

Visualization in HCI

05 - 499 / 05 - 899 Section C



Perception

February 13, 2017

Perception

Identification and interpretation of sensory information

From the physical stimulus to recognizing information

Shaped by learning, memory, expectation

Cognition

The processing of information, applying knowledge

Hear someone speak: Perception

Understand the language and the words: Cognition

Perception vs. Cognition

Perception

Eye, optical nerve, visual cortex

Basic perception

First processing
(edges, planes)

Not conscious

Reflexes

Cognition

Recognizing objects

Relations between objects

Conclusion drawing

Problem solving

Learning, ...

RED

GREEN

BLUE

YELLOW

PINK

ORANGE

BLUE

GREEN

BLUE

WHITE

GREEN

YELLOW

ORANGE

BLUE

WHITE

BROWN

RED

BLUE

YELLOW

GREEN

PINK

YELLOW

GREEN

BLUE

RED

Looking vs. Seeing



Emergence Images. perceptual hysteresis



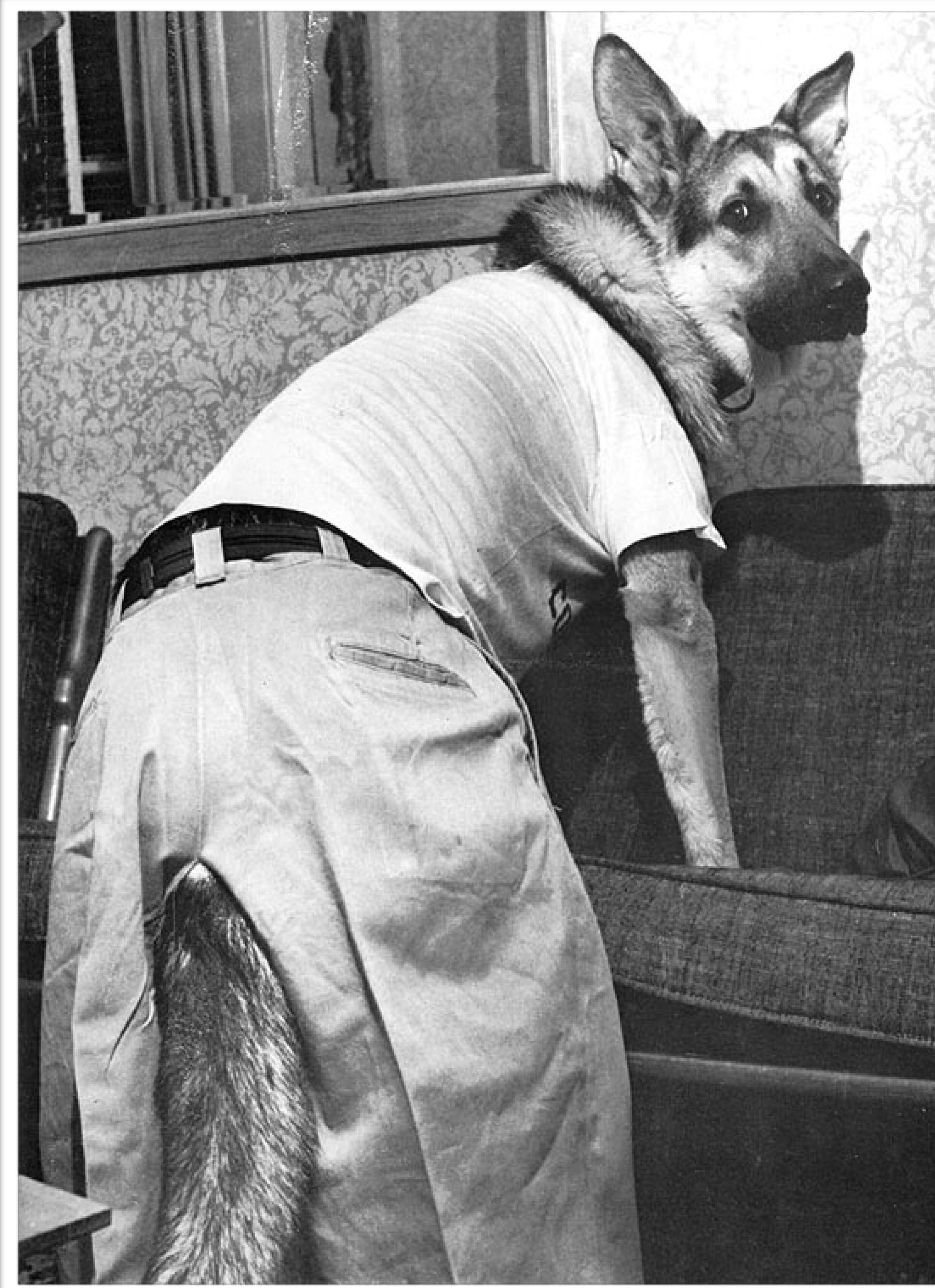
Looking only at patches doesn't work

http://graphics.stanford.edu/~niloy/research/emergence/emergence_image_siga_09.html





we rely on priors



Pareidolia



Faces in Things @FacesPics · Mar 9

These chairs have seen some terrible things pic.twitter.com/Gjlc9wuP47



Faces in Things @FacesPics · Mar 22

Hey little guy! pic.twitter.com/nt2BgwZeTR



Faces in Things @FacesPics · Mar 10

A terrified pickle pic.twitter.com/Ffph1wzTyv



Faces in Things @FacesPics · Feb 14

Deep in thought Deep Fryer pic.twitter.com/1Qyqjmslka



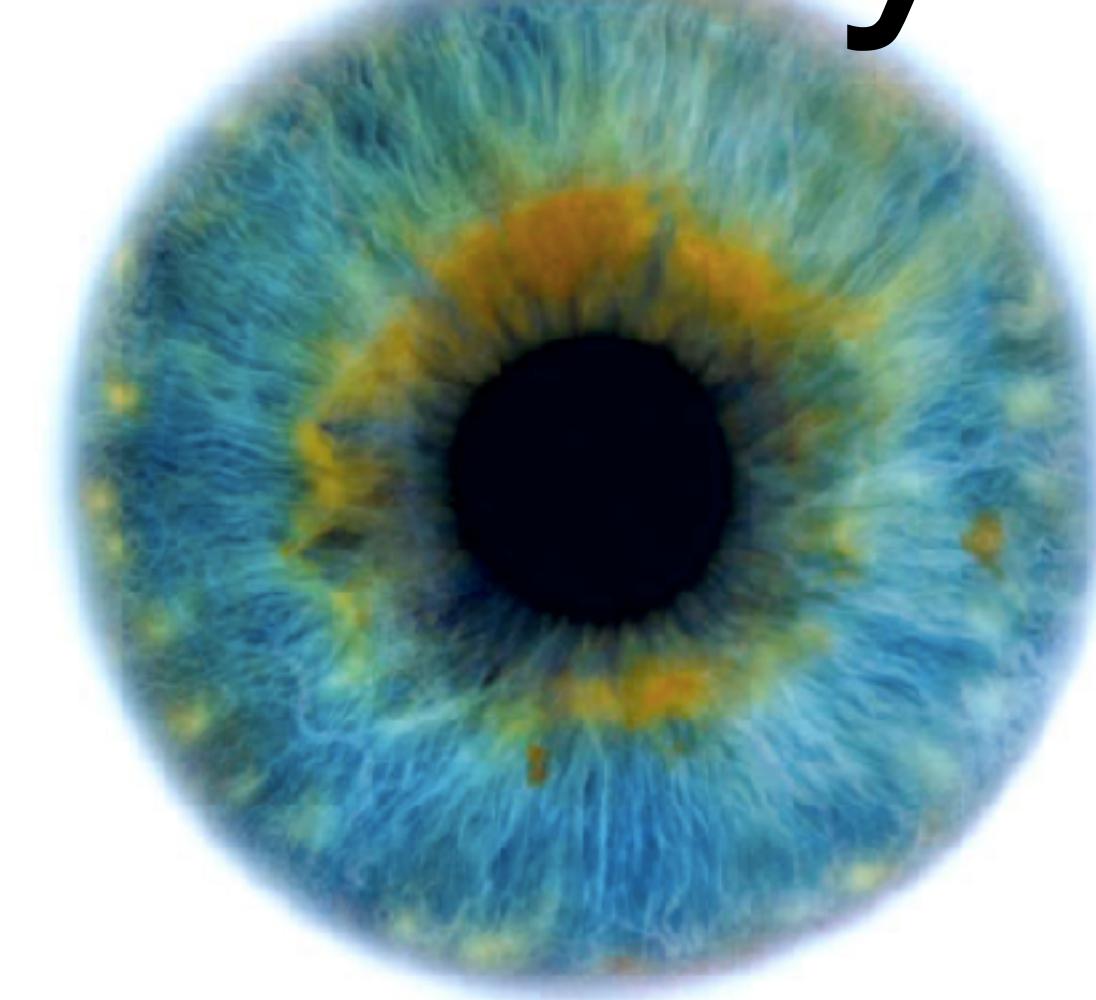
Take Home Point

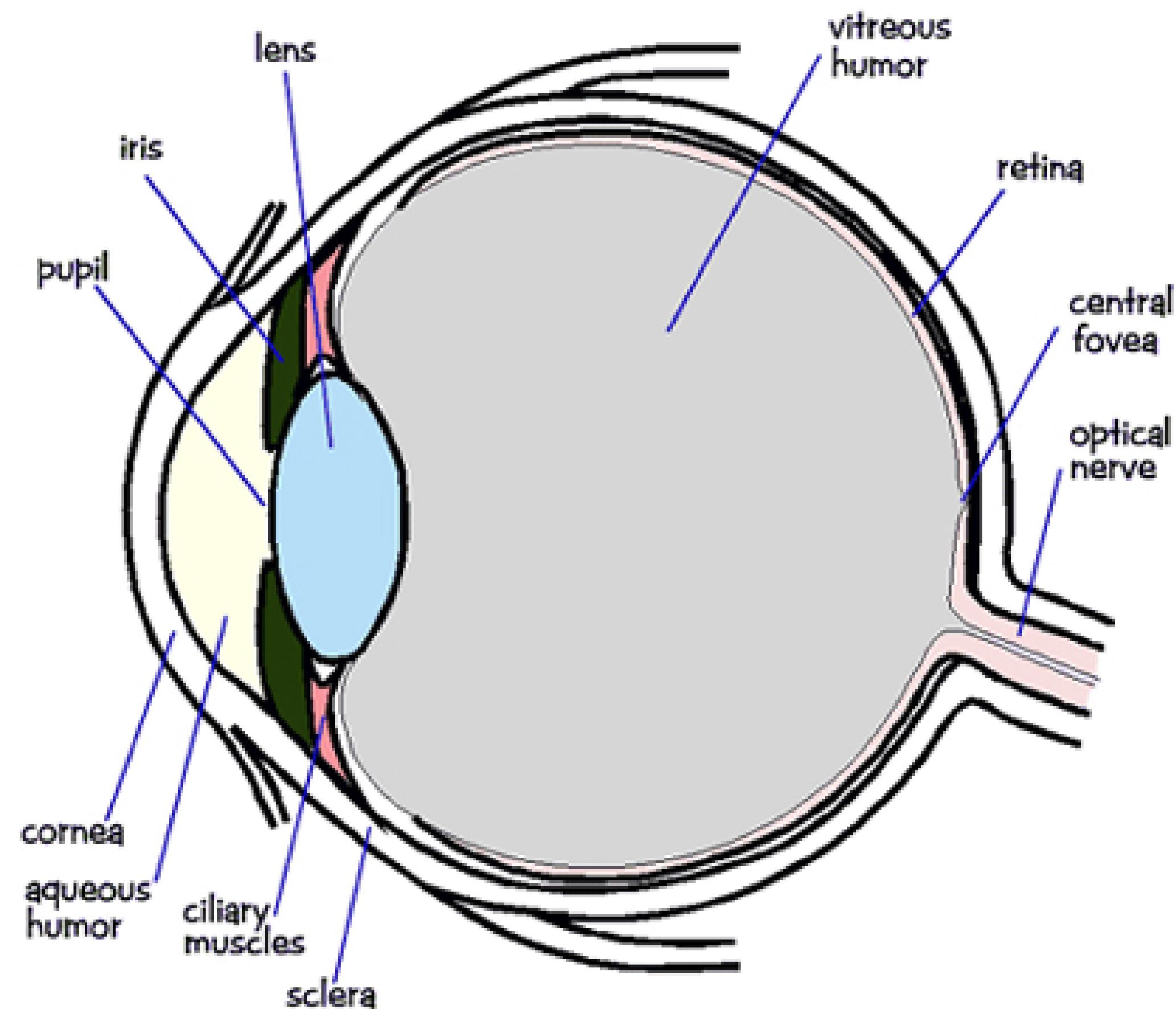
Vision is “constructed” top down from the input

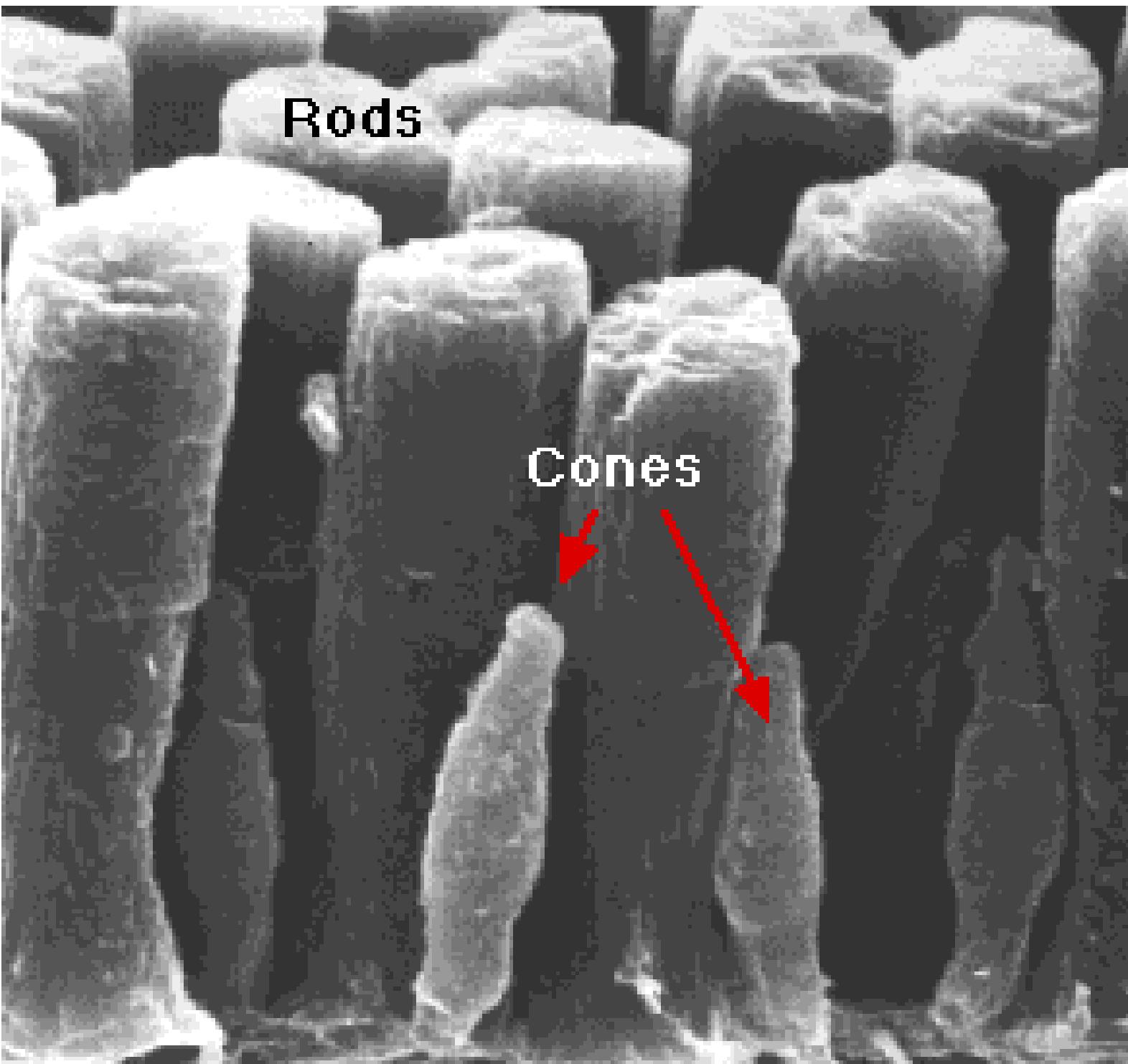
“What you see when you see a thing depends on what the thing is. What you see the thing as depends on what you know about what you are seeing.”

Zenon W. Pylyshyn
Canadian Cognitive Scientist
and Philosopher

The Eye







~120 million rods

~5-6 million cones

Category	Value	Percentage	Mean	Median
High Income	42,000	28.7%	10,000	10,000
Low Income	3,000	2.1%	1,000	1,000
Medium Income	8,000	5.6%	8,000	8,000
Total	15,000	20.8%	15,000	15,000
High Income	101,837	26.8%	467,400	400
Low Income	128,112	24.9%	640,56	400
Medium Income	23,953	22.7%	83,184	83,184
Total	353,902	24.5%	82,944	82,944
High Income	156,418	26.7%	416,061	300
Low Income	4,278	17.3%	9,250	9,250
Medium Income	11,565	19.8%	13,810	13,810
Total	172,251	28.6%	13,810	13,810
High Income	176,000	28.9%	490,000	400
Low Income	71,000	28.7%	97,000	97,000
Medium Income	21,000	28.7%	21,000	21,000
Total	268,000	28.7%	268,000	268,000

Human Visual System

VIDEO!

Vision works as sequence of **fixations** and **saccades**

fixations: maintaining gaze on single location (200-600 ms)

saccades: moving between different locations (20-100 ms)

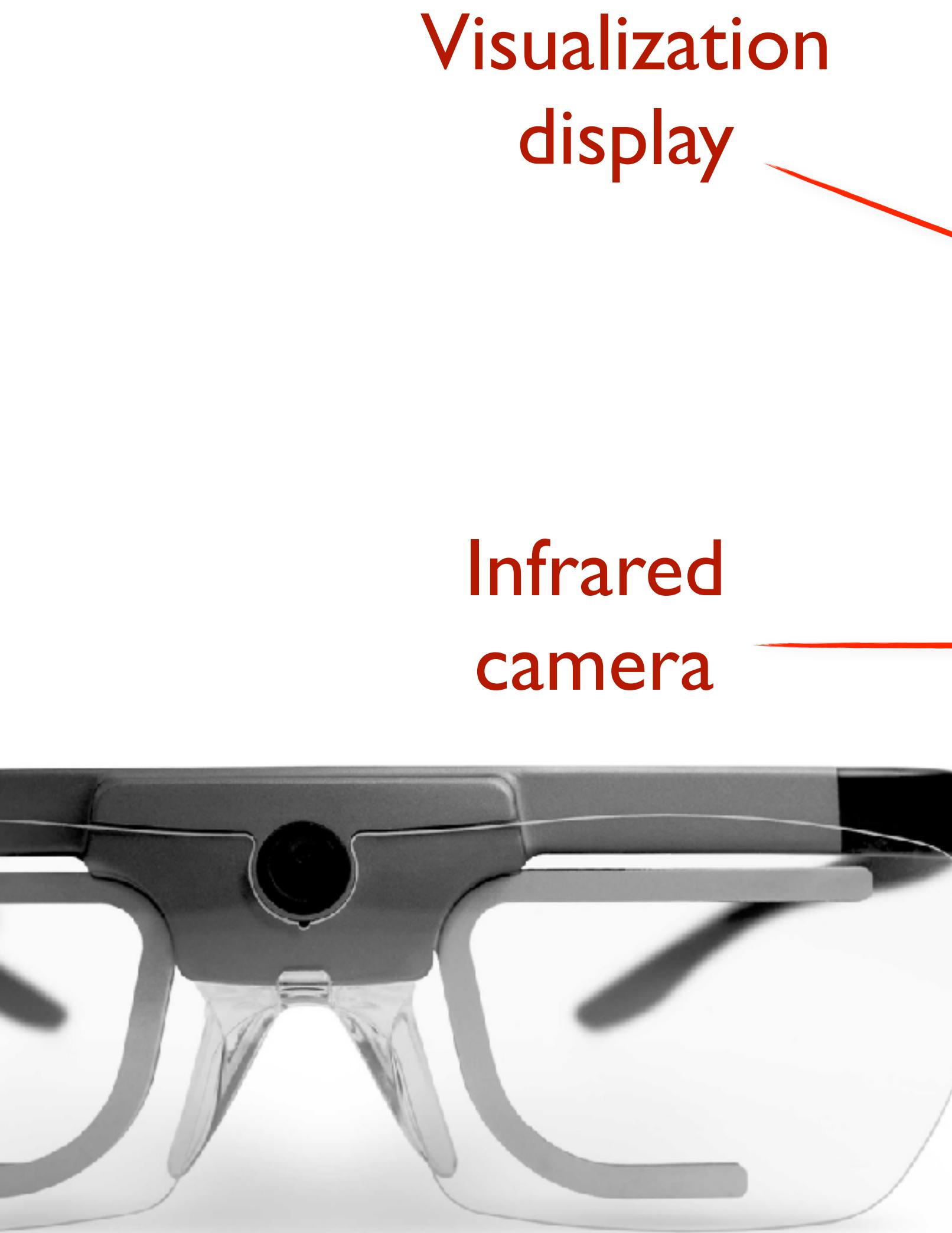
Vision not similar to a camera

More similar to a dynamic and ongoing construction project

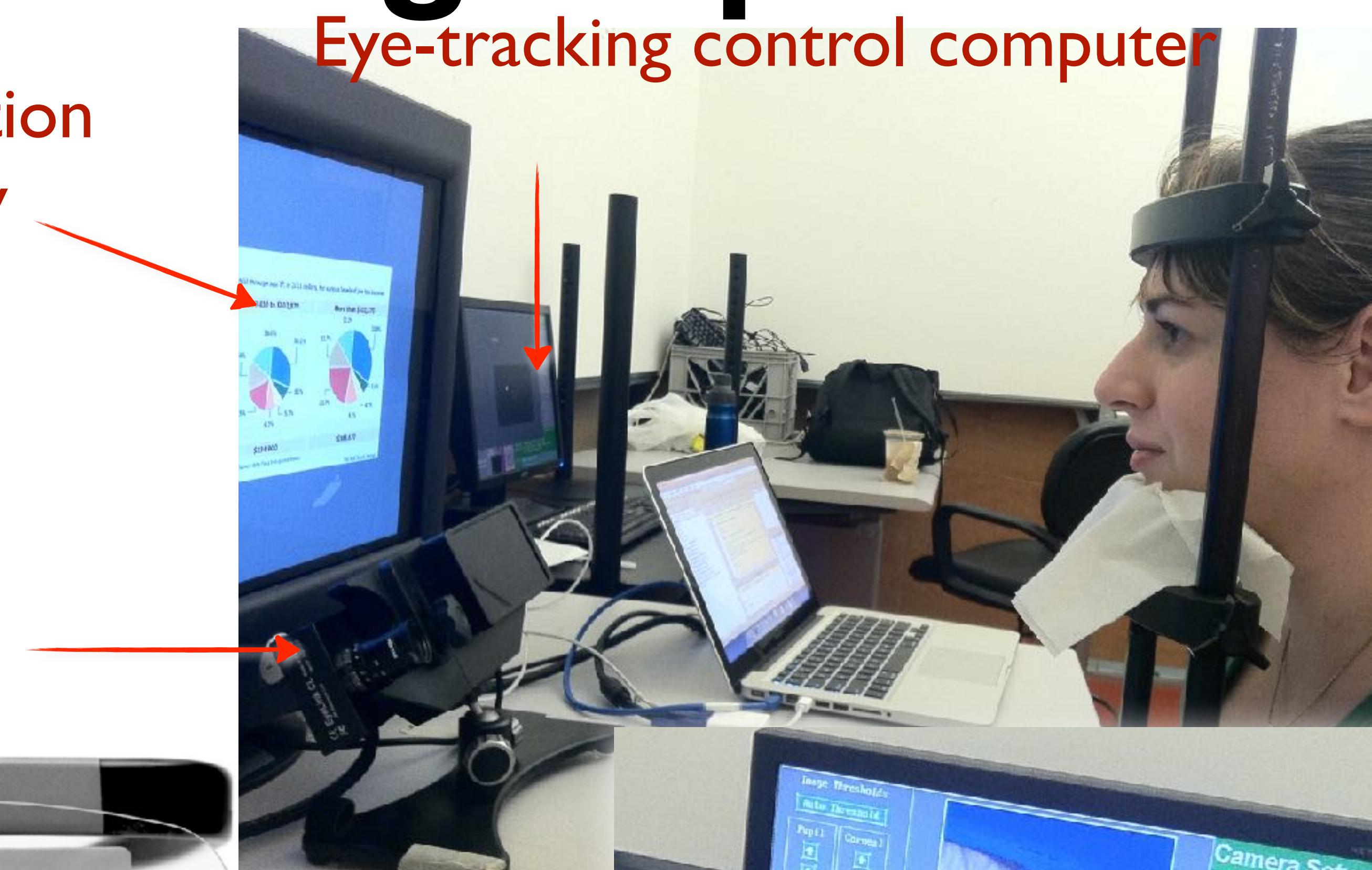




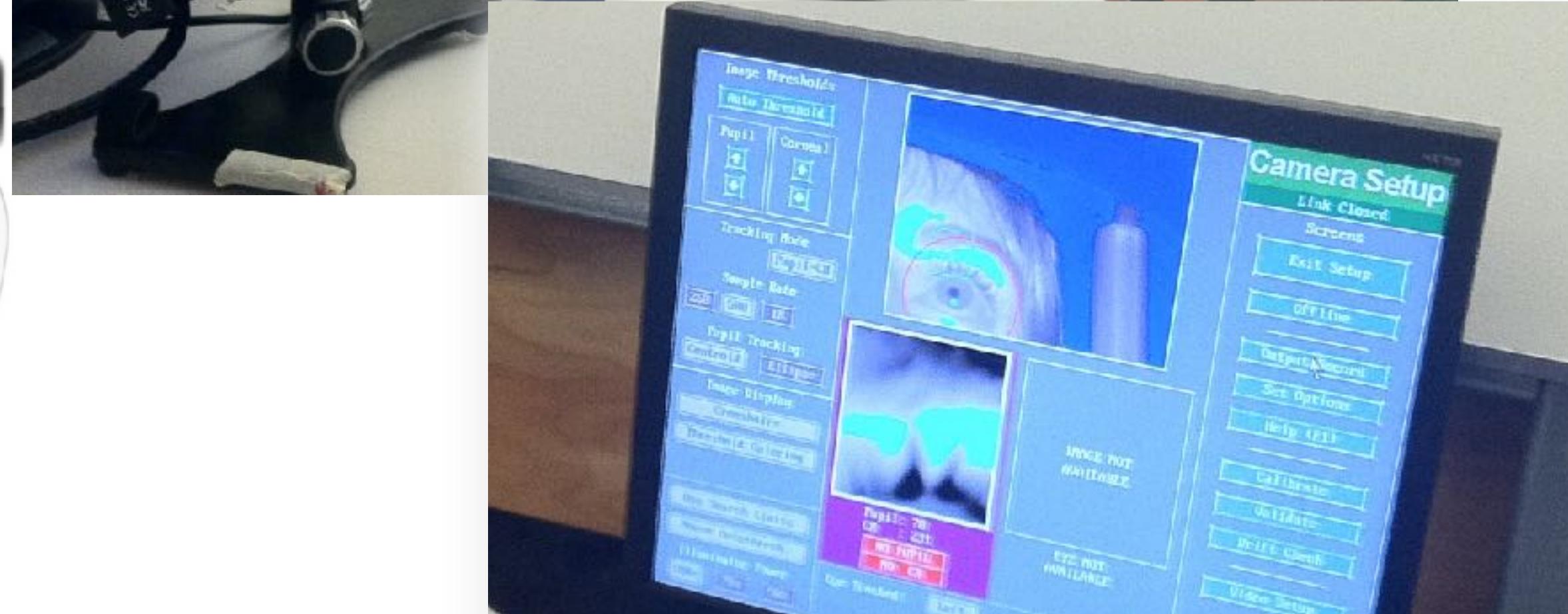
Eye-Tracking Experiment



Visualization
display



Eye-tracking control computer



Video!



SensoMotoric Instruments presents

Karaoke

Gaze Tracking and User Observation

Human Visual System

VIDEO!

No general purpose vision

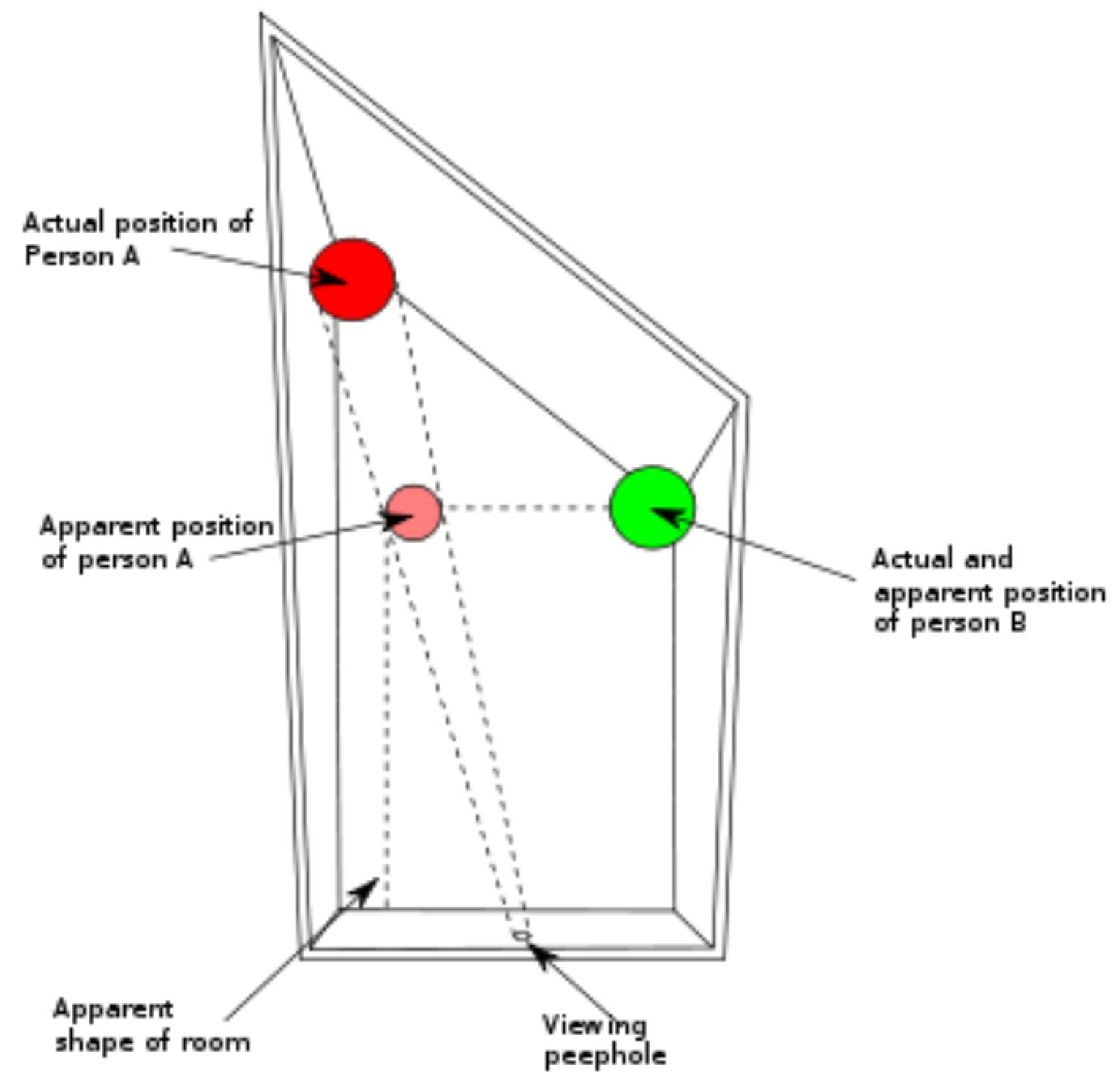
What we see depends on our goals and expectations

