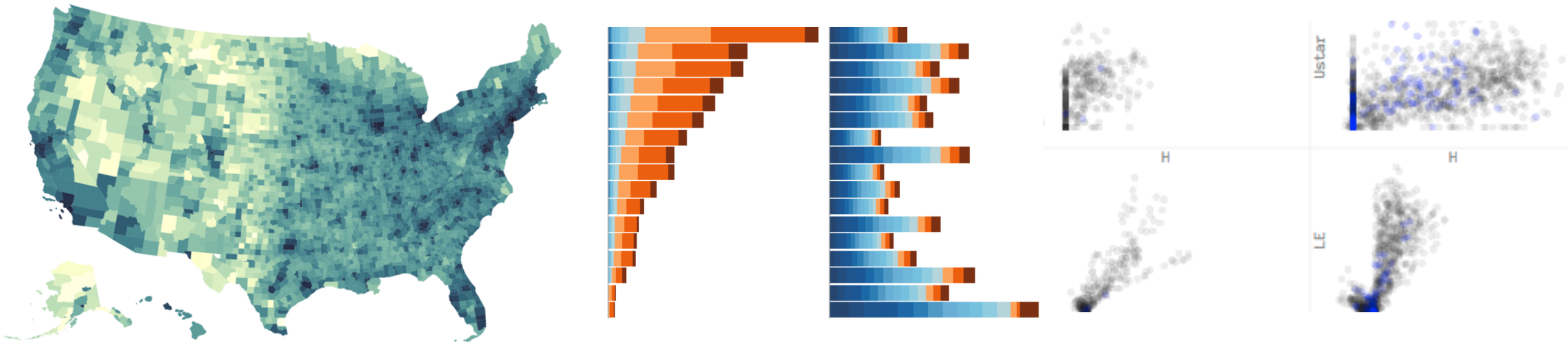


CS526

Computer Graphics II

Week 2: Intro to Visual Perception &Cognition

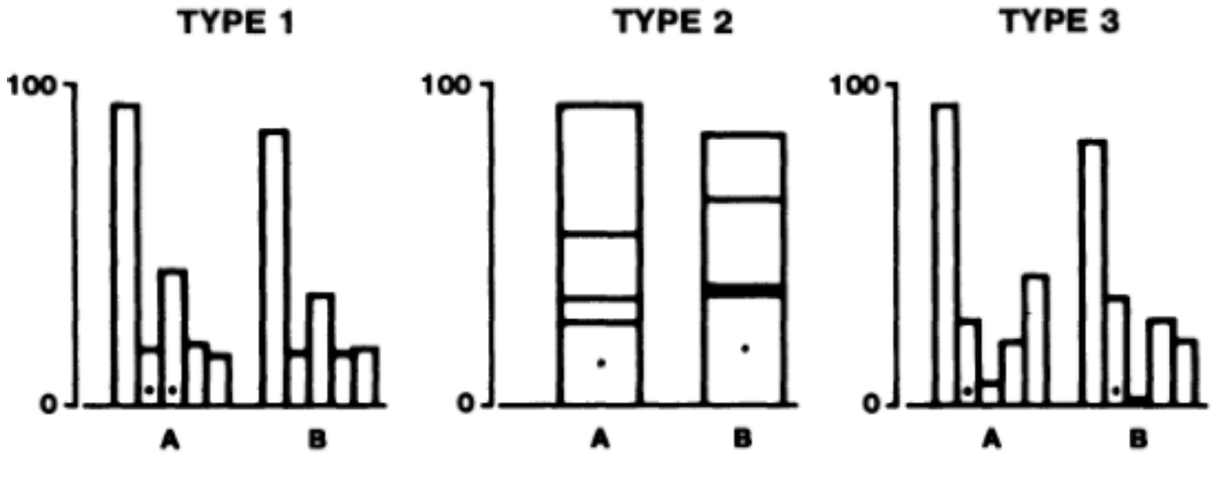
Khairi Reda | redak@uic.edu
UIC CS

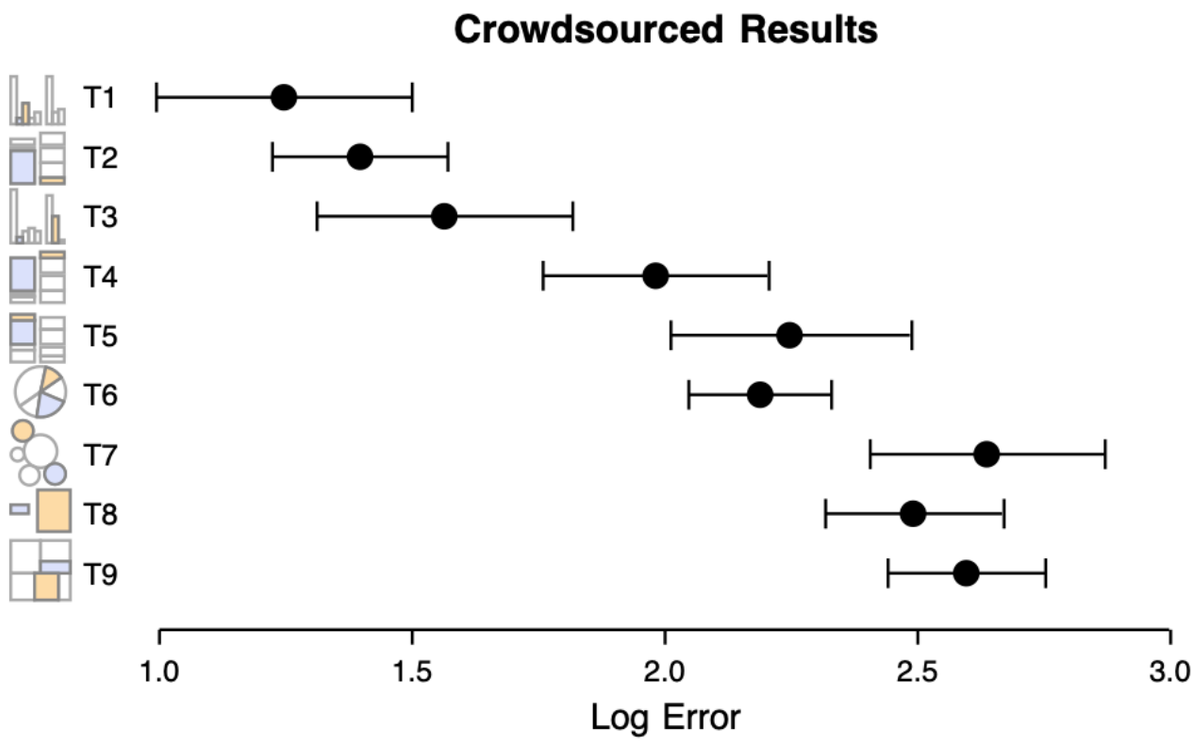
Administrativia...

Sign up for paper slots

- By end of the week
- **Note:** may need to shift paper schedule around a bit

Project 1 out today

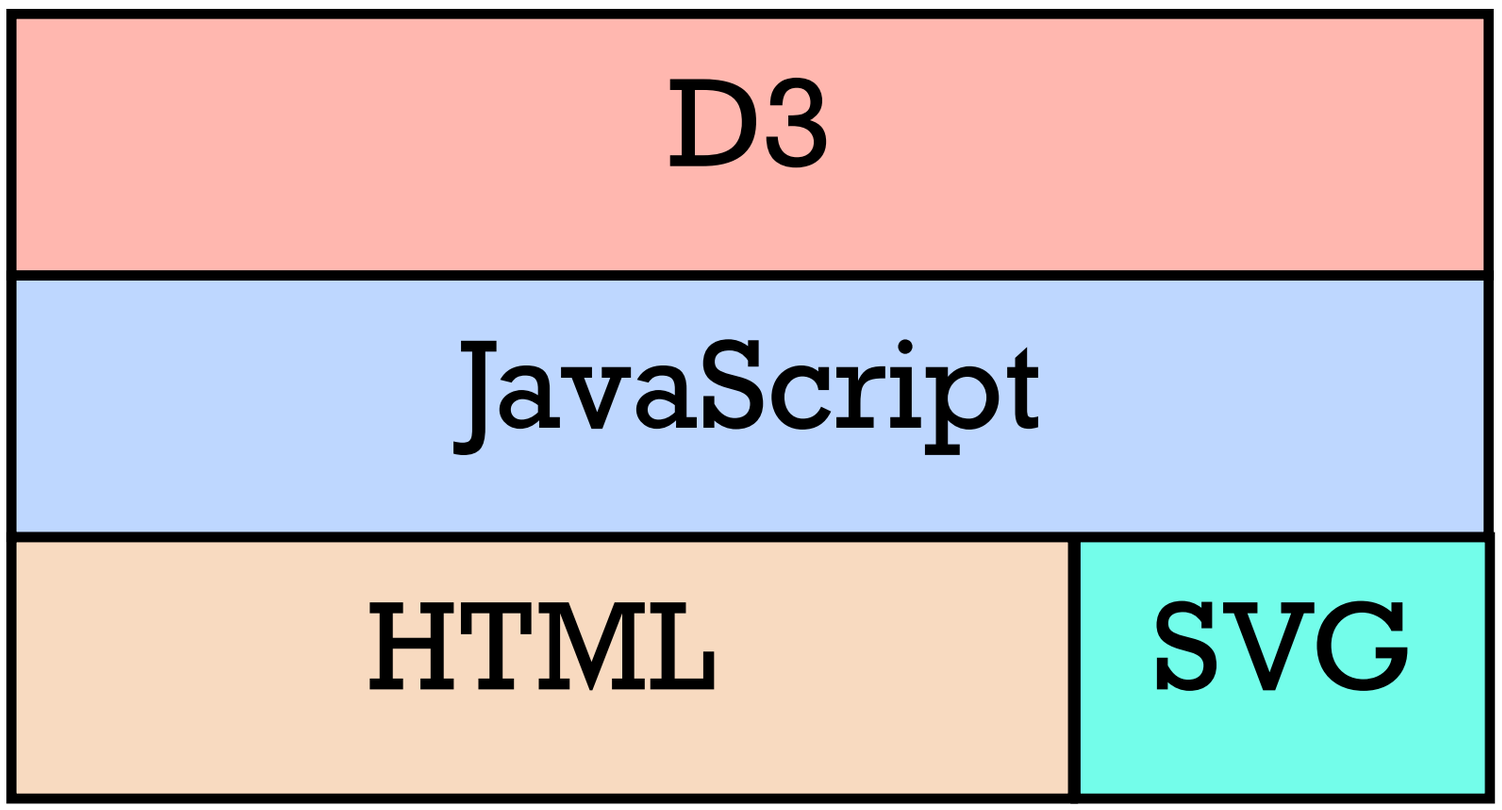




- Design and conduct a user study to evaluate visualizations
- Create a user interface / experiment platform in D3
- Analyze and report data
- Replicate existing results (Cleveland & McGill, Heer &Bostock), and extend to new visualizations

Last week...

The D3 stack



Hypertext markup language

Scalable
Vector graphics

This week

Fundamentals of Visual Perception and Cognition

Perception vs. Cognition

Perception

Identification and interpretation of physical sensory input

Cognition

The processing of information and applying knowledge

Recording and retrieving information from memory

Perception: Hearing someone speak

Cognition: Understanding words, remembering information

Based on a slide by Alex Lex

Perception vs. Cognition

Perception

- Basic visual features (e.g., edges, orientation, shapes, color)
- Unconscious

Cognition

- Object recognition
- Relationship between objects
- Learning new patterns
- Problem solving
- Deliberate
- Requires **attention**

Based on a slide by Alex Lex

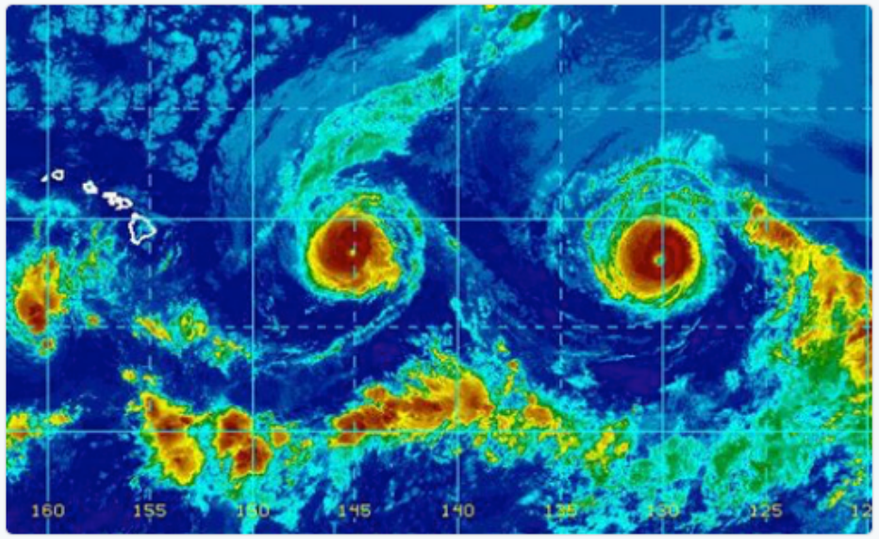
The boundary between perception and cognition is hard to delineate

```
Perception -> cognition
Cognition  -> perception
```

Faces in Things

Faces in Things @FacesPics · Aug 30

The sea was angry that day, my friends



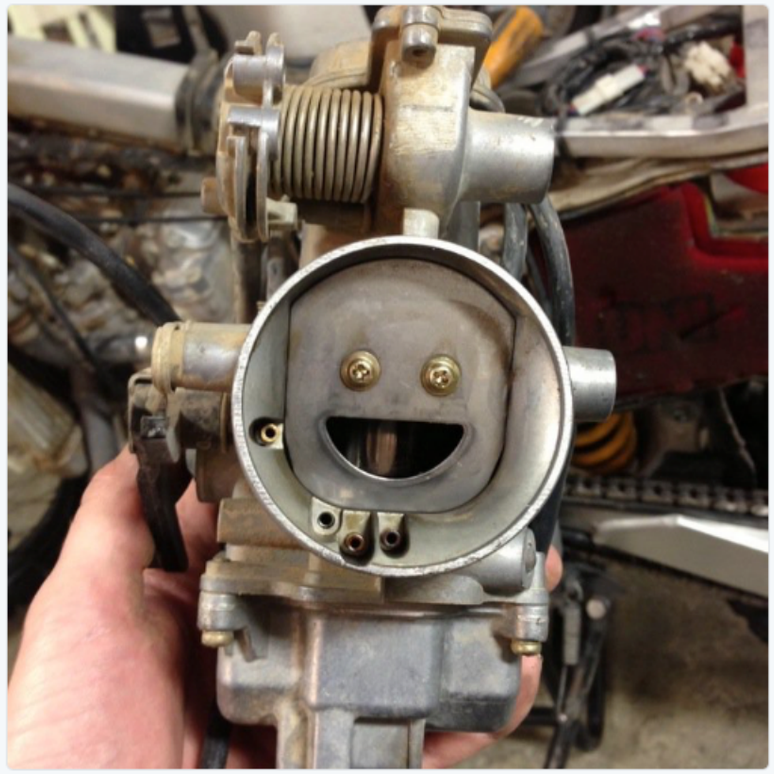
1.2K 2.5K •••

Faces in Things @FacesPics · Jun 25

Jay Leno looks stunned

Faces in Things @FacesPics · Aug 1

A cheery fellow in a garage



573 1.6K •••

Take home point

What we see is influenced by visual features our brain perceive (bottom-up) and by what we believe beforehand (top-down)

The human visual system

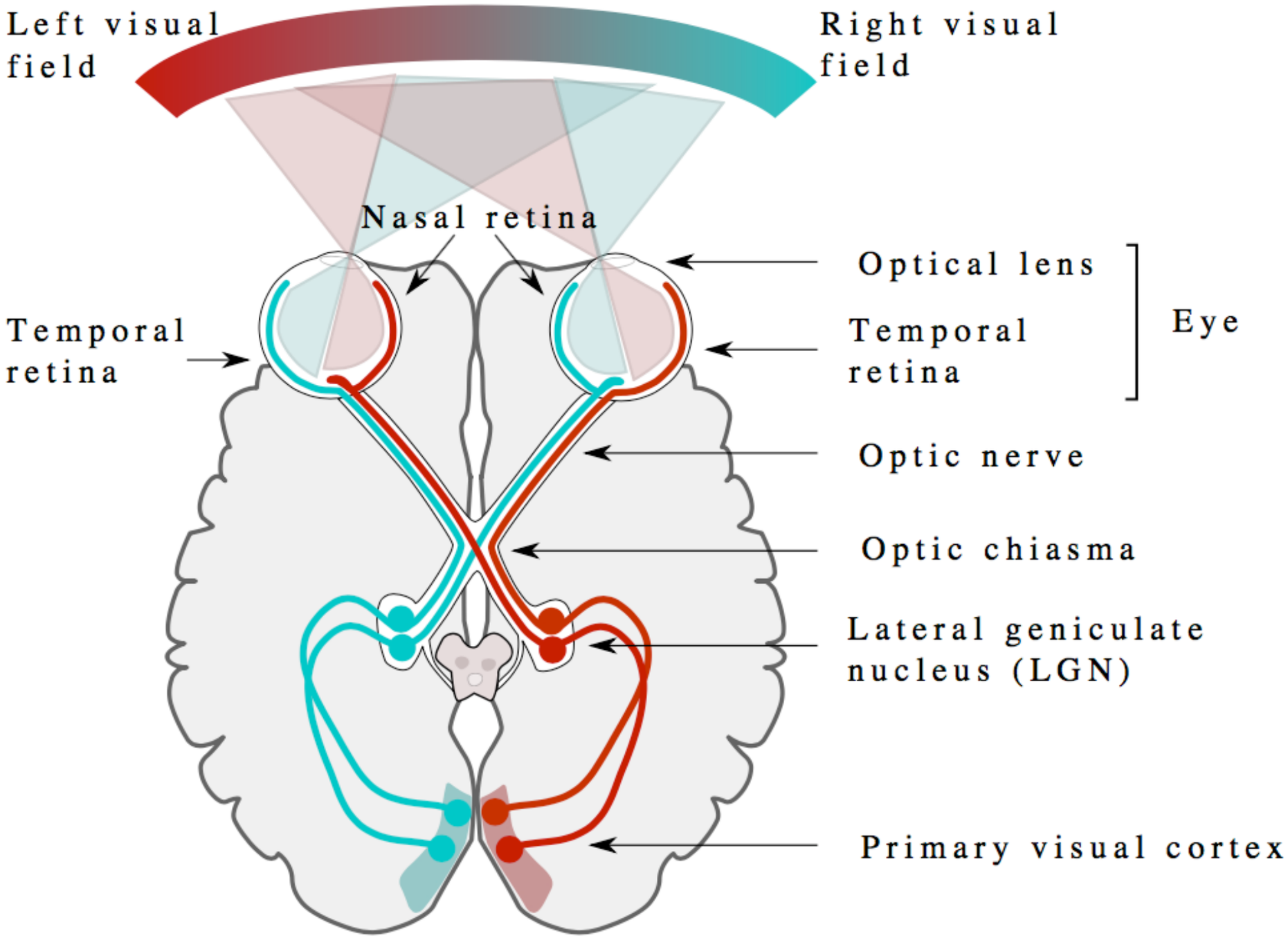
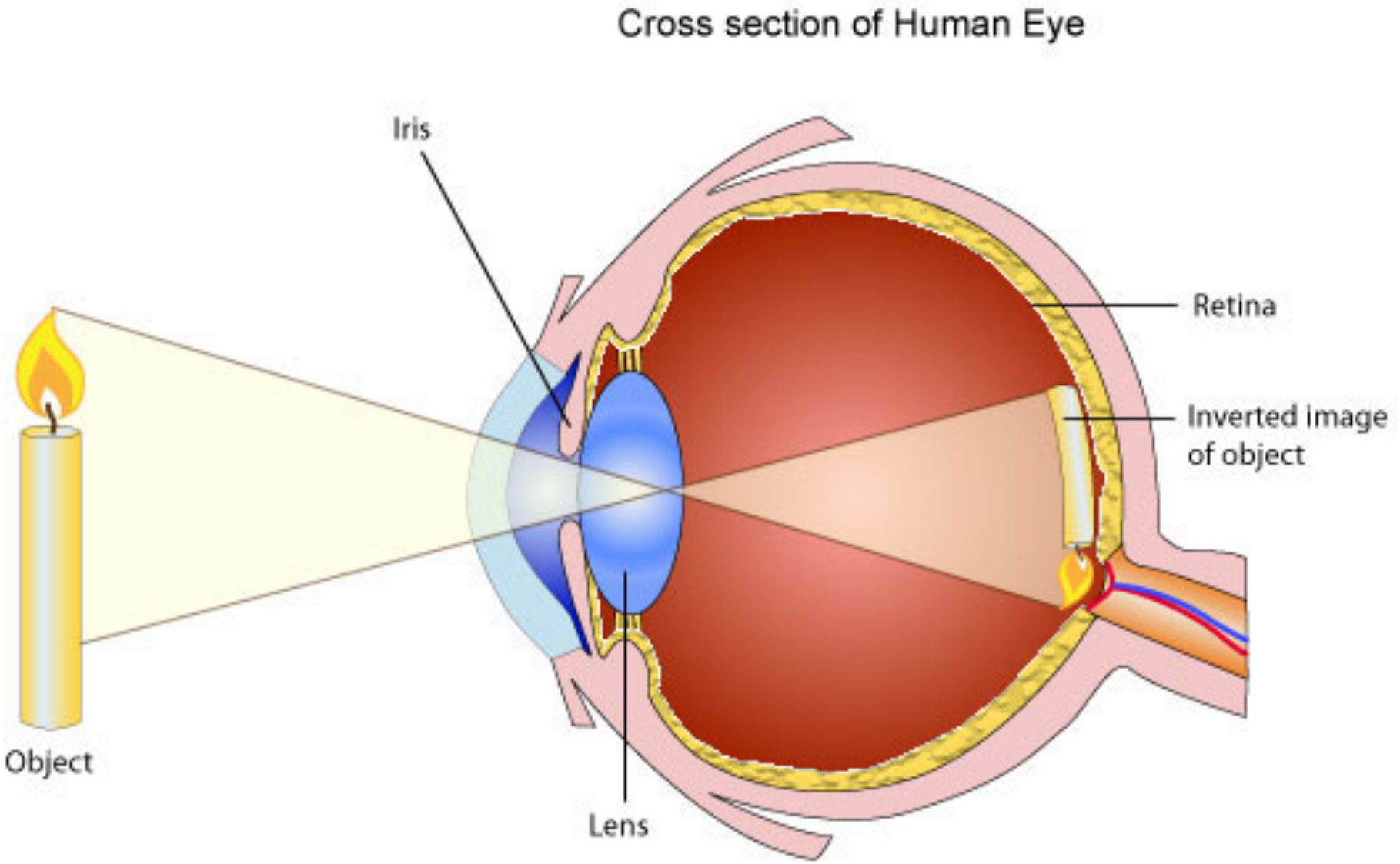


