CS 171

Perception

Hanspeter Pfister (pfister@g.harvard.edu)

Today

Contrast

Motion

Color

Feedback

- What's the difference between a mark, a channel, and an encoding?

- How do Bertin and Tufte relate to human perception and cognition?

- Tension between "effective" vs. "engaging" vis.

  What is useful (engaging) chart junk vs. real chart junk? How to balance memorability vs. clarity? What about aesthetics? What about context and narrative?

The Junk Chart Debate

Useful Junk? The Effects of Visual Embellishment on Comprehension and Memorability of Charts

Scott Bateman, Regan L. Mandryk, Carl Gutwin, Aaron Genest, David McDine, Christopher Brooks
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ABSTRACT
Guidelines for designing information charts often state that the presentation should reduce 'chart junk' – visual embellishments that are not essential to understanding the data. In contrast, some popular chart designers wrap the presented data in detailed and elaborate imagery, raising the questions of whether this imagery is really as detrimental to understanding as has been proposed, and whether the visual embellishment may have other benefits. To investigate these issues, we conducted an experiment that compared embellished charts with plain ones, and measured both interpretation accuracy and long-term recall. We found that people's accuracy in describing the embellished charts was no worse than for plain charts, and that their recall after a two-to-three-week gap was significantly better. Although we are cautious about recommending that all charts be produced in this style, our results question some of the premises of the minimalist approach to chart design.

Author Keywords
Charts, information visualization, imagery, memorability.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Human Factors

INTRODUCTION
Many experts in the area of chart design, such as Edward Tufte, criticize the inclusion of visual embellishment in charts and graphs; their guidelines for good chart design often suggest that the addition of *chart junk,* decorations and other kinds of non-essential imagery, to a chart can make interpretation more difficult and can distract readers from the data [22]. This *minimalist* perspective advocates plain and simple charts that maximize the proportion of *data-ink* – or the ink in the chart used to represent data.

CHI 2010, April 10–15, 2010, Atlanta, Georgia, USA.

Despite these minimalist guidelines, many designers include a wide variety of visual embellishments in their charts, from small decorations to large images and visual backgrounds. One well-known proponent of visual embellishment in charts is the graphic artist Nigel Holmes, whose work regularly incorporates strong visual imagery into the fabric of the chart [7] (e.g., Figure 1).

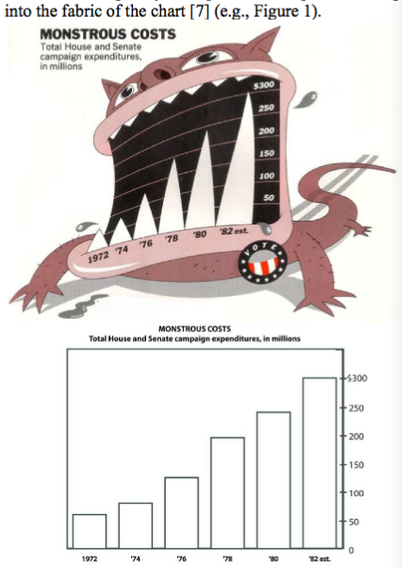

Figure 1. A chart by Holmes [7] (above), and a 'plain' version.

These kinds of charts appear regularly in many mass-media publications, and the widespread use of embellished designs raises questions about whether the minimalist position on chart design is really the better approach. Two issues in particular are raised: first, whether visual embellishments do in fact cause comprehension problems; and second, whether the embellishments may provide additional information that is valuable for the reader. For example, the added visual imagery in a Holmes-style chart could draw

Visualization Rhetoric: Framing Effects in Narrative Visualization

Jessica Hullman, *Student Member, IEEE,* and Nicholas Diakopoulos, *Member, IEEE*

Abstract—Narrative visualizations combine conventions of communic
intended story. We demonstrate *visualization rhetoric* as an analytica
prioritize particular interpretations in visualizations that "tell a story"
parallel between narrative visualization interpretation and evidence fr
and literary studies. Devices for understanding the rhetorical nature of
by the rigorous application of concepts from critical theory, semiotics,
design tactics represent additions or omissions of information at variou
and interactivity—and how visualizations denote and connote pheno
codes. Classes of rhetorical techniques identified via a systematic an
characterized according to their rhetorical contribution to the visualizati
from the potentially positive aspects of visualization rhetoric in design
framework can shed light on how a visualization design prioritizes sp
into visualization rhetoric can improve understanding of visualization int

Index Terms—Rhetoric, narrative visualization, framing effects, semioti

1 Introduction

Narrative information visualizations are a style of visualization that often explores the interplay between aspects of both explorative and communicative visualization [38]. They typically rely on a combination of persuasive, rhetorical techniques to convey an intended story to users as well as exploratory, dialectic strategies aimed at providing the user with control over the insights she gains from interaction. Segel and Heer take an initial step towards highlighting how varying degrees of authorial intention and user interaction are achieved by general design components in narrative visualization [38]. This blend of explorative and communicative features presents another research opportunity though: to better understand a user's interpretation process of a narrative visualization in light of the rhetorical conventions that the author employs. By *explicating rhetorical techniques and how such techniques may affect user interpretation*, researchers and designers alike stand to gain a tool for understanding how visualizations communicate.

In this work we examine the design and end-user interpretation of narrative visualizations in order to deepen understanding of how common design techniques represent rhetorical strategies that make certain interpretations more probable. How are rhetorical techniques used in visualization and what are the effects of these techniques on user interpretations of data? Studies in semiotics, journalism, and critical theory indicate particular rhetorical techniques used to communicate an intended message [1, 2, 23]. while evidence from decision theory, survey design, and political theory [21, 36, 37] suggests that subtle variations in a representation's rhetorical or persuasive techniques can generate large effects on users' interpretations of a message. Investigations related to InfoVis provide initial evidence that how data is framed or presented can significantly affect interpretation [3].

Given the motivation to better understand the interpretation process of visualization, this paper investigates rhetorical strategies and effects in narrative visualization by addressing the following research questions:

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For information on obtaining reprints of this article, please send email to: tvcg@computer.org.

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What Makes a Visualization Memorable?

Michelle A. Borkin, *Student Member, IEEE,* Azalea A. Vo, Zoya Bylinskii, Phillip Isola, *Student Member, IEEE,* Shashank Sunkavalli, Aude Oliva, and Hanspeter Pfister, *Senior Member, IEEE*

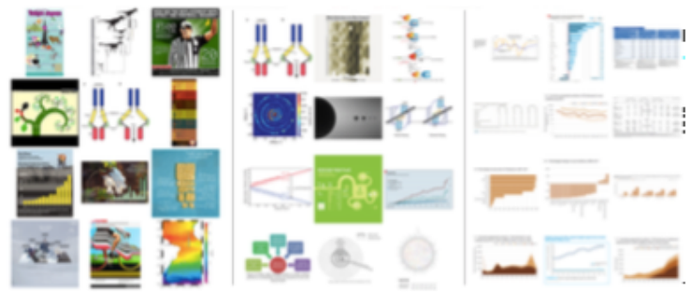

Fig. 1. **Left:** The top twelve overall most memorable visualizations from our experiment (most to least memorable from top left to bottom right). **Middle:** The top twelve most memorable visualizations from our experiment when visualizations containing human recognizable cartoons or images are removed (most to least memorable from top left to bottom right). **Right:** The twelve least memorable visualizations from our experiment (most to least memorable from top left to bottom right).

Abstract—An ongoing debate in the Visualization community concerns the role that visualization types play in data understanding. In human cognition, understanding and memorability are intertwined. As a first step towards being able to ask questions about impact and effectiveness, here we ask: "What makes a visualization memorable?" We ran the largest scale visualization study to date using 2,070 single-panel visualizations, categorized with visualization type (e.g., bar chart, line graph, etc.), collected from news media sites, government reports, scientific journals, and infographic sources. Each visualization was annotated with additional attributes, including ratings for data-ink ratios and visual densities. Using Amazon's Mechanical Turk, we collected memorability scores for hundreds of these visualizations, and discovered that observers are consistent in which visualizations they find memorable and forgettable. We find intuitive results (e.g., attributes like color and the inclusion of a human recognizable object enhance memorability) and less intuitive results (e.g., common graphs are less memorable than unique visualization types). Altogether our findings suggest that quantifying memorability is a general metric of the utility of information, an essential step towards determining how to design effective visualizations.

Index Terms—Visualization taxonomy, information visualization, memorability

1 Introduction

The Visualization community has recently witnessed a divide over the value and impact of excessive chart annotation and decoration (i.e., "chart junk"). The conventional view, promoted by visualization experts such as Edward Tufte and Stephen Few, holds that visualizations should not include chart junk and should show the data as clearly as possible without any distractors [13, 14, 37, 38]. This view has also been supported by psychology lab studies, which show that simple and clear visualizations are easier to understand [11, 24]. At the other end of the spectrum, researchers have published that chart junk can possibly improve retention and force a viewer to expend more cognitive effort to understand the graph, thus increasing their knowledge and understanding of the data [4, 8, 19]. However, the findings of these studies have been widely debated [13, 14].

What researchers agree on is that chart junk is not the only factor that influences how a person sees, interprets, and remembers a visualization. Other aspects of the visualization, such as graph type, color, or aesthetics, also influence a visualization's cognitive workload and retention [8, 19, 39]. To disentangle these confounding factors we set out to answer the basic question: "What makes a visualization memorable?" Clearly, a more memorable visualization is not necessarily a more comprehensible one. However, knowing what makes a visualization memorable is a step towards answering higher level questions like "What makes a visualization engaging?" or "What makes a visualization effective?". Recent work has shown that memorability of images of natural scenes is consistent across people, suggesting that some images are intrinsically more memorable than others, independent of an individual's contexts and biases [20]. We are interested in understanding if these findings hold for visualizations, and what key factors make some visualizations *intrinsically* more memorable than others.

Here, we designed and executed a study to measure the memora-

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- *Zoya Bylinkii is with the Computer Science and Artificial Intelligence Laboratory at the Massachusetts Institute of Technology. E-mail: zoya@mit.edu.*
- *Phillip Isola is with the Department of Brain and Cognitive Sciences at the Massachusetts Institute of Technology. E-mail: phillipi@mit.edu.*
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- *Aude Oliva is with the Computer Science and Artificial Intelligence Laboratory at the Massachusetts Institute of Technology. E-mail: oliva@mit.edu.*
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For information on obtaining reprints of this article, please send e-mail to: tvcg@computer.org.

Activity

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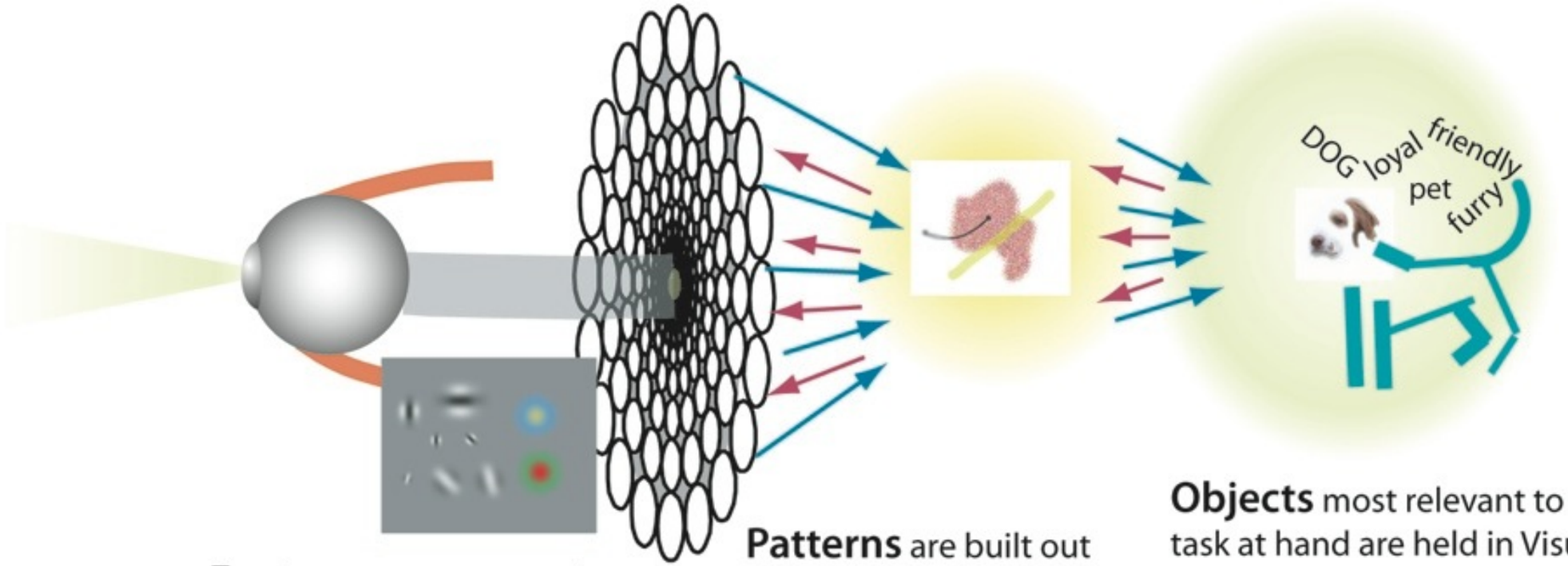
Why is counting Vs easier than counting Qs?

MTHIVLWYADCEQGHKILKMTWYN
ARDCAIREQGHLVKMFPSTWYARN
GFPSVCEILQGKMFPSNDRCEQDIFP
SGHLMFHKMVPSTWYACEQTWRN

Perception is active & constructive, combining bottom-up and top-down information



Features are processed in parallel from every part of the visual field. Millions of features are processed simultaneously.

Patterns are built out of features depending on attentional demands. Attentional tuning reinforces those most relevant.

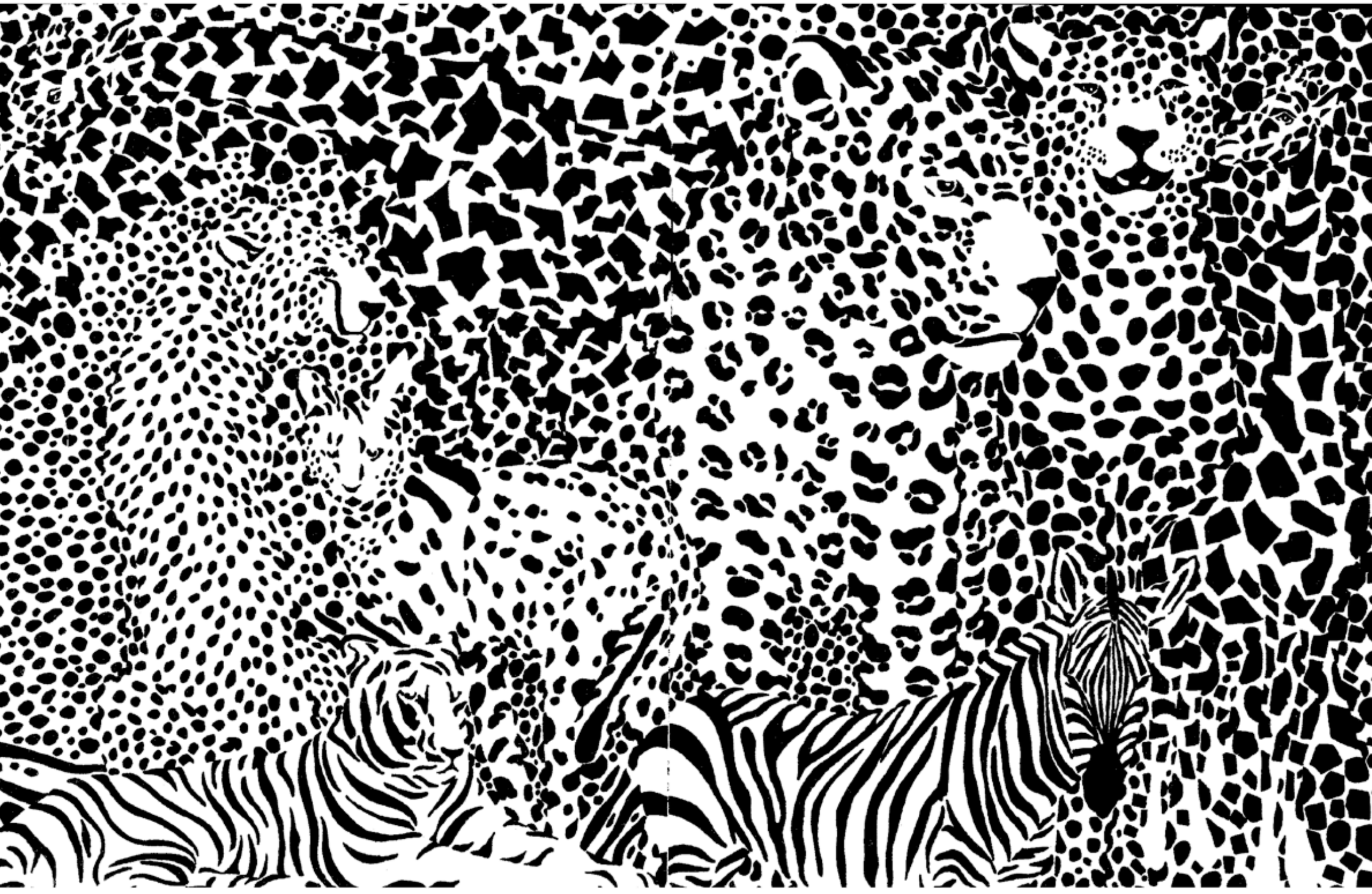
Objects most relevant to the task at hand are held in Visual Working Memory. Only between one and three are held at any instant. Objects have both non-visual and visual attributes.

Bottom-up information drives pattern building

Top-down attentional processes reinforce relevant information

Biased Competition

C. Ware, 'Visual Thinking for Design'



"Ranger Rick:, ca. 1980s
Courtesy of Terry Yoo / Ross Whitacker

The Eye

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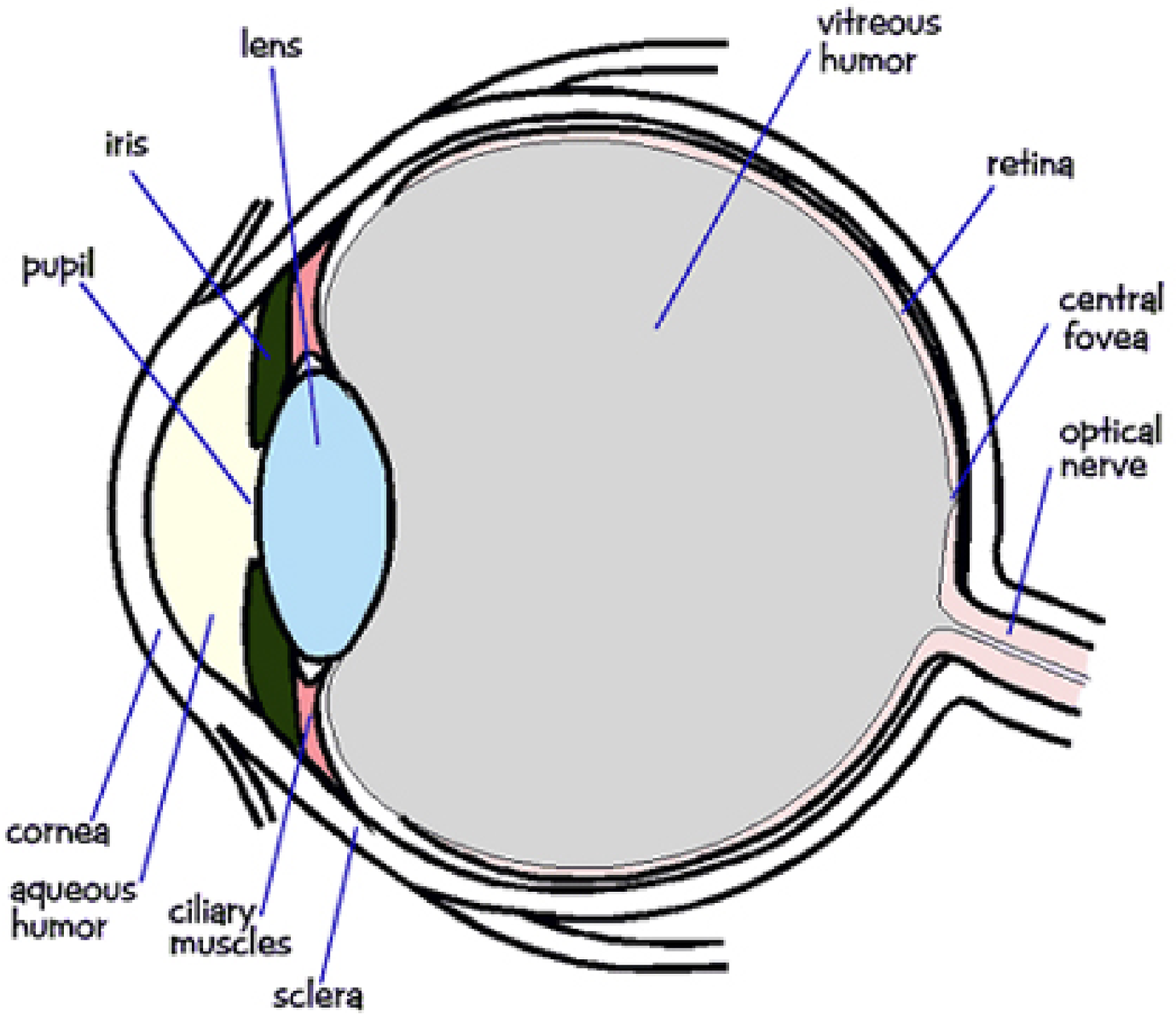
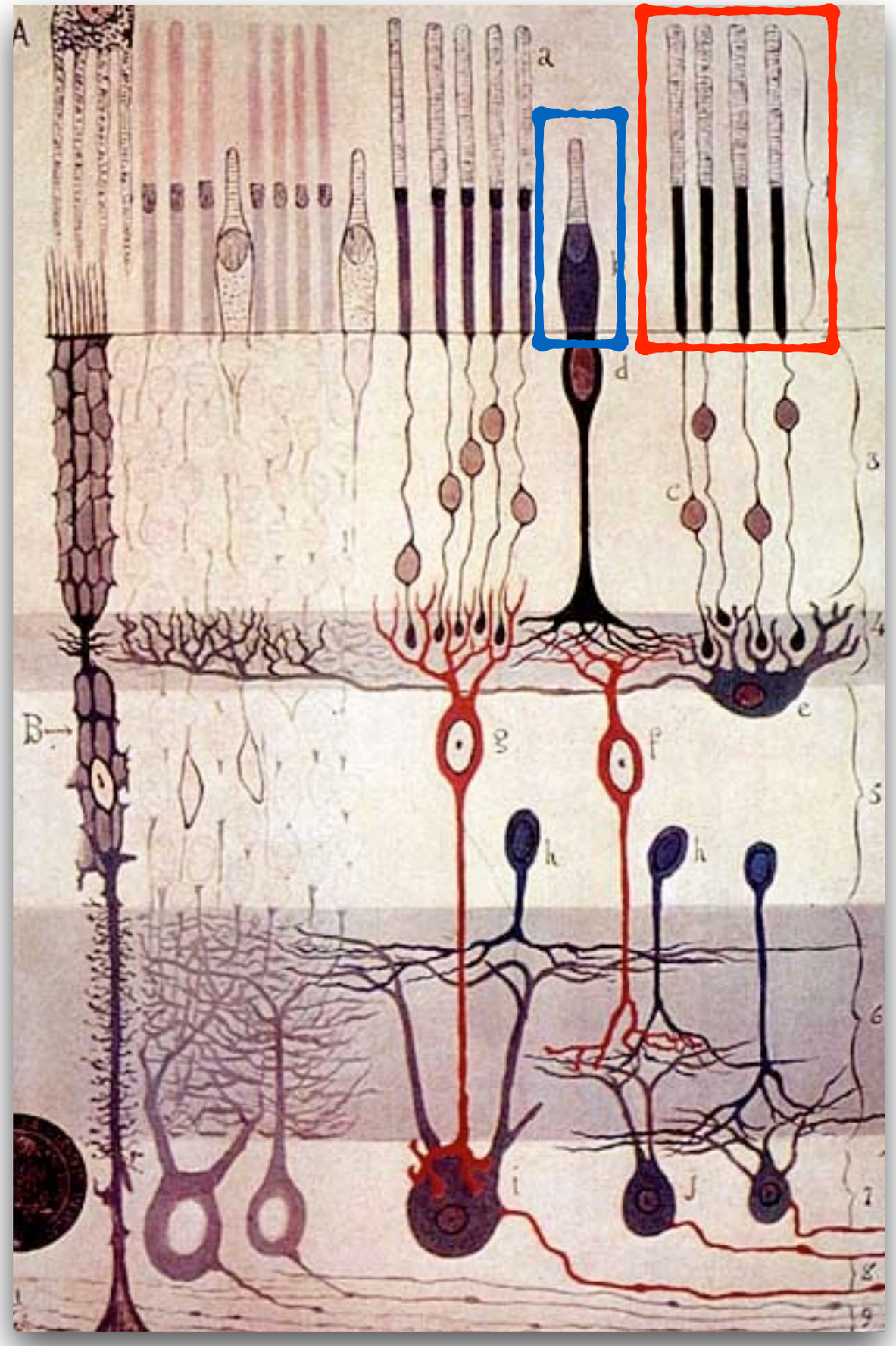

lens
vitreous humor
iris
retina
pupil
central fovea
optical nerve
cornea
aqueous humor
ciliary muscles
sclera