Relative judgments: strong

Absolute judgments: weak



Ames Room

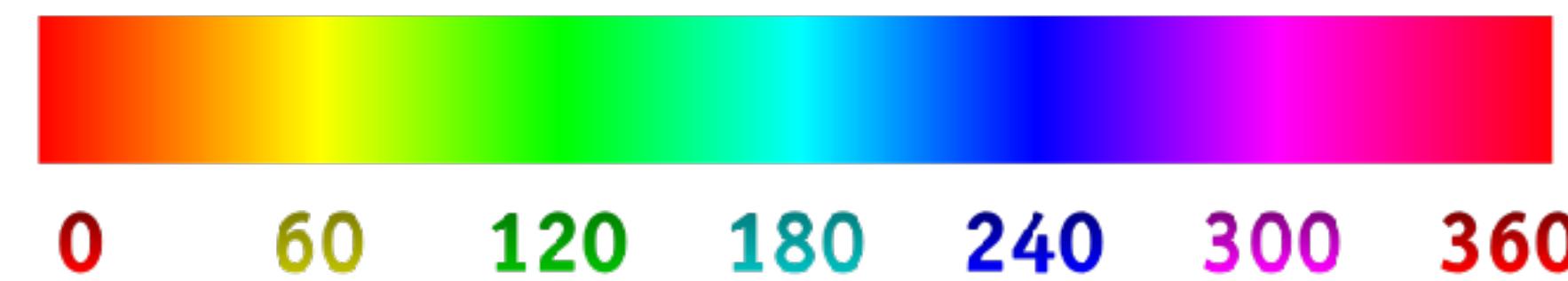




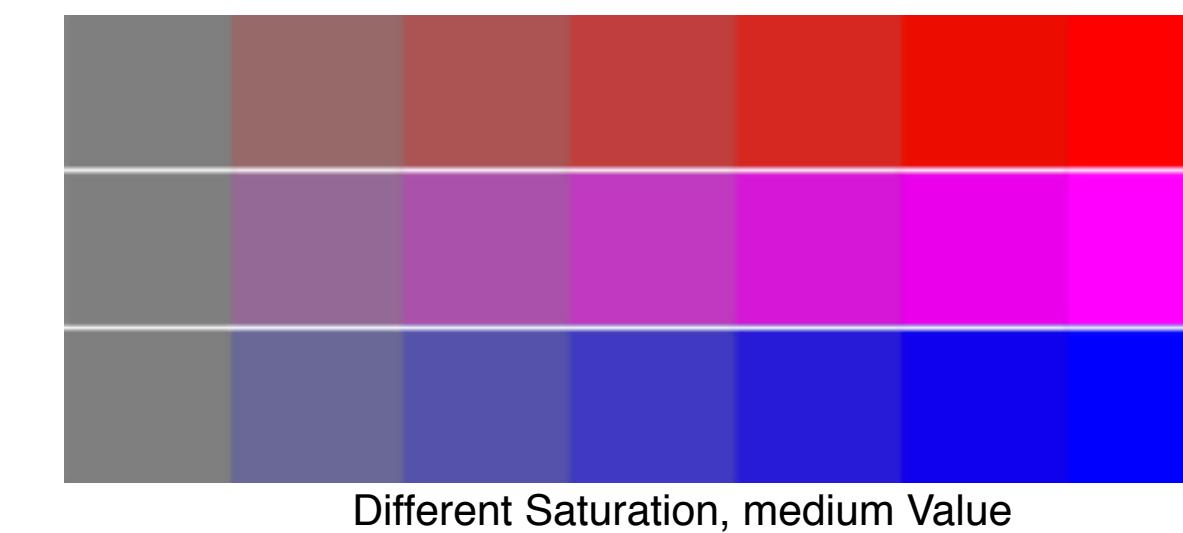
Color

Dimensions of Color

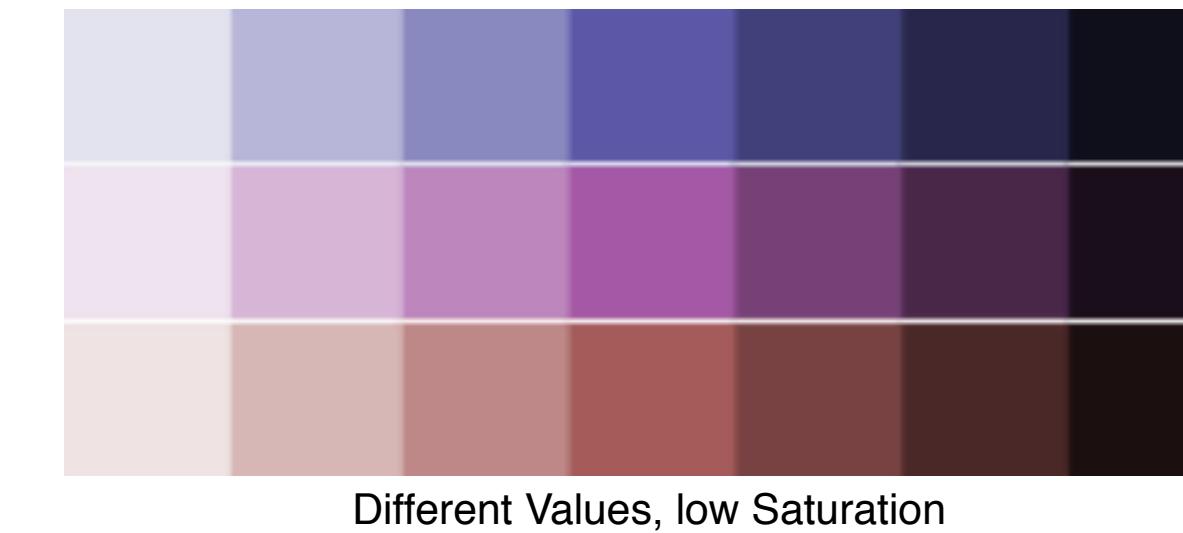
Hue



Saturation



Luminance

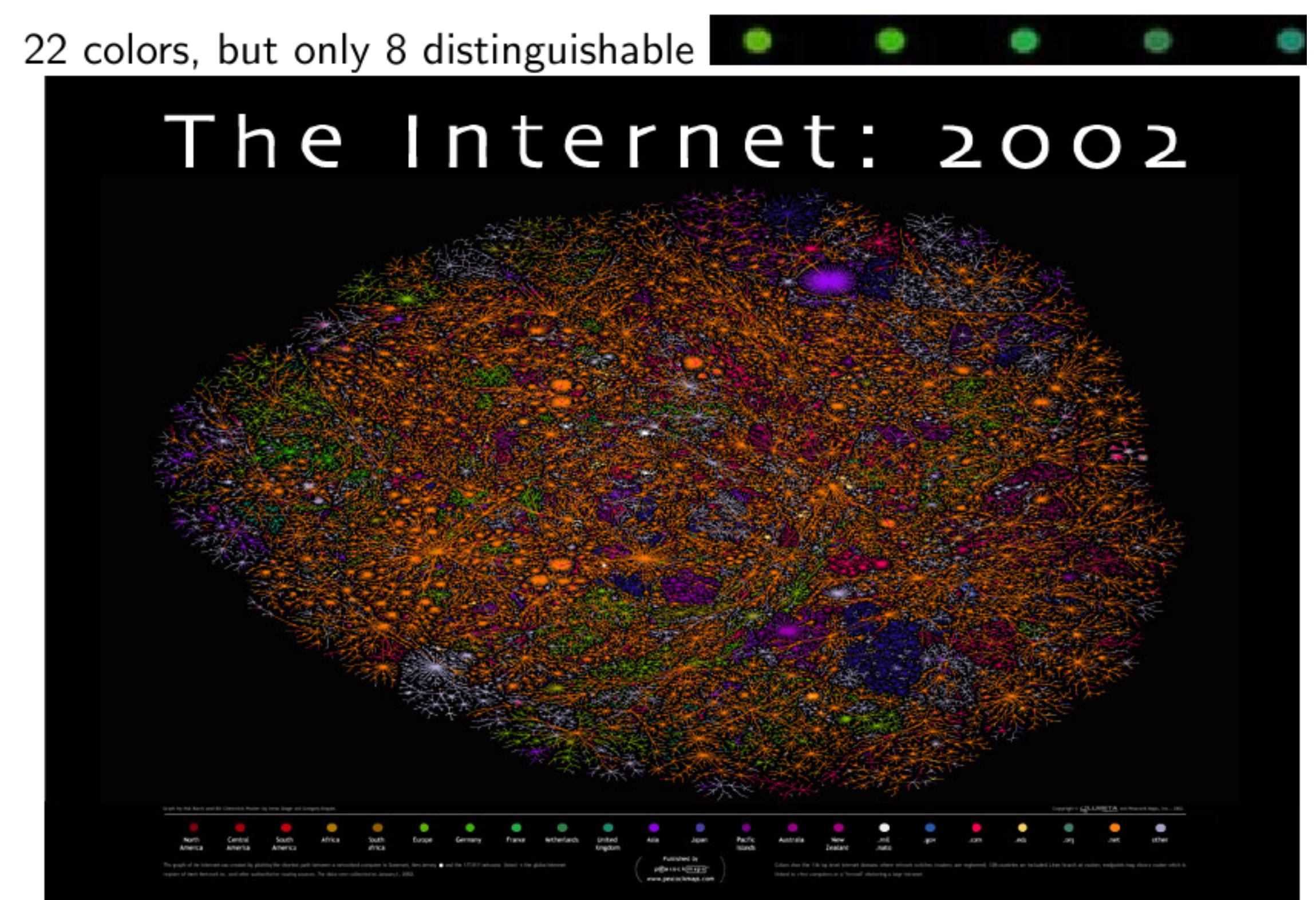


Qualitative Data Vis

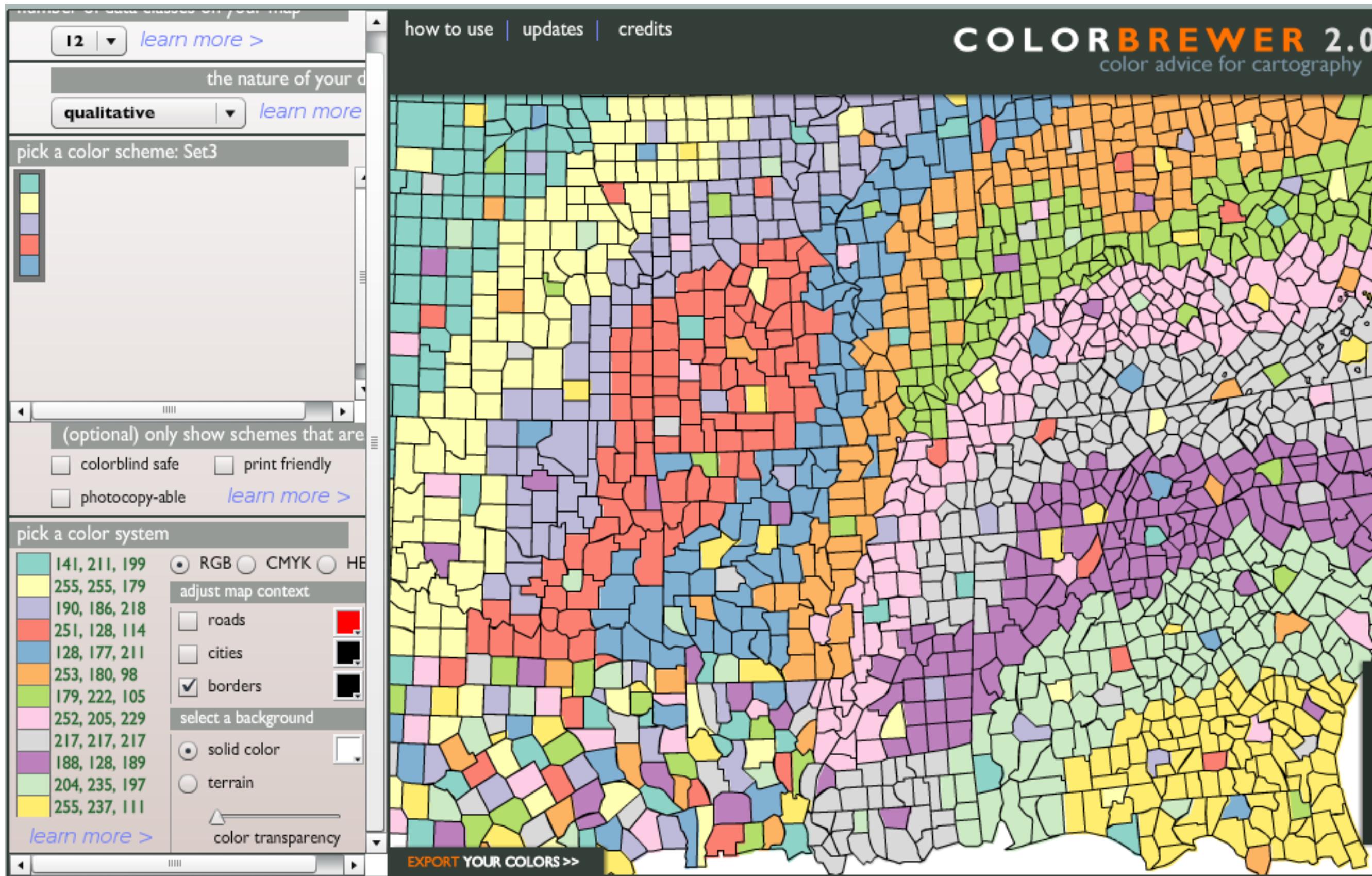
Color labeling (nominal information coding)

recommended: about 6, no more than 10

22 colors, but only 8 distinguishable



Application: Labeling



Carefully designed color scheme for 12 colors [colorbrewer]

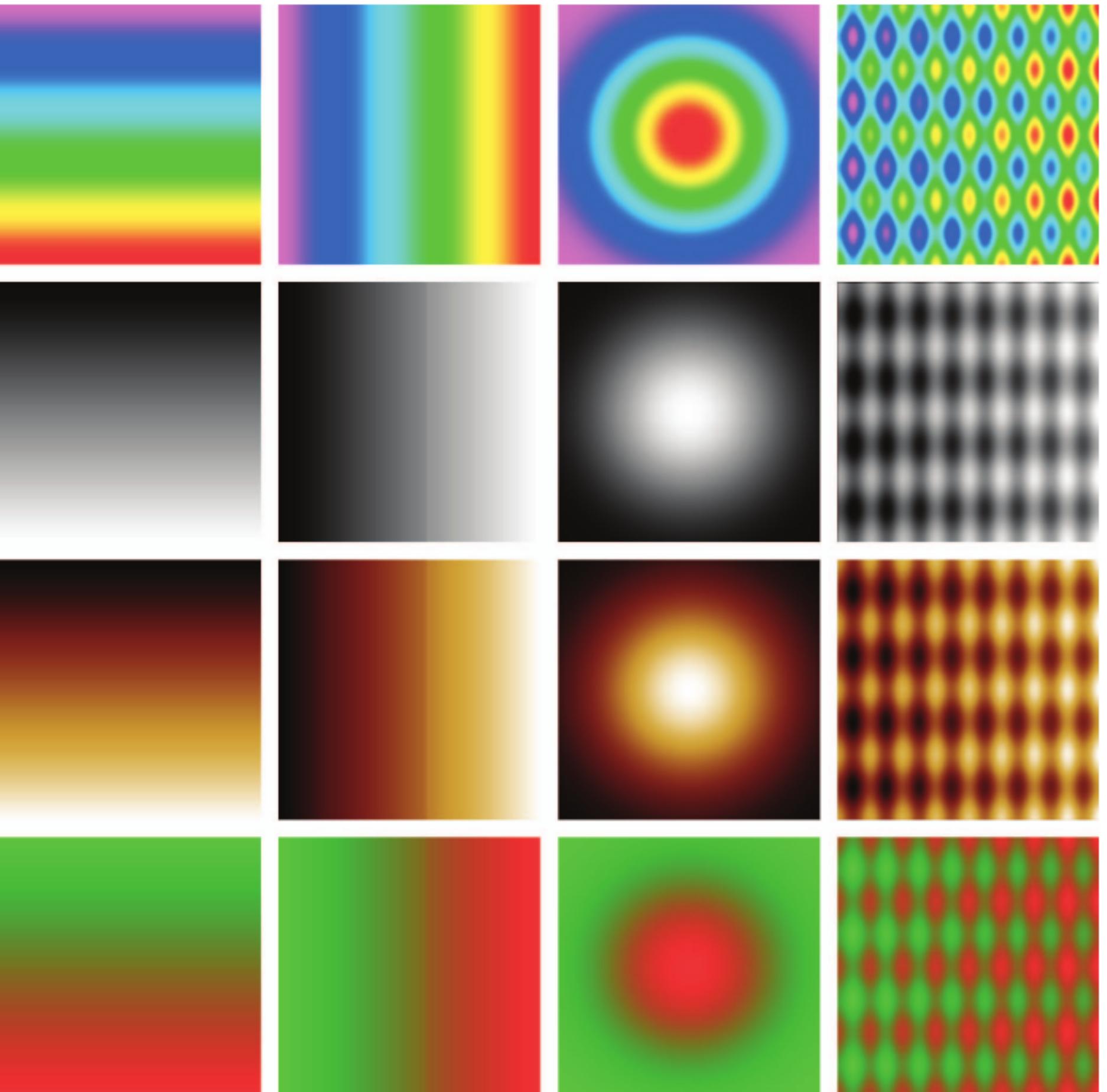
Quantitative Data Vis

use value

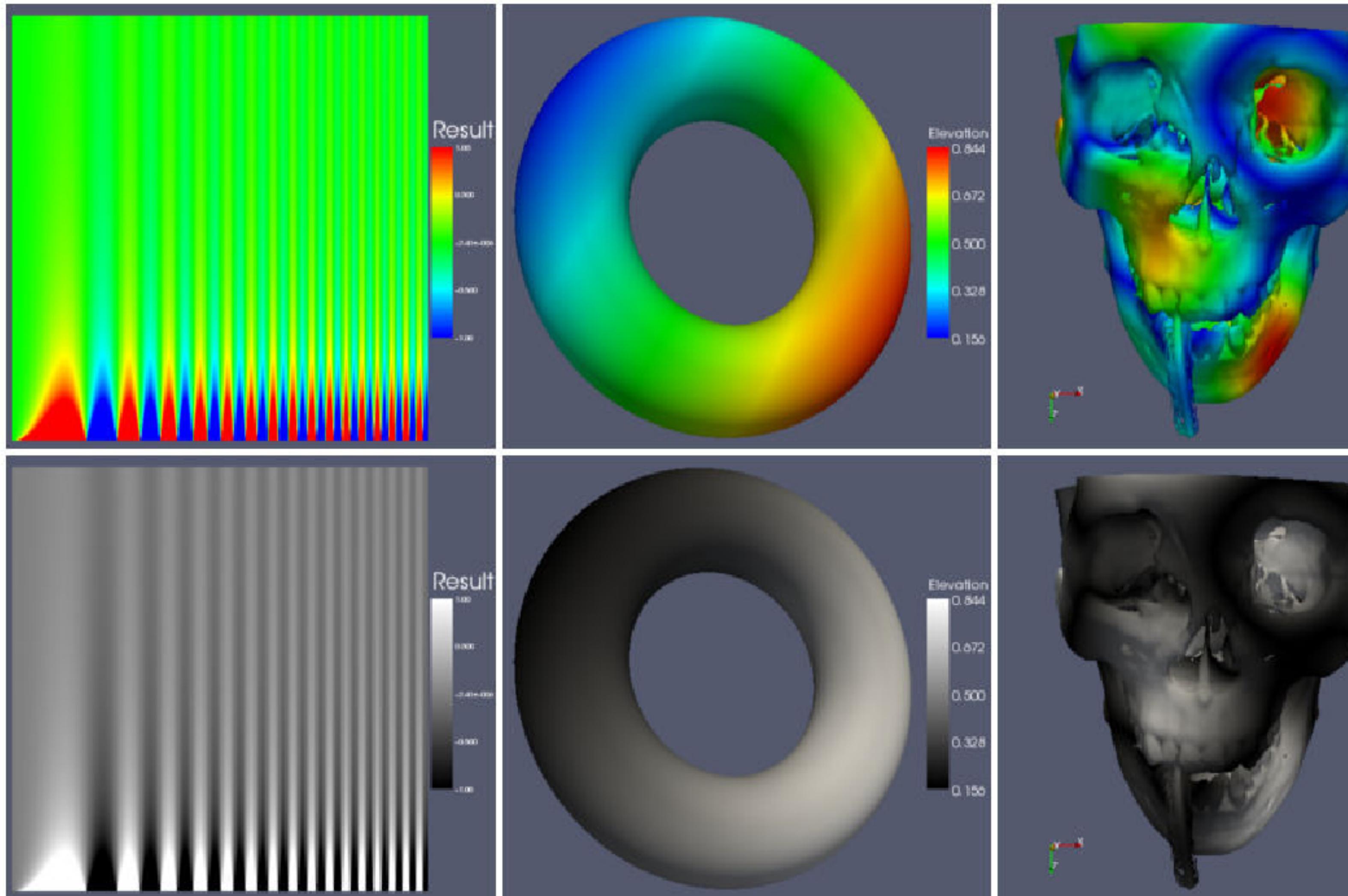
saturation works but not as good

don't use hue!

Danger: rainbow color map



Rainbow vs. Value Color map



Design Critique

Four Ways to Slice Obama's 2013 Budget Proposal

Explore every nook and cranny of President Obama's federal budget proposal.

All Spending Types of Spending Changes Department Totals

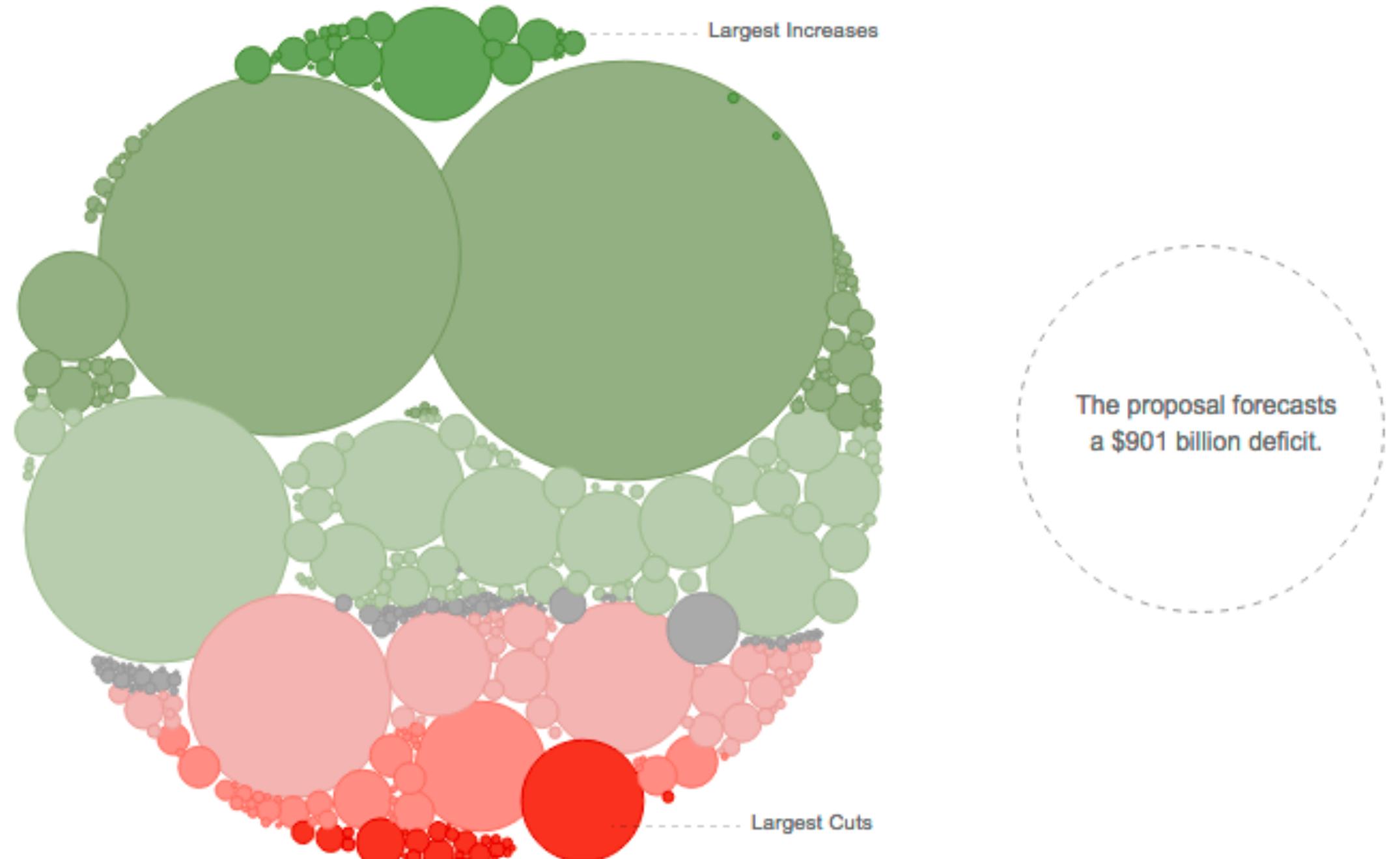
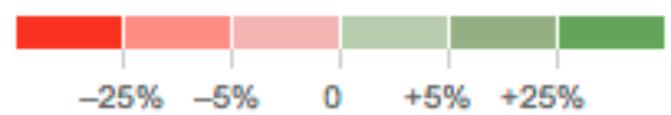
How \$3.7 Trillion Is Spent

Mr. Obama's budget proposal includes \$3.7 trillion in spending in 2013, and forecasts a \$901 billion deficit.

Circles are sized according to the proposed spending.



Color shows amount of cut or increase from 2012.

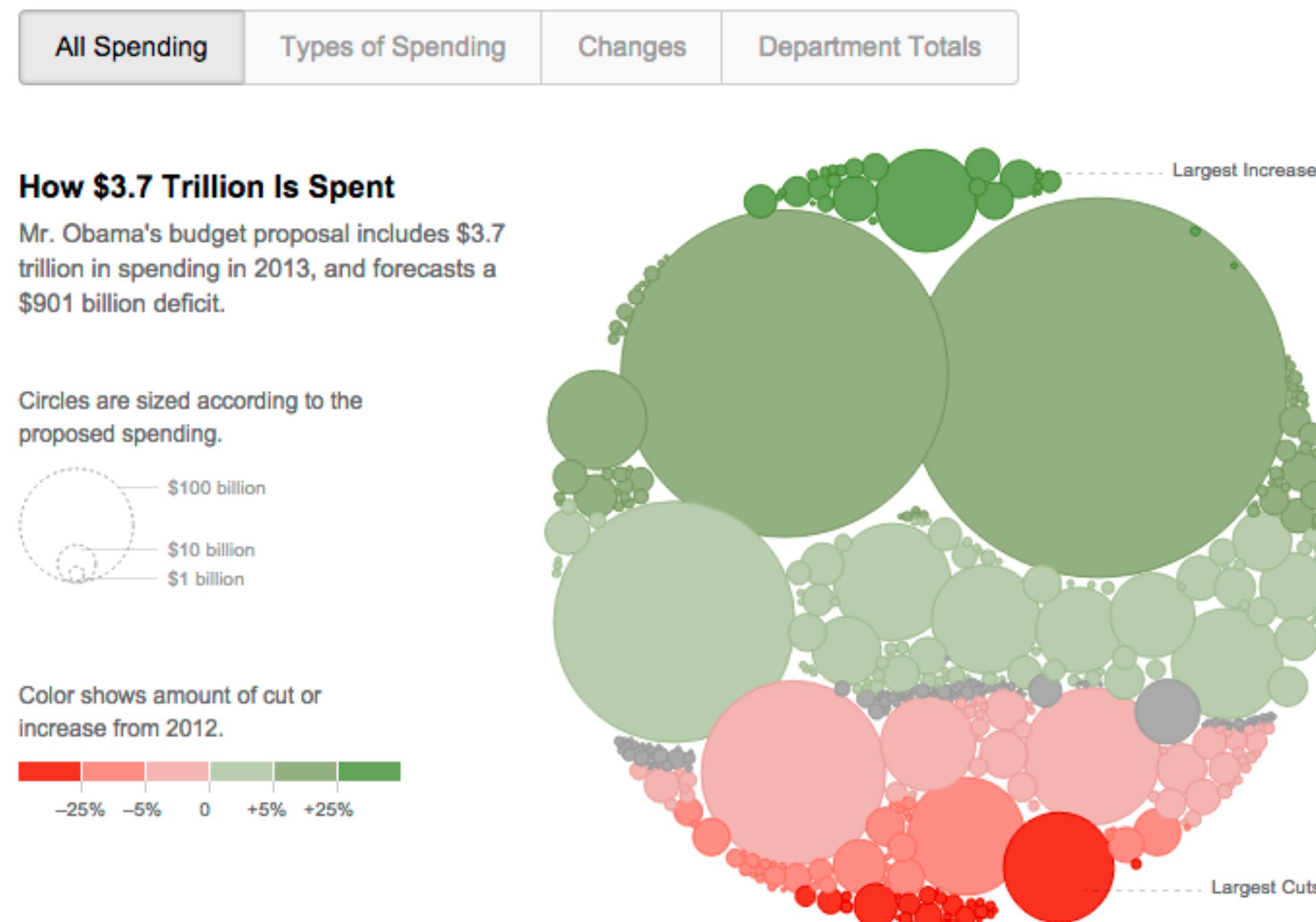


Source: <http://bit.ly/feb13-source>

In your discussion group please answer the following questions:

Four Ways to Slice Obama's 2013 Budget Proposal

Explore every nook and cranny of President Obama's federal budget proposal.



Source: <http://bit.ly/feb13-source>

- What is the primary visual encoding in panel 1? Is there a redundant encoding? Are these good choices?
- What tasks do you think the creators had in mind?
- How is position used in panel 1? How is position used (both in x and y) in panel 3 (changes)?
- What do you think about the use of animation?
- What do you think about the vis in panel 4 (Departmental Totals)?
- Is the visualization easy to understand?
- Can you read the data from the visualization?
- Why do you like / dislike this visualization?
- Can you suggest any improvements? How would you redesign it?

Color Blindness

10% of males, 1% of females (probably due to X-chromosomal recessive inheritance)

Most common: red-green weakness / blindness

Reason: lack of medium or long wavelength receptors, or altered spectral sensitivity (most common: green shift)



Normal Color Perception

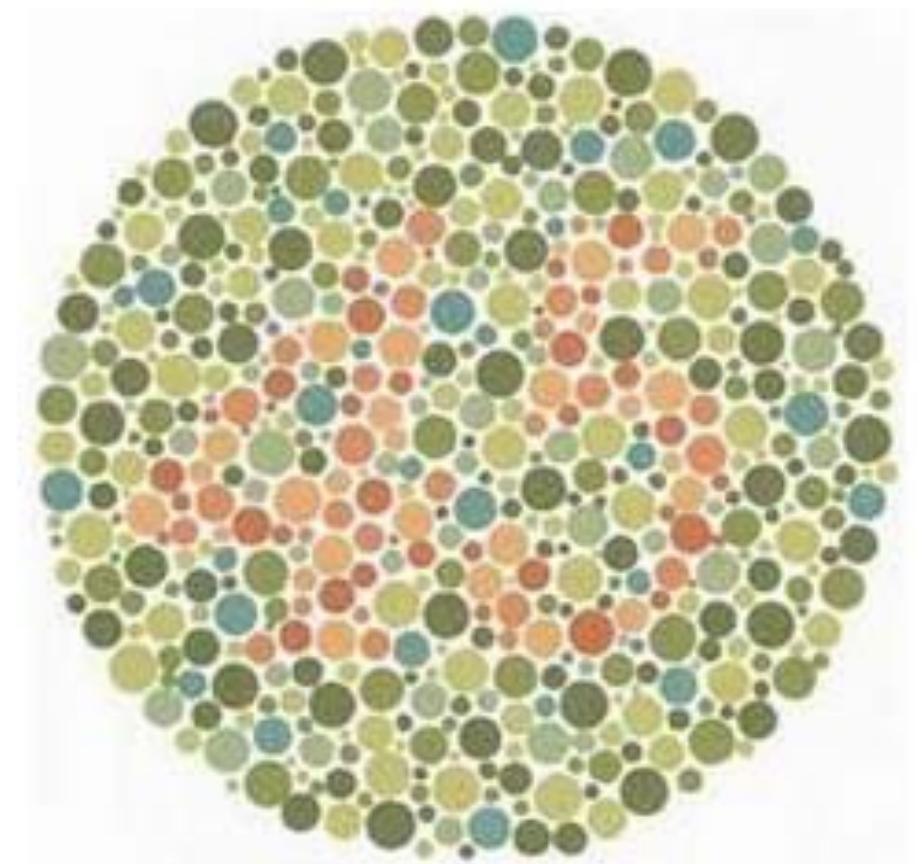
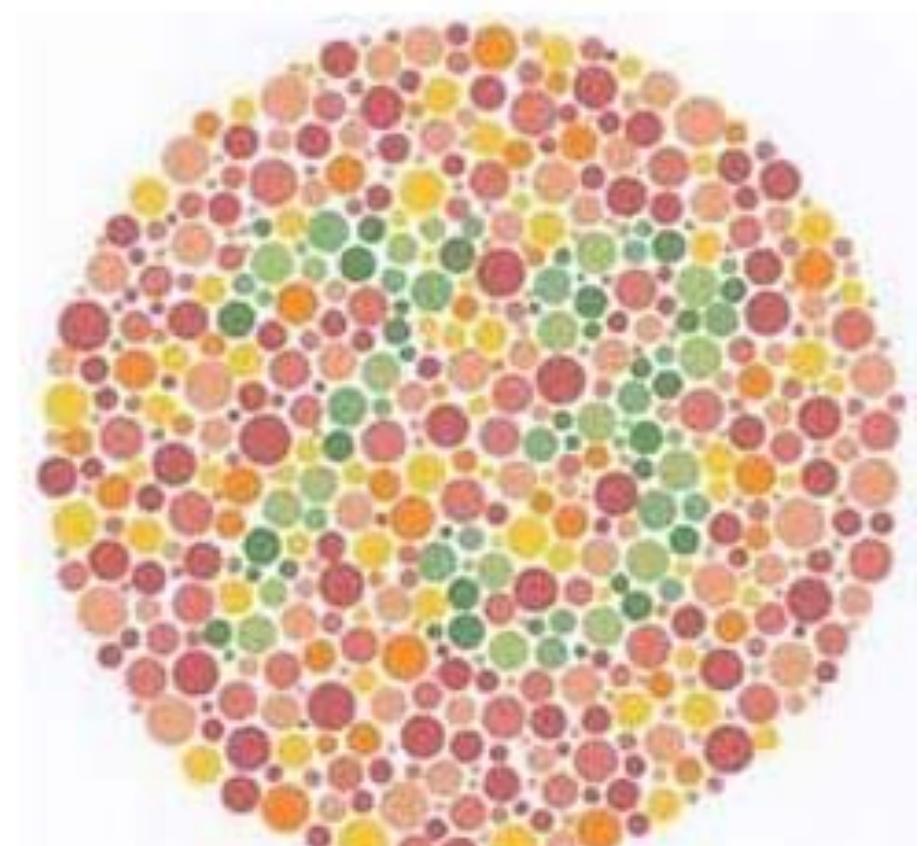
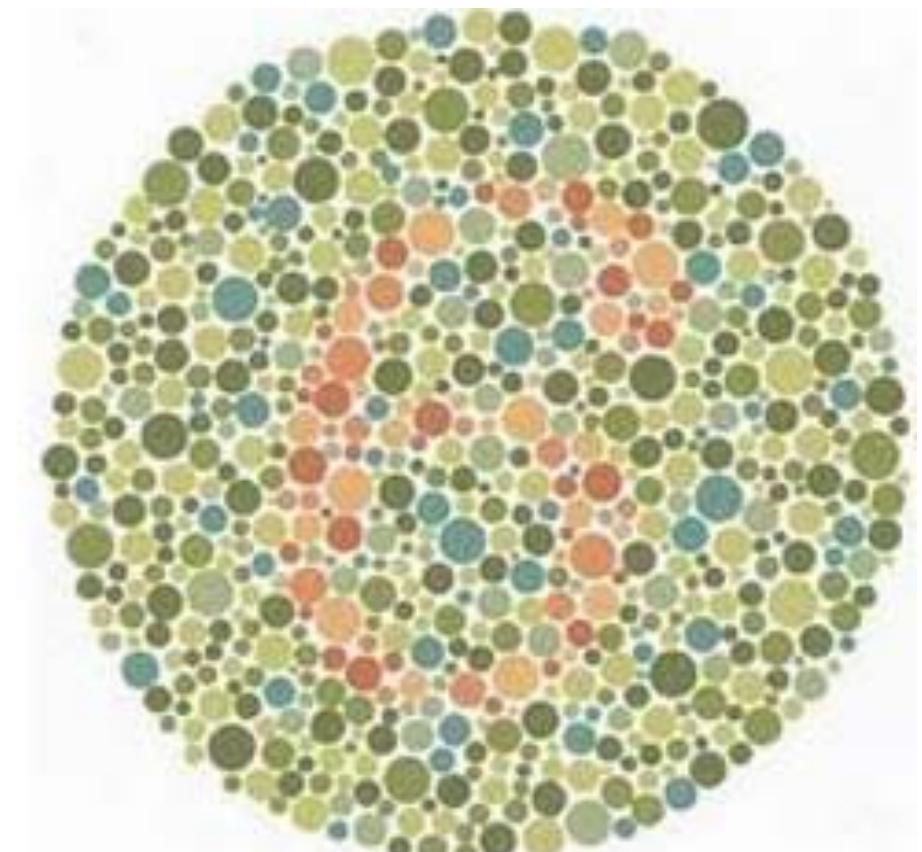
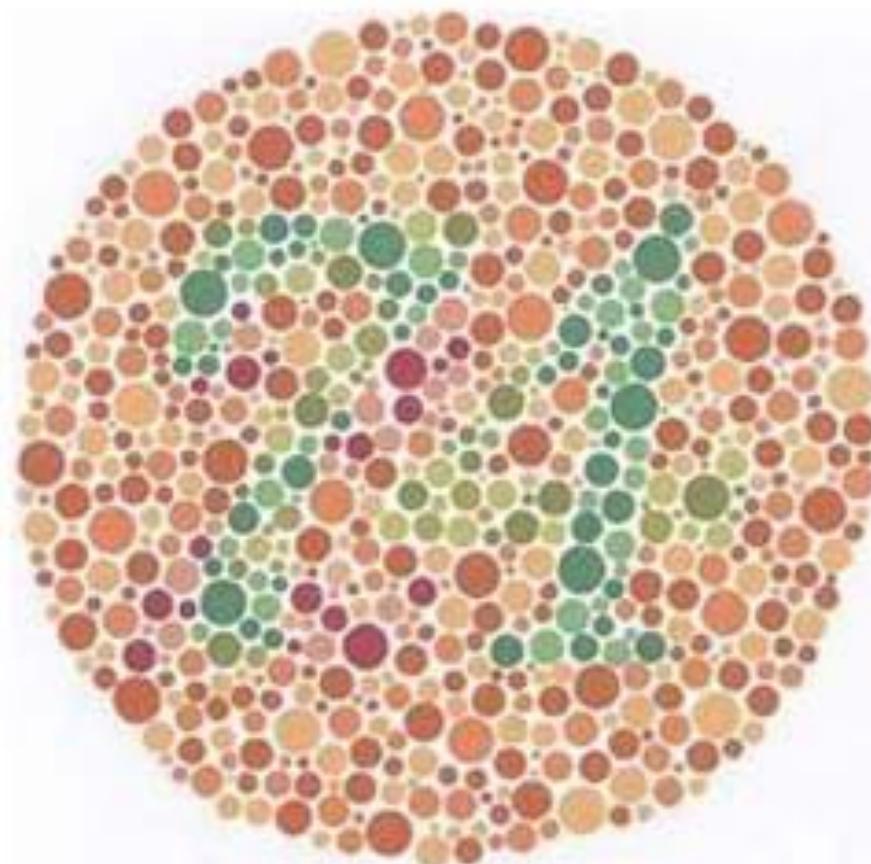
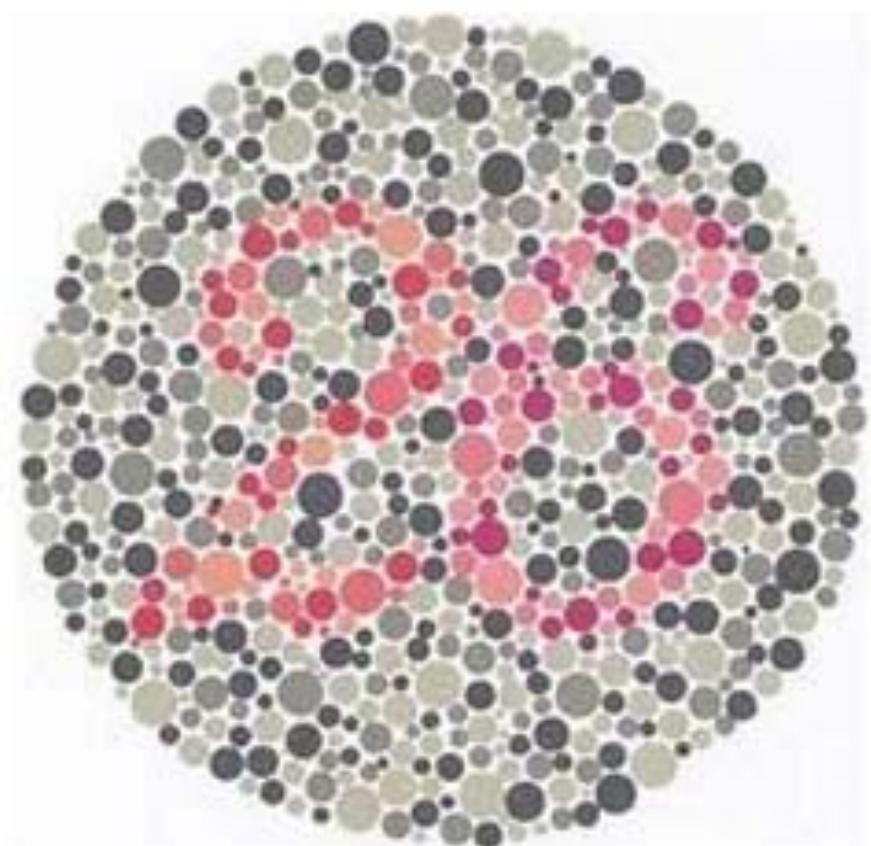
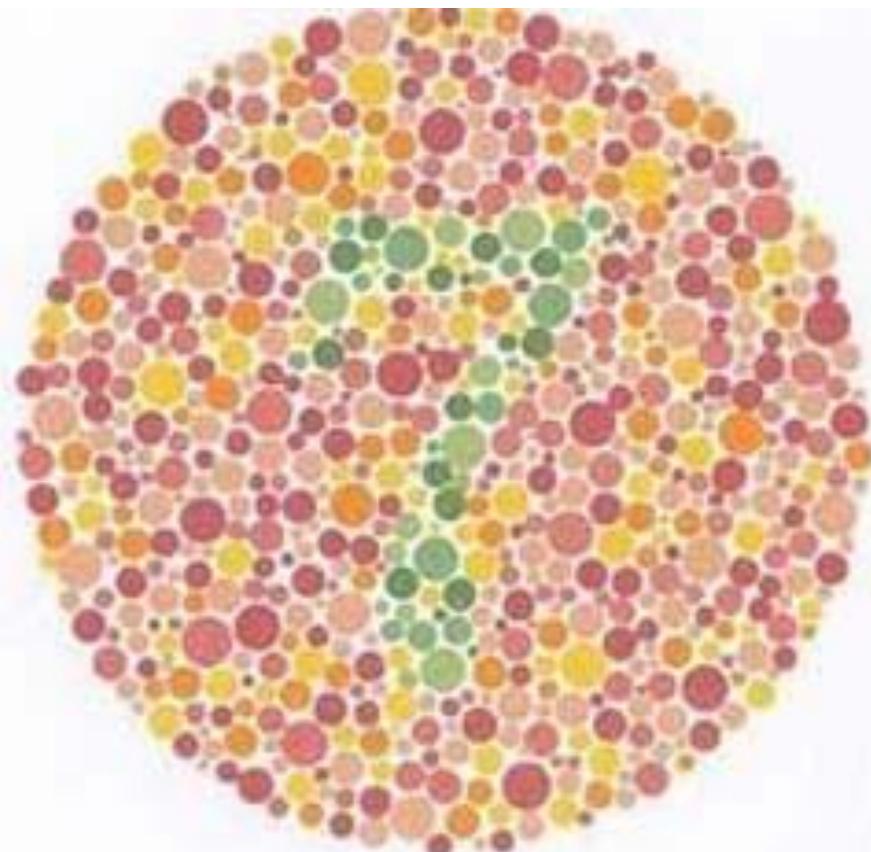
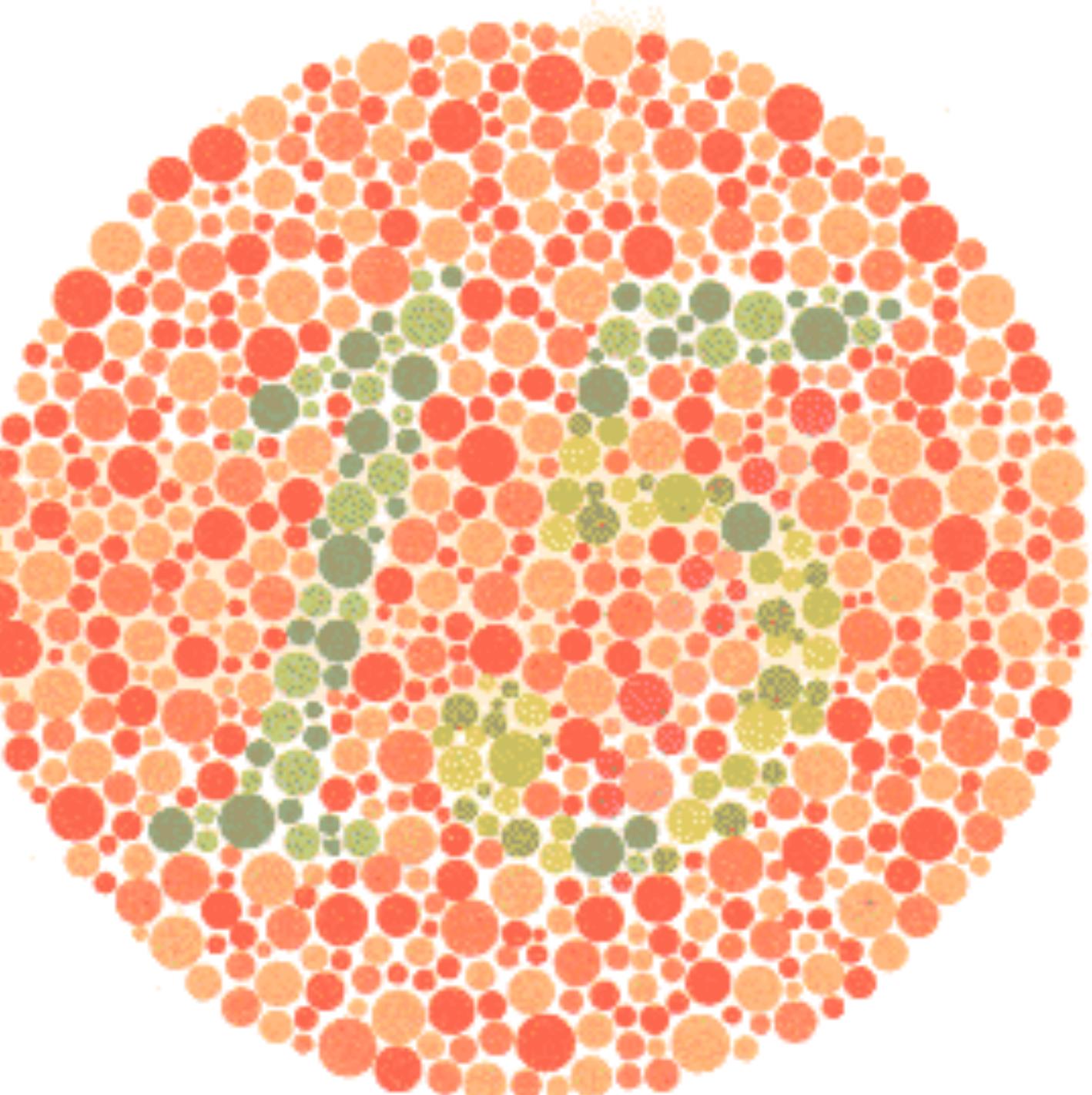
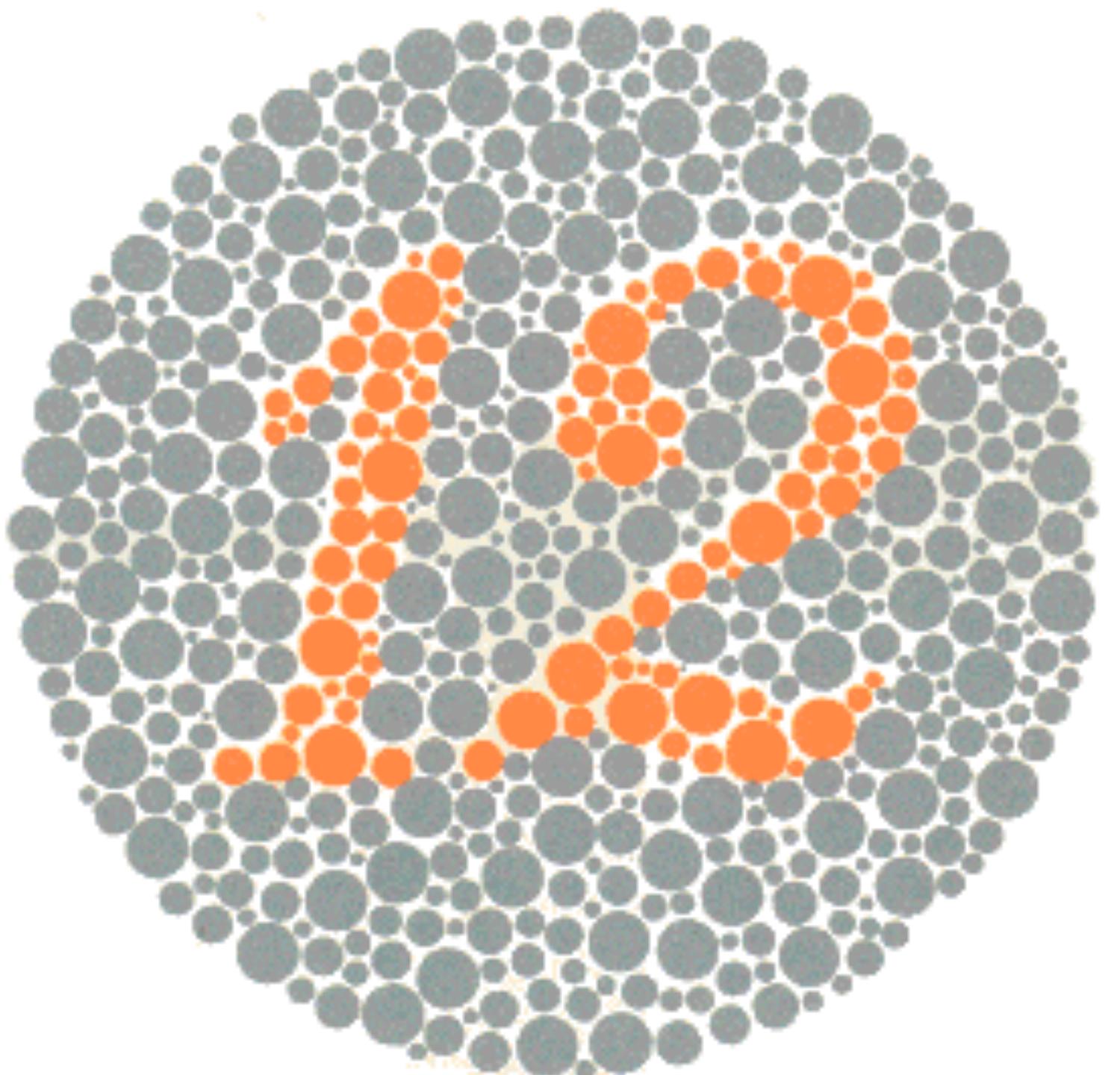