Illustration from Wikipedia

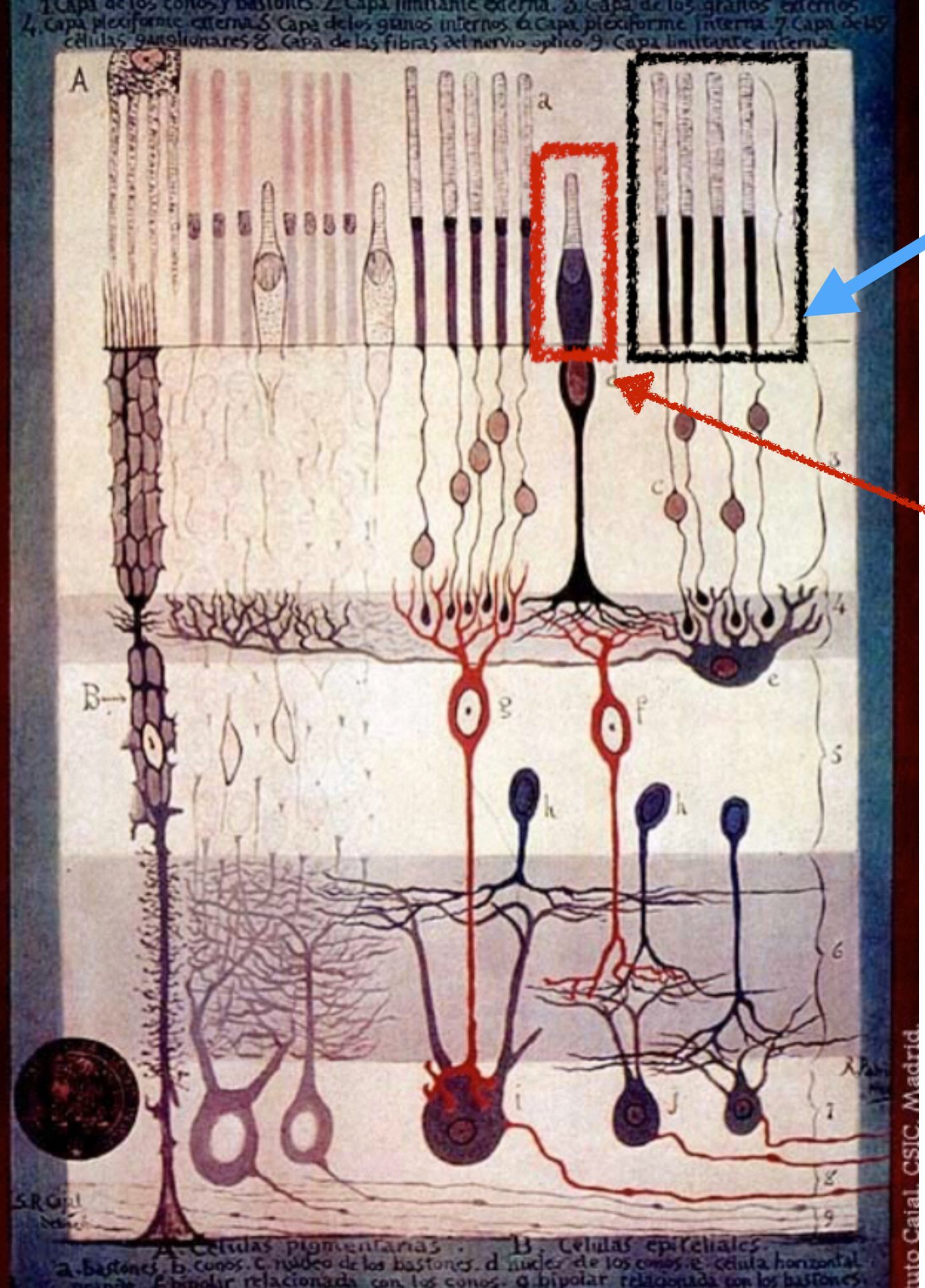
The human eye



light

electricity

http://www.fortworthastro.com/images/eye_xsection_01.jpg



rods ~120 million

highly-sensitive to light

not sensitive to color

good for low-light vision

cones ~5-6 million

sensitive to color

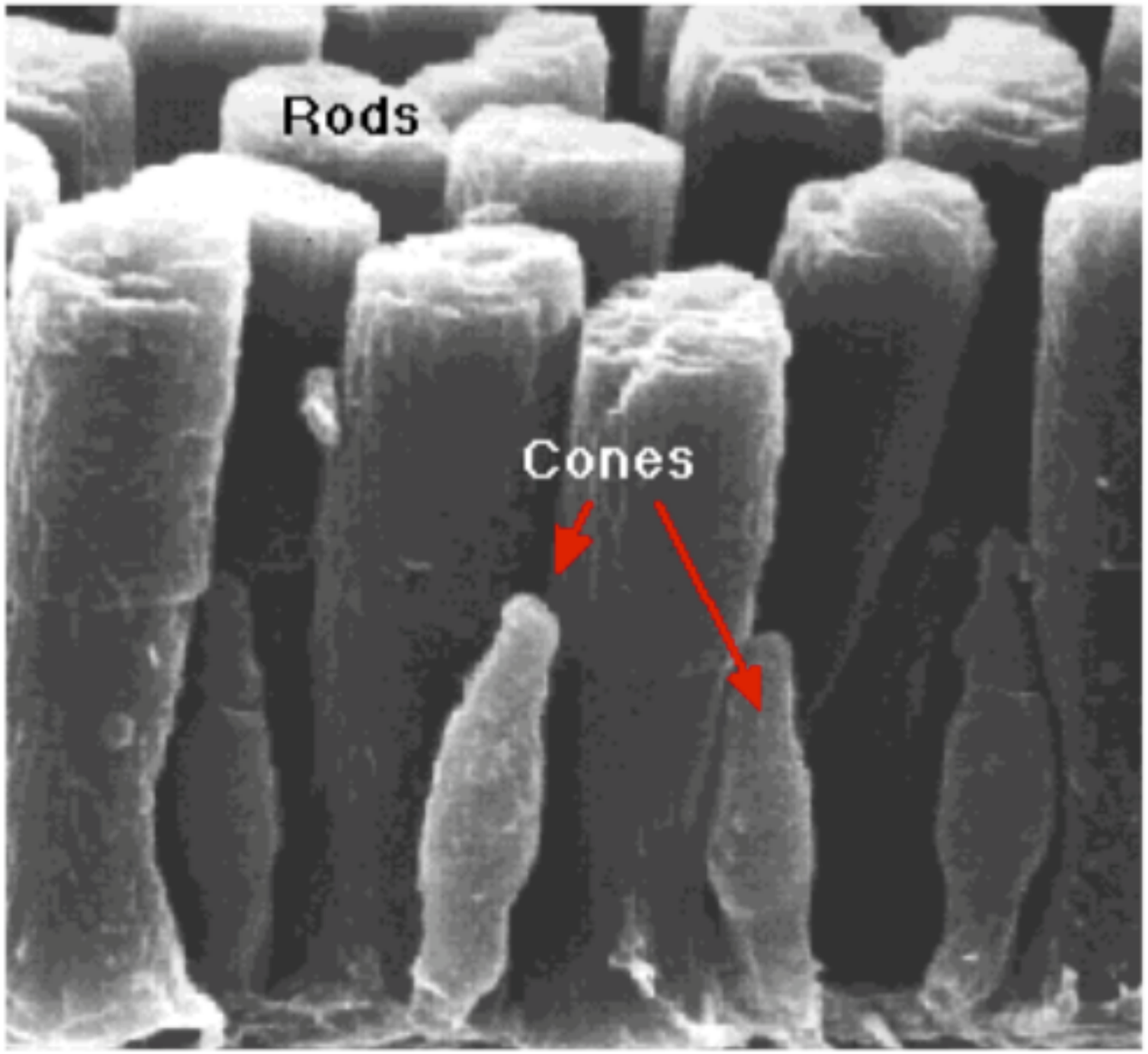
require good lighting

sharp vision

ganglion cells

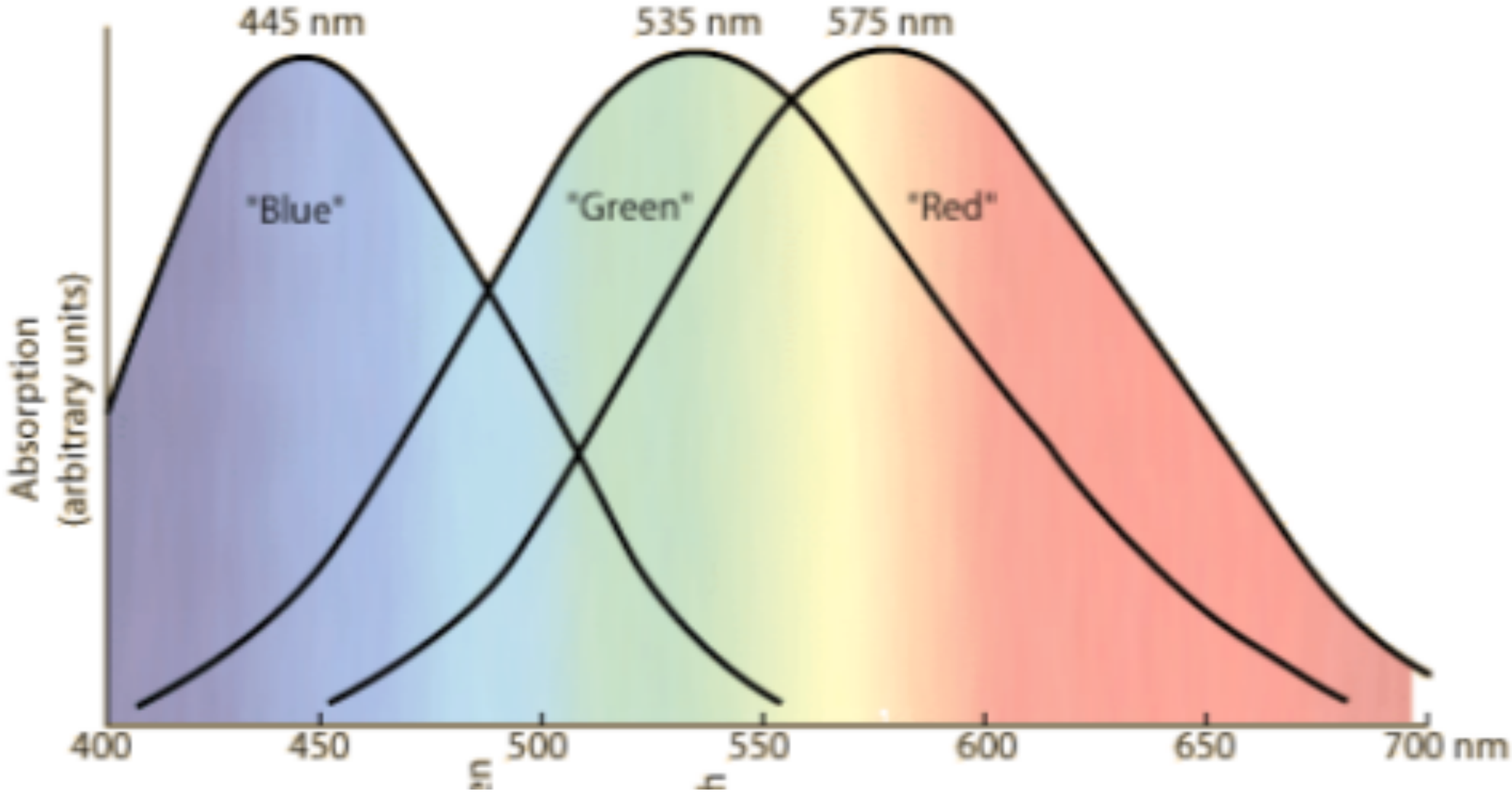
"Structure of the Mammalian Retina", Ramon y Cajal
Based on a slide by Alex Lex

Electron microscopy of photoreceptors



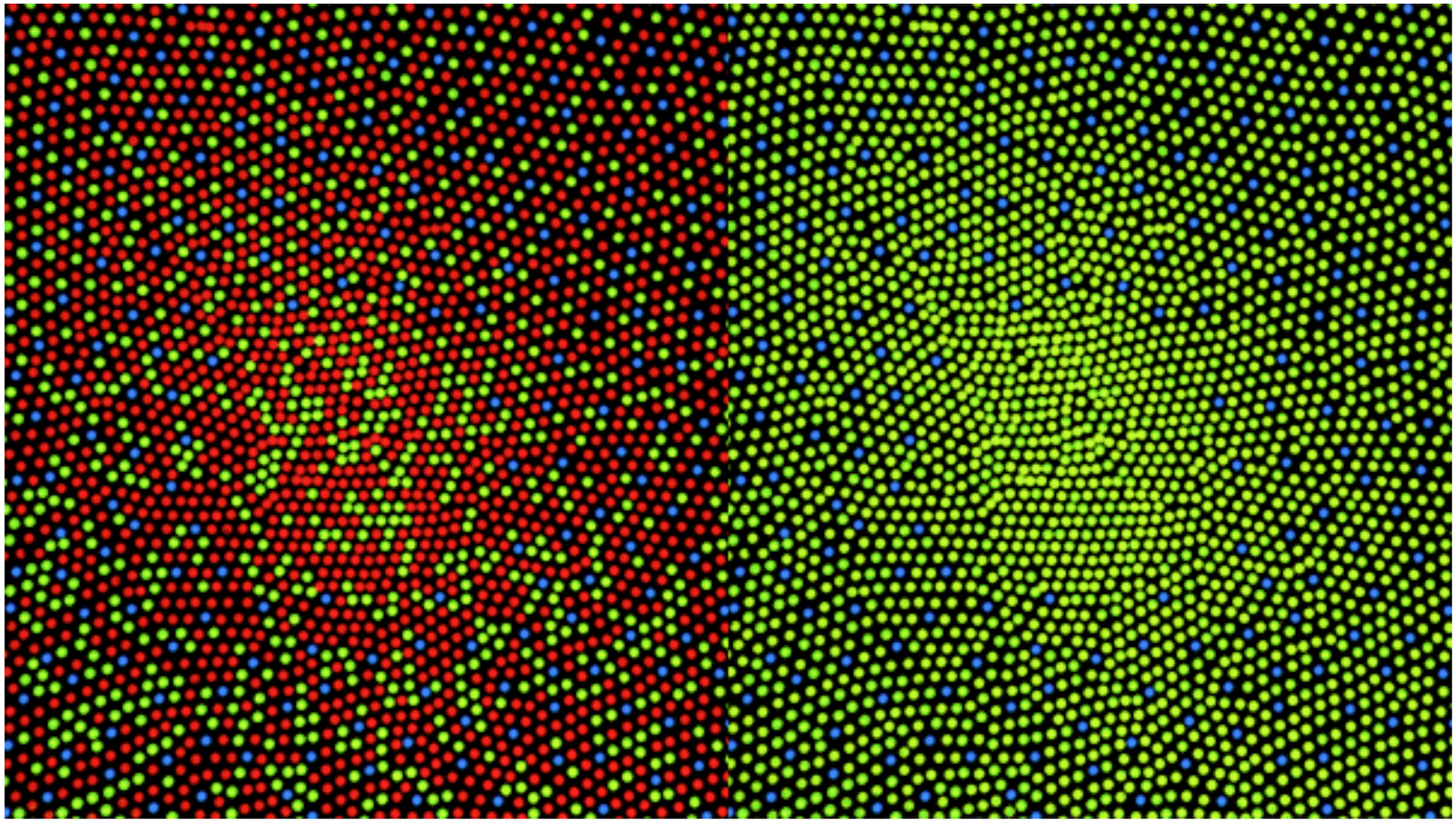
Wandell, “Foundations of Vision”

Cones types



HyperPhysics, Georgia State University

Cone distribution by pigment

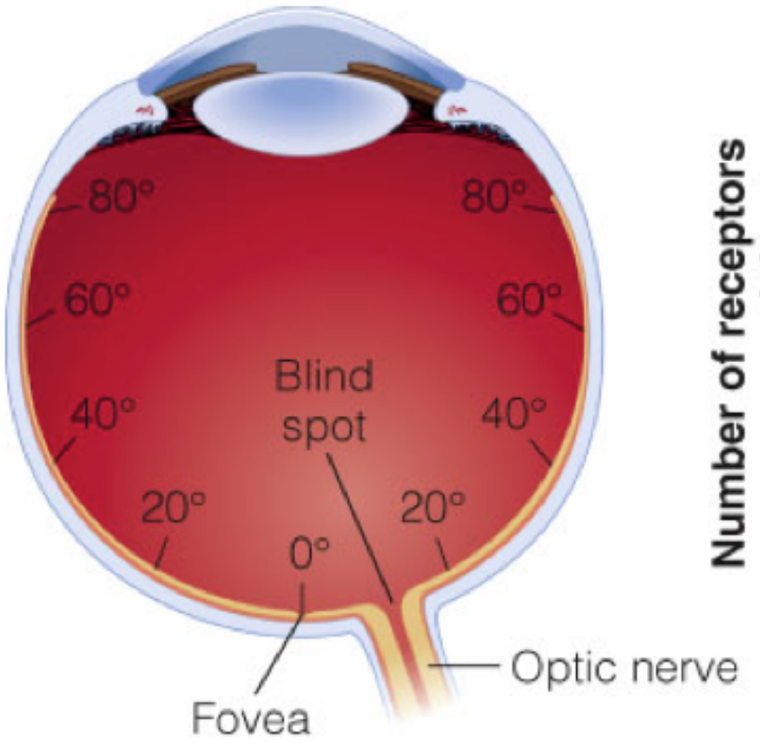


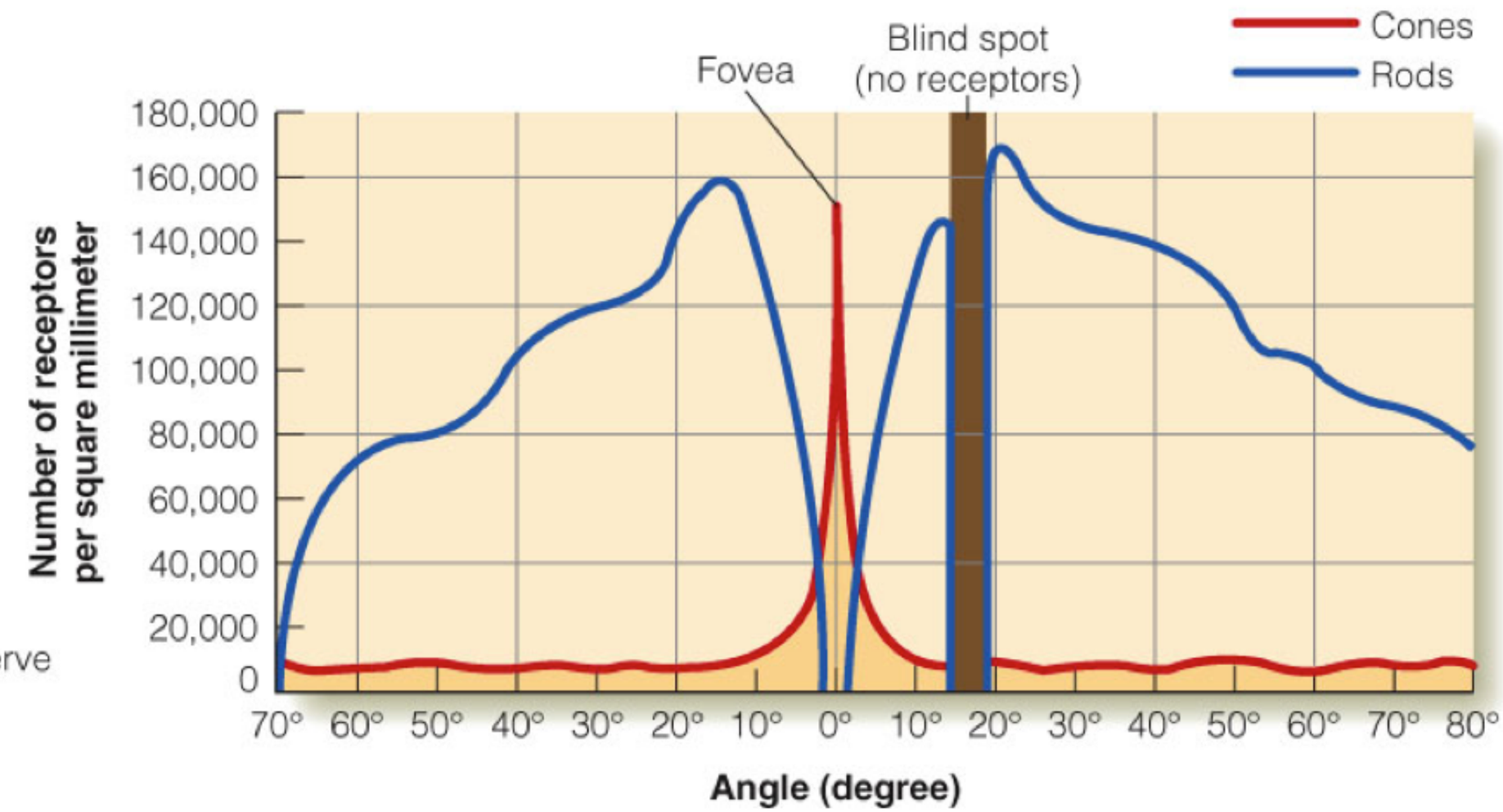
normal vision

color blindness
(red deficiency)