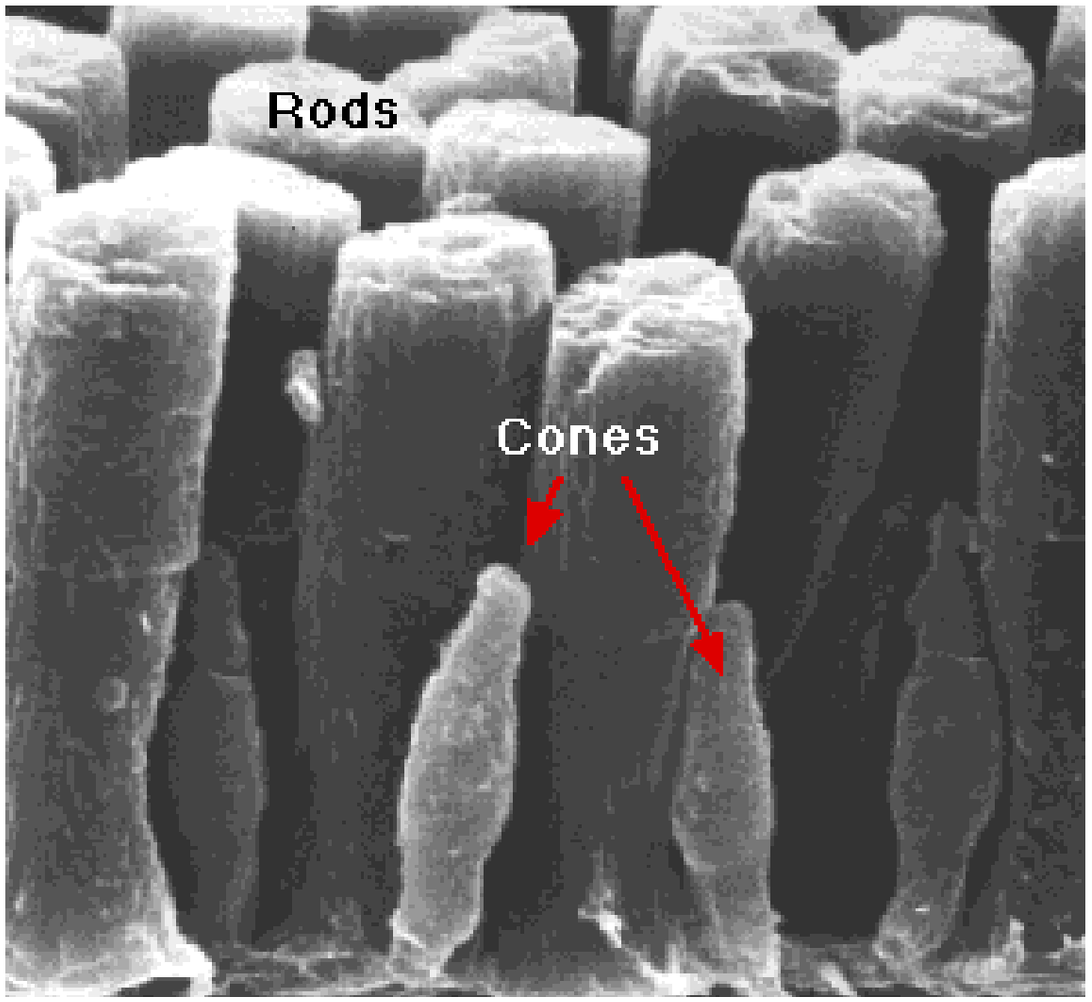


Cones

Rods

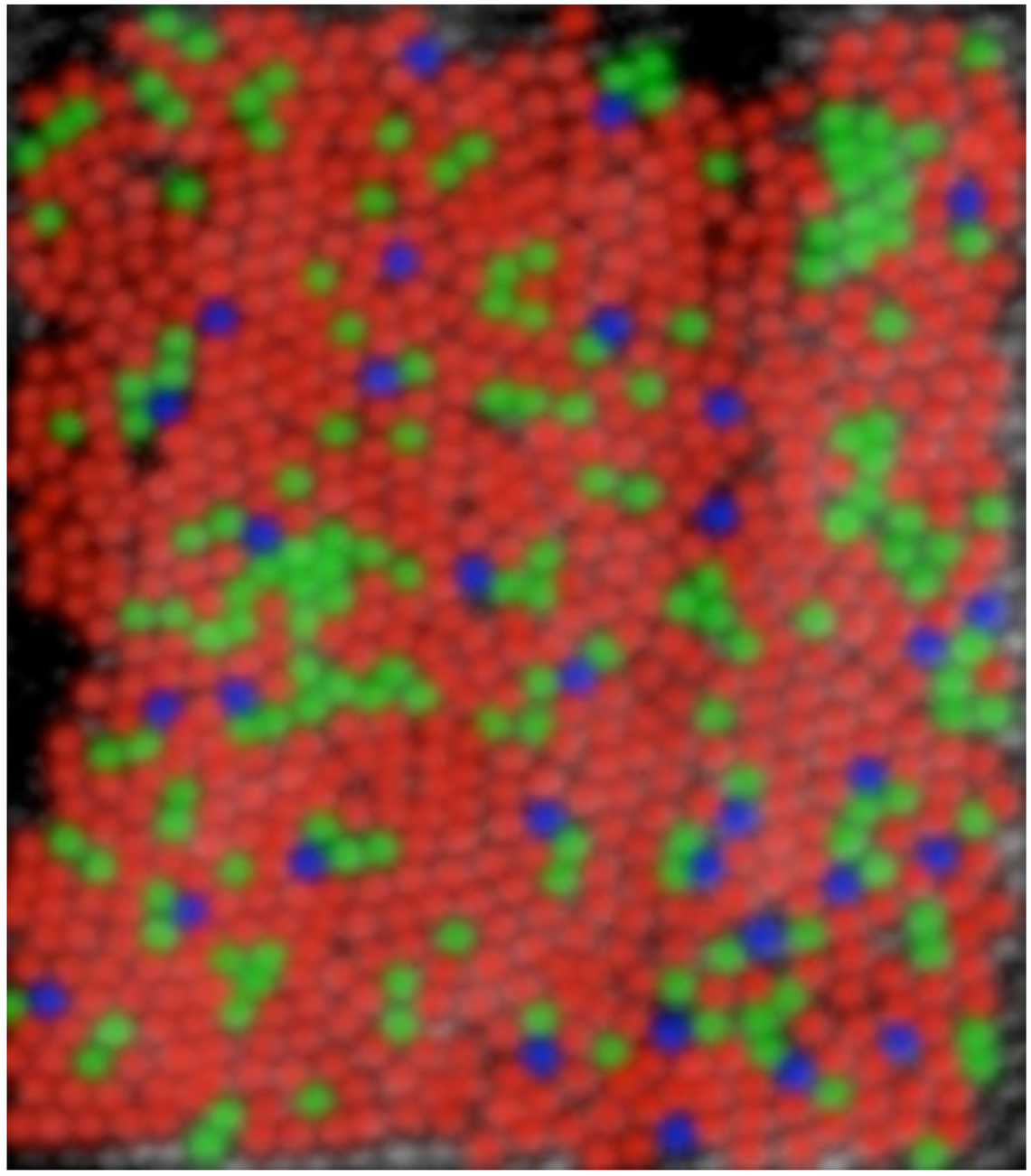
Ganglion Cells

"Structure of the Mammalian Retina"
c.1900 By Santiago Ramon y Cajal



120 million rods

5-6 million cones

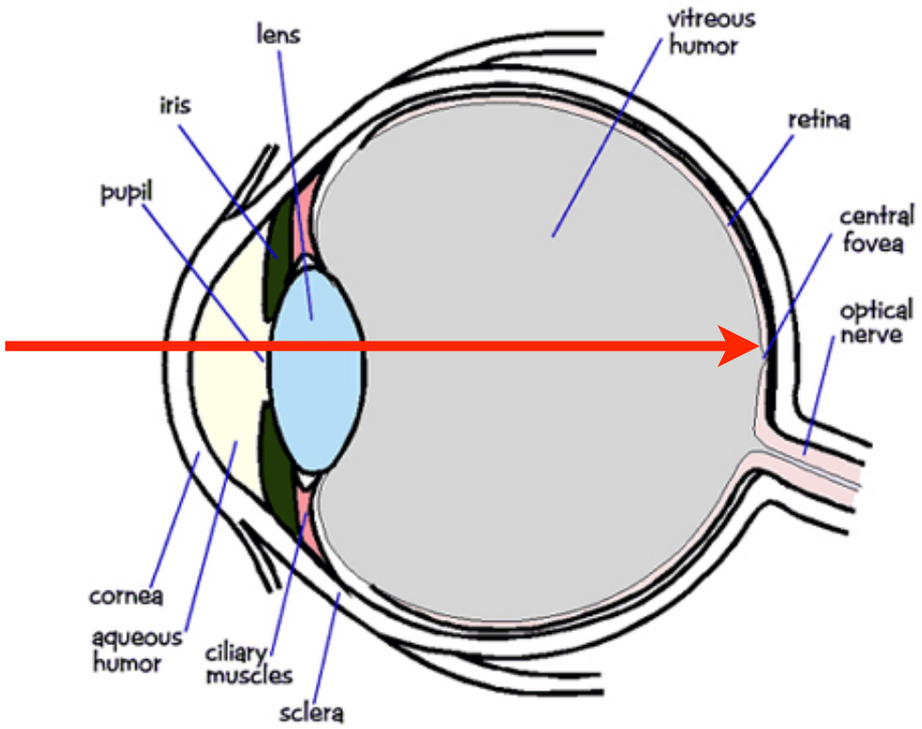


R 63% - G 31% - B 6%

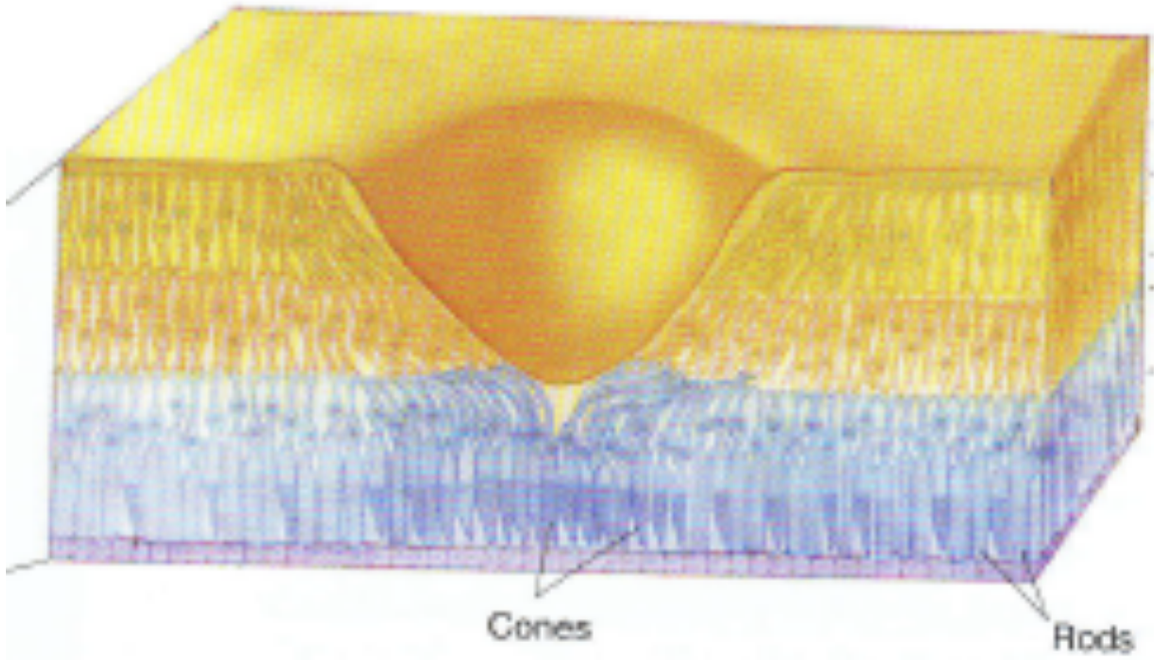
Wandell, “Foundations of Vision” (left)

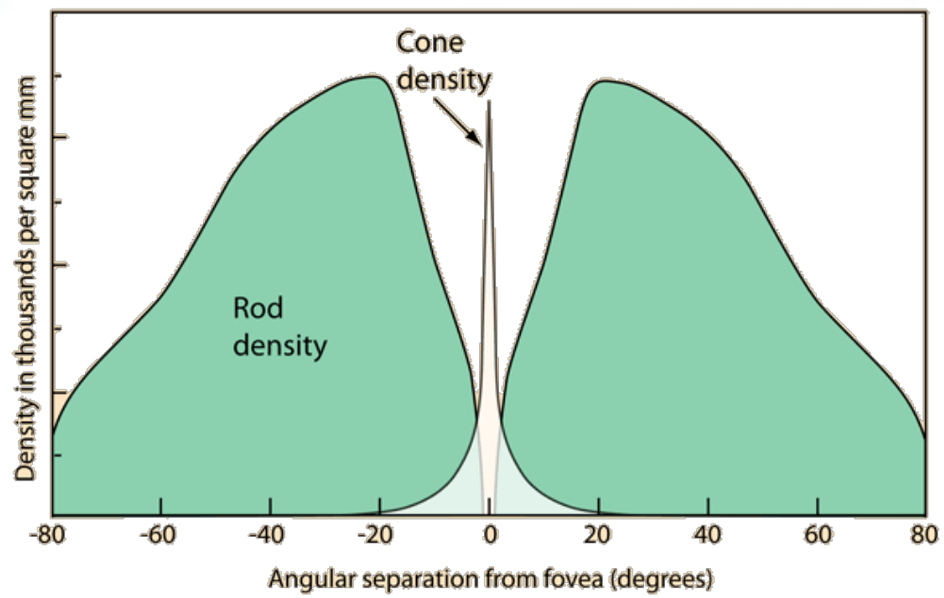
David R. Williams, Univ. of Rochester (right)

The Fovea

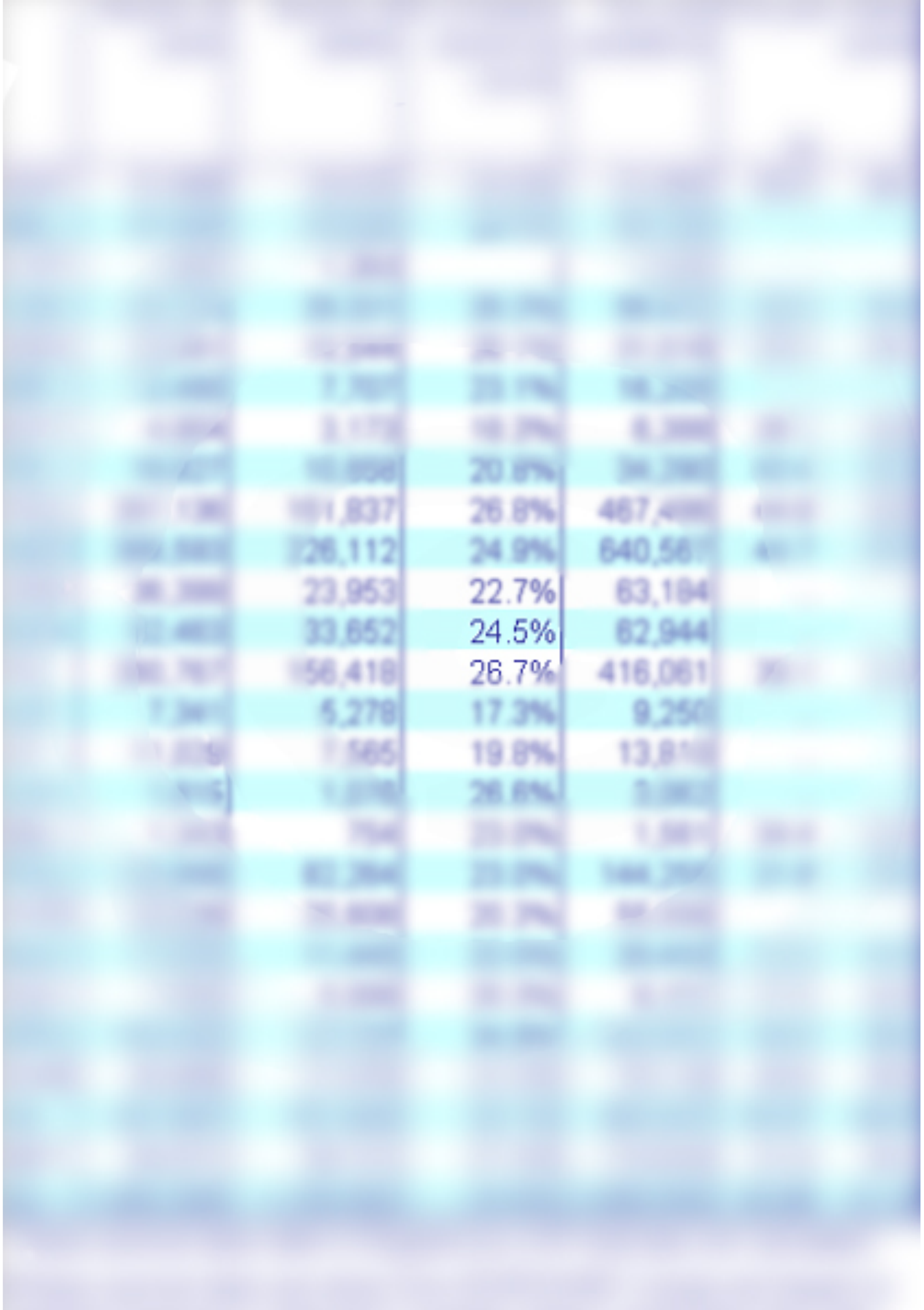


Bear, Connors, Paradiso, "Neuroscience"





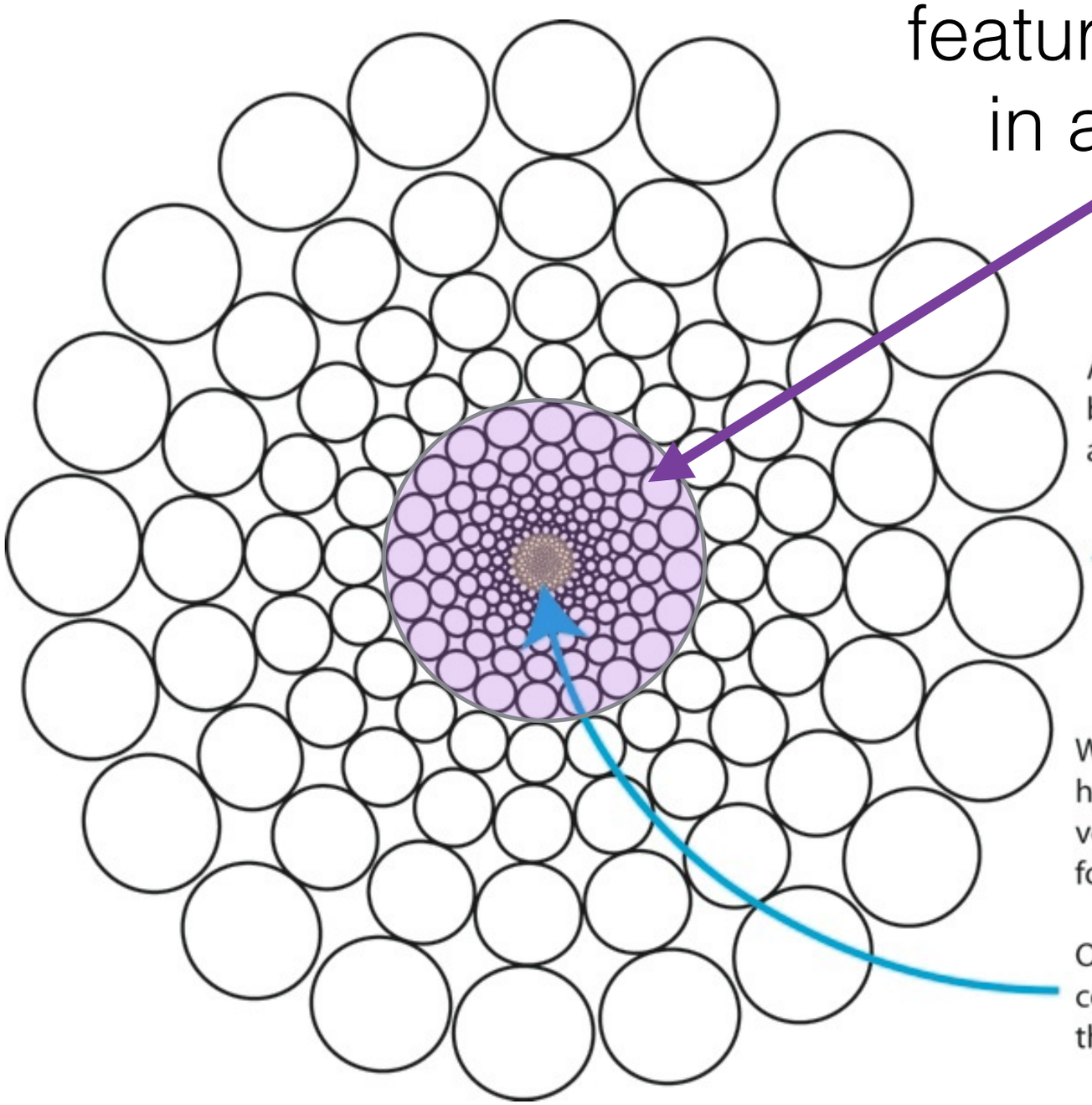
http://hyperphysics.phy-astr.gsu.edu/hbase/vision/rodcone.html



C. Ware, "Visual Thinking for Design"

Fovea & Receptive Fields

features can be <u>detected</u>
in area around fovea

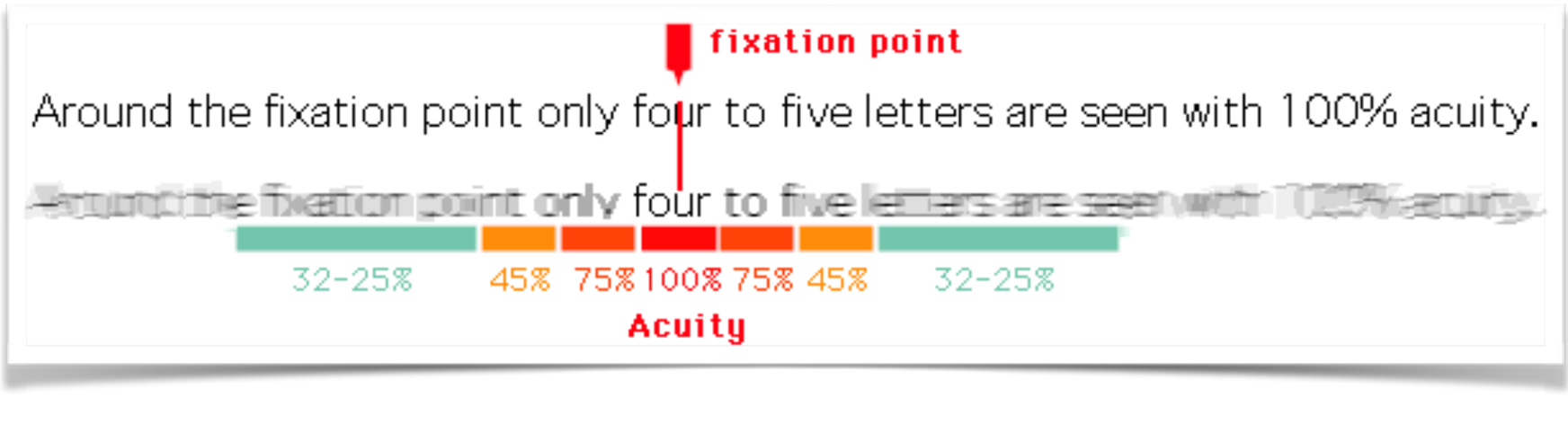


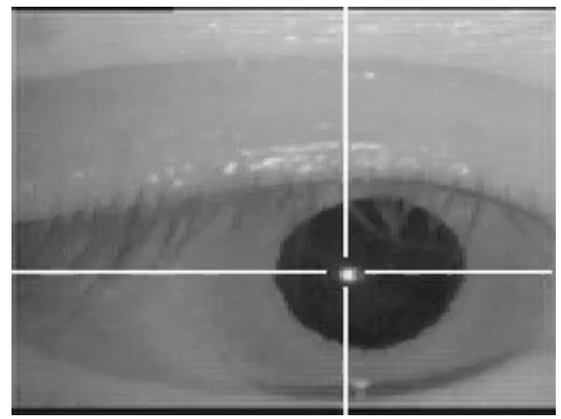
At the edge of the visual field we can only barely see something the size of of a fist at arm's length.