Deutanopia (no green receptors)

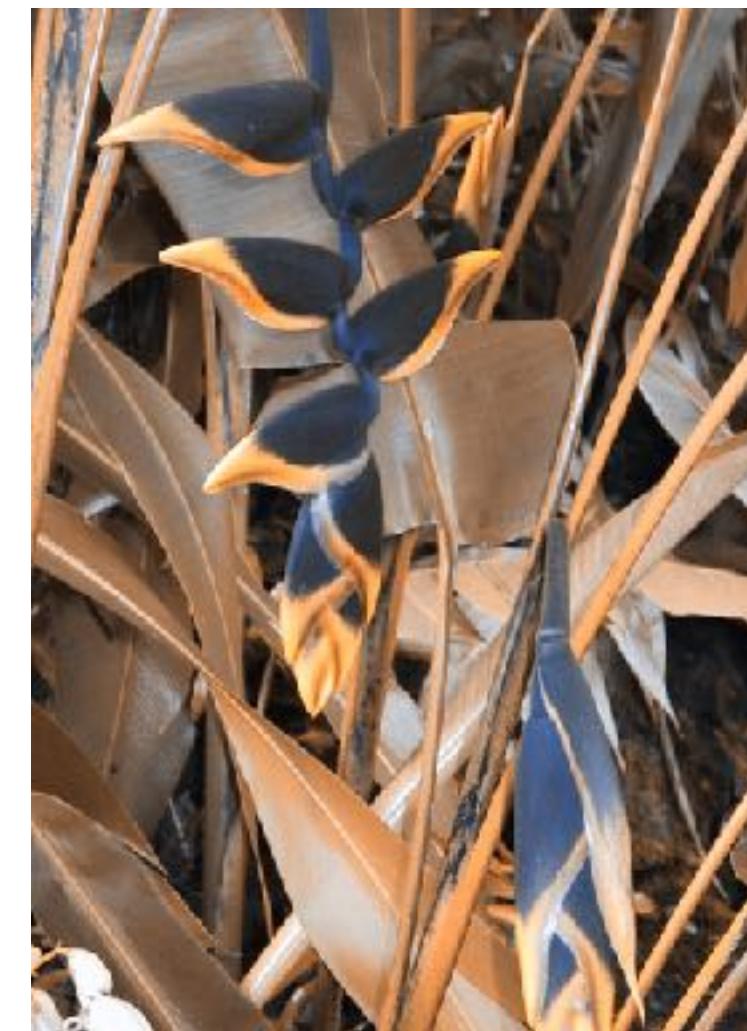


Protanopia (no red receptors)

Color Blindness Tes



Color Blindness



Protanope

No L cones

Red / green
deficiencies

Deuteranope

No M cones

Tritanope

No S cones

Blue / Yellow
deficiency

All Spending Types of Spending Changes Department Totals

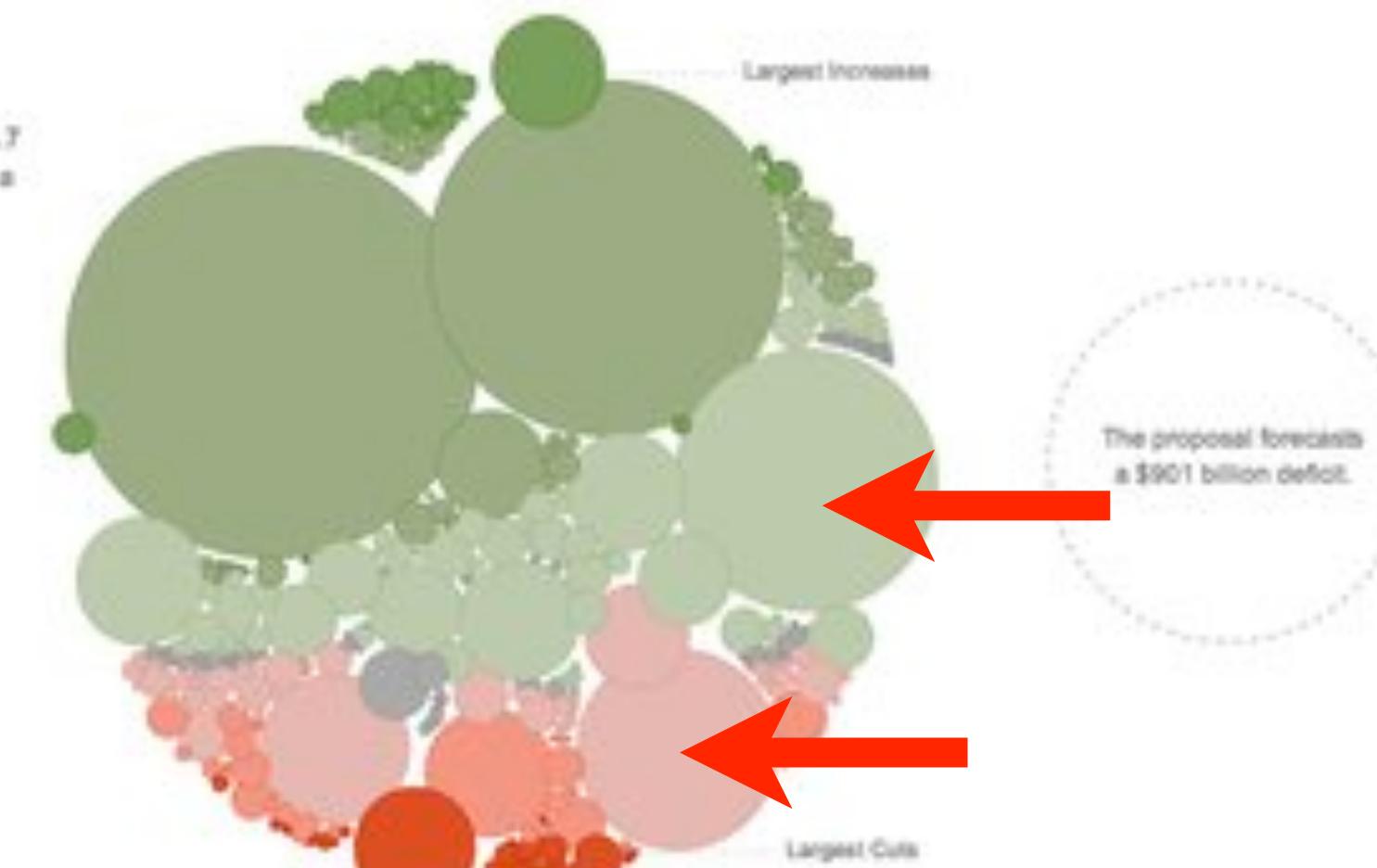
How \$3.7 Trillion Is Spent

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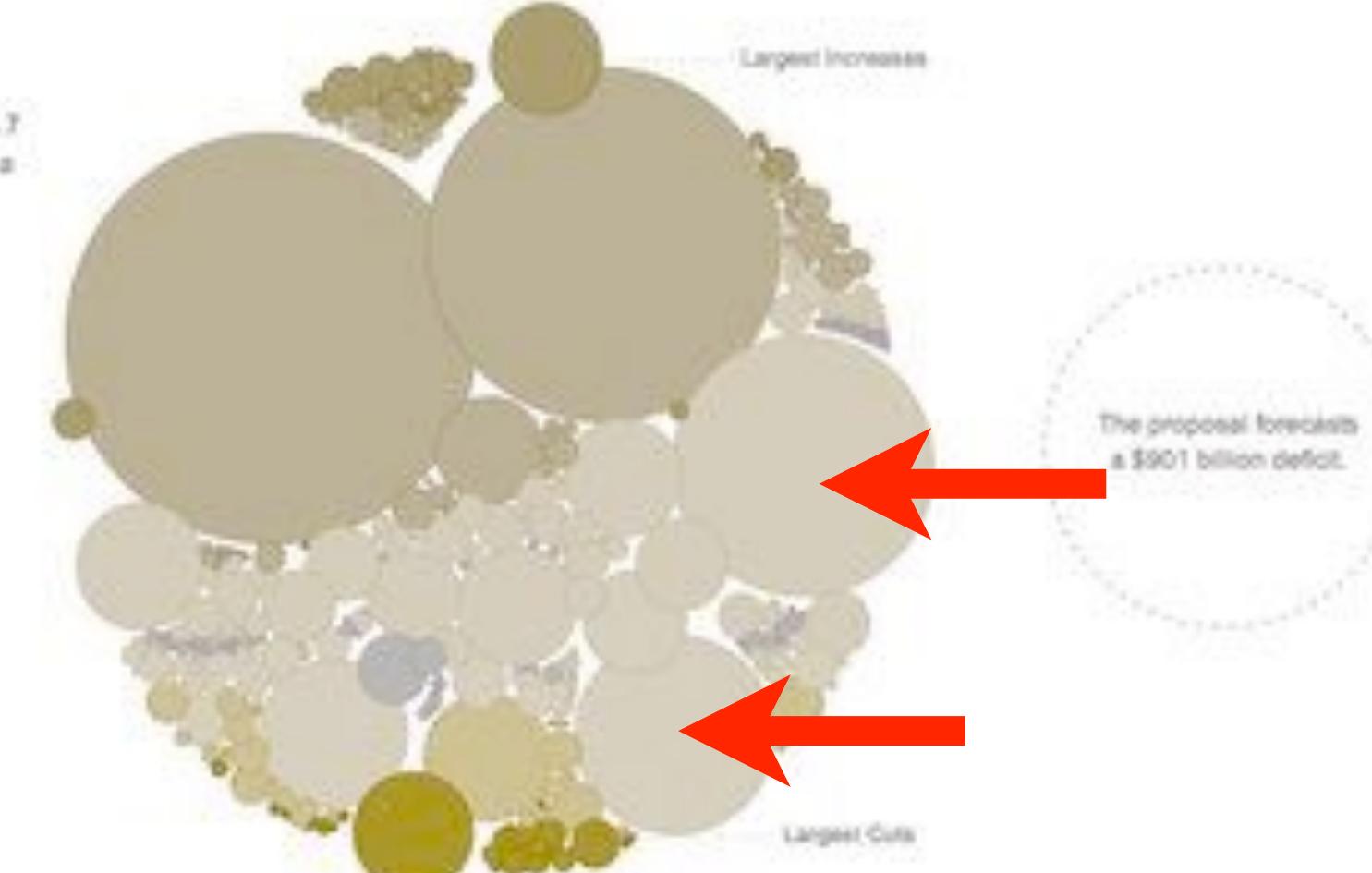
How \$3.7 Trillion Is Spent

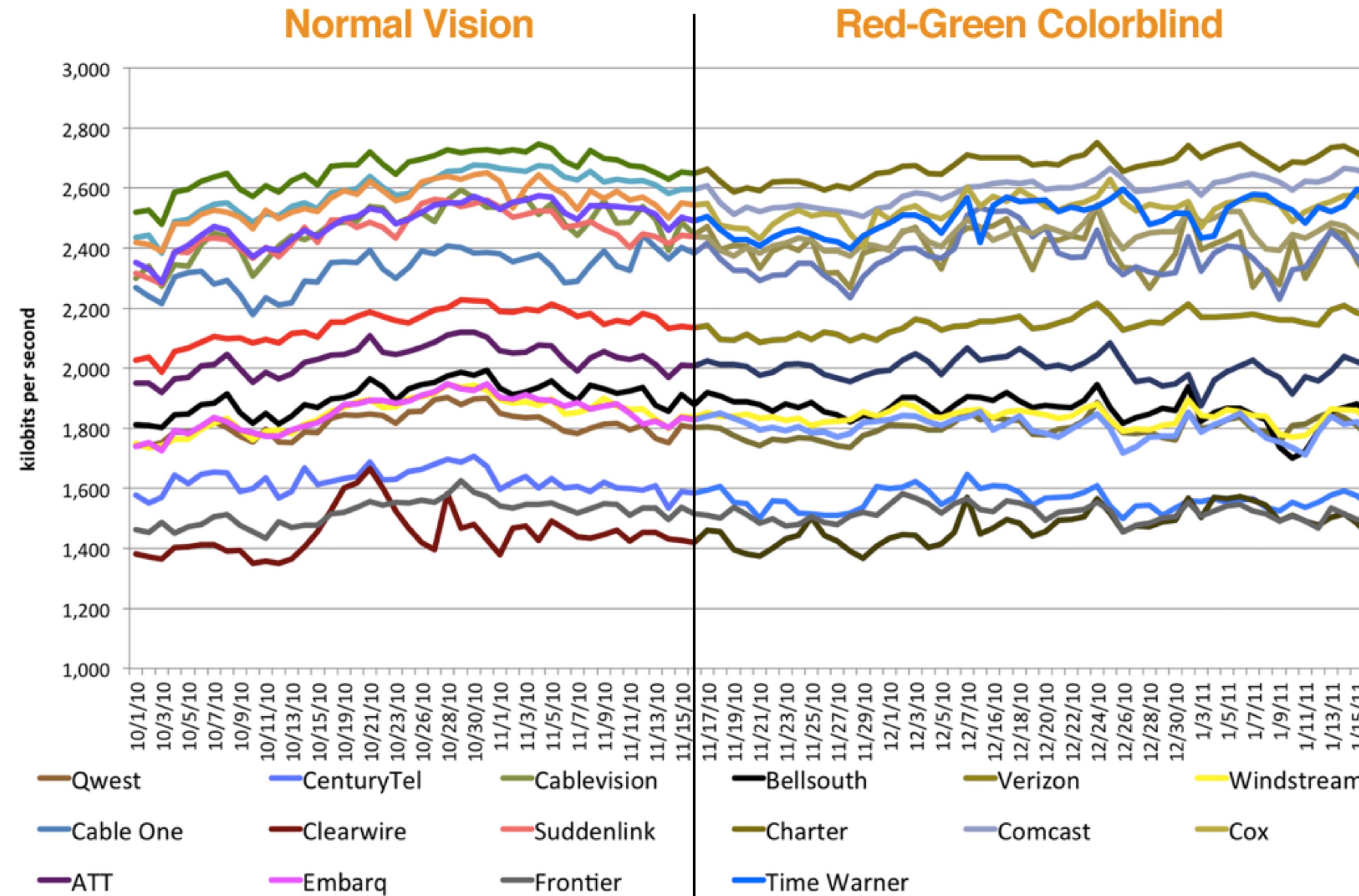
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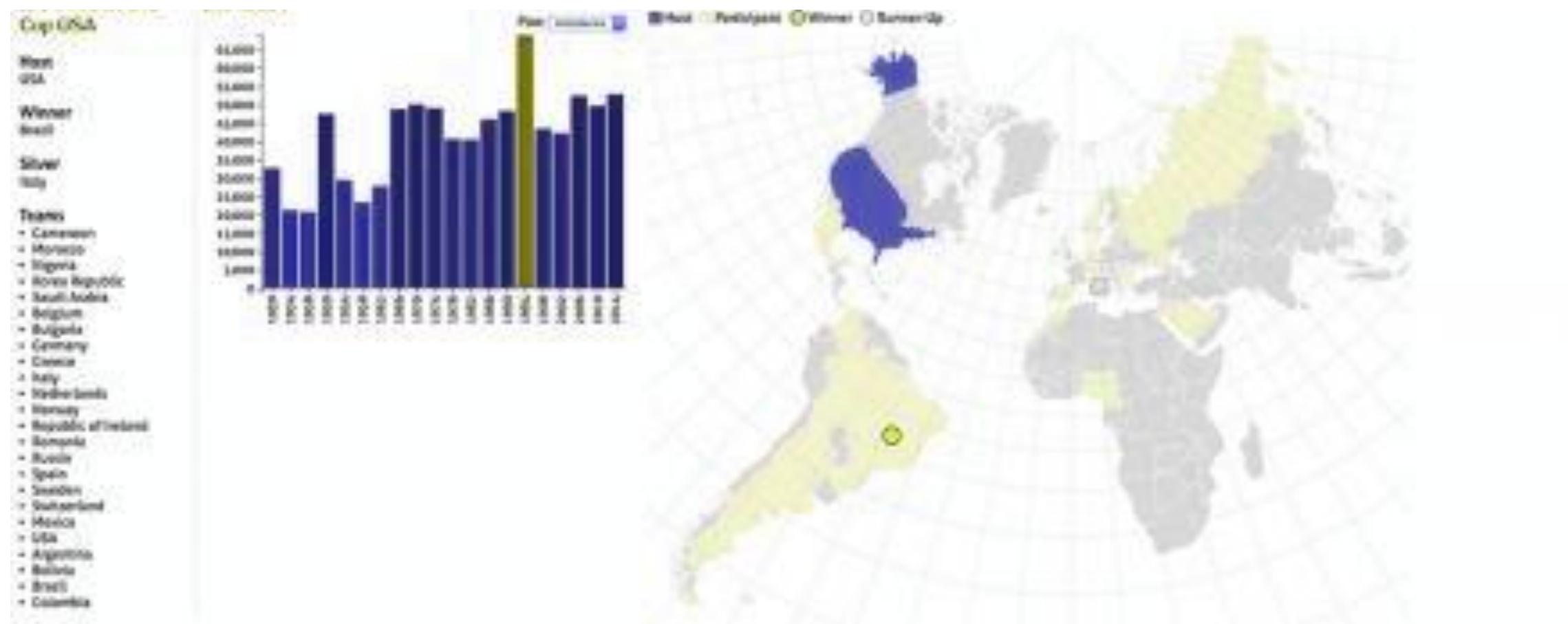
Andy Baio

Simulate Color Vision Deficiencies

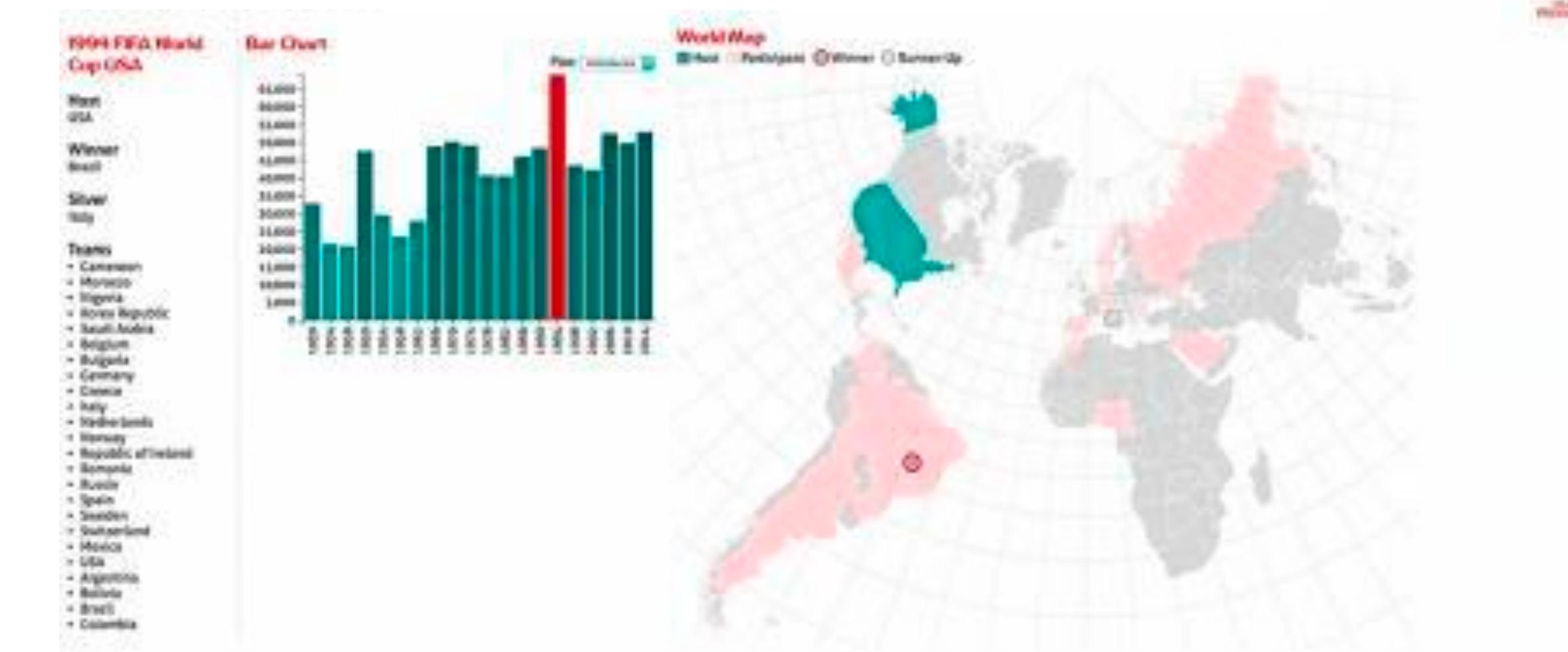
<http://www.color-blindness.com/coblis-color-blindness-simulator/>

<http://www.vischeck.com/>

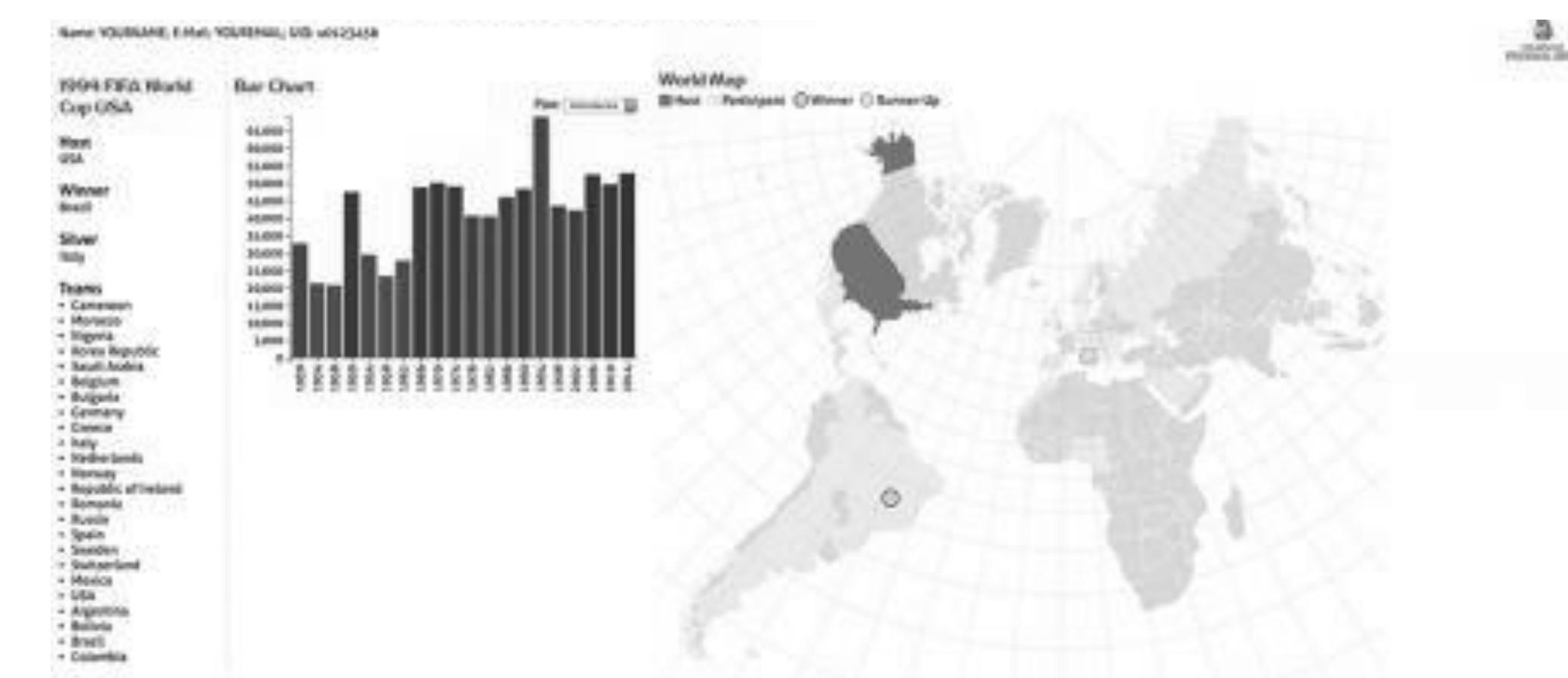
The screenshot shows the Cobliss Color Blindness Simulator homepage. At the top right are social media icons for Twitter, Facebook, Google+, LinkedIn, and YouTube. Below them are navigation links: Home, CVD Essentials, Color Blindness Tests, Color Tools, and Contact. A search bar and a 'Subscribe' button are also present. The main content area features a large image of a bar chart and a map of Africa, both of which appear distorted or colored differently to simulate color vision deficiencies. To the right of the chart is a list of color vision conditions with radio buttons: Normal Color Vision, Red-Blind/Protanopia, Green-Blind/Deutanopia, Blue-Blind/Tritanopia, Red-Weak/Protanomaly, Green-Weak/Deutanomaly, Blue-Weak/Tritanomaly, Monochromacy/Achromatopsia, and Blue Cone Monochromacy. The 'Blue Cone Monochromacy' option is selected. Below this is a 'CVD Simulator' interface with a 'Select' button and an 'Upload Image' button. To the right of the simulator is a 'Color Blind Test' section with two buttons: '(1) Color Blind Test' and '(2) Red Green Color Blind'. At the bottom right is a 'FREE Color Blind Check' section with text about a new test and a link to the website. It also features a logo with a green square and an orange circle.



Red-Blind



Blue Blind



Monochromacy

Luminance, Brightness, Lightness

Luminance

measured amount of light (luminous intensity per area)