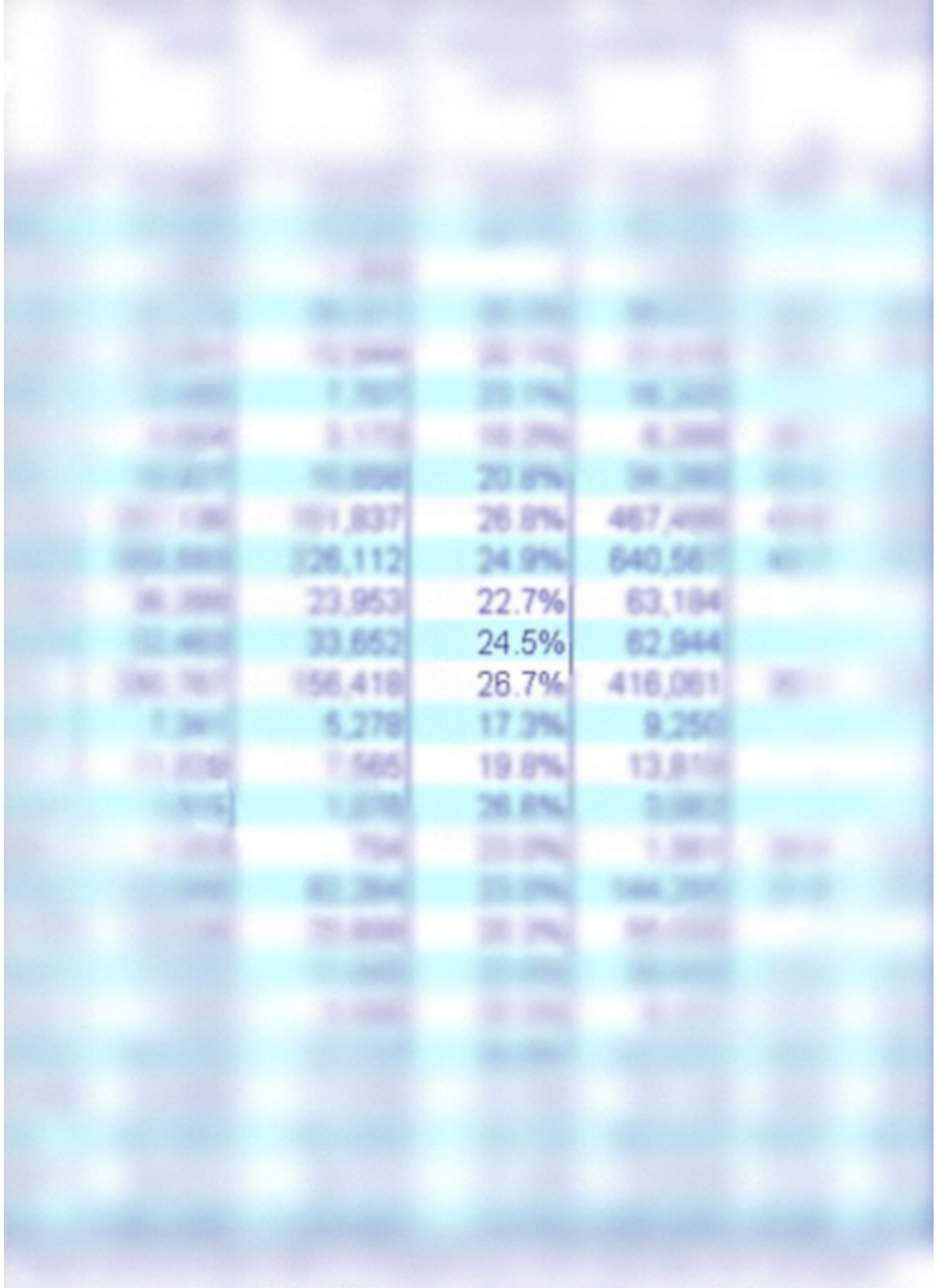
Wikipedia

Density of rods/cones





E. Goldstein, “Sensation and Perception”
Adapted from Lindsay & Norman, 1977
Via Miriah Meyer



C. Ware
Visual Thinking for Design

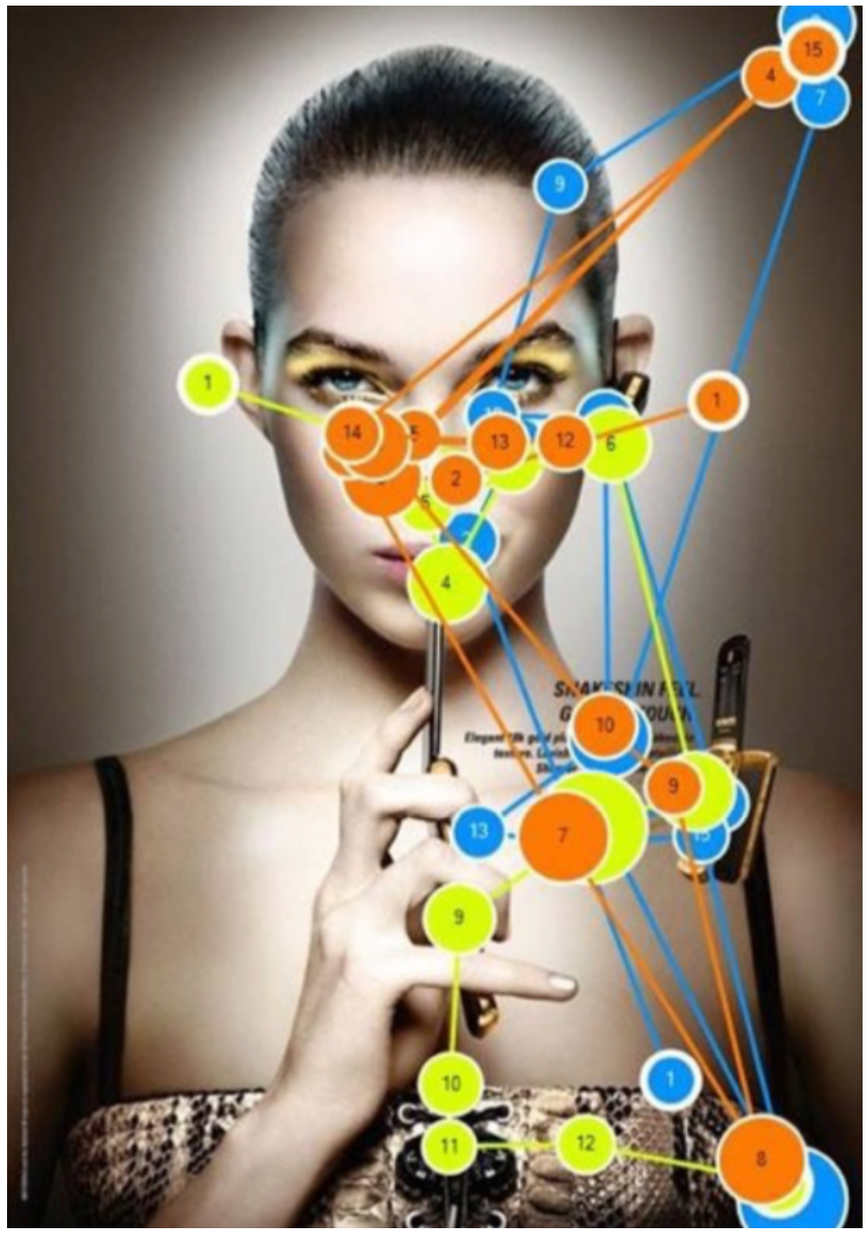
Vision — eye movement

Human vision does not work like a camera

The eye makes a series of **fixations** and **saccades**

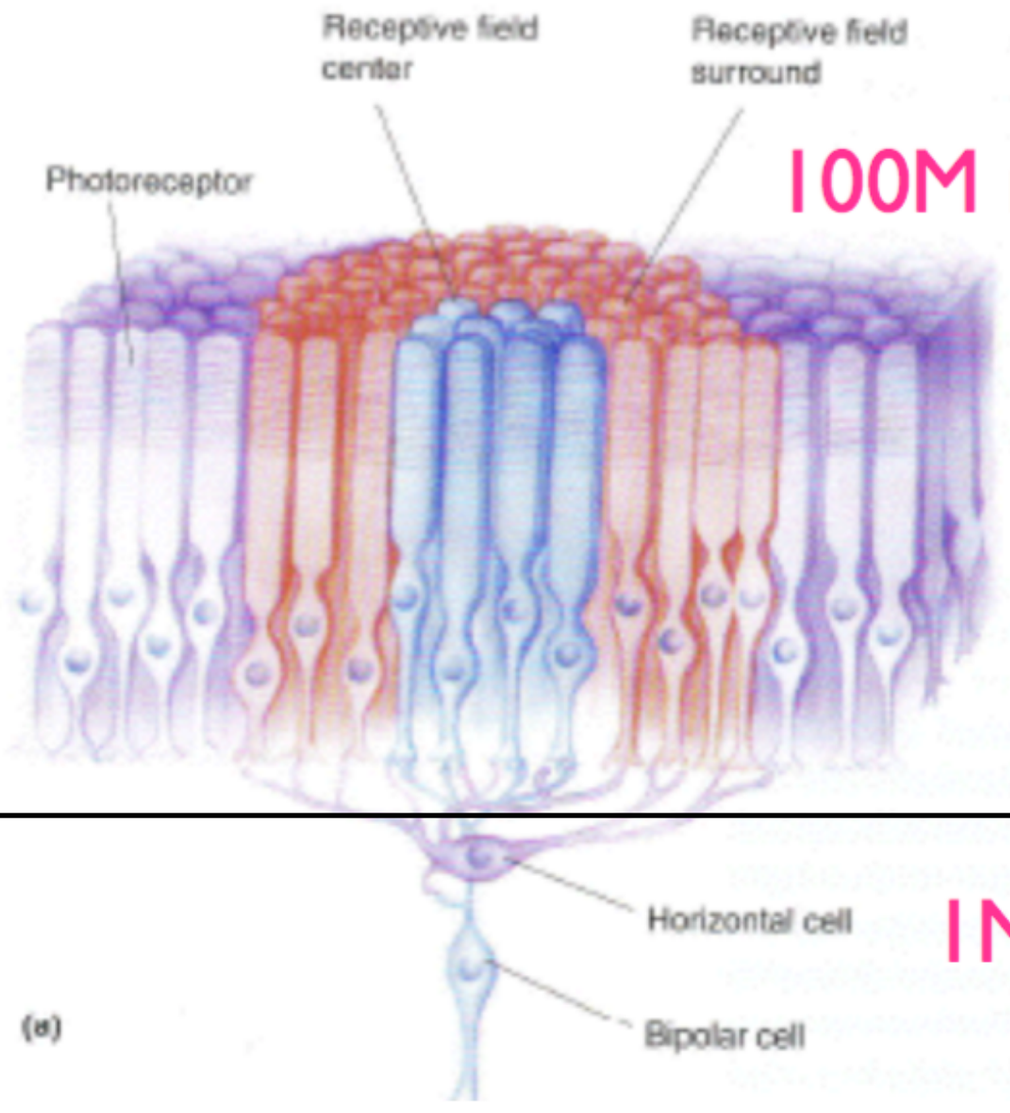
fixation: maintaining gaze over a single location (**200-600ms)**

saccade: movement between locations **20-100ms**



Based on a slide by Alex Lex

Retinal Ganglion Cells

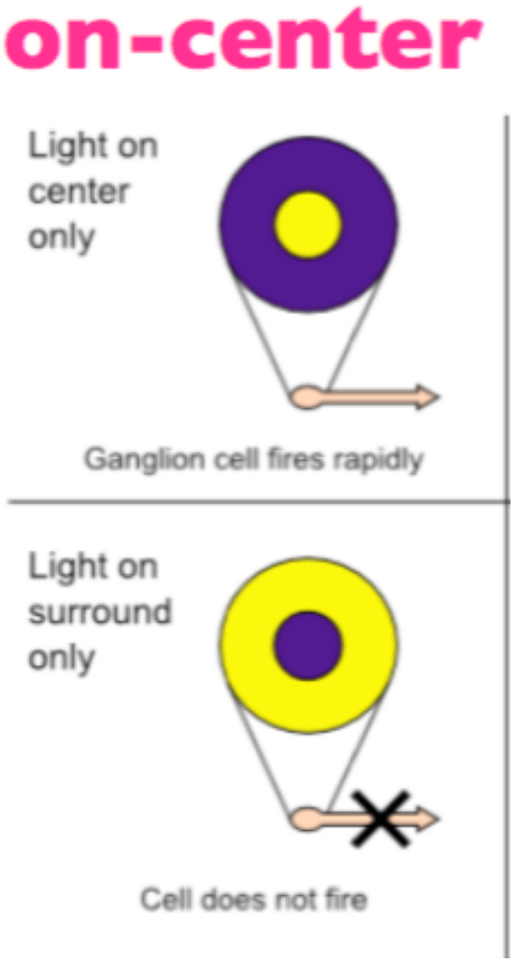


100M rods and cones

1M ganglion cells

Bear, Connors, Paradiso, “Neuroscience”
Via Miriah Meyer

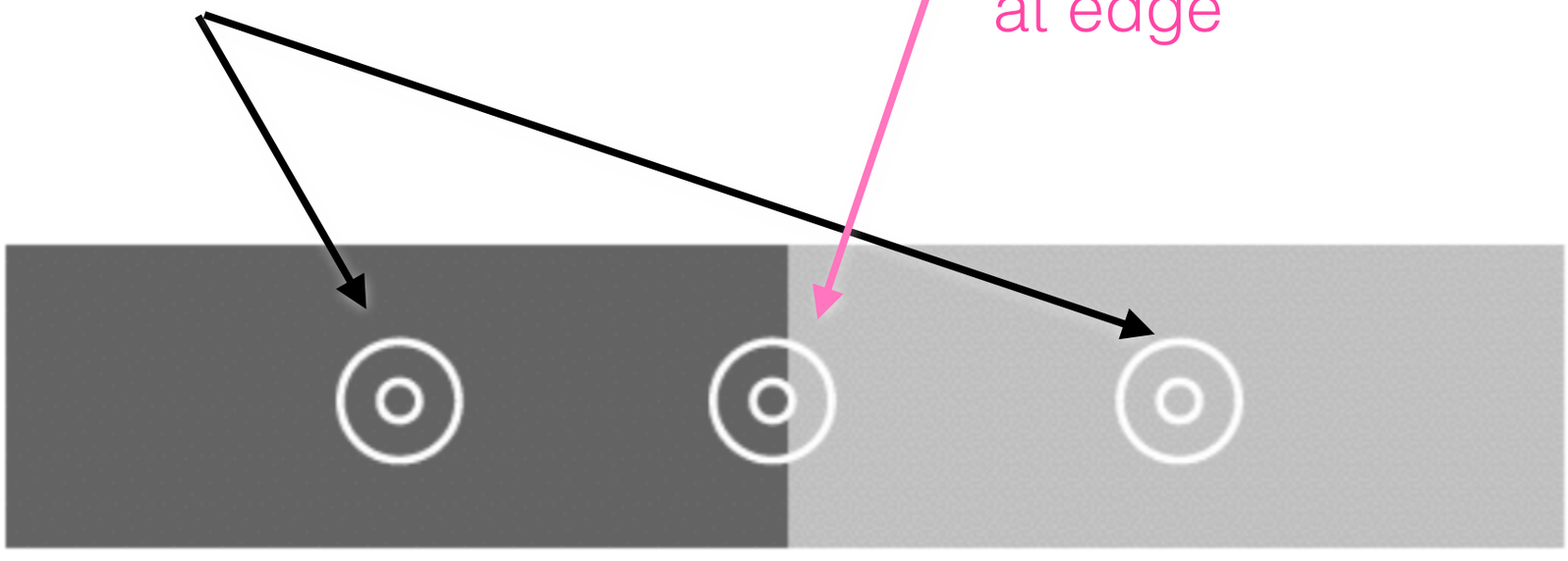
Retinal Ganglion Cells

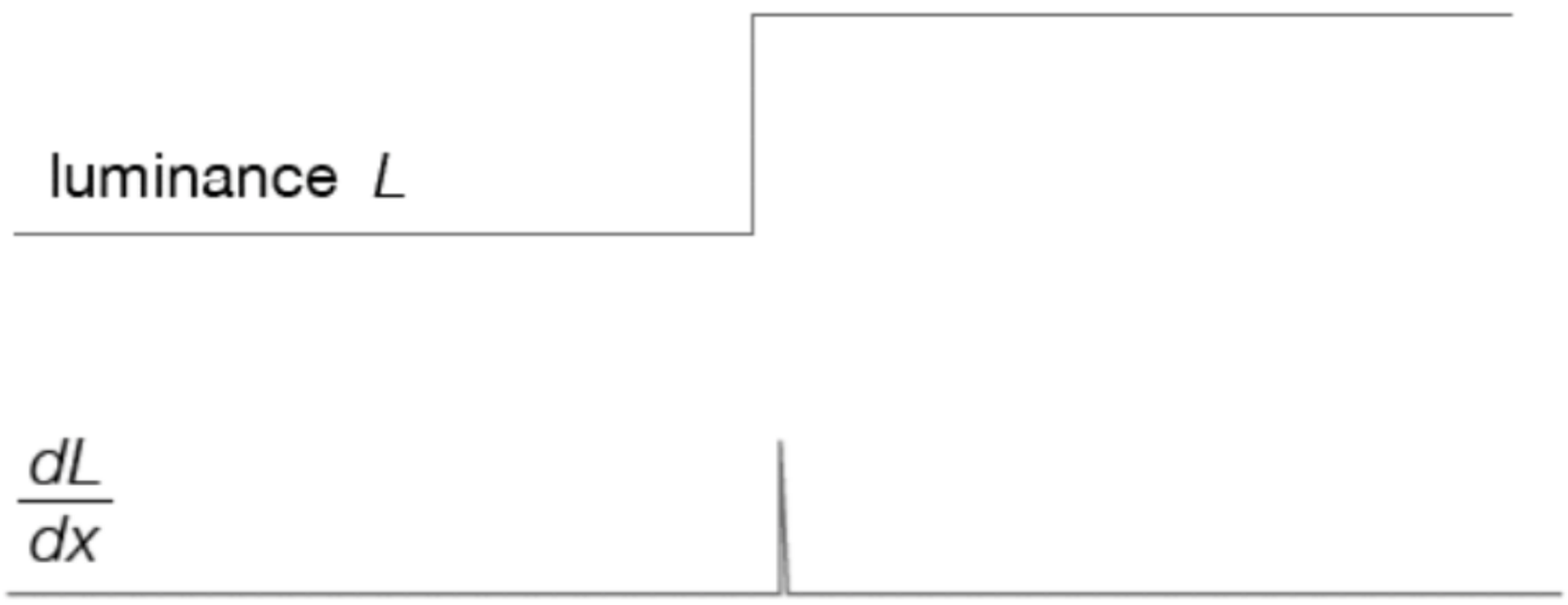


Wikipedia
Via Miriah Meyer

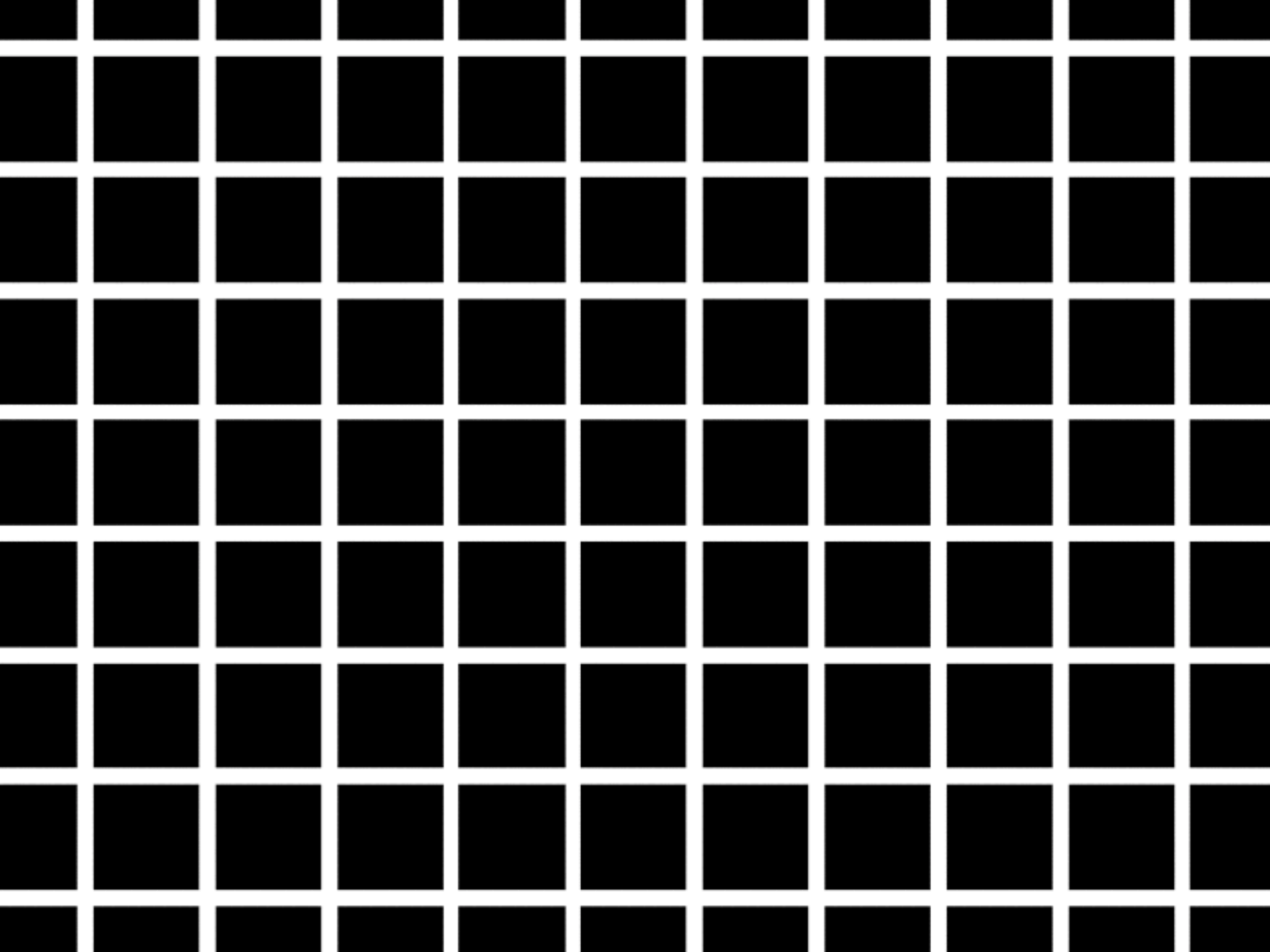
low activity from
center and surround

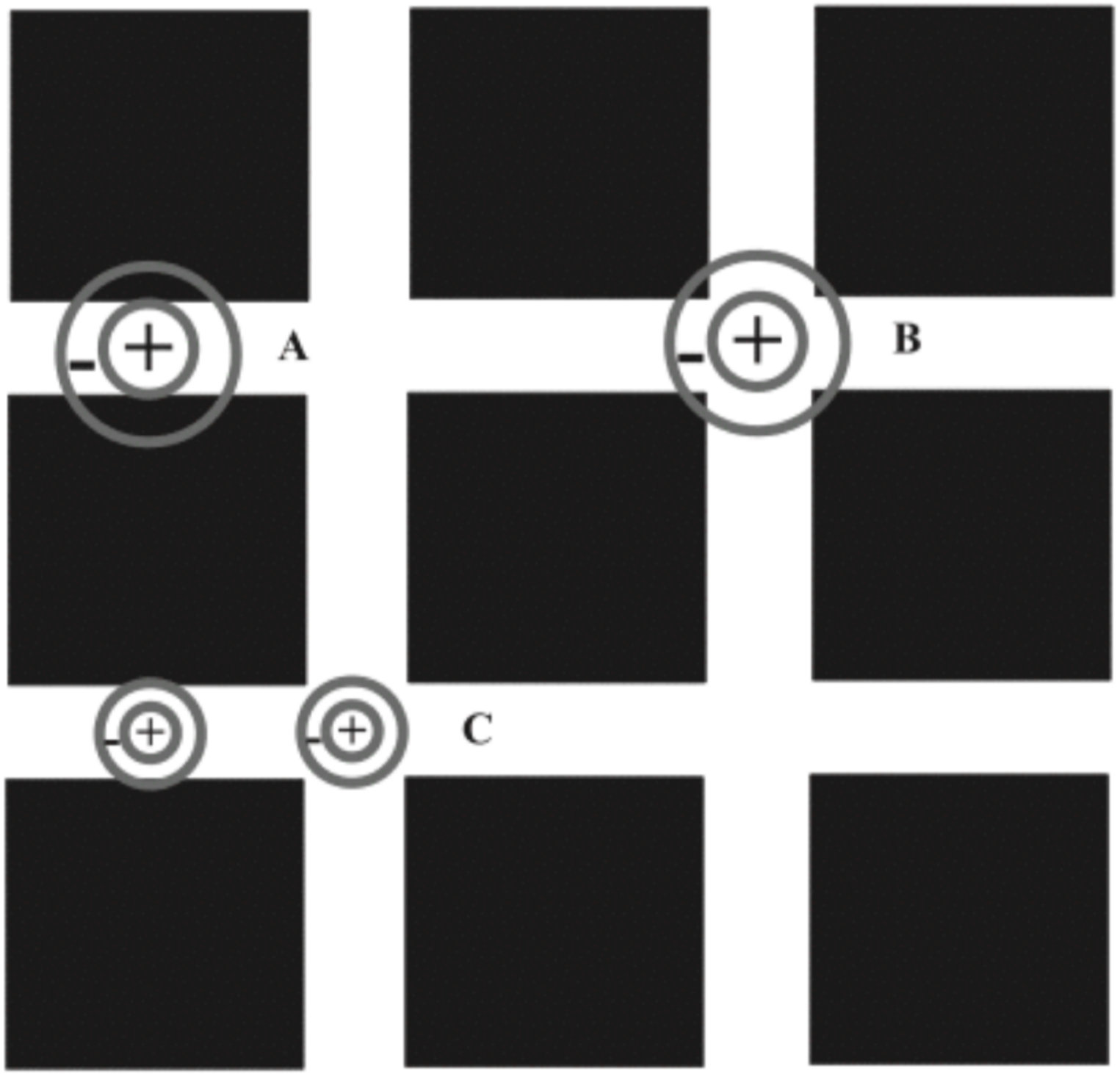
activity increased
(or decreased)
at edge