We can resolve about 100 points on the head of a pin held at arm's length in the very center of the visual field called the fovea.

Over half of our visual processing power is concentrated in a sligtly larger area called the parafovea.

Example: Reading

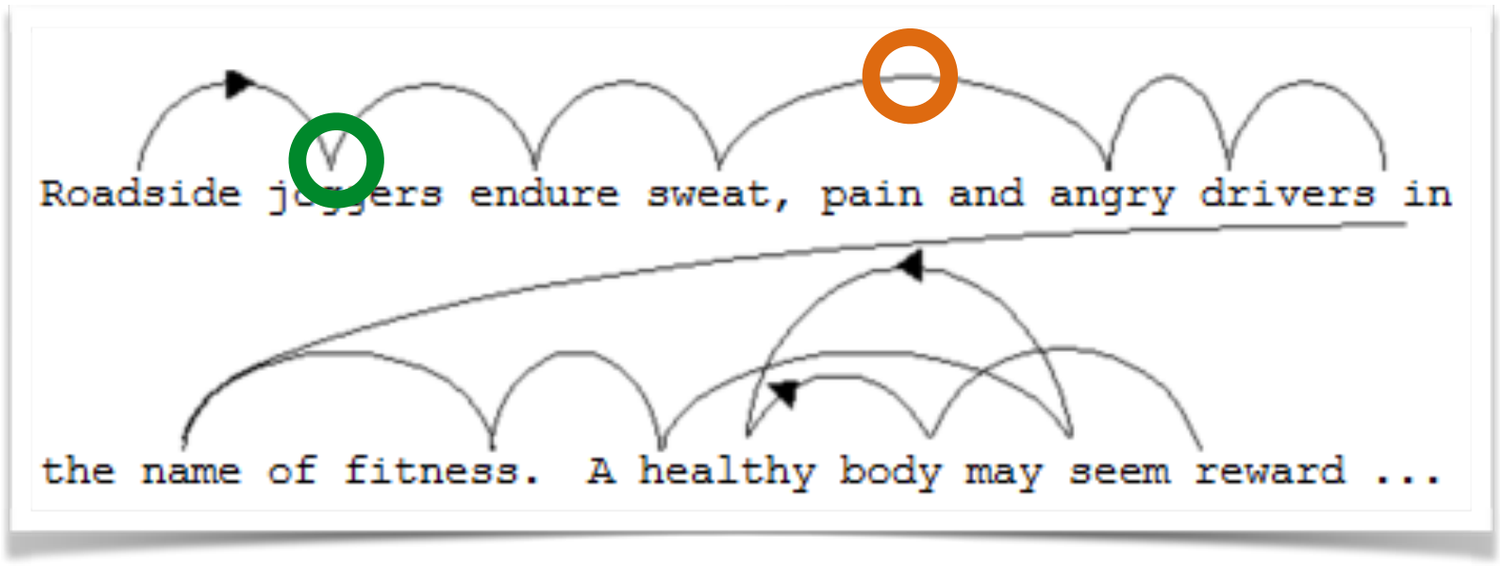




Saccadic Eye Movement

fixation (200-600ms)

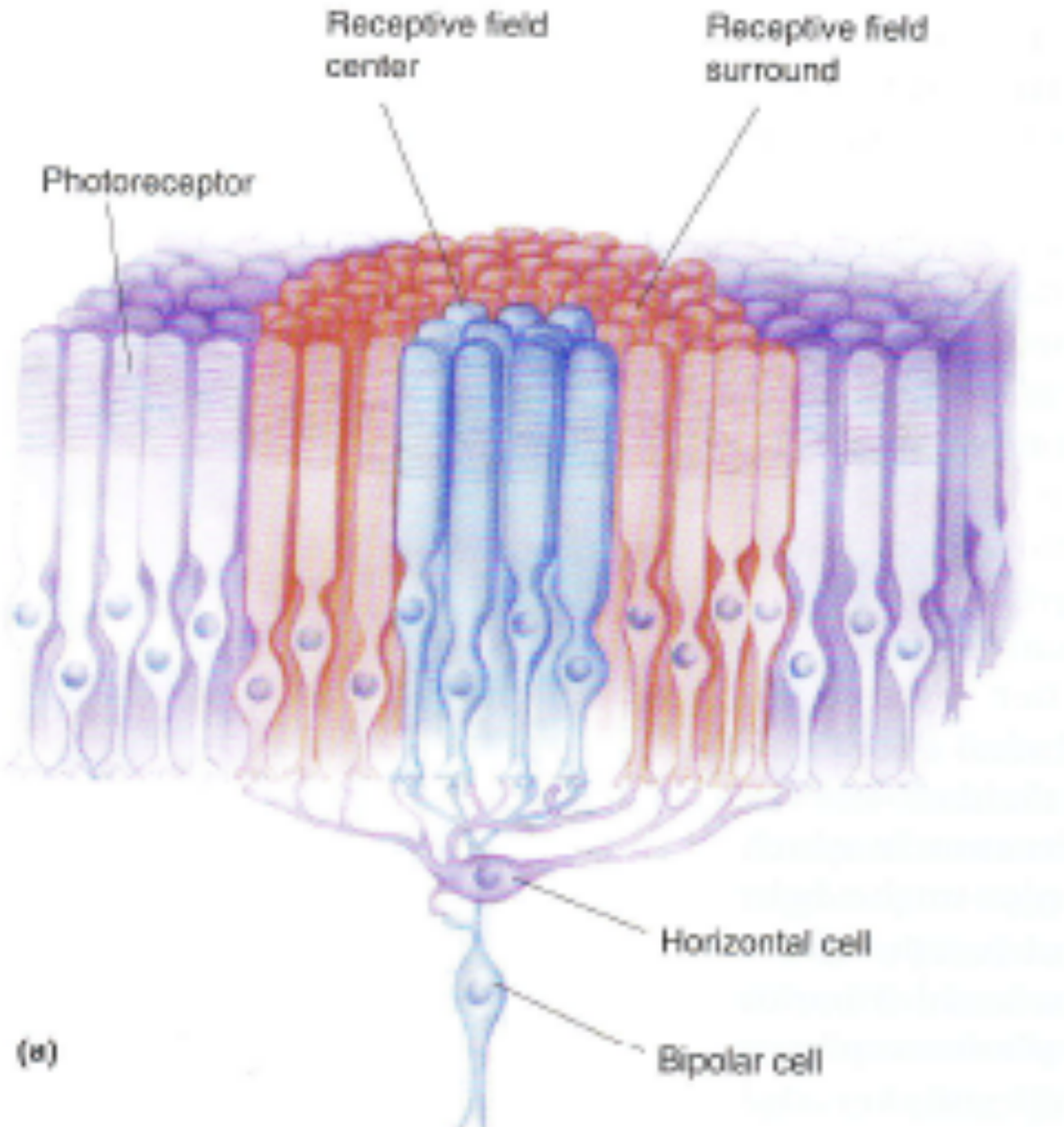
saccade (20-100ms)



http://www.learning-systems.ch/multimedia/vis_e02.htm

https://www.microsoft.com/typography/ctfonts/wordrecognition.aspx

Center-Surround Organization



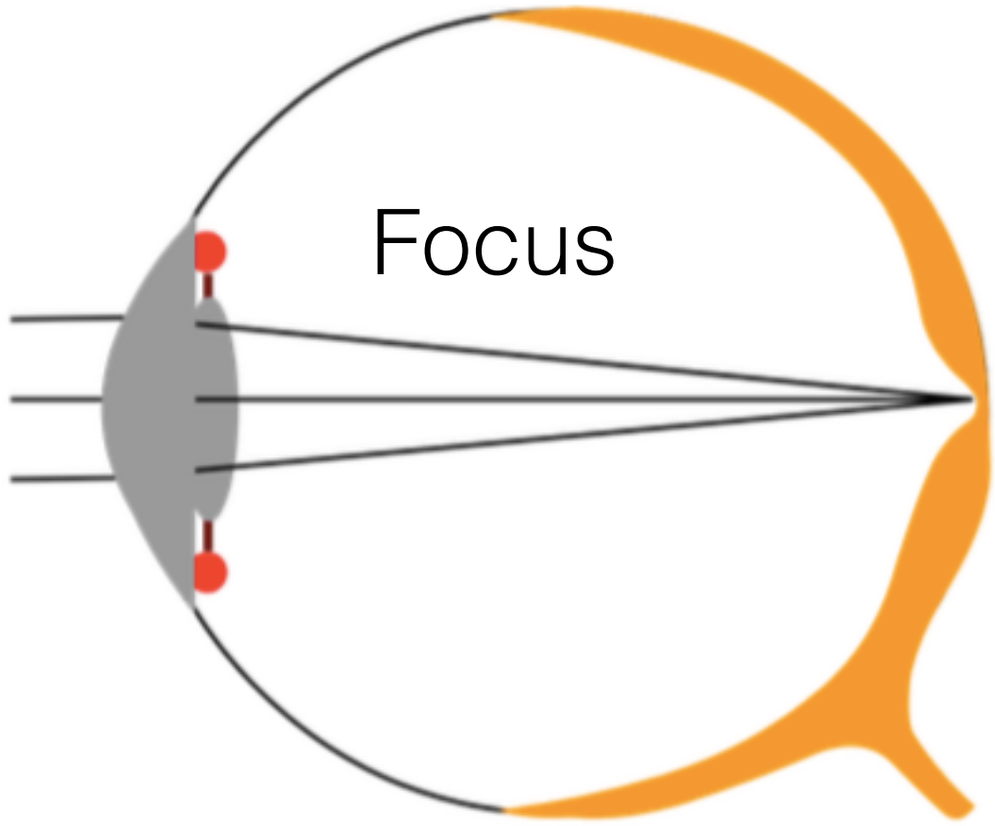
~126 Million
Rods and Cones

Massive compression!

~1 Million
Ganglion Cells &
Optical Nerve Fibers

Bear, Connors, Paradiso, 'Neuroscience'

What the Eye Does



Color &
Intensity
Differences

Tutis Vilis, The Physiology of the Senses
http://www.tutis.ca/Senses/

Activity

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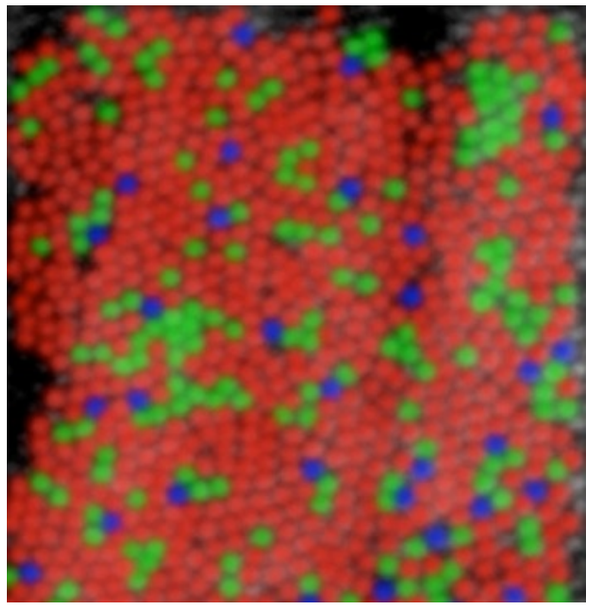
Compare the visual capabilities of a (human) eye and a digital photo camera. (2 min)

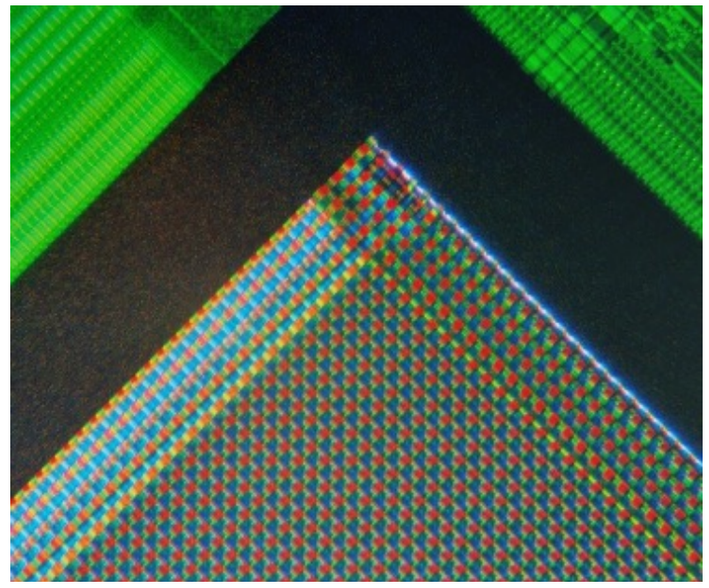
Eye Receptors - Cones



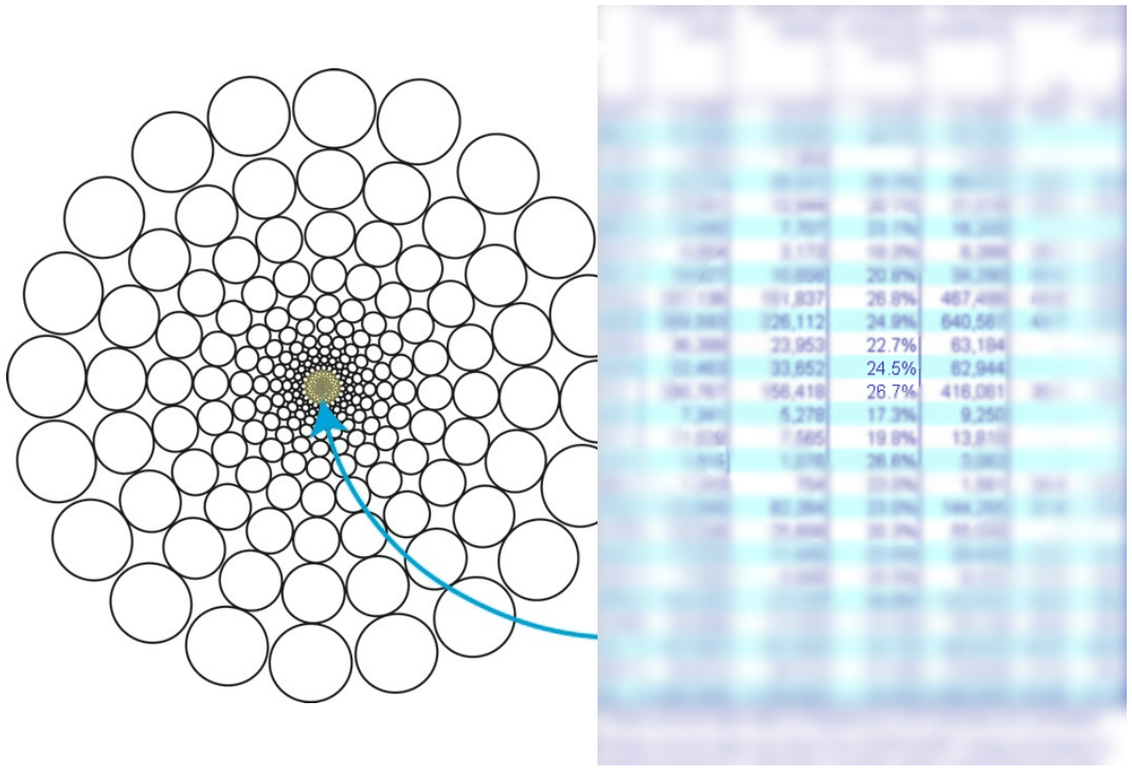
R 63% - G 31% - B 6%

vs.

Camera Sensors



R 25% - G 50% - B 25%



Brain Pixel

vs.

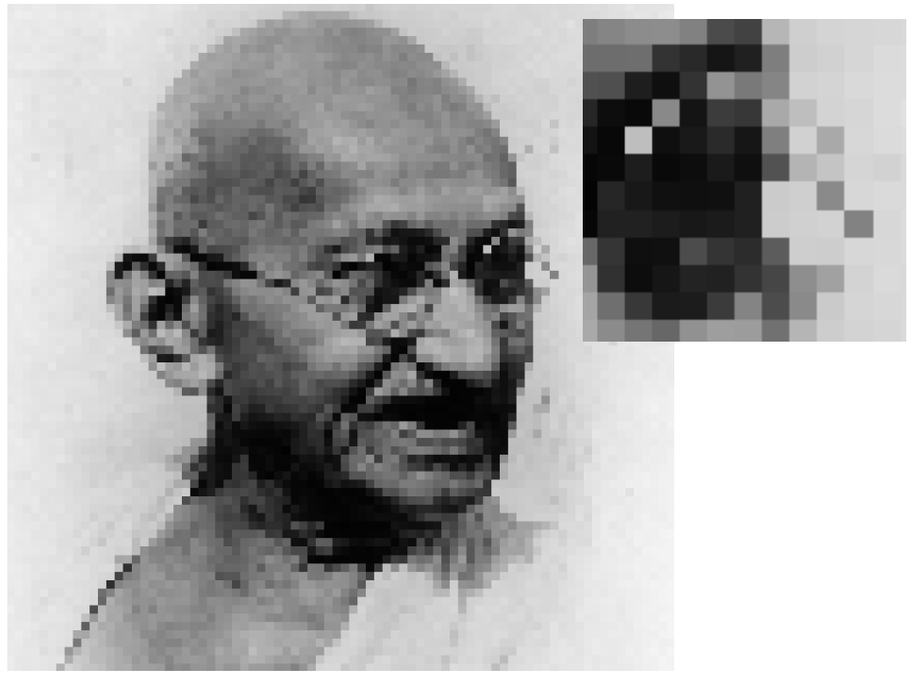


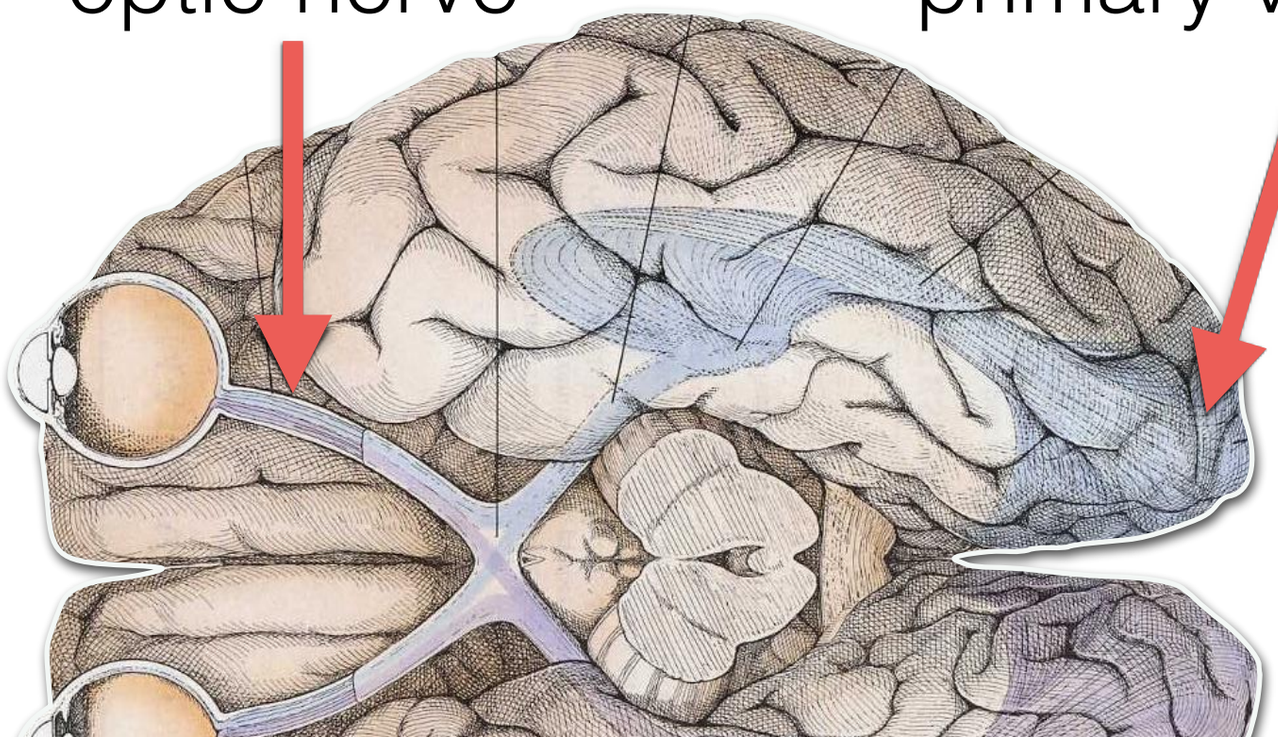
Image Pixel

https://commons.wikimedia.org/wiki/File:A_micrograph_of_the_corner_of_the_photosensor_array_of_a_%E2%80%98webcam%E2%80%99.jpeg

