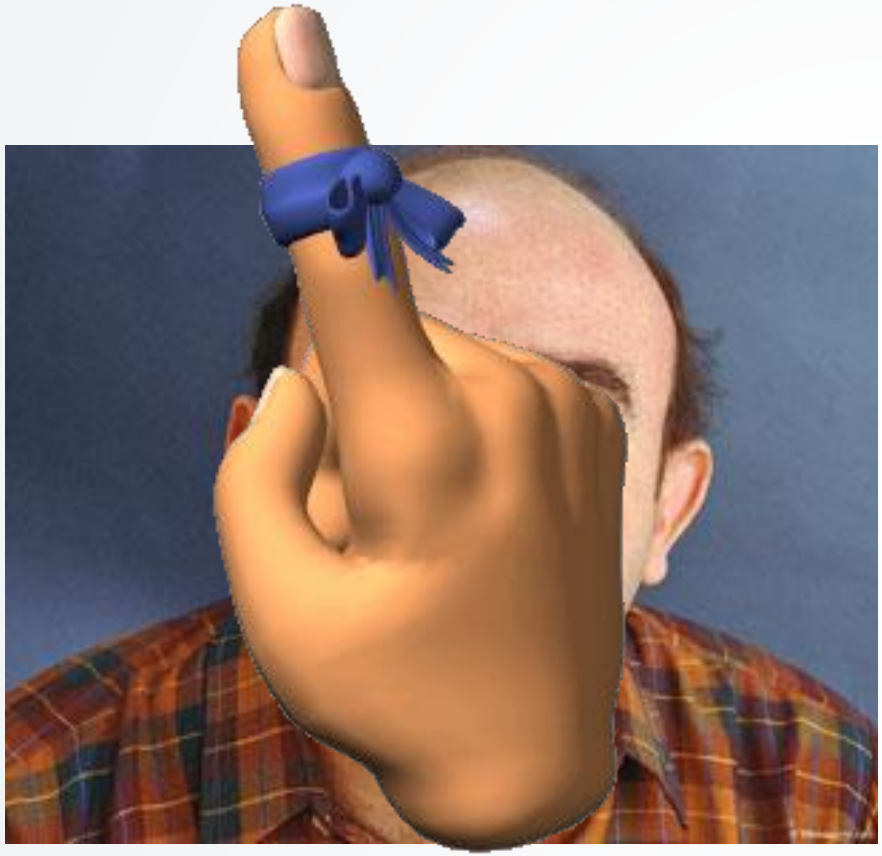
- pictorial cues (e.g., linear perspective)
- aerial perspective (differing contrast)
- texture gradients (decreased detail from front to back)
- interposition
- shading (production of shadows by 3-D objects)
- familiar size as anchor
- motion parallax

Monocular Cue

- You really only need one eye to use these (used in art classes to show depth).
- Linear Perspective
- Interposition
- Relative size
- Texture gradient
- Shadowing



Binocular Cues

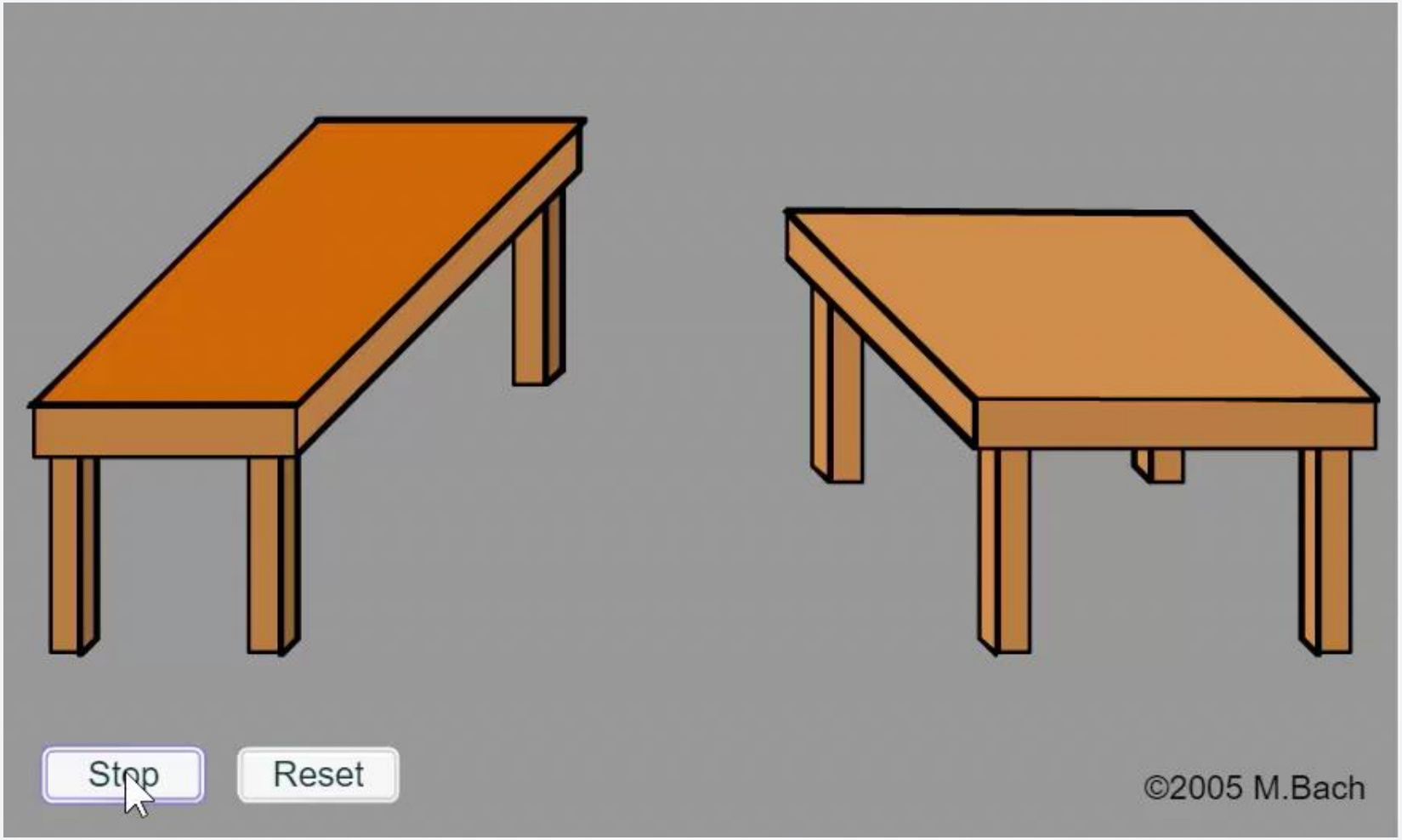


- We need both of our eyes to use these cues.
- **Retinal Disparity** (as an object comes closer to us, the differences in images between our eyes becomes greater.
- **Convergence** (as an object comes closer our eyes have to come together to keep focused on the object).

Seeing is Not Believing

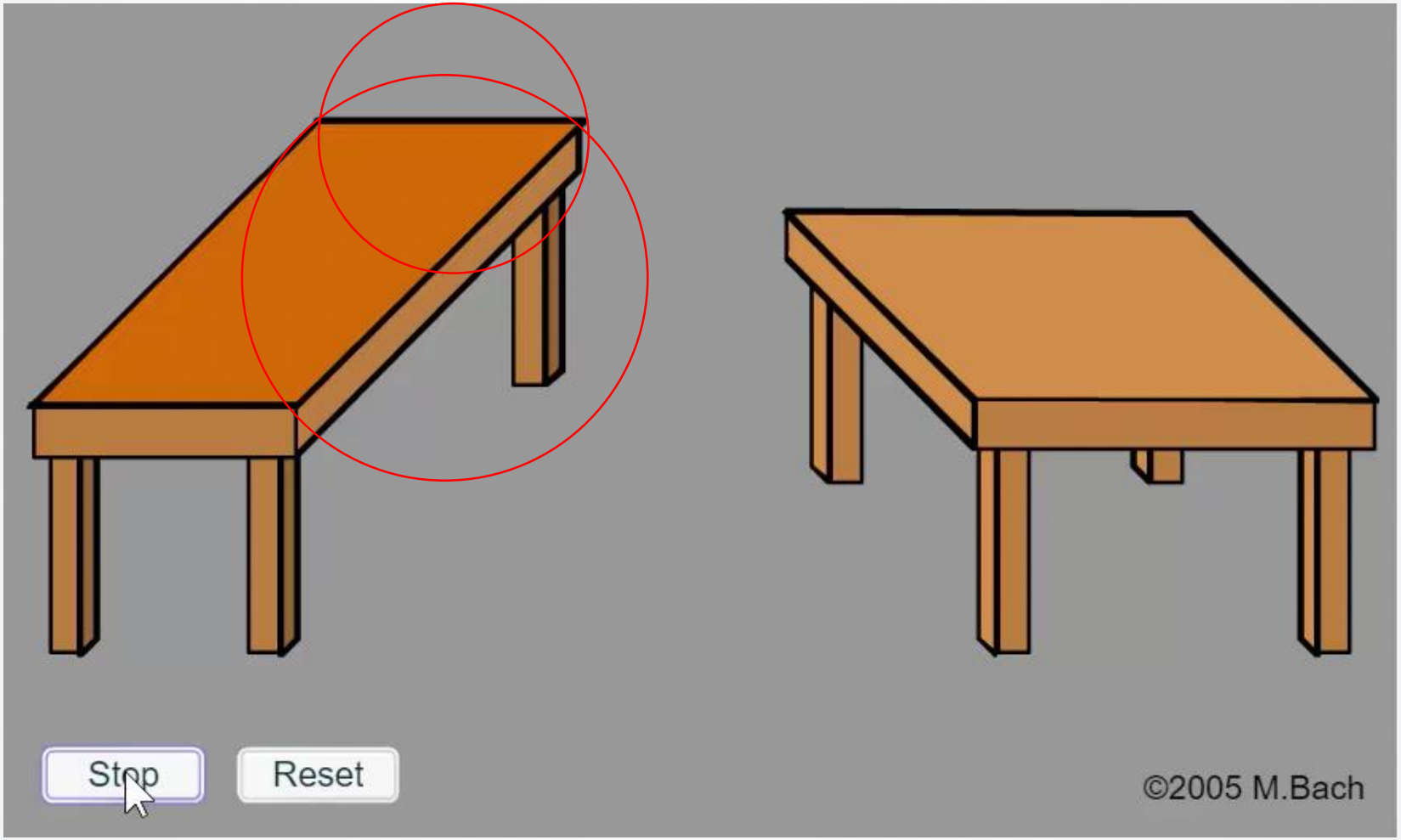
Impossible Box

Shepard's Rotated Table



© http://www.michaelbach.de/ot/sze_shepardTables

Shepard's Rotated Table



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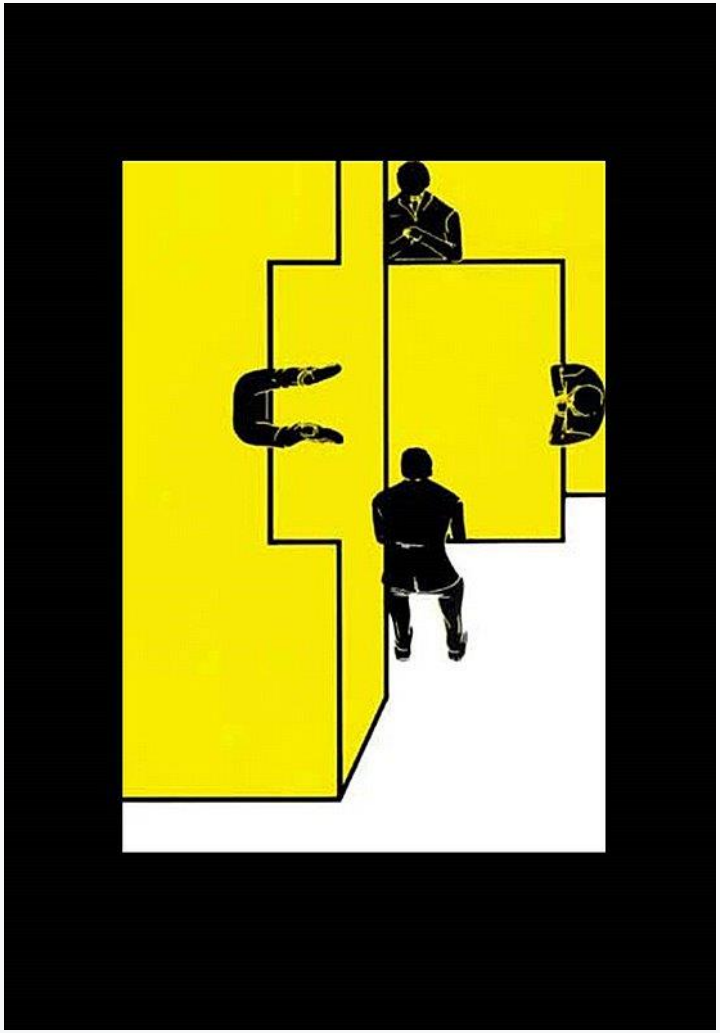
Shigeo Fukuda