Miriah Meyer

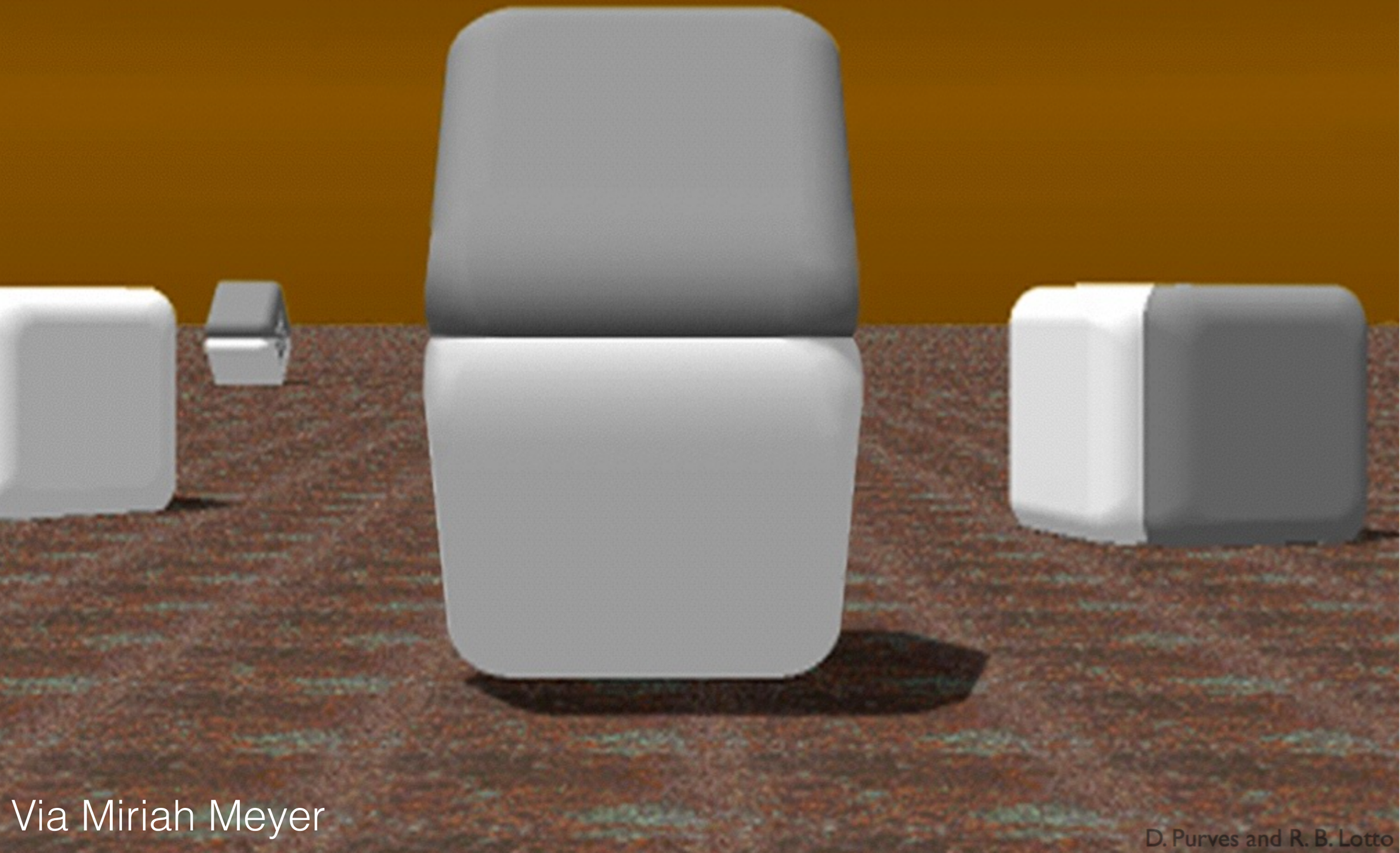




Annie Prud’homme-Généreux

Via Miriah Meyer

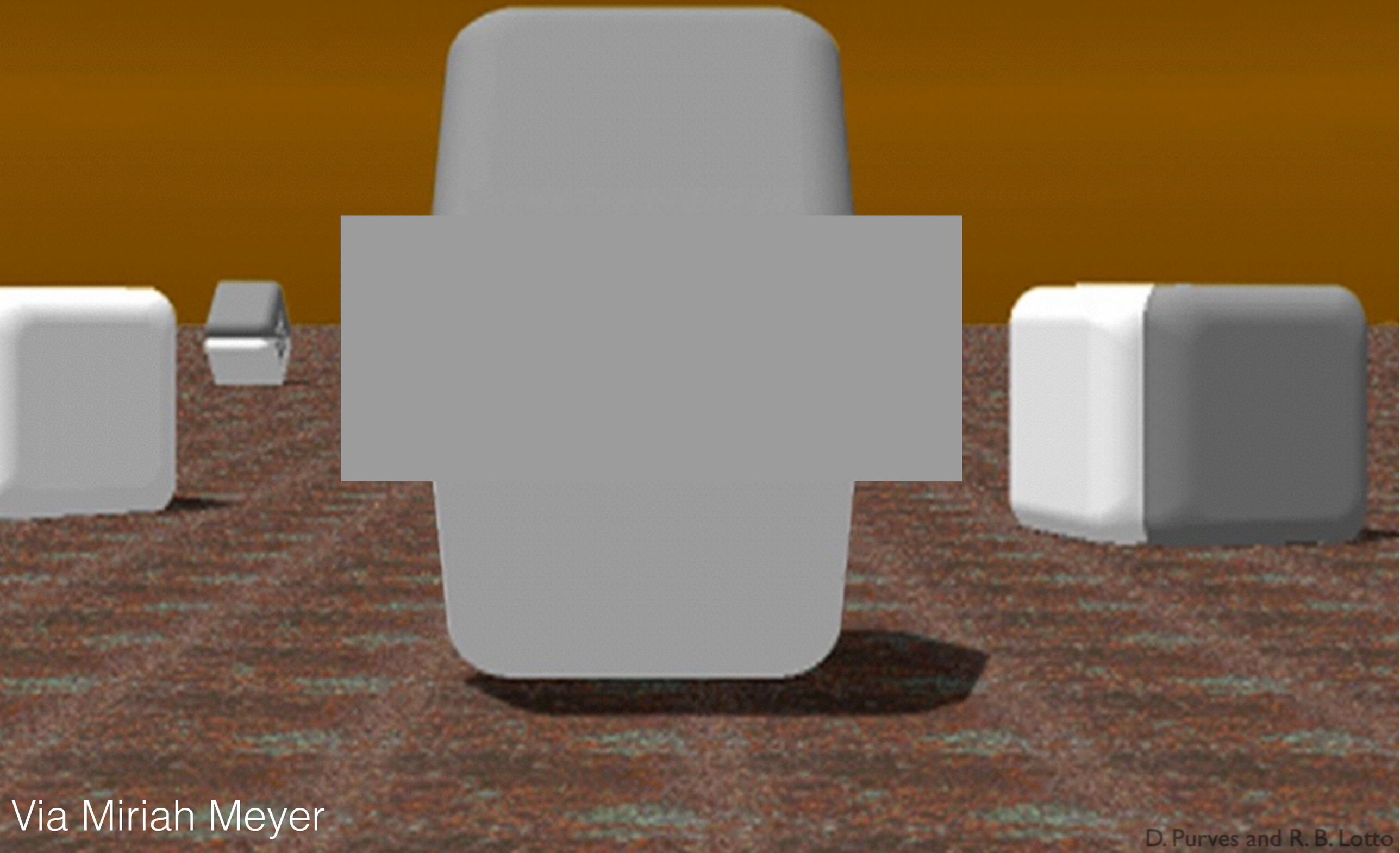
Cornsweet Illusion



Via Miriah Meyer

D. Purves and R. B. Lotto

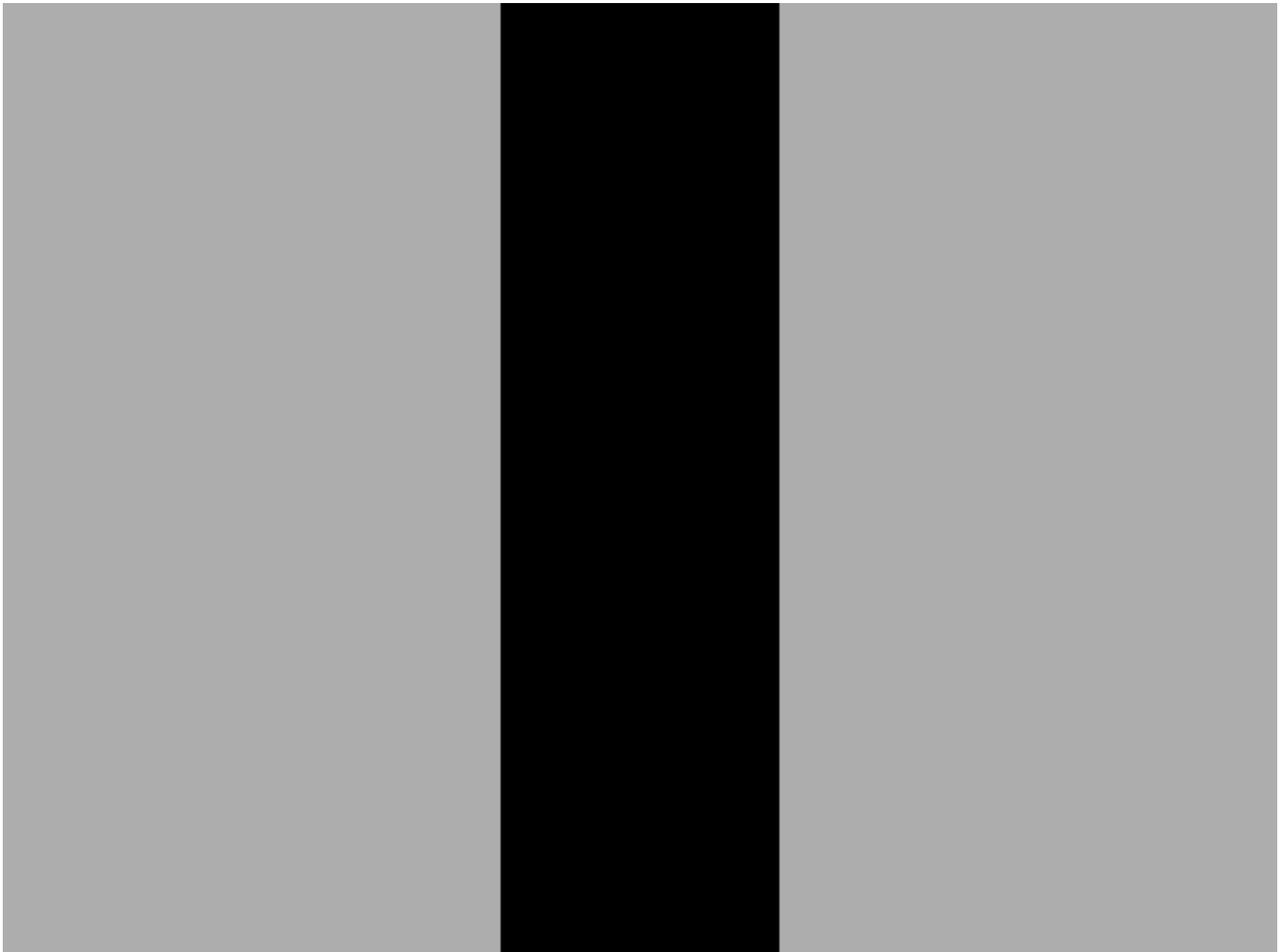
Cornsweet Illusion



Via Miriah Meyer

D. Purves and R. B. Lotto

Cornsweet illusion



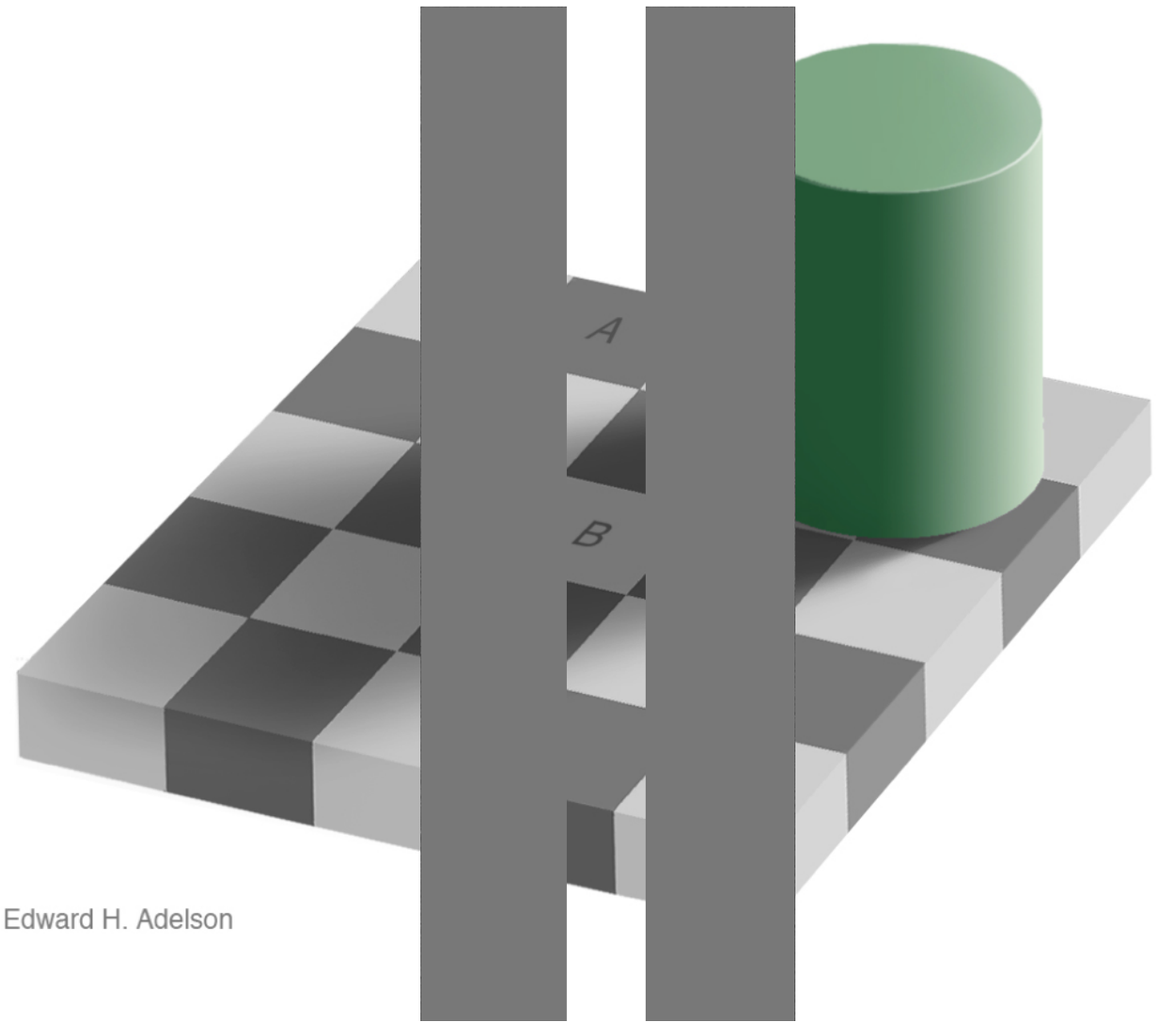
Visual perception is relative

Visual perception is relative

Differences in color are relative

Visual perception is relative

Differences in contrast is relative



Edward H. Adelson

Visual perception is relative

Color interaction

Wong 2010

Via Miriah Meyer

Visual perception is relative

Sizes are relative (Ames room)

https://www.youtube.com/watch?v=hCV2Ba5wrcs

Take home point

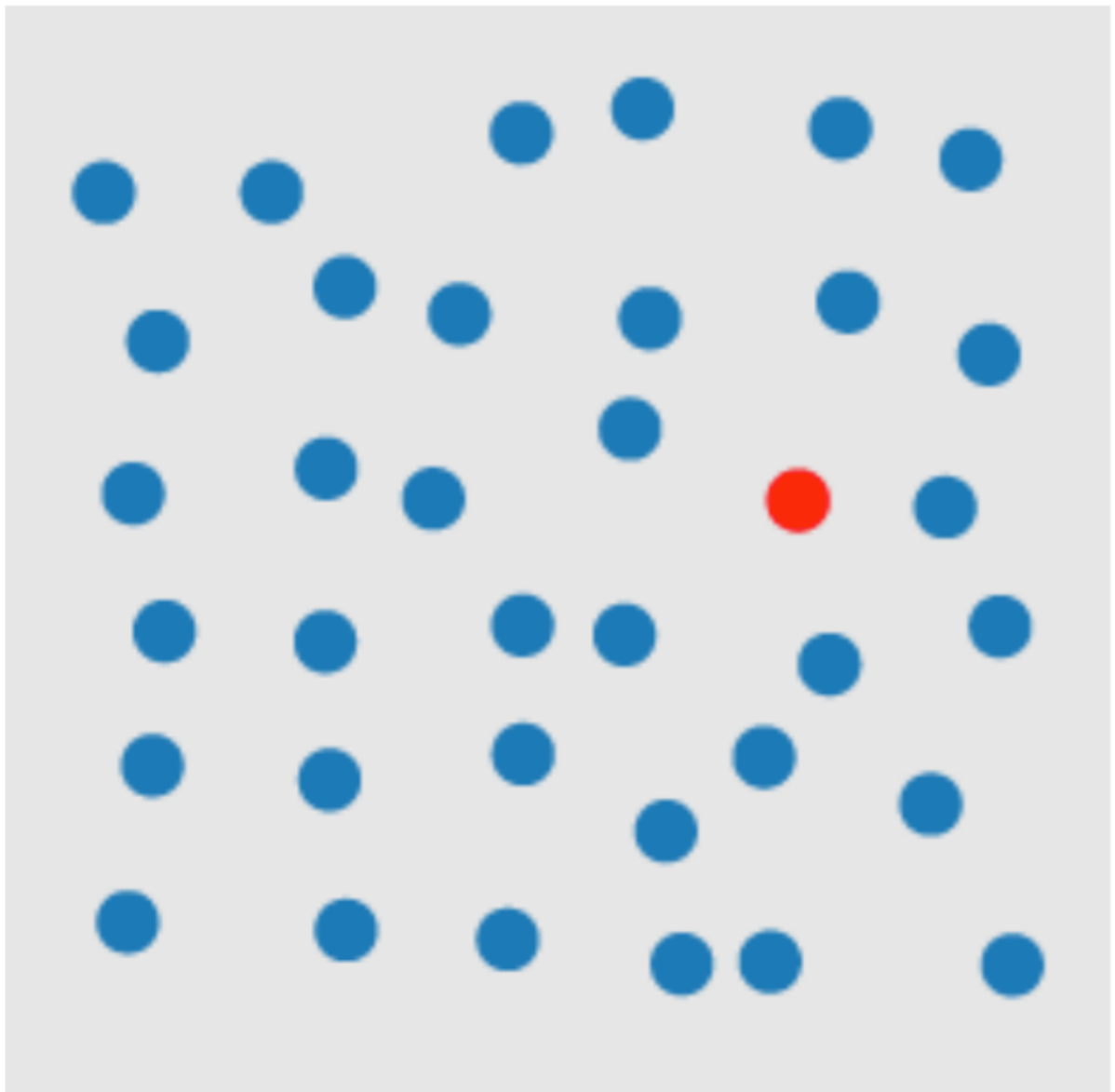
Our visual system see differences, not absolute values.

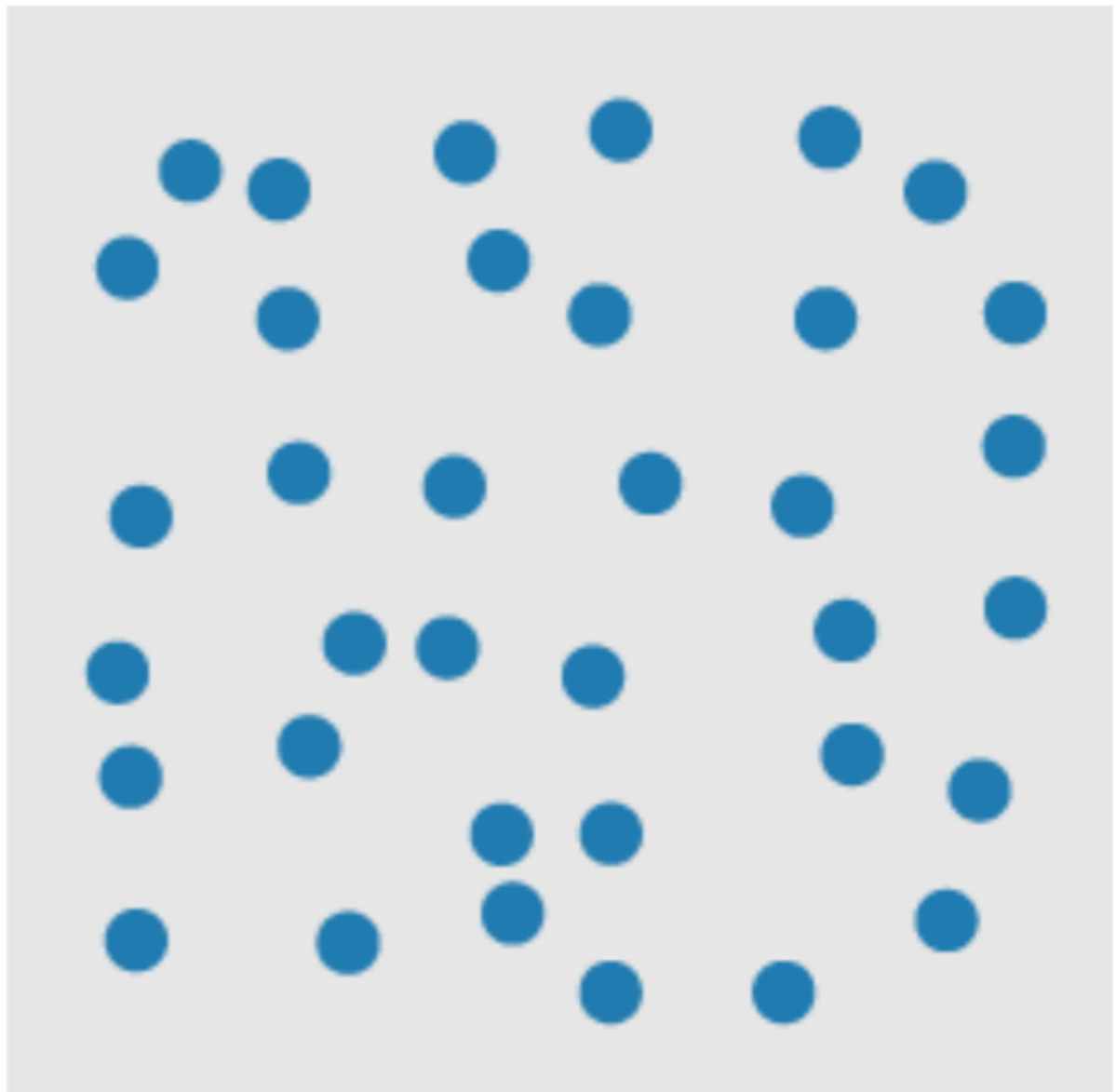
Based on a slide by Miriah Meyer

POPOUT

which side has the outlier?