Beyond the Eye

optic nerve

primary visual cortex (V1)



http://hubel.med.harvard.edu/book/60htm.htm

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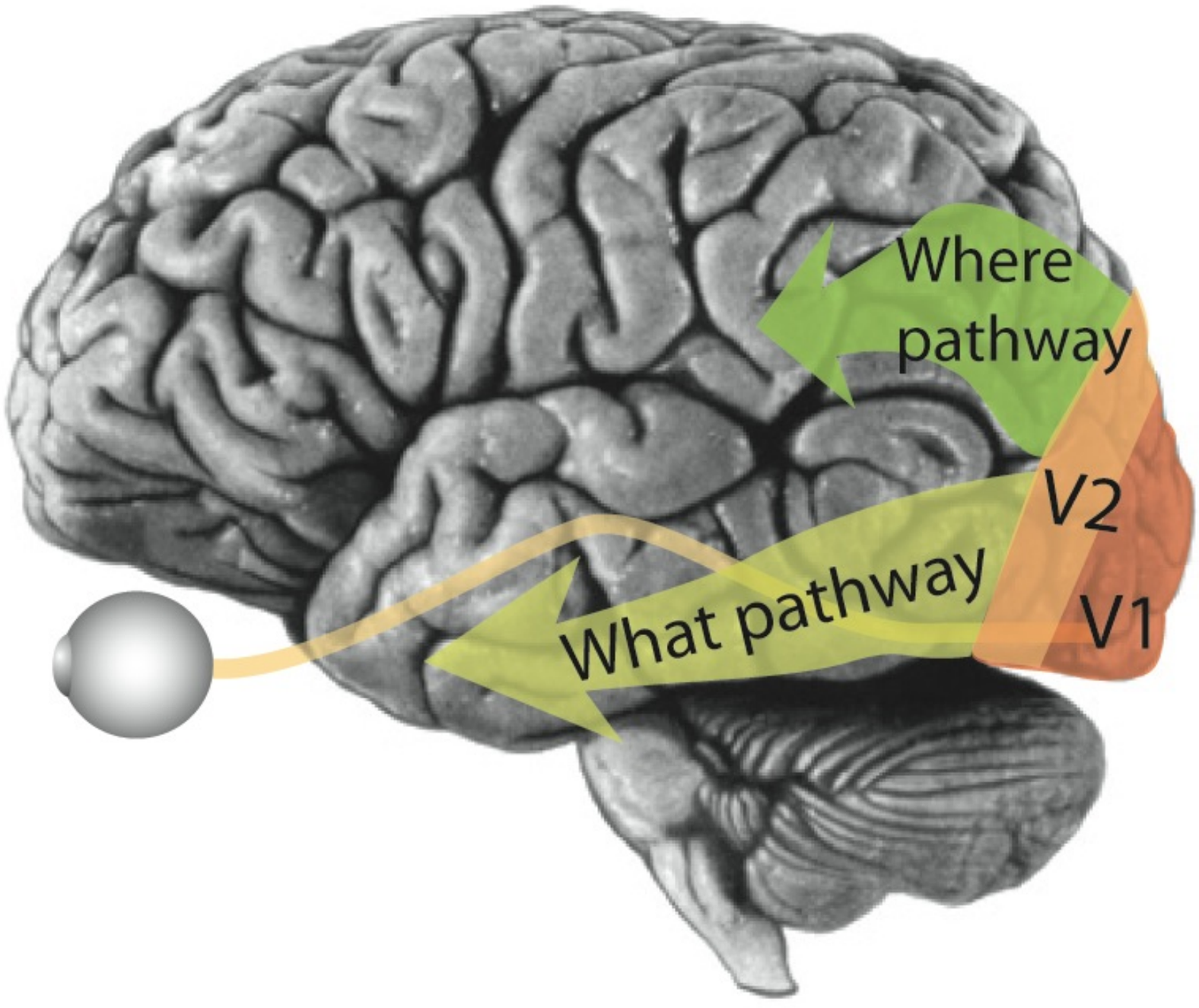
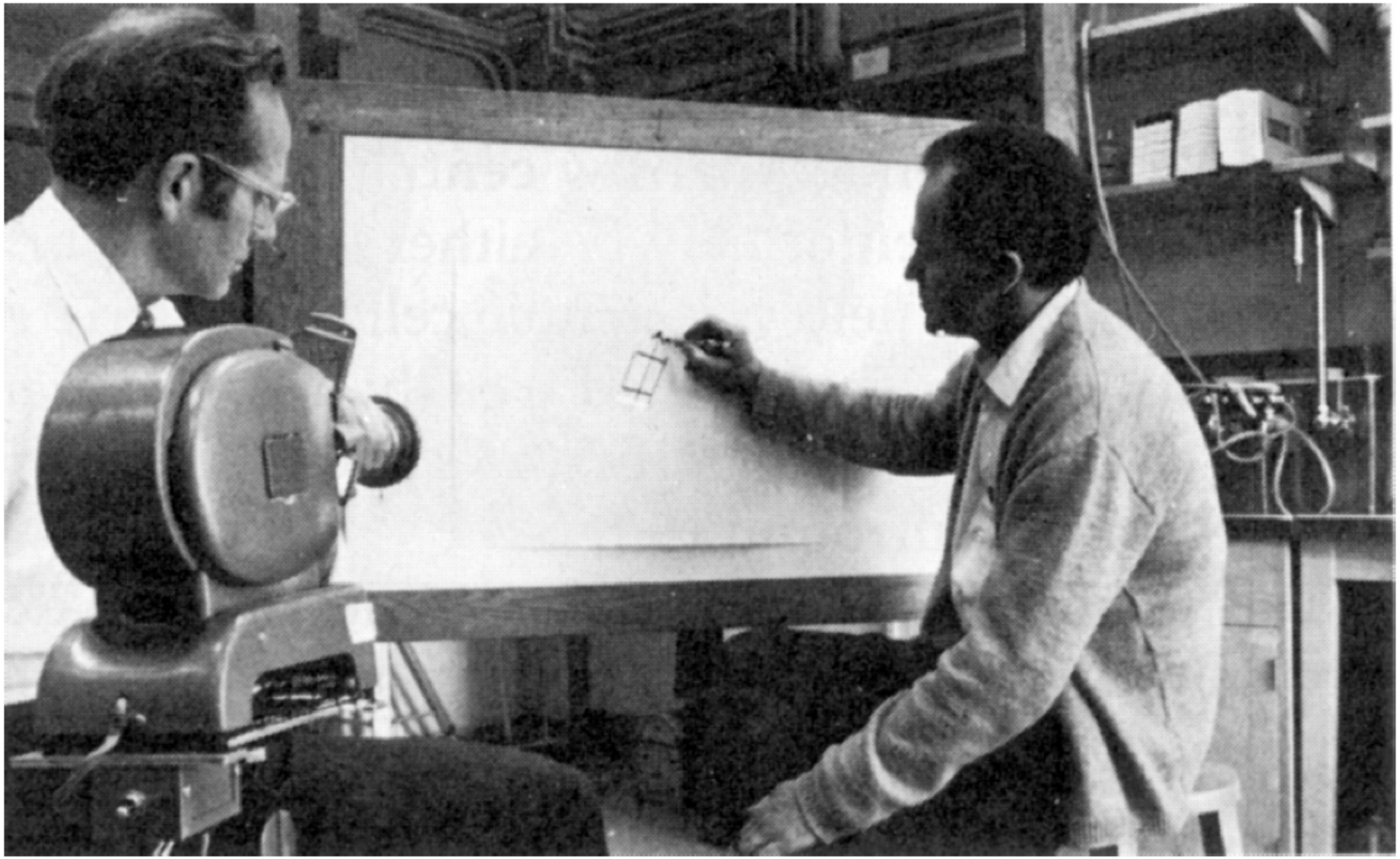
Where & What Pathways

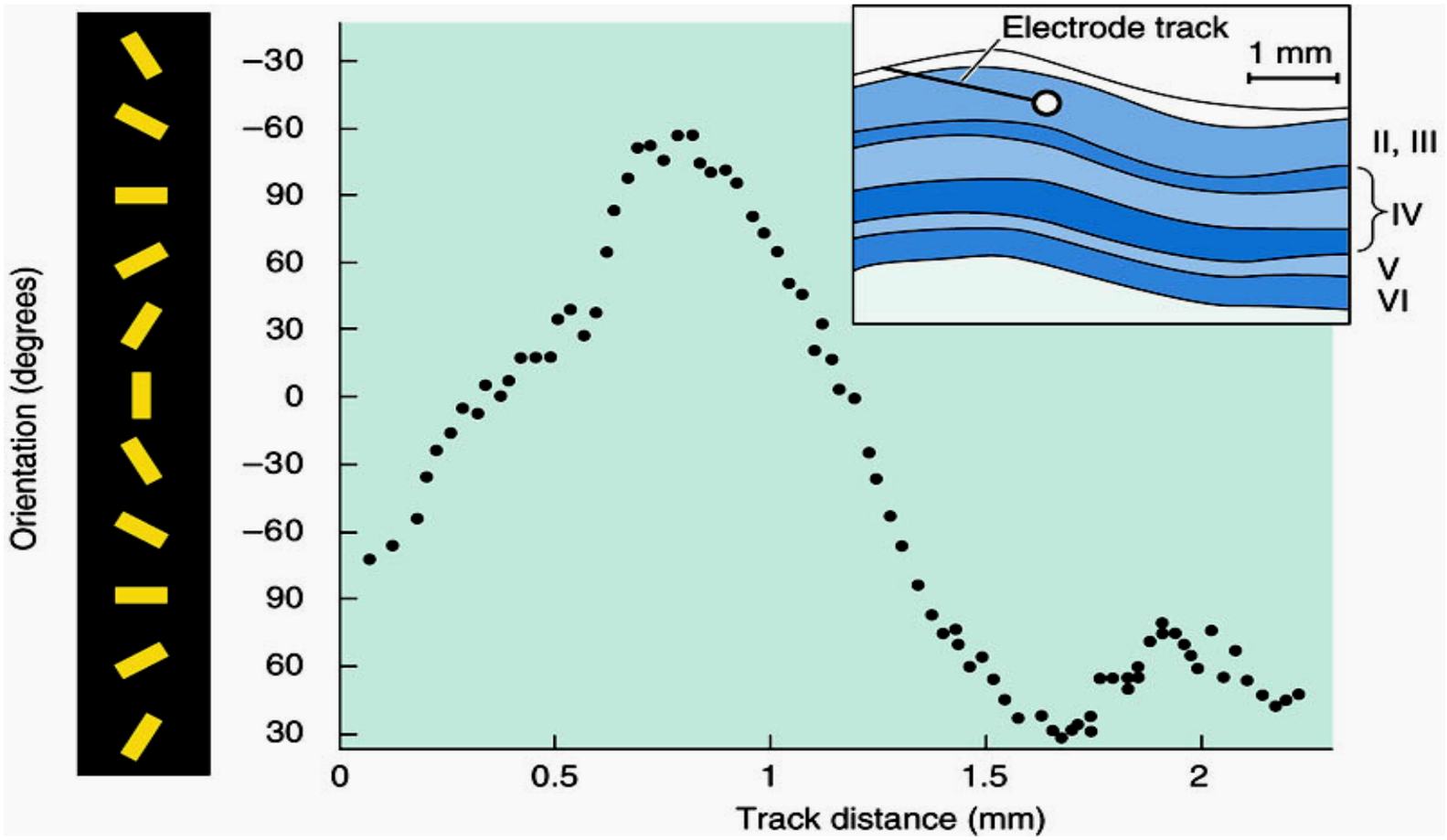


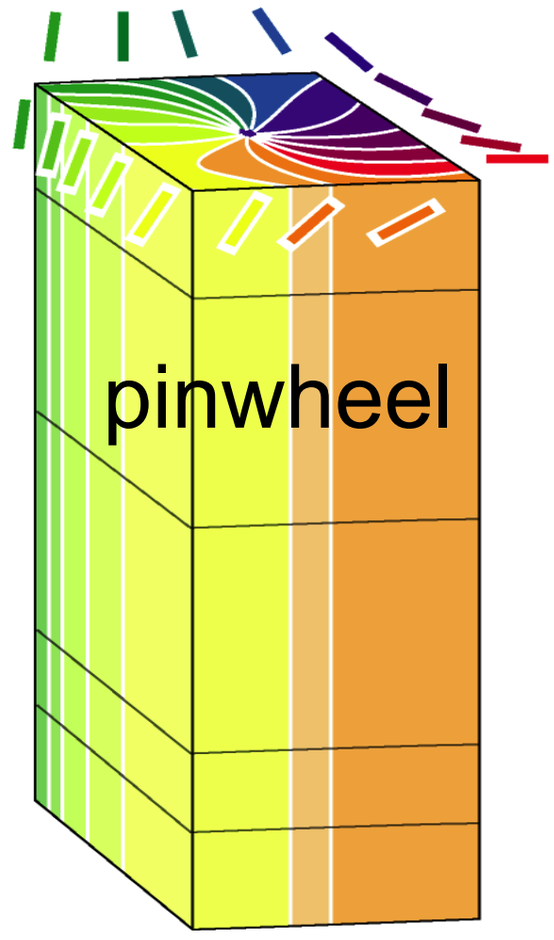
C. Ware, ‘Visual Thinking for Design’



Hubel and Wiesel, circa 1969 (from Nicholls et al., 1992)

Hypercolumns in V1

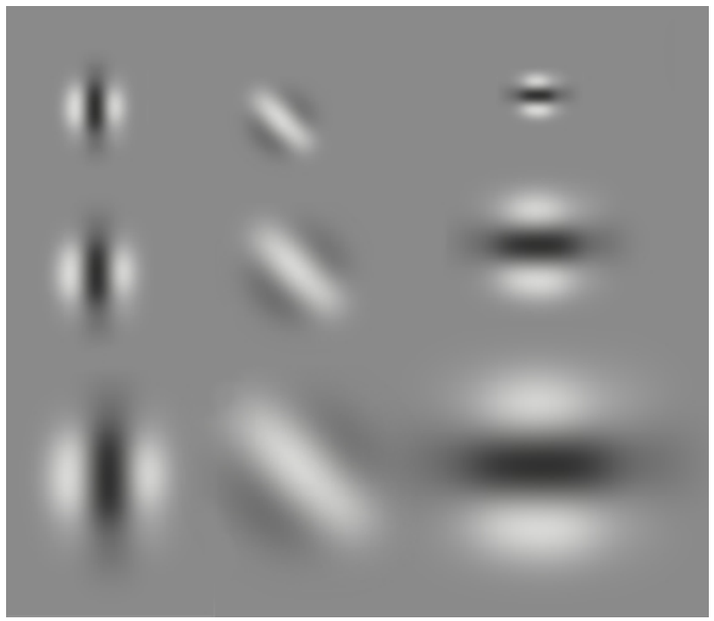




Hubel & Wiesel, Harvard, 1959

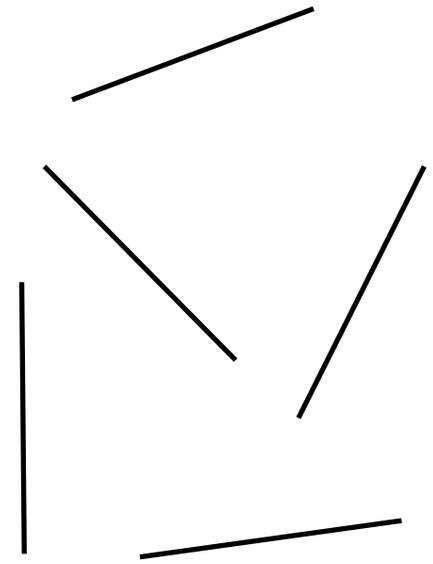
Bear, Connors, Paradiso, ‘Neuroscience’

Visual Channels (Features)



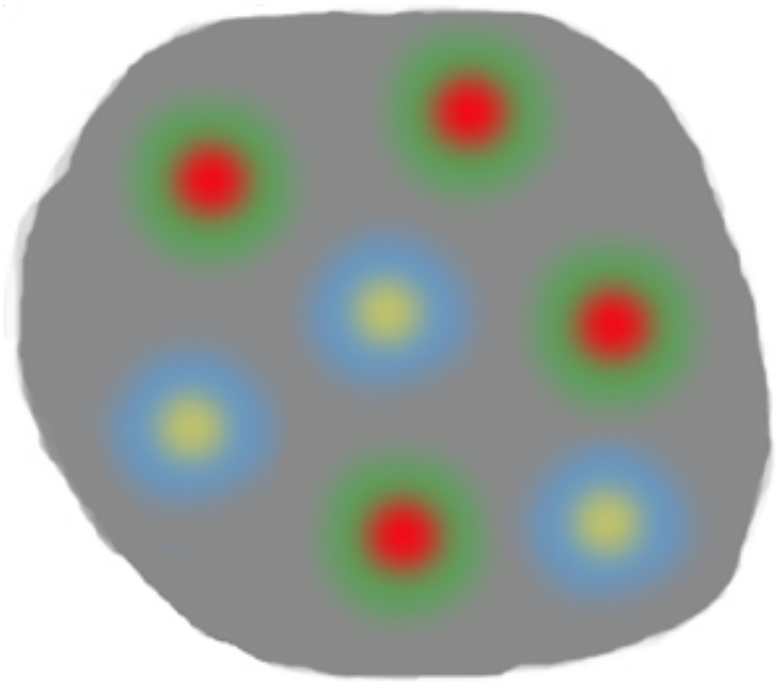
Contrast

Some sensitivity to color



Motion

Insensitive to color



Color

R/G and Y/B changes

C. Ware, ‘Visual Thinking for Design’

Contrast

M. Meyer

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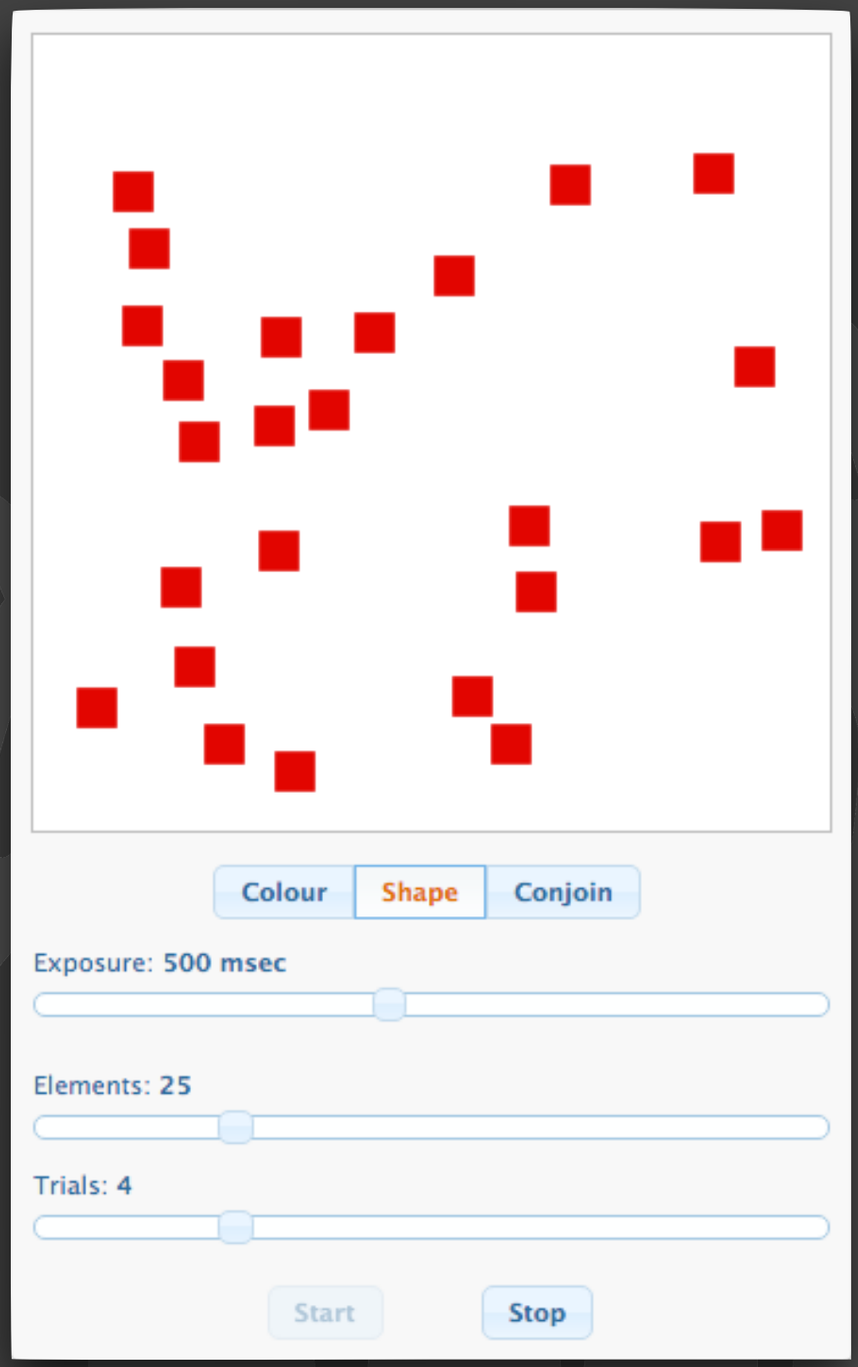
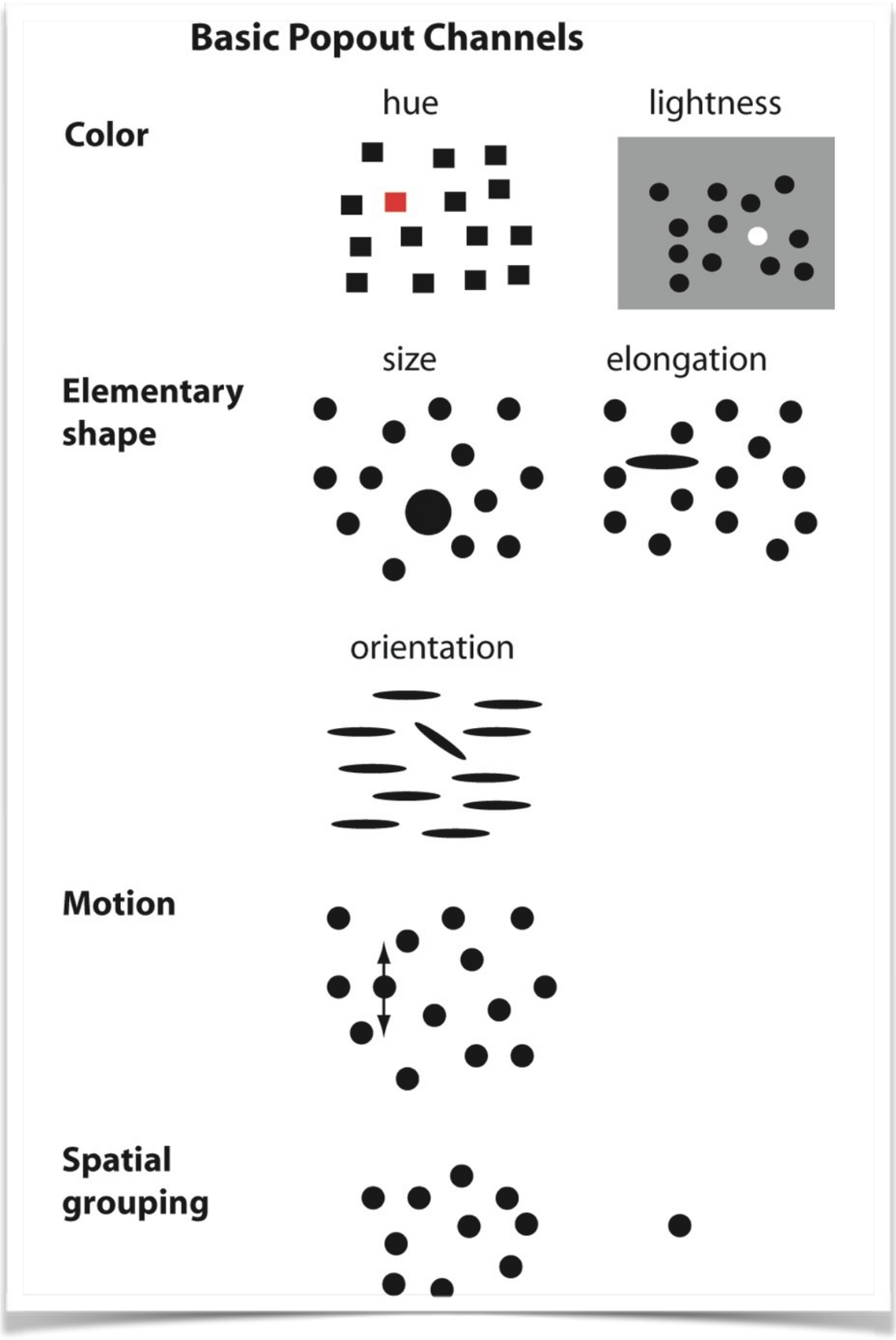
Activity

Chris Healey Pop-Out demo. (3 min)