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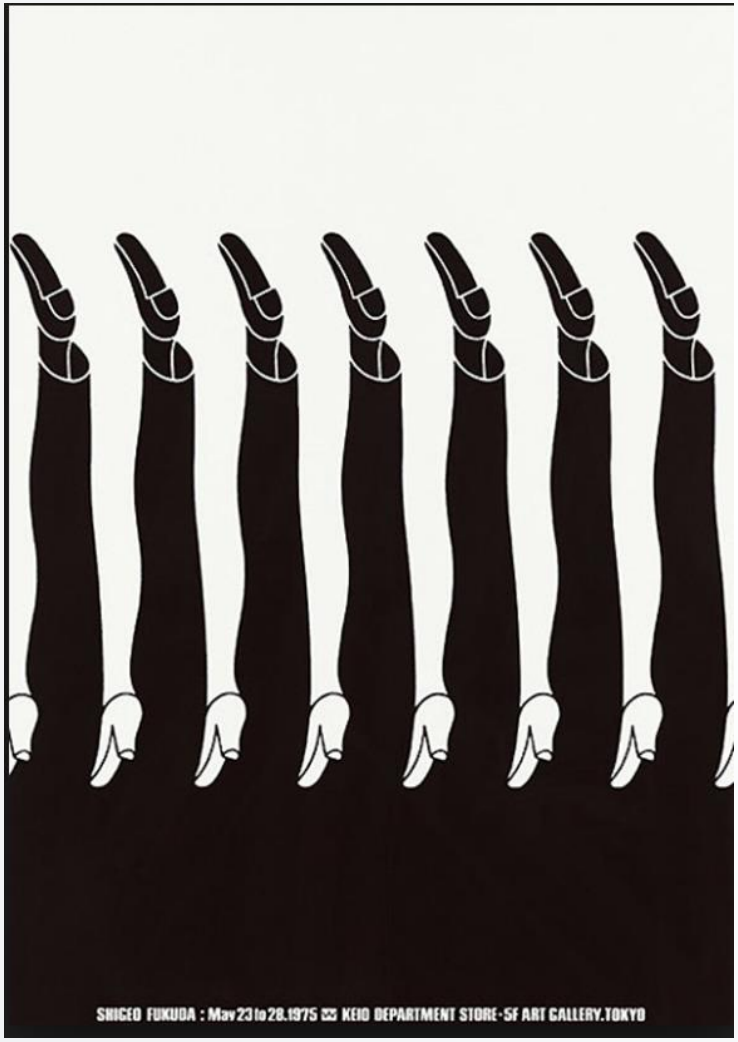
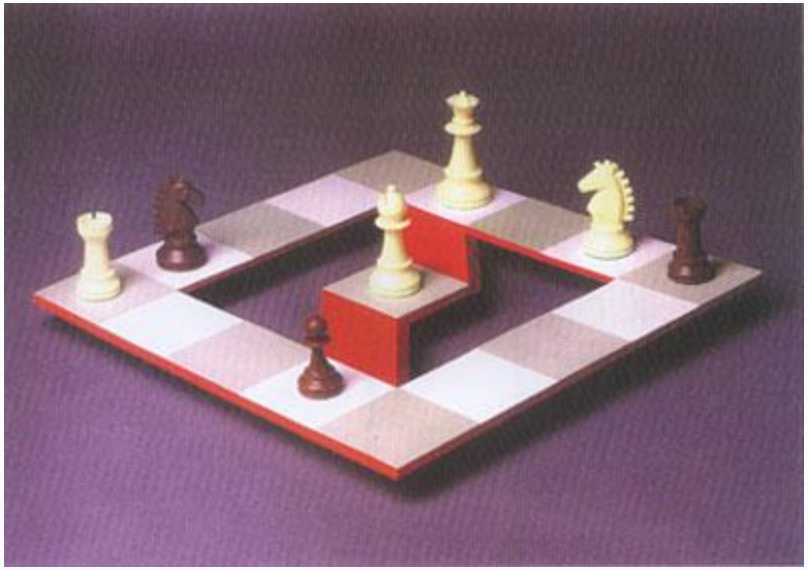
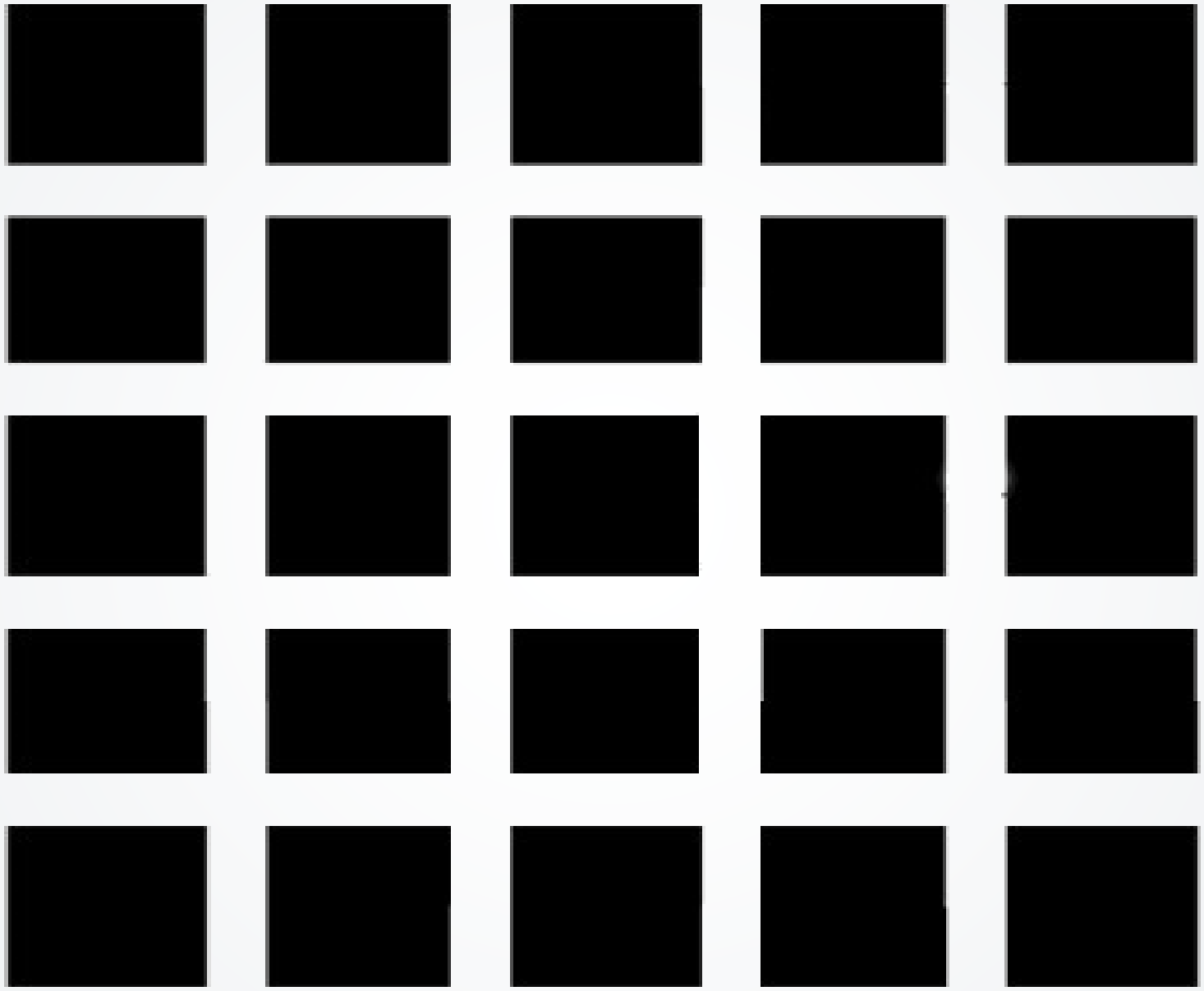
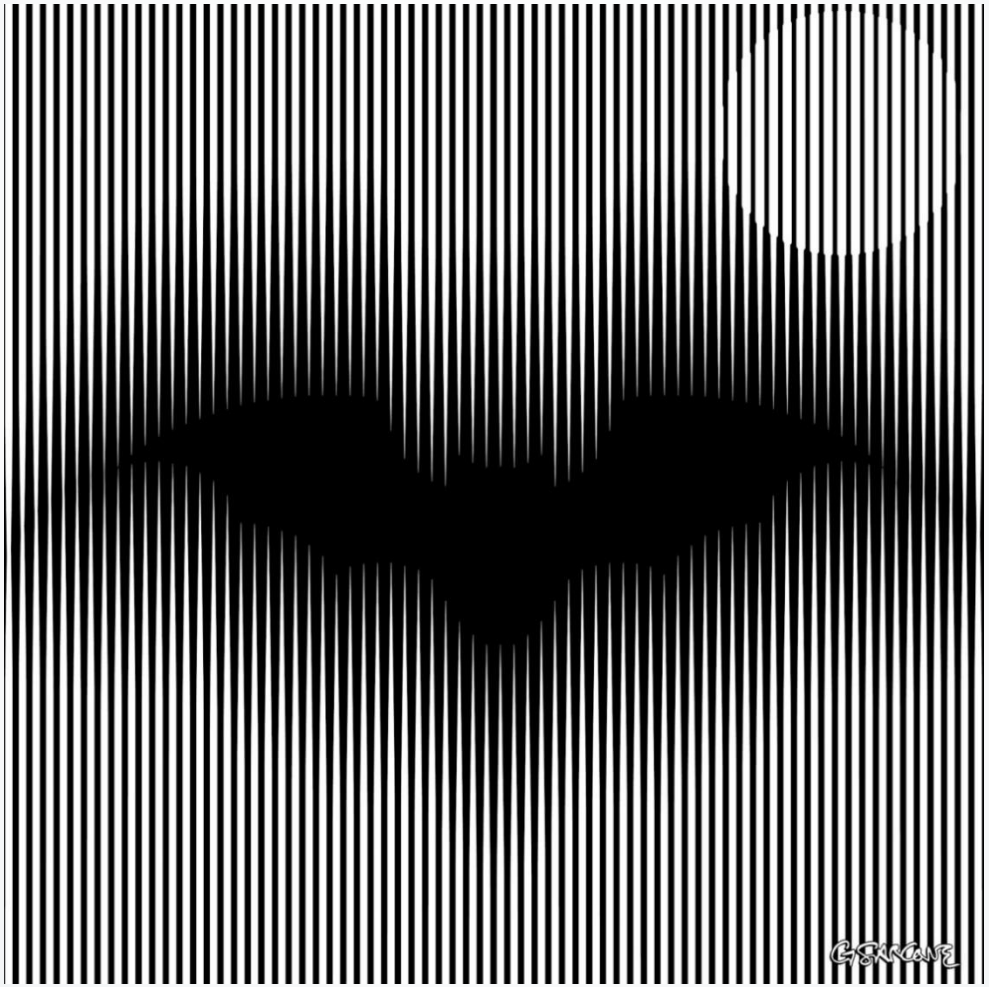