Brightness

perceived amount of light

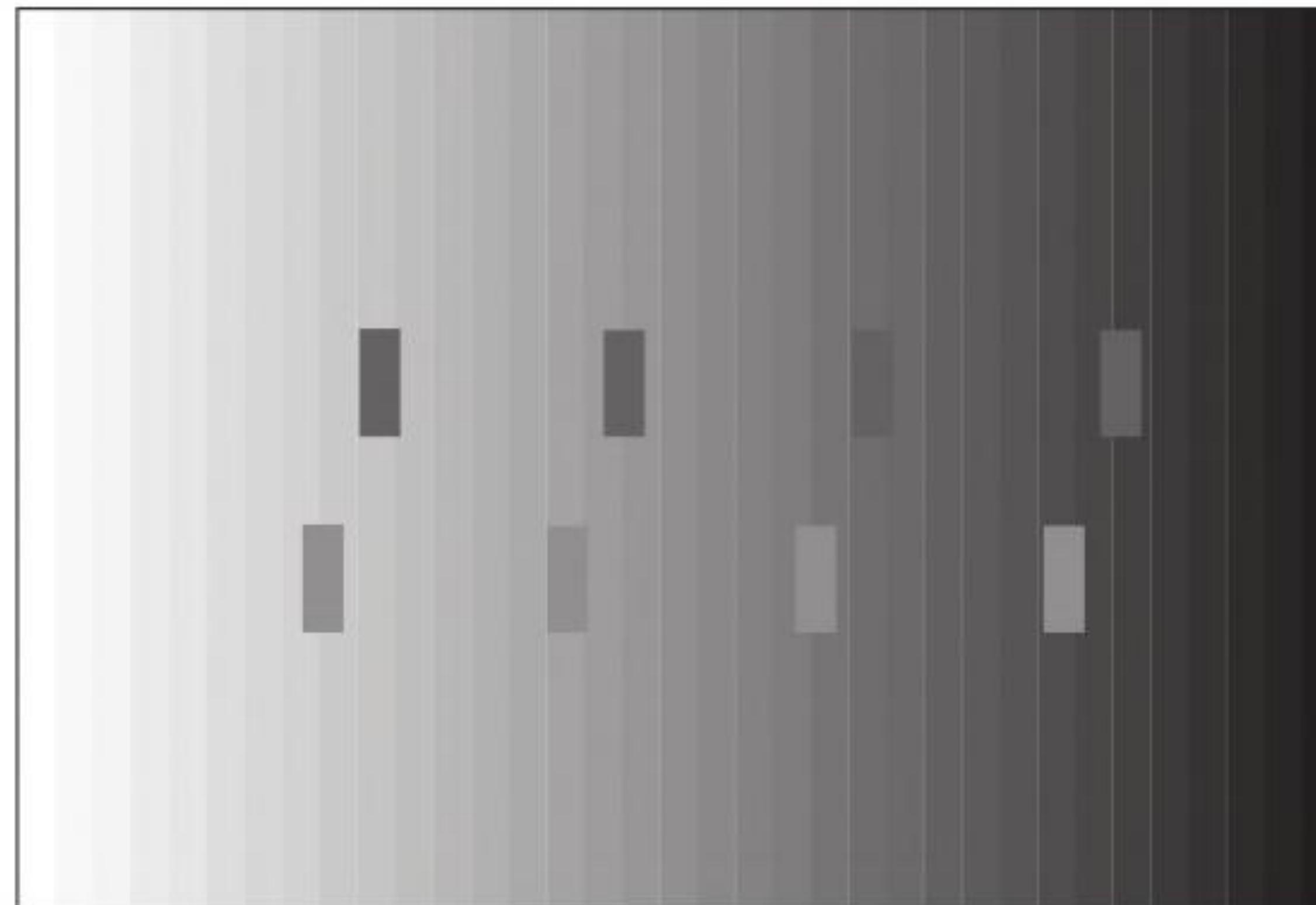
Lightness

perceived reflectance of a surface

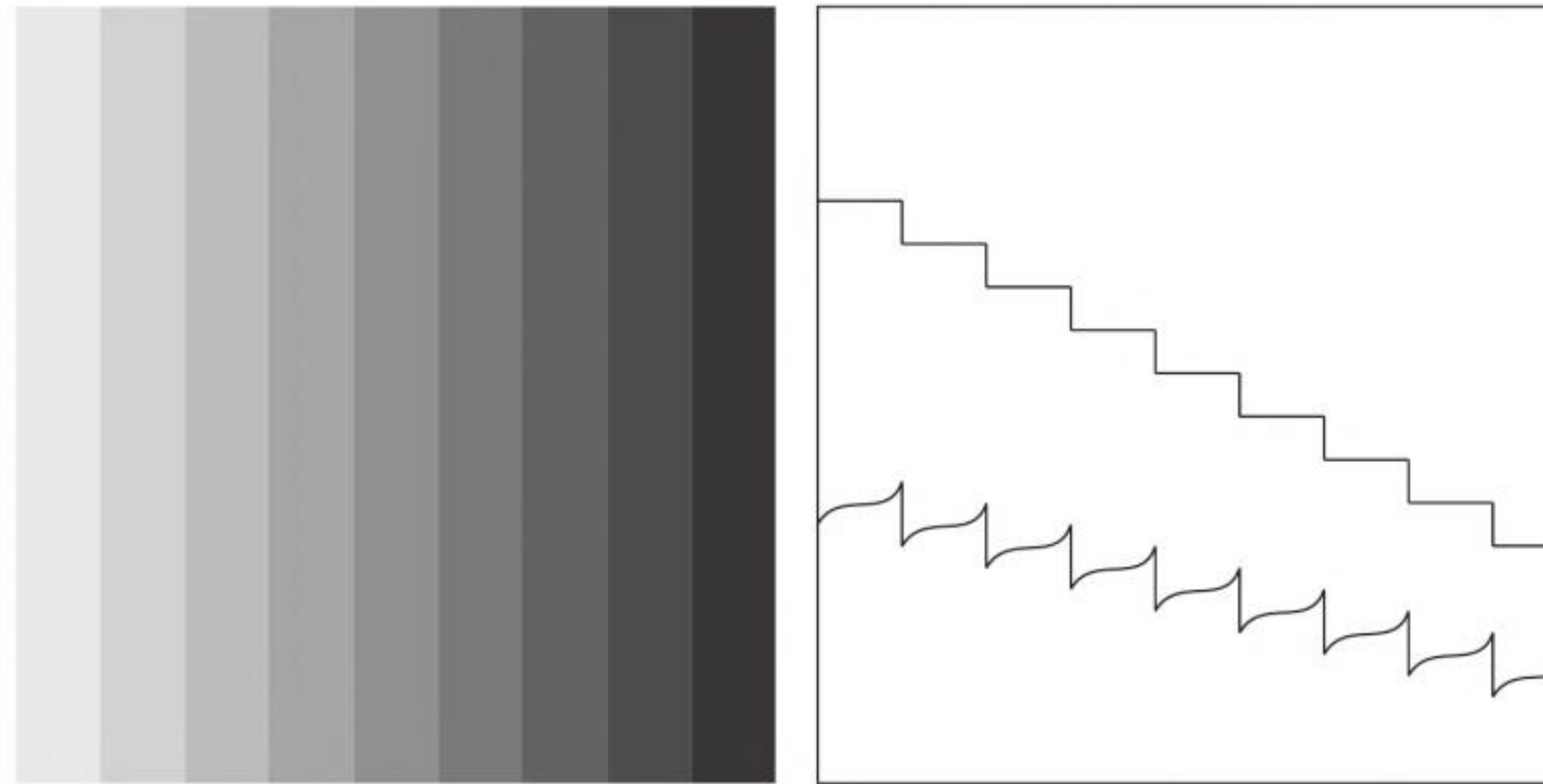
lightness of a color

Simultaneous Brightness Contrast

The perceived brightness of an object is relative to its background



Chevreul Illusion



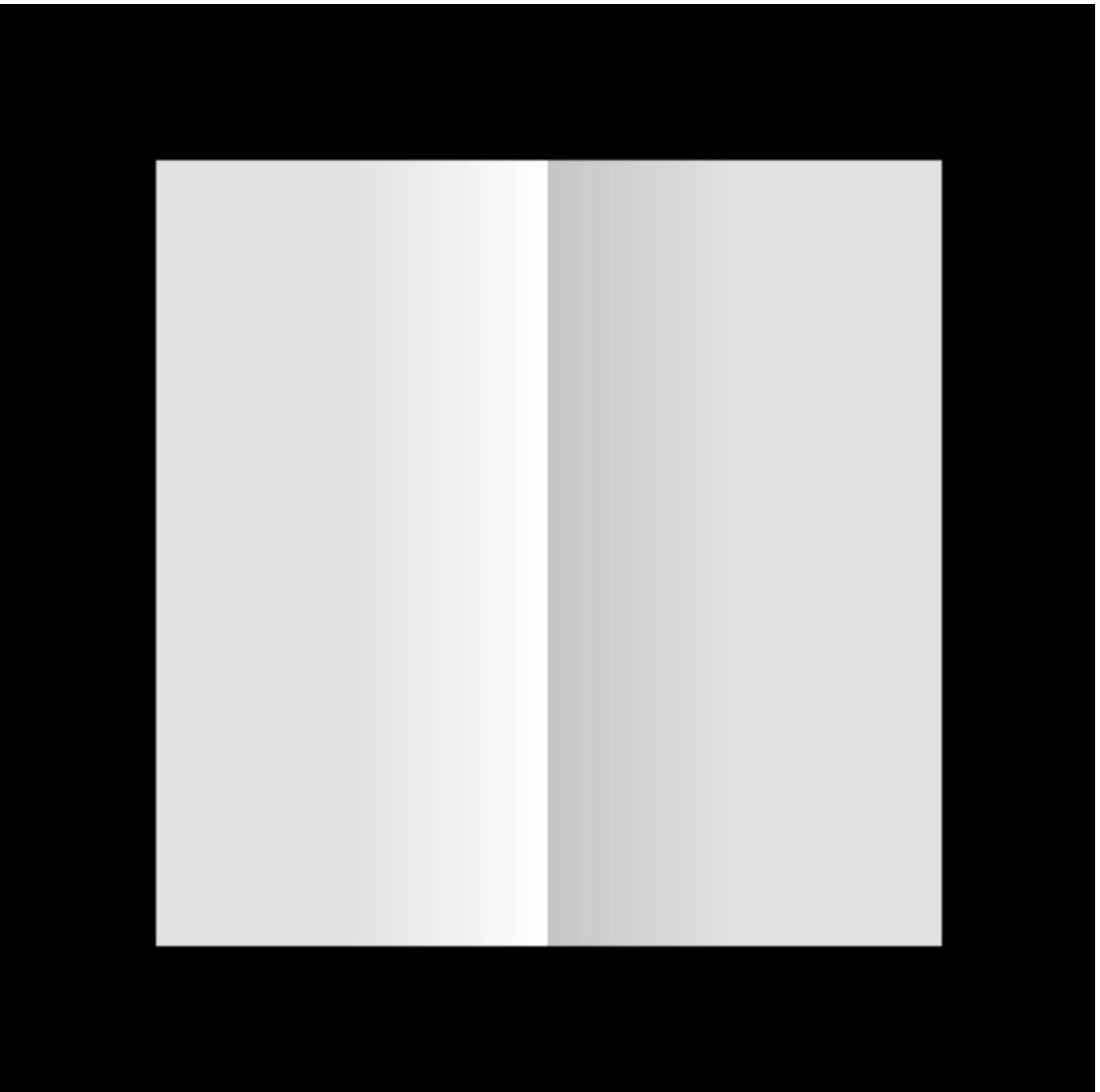
Edge Enhancement

Cornsweet effect

Make objects more distinct



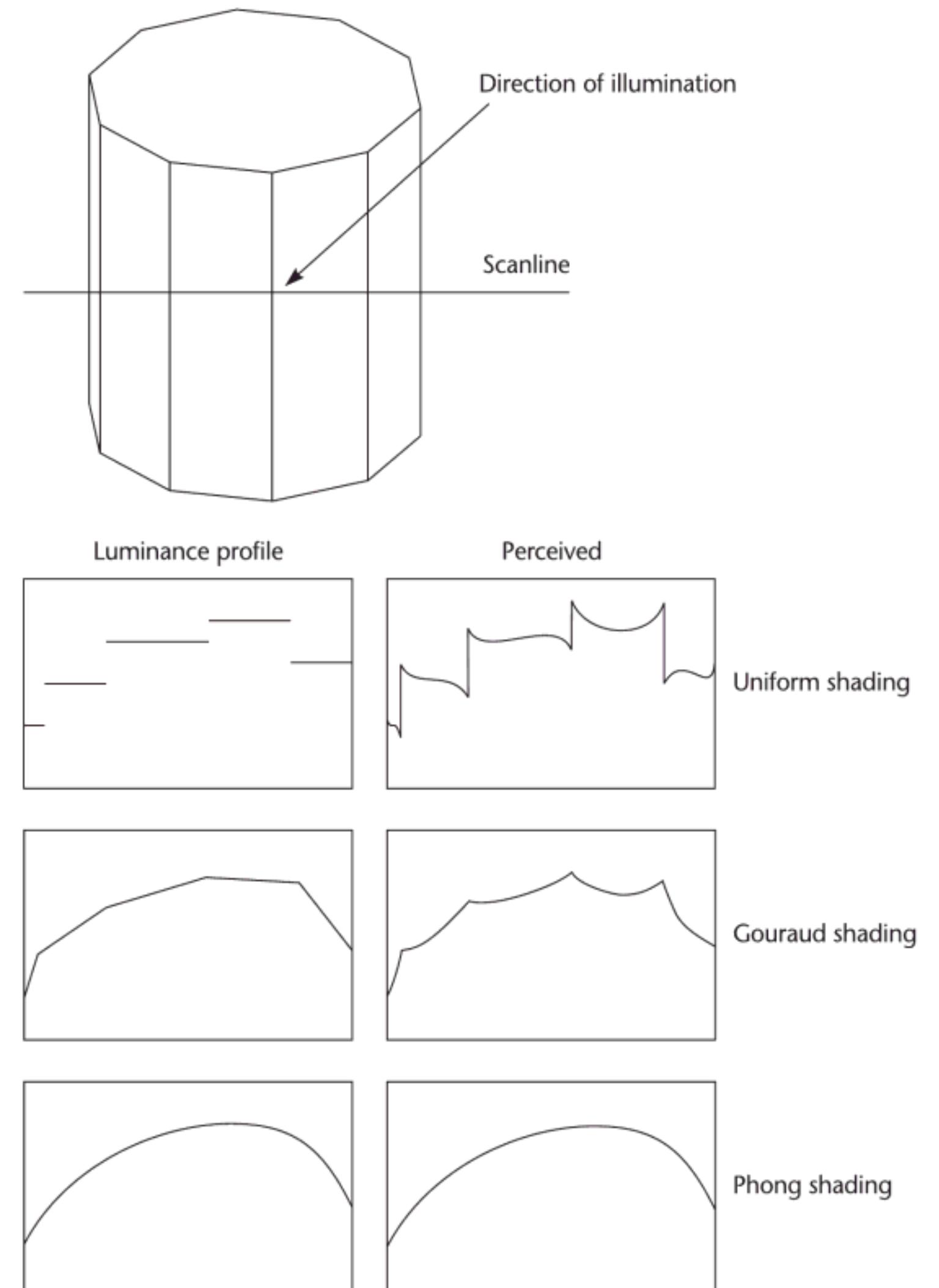
Seurat's Bathers



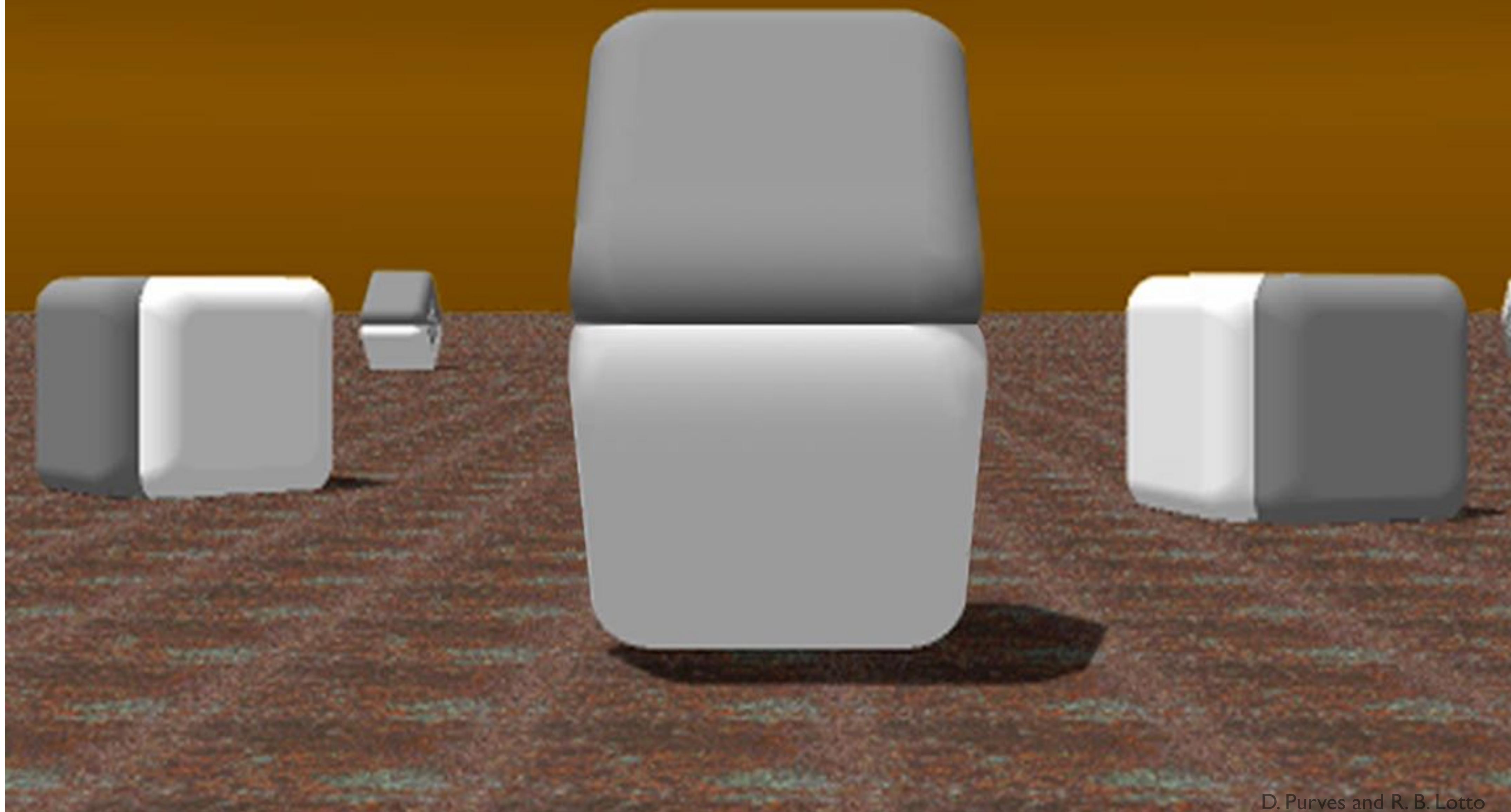
Why is this an issue?

Can result in large errors of judgment

Amplifies artifacts in computer graphics shading



Cornsweet Illusion



Cornsweet Illusion



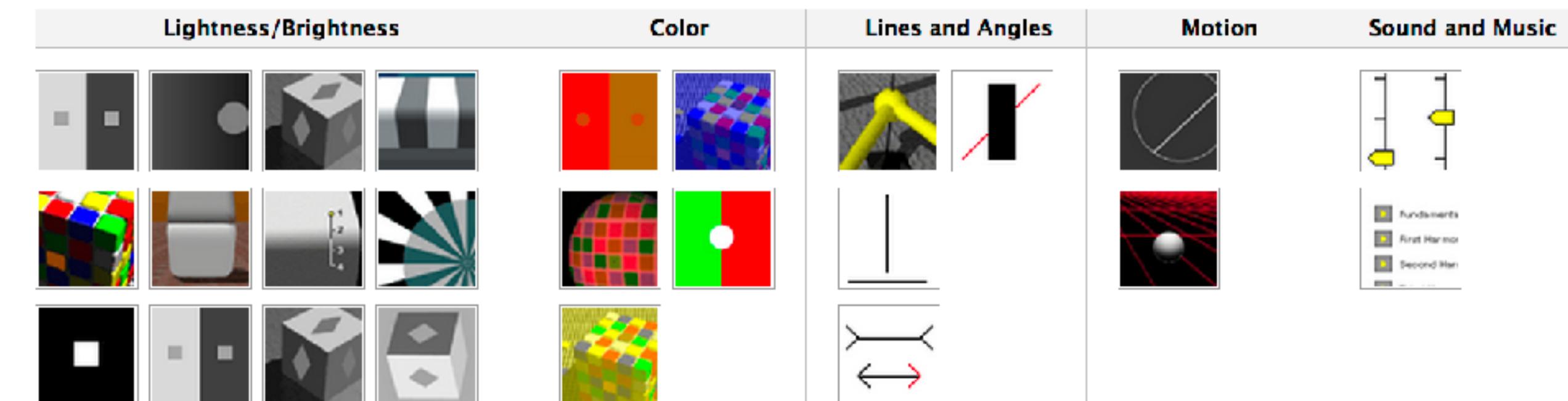
Demo

<http://purveslab.net/see-for-yourself/>

purves-lab

Laboratory of Dale Purves, M.D. Center for Cognitive Neuroscience Duke University

MAIN NEWS PEOPLE RESEARCH PUBLICATIONS RESOURCES [SEE FOR YOURSELF](#) CONTACT

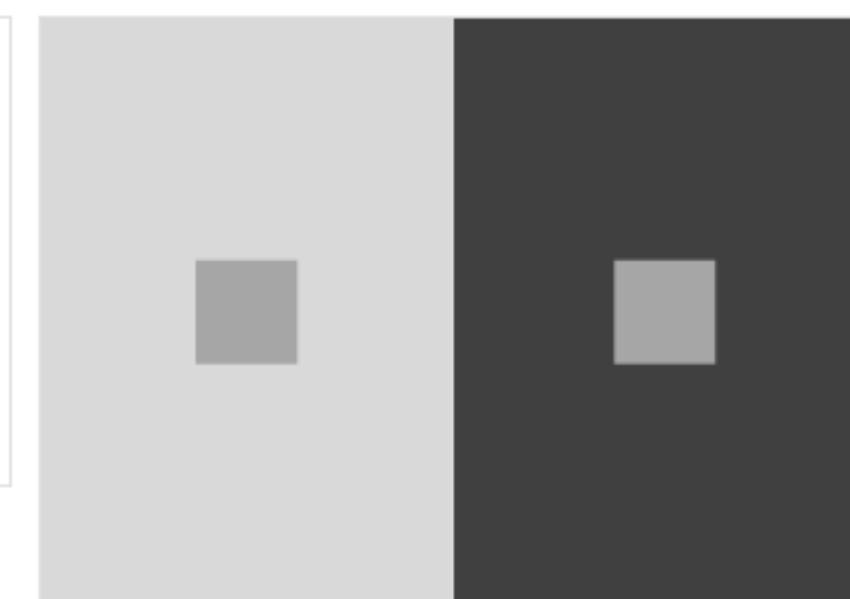


Brightness contrast: standard

In viewing this stimulus, people invariably perceive the square on the brighter surround (left) to be darker than the square on the darker surround (right). Click on the "Play" button to convince yourself that the squares are equiluminant or click on the "Move mask" button to manually position the mask over the squares.

[» Read the empirical explanation](#)

[» Download high resolution images](#)



Preattentive Processing

Preattentive Processing

Properties detected by the low-level visual system

very rapid - 200-250 milliseconds

very accurate

processed in parallel

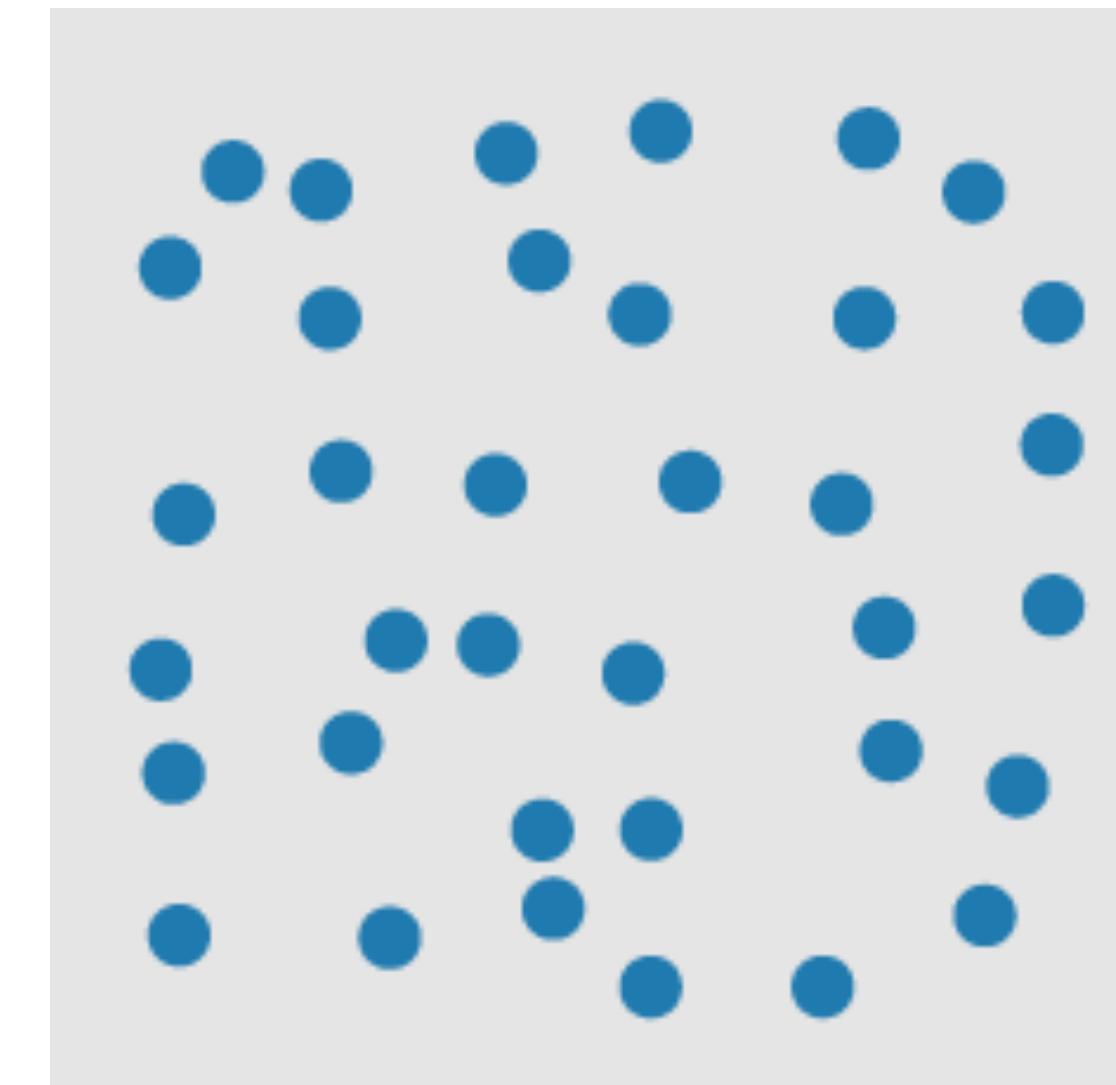
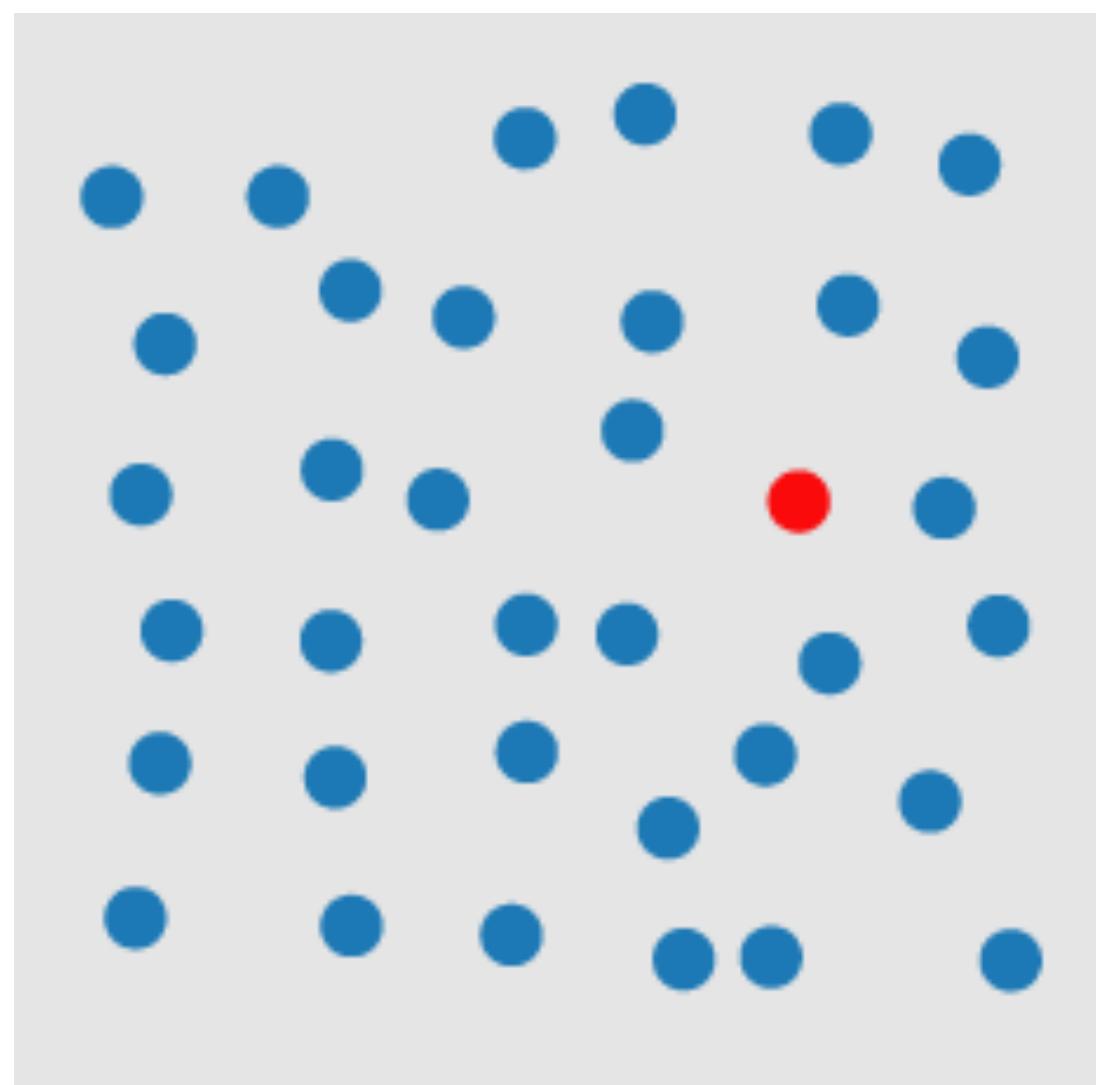
happens before focused attention -> “pre”-attentive

attention is very important for cognition

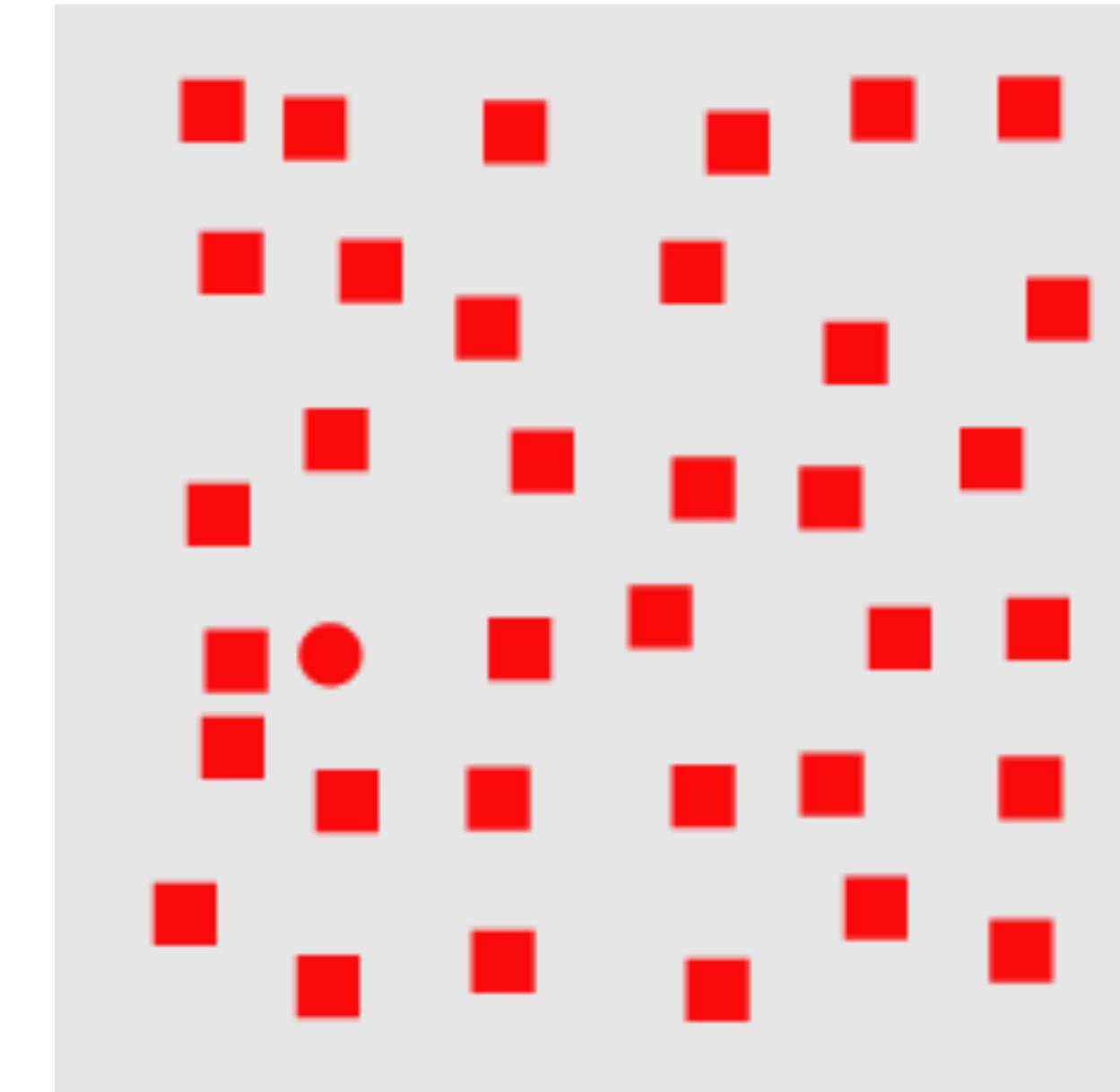
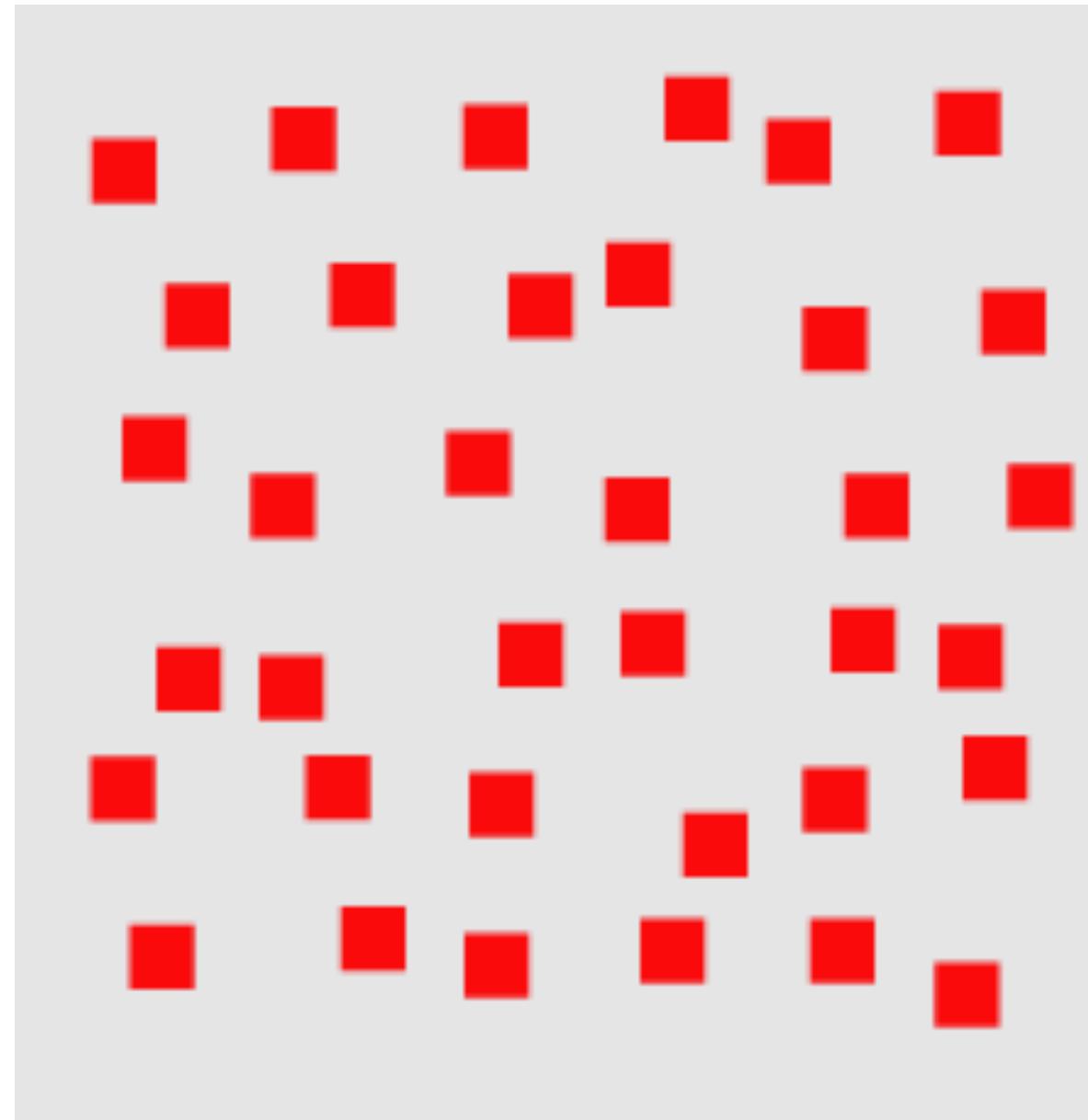
Independent of the number of distractors!

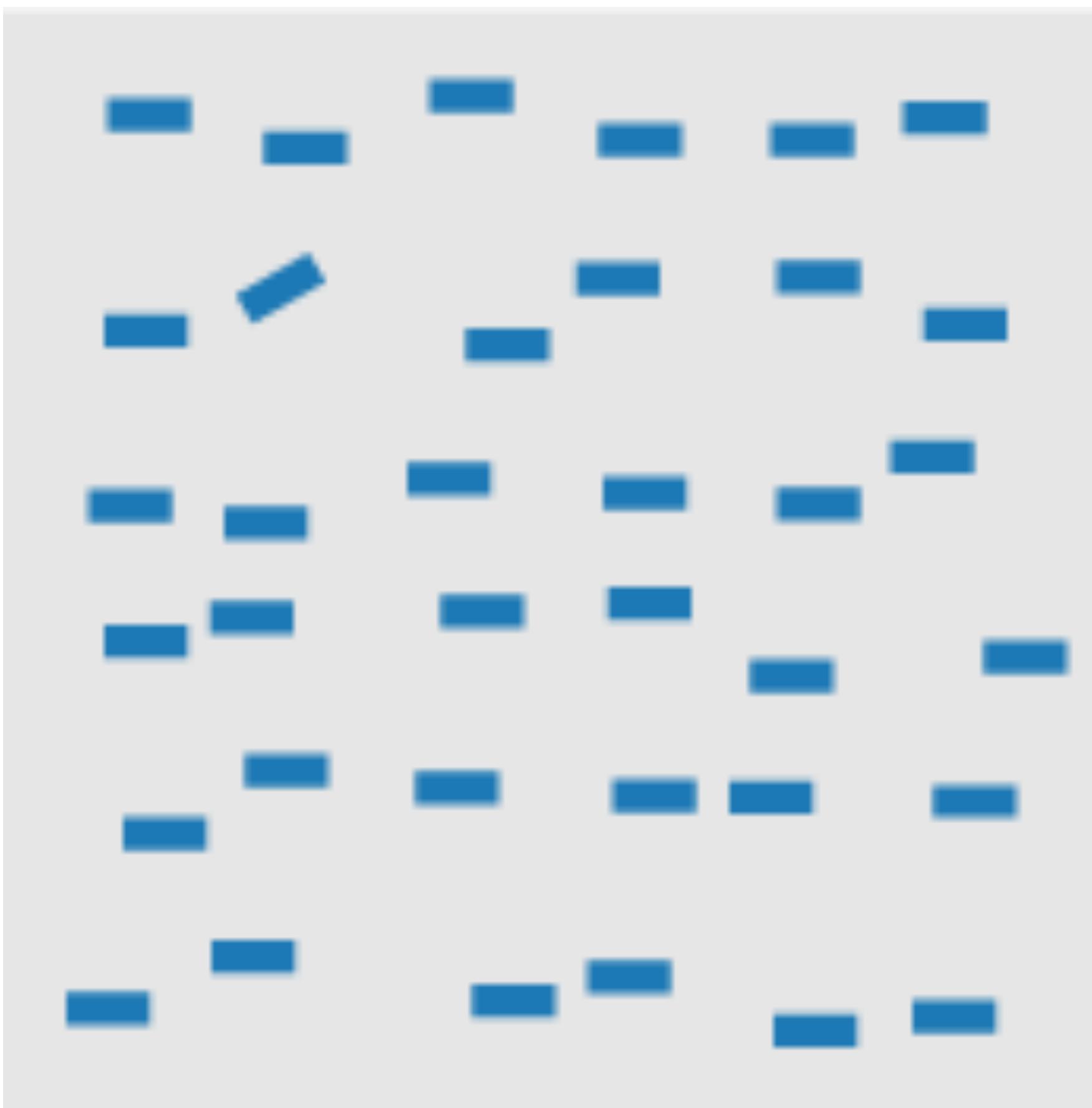
Opposite: sequential search (processed serially)