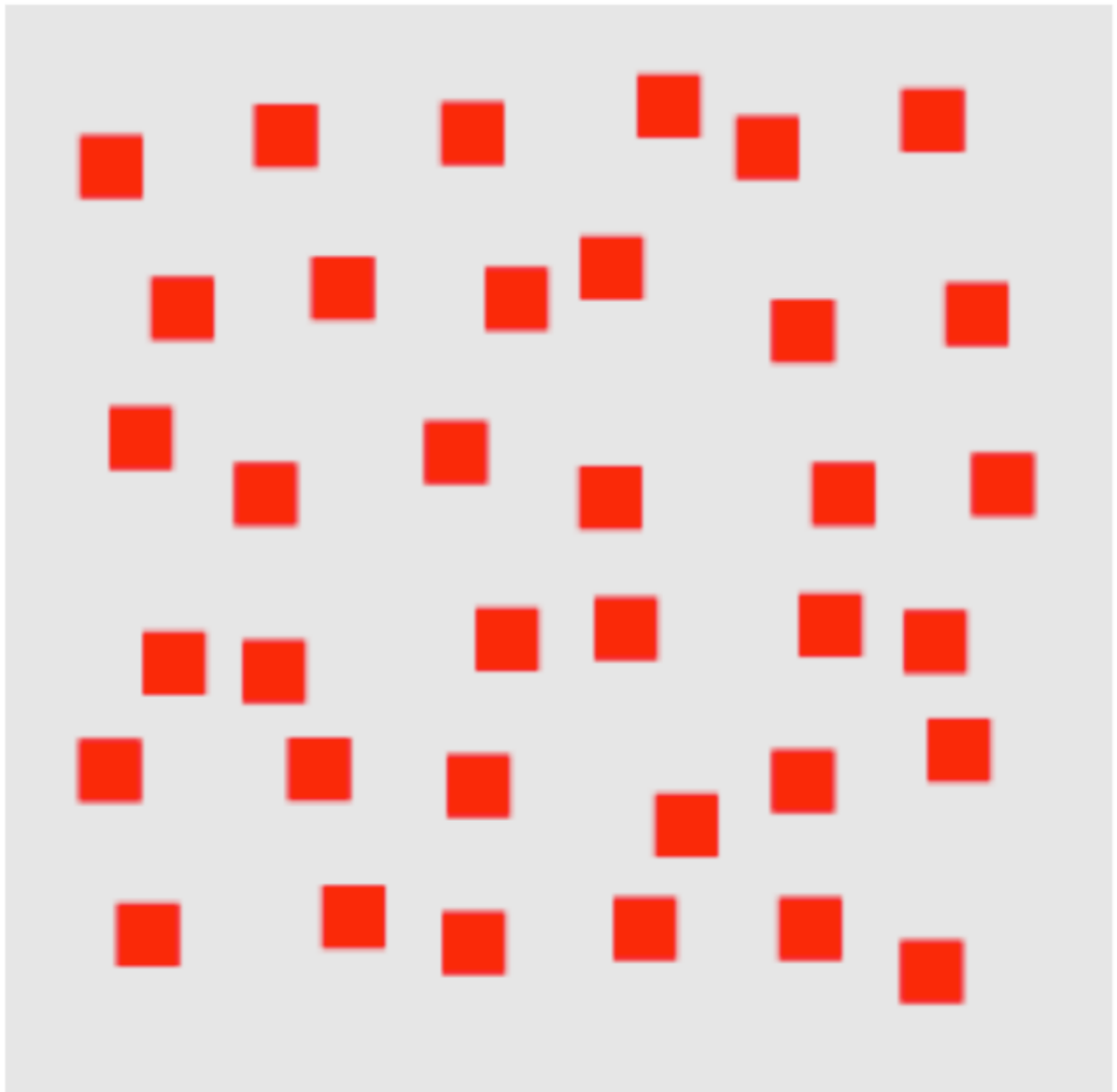
which side has the outlier?

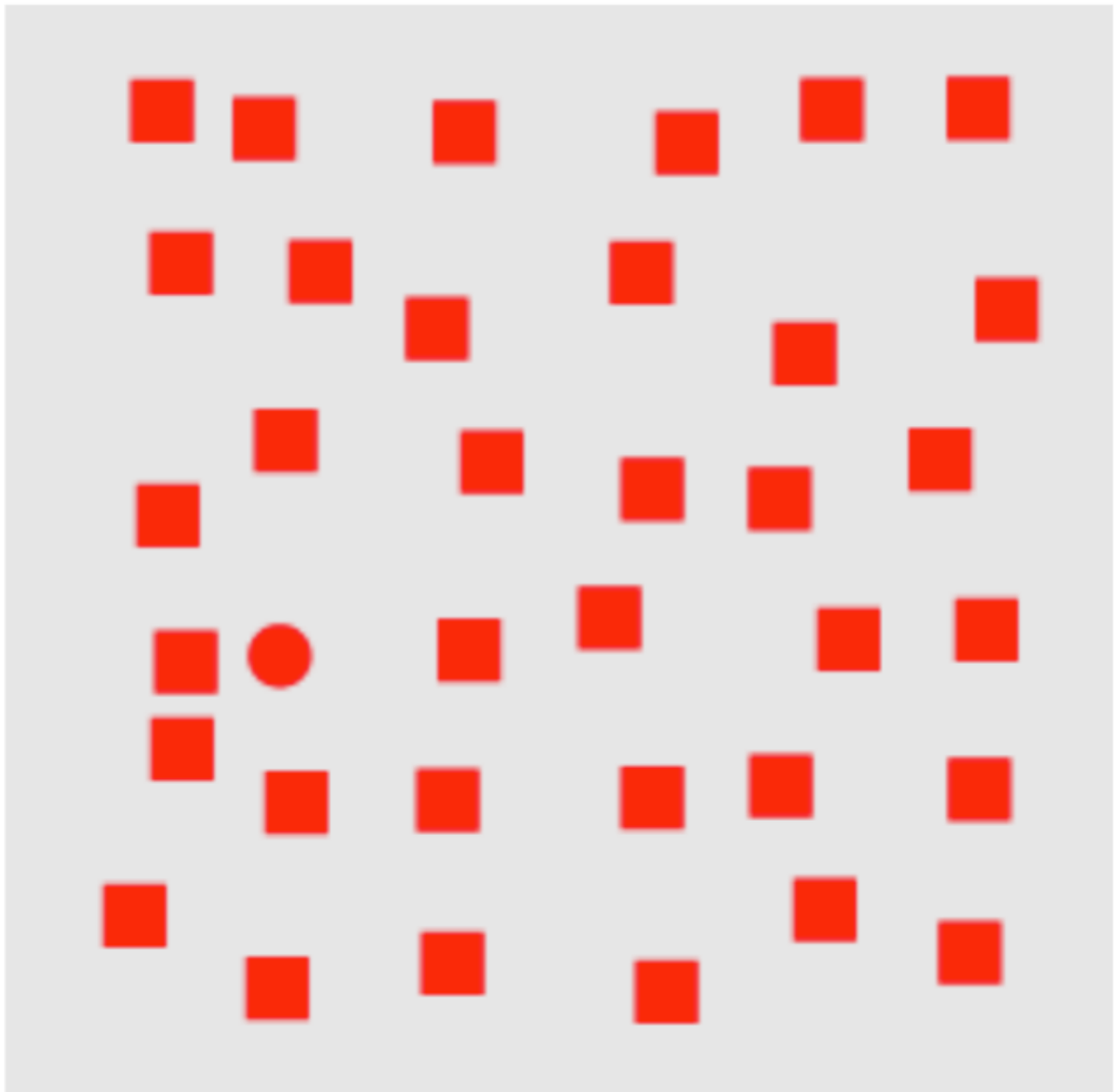




C. Healey, 2007

which side has the outlier?

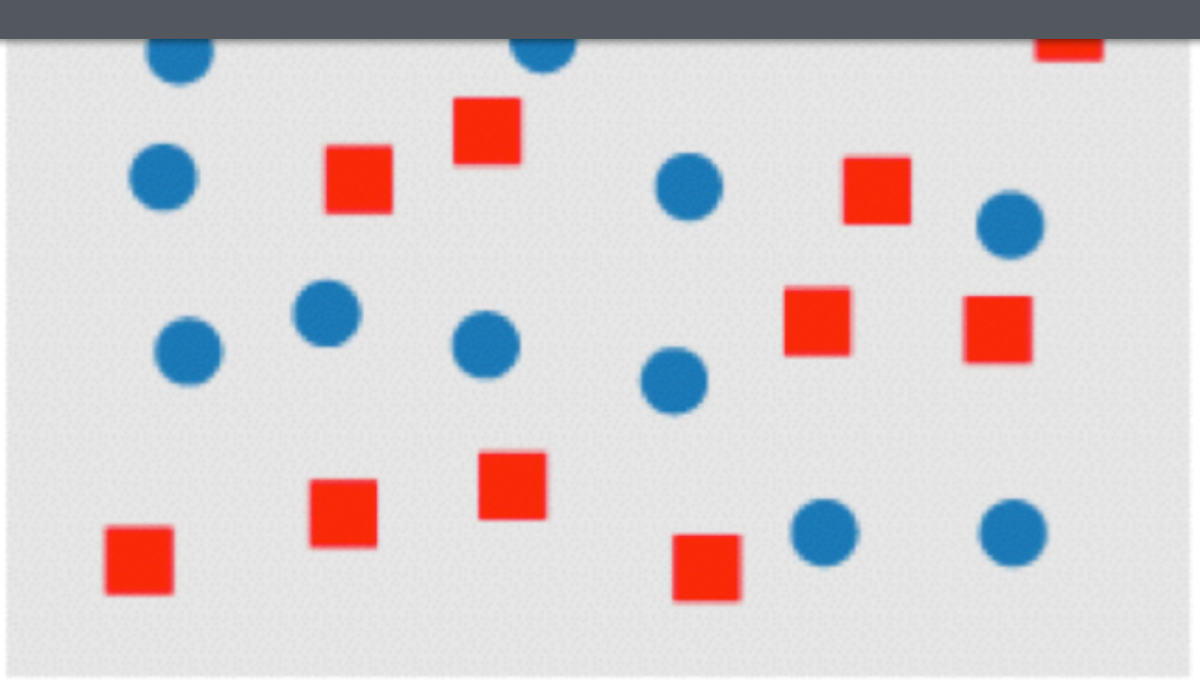


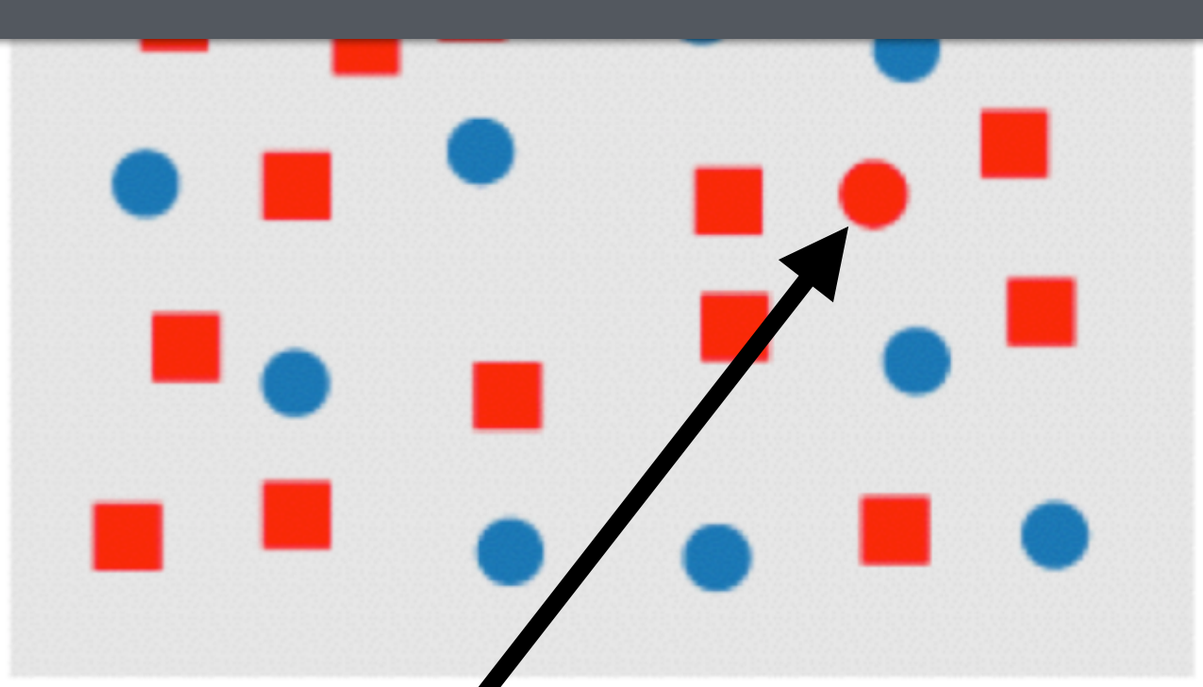


C. Healey, 2007

which side has the outlier?

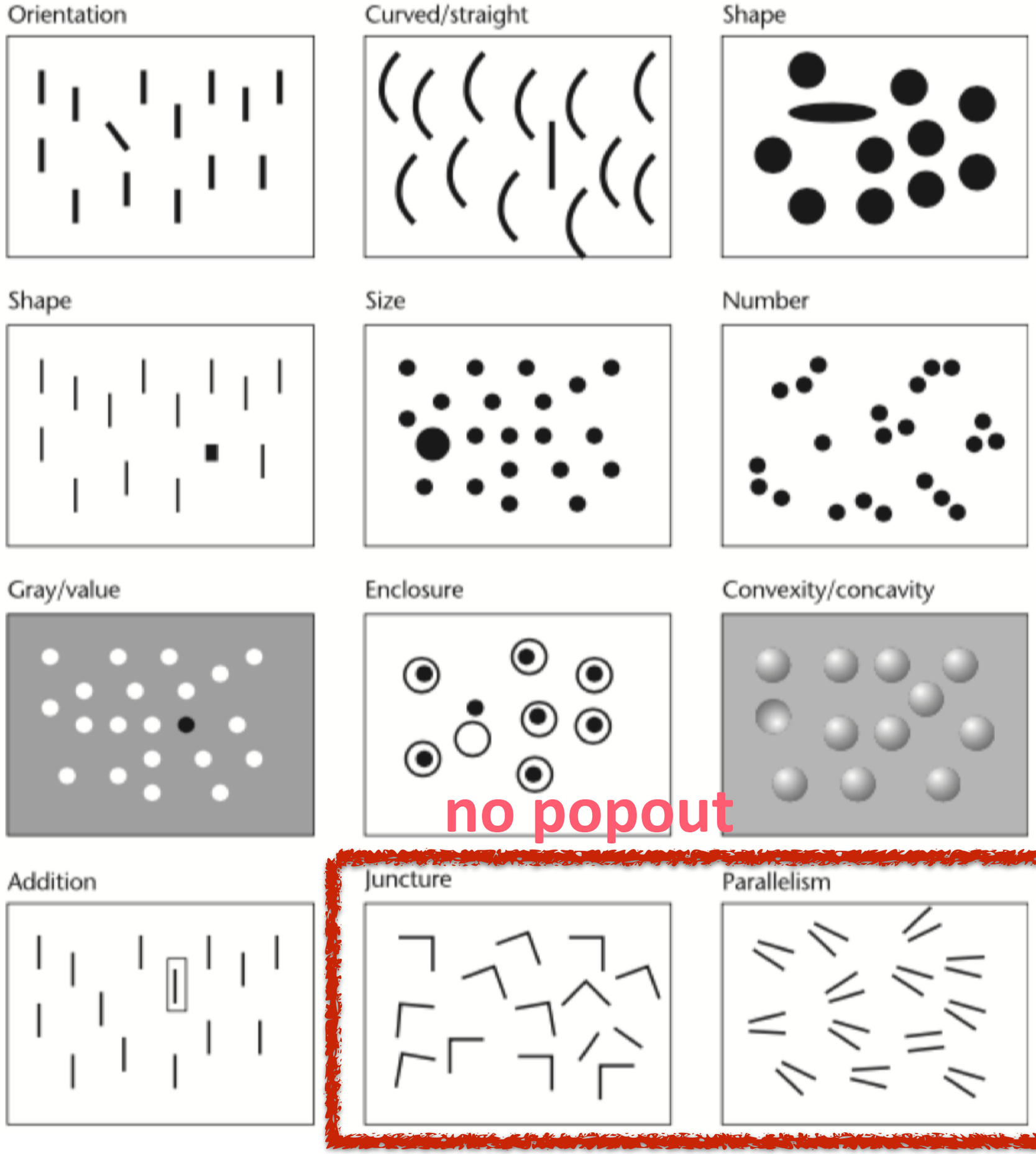
use **a single popout channel** at a time
(e.g., either difference in color or shape alone)
to draw attention





C. Healey, 2007

Popout channels

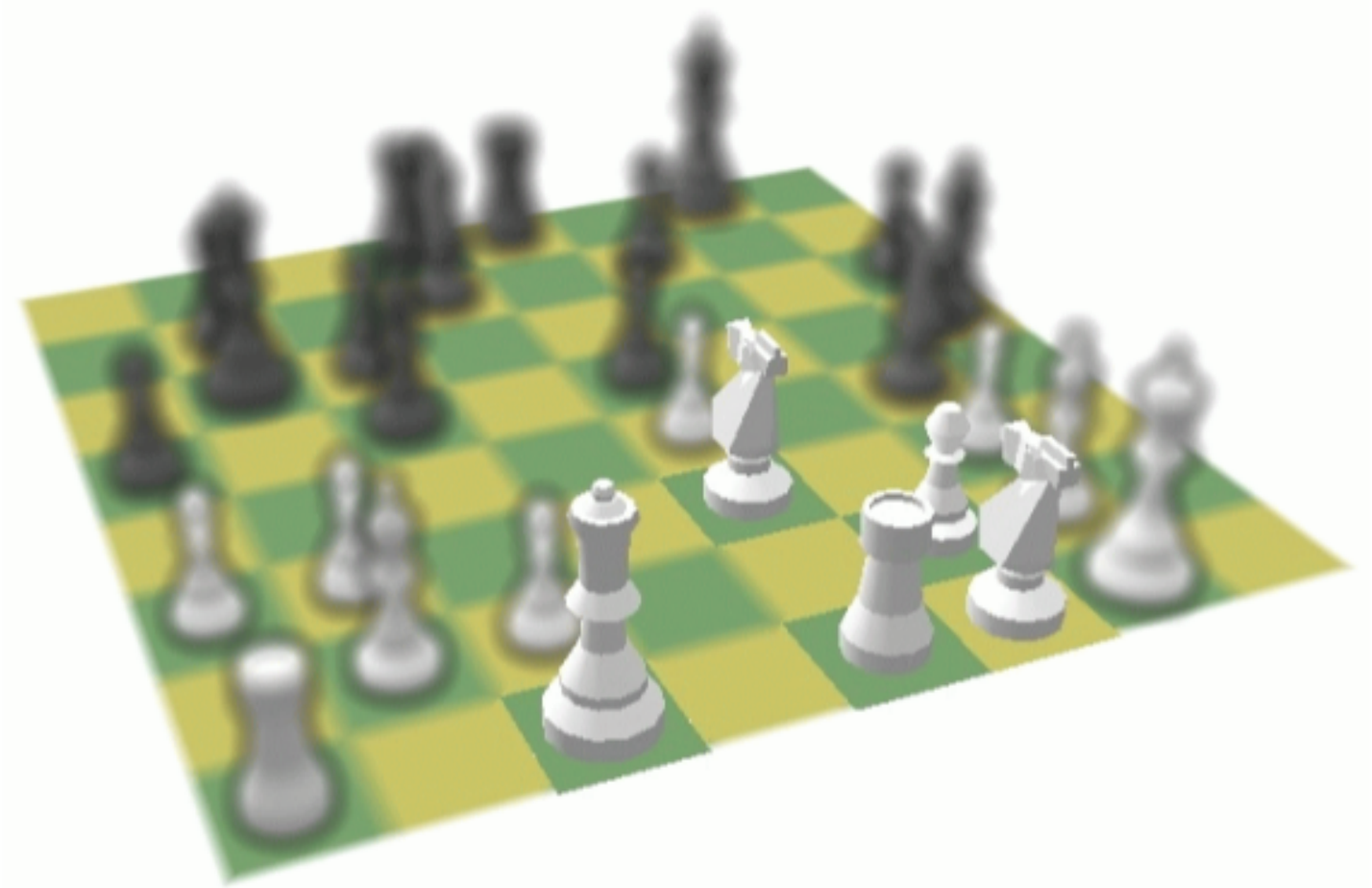


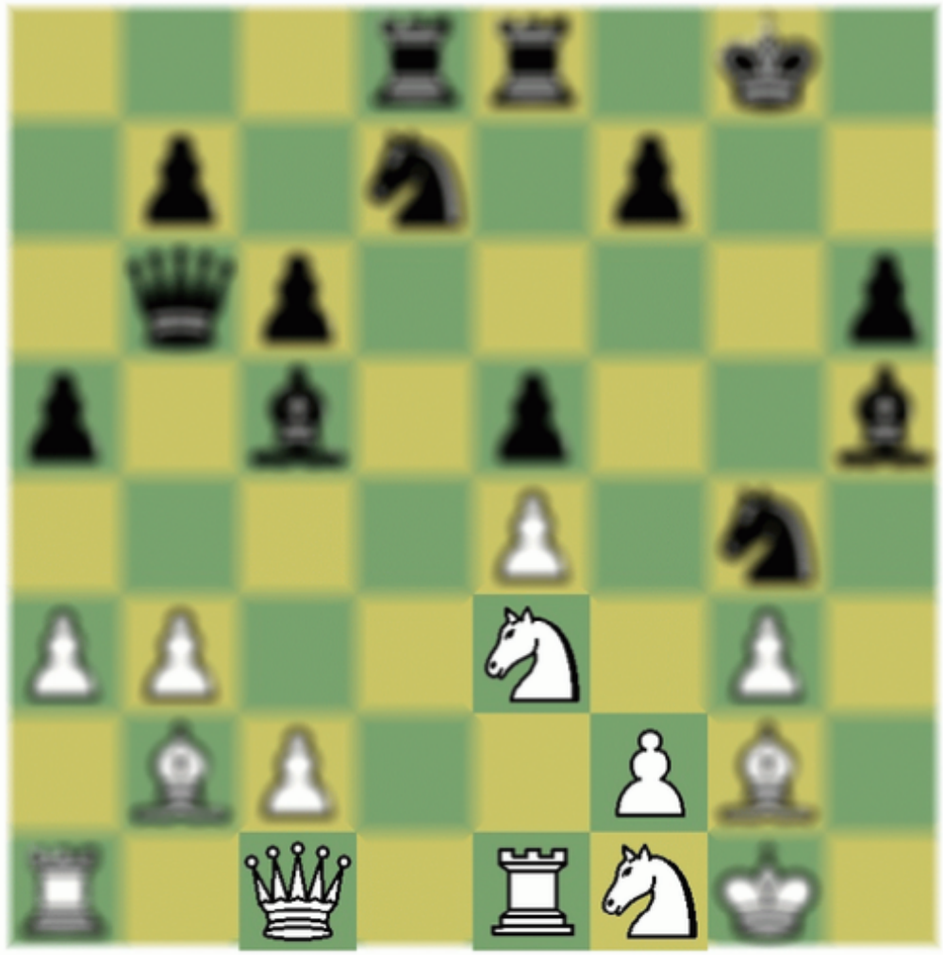
C. Ware
“Information Visualization”