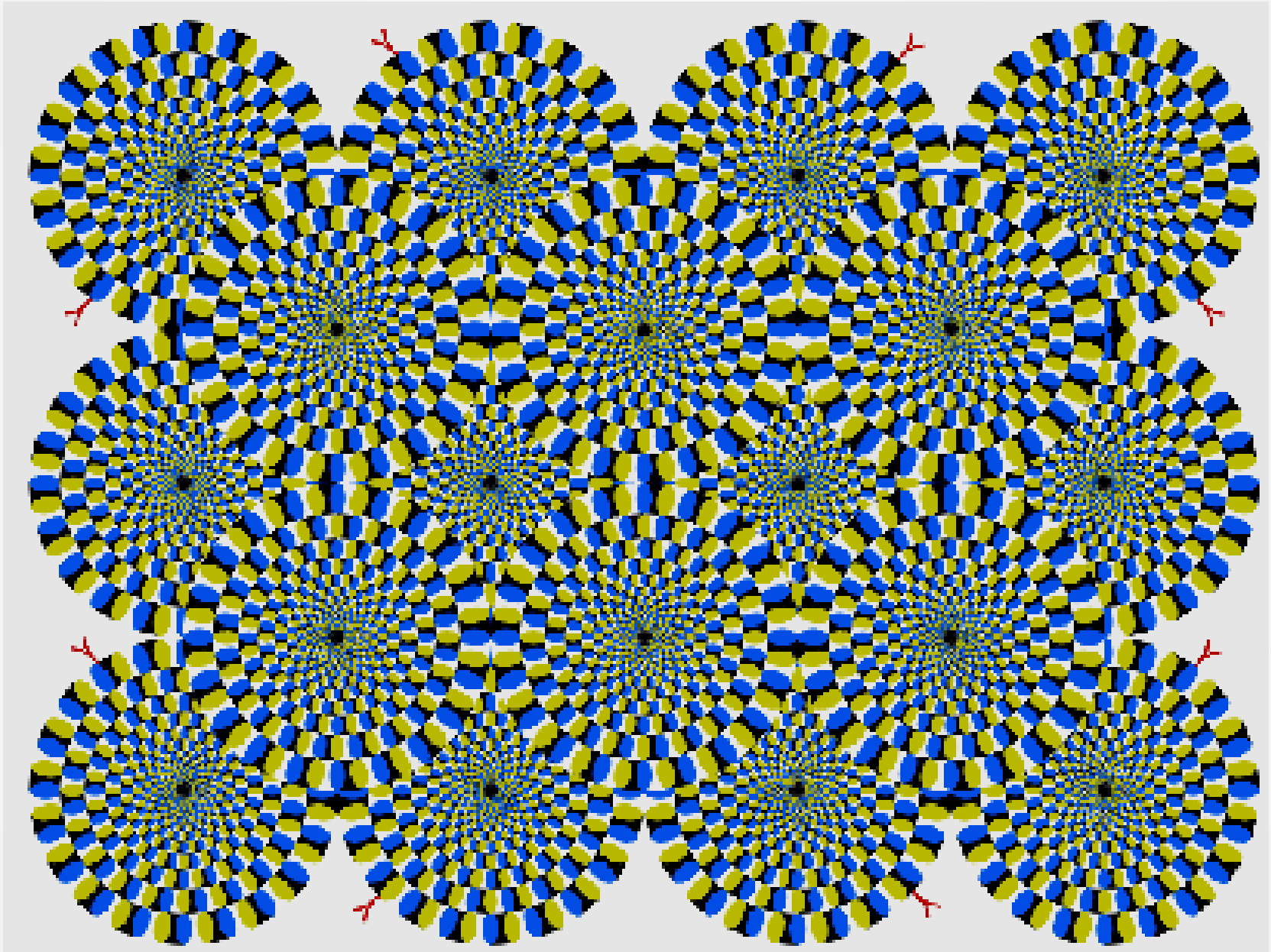
Impossible Chess

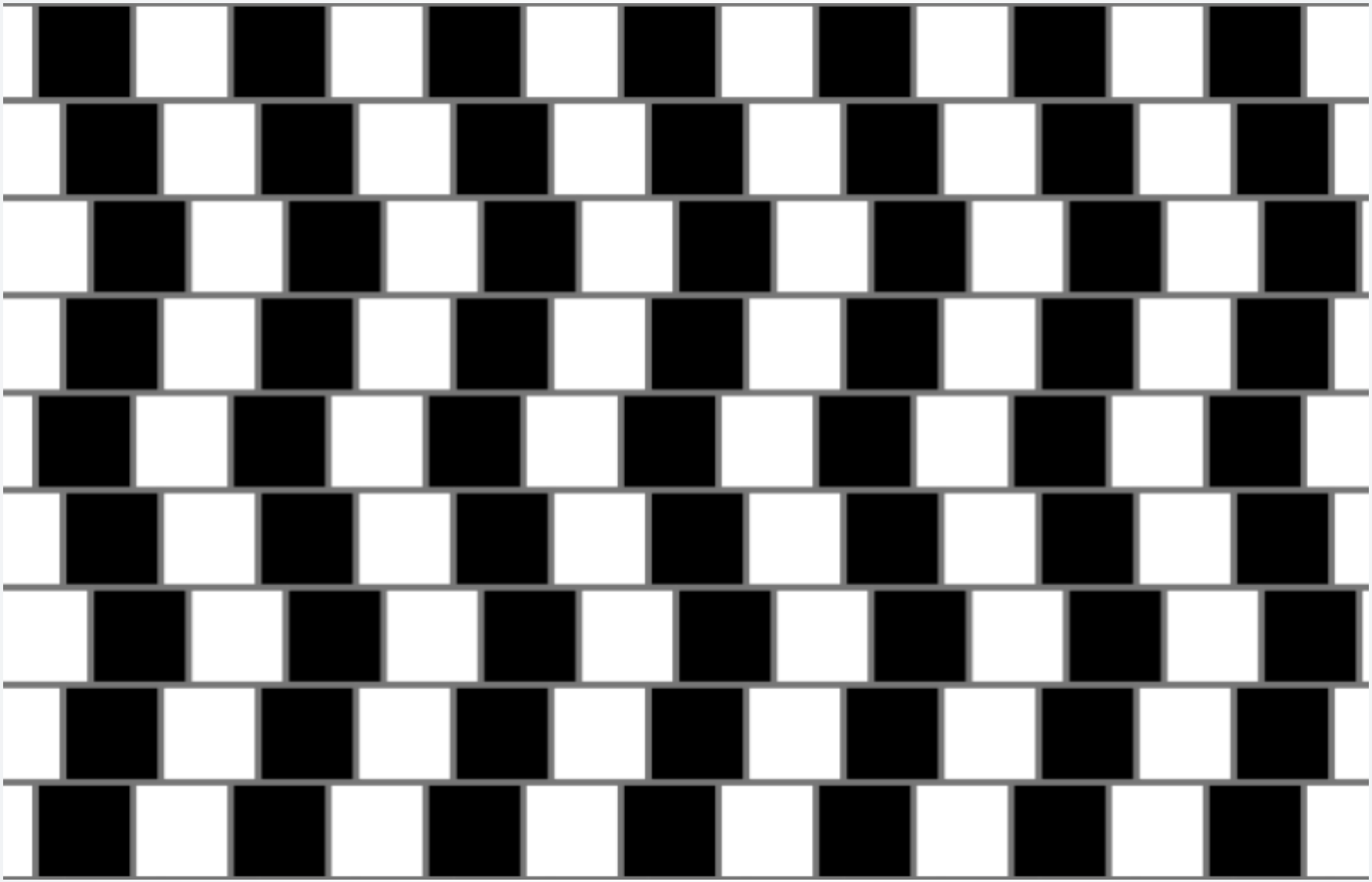




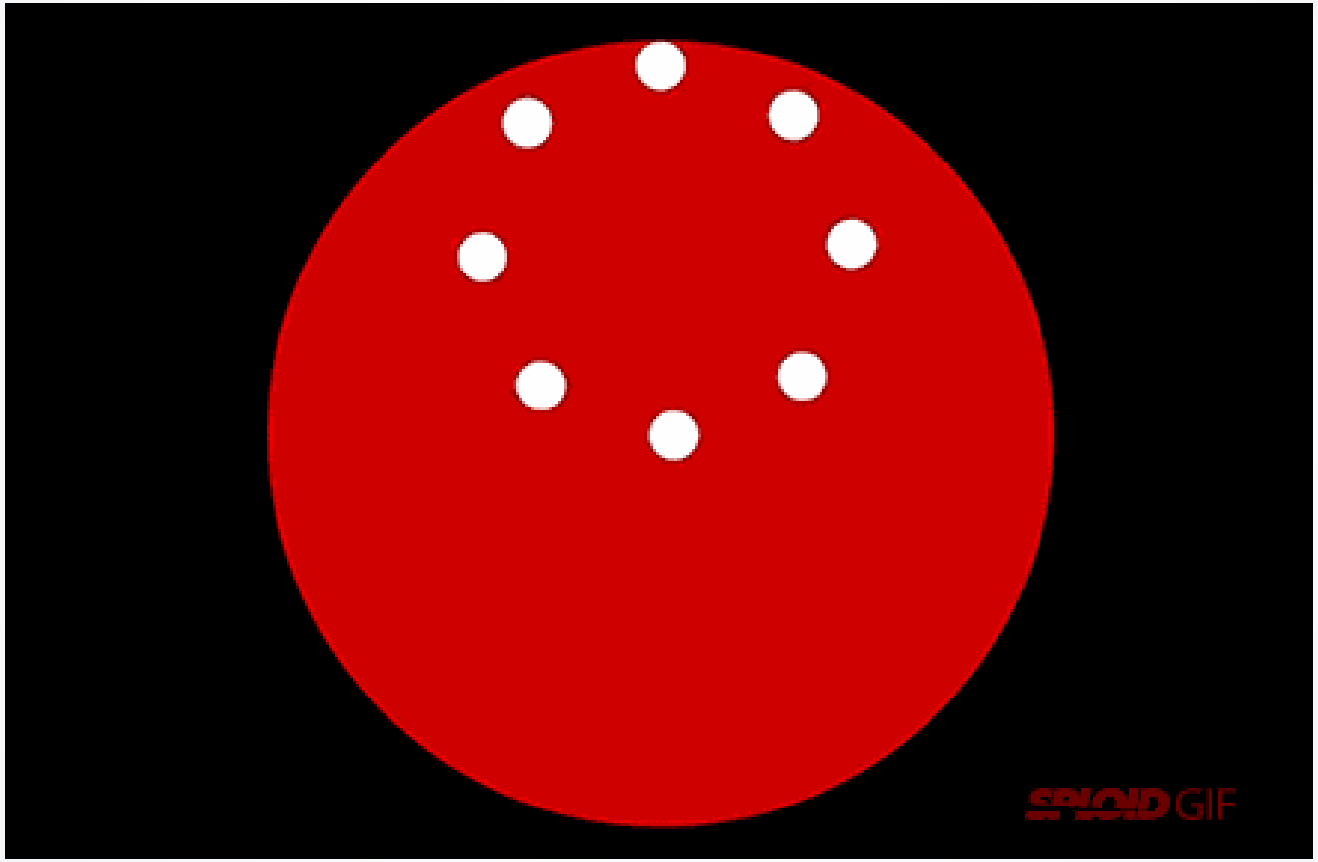
Flying Black Bat







Illusion



Outline

① Visual Perception

② Cognition

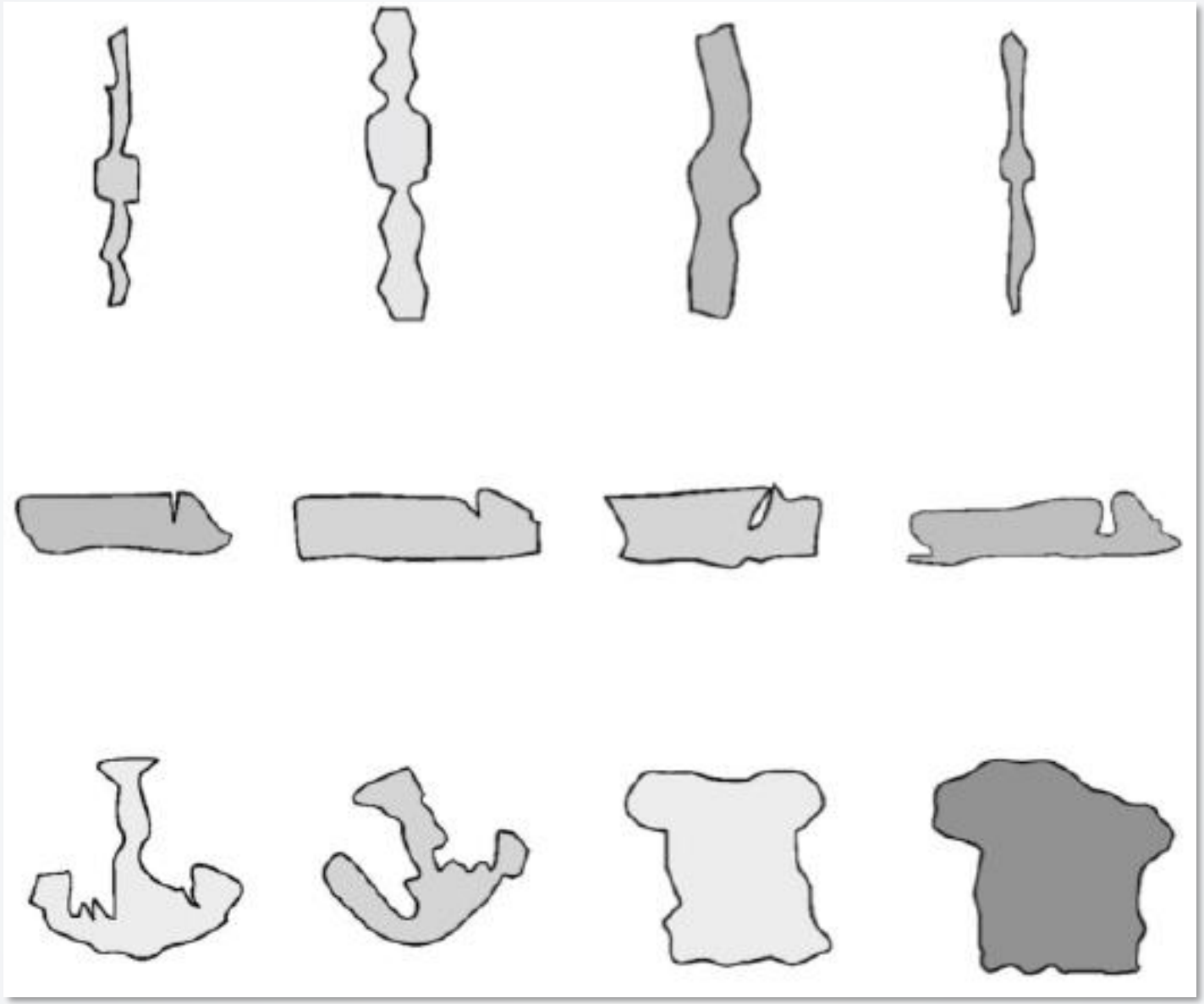
③ Shape

④ Color

⑤ Toolkits

There's more to seeing than just what's there

conceptual interpretation affects memory



conceptual interpretation affects memory

we rely on priors

Take Home Point

Vision is "constructed" from the input

"What you see when you see a thing depends on what the thing is. What you see the thing as depends on what you know about what you are seeing."

Polyshyn

Outline

① Visual Perception

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Object Recognition: Key Question

- When does one object end and another begin? (grouping/segmentation)

- Viewpoint independence (perception of objects as objects, regardless of view)

- How do we know that two things belong together, and how do we know that dogs are dogs and not cats? (categorization)

More Key Issues

- The "binding problem":

  If perception of a given object is distributed throughout visual areas, how does the brain combine features to produce unitary percept?

- Conscious vs. unconscious perception:

  Perception of some object or object qualities may proceed pre-consciously or without effort (a general principle).

- Example: Threat

Gestalt Theory

Wolgang Köhler
1887-1967

Kurt Koffka
1886-1941

Max Wertheimer
1880-1943

为什么我们在观看事物的时候会把一部分当做前景，其余部分当做背景？

为什么我们能区分形状？

什么形状是好的？

格式塔(Gestalt)原则

- 结构比元素重要，视觉形象首先作为统一的整体被认知
- 原则(蕴涵律)
  - 接近性(proximity)
  - 相似性(similarity)
  - 连续性(continuity)
  - 闭合性(closure)
  - 简单性(simplicity)

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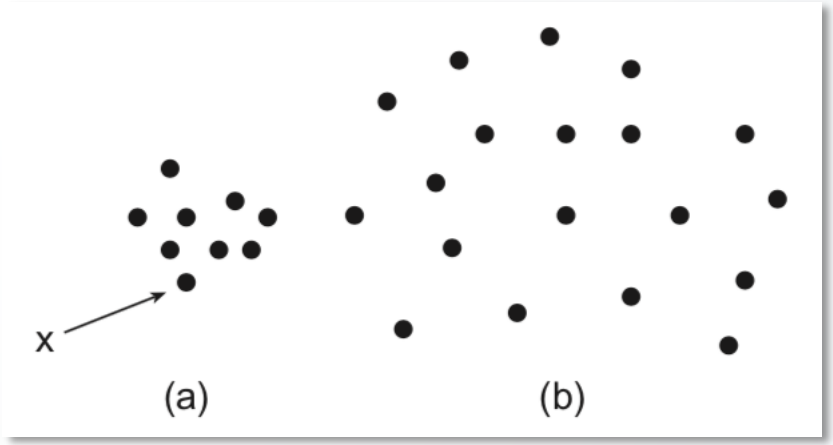

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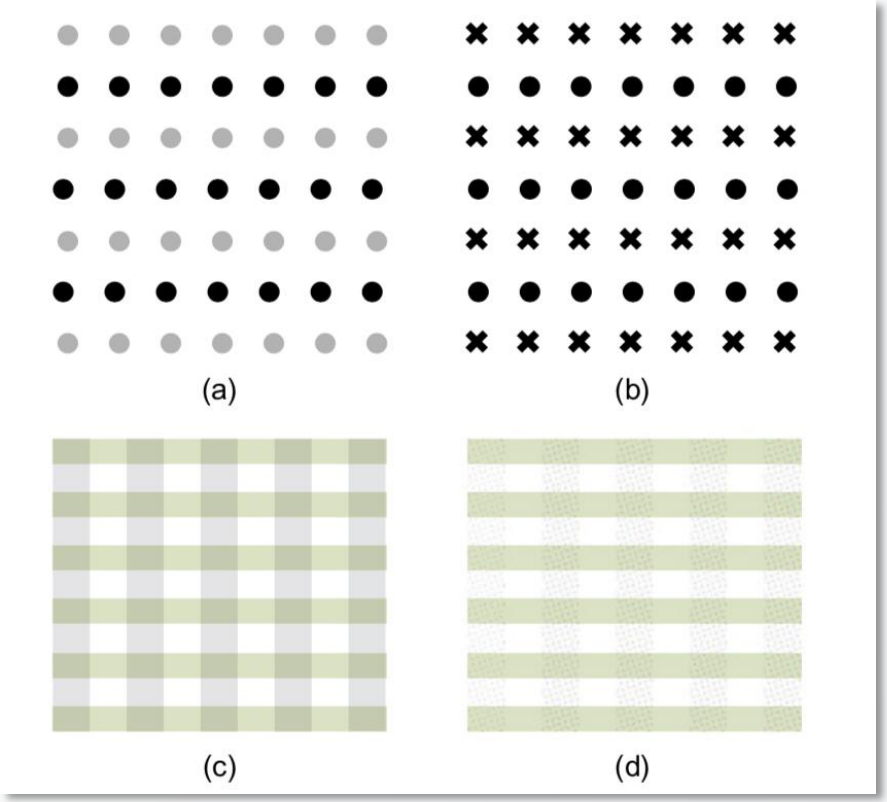