Difference in Hue

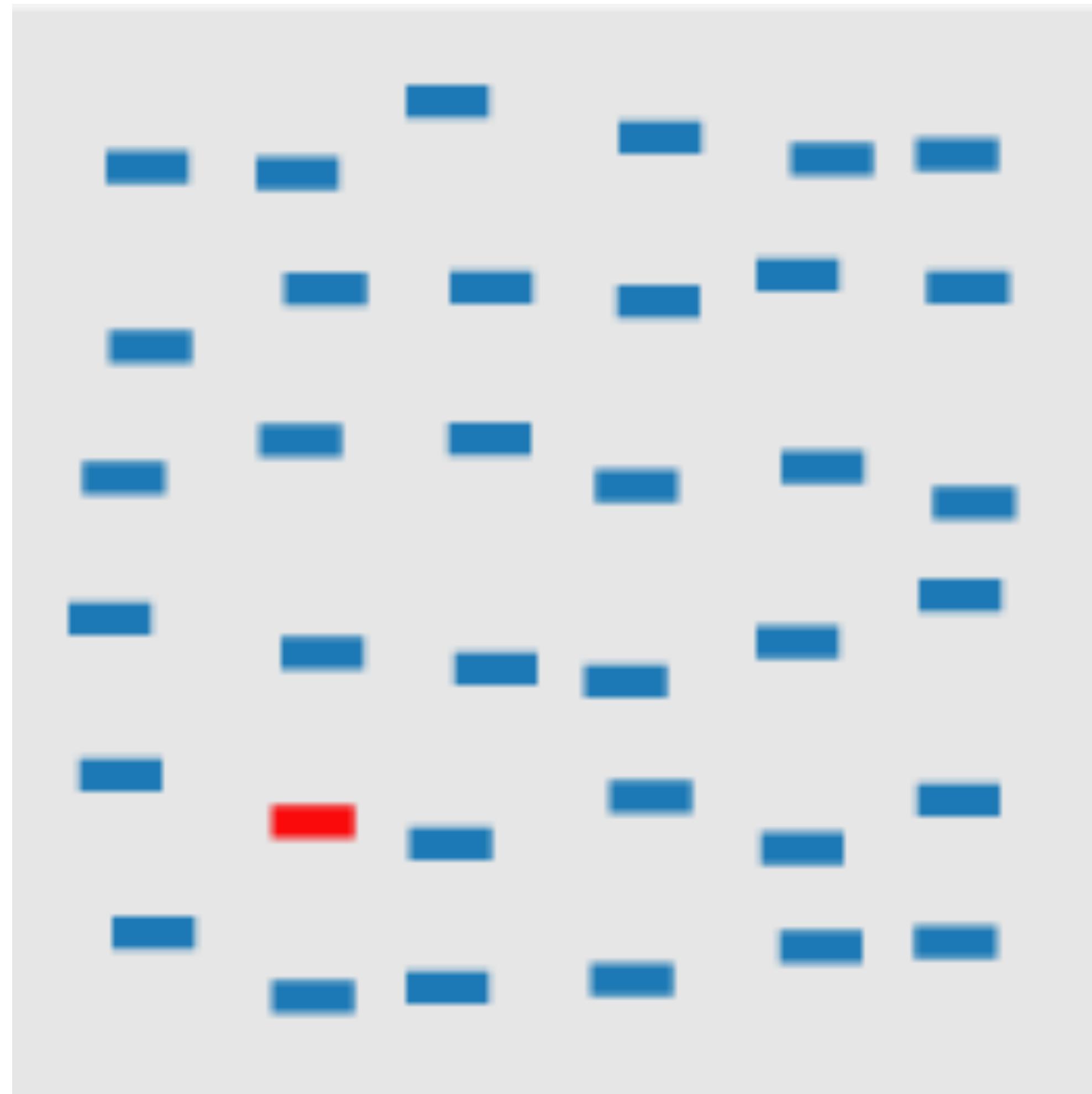


Difference in Curvature / Form





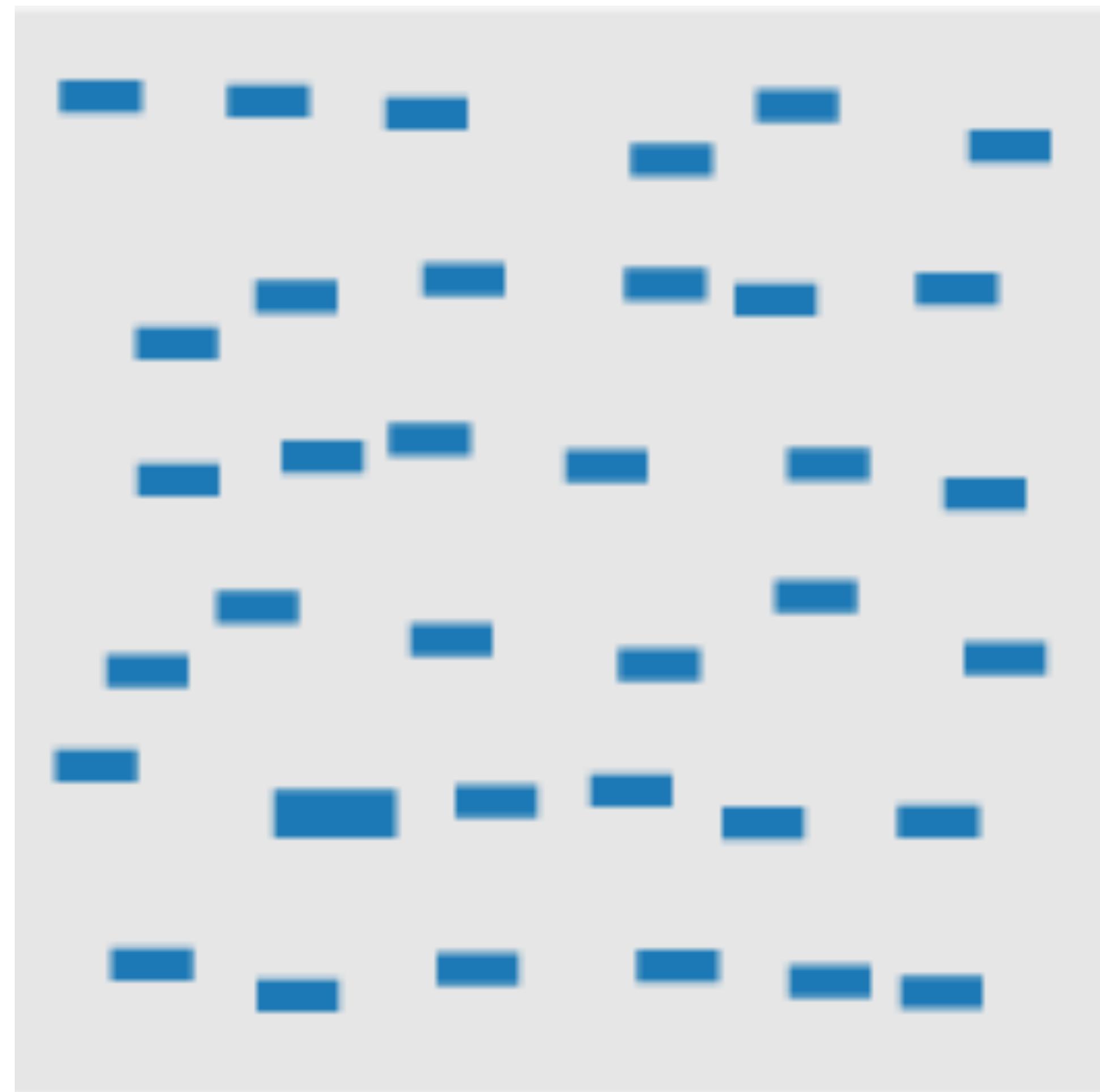
orientation



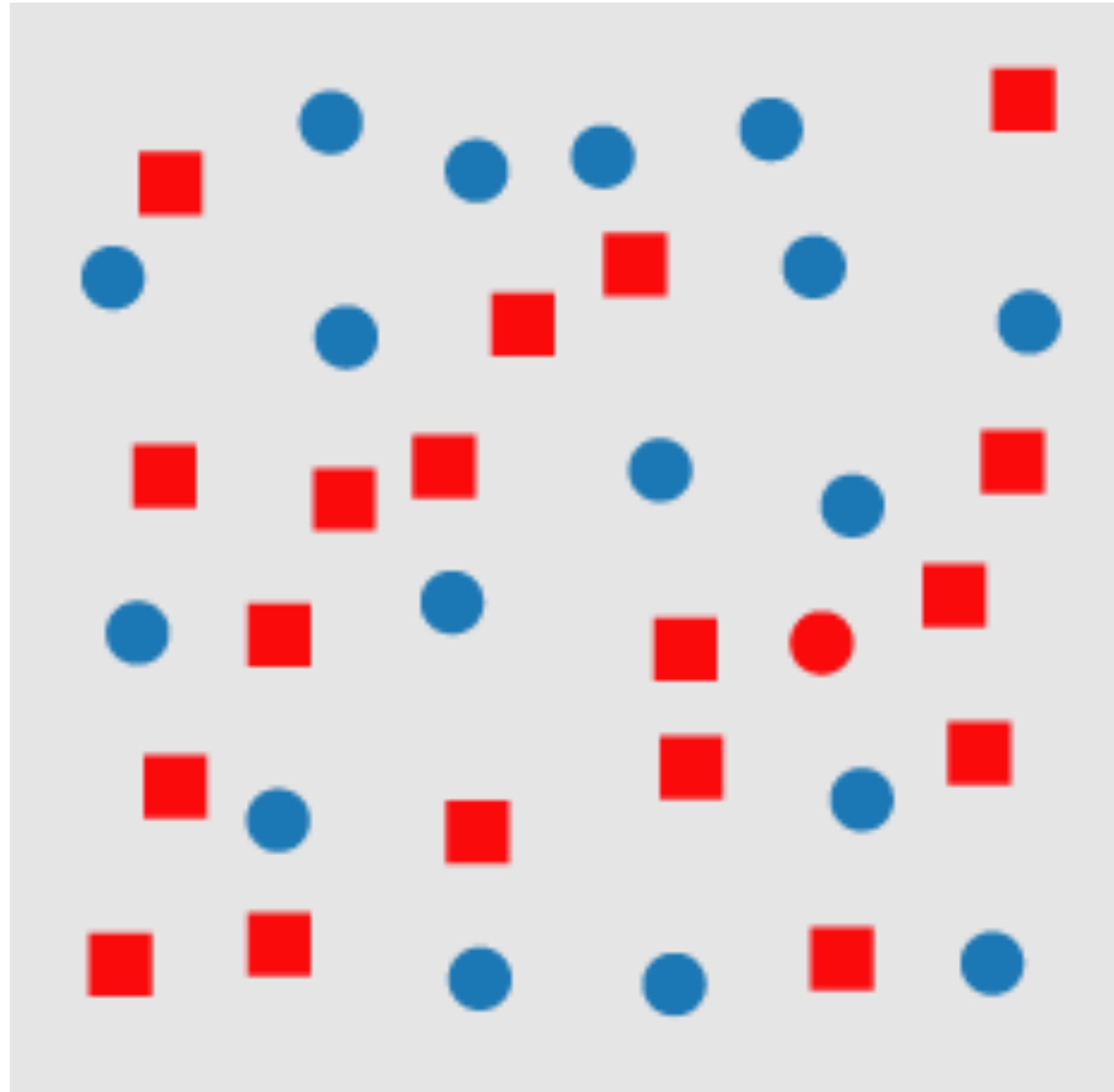
hue



closure

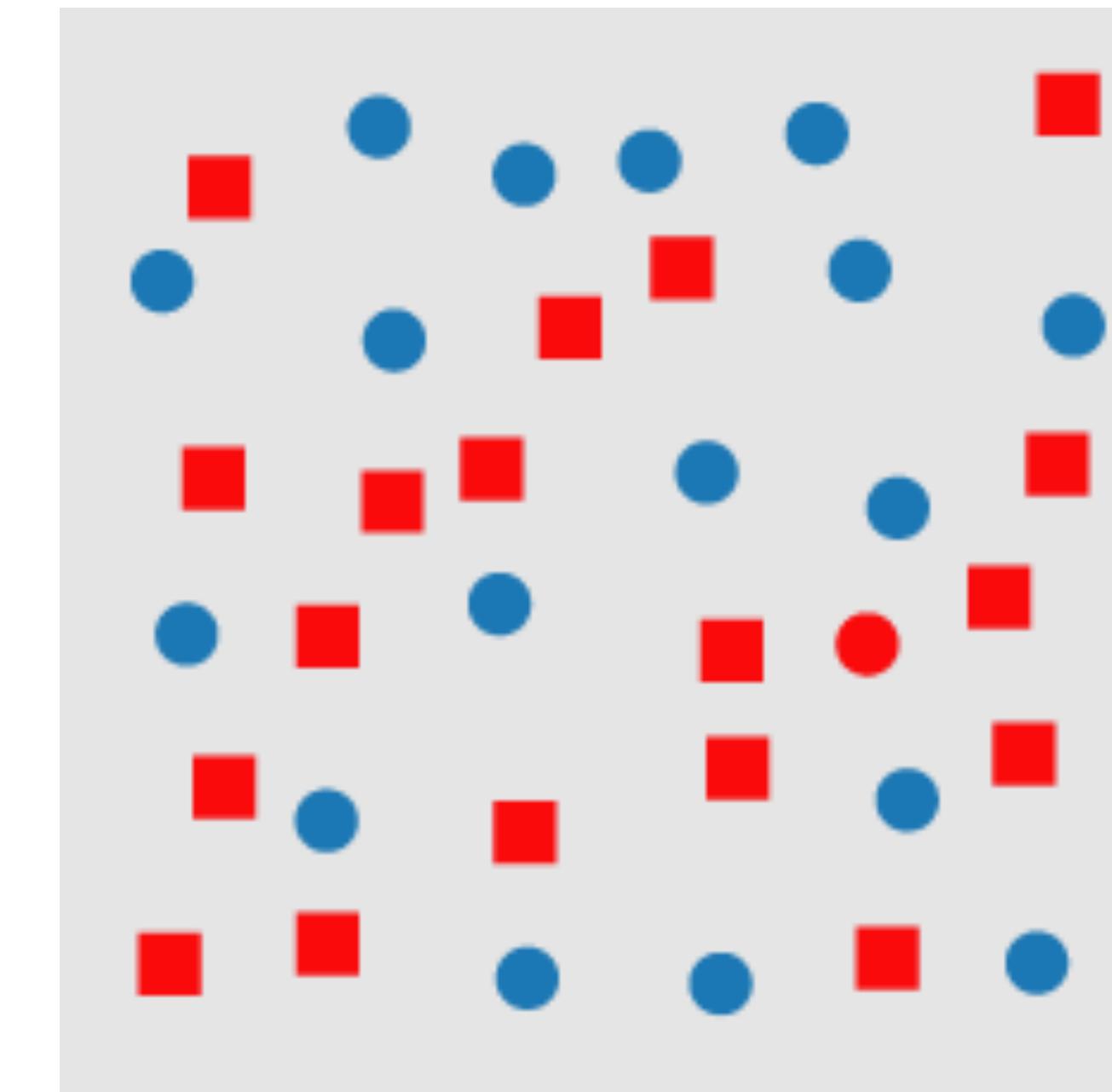
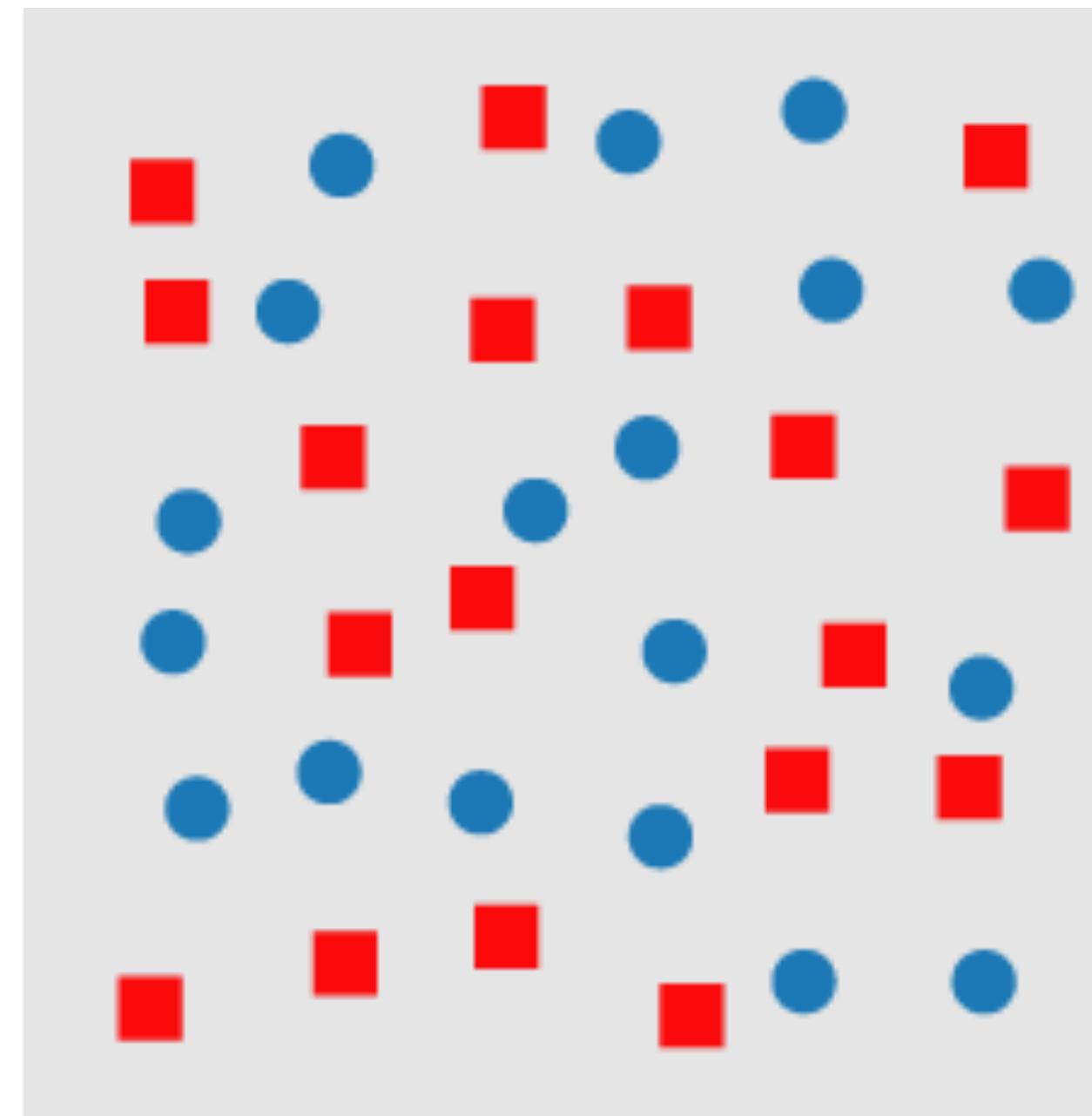


size



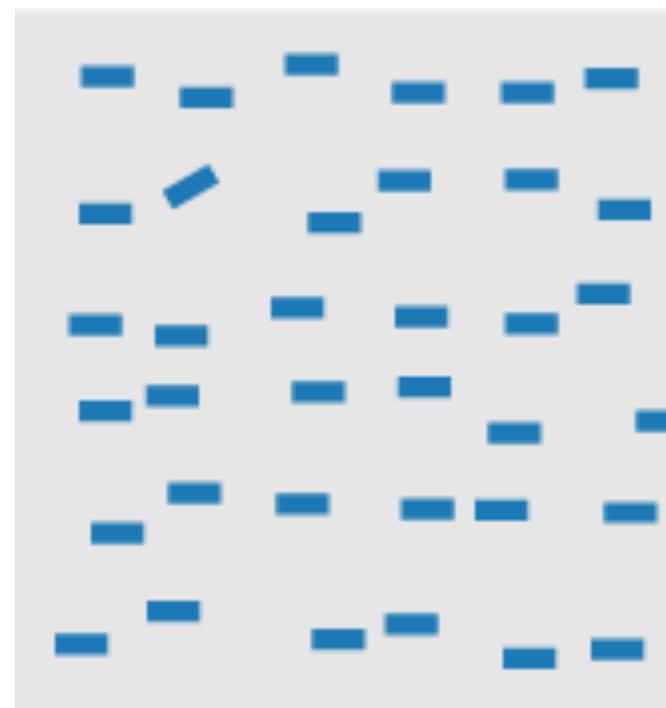
?

Not Valid for Combinations

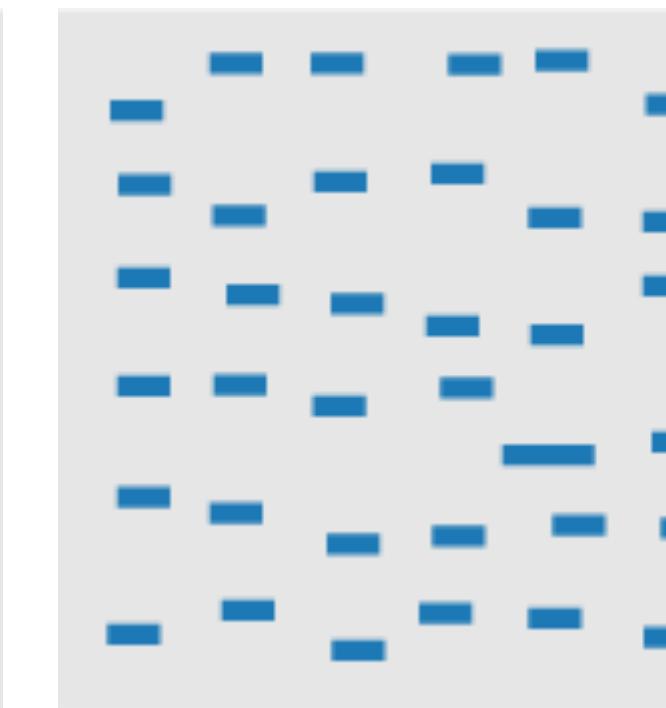


Conjunction Targets – no unique visual property
target: red, circle
distractor objects have both properties

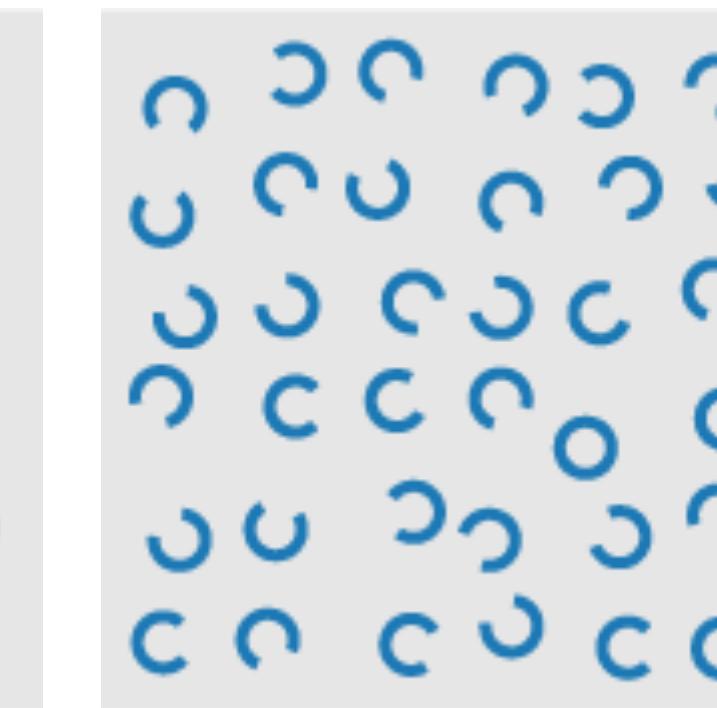
Some Preattentive Properties



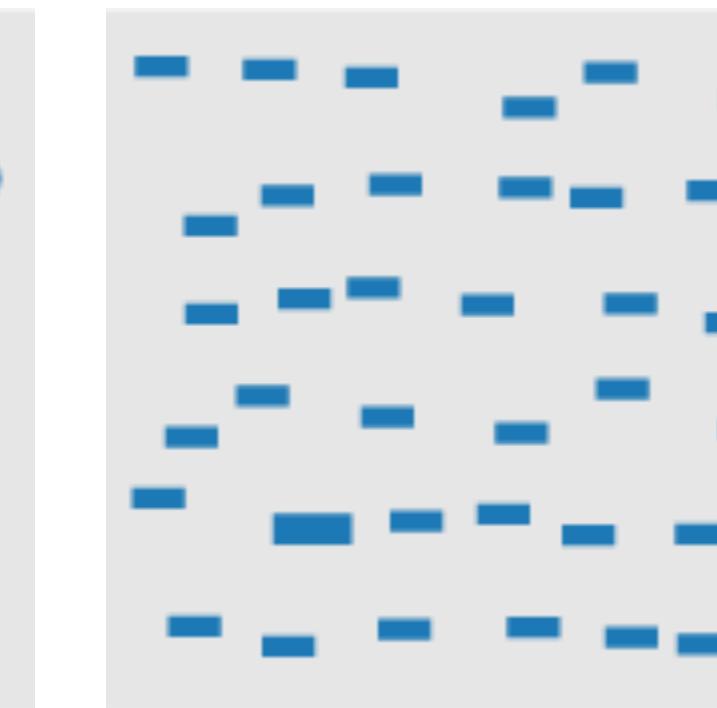
orientation



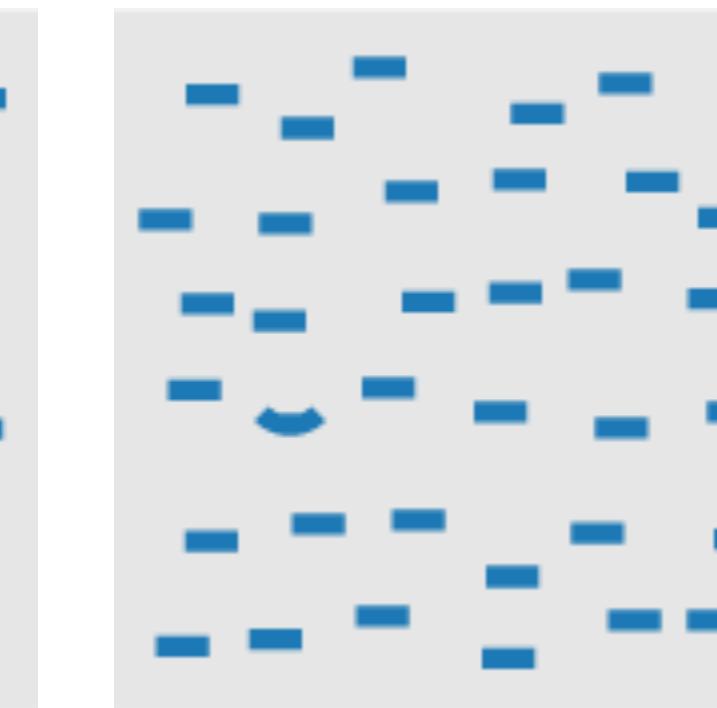
length



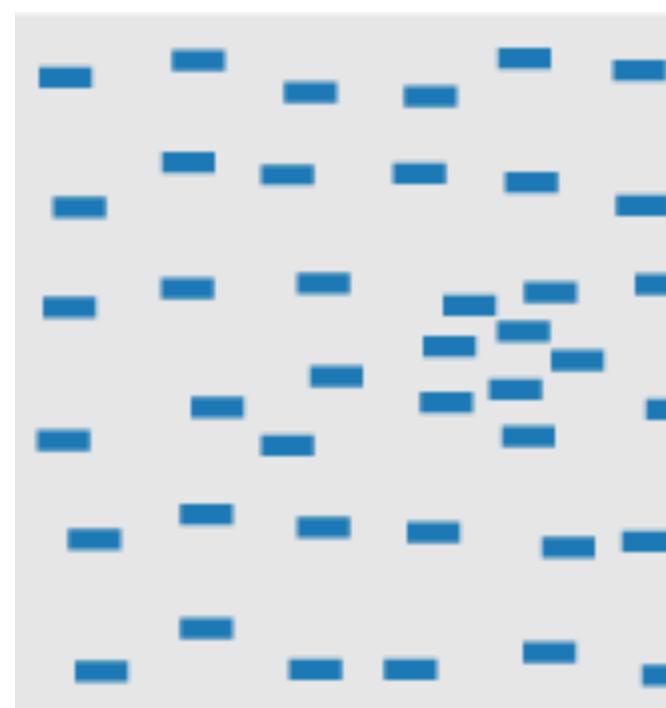
closure



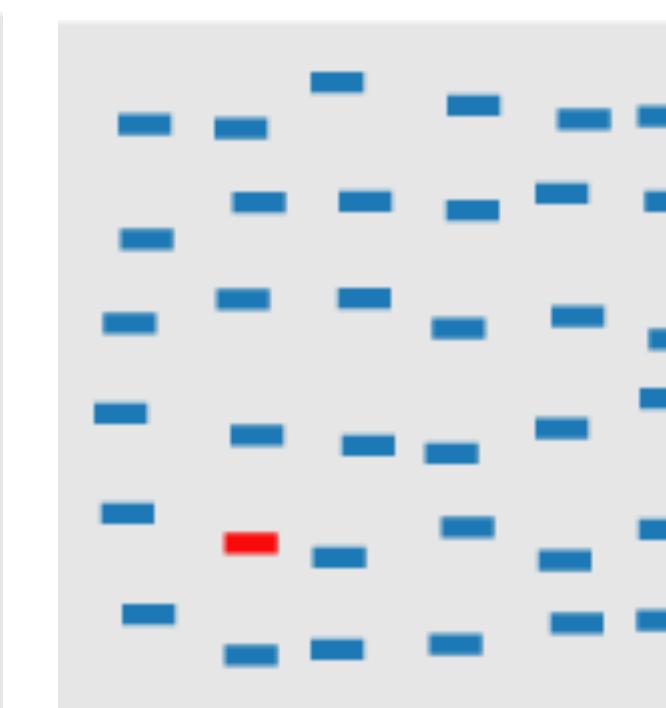
size



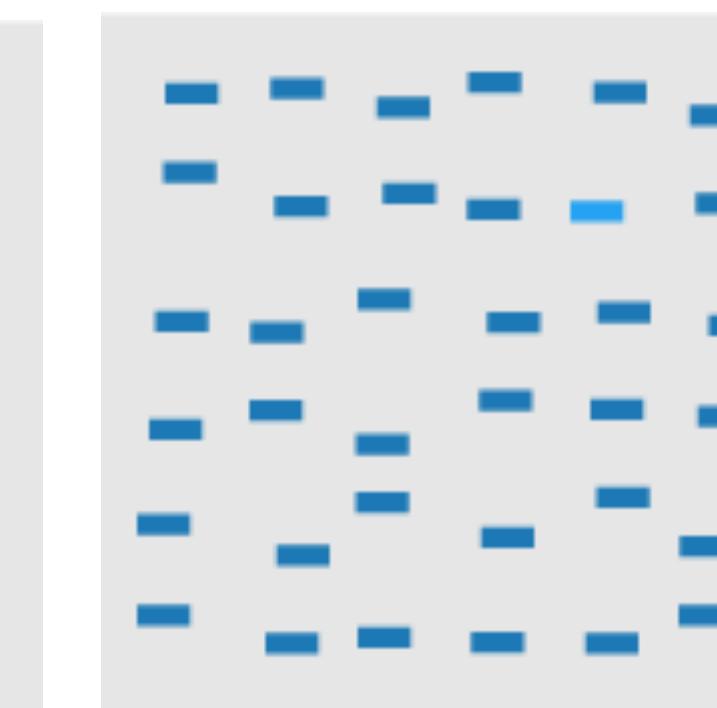
curvature



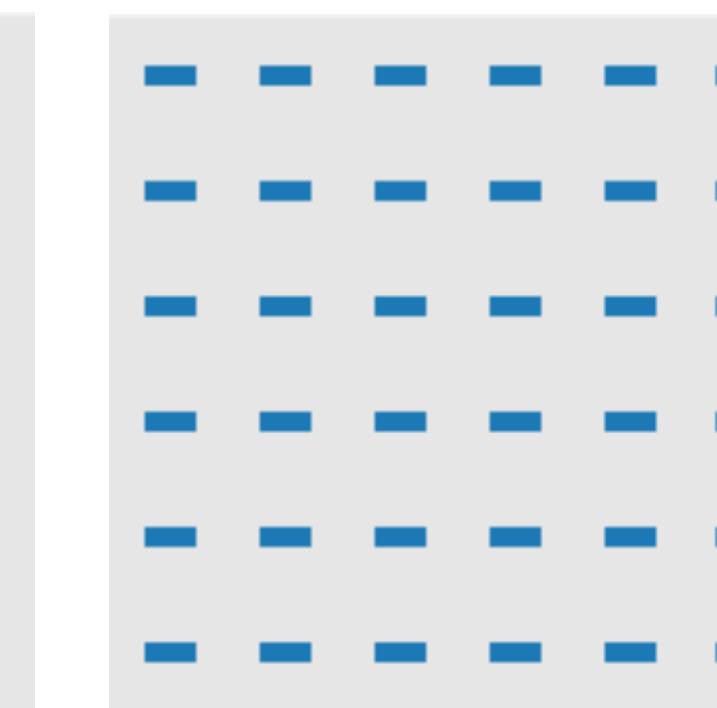
density



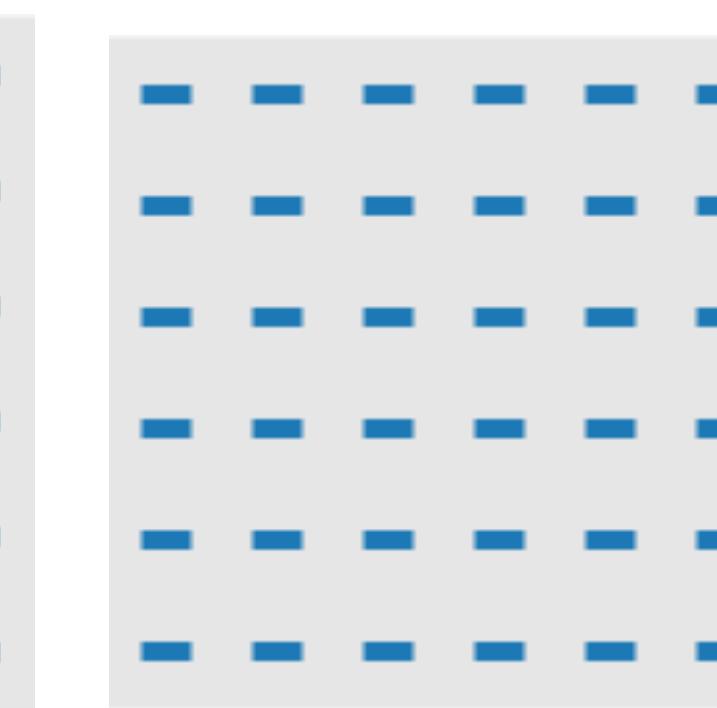
hue



hue



flicker



direction of motion

Tasks

target detection

detect the presence or absence of a target

boundary detection

detect a texture boundary between two groups of elements, where all of the elements in each group have a common visual property

region tracking

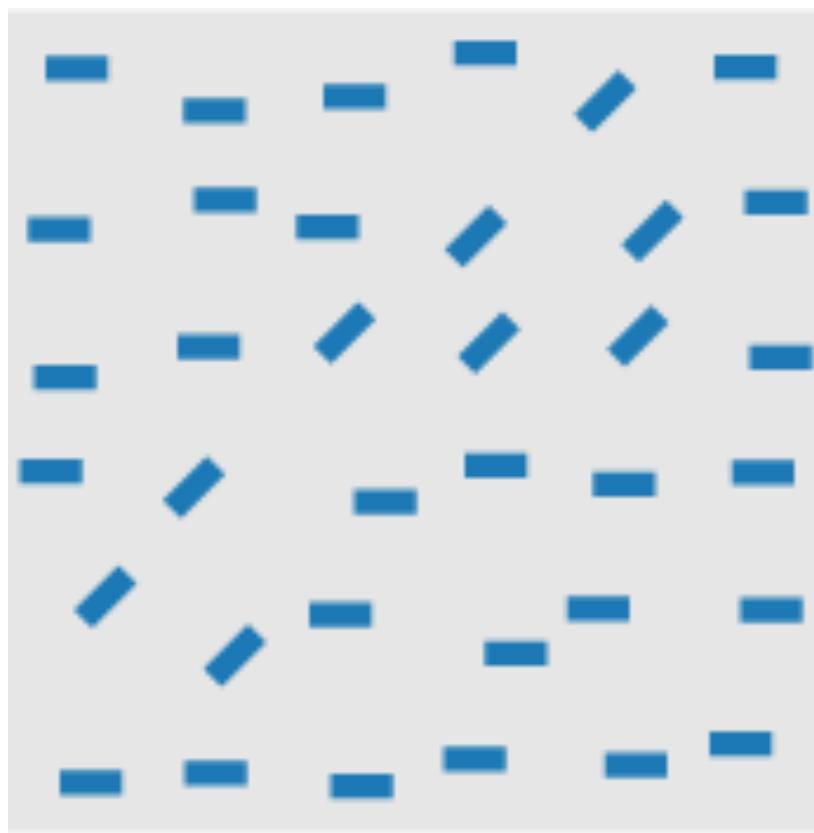
track one or more elements with a unique visual feature as they move in time and space

counting and estimation

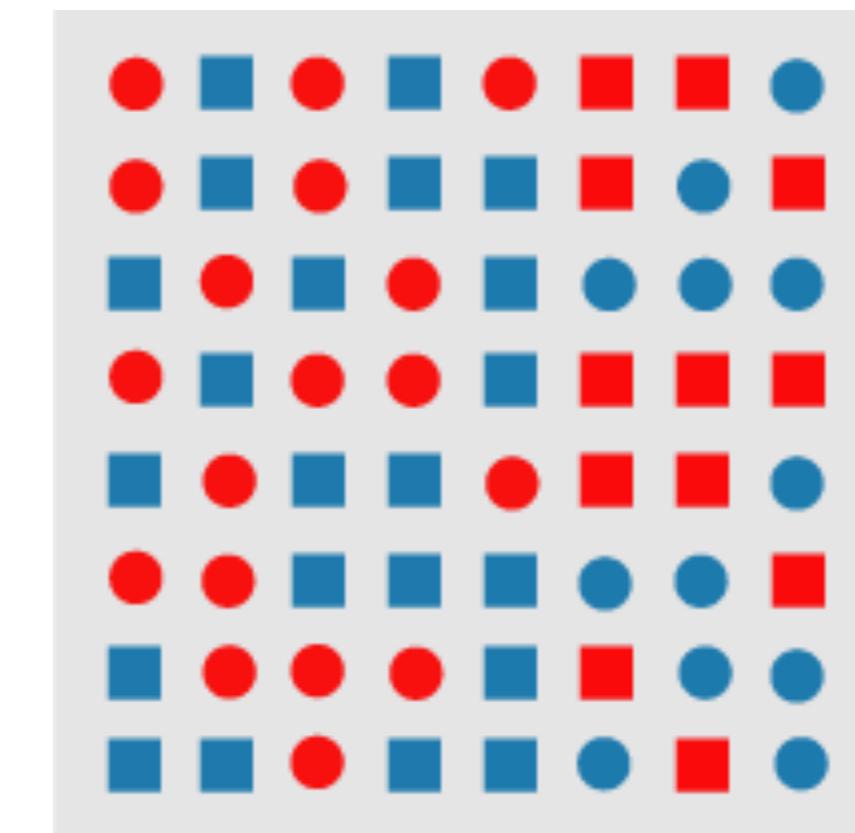
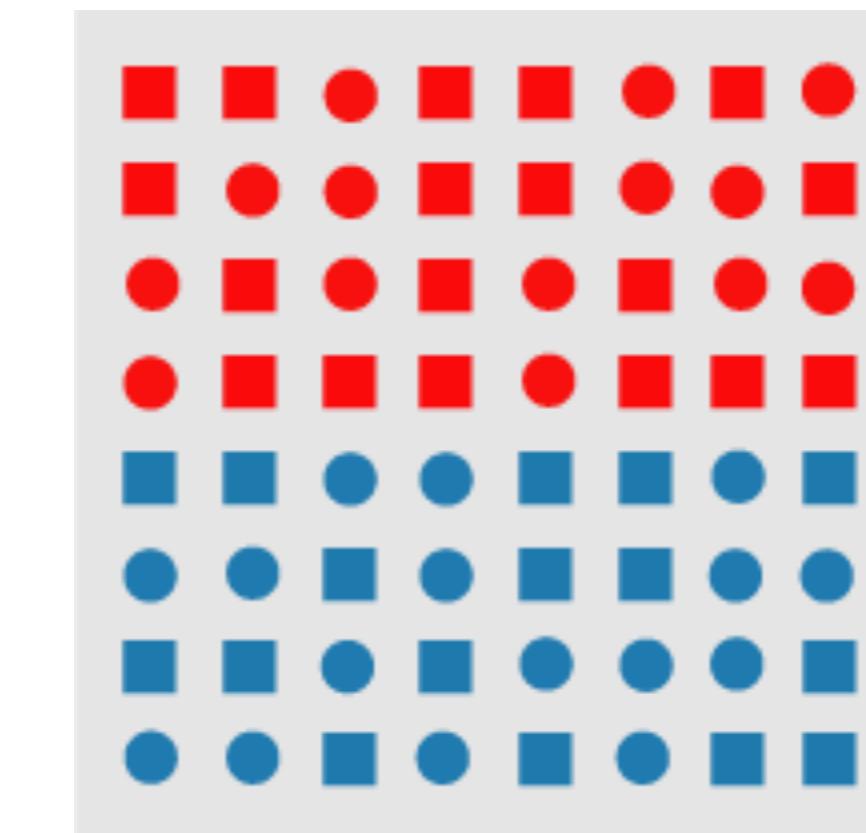
users count or estimate the number of elements with a unique visual feature.