Semantic Depth of Field

C. Ware
“Information Visualization”

Semantic Depth of Field





R. Kosara

Popout / pre-attentive processing

- Very fast at grabbing attention (less than 200 milli seconds)

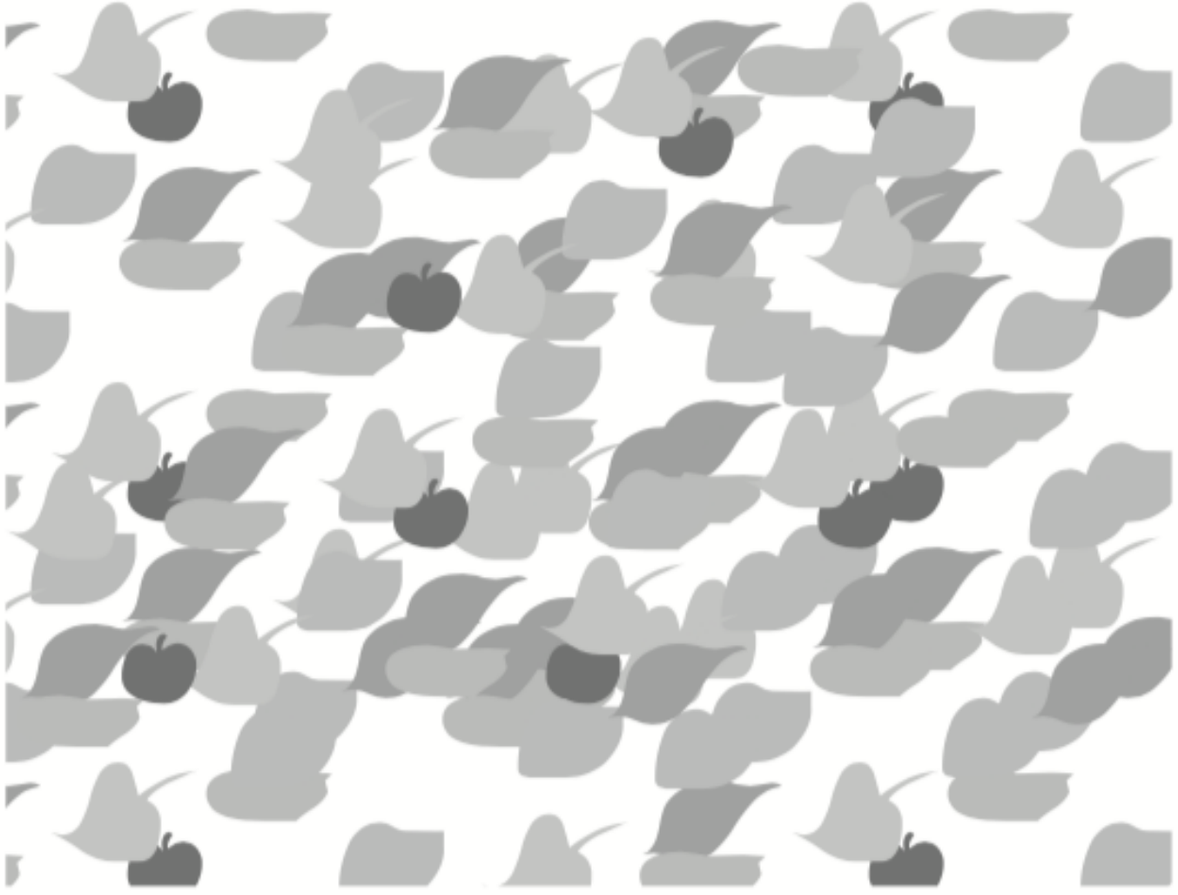
- Popout elements have to be salient compared to surrounding

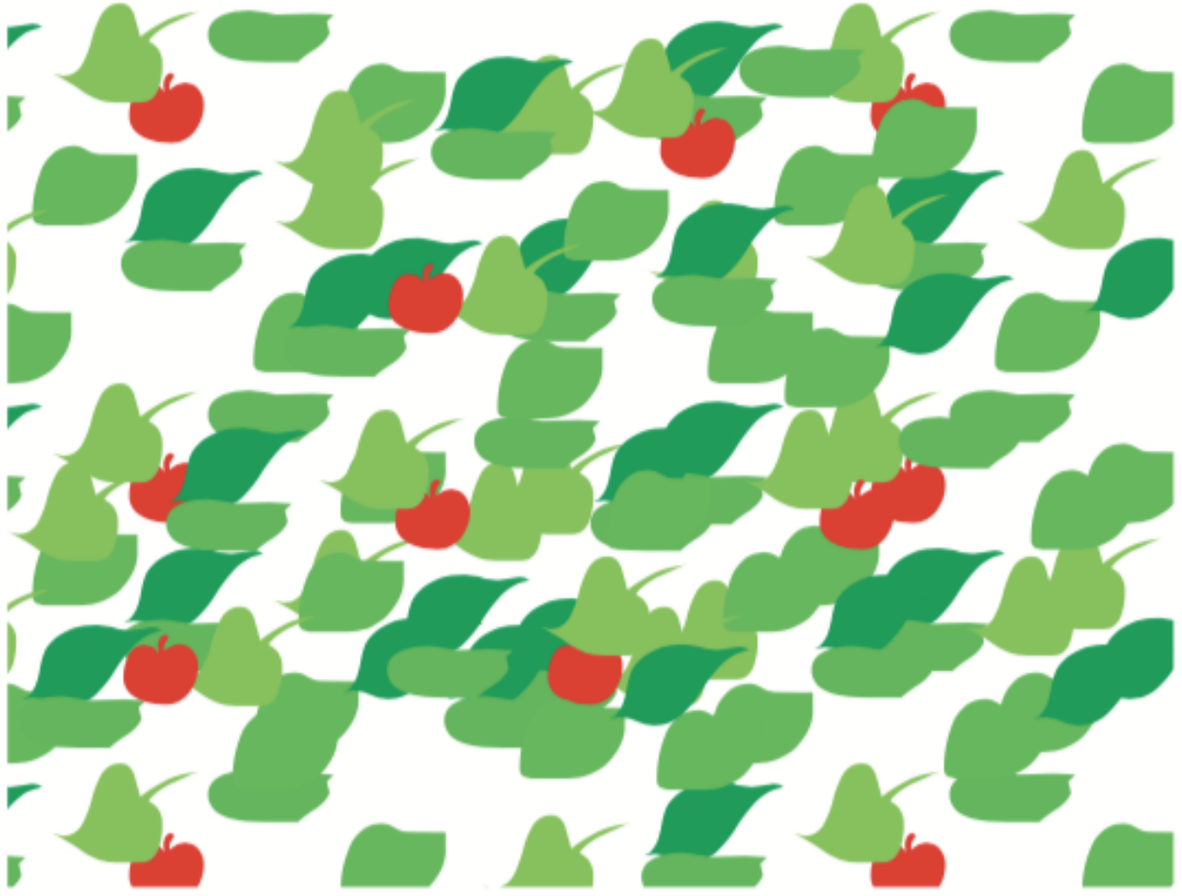
- Elements that are a **conjunction** of multiple channels often do not pop out

How does pre-attentive processing / pop outs work?

We don't know for sure, but there are some theories:

https://www.csc.ncsu.edu/faculty/healey/PP/index.html#Preattentive_Theory





Take home point

We can easily see objects that are different in color and shape, or that are in motion

Visual features must be carefully designed.

Conjunctions must be avoided, if popout is desired

Use color and shape sparingly to make the important information pop out

Based on slides by Miriah Meyer & Alex Lex

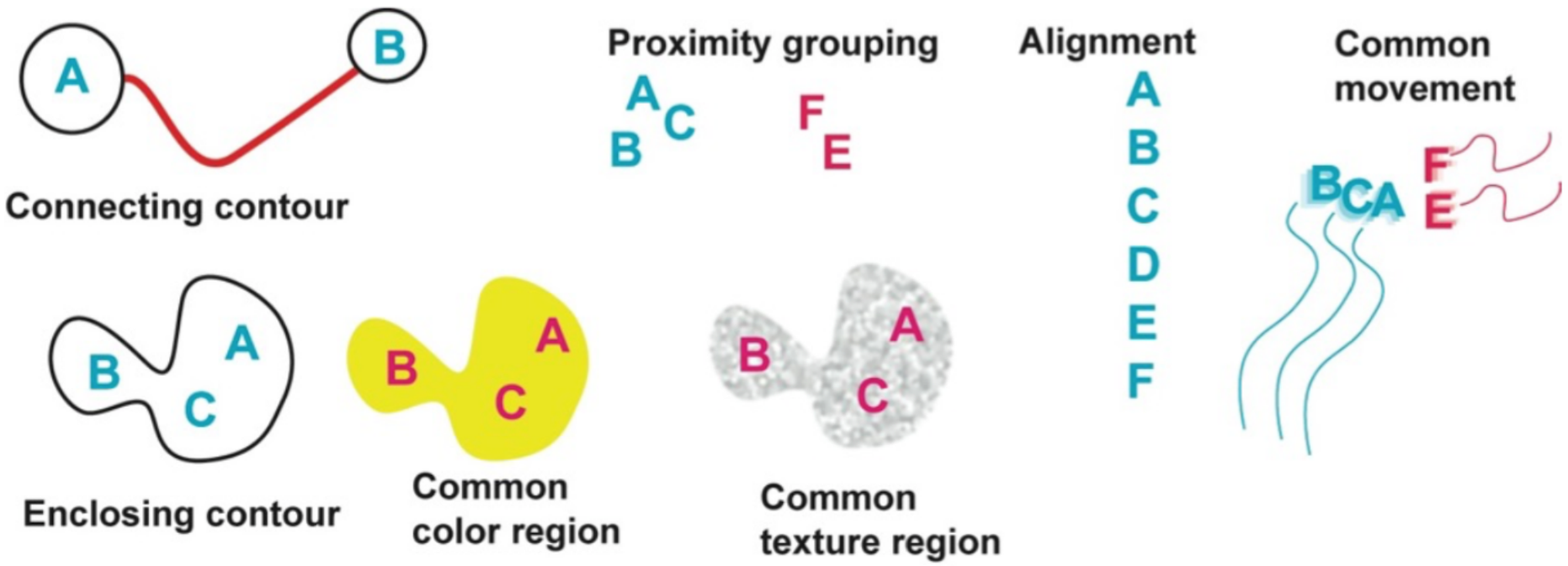
Gestalt grouping principles

Gestalt grouping principles

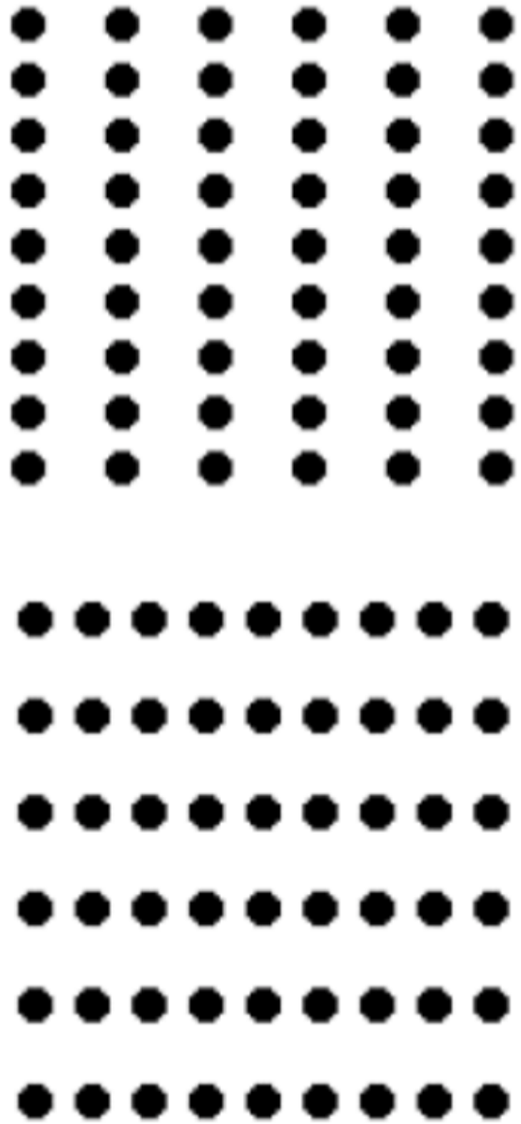
gestalt: form in German

"The whole is *other* than the sum of its parts"

Our brain has innate capacity to see patterns that transcend the visual stimuli the produce them

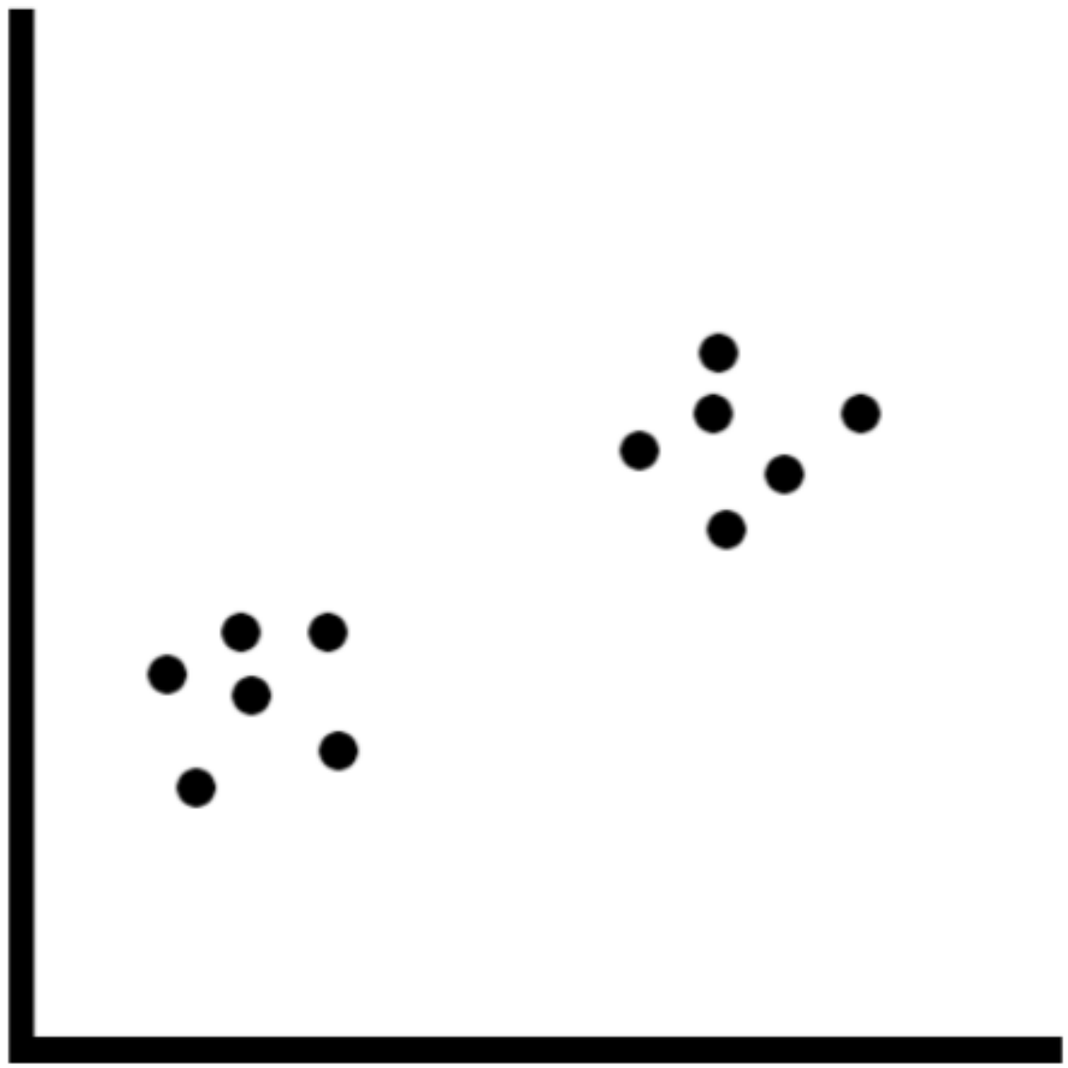


proximity

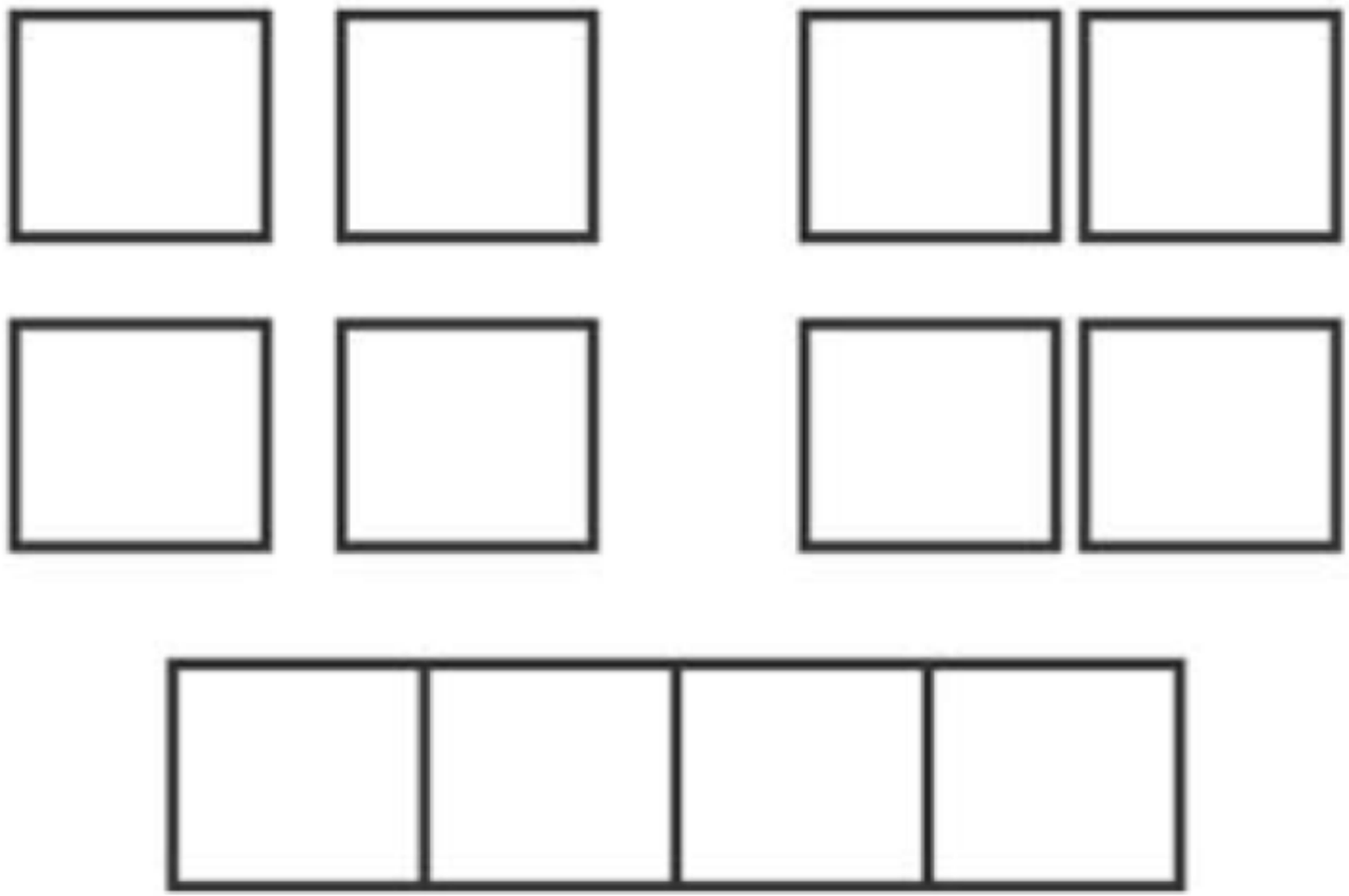


Andy Rutledge, “Gestalt Principles of Perception”