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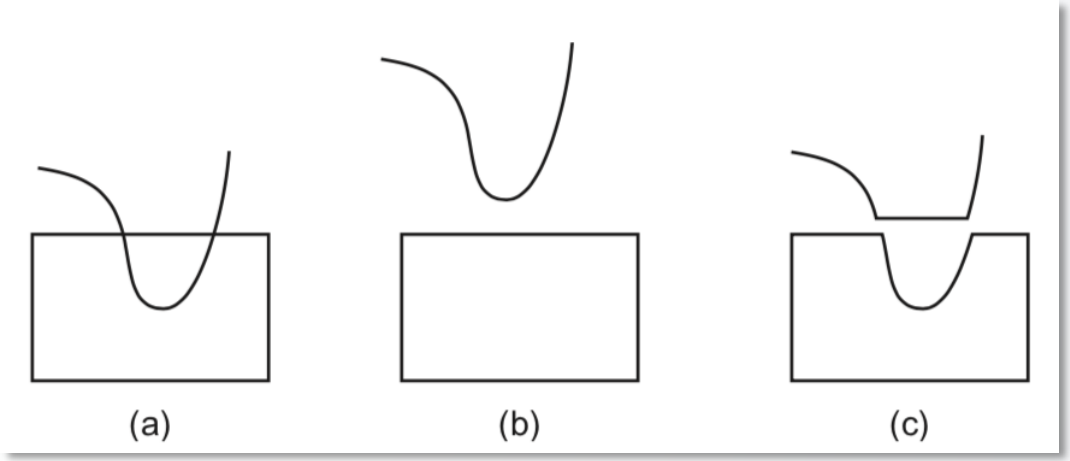

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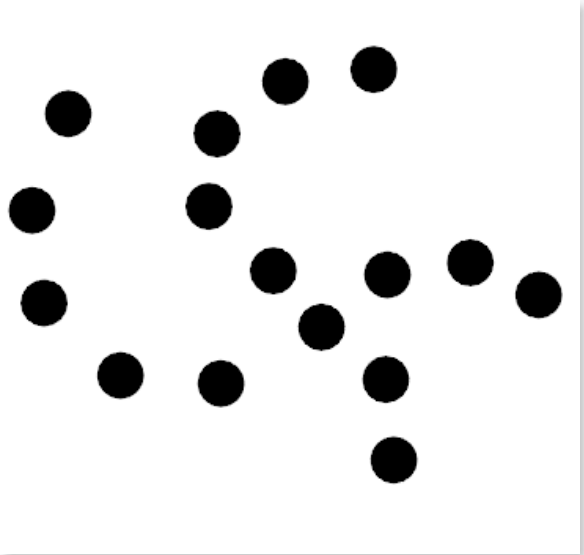

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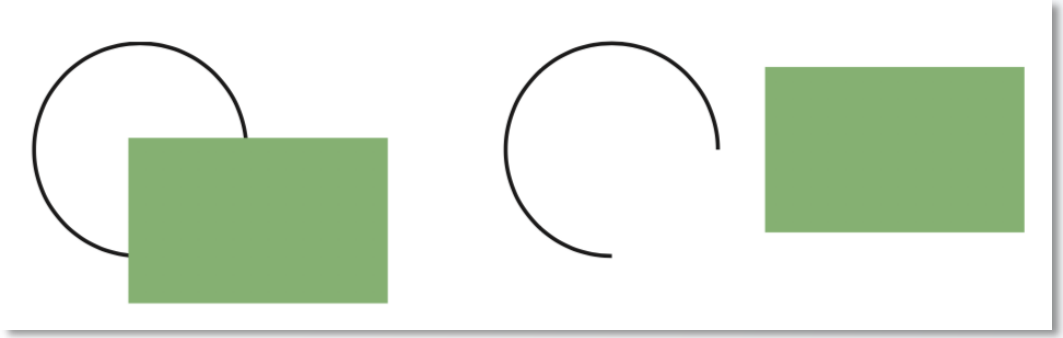

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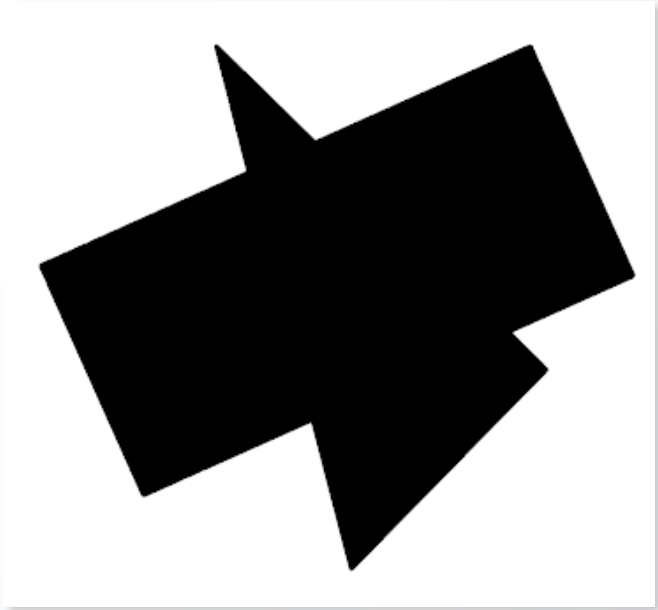

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  - 共势原则(common fate)
  - 好图原则(pragnanz)
  - 对称原则(symmetry)
  - 经验原则(past experience)

从一堆字符中认知语句

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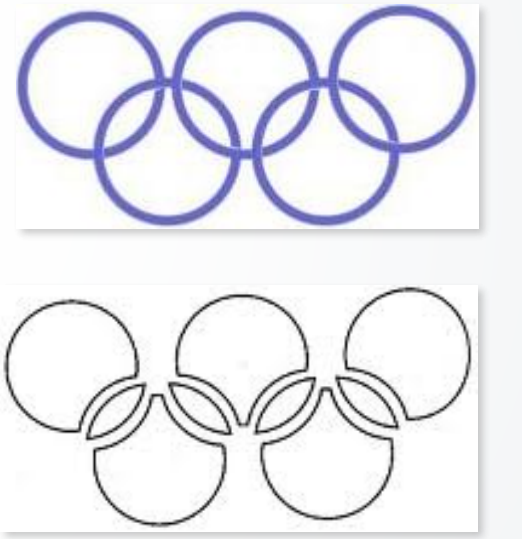
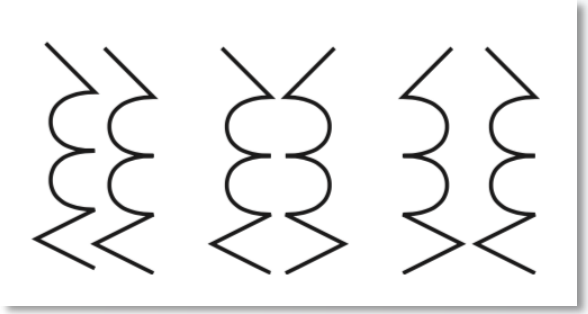


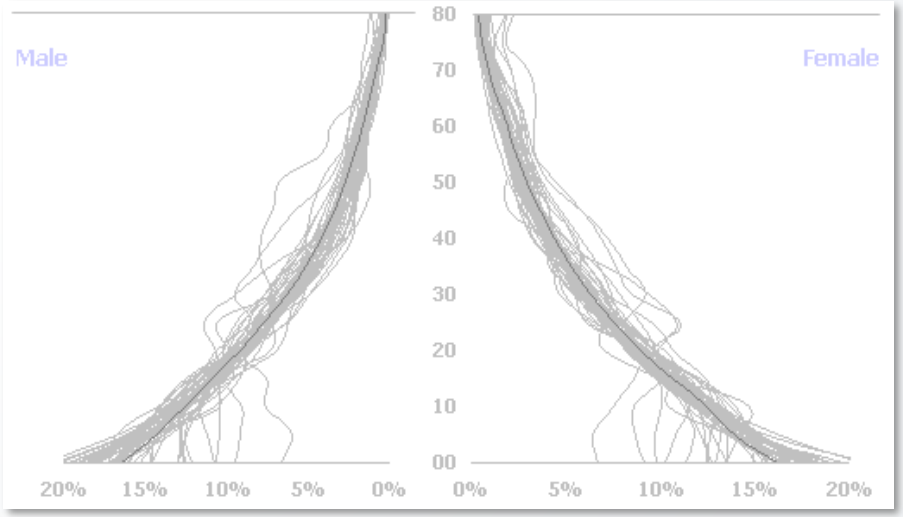
对五环形状的两种识别
上：*奥运环；下:割裂的圆环。*

格式塔(Gestalt)原则

- 结构比元素重要，视觉形象首先作为统一的整体被认知



- 原则(蕴涵律)
  - 共势原则(common fate)
  - 好图原则(pragnanz)
  - 对称原则(symmetry)
  - 经验原则(past experience)



格式塔(Gestalt)原则

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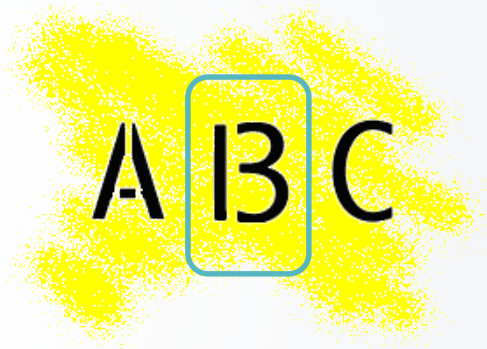
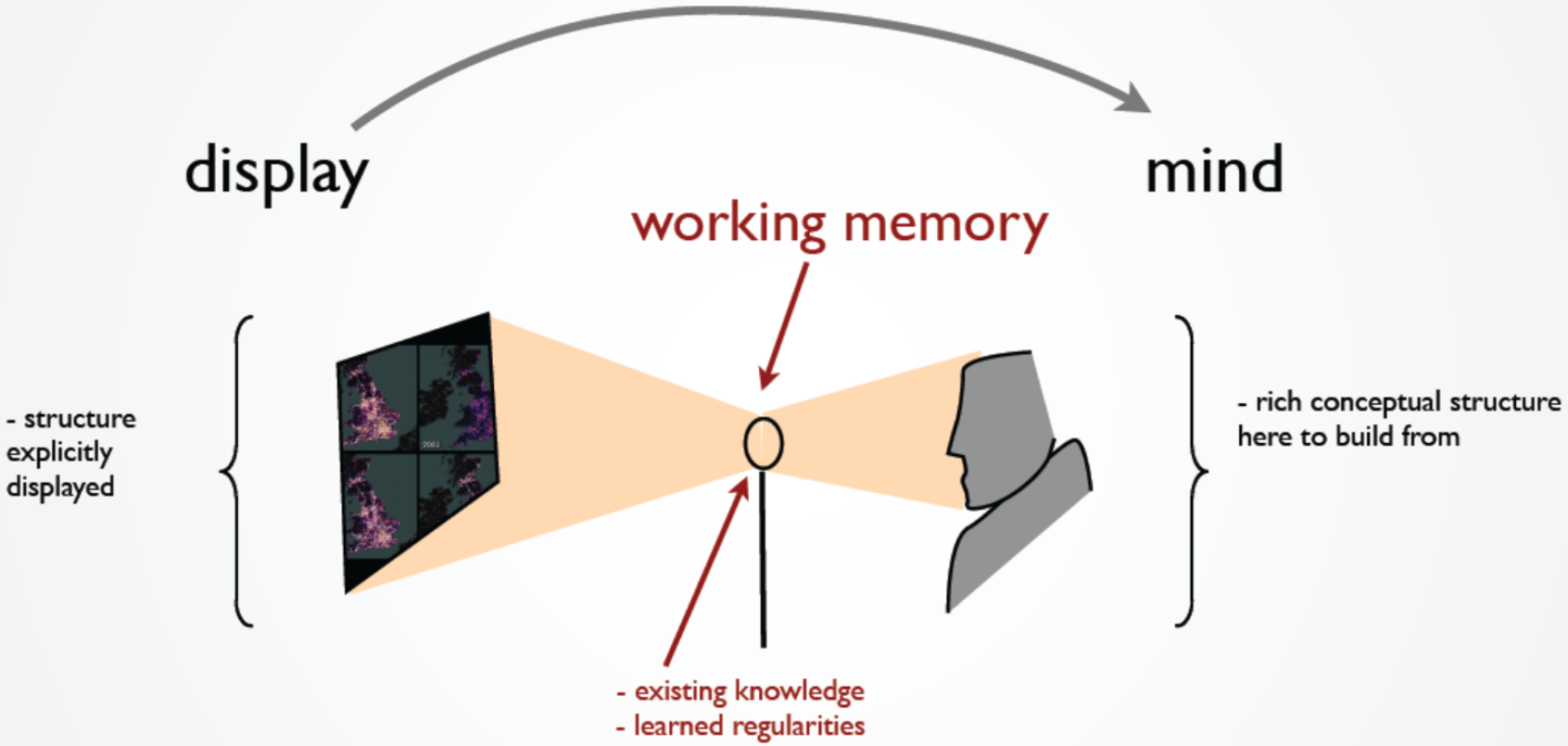


Take Home Picture



Active concepts in working memory can be synthesized

"The power of a visualization is that we can have a far more complex concept structure represented externally in a visual display than can be held in visual and verbal working memory."