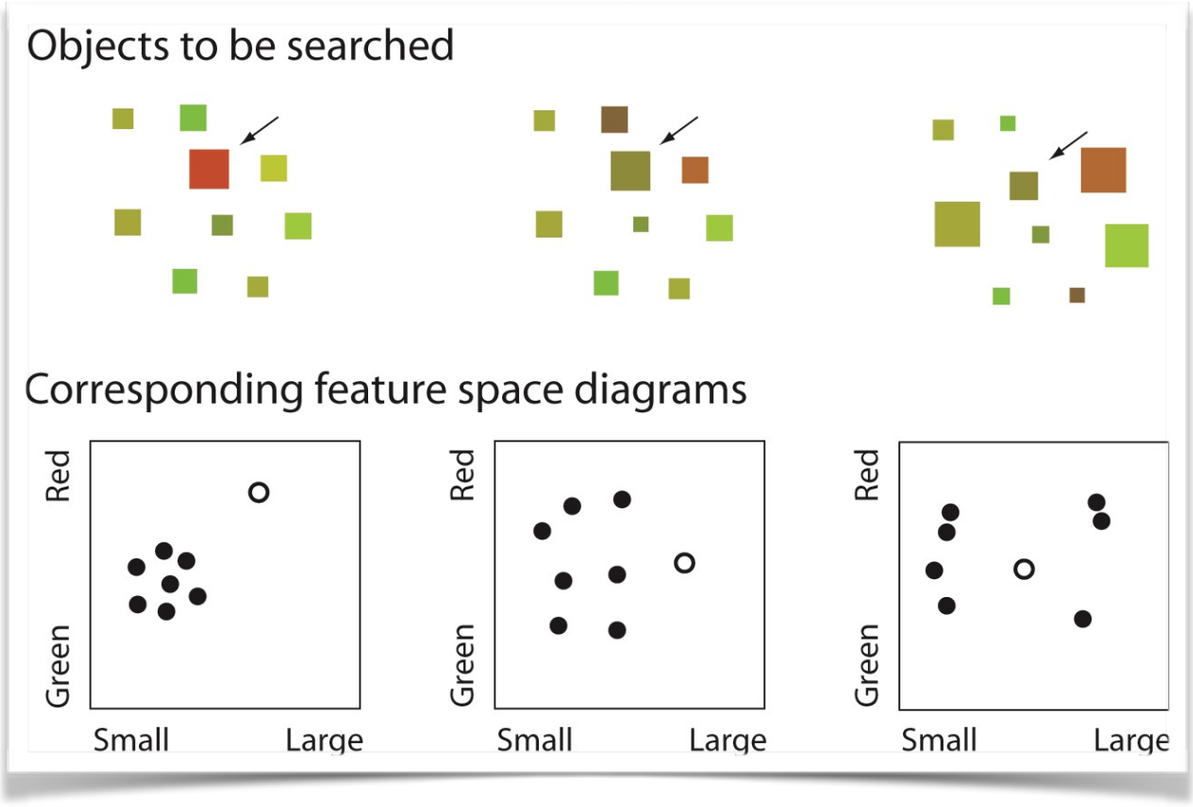


C. Healy 2007

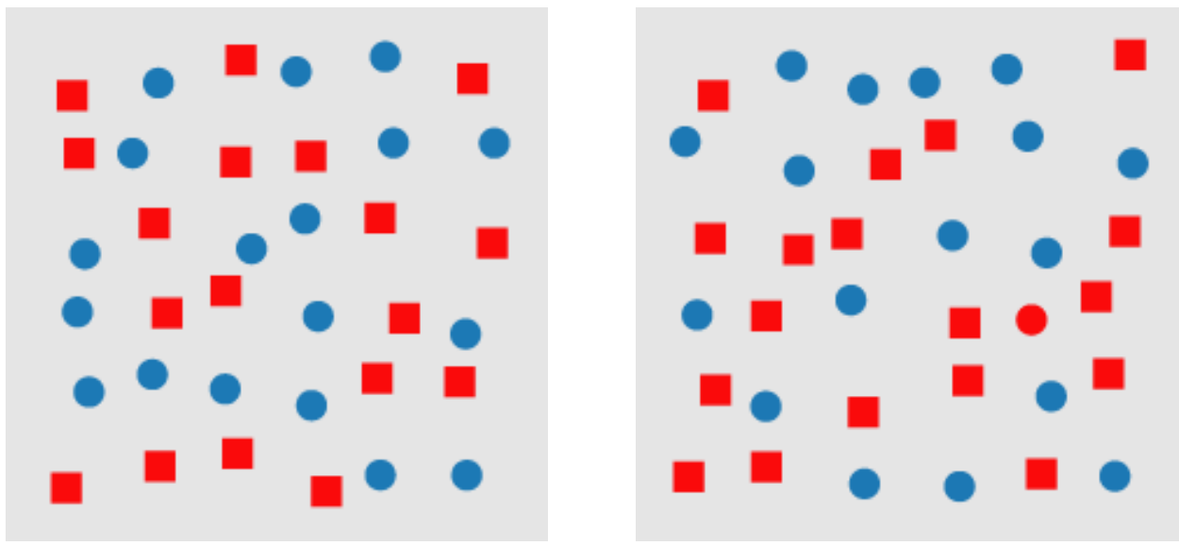


C. Ware, ‘Visual Thinking for Design’

Feature Space Diagram

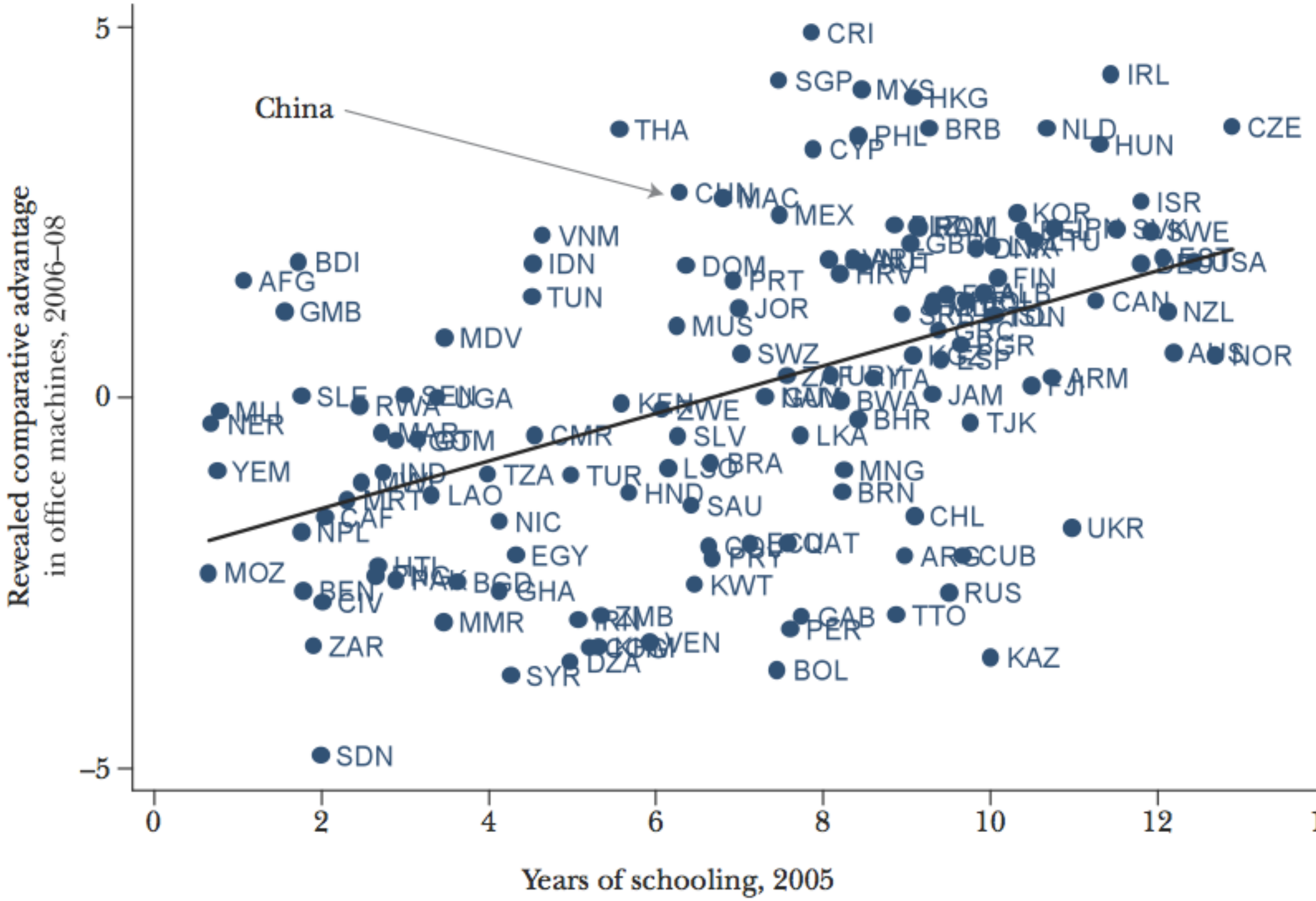


Visual Conjunctive Search



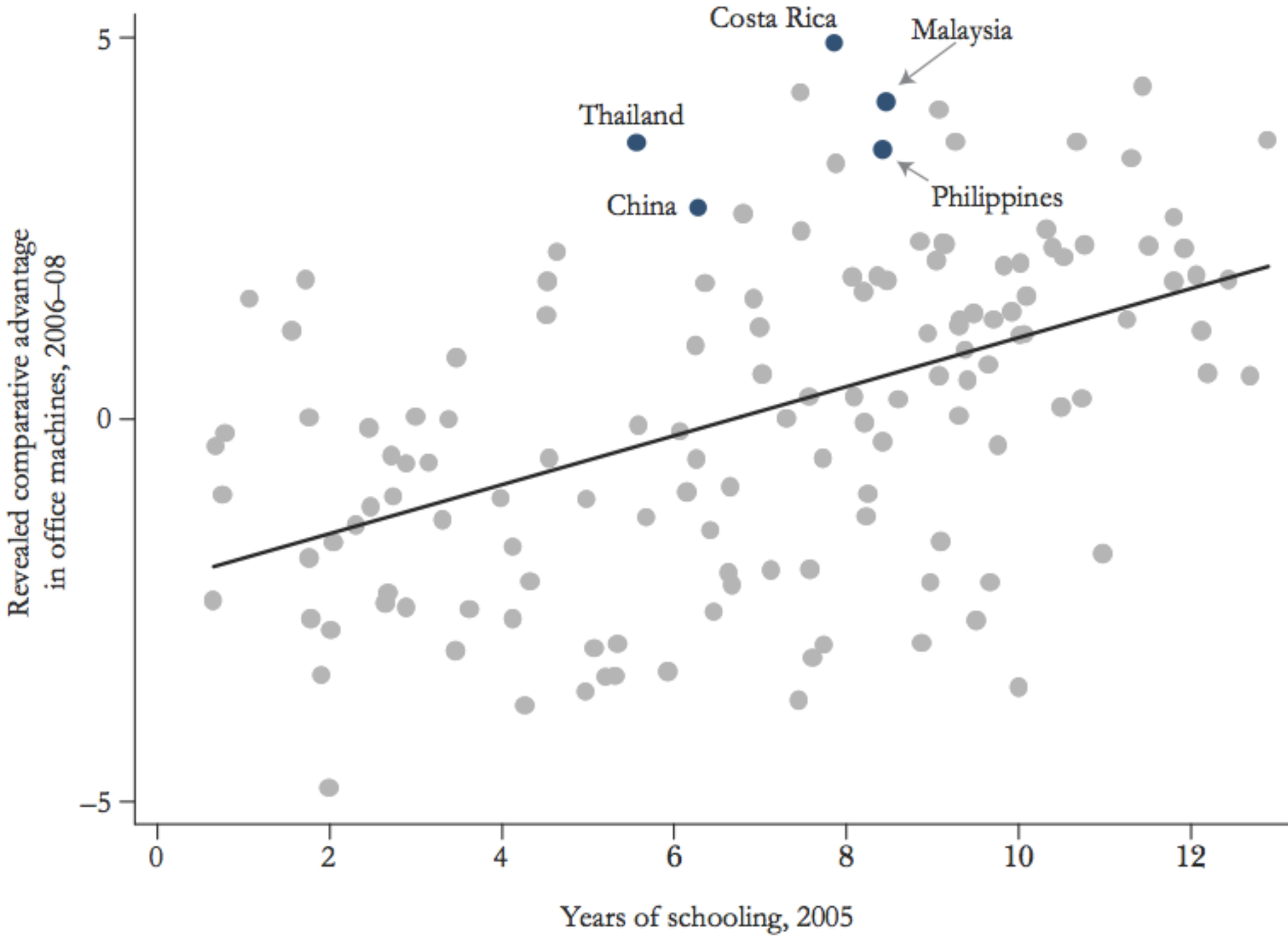
C. Healy 2007

Education and Exports of Office Machines



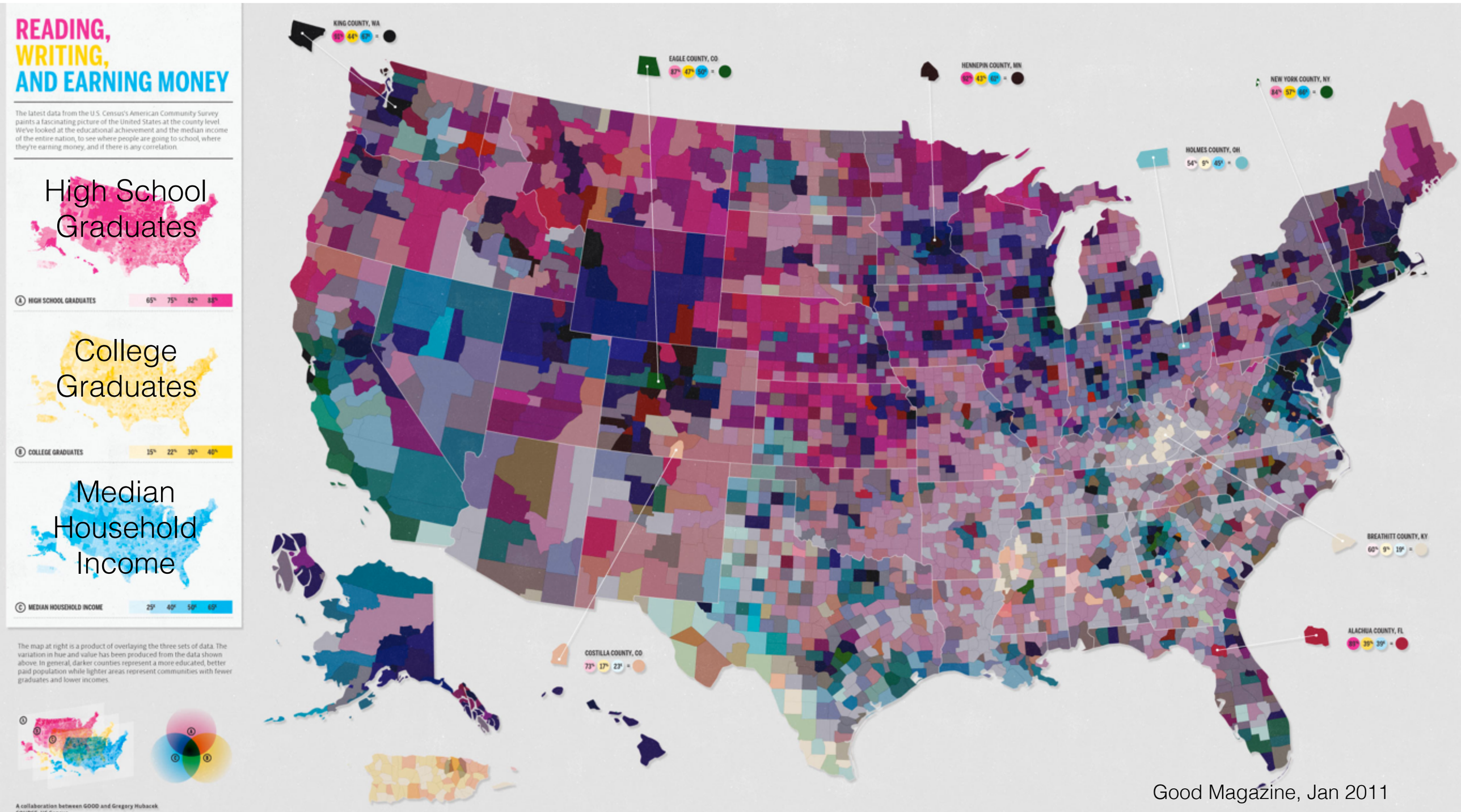
J. A. Schwabish, An Economist's Guide to Visualizing Data

Education and Exports of Office Machines



J. A. Schwabish, An Economist's Guide to Visualizing Data

Are the richest Americans also the best educated?



Good Magazine, Jan 2011

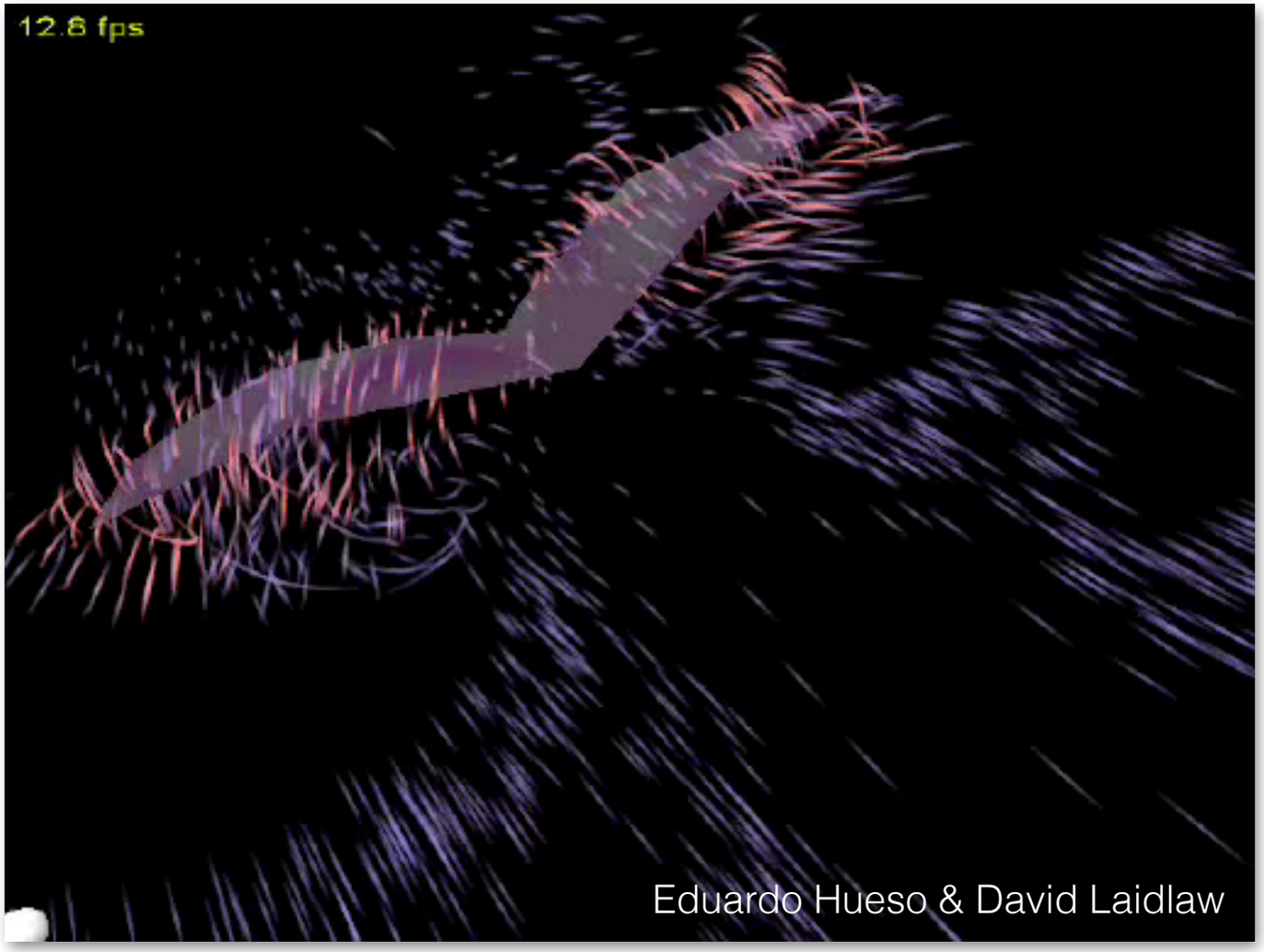
Separable - Integral

Separable ⟷ Integral

color location | color motion | color shape | size orientation | x-size y-size | red-green yellow-blue

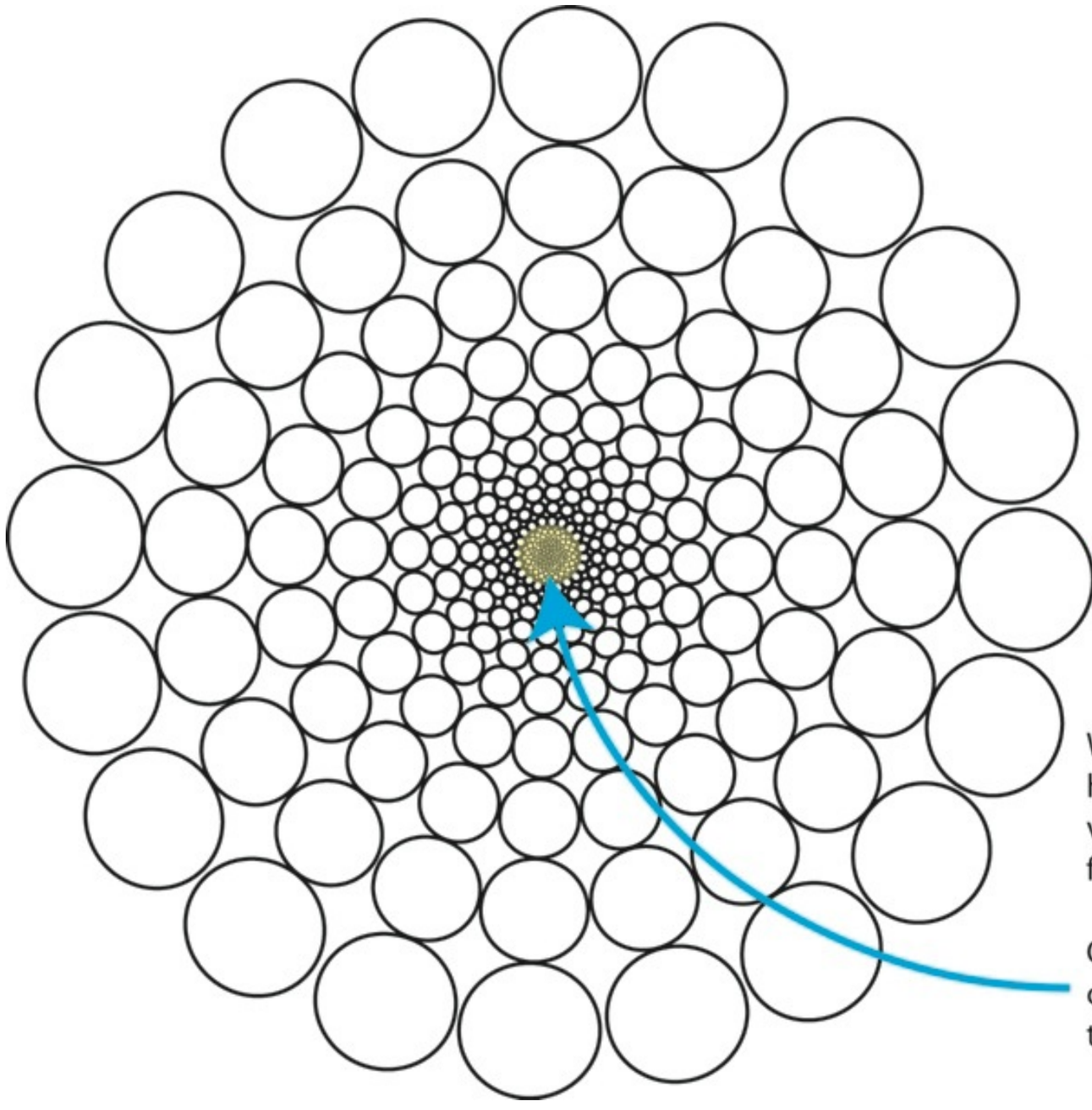
C. Ware, ‘Information Visualization’

Motion



CS
171

Motion Detection



At the edge of the visual field we can only barely see something the size of of a fist at arm's length.

We can resolve about 100 points on the head of a pin held at arm's length in the very center of the visual field called the fovea.