proximity

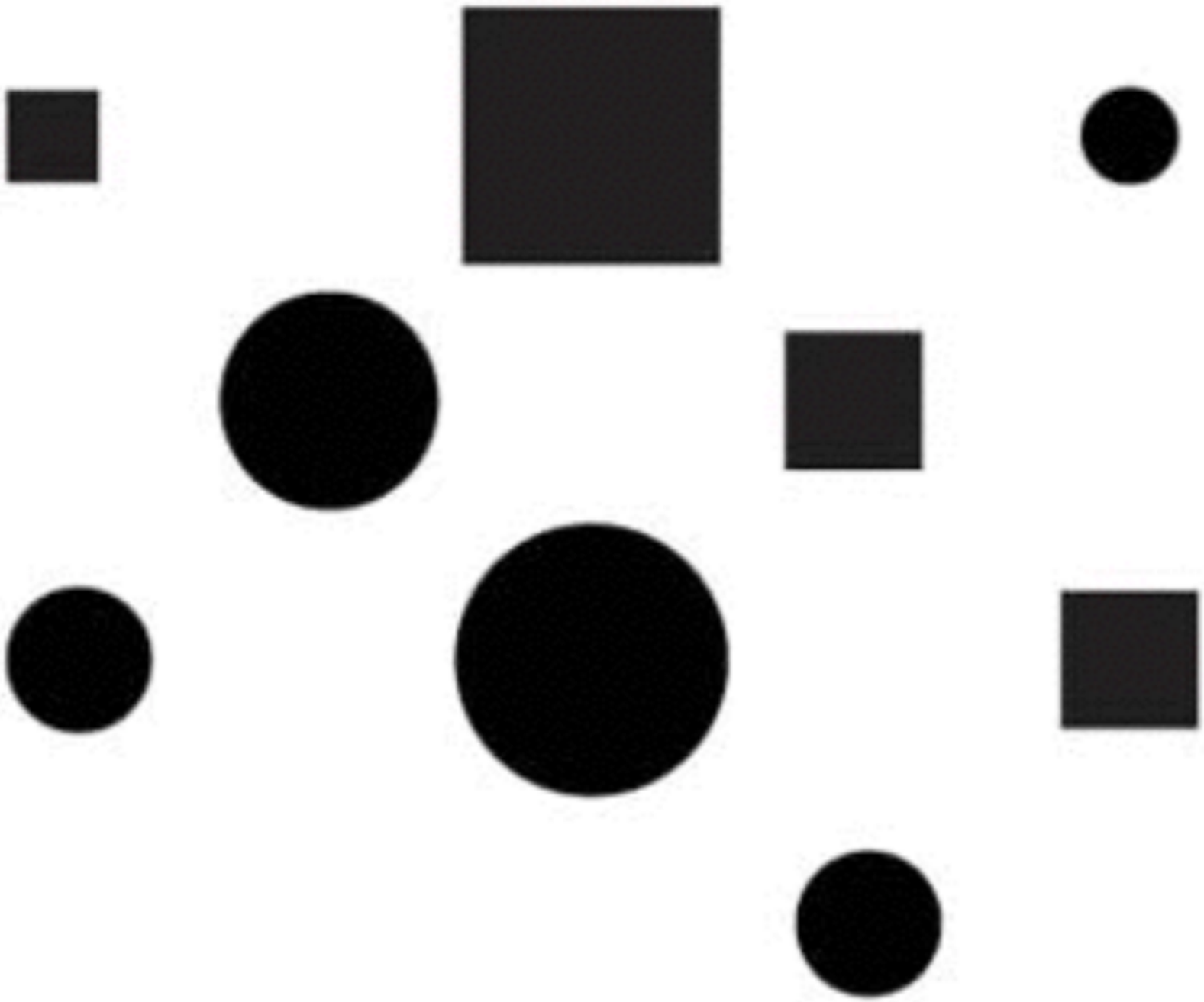


proximity



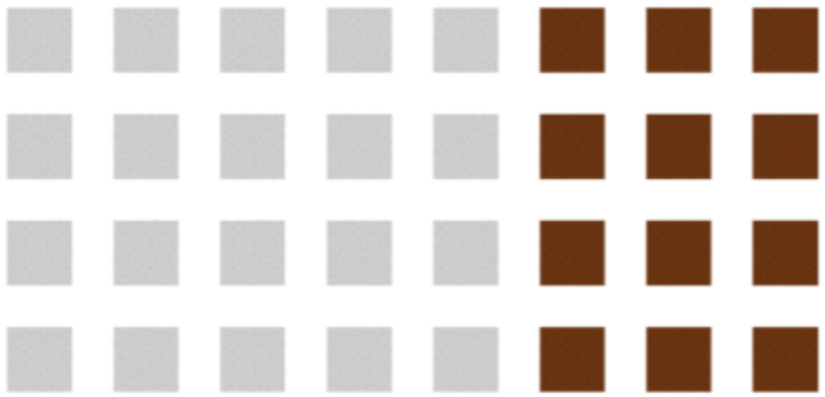
B. Wong, “Gestalt Principles, I”

similarity



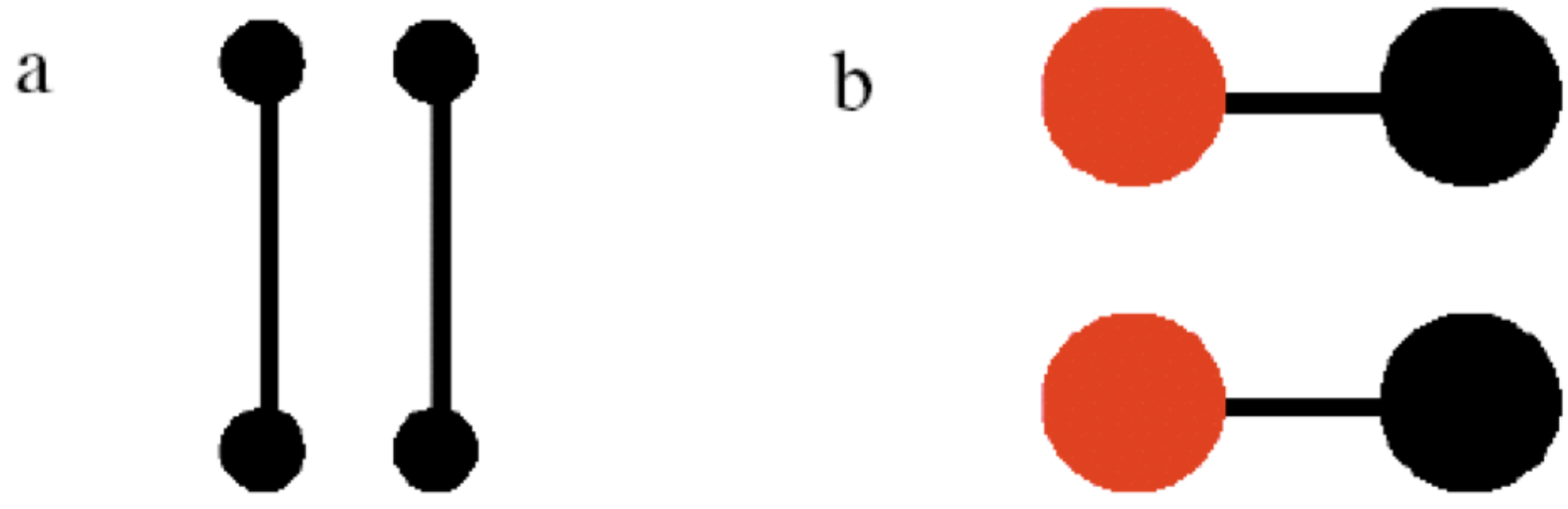
B. Wong, “Gestalt Principles, I”

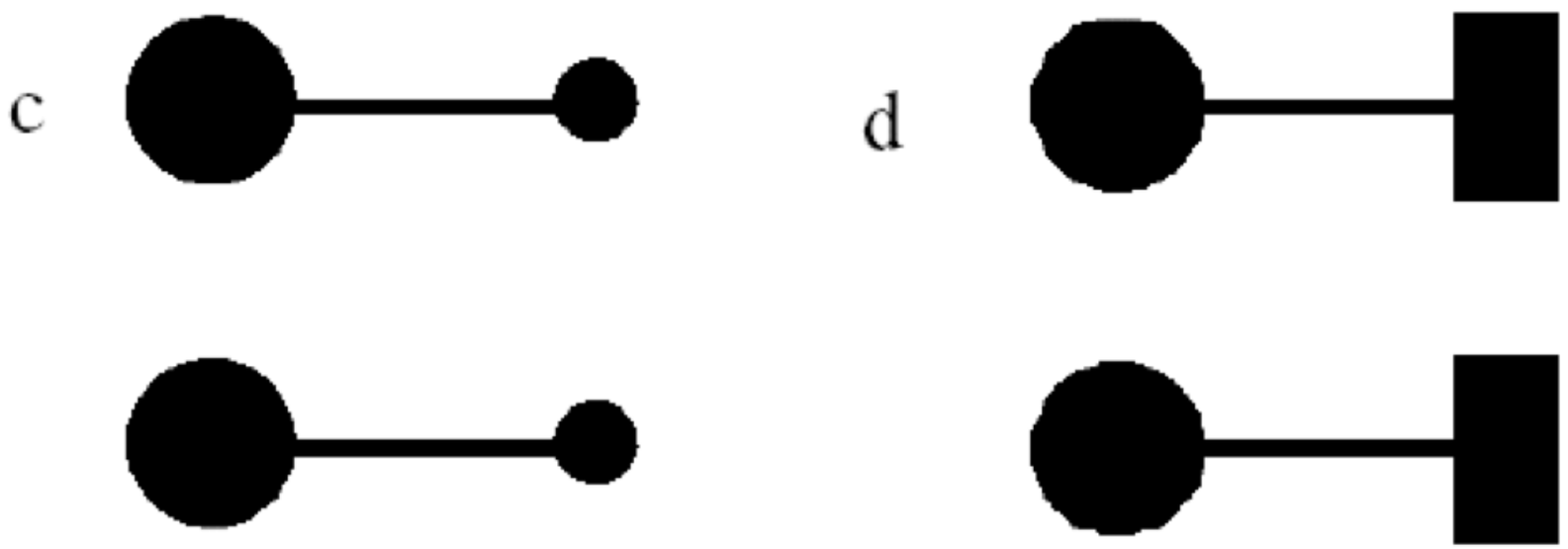
similarity



Andy Rutledge, “Gestalt Principles of Perception”

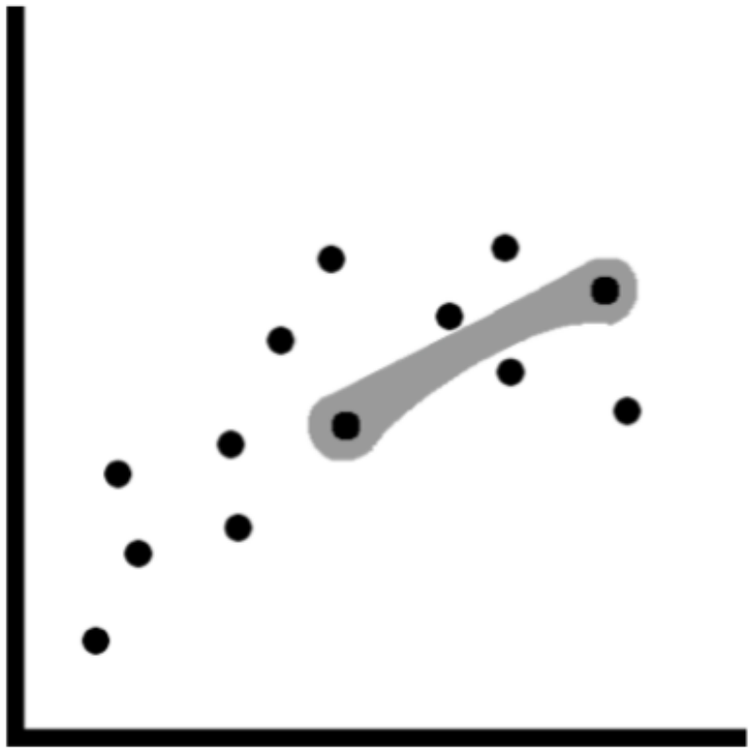
connectedness



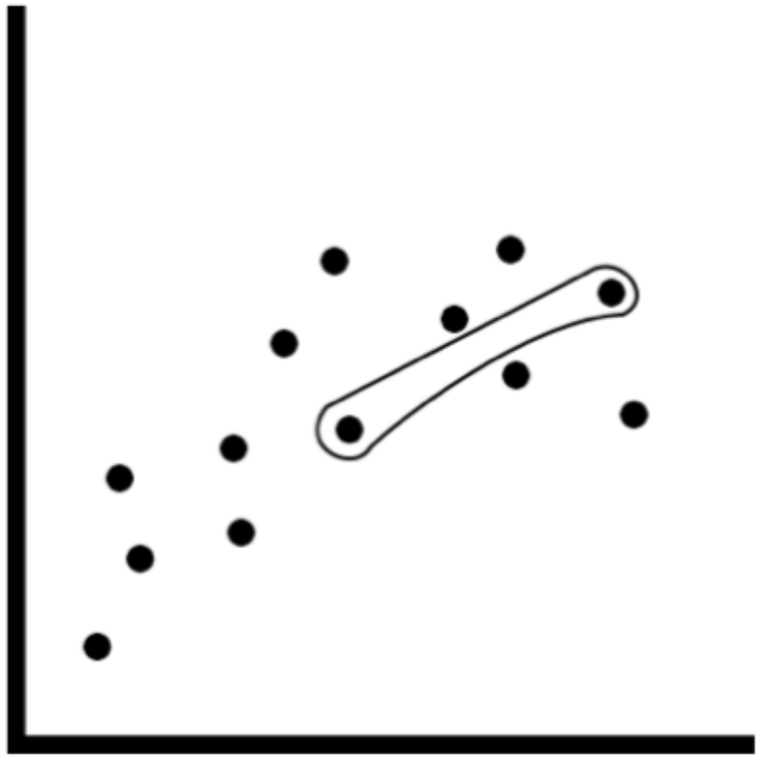


Ware, “Information Visualization”

link



surface



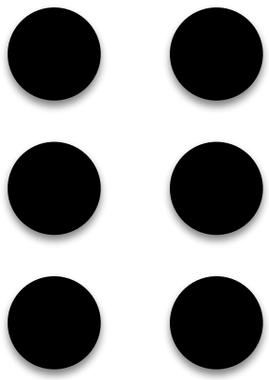
outline

enclosure

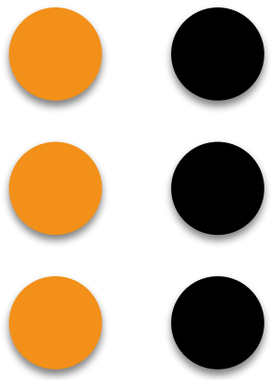
Alex Lex

A little experiment…

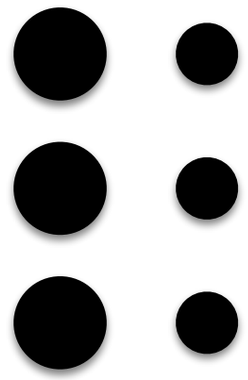
How many groups do you see?



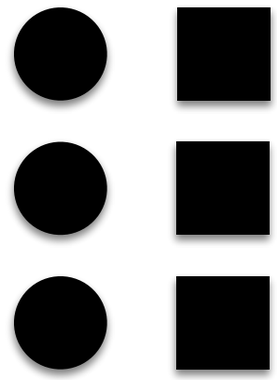
proximity



color similarity



size similarity

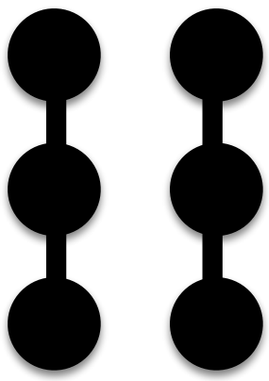


shape similarity

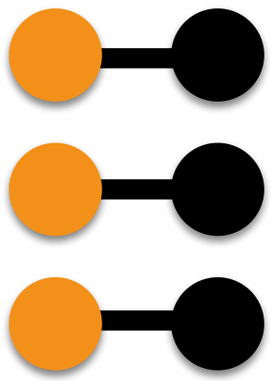
Based on a slide by Alex Lex

A little experiment…

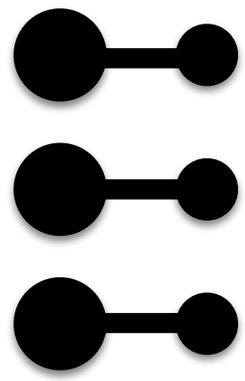
How many groups do you see?



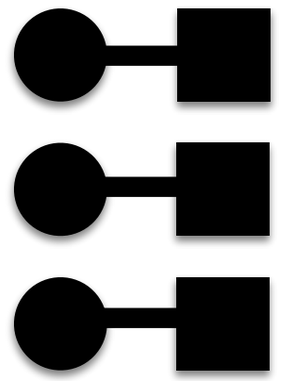
proximity



color similarity



size similarity

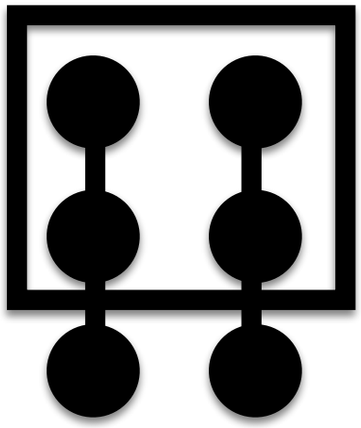


shape similarity

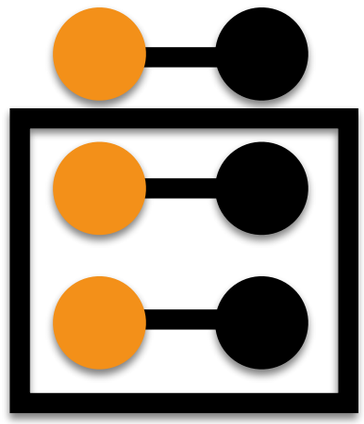
Based on a slide by Alex Lex

A little experiment…

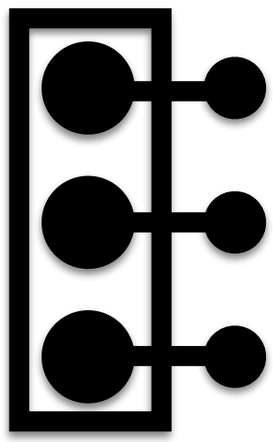
How many groups do you see?