- Colin Ware

Outline

① Visual Perception

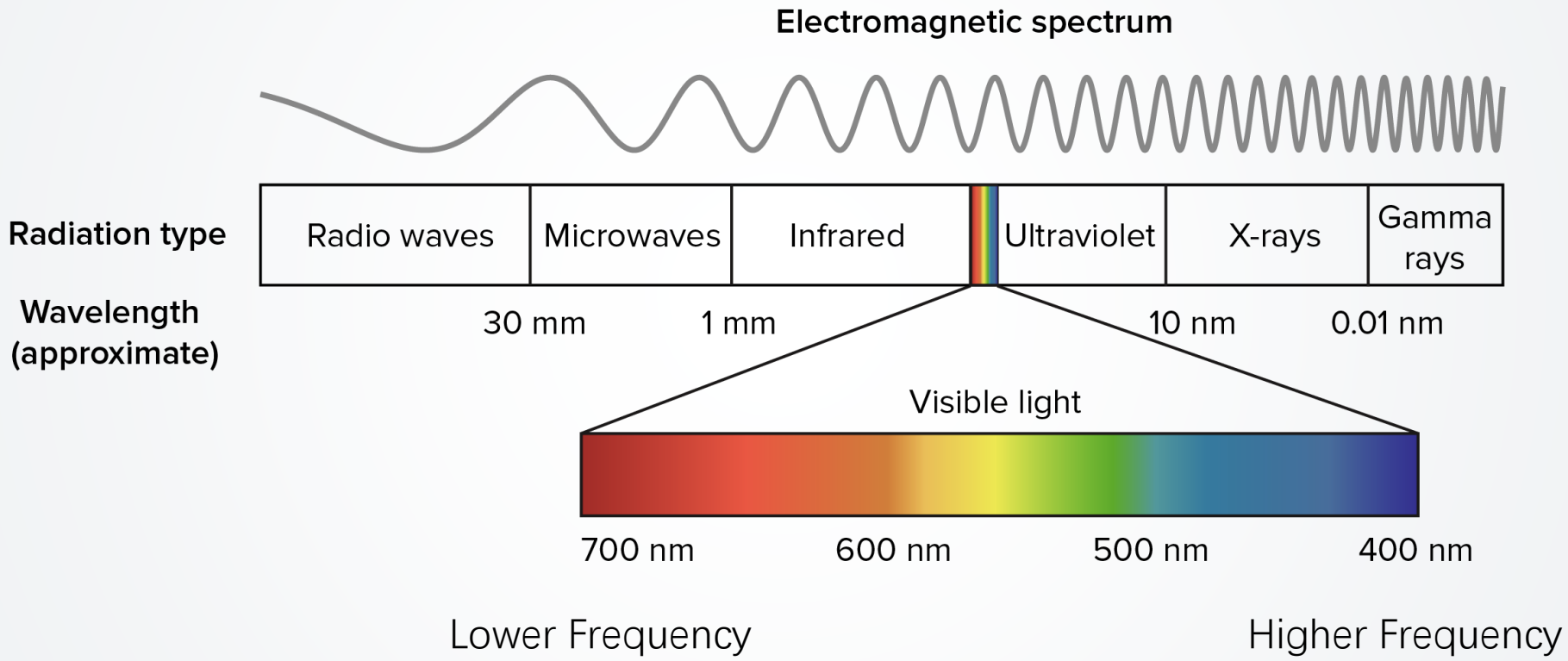
② Cognition

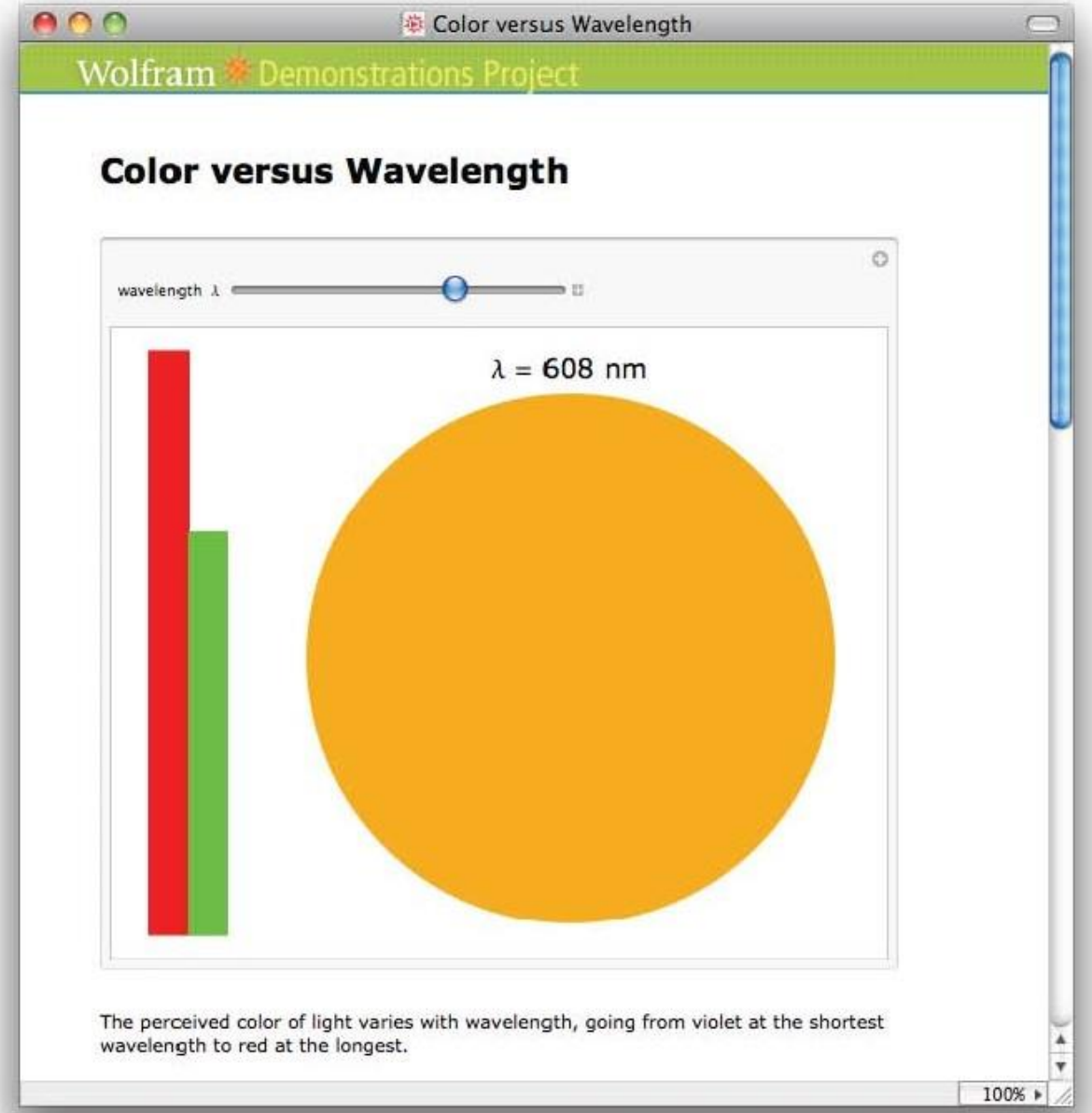
③ Shape

④ Color

⑤ Toolkits

Spectrum of Light




Color versus Wavelength
Wolfram Demonstrations Project
Color versus Wavelength
wavelength λ
λ = 608 nm
The perceived color of light varies with wavelength, going from violet at the shortest wavelength to red at the longest.
100%

Cone Response

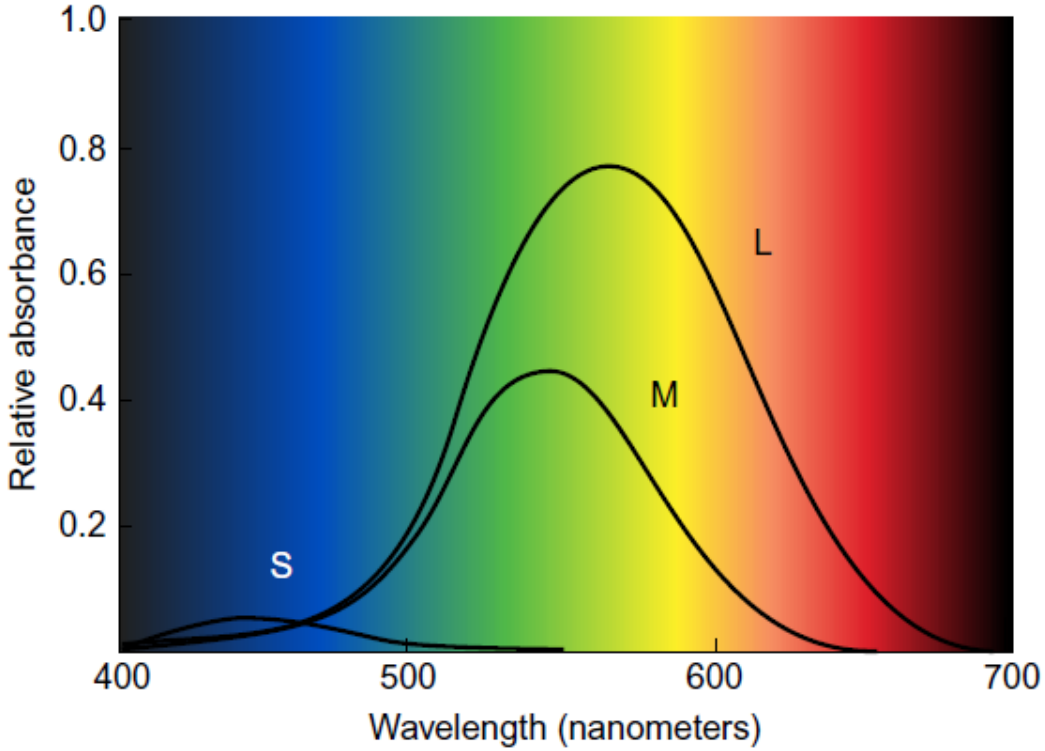


Figure 4.2 Cone sensitivity functions. The colors are only rough approximations to spectrum hues. *Abbreviations*: S, short-wavelength cone sensitivity; M, medium-wavelength cone sensitivity; L, long-wavelength cone sensitivity.

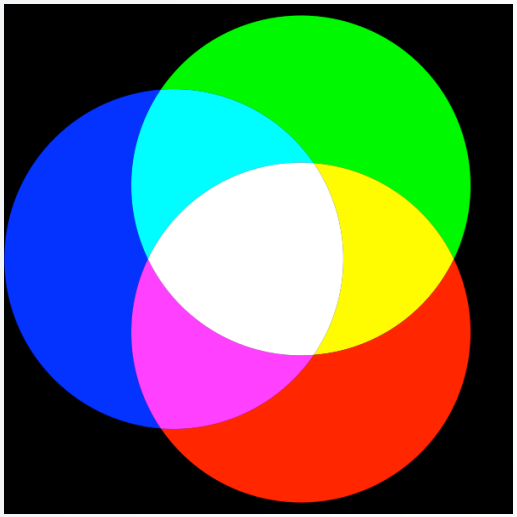
C. Ware. Information Visualization: Perception for Design: Second Edition. 2004.

What are the primary colors?

- Red, Green, Blue
- Red, Yellow, Blue
- Orange, Green, Violet
- Cyan, Magenta, Yellow
- All of the above