Over half of our visual processing power is concentrated in a sligtly larger area called the parafovea.

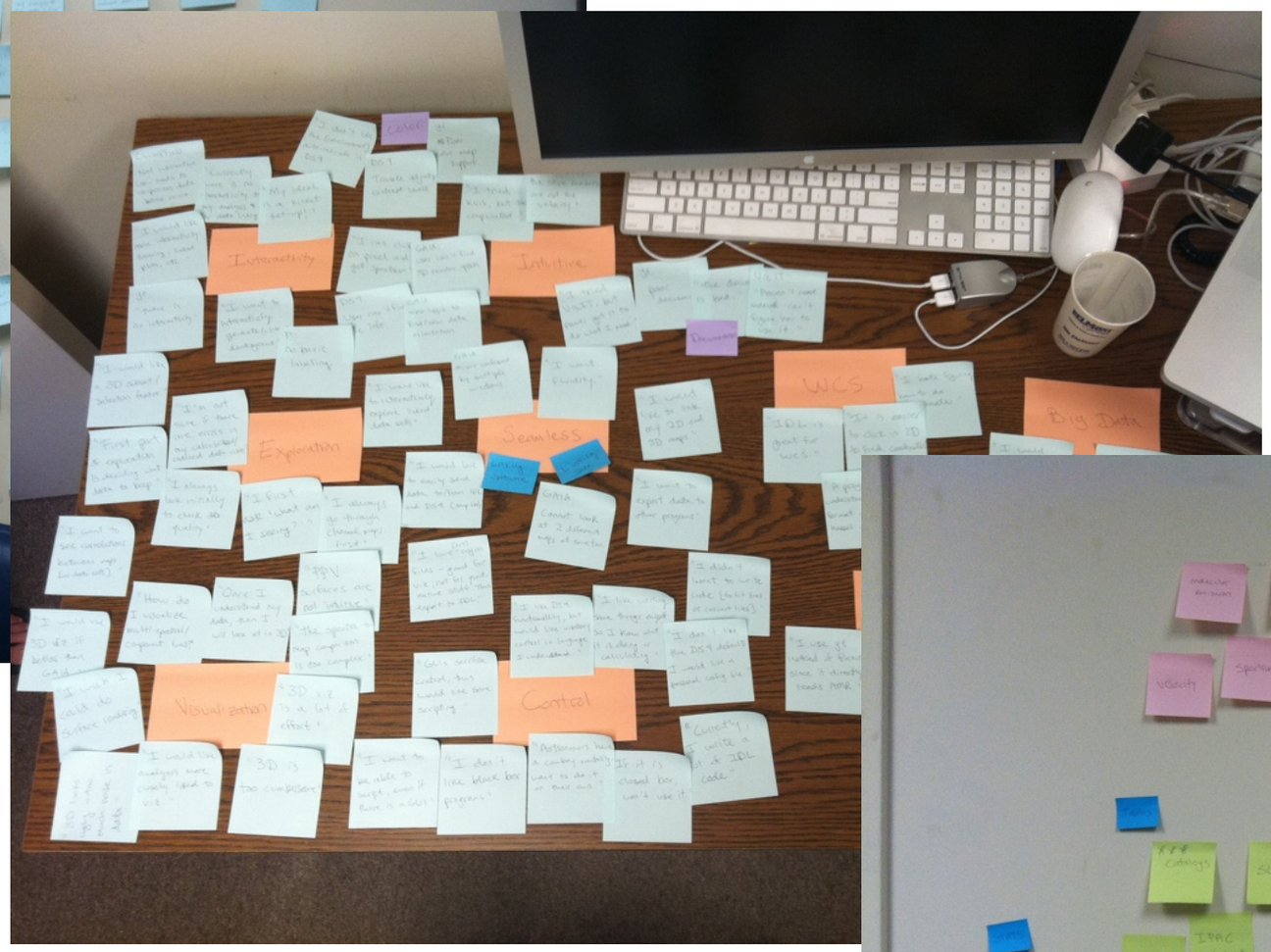
Activity

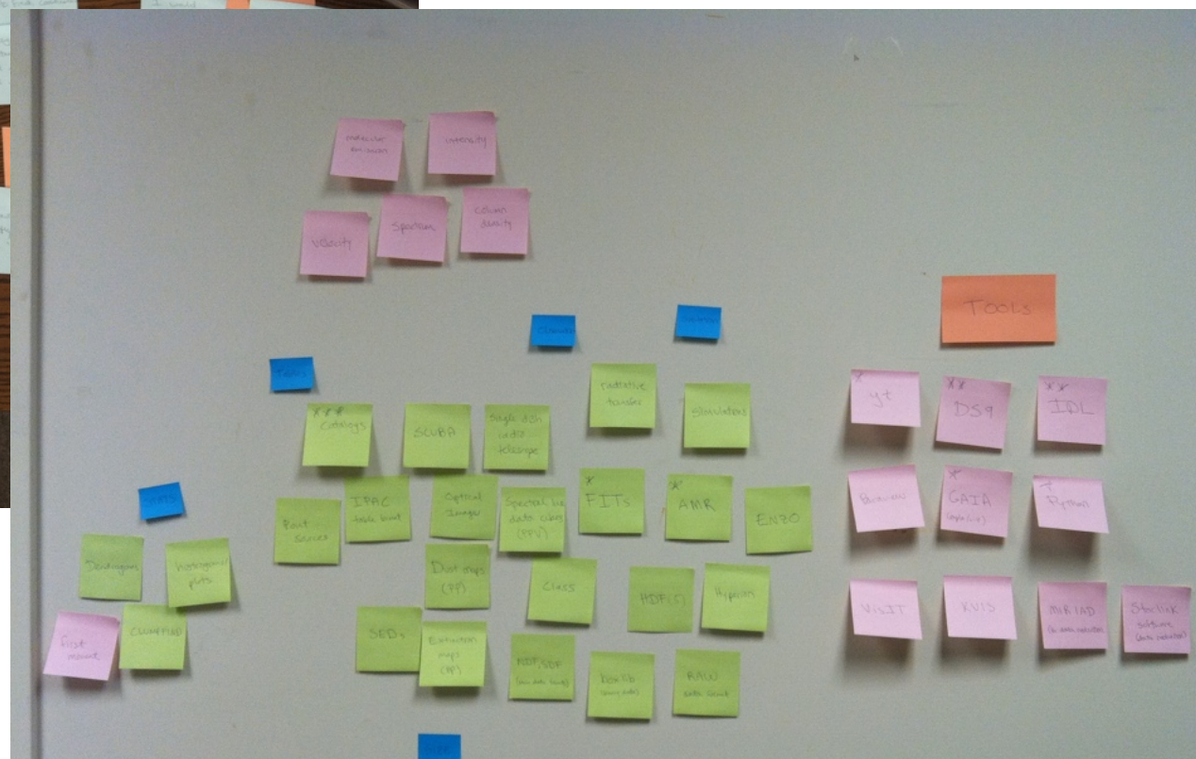
CS 171

Find examples where motion / animation is used in daily 'electronic' life. (2 min)

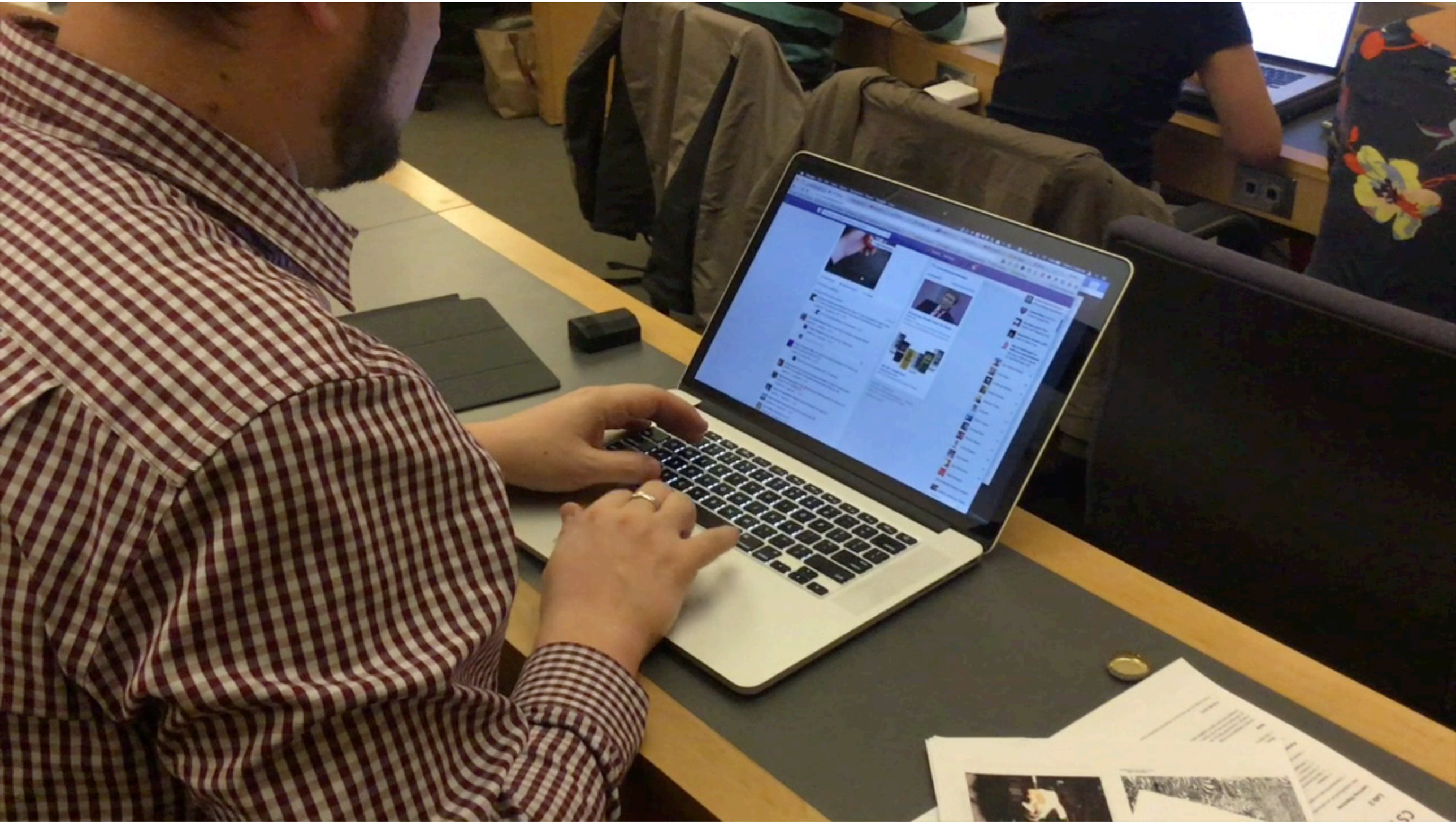
In small groups (4-5 people), create affinity diagrams by clustering your examples and giving the clusters names. (5 min)