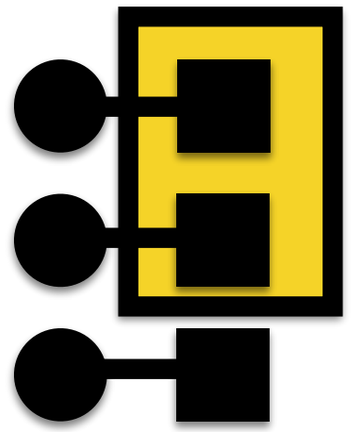
proximity



color similarity



size similarity

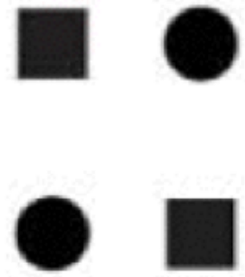


shape similarity

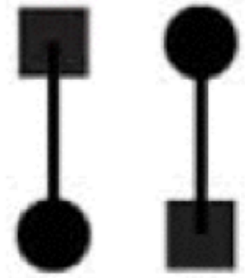
Based on a slide by Alex Lex

grouping

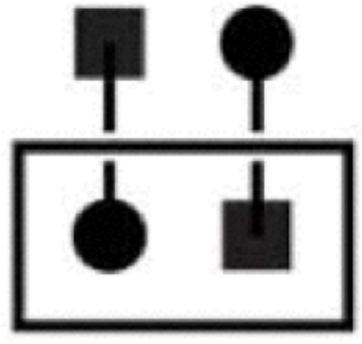
Similarity



Connection

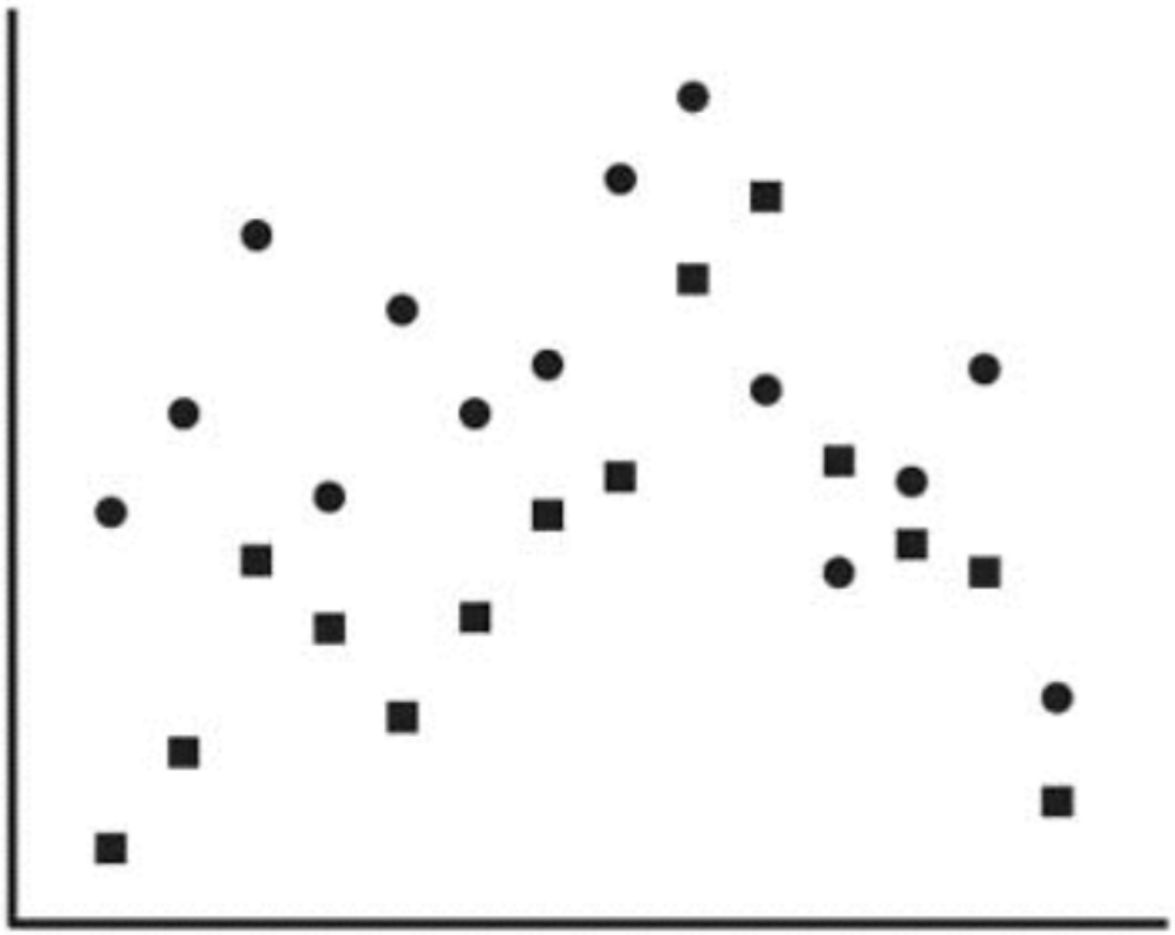


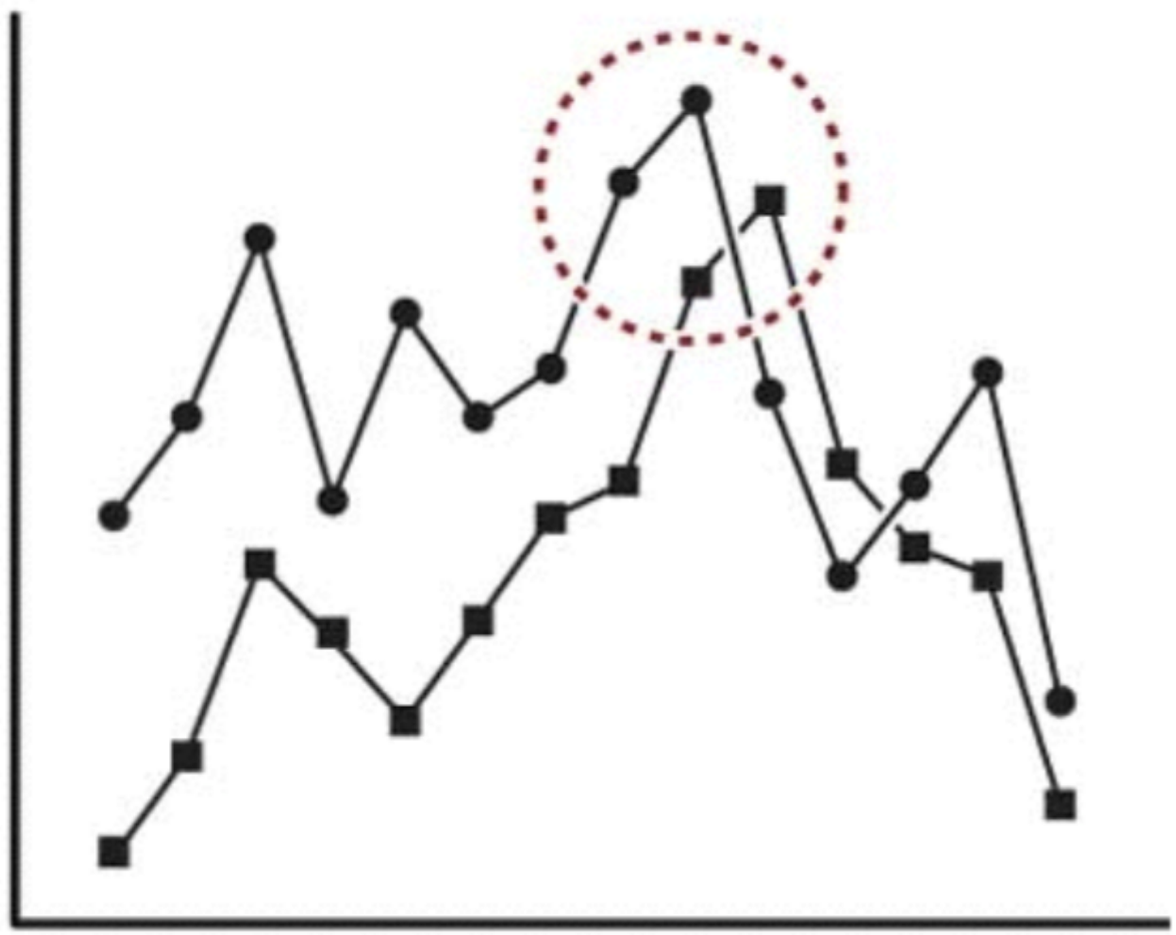
Enclosure



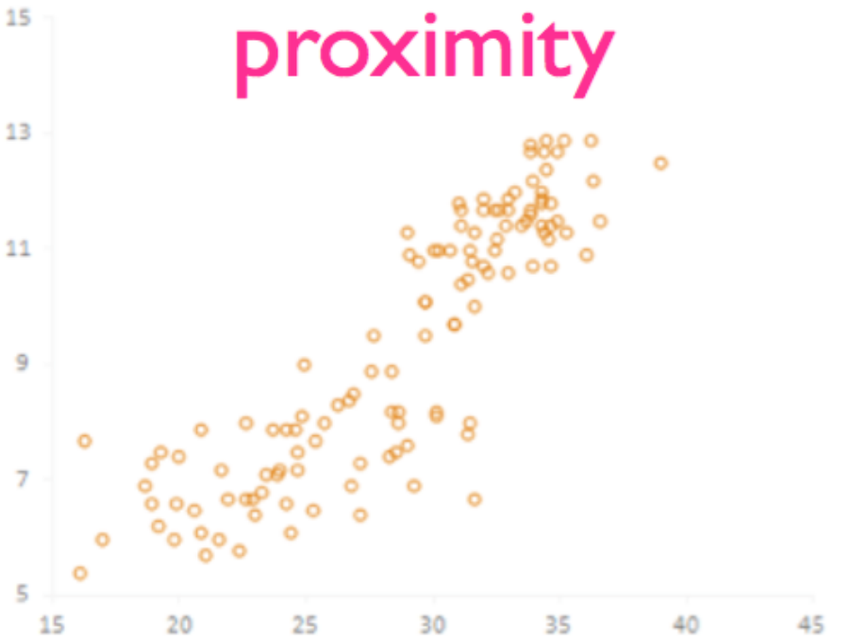
B. Wong, “Gestalt Principles, I”

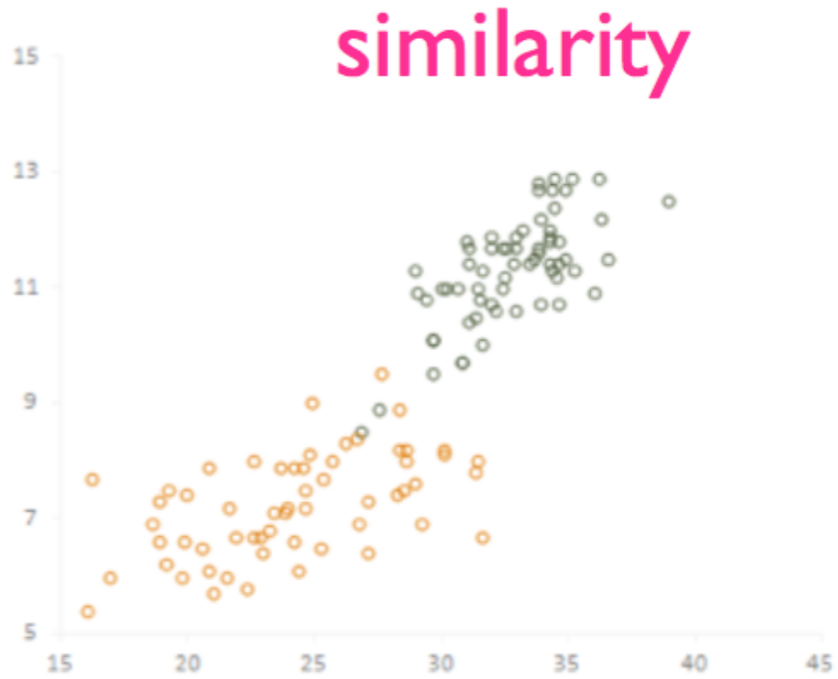
grouping





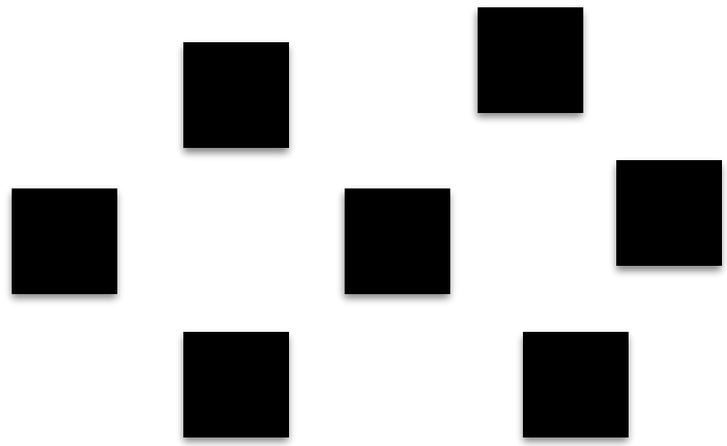
grouping





Jorge Camoes
Via Miriah Meyer

grouping - common fate



closure

closure

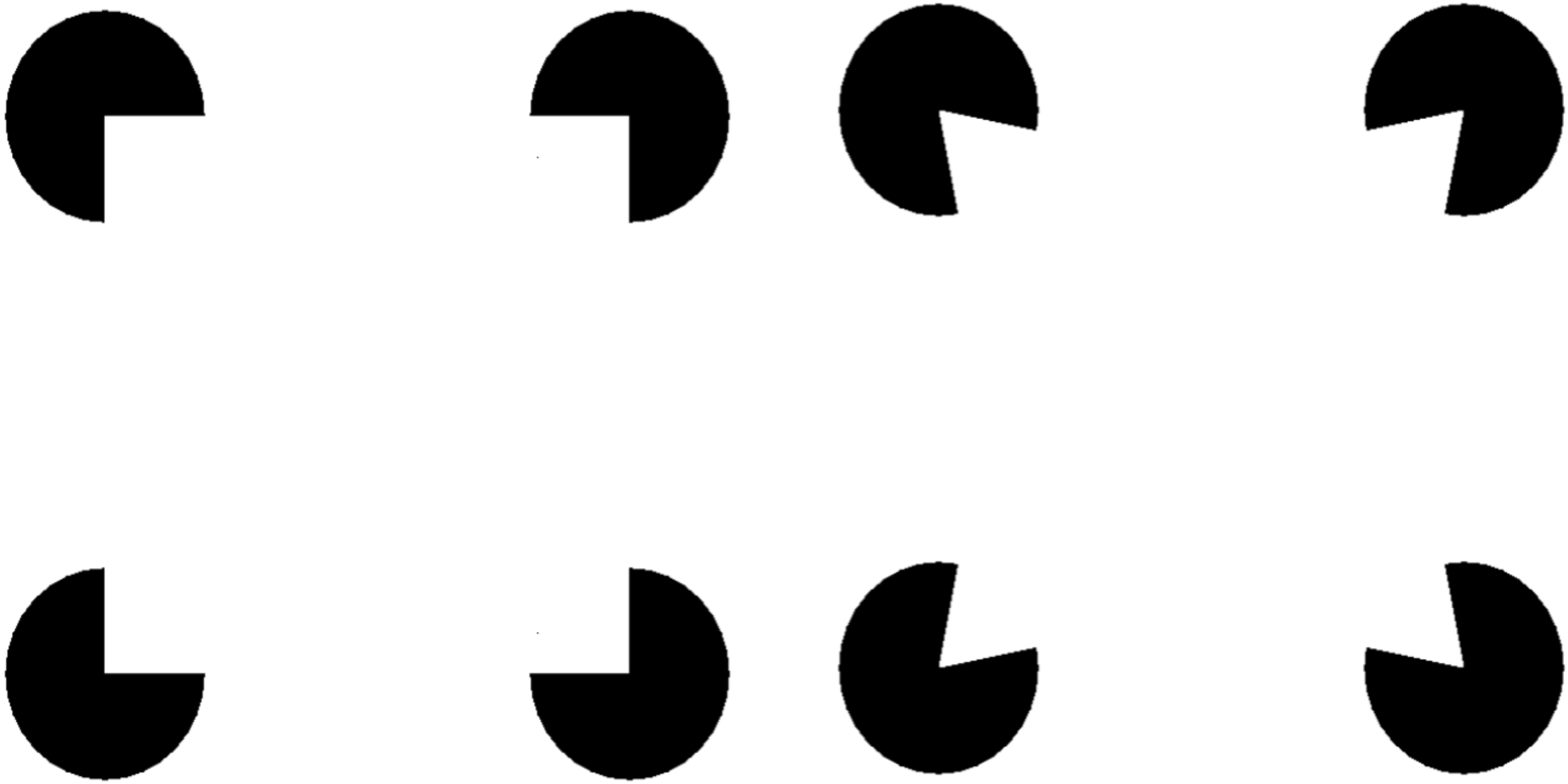
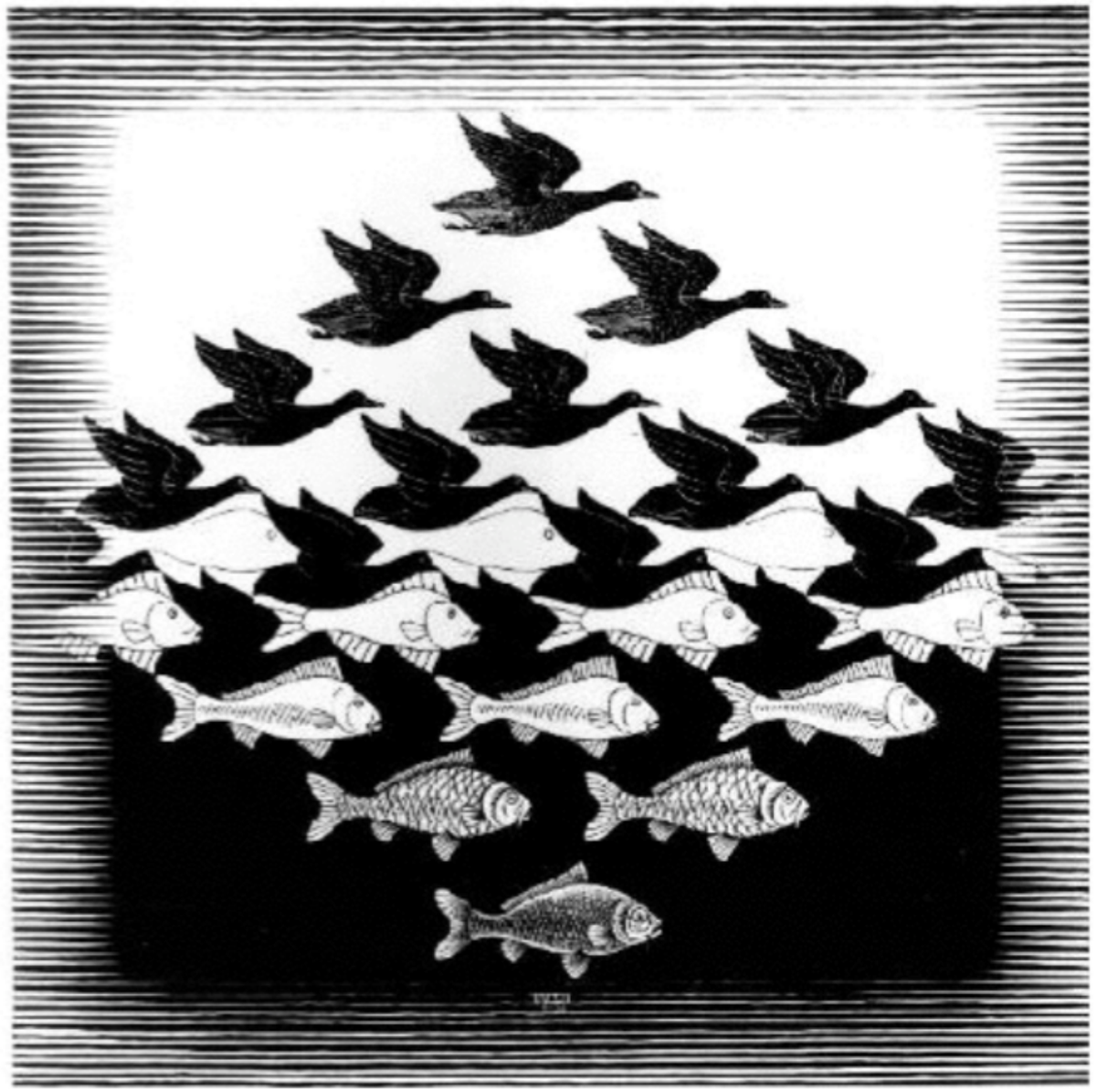


figure / background



M.C. Escher: *Sky and Water I* 1938 woodcut

Gestalt principles

similarity: objects that look like each other (in size, color, or shape) are related

proximity: objects that are visually close to each other are related

connections: objects that are visually connected are related

closure: we see incomplete shapes as complete

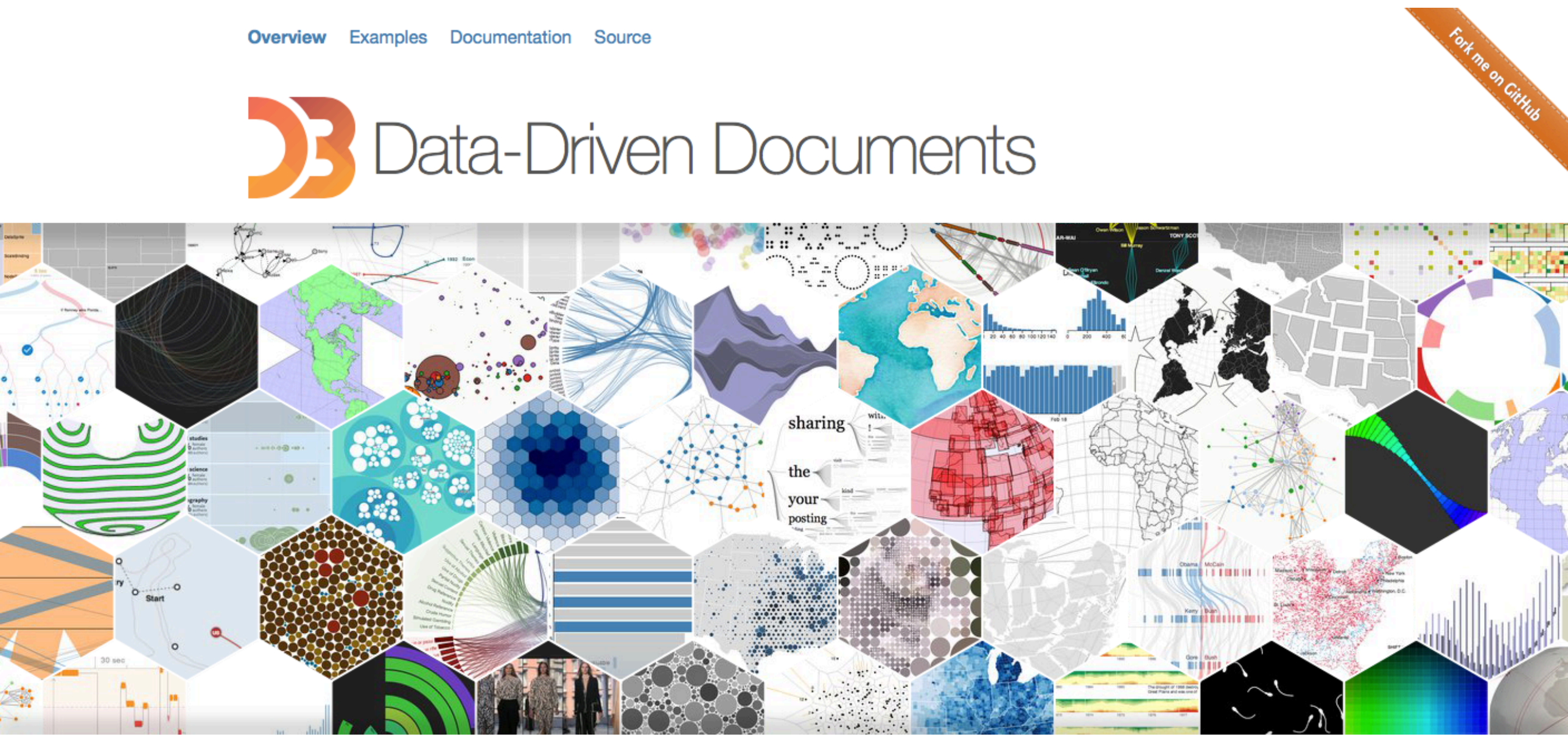
figure / ground: elements are perceived as either figures or background

common fate: elements with the same moving direction are perceived as a unit

next week...

color perception

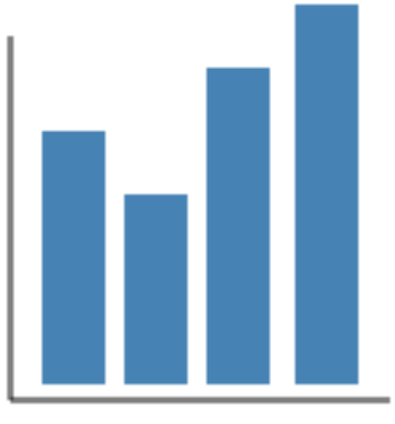
D3: Data-Driven Documents



SVG: a bar chart

```
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <title></title>
    <style>
      rect {
        fill: steelblue
      }
    </style>
</head>
<body>
<svg width="200" height="200">
        <rect x="50" y="50" width="20" height="80"/>
        <rect x="76" y="70" width="20" height="60"/>
        <rect x="102" y="30" width="20" height="100"/>
        <rect x="130" y="10" width="20" height="120"/>
        <line x1="40" x2="160" y1="135" y2="135" stroke="black"/>
        <line x1="40" x2="40" y1="20" y2="135" stroke="black"/>


</svg>
</body>
</html>
```



Exercise:

Create a bar chart in SVG to visualize the following dataset:

Pets animals from a neighborhood survey:

cats	45
dogs	21
iguanas	102

Use the following SVG elements:

```
<rect x="" y="" width="" height=""/>

<line x1="" x2="" y1="" y2="" />

<text x="" y="">Label here</text>
```

```
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <title></title>
    <style>
      rect {
        fill: steelblue
      }
    </style>
</head>
<body>
<svg width="200" height="200">
        <rect x="50" y="50" width="20" height="80"/>
        <rect x="76" y="70" width="20" height="60"/>
        <rect x="102" y="30" width="20" height="100"/>
        <rect x="130" y="10" width="20" height="120"/>
        <line x1="40" x2="160" y1="135" y2="135" stroke="black"/>
        <line x1="40" x2="40" y1="20" y2="135" stroke="black"/>


</svg>
</body>
</html>
```

Exercise 2:

Repeat the previous exercise. Instead of “hardcoding” the attributes of SVG elements, adjust them programmatically using JavaScript

```
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <title></title>
</head>
<body>
<svg width="400" height="200">

    <rect id="bar1" x="50" y="50" width="30" height="100" style="fill: steelblue"/>
    <rect id="bar2" x="92" y="50" width="30" height="100" style="fill: steelblue"/>
    <rect id="bar3" x="134" y="50" width="30" height="100" style="fill: steelblue"/>

    <line x1="40" x2="220" y1="150" y2="150" stroke="black"/>
    <line x1="40" x2="40" y1="0" y2="150" stroke="black"/>

</svg>

  <script type="text/javascript">

    var CHART_HEIGHT = 130;

    var pets = [45, 21, 102];

    for (var i=0; i<pets.length; i++) {

        var bar = document.getElementById("bar" + (i+1));

        bar.setAttribute('height', (pets[i] / 102) * CHART_HEIGHT);
    }
  </script>

</body>
</html>
```

Pets dataset as an array

For loop to iterate through dataset

Get a reference to a “rect” element

Adjust “height” attribute

Exercise 3:

Repeat the previous exercise. Instead of using pure JavaScript, use D3 selections

```
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <script src="https://d3js.org/d3.v3.min.js"></script>
    <title></title>
</head>
<body>
<svg width="400" height="200">

    <rect id="bar1" x="50" y="50" width="30" height="100" style="fill: steelblue"/>
    <rect id="bar2" x="92" y="50" width="30" height="100" style="fill: steelblue"/>
    <rect id="bar3" x="134" y="50" width="30" height="100" style="fill: steelblue"/>

    <line x1="40" x2="220" y1="150" y2="150" stroke="black"/>
    <line x1="40" x2="40" y1="0" y2="150" stroke="black"/>

</svg>

  <script type="text/javascript">

    var CHART_HEIGHT = 130;

    var pets = [45, 21, 102];

    var selection = d3.select('svg').selectAll('rect').data(pets)
    selection.attr('height', function(d) { return (d/102) * CHART_HEIGHT; });
  </script>

</body>
</html>
```

selection and data binding

Change visual attributes of rectangles (height, specifically)

Exercise 4:

Loading a CSV file and visualizing the data

http://khreda.com/teaching/cs526/d3-excercises/