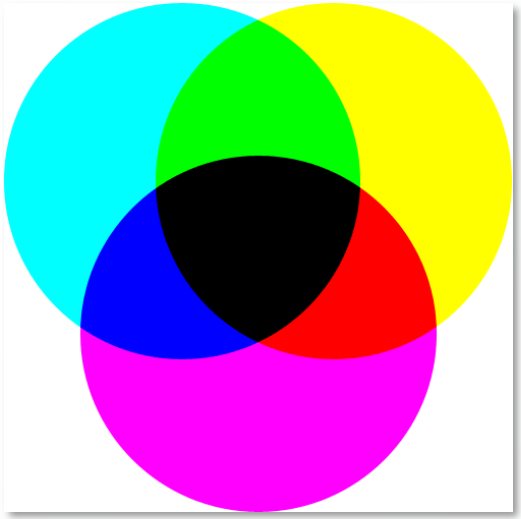
Color System

Additive System

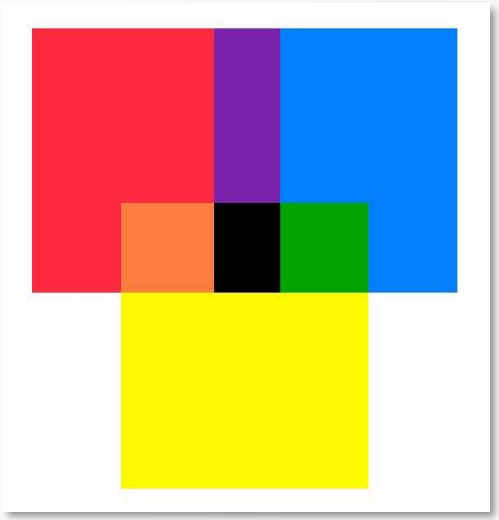


RGB

Subtractive System



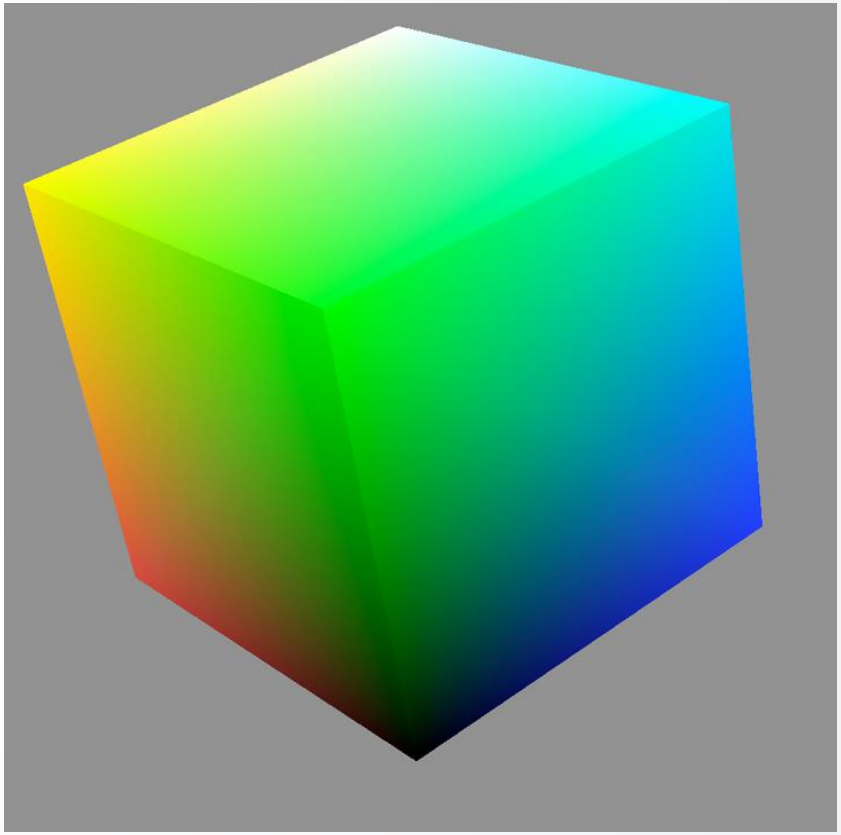
CMYK



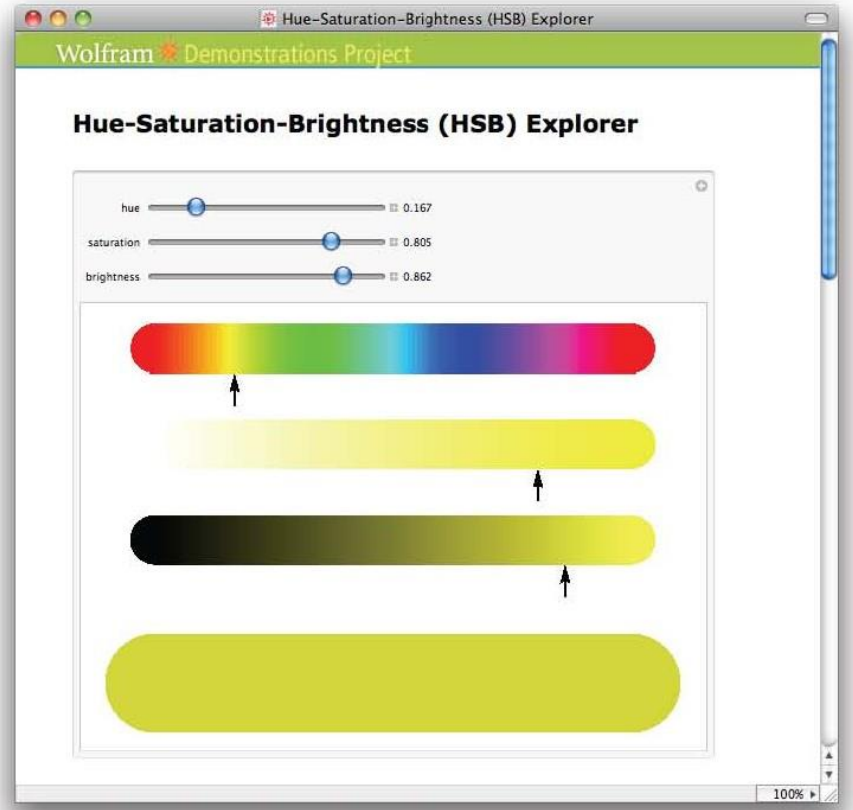
RYB

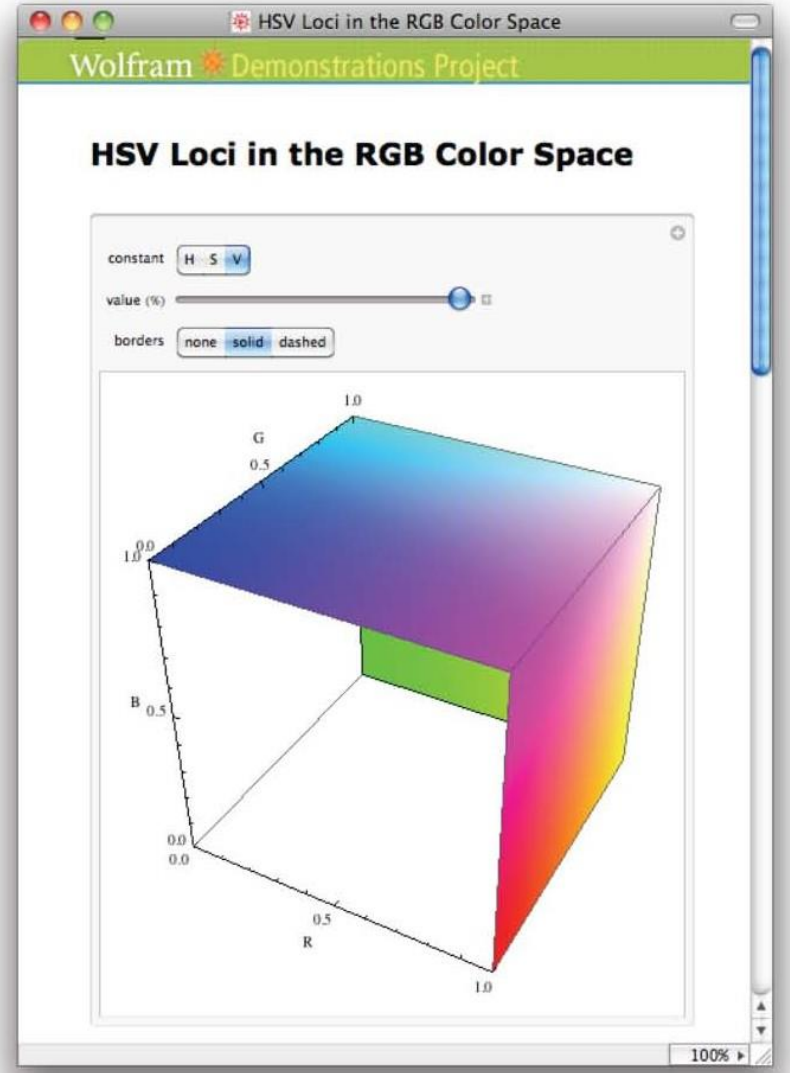
RGB Color Space

- Colors that can be represented by computer monitors
- Not perceptually uniform



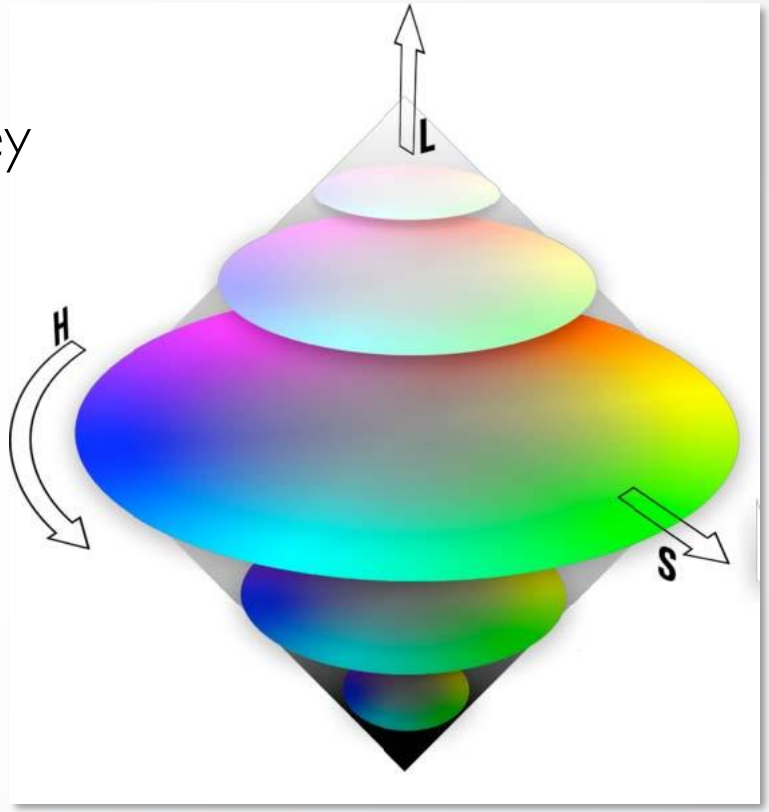
C. Ware, "Visual Thinking for Design"


Hue–Saturation–Brightness (HSB) Explorer
Wolfram Demonstrations Project
Hue-Saturation-Brightness (HSB) Explorer
hue
0.167
saturation
0.805
brightness
0.862
100%


HSV Loci in the RGB Color Space
Wolfram Demonstrations Project
HSV Loci in the RGB Color Space
constant
H
S
V
value (%)
borders
none
solid
dashed
G
B
R
1.0
0.5
0.0
100%

HSL Color Space

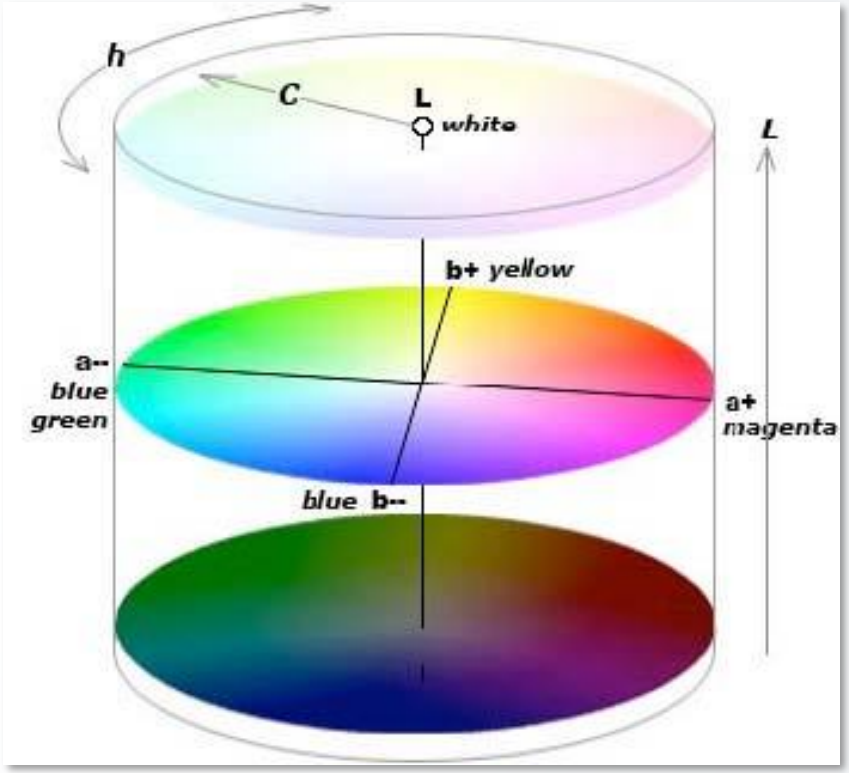
- Hue - what people think of color
- Saturation - purity, distance from grey
- Lightness - from dark to light
- Not perceptually uniform



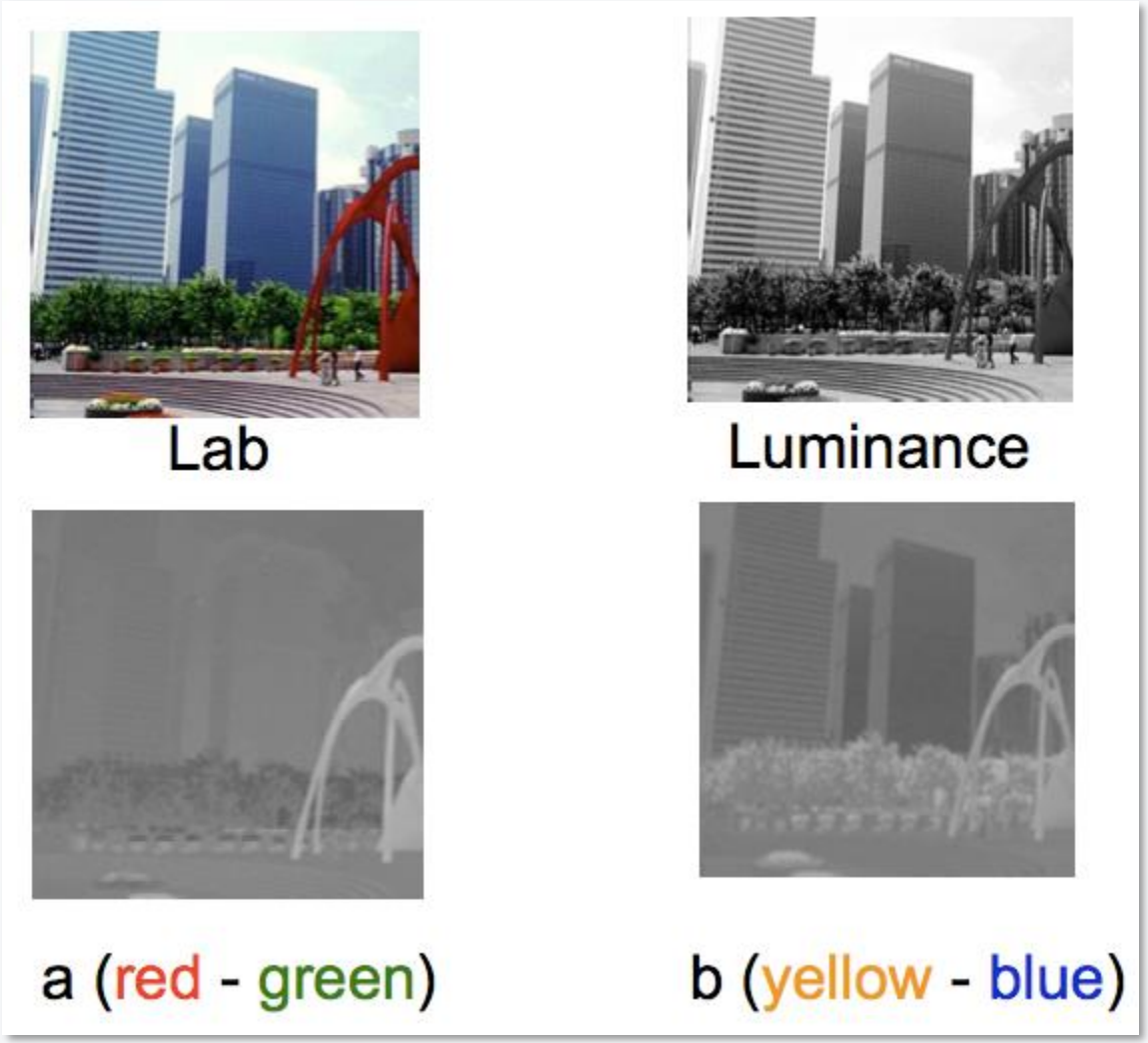
wikipedia.org

Lab Color Space

- Perceptually uniform
- L approximates human perception of lightness
- a, b approximate R/G and Y/B channels