Tasks

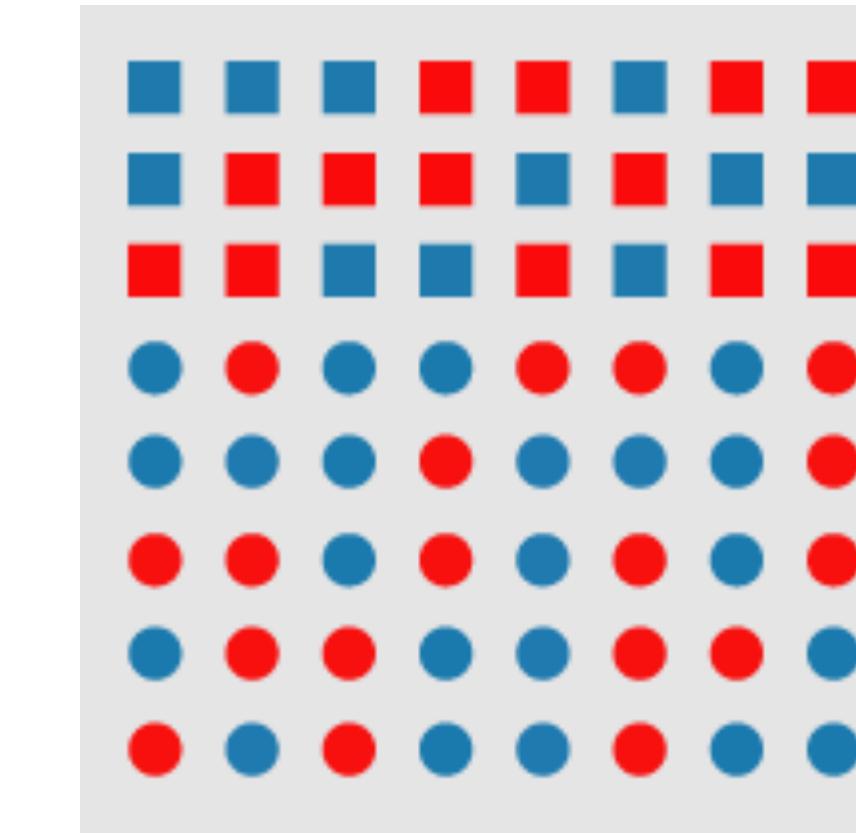
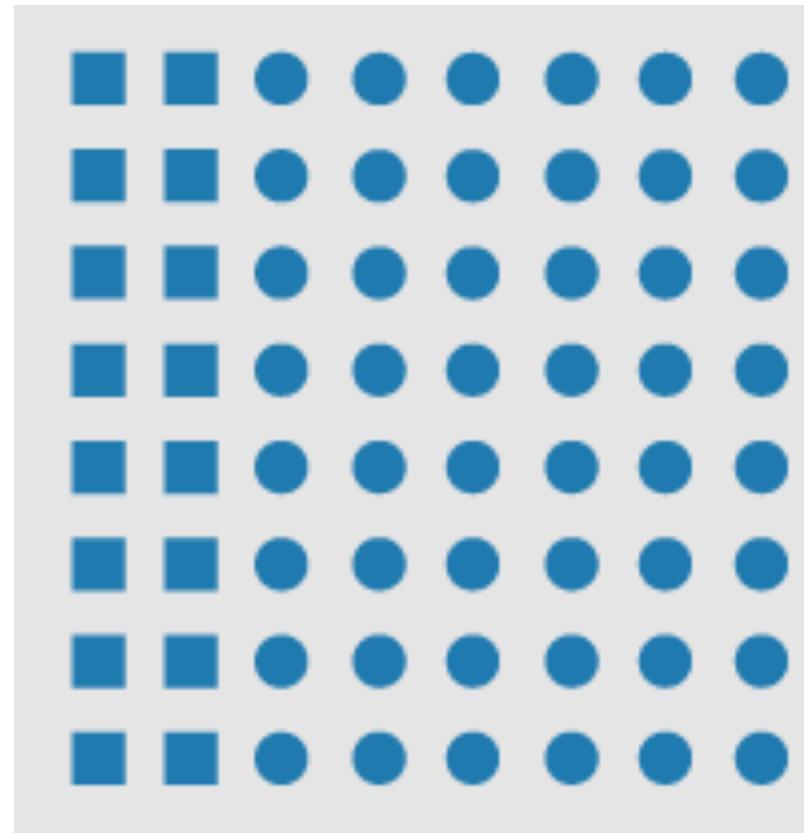
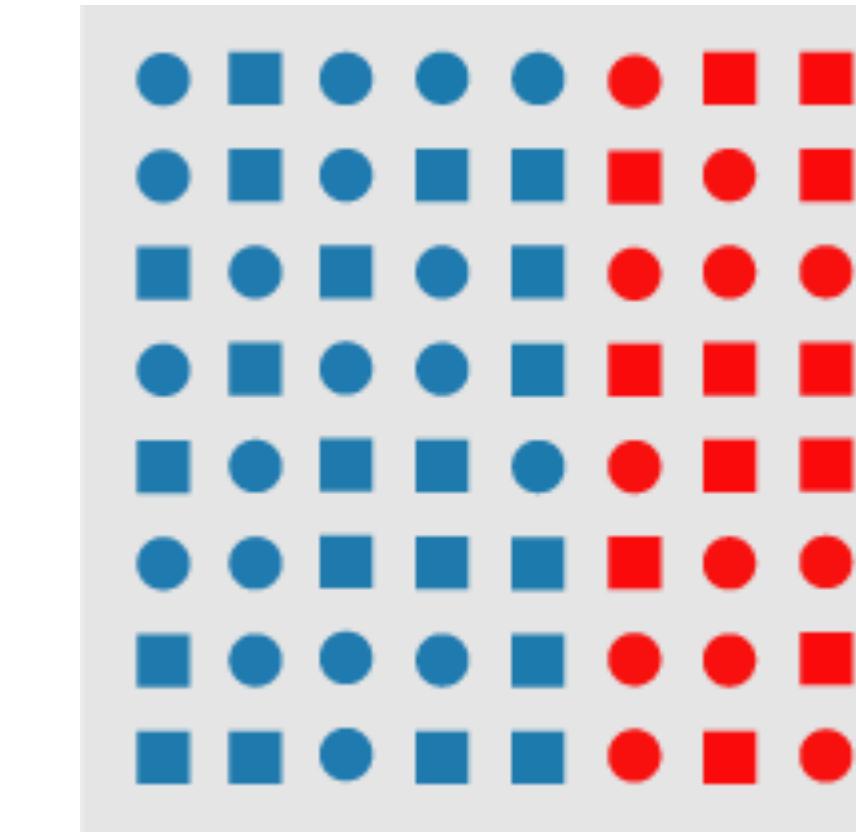
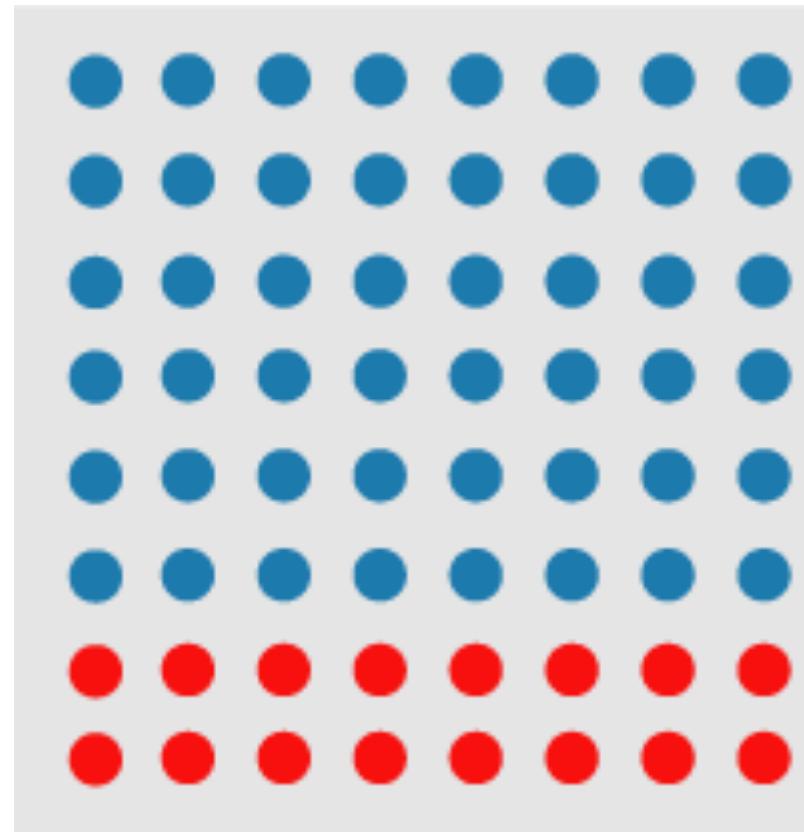
Number Estimation



Boundary Detection



Hierarchy of Preattentive Features



Examples online!

Theories of Preattentive Processing

Not known for sure how it works

Several theories:

<http://www.csc.ncsu.edu/faculty/healey/PP/index.html>

Preattentive Processing in Vis

Can be used to draw attention to areas of interest

Can be used to express similarity/group memberships

Visual features must be carefully designed

Conjunctions must be avoided

Examples are “Cues” (Focus and Context technique)

Change Blindness

Change Blindness

Details of an image cannot be remembered across separate scenes

except in areas with focused attention

Interruption (e.g. a blink, eye saccade or blank screen) amplifies this effect

Not failure of vision system

failure due to inappropriate attentional guidance





Ron Rensink 2002



Ron Rensink 2002



Ron Rensink 2002



Ron Rensink 2002

Change Blindness

Various theories about causes

Overwriting: Information that was not abstracted is lost

First Impression: Only initial view is abstracted

Nothing is Stored: Only abstract concepts are committed to memory

Everything is Stored, Nothing is Compared: We compare only when we are forced to

Feature Combination: scenes are combined as long as they make sense

Influencing factors

attention

expectation (knowing something will change)

semantic importance of changed object

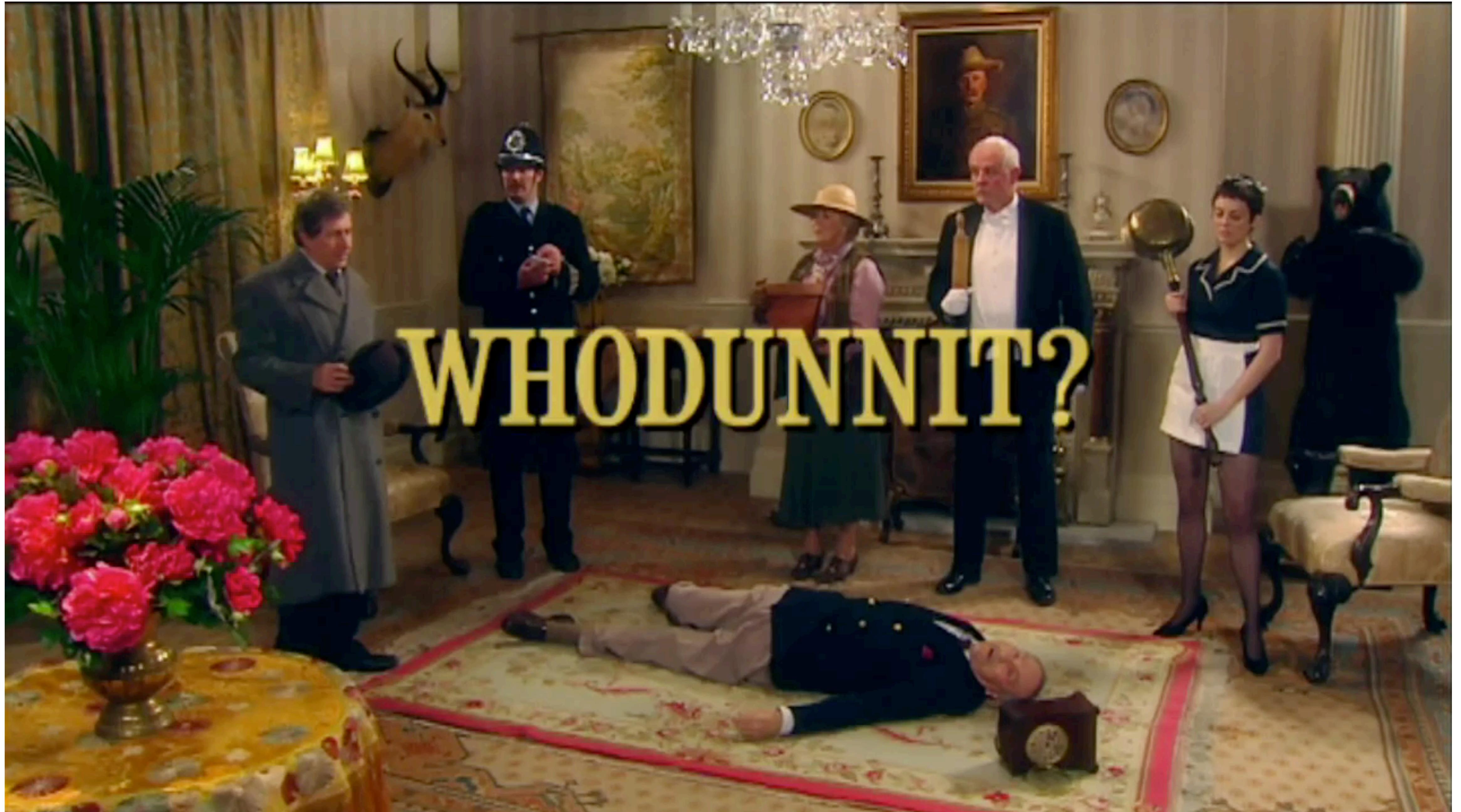
low level object properties overlooked more easily



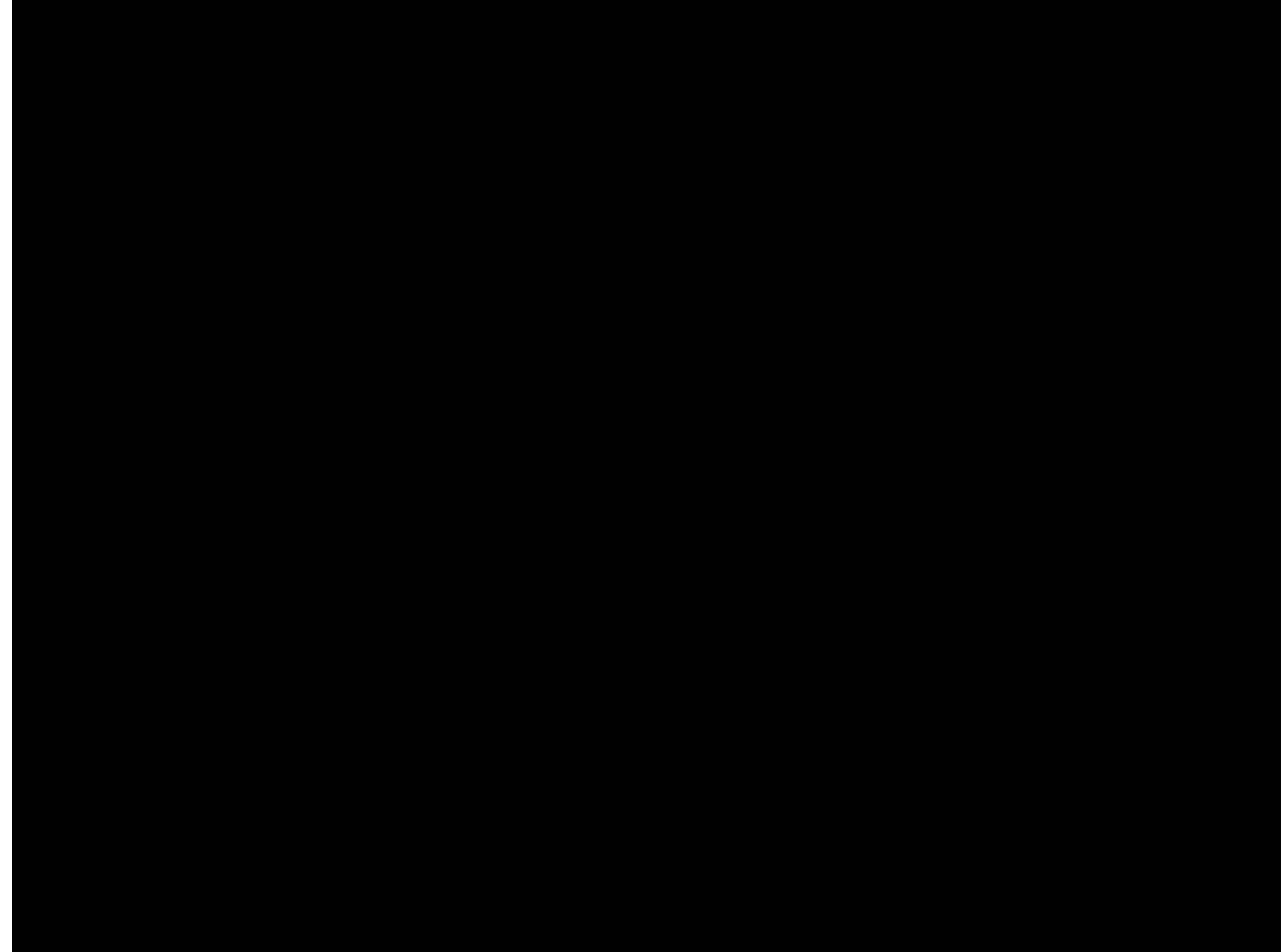


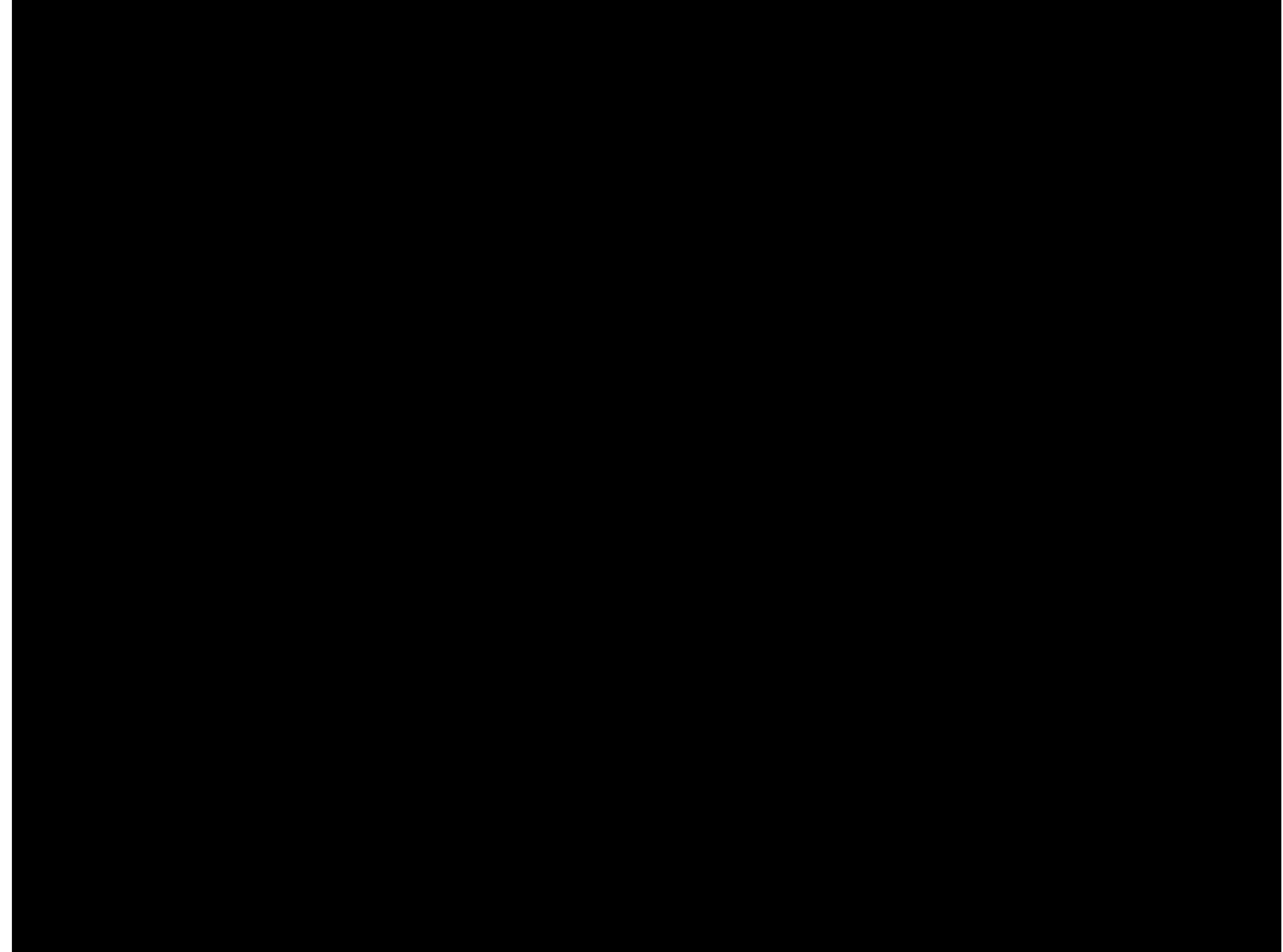


Attention Blindness



WHODUNNIT?





Take Home Points

To find meaning in what we see **we must selectively pay attention** to what is important

Low-level vision is driven by object features rather than a conscious effort where to look (e.g., pre-attentive processing)

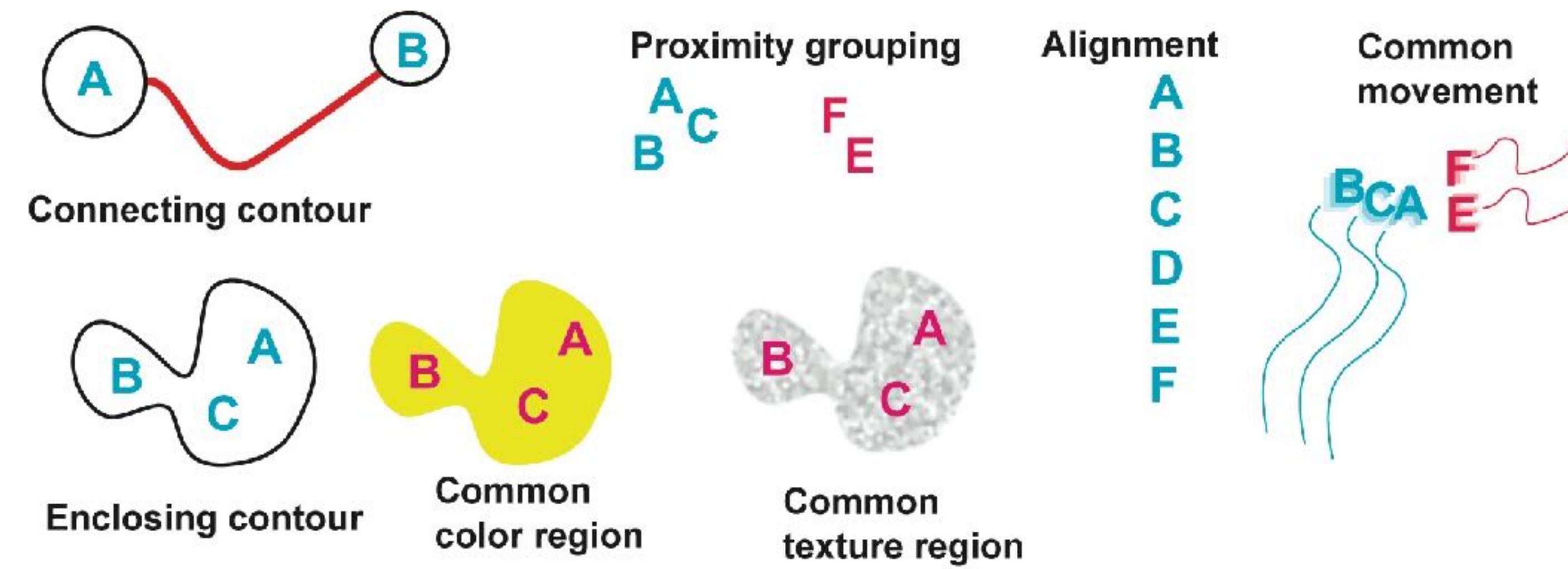
Attention is driven by preexisting knowledge, expectations, and goals stored in long-term memory

Gestalt Principles

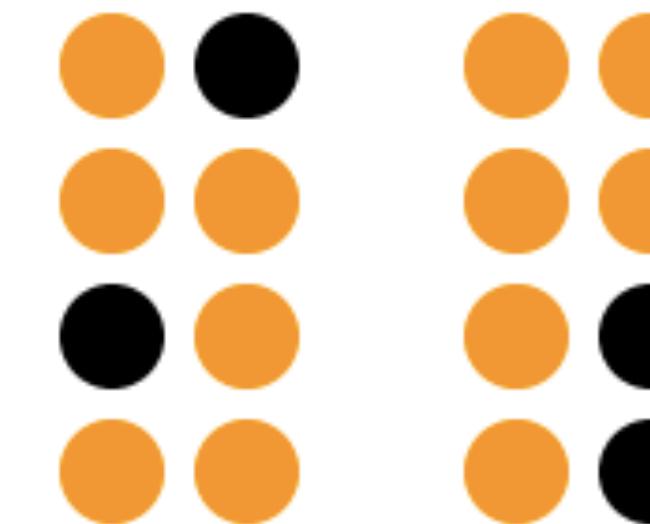
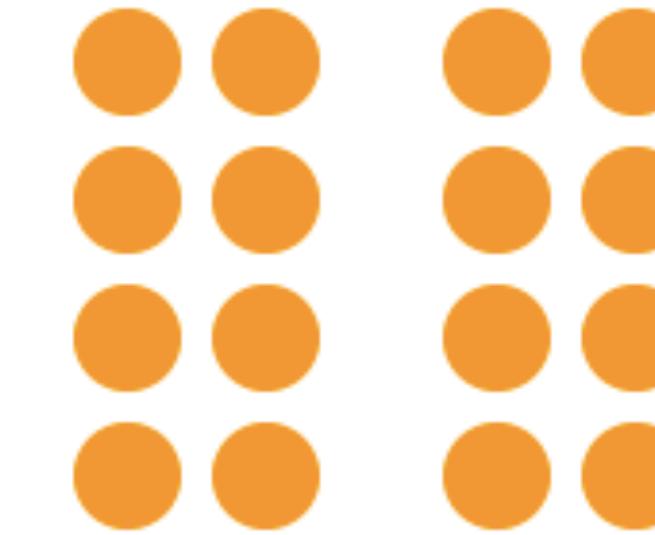
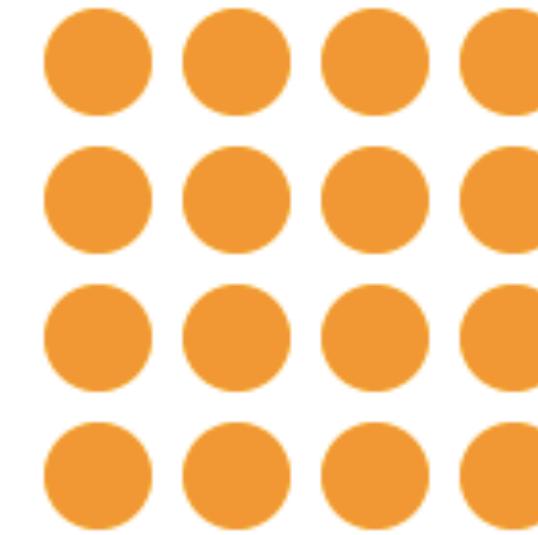
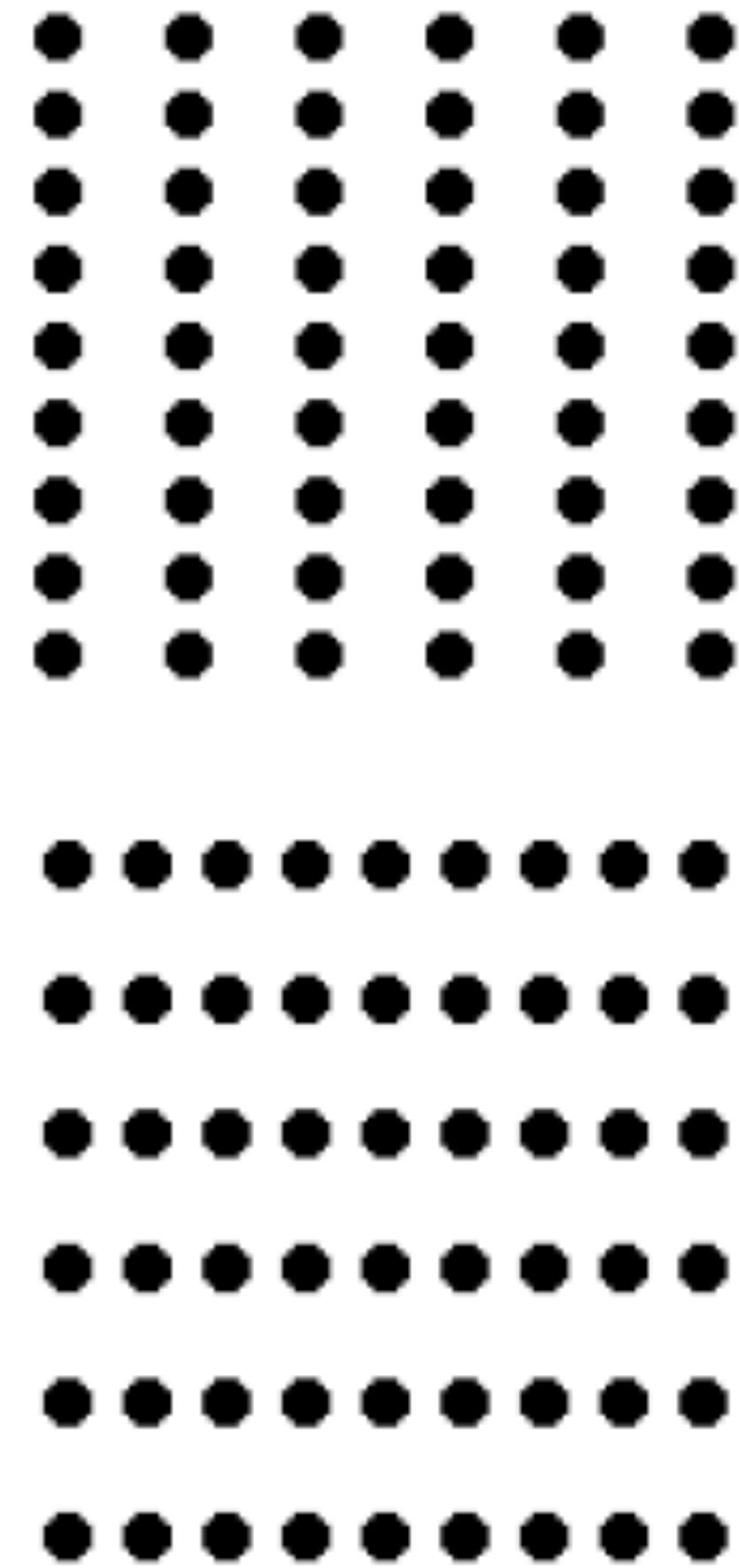
Wertheimer, 1923, and recent extensions

Gestalt Principles

Patterns that transcend the visual stimuli that produced them

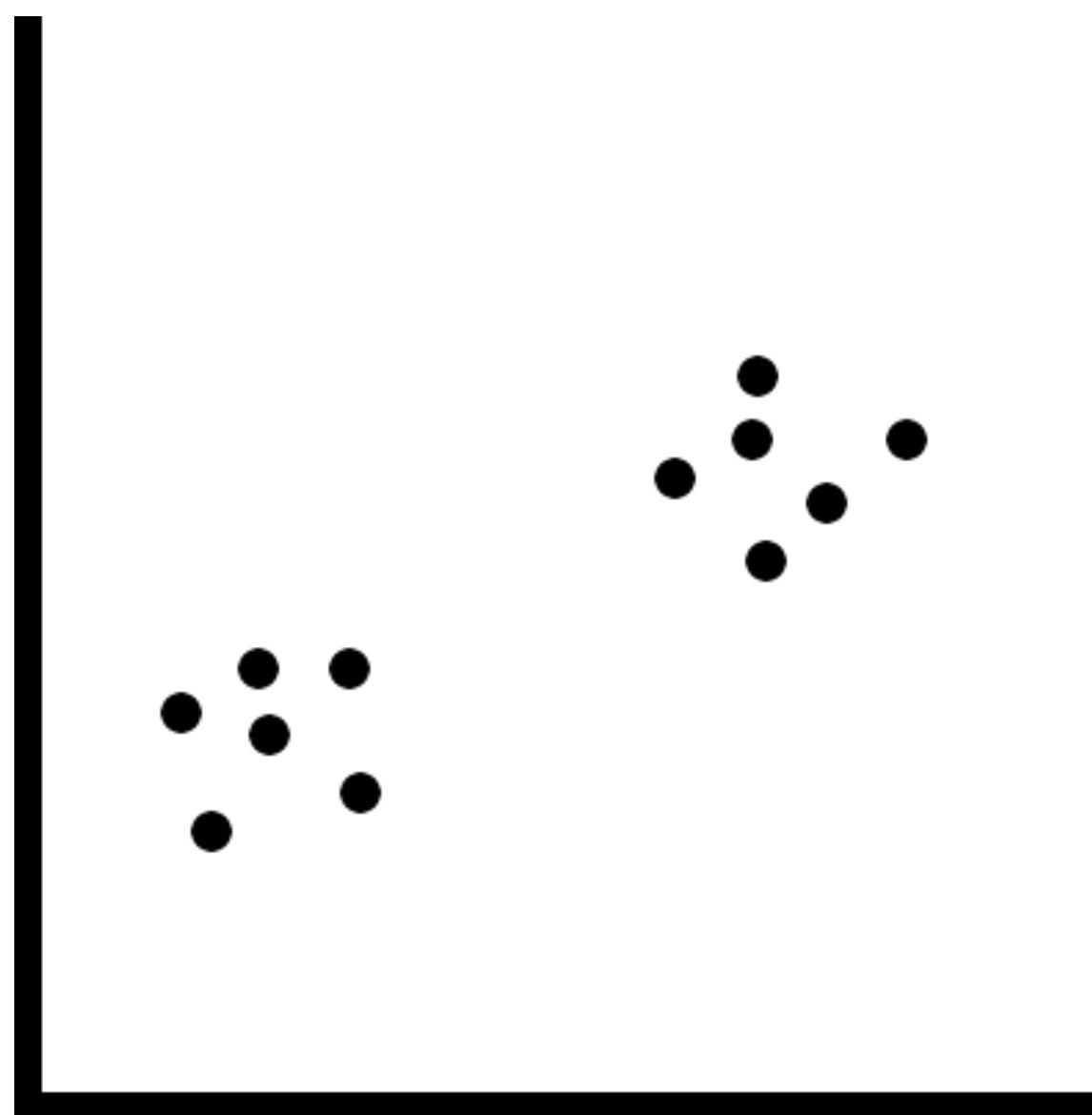


Proximity

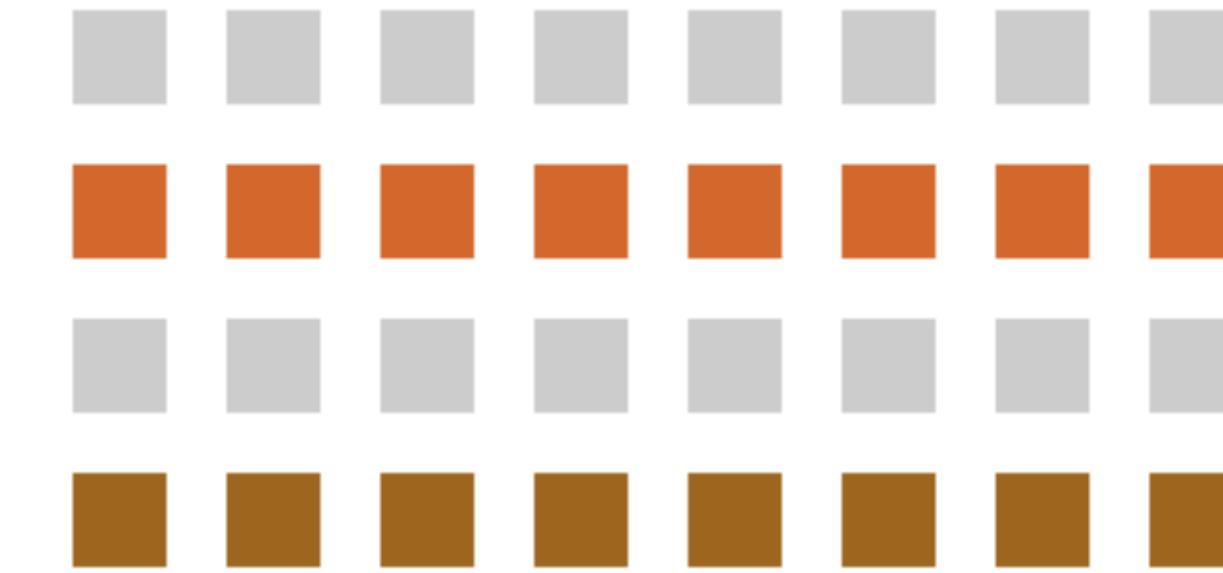


Proximity

Grouping/linking by placing entities in close proximity



Similarity

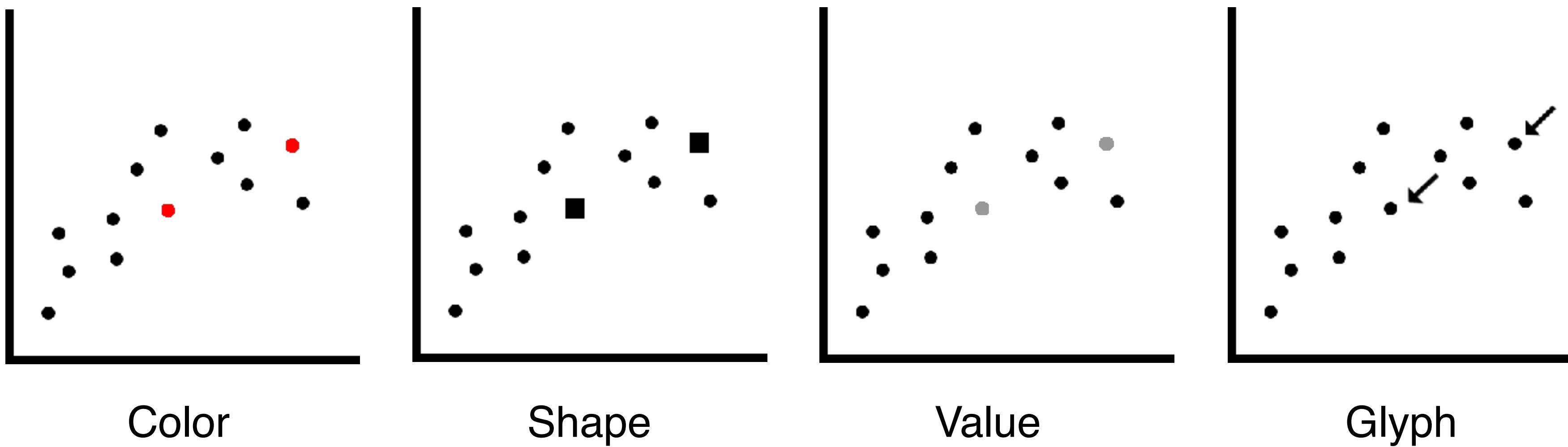


Similarity

Co-modulation of a **channel**

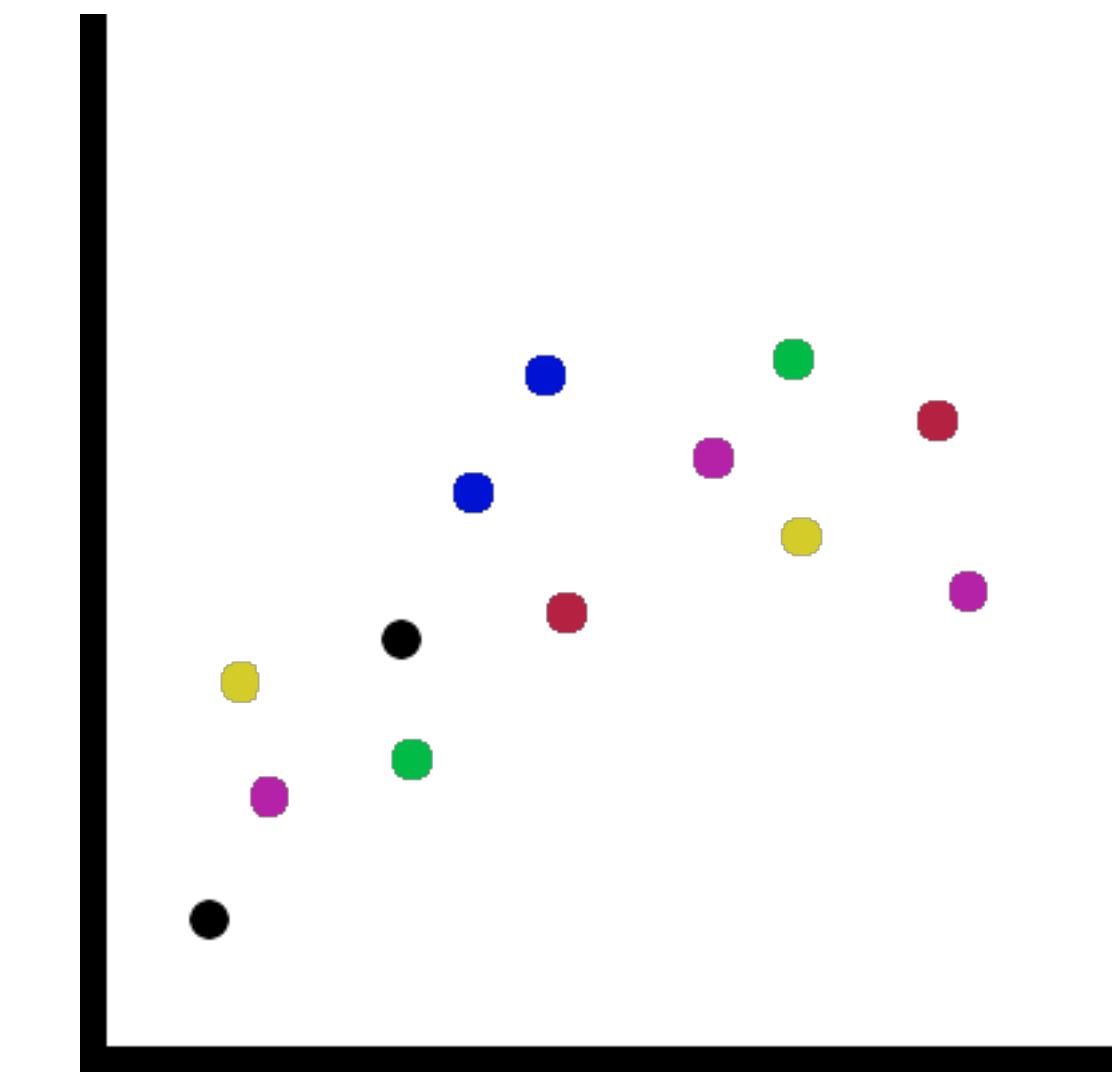
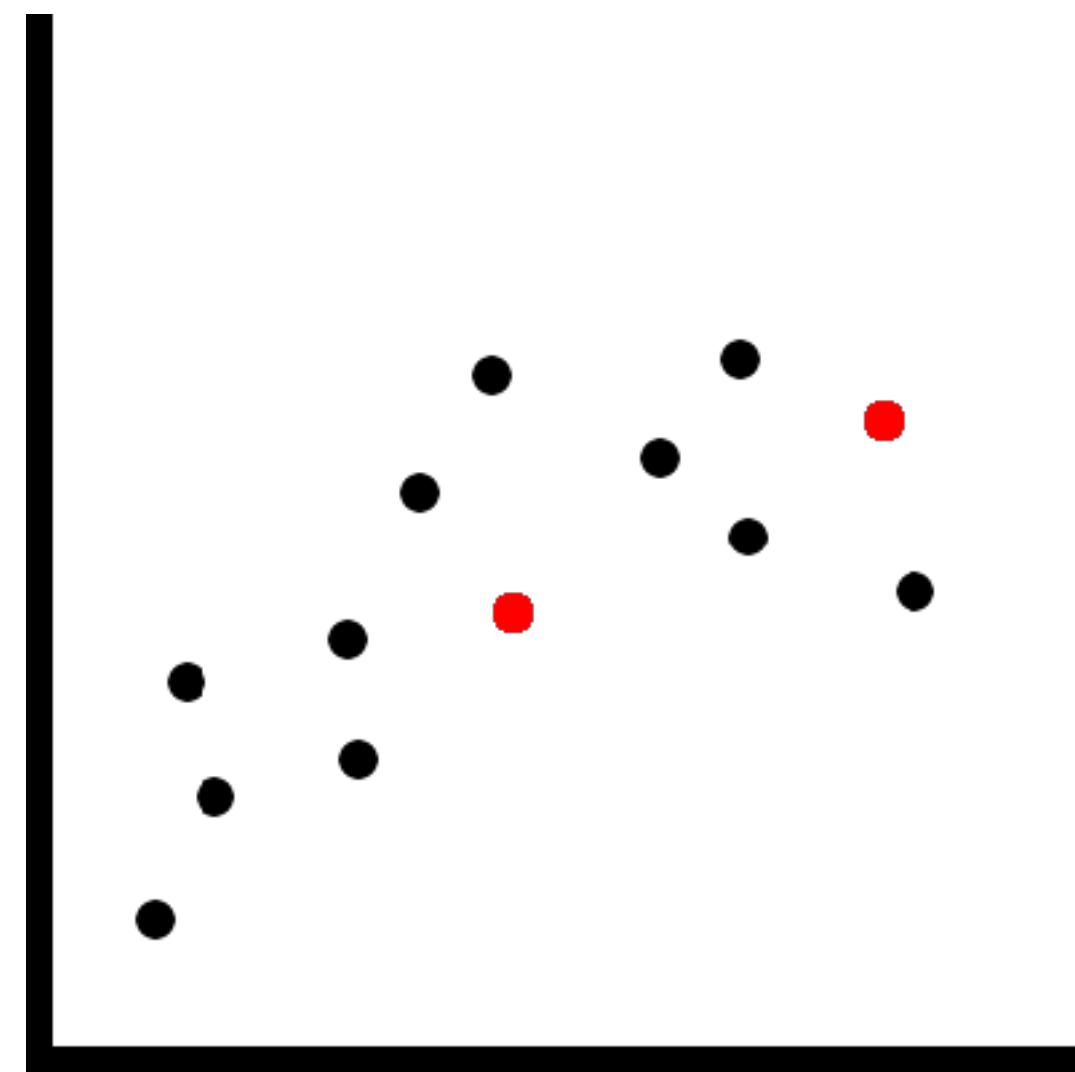
color, shape, size, value, orientation, texture, ...