Affinity Diagramming

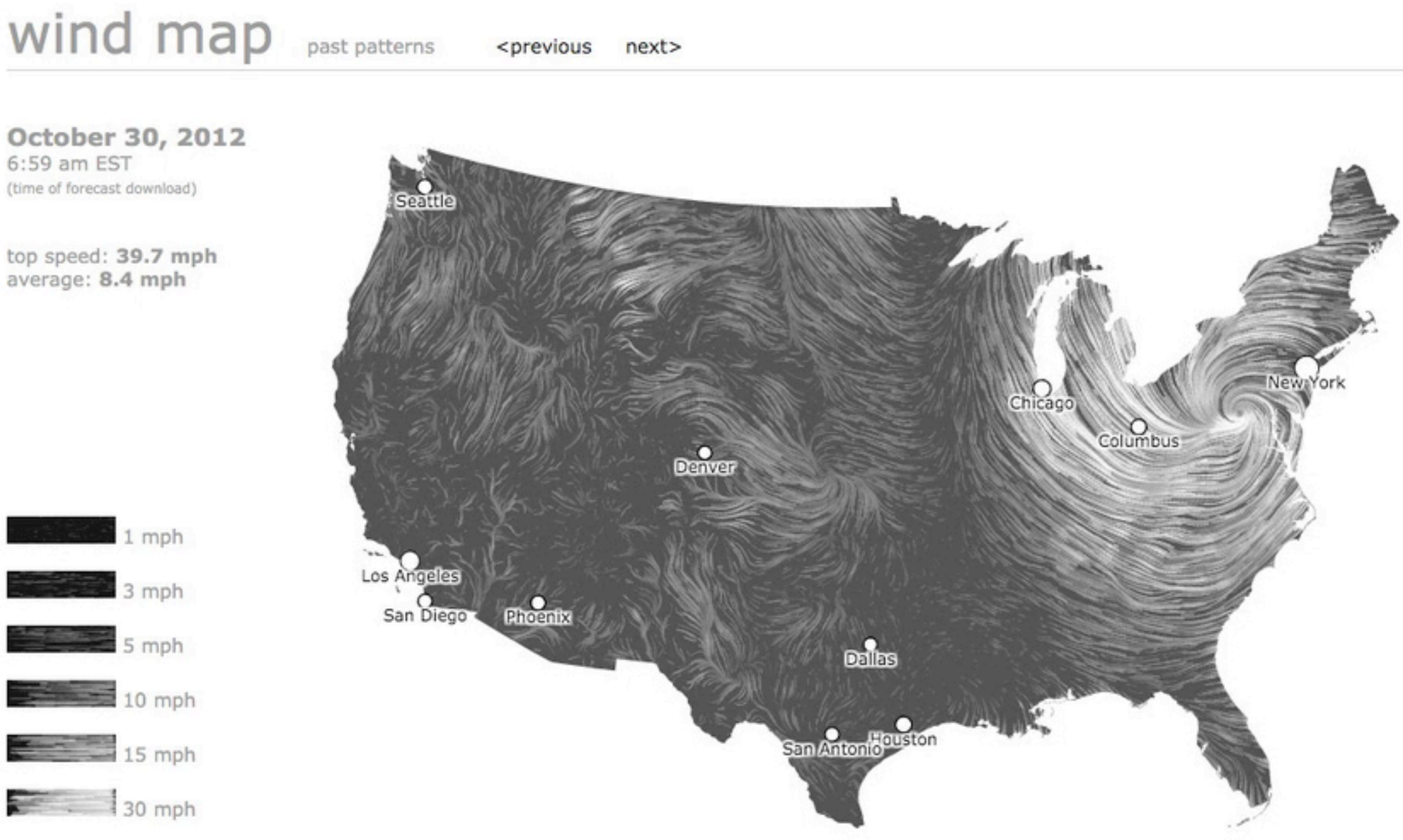




Electronic Distractors

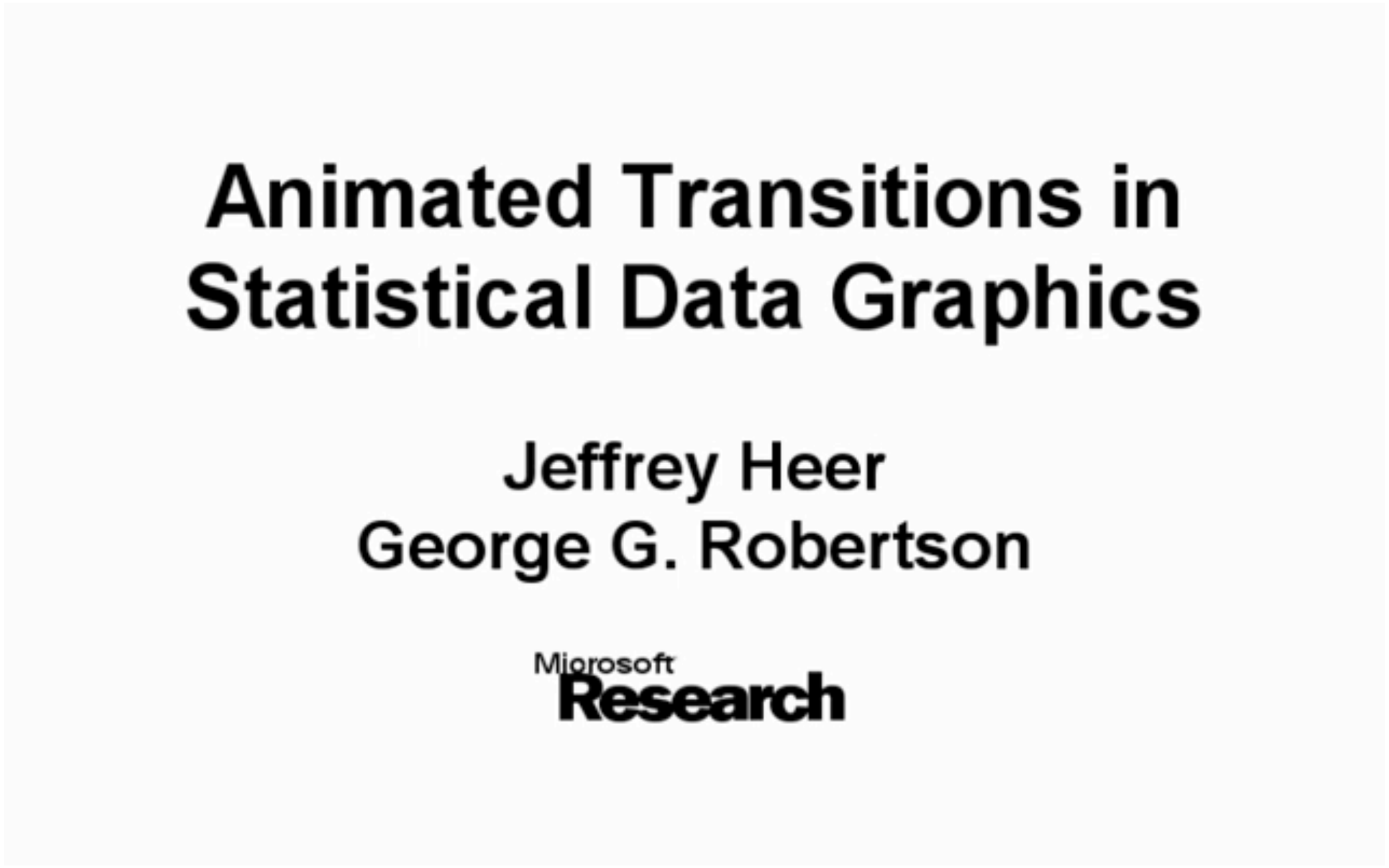


Motion as Visual Variable

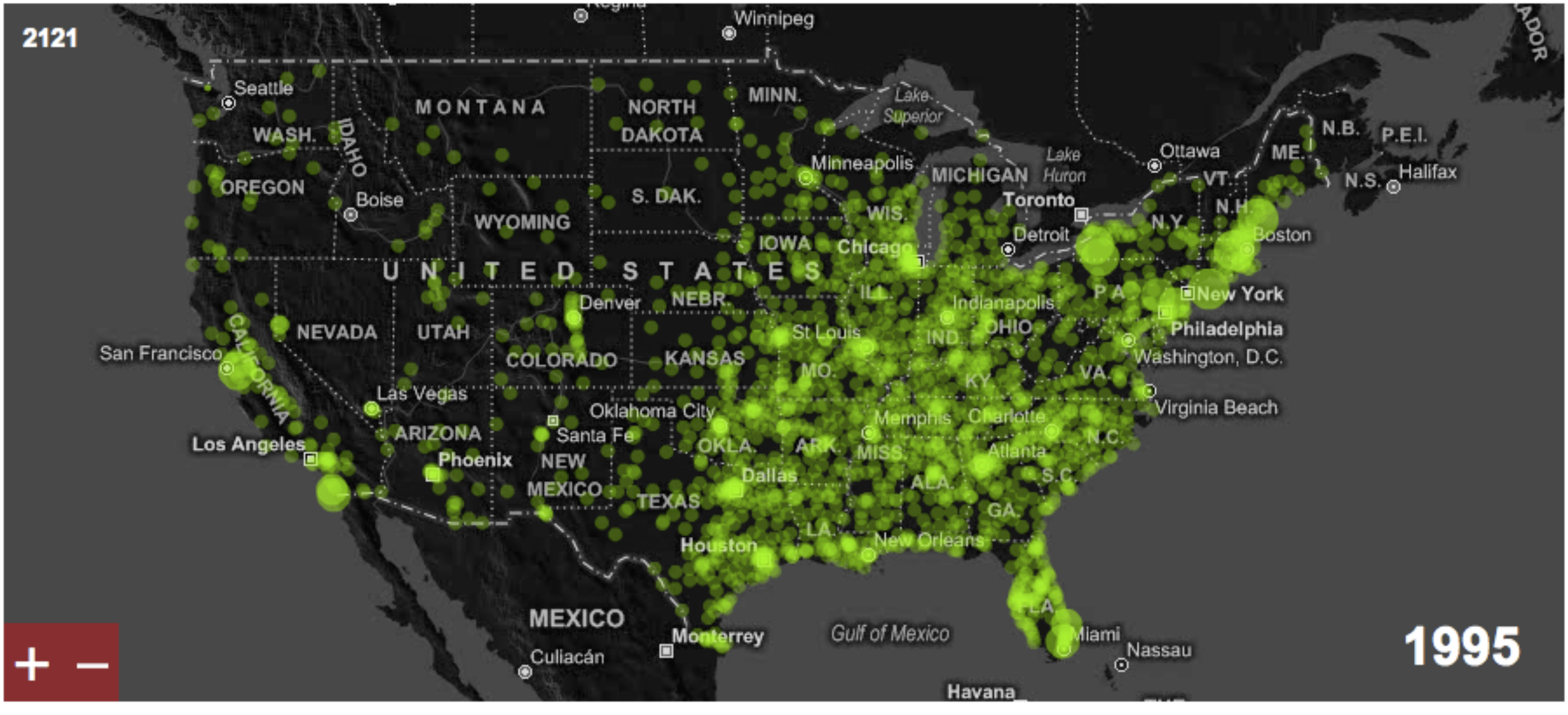


http://hint.fm/wind/

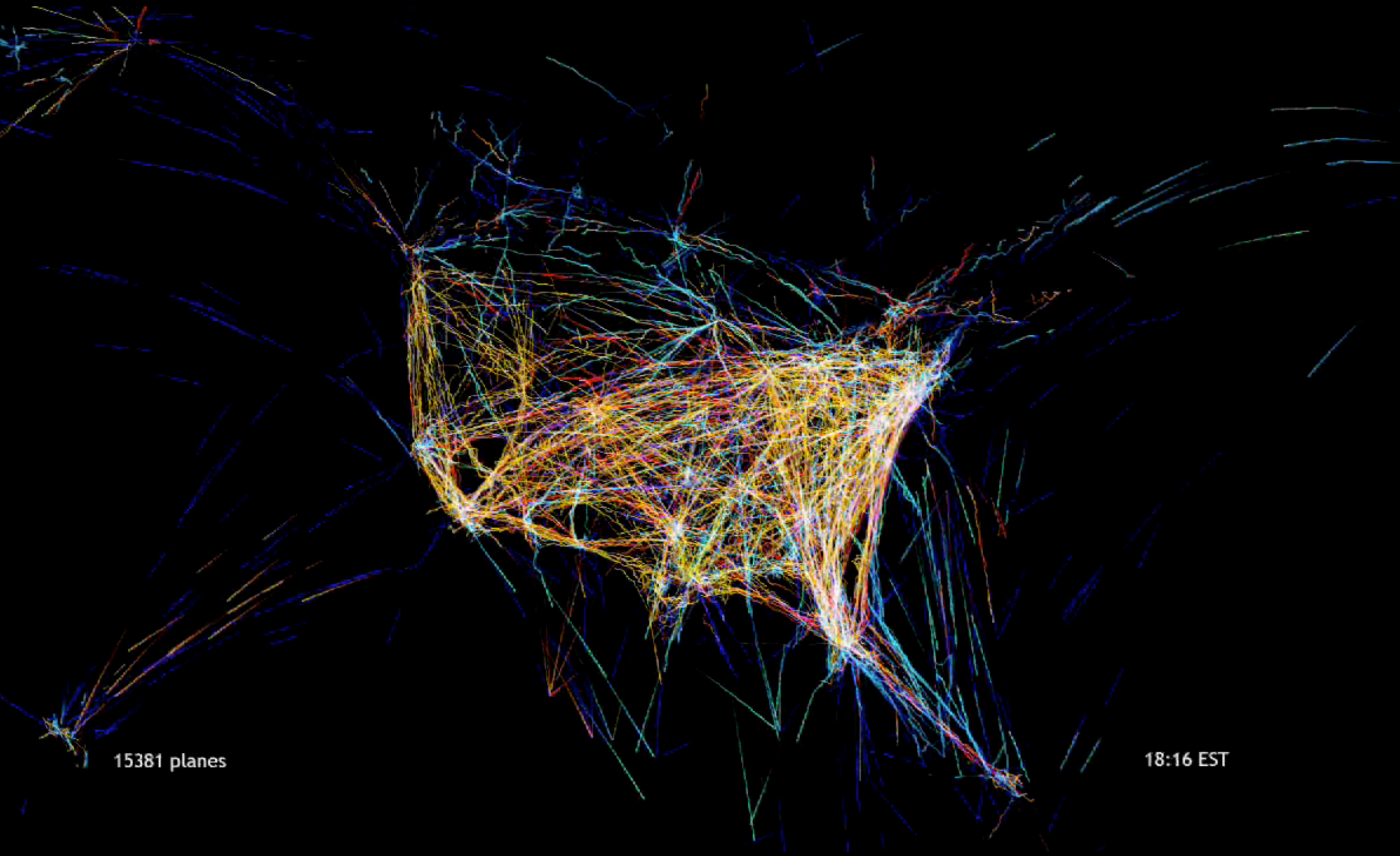
Transitions



Changes over Time

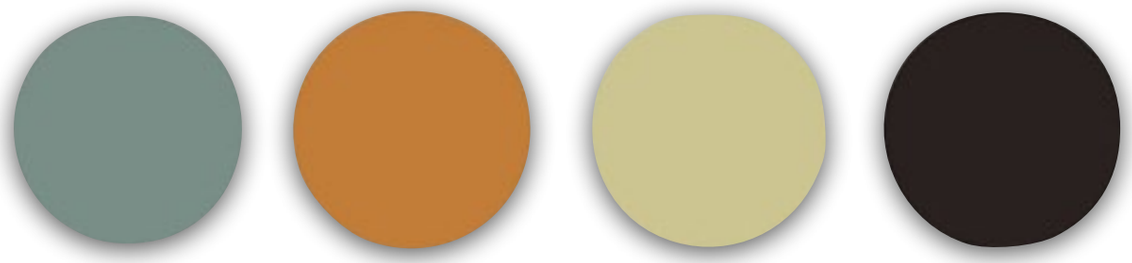


Flowing Data



Flight Patterns, Aaron Koblin

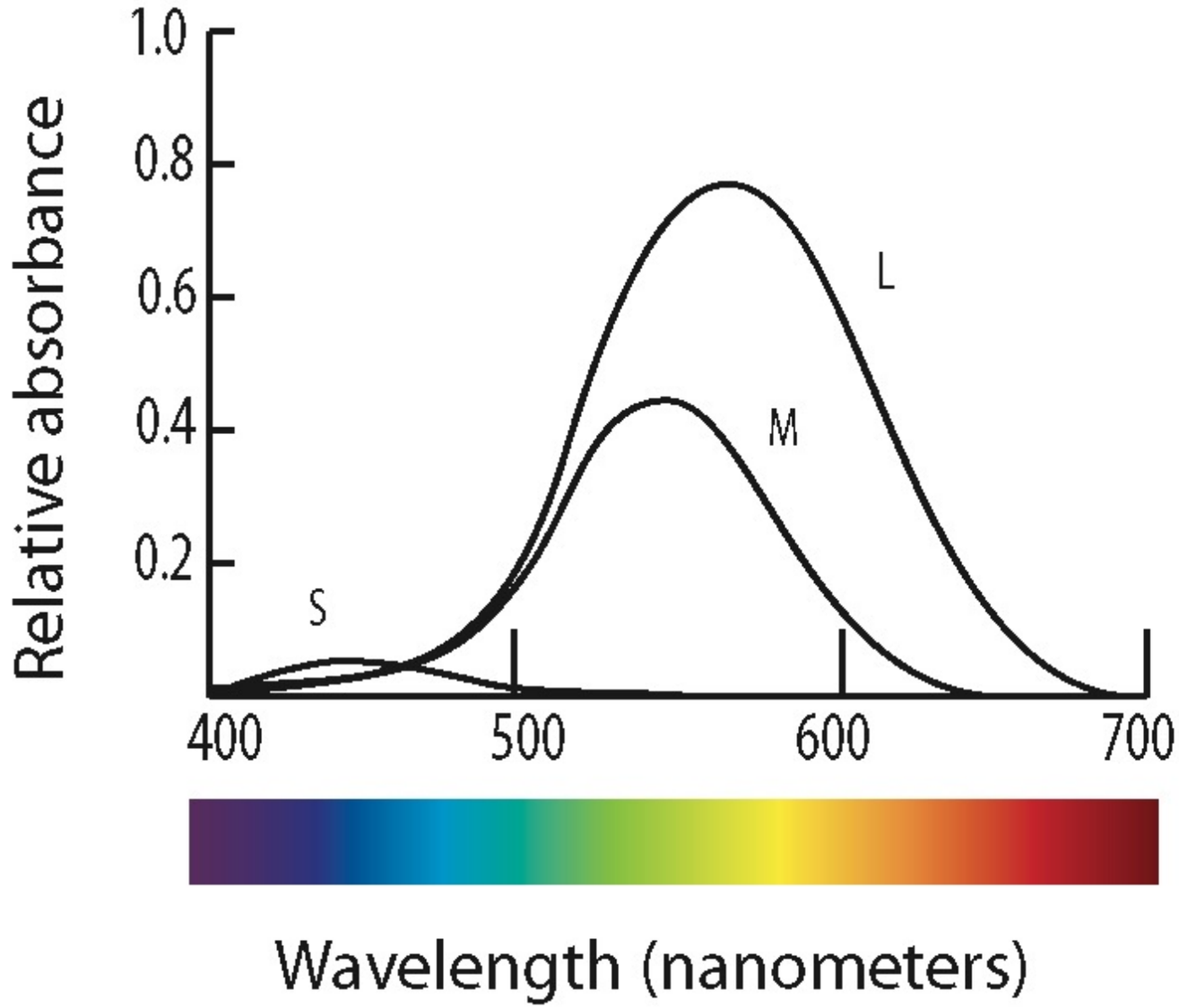
Color



CS 171

http://anotherimg.dazedgroup.netdna-cdn.com/706/azure/another-prod/300/0/300560.jpg

Cone Response



C. Ware, ‘Visual Thinking for Design’

#TheDress

Kim Kardashian West
@KimKardashian

Following

What color is that dress? I see white & gold. Kanye sees black & blue, who is color blind?

RETWEETS 3,996 FAVORITES 6,562

8:41 PM - 26 Feb 2015

+21

Mindy Kaling
@mindykaling

Follow

IT'S A BLUE AND BLACK DRESS! ARE YOU FUCKING KIDDING ME

RETWEETS 9,924 LIKES 17,998

8:43 PM - 26 Feb 2015

B.J. Novak @bjnovak · 26 Feb 2015
white and gold

2.9K 5.6K

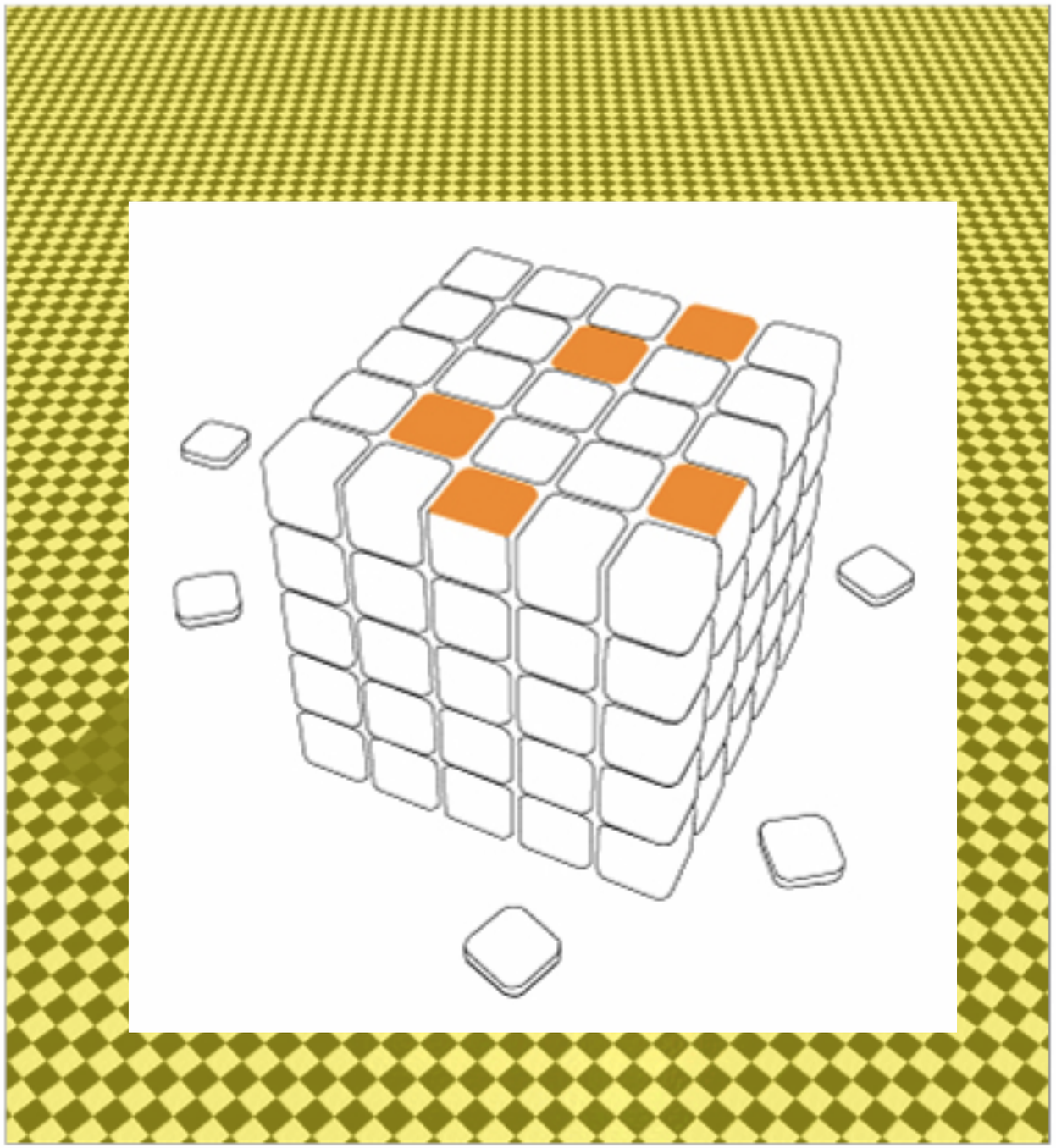
Mindy Kaling @mindykaling · 26 Feb 2015
"@bjnovak: white and gold". ARE YOU INSANE

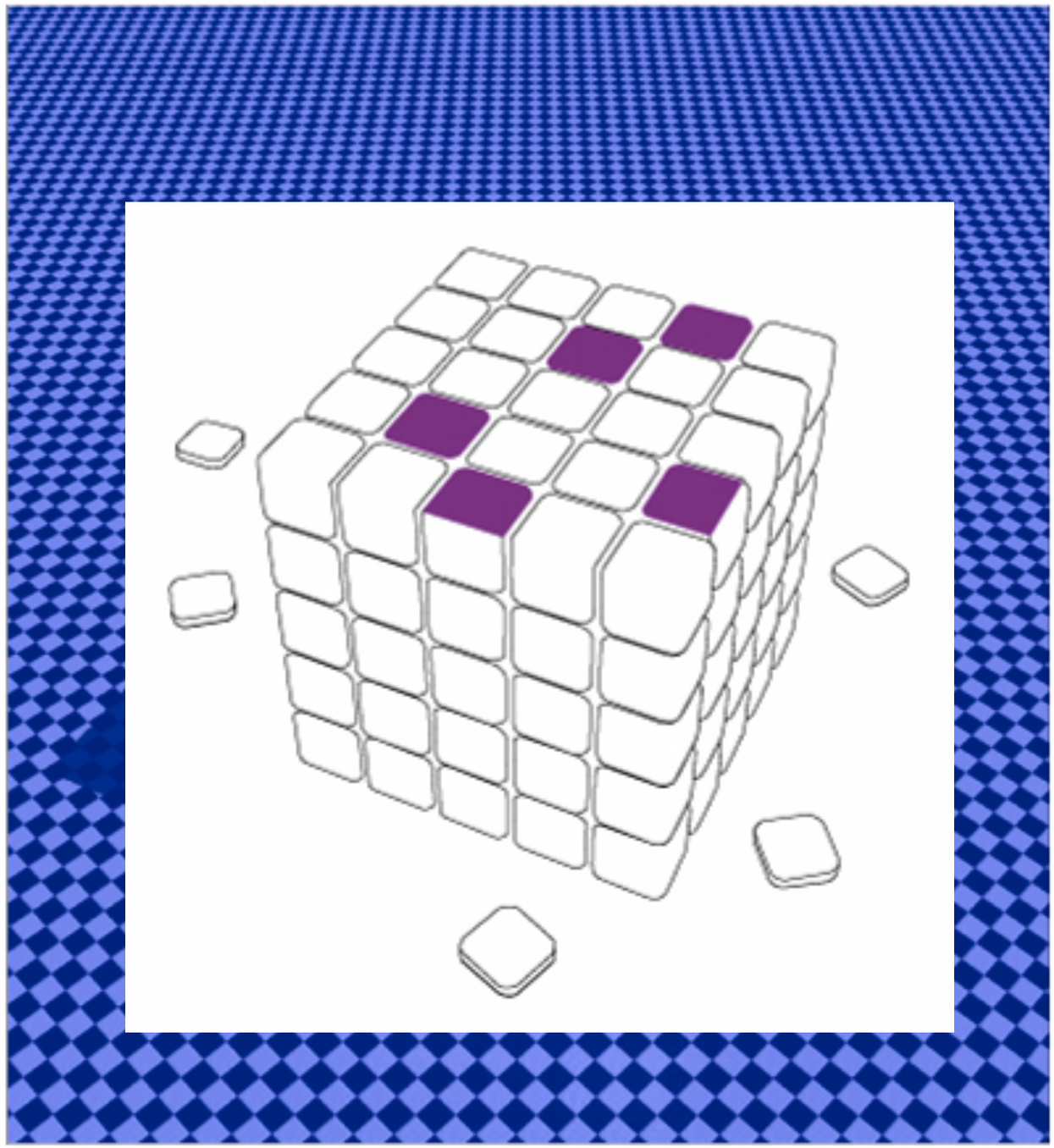
Taylor Swift
@taylorswift13

Follow

I don't understand this odd dress debate
and I feel like it's a trick somehow.
I'm confused and scared.
PS it's OBVIOUSLY BLUE AND BLACK