Lab Color Space



Based on slide from A. Oliva

Outline

① Visual Perception

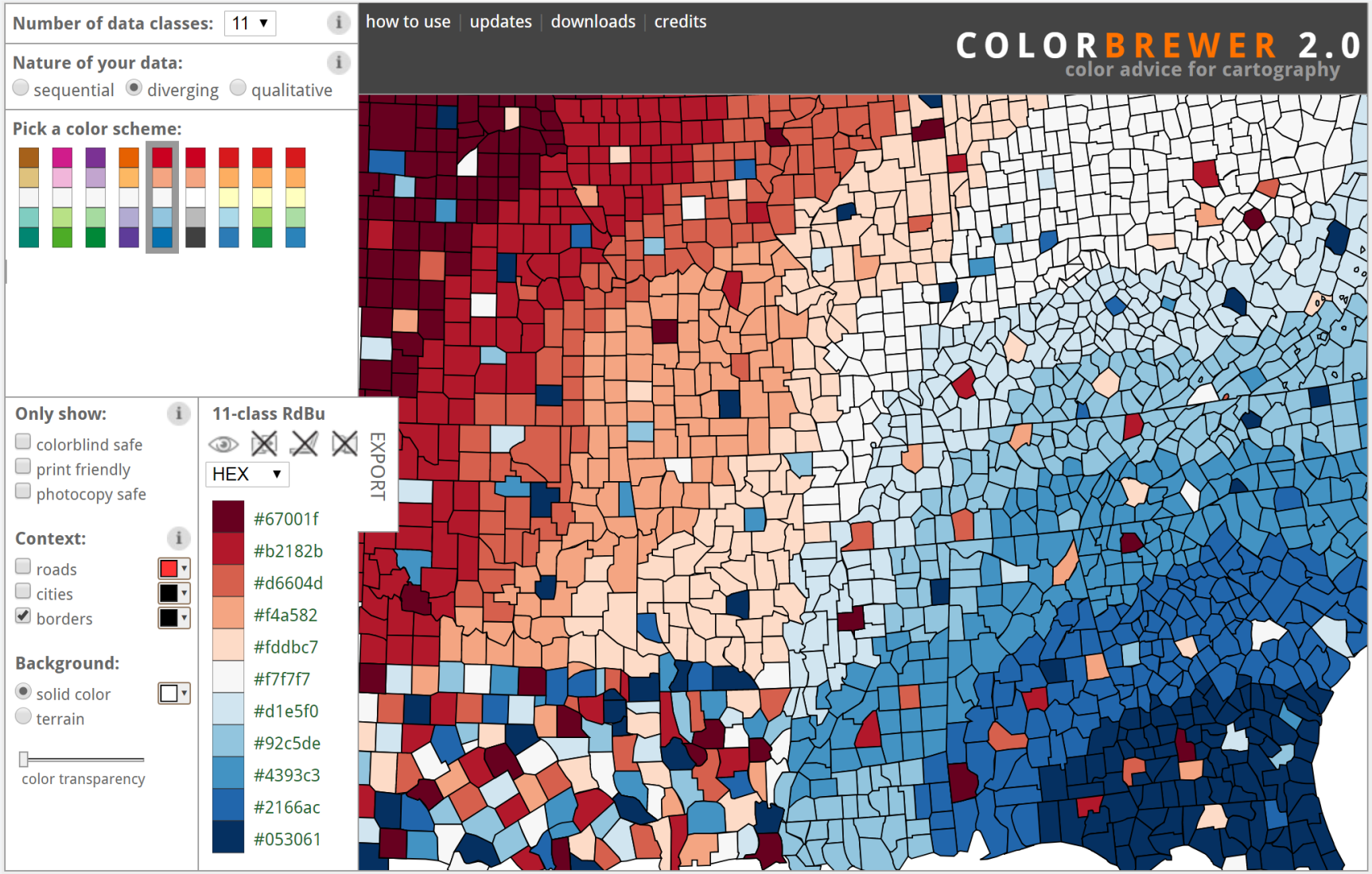
② Cognition

③ Shape

④ Color

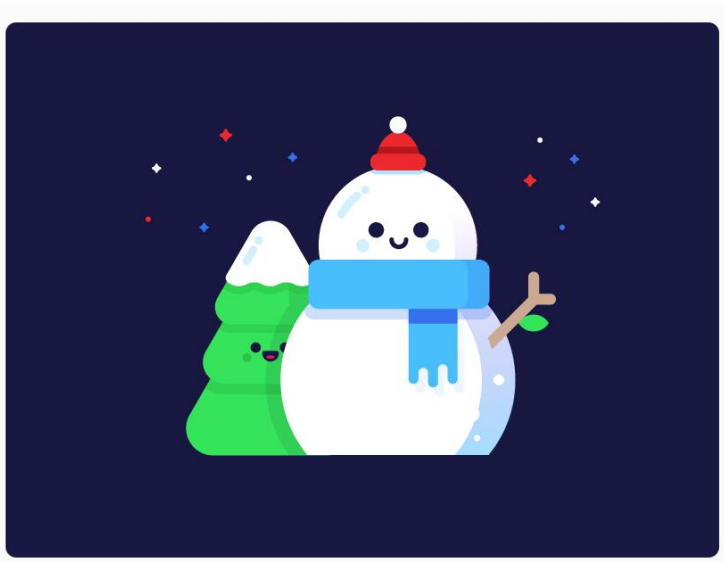
⑤ Toolkits

ColorBrewer



http://colorbrewer2.org

Color Farm



Madebyelvis

D1EDFF

38BBFF

F22117

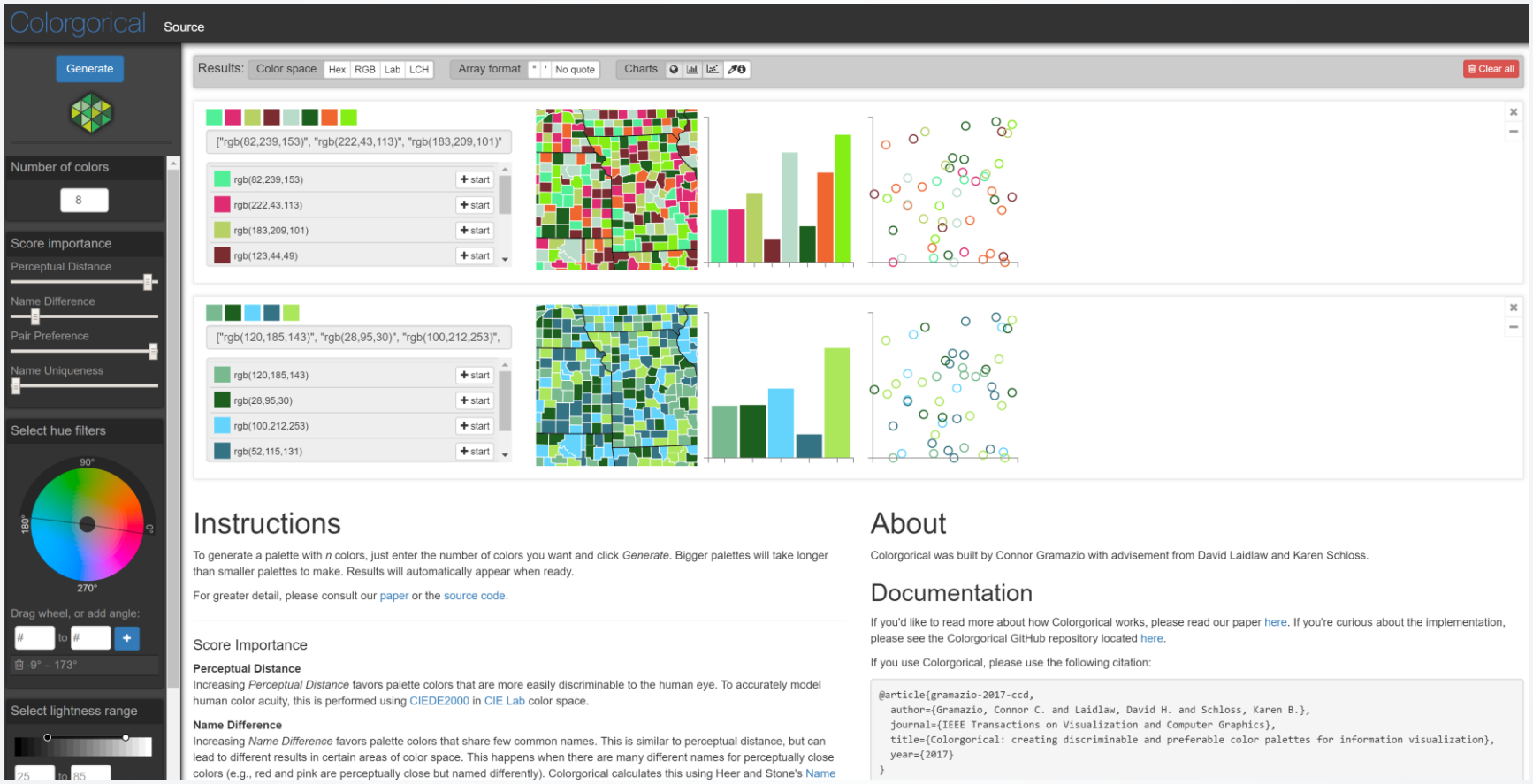
01E748

181544

2B67F5

http://color.farm

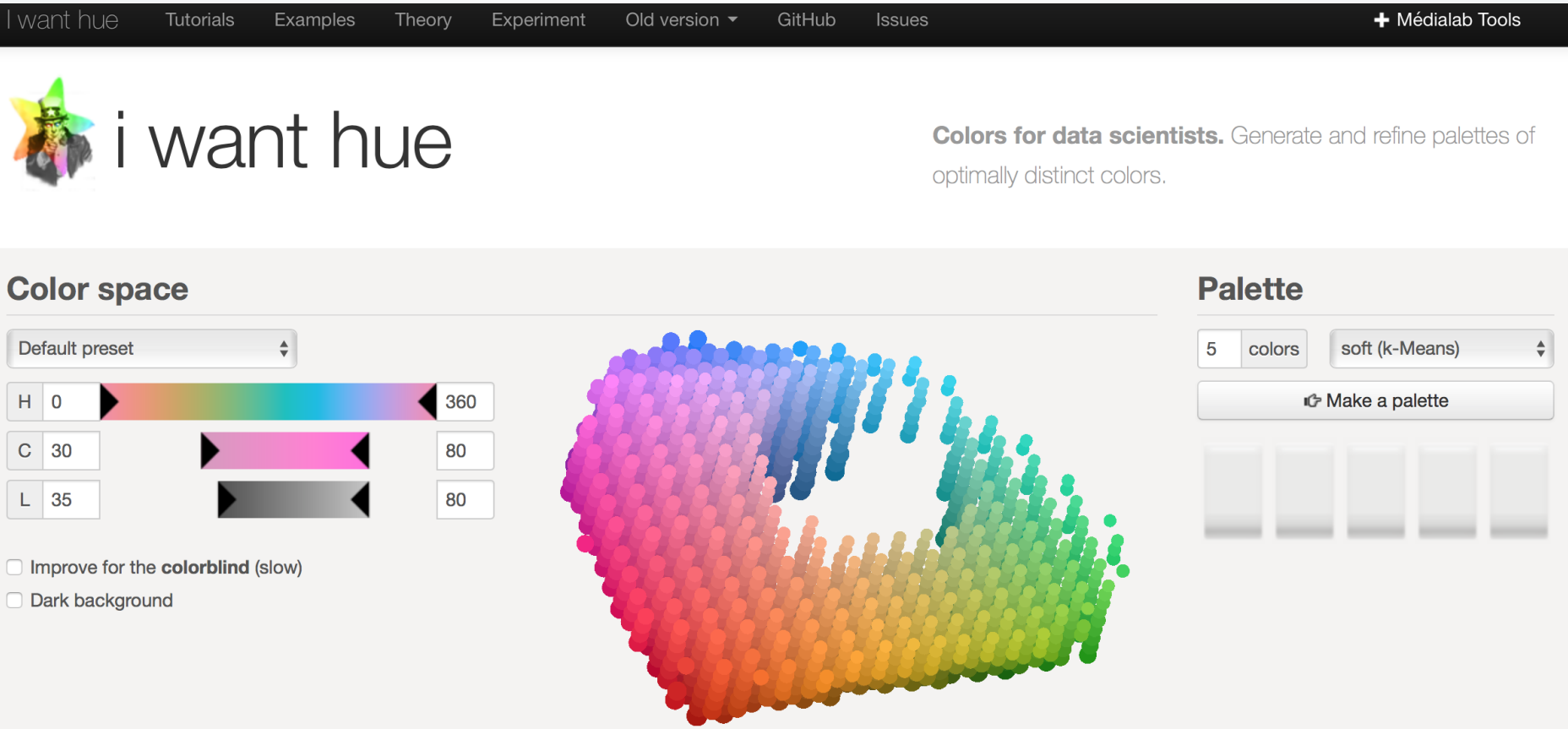
Colorgorical



http://vrl.cs.brown.edu/color

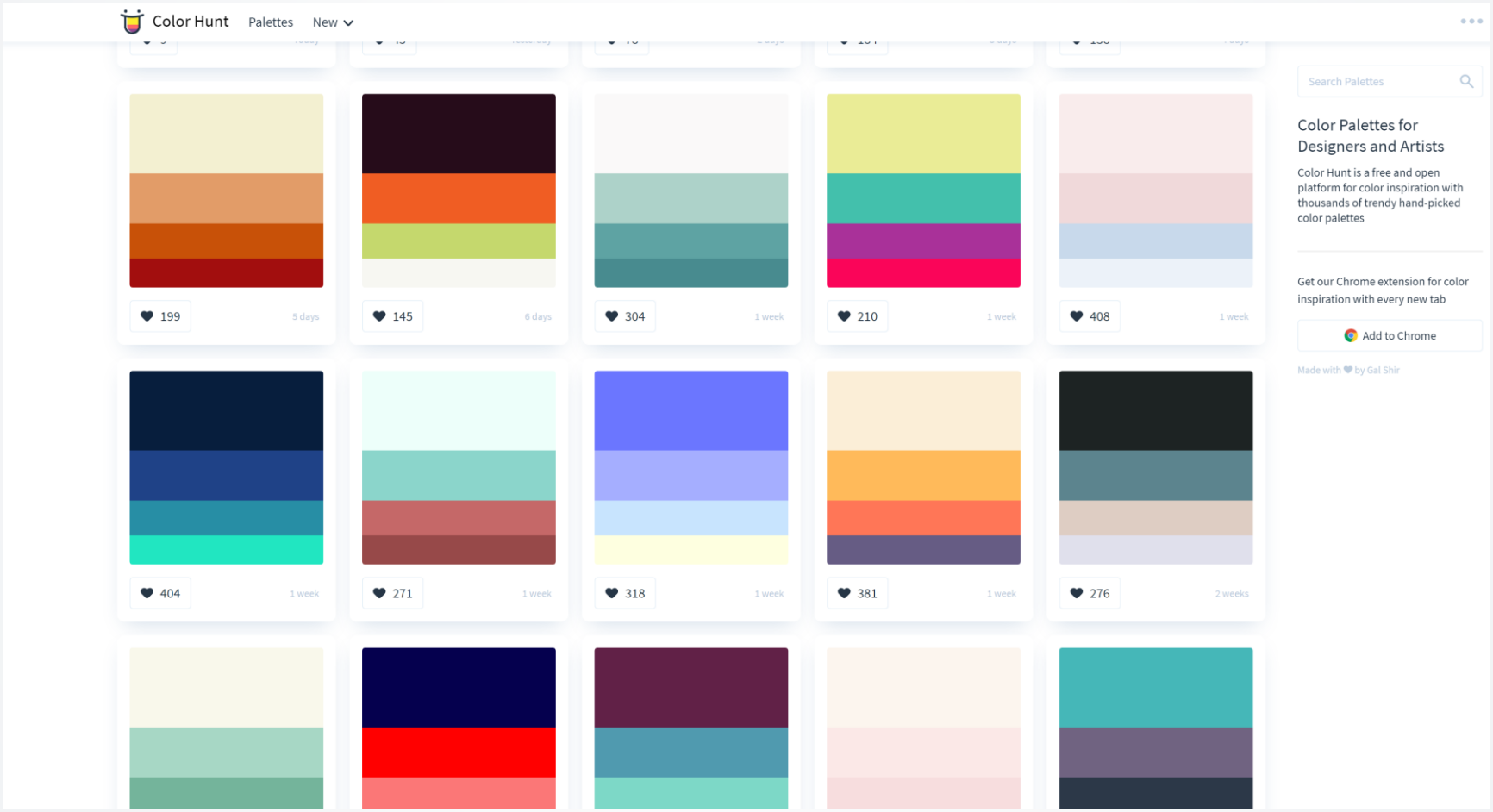
Gramazio C C et al., Creating discriminable and preferable color palettes for information visualization[J]. IEEE transactions on Visualization and Computer Graphics, 2017, 23(1): 521-530.