Adding a glyph, label, frame, background



Color – Perception Issues (1/2)

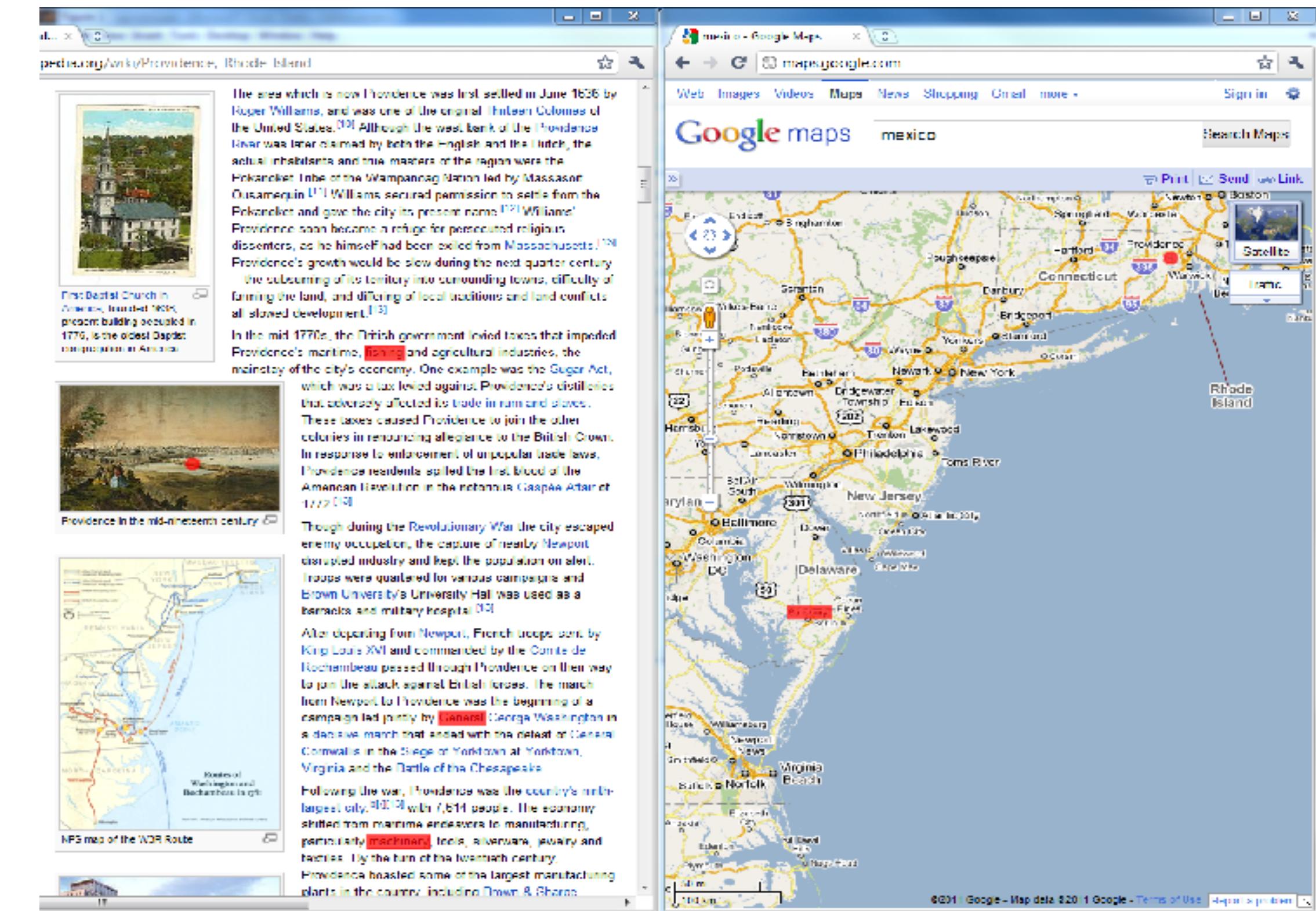
Preattentive properties: Very good for 1-2 simultaneous,
serial search for more



Color – Perception Issues (2/2)

Slower in a cluttered environment

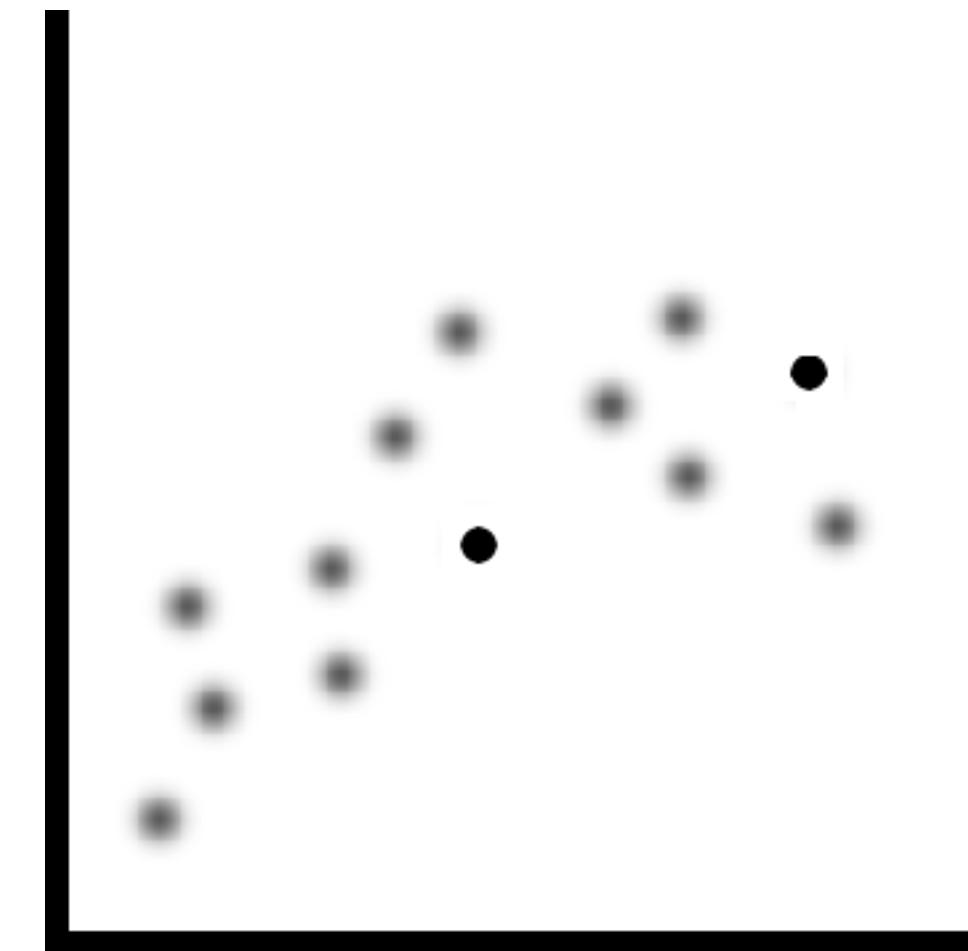
Size of colored object relevant.



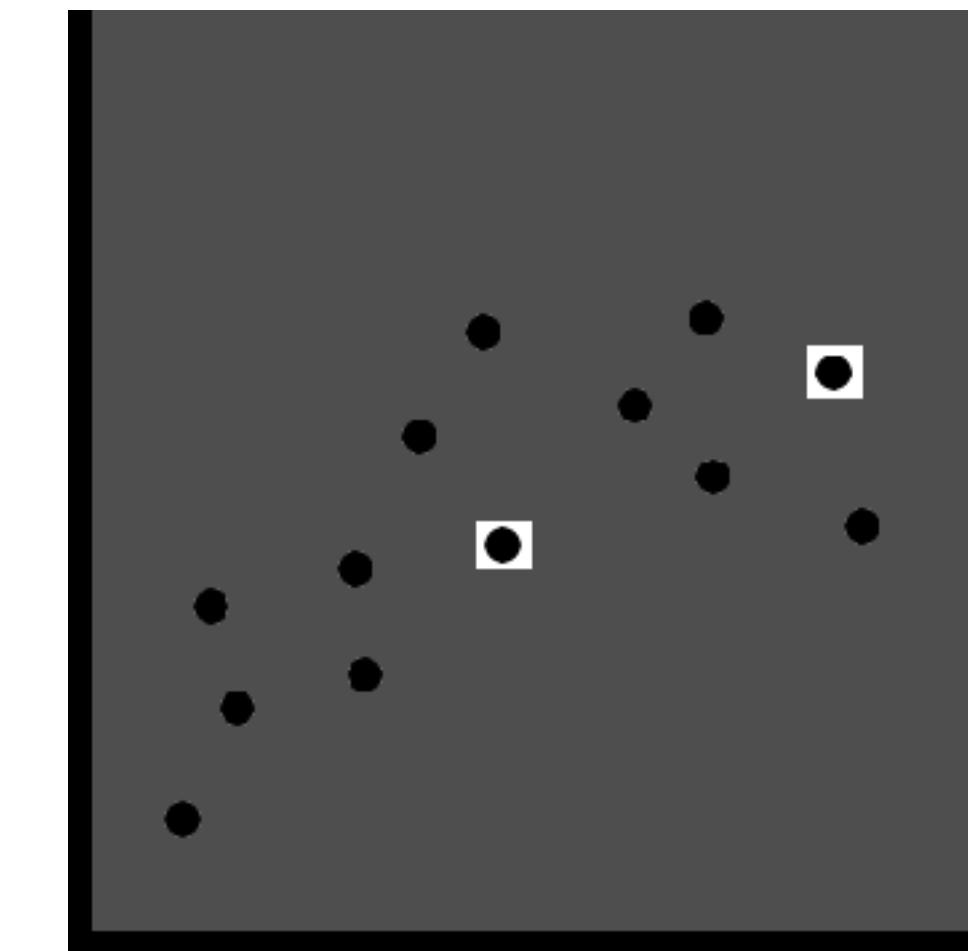
Similarity

Modulate everything else

Blurring, darkening, desaturating, etc.



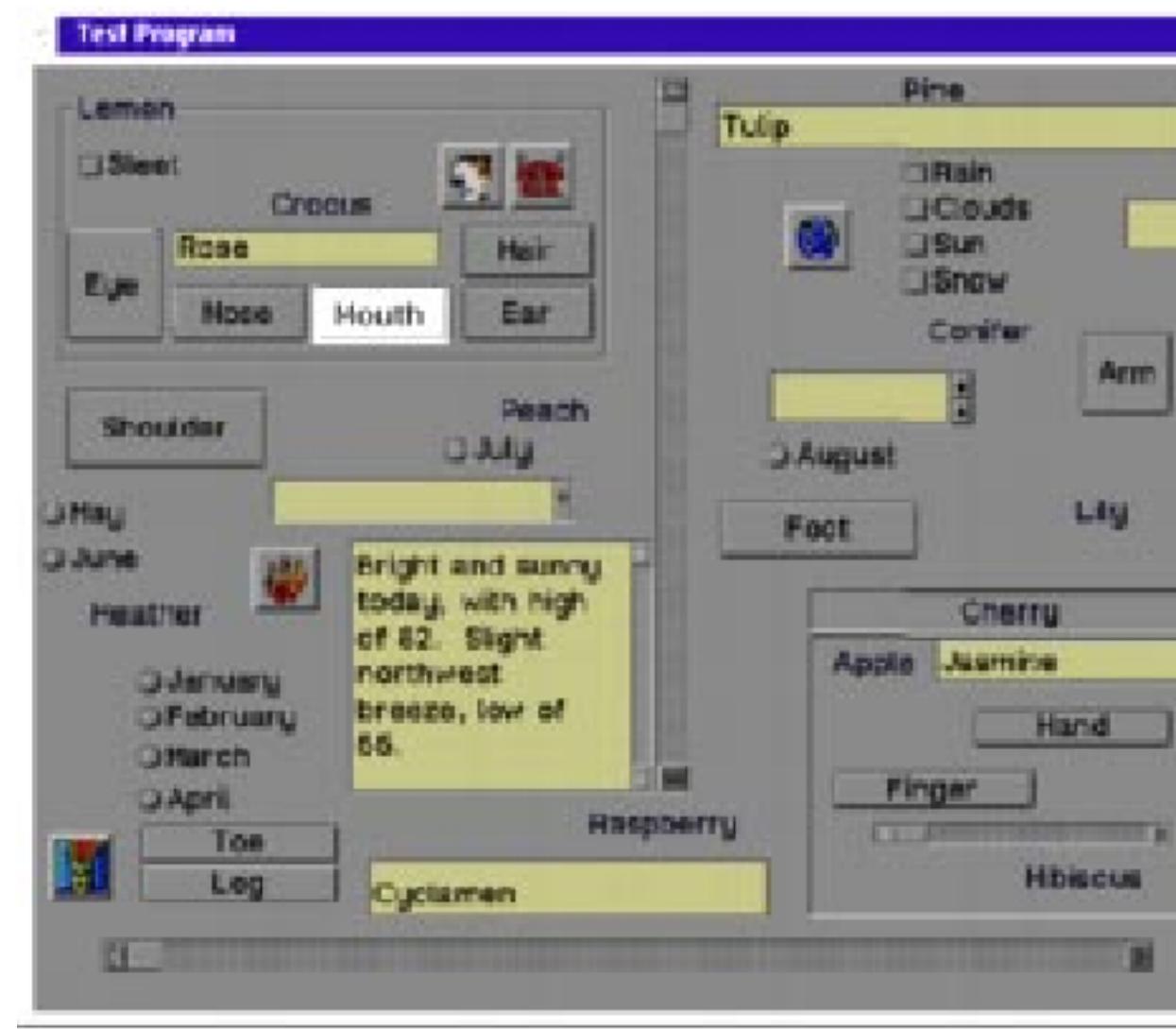
Blur



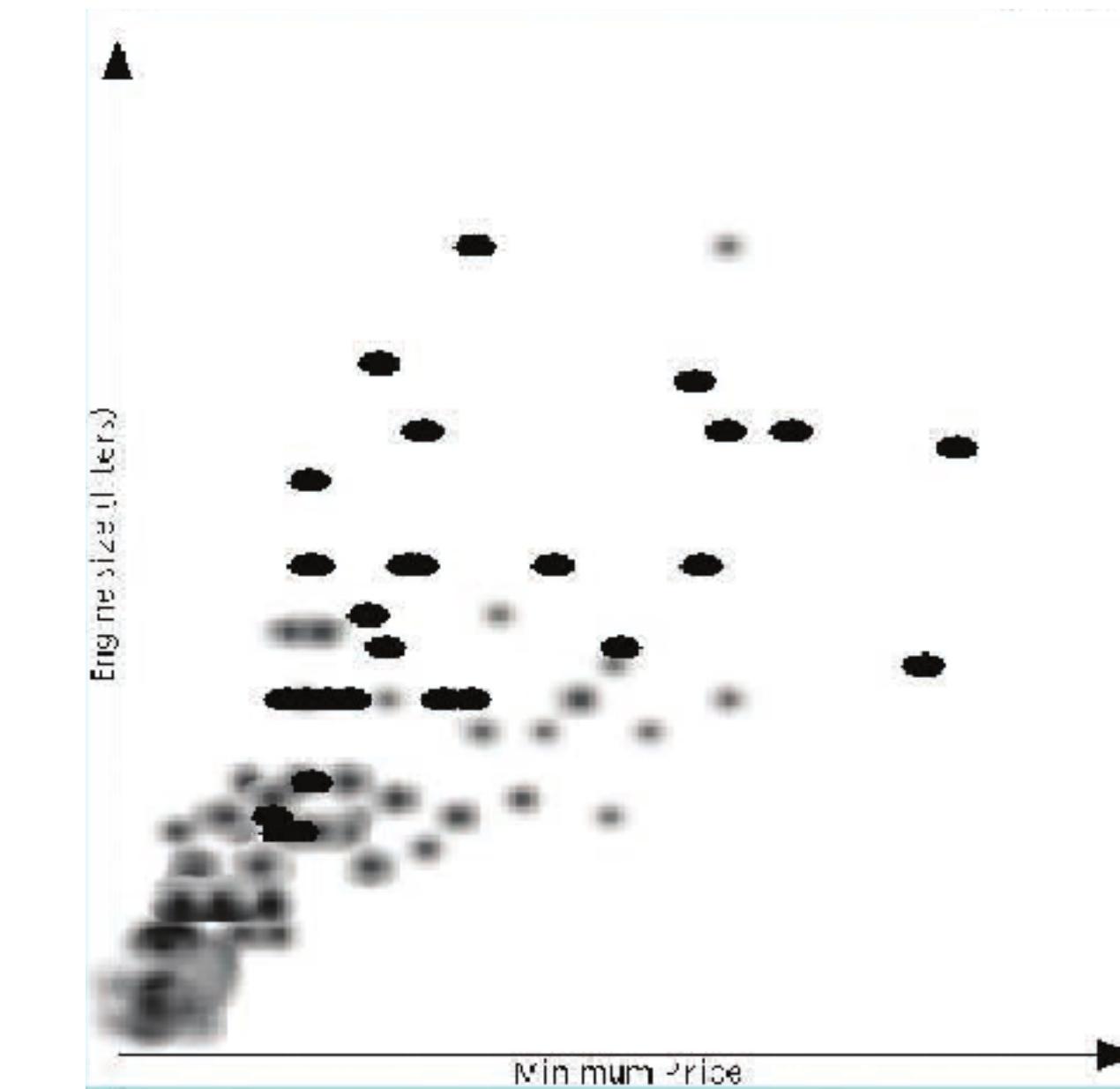
Darkening

Modulating Everything Else: Reccomendation, Example

Don't use unless the sole objective is to guide attention toward one (set of) items

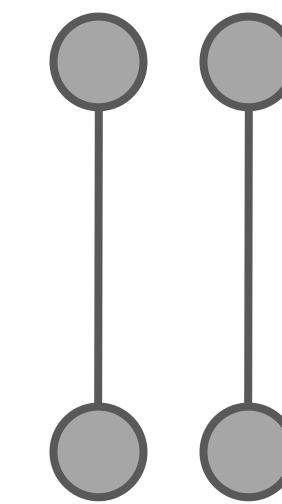


[Zhai et al., 1997]

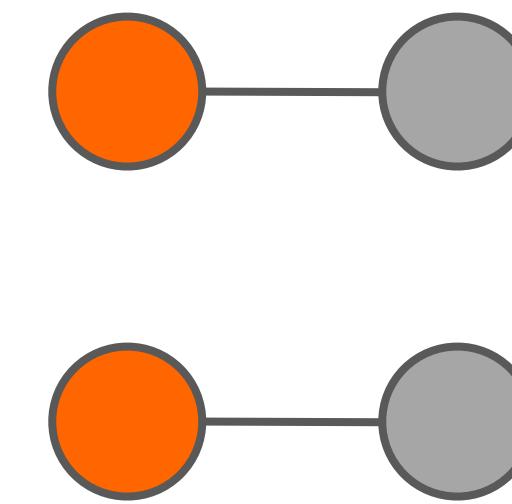


[Kosara et al., 2002]

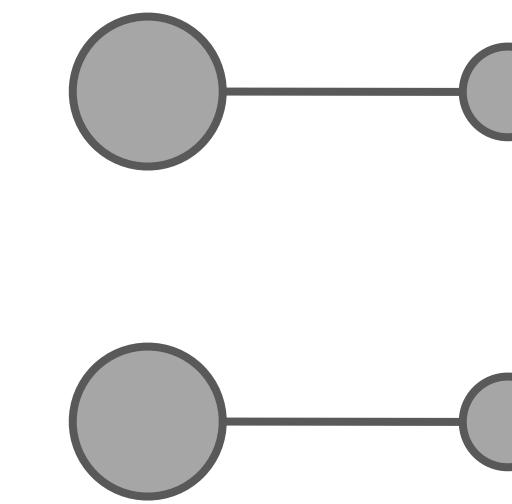
A Little Experiment...



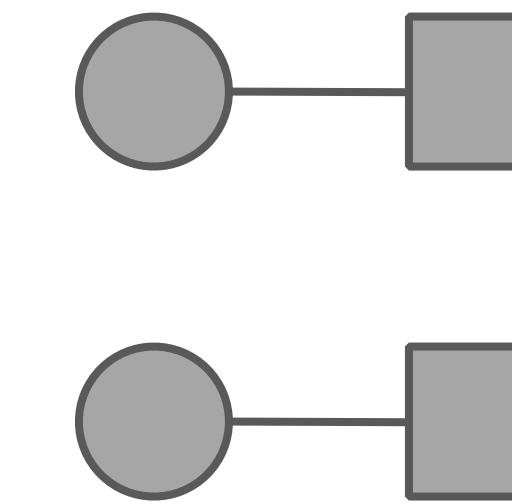
Proximity



Color



Size

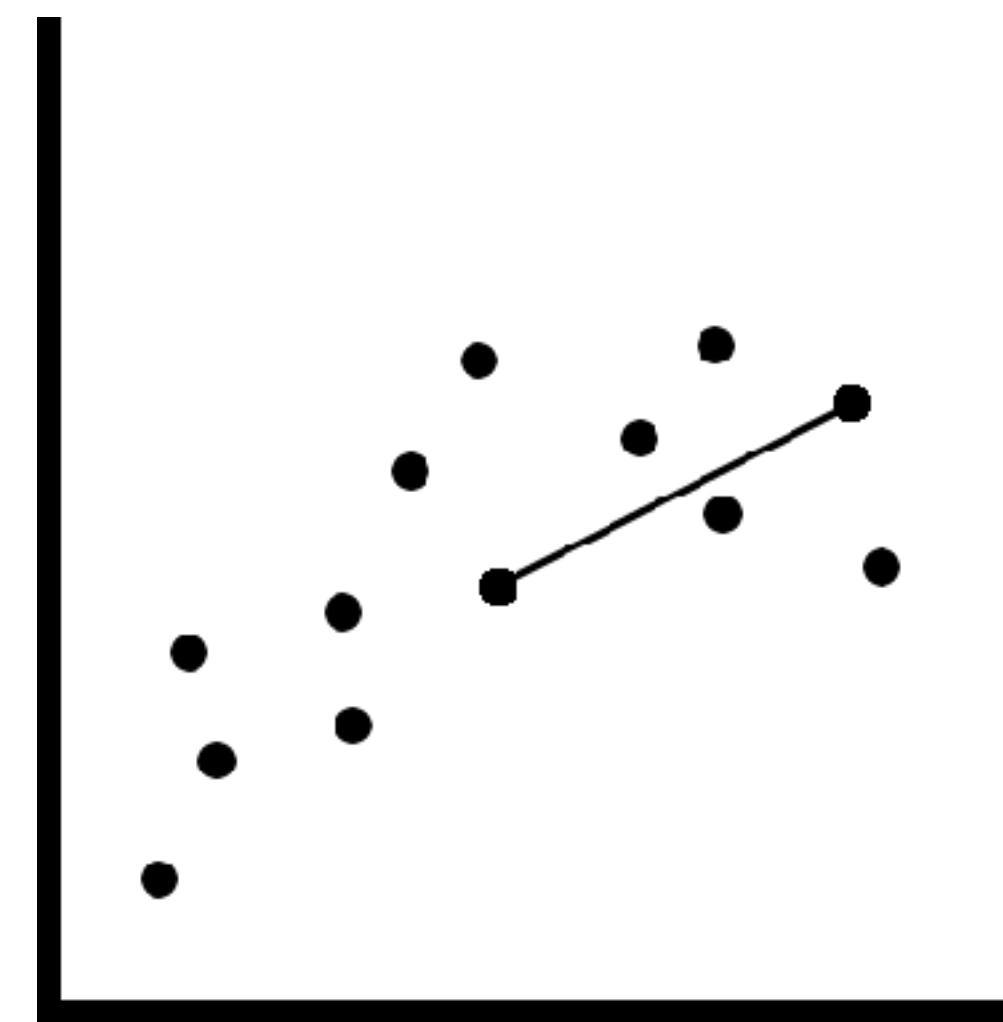


Shape

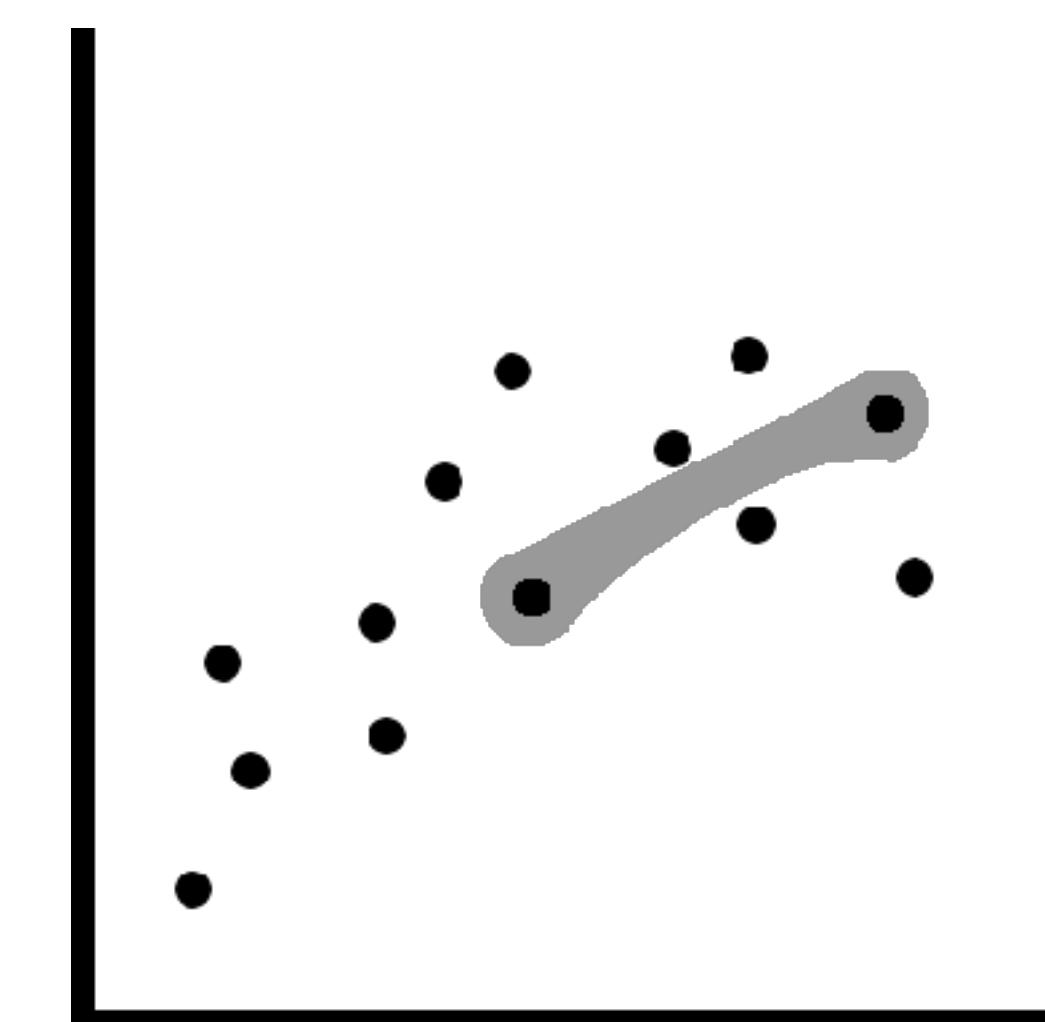
Connectedness and Common Region

Connected items with a line or curve

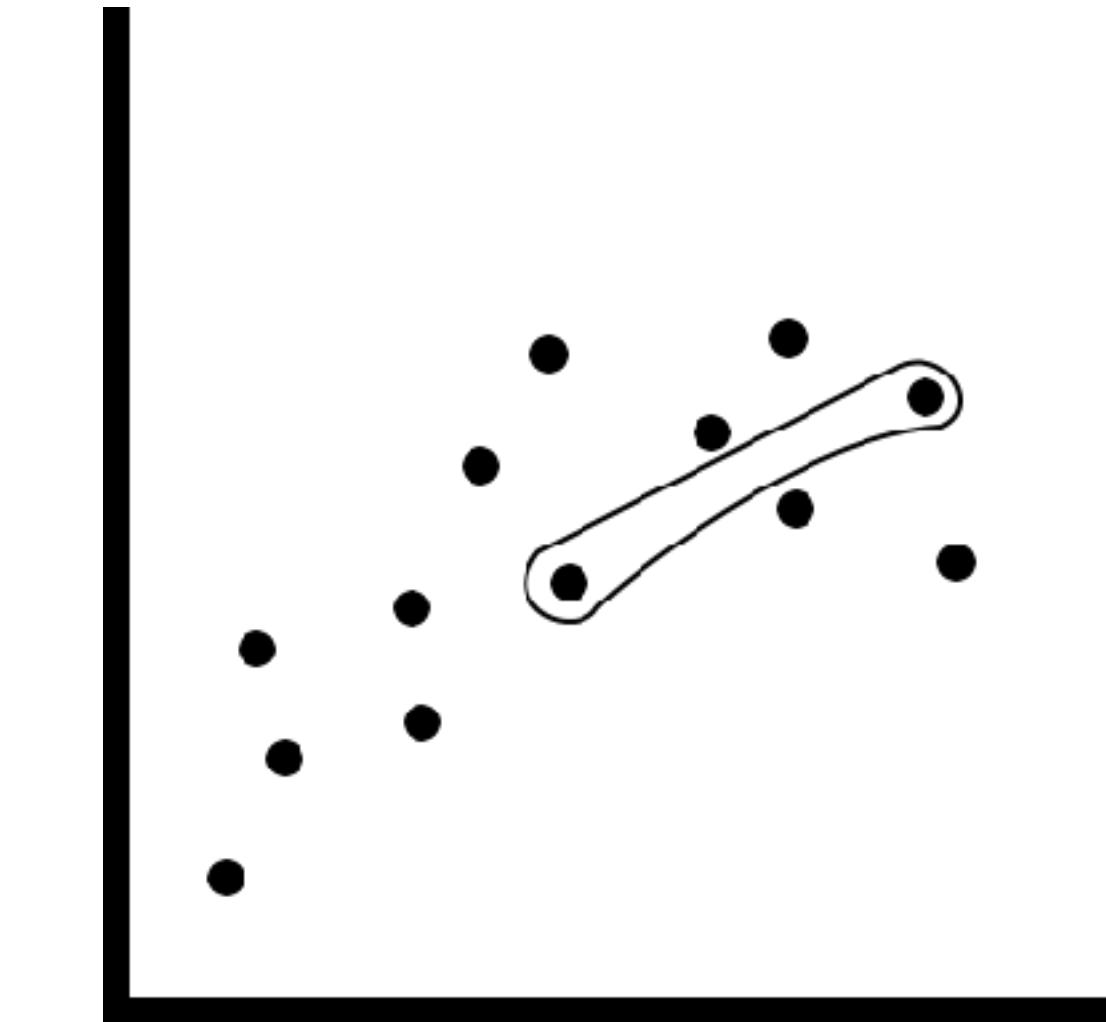
Surround items with a outline, surface, volume