I want hue



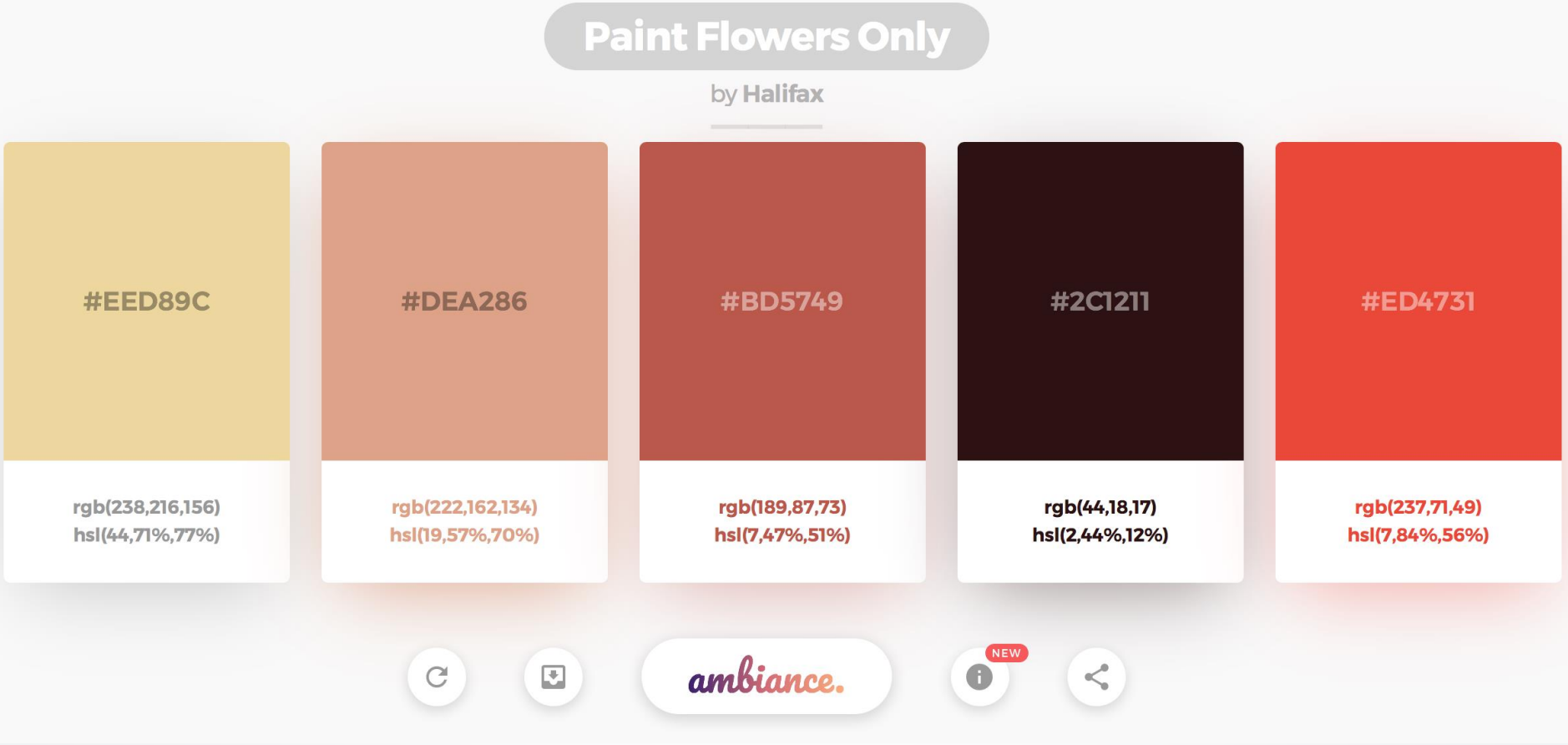
http://tools.medialab.sciences-po.fr/iwanthue/

Color Hunt



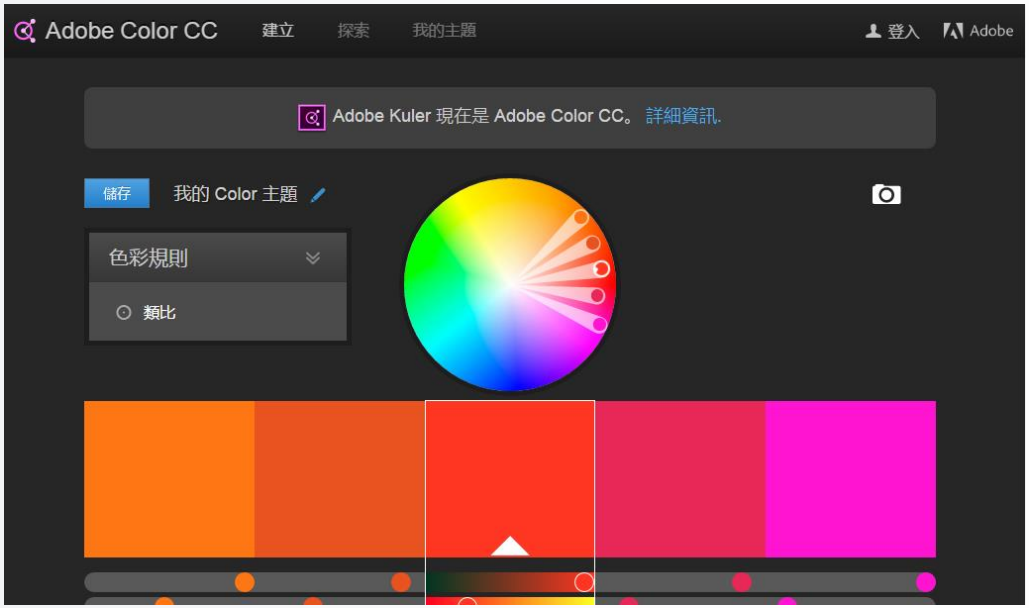
https://colorhunt.co/

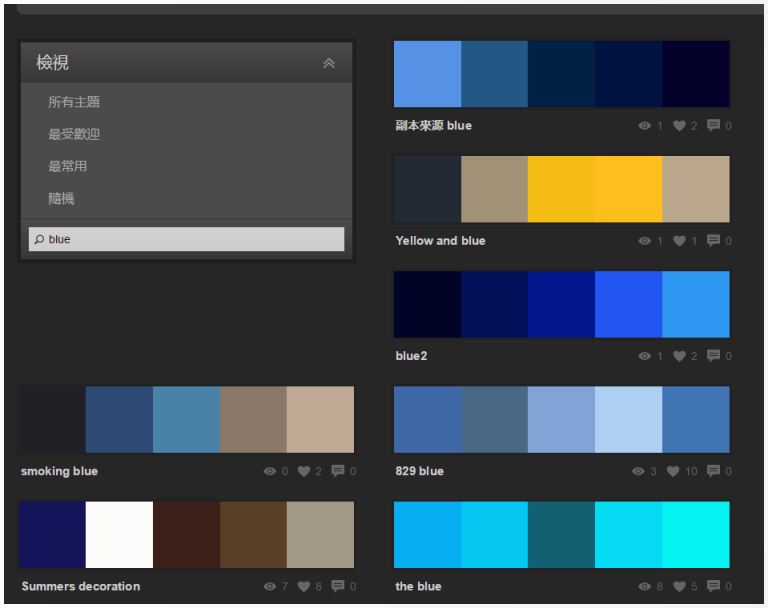
Ambiance



http://ambiance.somethingjustlikethis.com

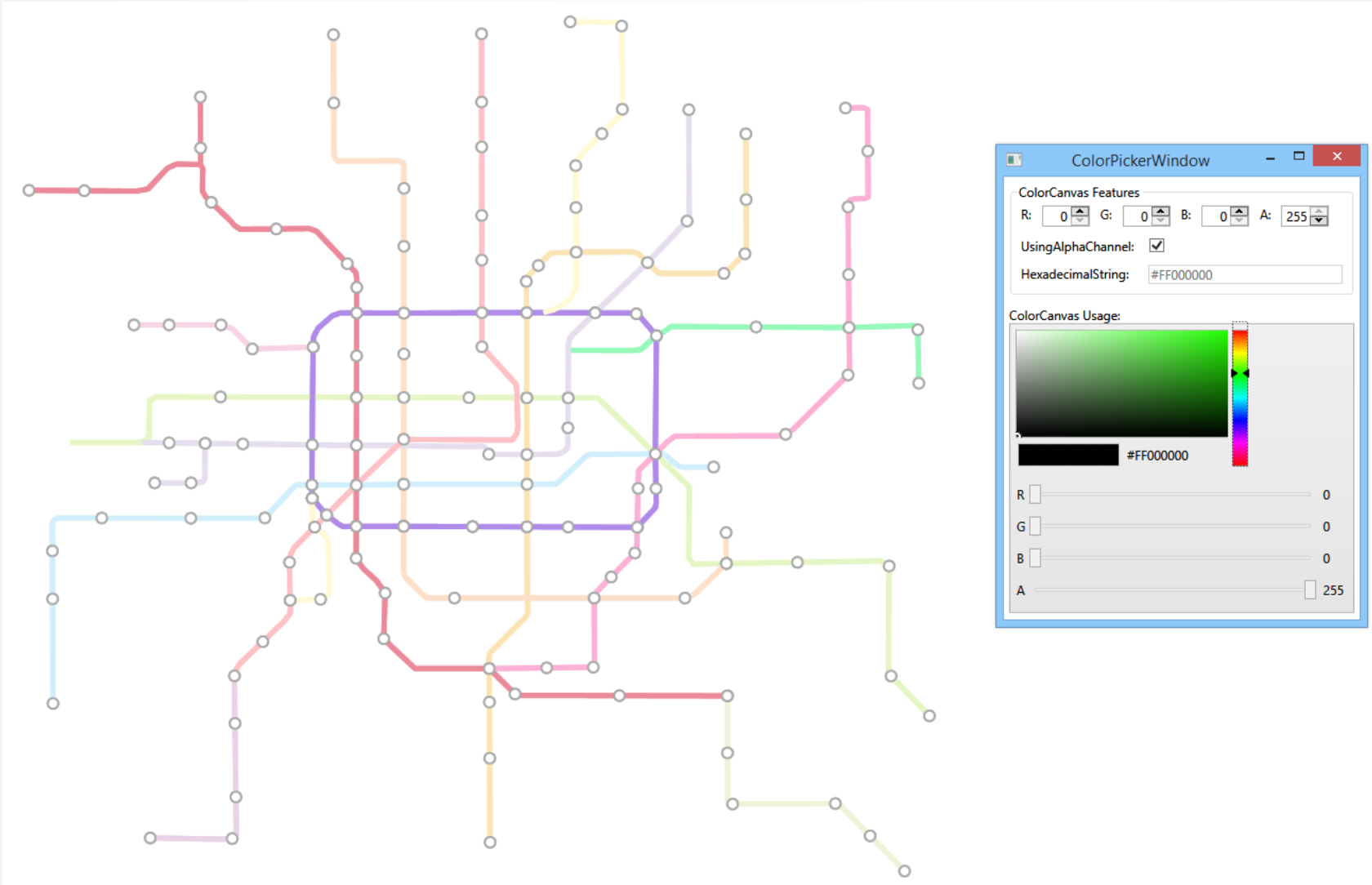
Color Wheel





https://color.adobe.com/zh/create/color-wheel

Build Tools Ourselves ☺



Classic and Going topic

InfoVis: Perception & Cognition 2
Session Chair: Karen Schloss

Mitigating the Attraction Effect with Visualizations (J)
Authors: Evanthia Dimara, Gilles Bailly, Anastasia Bezerianos, Stever
Video Preview

Face to Face: Evaluating Visual Comparison (J)
Authors: Brian David Ondov, Nicole Jardine, Niklas Elmqvist, Steven
Video Preview

Task-Based Effectiveness of Basic Visualizations (T)
Authors: Bahador Saket, Alex Endert, Çagatay Demiralp
Video Preview

At a Glance: Approximate Entropy as a Measure of Line Chart Visualization Complexity (J)
Authors: Eugene Wu, Remco Chang, Abigail Mosca, Gabriel Ryan
Video Preview

Correlation Judgment and Visualization Features: A Comparat (T)
Authors: Fumeng Yang, Lane Harrison, Ronald A. Rensink, Steven Fr
Remco Chang
Video Preview

InfoVis: Perception & Cognition 1
Session Chair: Danielle Szafir

Mapping Color to Meaning in Colormap Data Visualizations (J)
Authors: Karen B. Schloss, Connor C. Gramazio, Allison T. Silverman, Madeline L. Parker, Audrey S. Wang
Video Preview

Optimizing Color Assignment for Perception of Class Separability in Multiclass Scatterplots (J)
Authors: Yunhai Wang, Xin Chen, Tong Ge, Chen Bao, Michael Sedlmair, Chi-Wing Fu, Oliver Deussen, Baoquan Chen
Video Preview

Looks Good To Me: Visualizations As Sanity Checks (J)
Authors: Michael Correll, Mingwei Li, Gordon L Kindlmann, Carlos Scheidegger
Video Preview

Is There a Robust Technique for Selecting Aspect Ratios in Line Charts? (T)
Authors: Yunhai Wang, Zeyu Wang, Lifeng Zhu, Jian Zhang, Chi-Wing Fu, Changhe Tu, Baoquan Chen, Zhanglin Cheng
Video Preview

Image-based Aspect Ratio Selection (J)
Authors: Yunhai Wang, Zeyu Wang, Chi-Wing Fu, Hansjörg Schmauder, Oliver Deussen, Daniel Weiskopf
Video Preview

http://ieeevis.org/year/2018/info/papers-sessions

Classic and Going topic

SP #1: Design and evaluation (Room Porto)

Chair: Alexander Lex

= Label Placement for Outliers in Scatterplots

Haris Mumtaz, Mereke van Garderen, Fabian Beck, Daniel Weiskopf

= The Impact of Distribution and Chart Type on Part-to-Whole Comparisons

Robert Kosara

= Circular Part-to-Whole Charts Using the Area Visual Cue

Robert Kosara

= The Human User in Progressive Visual Analytics

Luana Micallef, Hans-Jörg Schulz, Marco Angelini, Michaël Aupetit, Remco Chang, Jörn Kohlhammer, Adam Perer

= Visualizing Transportation Flows with Mode Split using Glyphs

Ignacio Pérez-Messina, Eduardo Graells-Garrido

= Color Names Across Languages: Salient Colors and Term Translation in Multilingual Color Naming Models

Younghoon Kim, Kyle Thayer, Gabriella Gorsky, Jeffrey Heer

https://www.eurovis.org/program/

Thanks