Connectedness



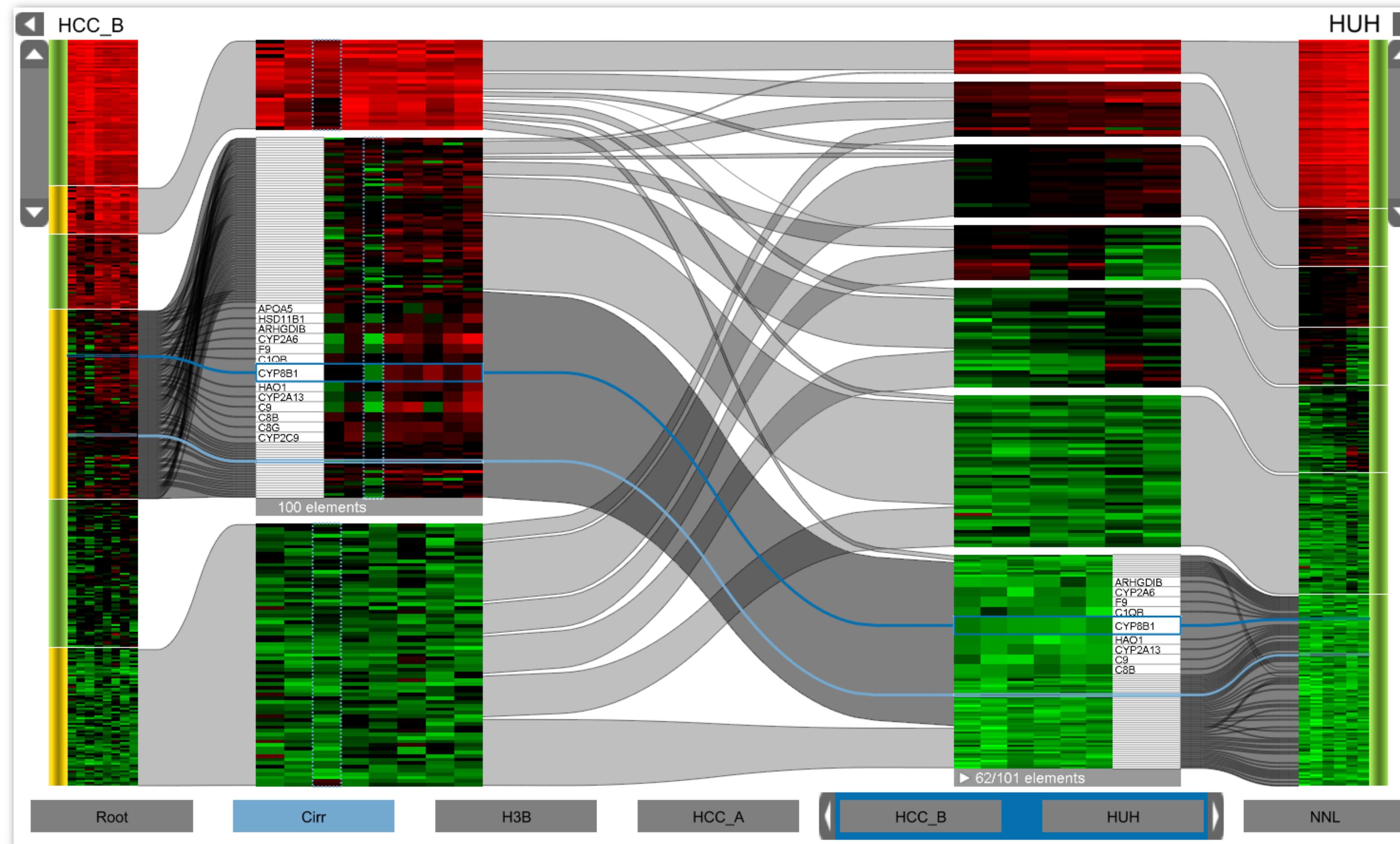
Surface



Common Region

Outline

Connection

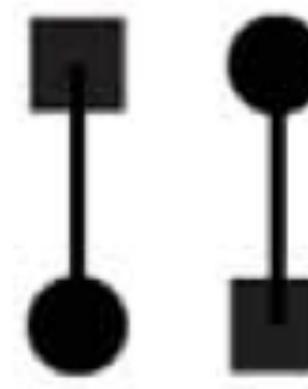


Enclosure

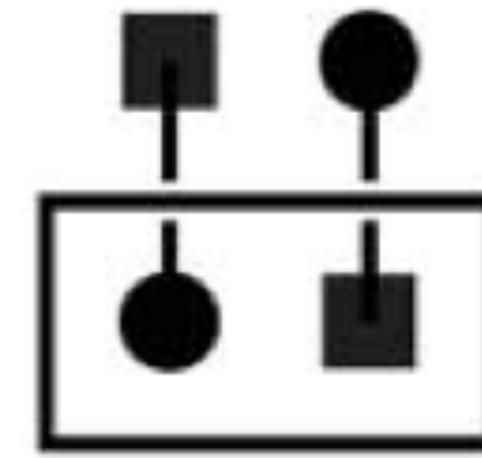
Similarity



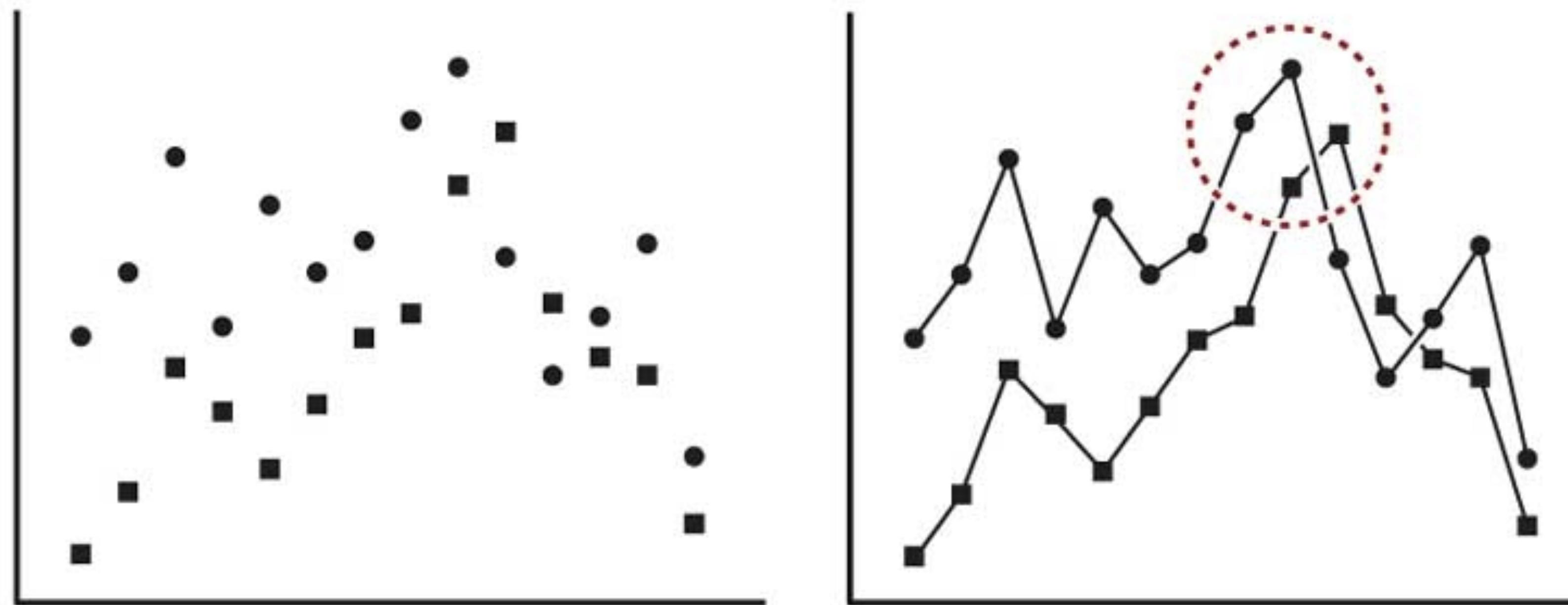
Connection



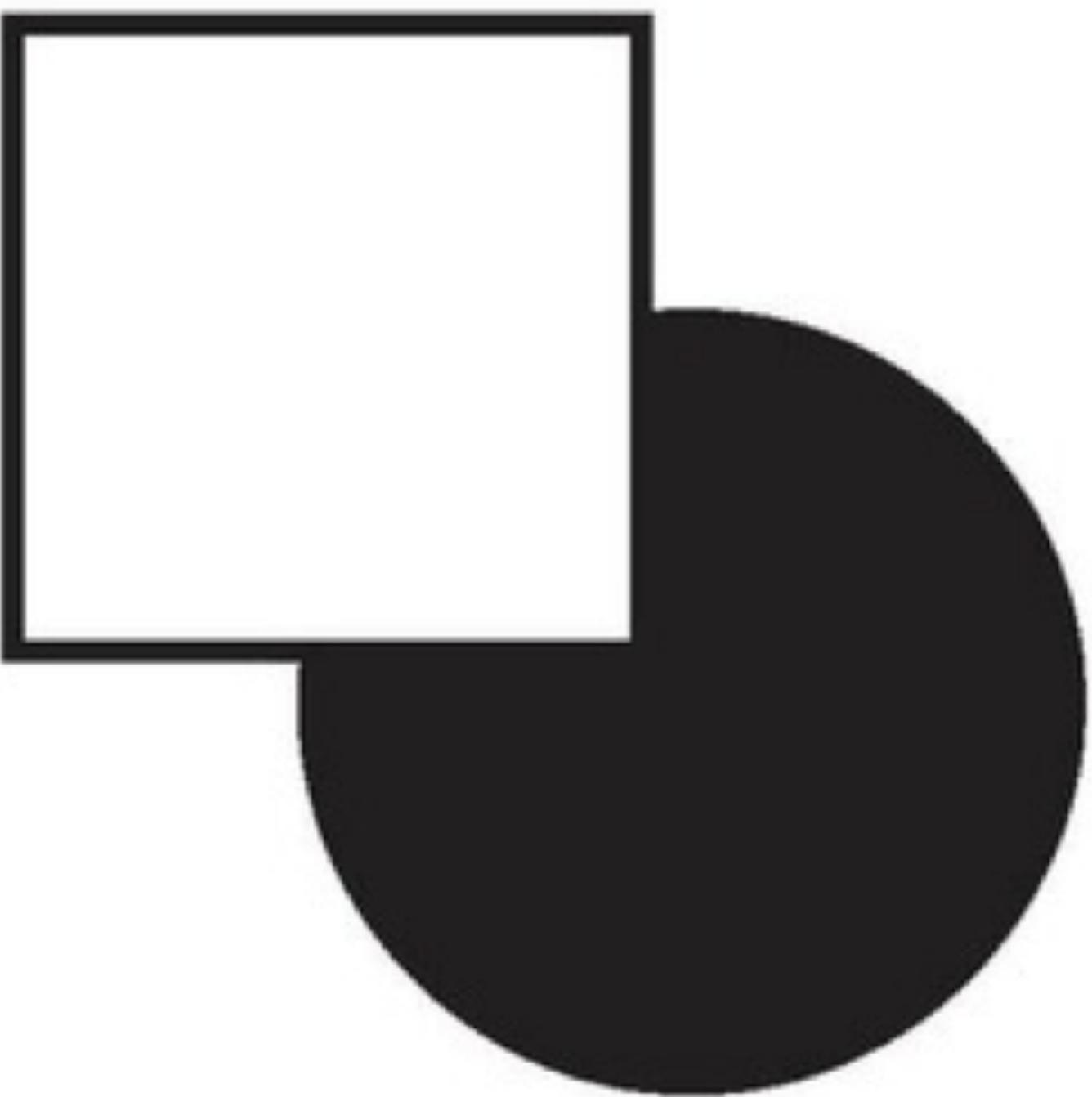
Enclosure



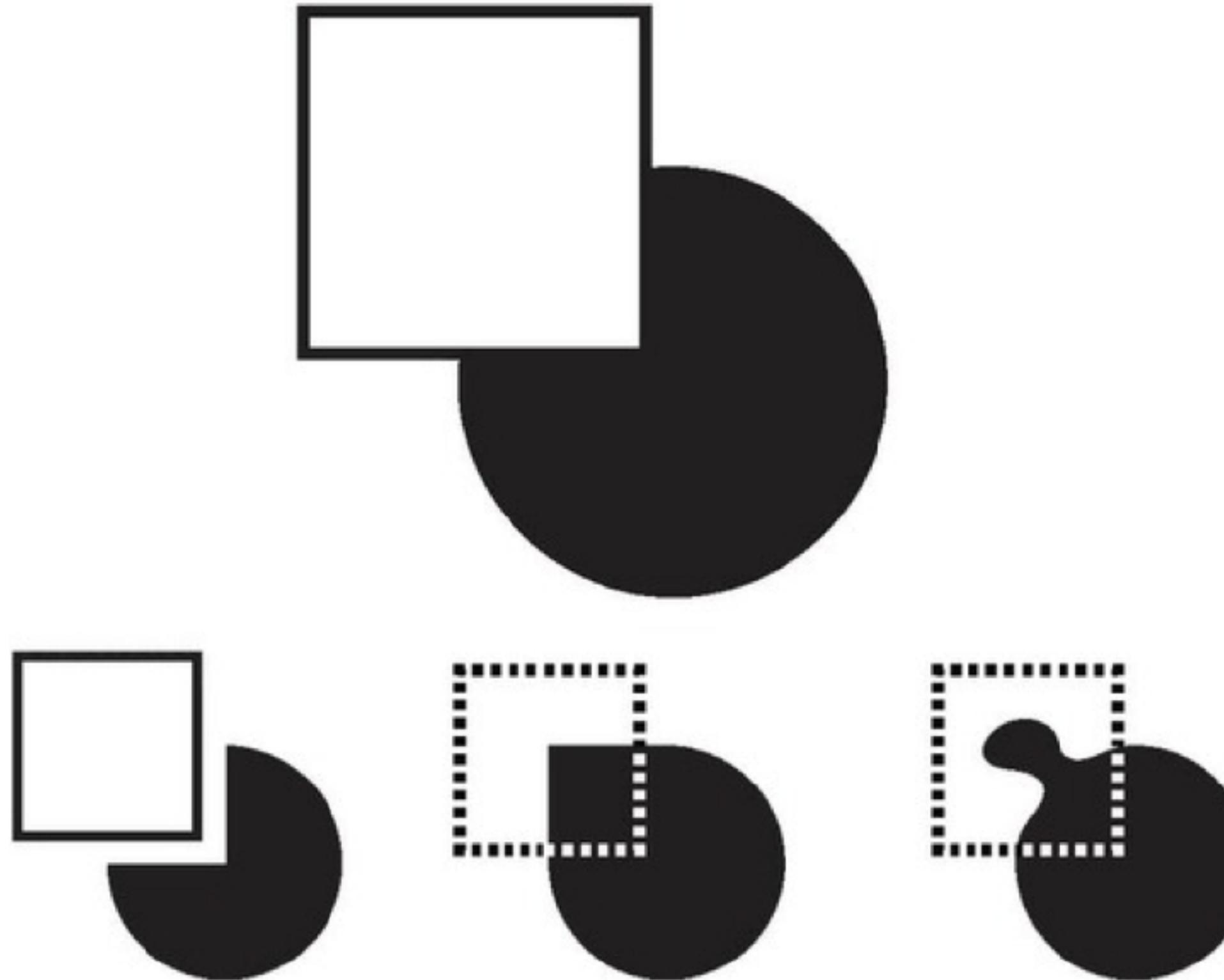
Enclosure



Continuity

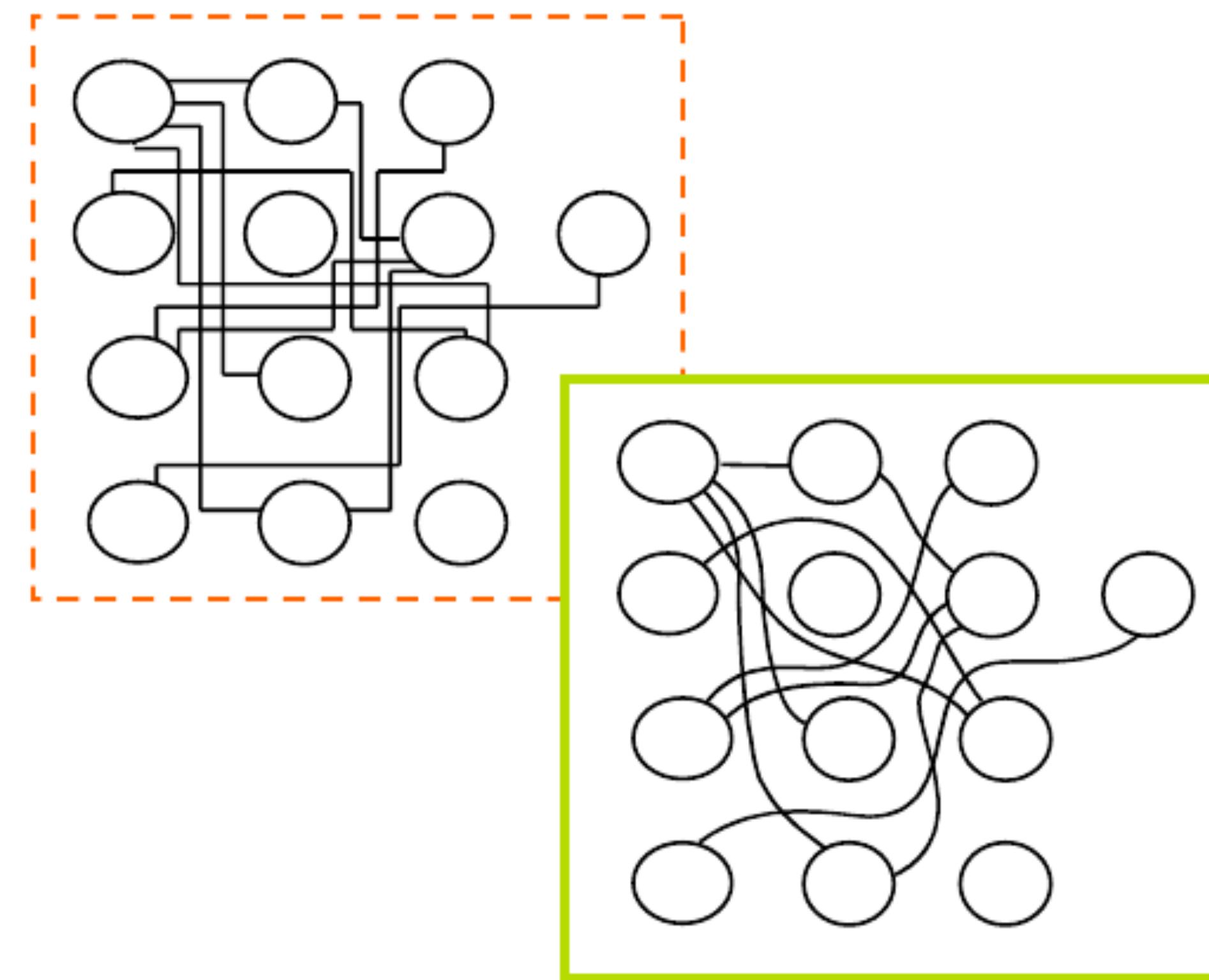
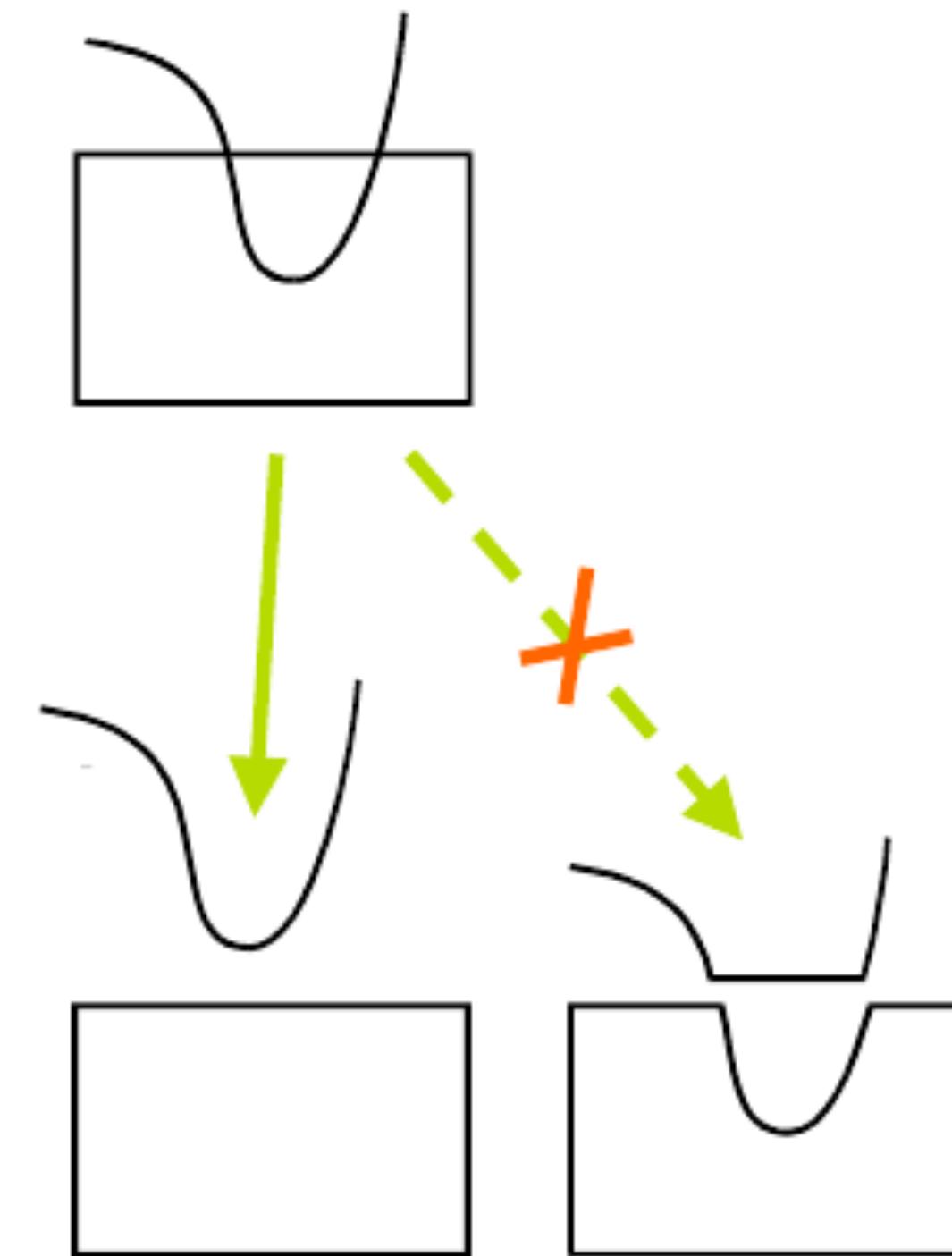


Continuity

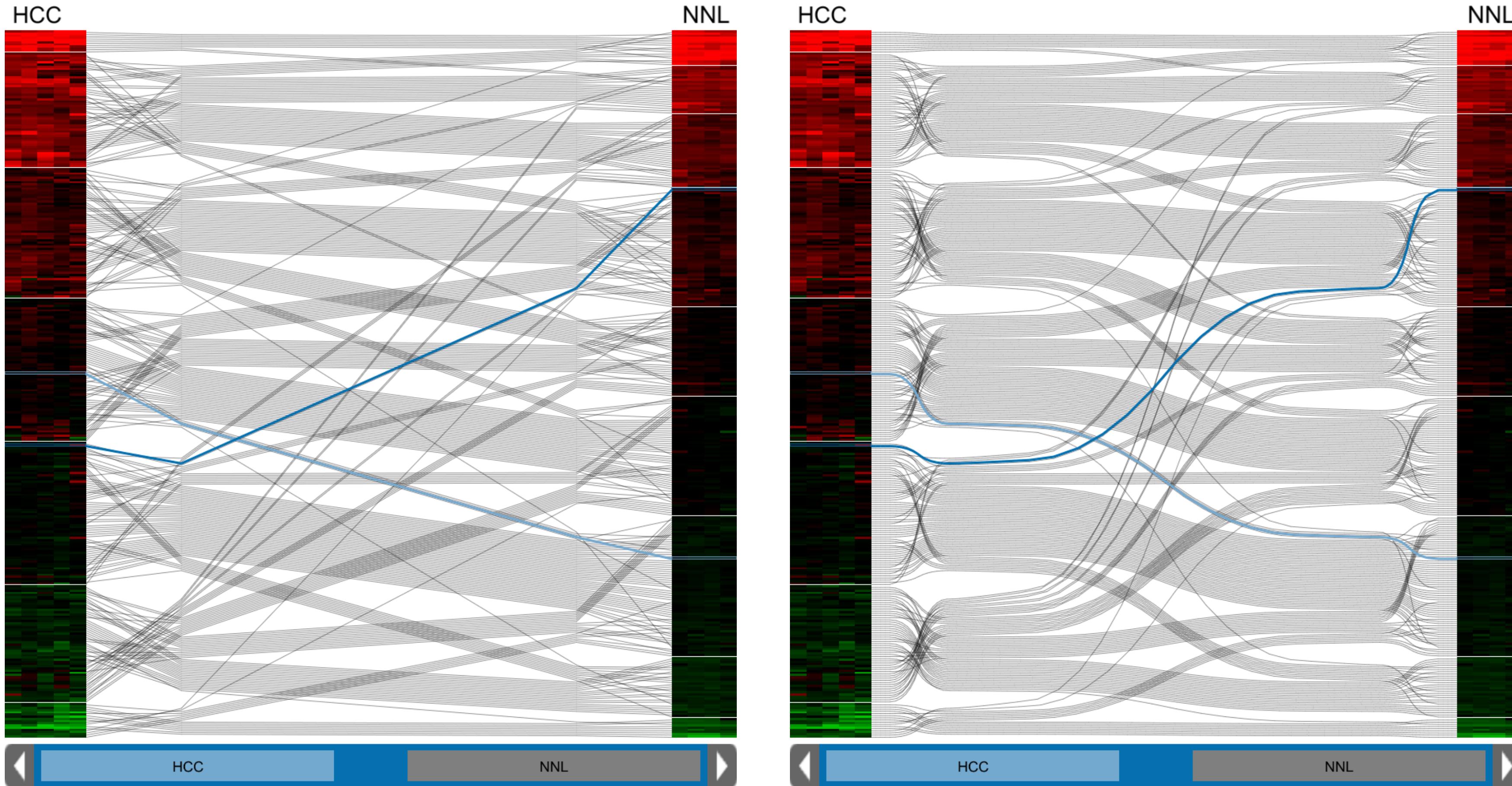


Continuity

Things: smooth & continuous



Continuity



Closure

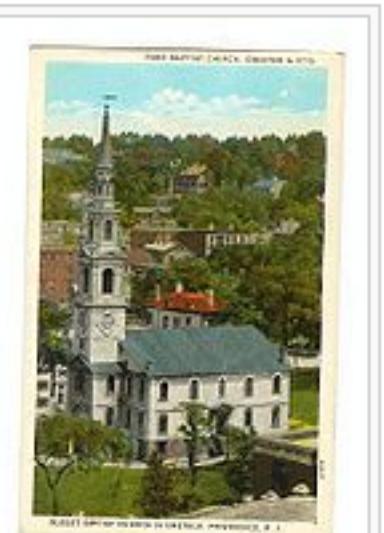


Closure



Applications in Vis

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The area which is now Providence was first settled in June 1636 by Roger Williams, and was one of the original Thirteen Colonies of the United States.^[10] Although the west bank of the Providence River was later claimed by both the English and the Dutch, the actual inhabitants and true masters of the region were the Pokanoket tribe of the Wampanoag Nation led by Massasoit Ousamequin.^[11] Williams secured permission to settle from the Pokanoket and gave the city its present name.^[12] Williams' Providence soon became a refuge for persecuted religious dissenters, as he himself had been exiled from Massachusetts.^[13] Providence's growth would be slow during the next quarter-century—the subsuming of its territory into surrounding towns, difficulty of farming the land, and differing of local traditions and land conflicts all slowed development.^[13]

In the mid-1770s, the British government levied taxes that impeded Providence's maritime, fishing and agricultural industries, the mainstay of the city's economy. One example was the Sugar Act, which was a tax levied against Providence's distilleries that adversely affected its trade in rum and slaves. These taxes caused Providence to join the other colonies in renouncing allegiance to the British Crown. In response to enforcement of unpopular trade laws, Providence residents spilled the first blood of the American Revolution in the notorious Gaspée Affair of 1772.^[13]

Though during the Revolutionary War the city escaped enemy occupation, the capture of nearby Newport disrupted industry and kept the population on alert. Troops were quartered for various campaigns and Brown University's University Hall was used as a barracks and military hospital.^[13]

After departing from Newport, French troops sent by King Louis XVI and commanded by the Comte de Rochambeau passed through Providence on their way to join the attack against British forces. The march from Newport to Providence was the beginning of a campaign led jointly by General George Washington in a decisive march that ended with the defeat of General Cornwallis in the Siege of Yorktown at Yorktown, Virginia and the Battle of the Chesapeake.

Following the war, Providence was the country's ninth-largest city.^[13] with 7,614 people. The economy shifted from maritime endeavors to manufacturing, particularly machinery, tools, silverware, jewelry and textiles. By the turn of the twentieth century, Providence boasted some of the largest manufacturing plants in the country, including Brown & Sharpe.



NPS map of the W3R Route

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A Google Map showing the location of Rhode Island. The map includes state boundaries for Connecticut, Massachusetts, New Hampshire, Vermont, New York, New Jersey, Delaware, Maryland, and Virginia. Major cities like Boston, Providence, Hartford, Scranton, Wilkes-Barre, Scranton, Allentown, Bethlehem, Philadelphia, Newark, New York, Newark, Atlantic City, and Cape May are labeled. Major highways I-95, I-90, I-84, I-80, I-295, I-395, and I-301 are shown. A red arrow points from the text "Rhode Island" to the island's location in the Atlantic Ocean.

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Following the war, Providence was the country's ninth-largest city^{[17][18]} with 7,614 people. The economy shifted from maritime endeavors to manufacturing, particularly machinery, tools, silverware, jewelry and textiles. By the turn of the twentieth century, Providence boasted some of the largest manufacturing plants in the country, including Reman & Sharpe.

First Baptist Church in America, founded 1638, present building occupied in 1776, is the oldest Baptist congregation in America

Providence in the mid-nineteenth century

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Rhode Island

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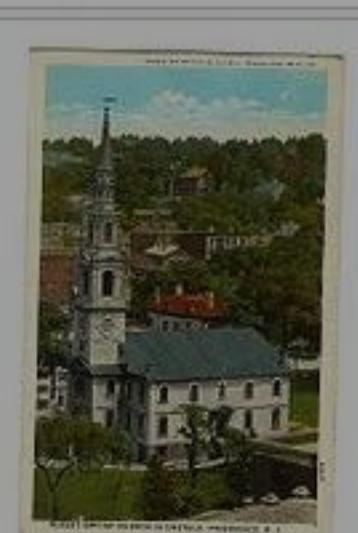
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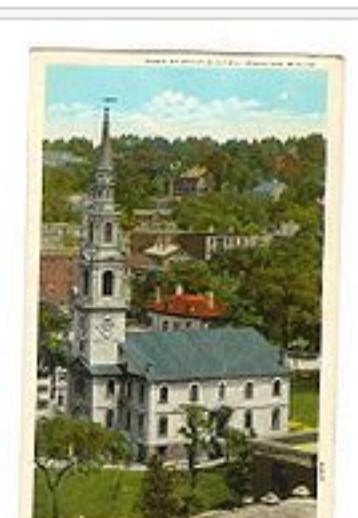
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First Baptist Church in America, founded 1638, present building occupied in 1776, is the oldest Baptist congregation in America



NPS map of the W3R Route

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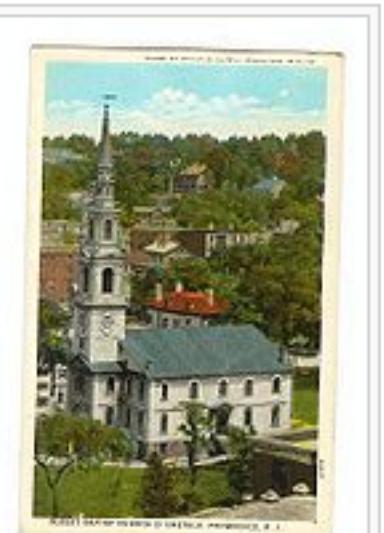
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A Google Map showing the region around New England. The map includes state borders for Connecticut, Rhode Island, Massachusetts, New Hampshire, Vermont, and New York. Major cities like Boston, Providence, Hartford, New Haven, and New York City are marked. Highways I-95, I-84, I-80, and I-91 are visible. A red dot marks the location of Providence, Rhode Island. A callout box labeled "Traffic" is open over the map. The map also shows the coastline and major rivers of the area.

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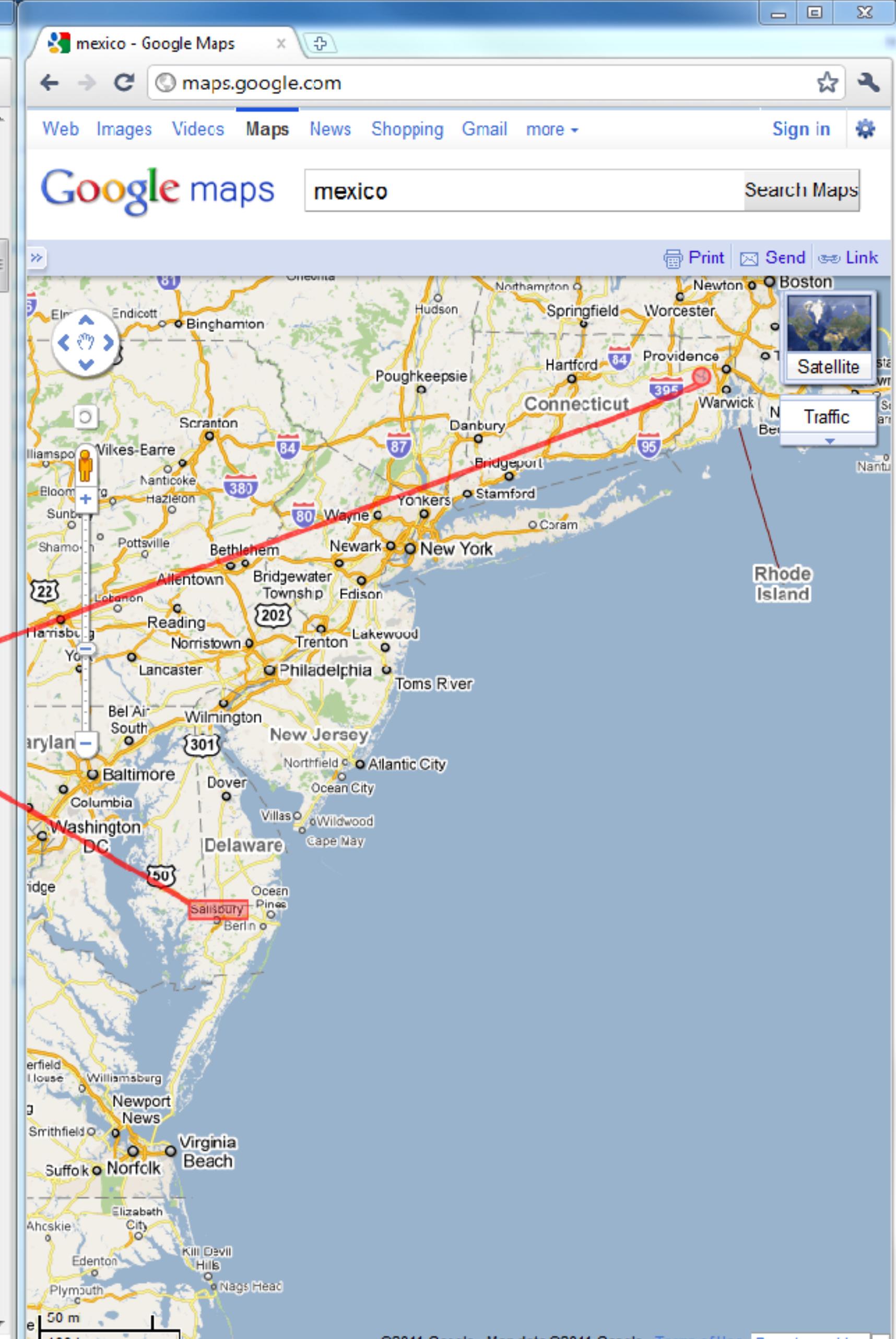
The area which is now Providence was first settled in June 1636 by Roger Williams, and was one of the original Thirteen Colonies of the United States.^[10] Although the west bank of the Providence River was later claimed by both the English and the Dutch, the actual inhabitants and true masters of the region were the Pokanoket Tribe of the Wampanoag Nation led by Massasoit Ousamequin.^[11] Williams secured permission to settle from the Pokanoket and gave the city its present name.^[12] Williams' Providence soon became a refuge for persecuted religious dissenters, as he himself had been exiled from Massachusetts.^[13] Providence's growth would be slow during the next quarter-century —the subsuming of its territory into surrounding towns, difficulty of farming the land, and differing of local traditions and land conflicts all slowed development.^[14]

In the mid-1770s, the British government levied taxes that impeded Providence's maritime, fishing and agricultural industries, the mainstay of the city's economy. One example was the Sugar Act, which was a tax levied against Providence's distilleries that adversely affected its trade in rum and slaves. These taxes caused Providence to join the other colonies in renouncing allegiance to the British Crown. In response to enforcement of unpopular trade laws, Providence residents spilled the first blood of the American Revolution in the notorious Gaspée Affair of 1772.^[15]

Though during the Revolutionary War the city escaped enemy occupation, the capture of nearby Newport disrupted industry and kept the population on alert. Troops were quartered for various campaigns and Brown University's University Hall was used as a barracks and military hospital.^[16]

After departing from Newport, French troops sent by King Louis XVI and commanded by the Comte de Rochambeau passed through Providence on their way to join the attack against British forces. The march from Newport to Providence was the beginning of a campaign led jointly by General George Washington in a decisive march that ended with the defeat of General Cornwallis in the Siege of Yorktown at Yorktown, Virginia and the Battle of the Chesapeake.

Following the war, Providence was the country's ninth largest city.^[17] with 7,614 people. The economy shifted from maritime endeavors to manufacturing, particularly machinery, tools, silverware, jewelry and textiles. By the turn of the twentieth century, Providence boasted some of the largest manufacturing plants in the country including Brown & Sharpe.



What is the problem?

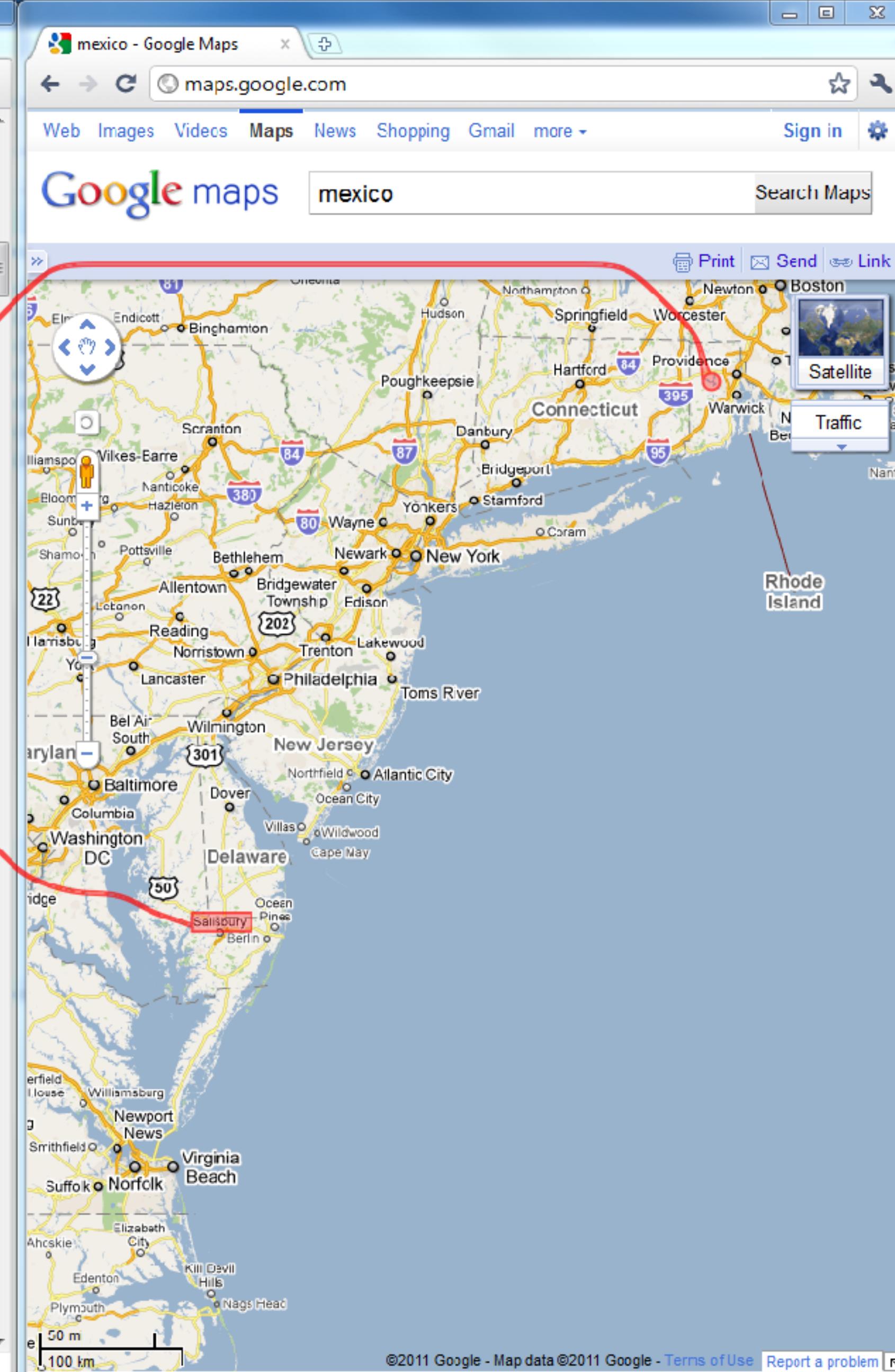
The area which is now Providence was first settled in June 1636 by [Roger Williams](#), and was one of the original [Thirteen Colonies](#) of the United States.^[10] Although the west bank of the [Providence River](#) was later claimed by both the English and the Dutch, the actual inhabitants and true masters of the region were the [Pocumtuck](#) Tribe of the Wampanoag Nation led by Massasoit Ousamequin.^[11] Williams secured permission to settle from the Pocumtuck and gave the city its present name.^[12] Williams' Providence soon became a refuge for persecuted religious dissenters, as he himself had been exiled from [Massachusetts](#).^[13] Providence's growth would be slow during the next quarter-century —the subsuming of its territory into surrounding towns, difficulty of farming the land, and differing of local traditions and land conflicts all slowed development.^[14]

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Context-Preserving Visual Links

Takeaways

Knowing about Perception is important for Vis and UI design

How to choose your colors

How to show relationships

How to draw attention

How to minimize risk of overlooking