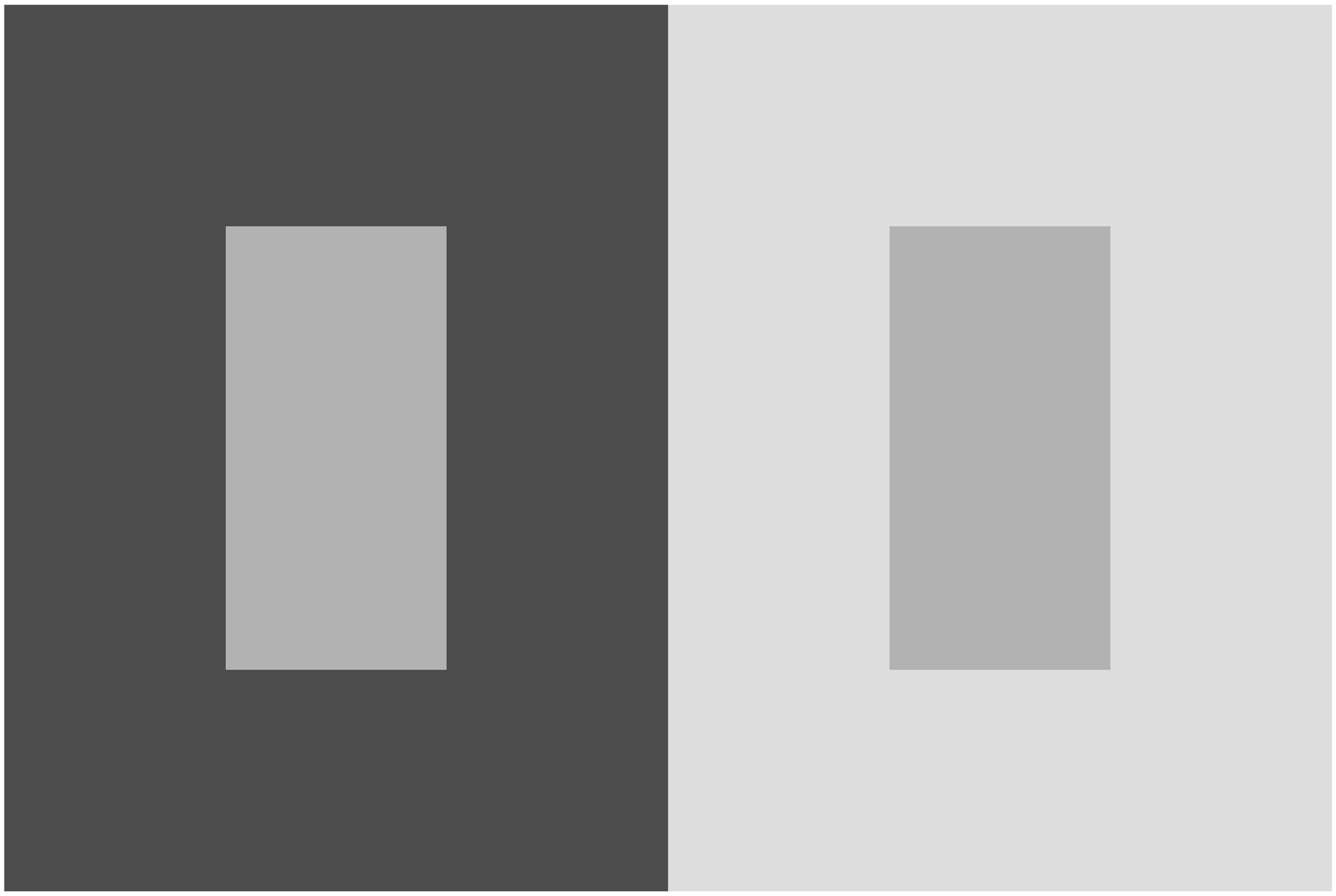
Chromatic Adaptation





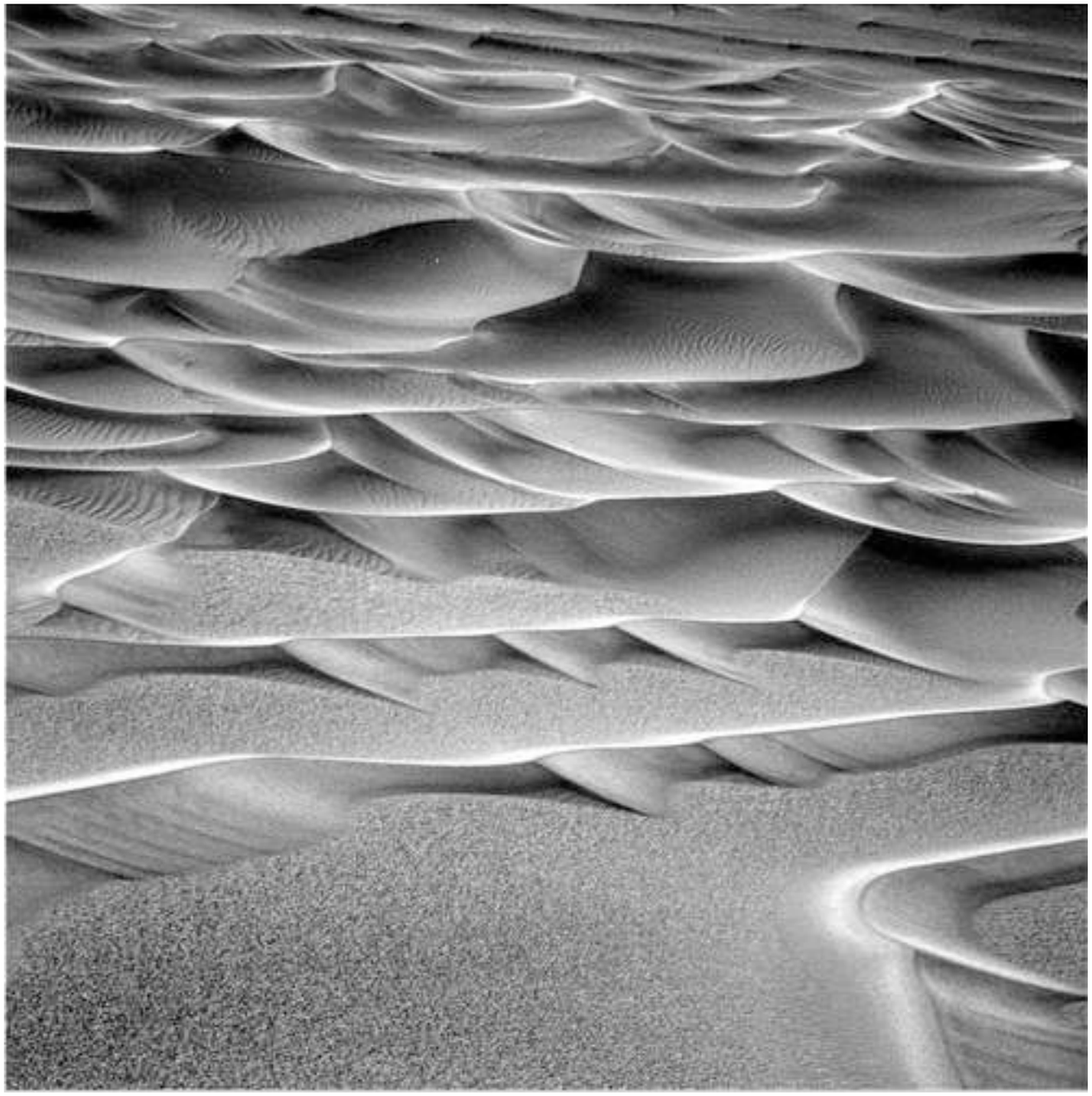
D. Purves and R. B. Lotto

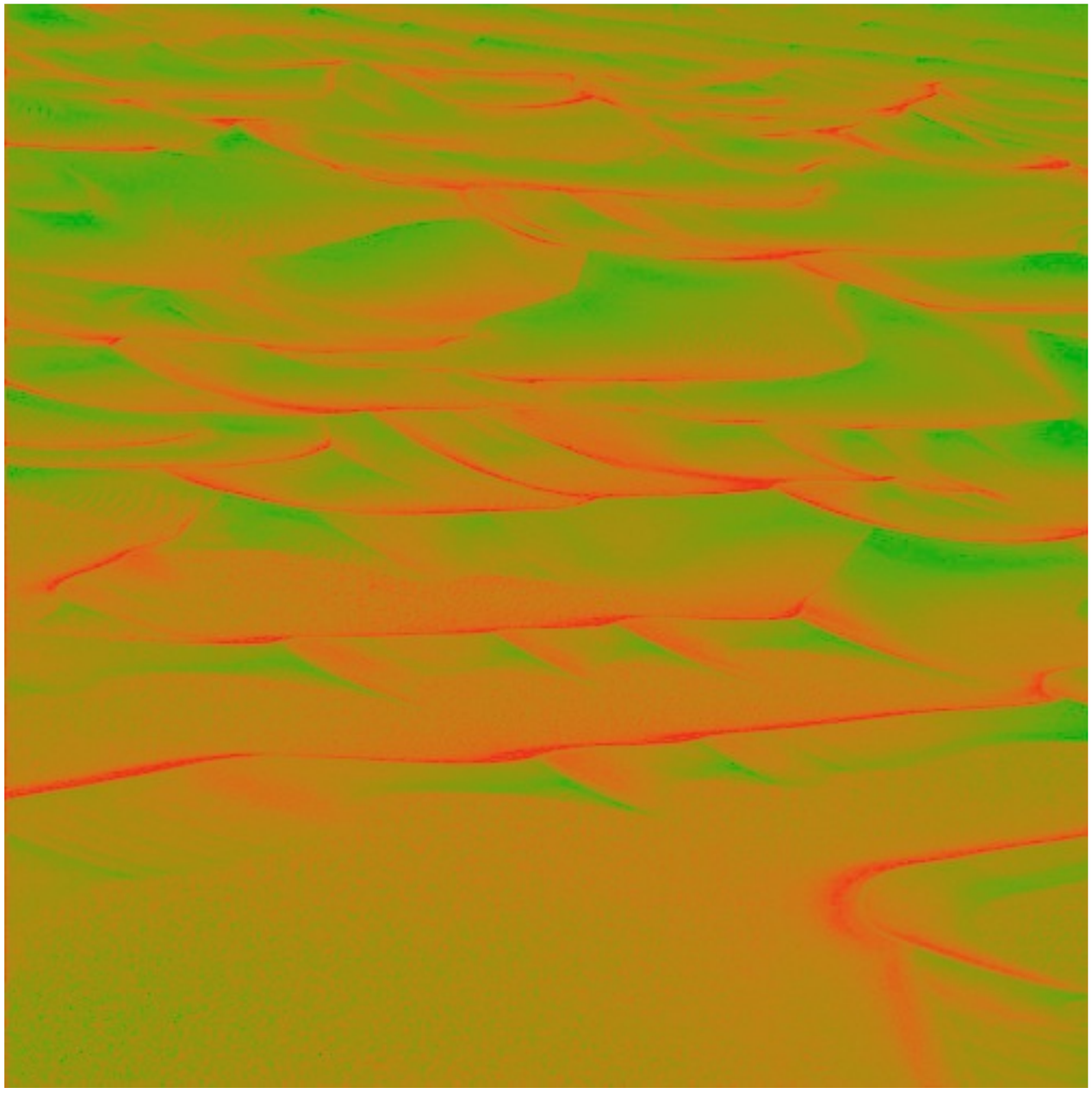
Simultaneous Contrast



Simultaneous Contrast

Contrast Sensitivity





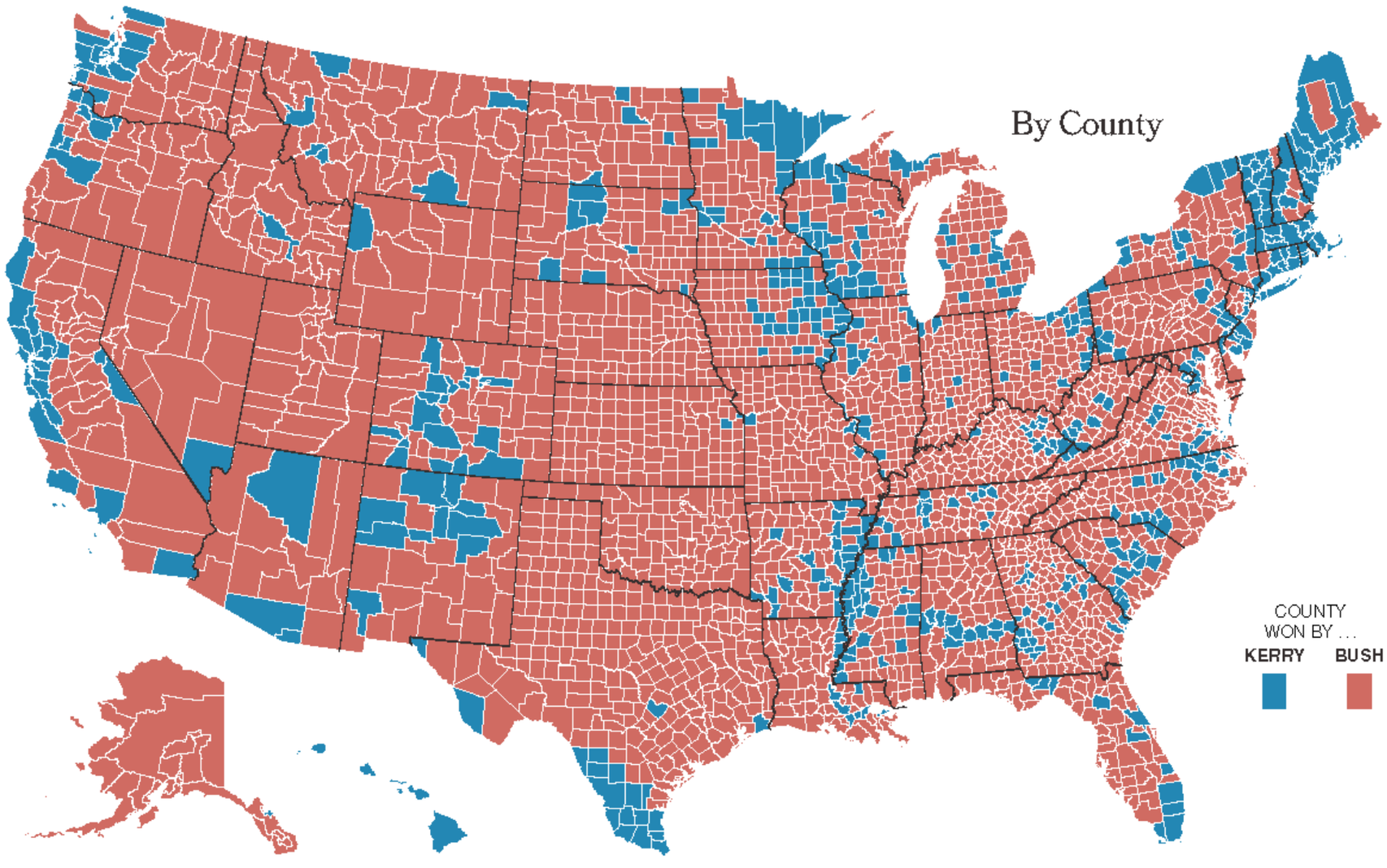
C. Ware, ‘Visual Thinking for Design’

Activity

CS 171

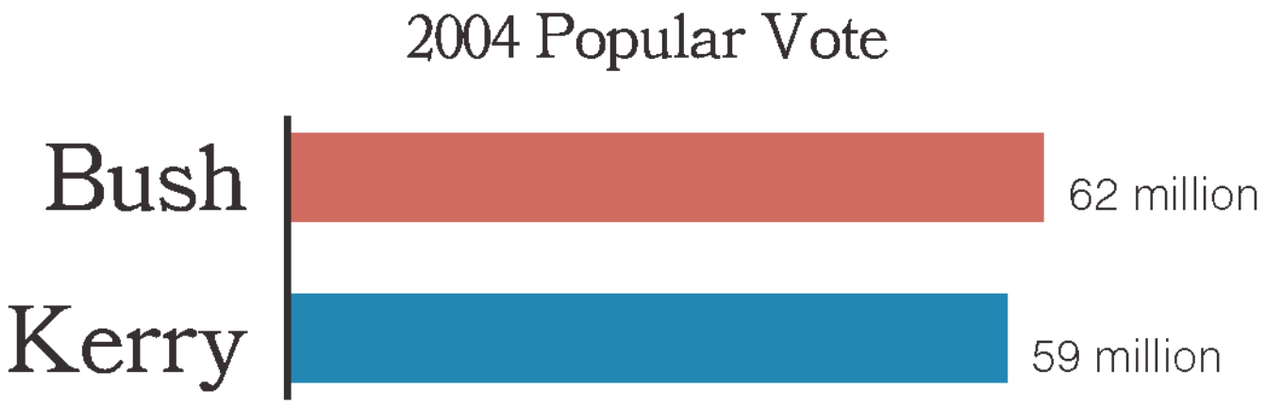
Create four election maps that show how the New England states voted for 4 different parties. (3 min)

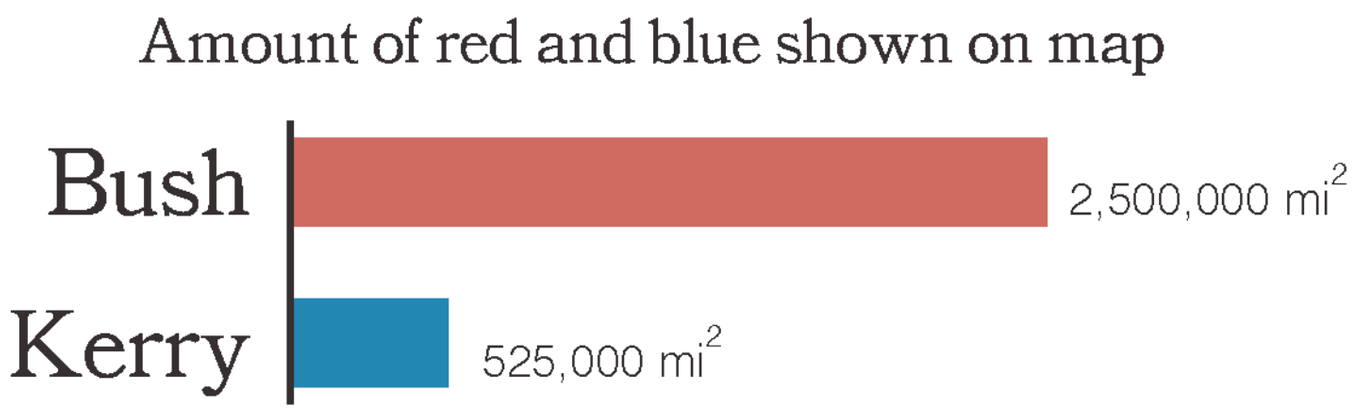
Kerry vs. Bush, 2004



Matthew Ericson, NY Times

Kerry vs. Bush, 2004





Matthew Ericson, NY Times

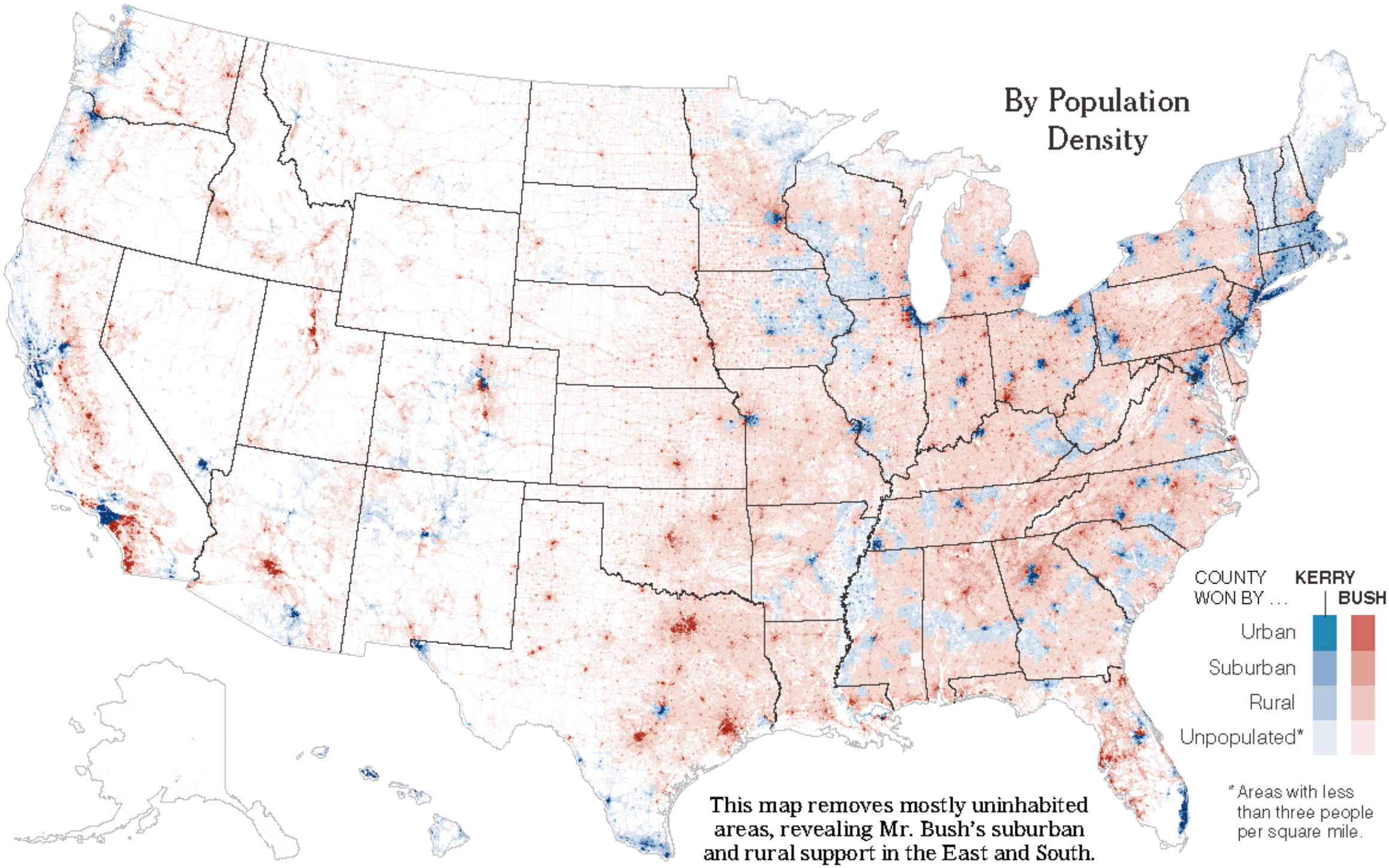
By County

COUNTY WON BY ... | PCT. OF VOTE KERRY | BUSH

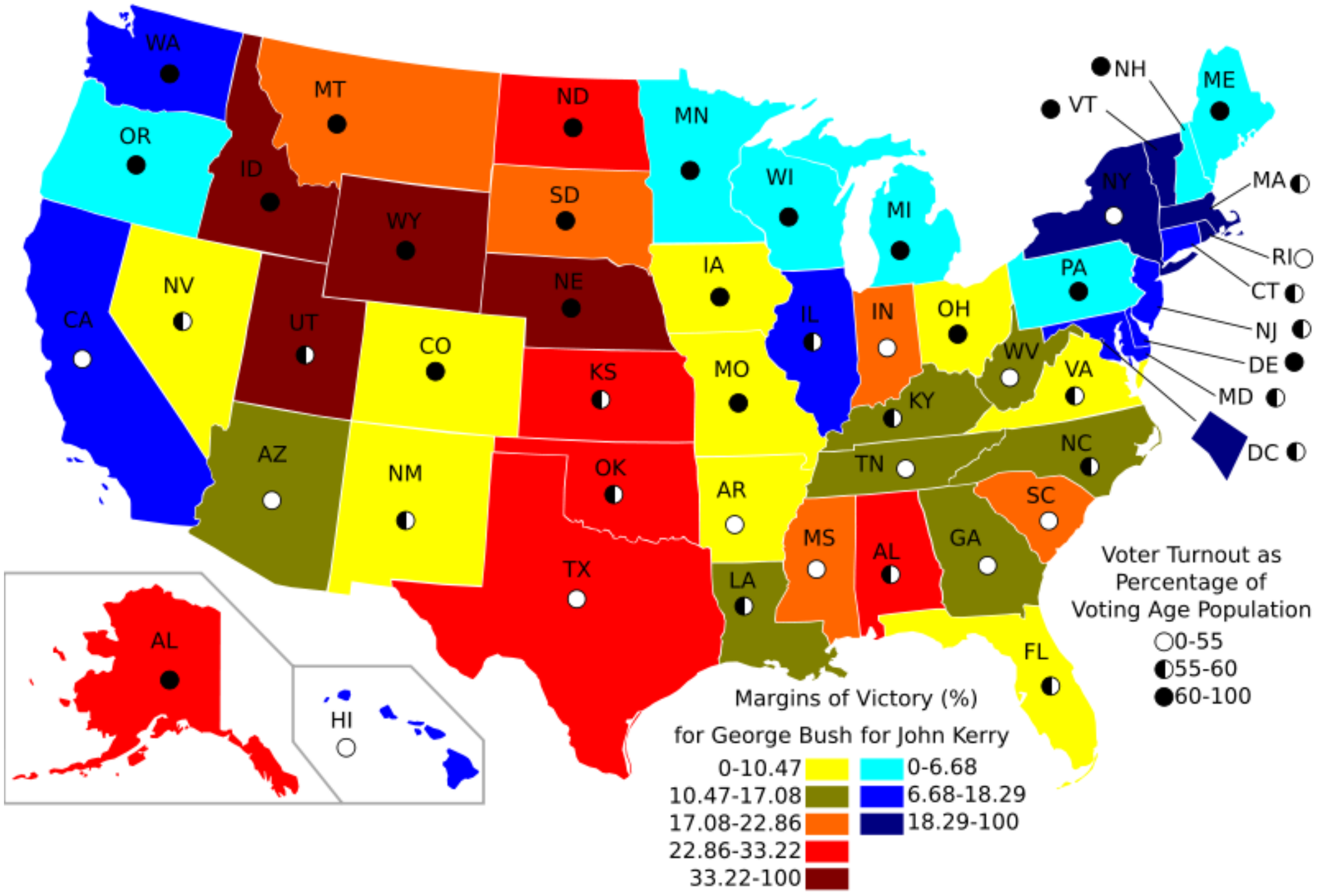
70%
60%
50%
Tie

The deep red down the center of this map highlights the president's support in sparsely populated areas.

Matthew Ericson, NY Times

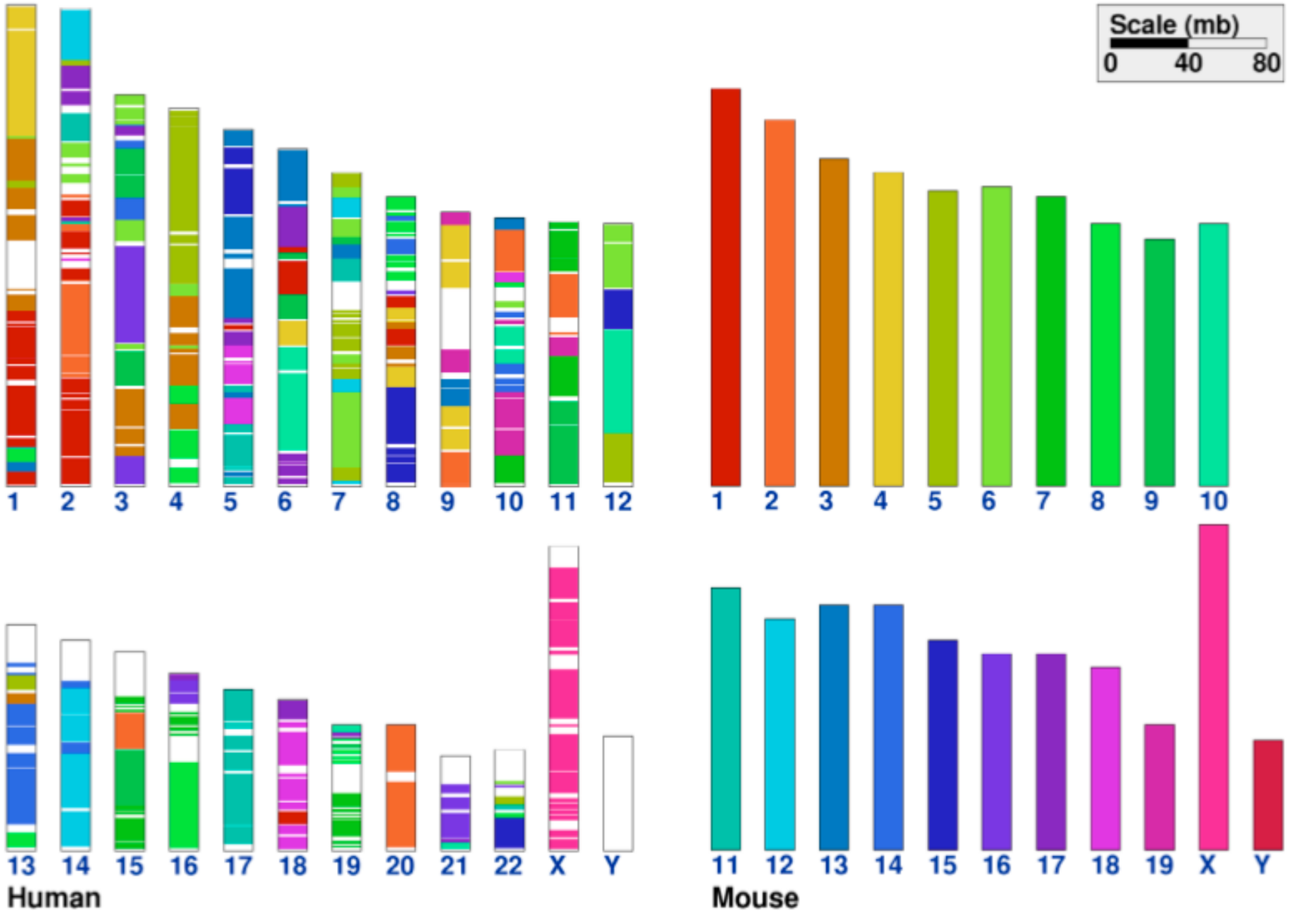


Matthew Ericson, NY Times



wikipedia.org

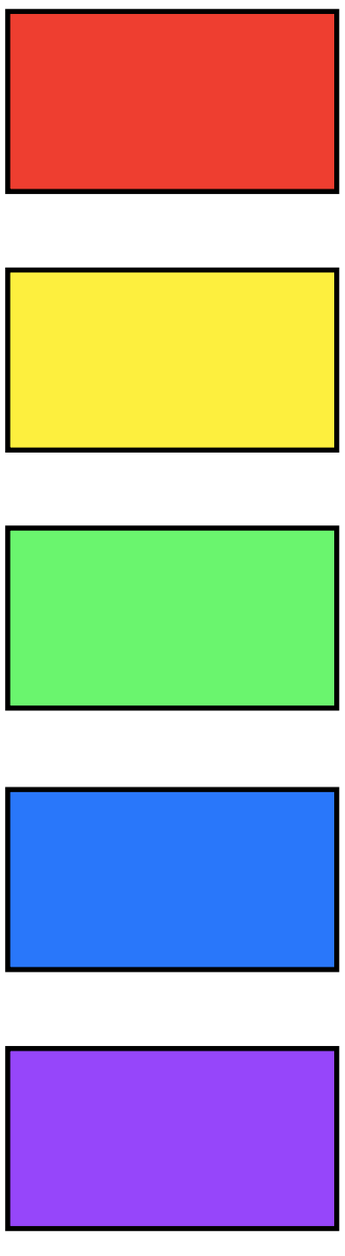
Color Discriminability



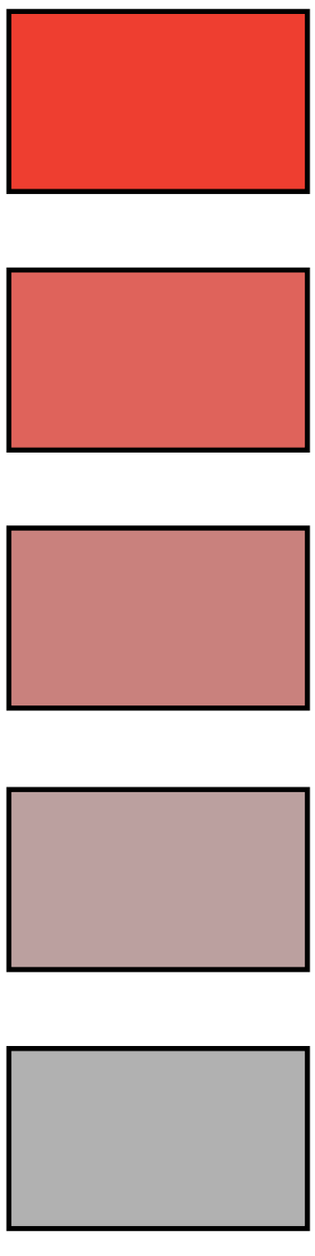
Sinha 2007

HSL Color Space

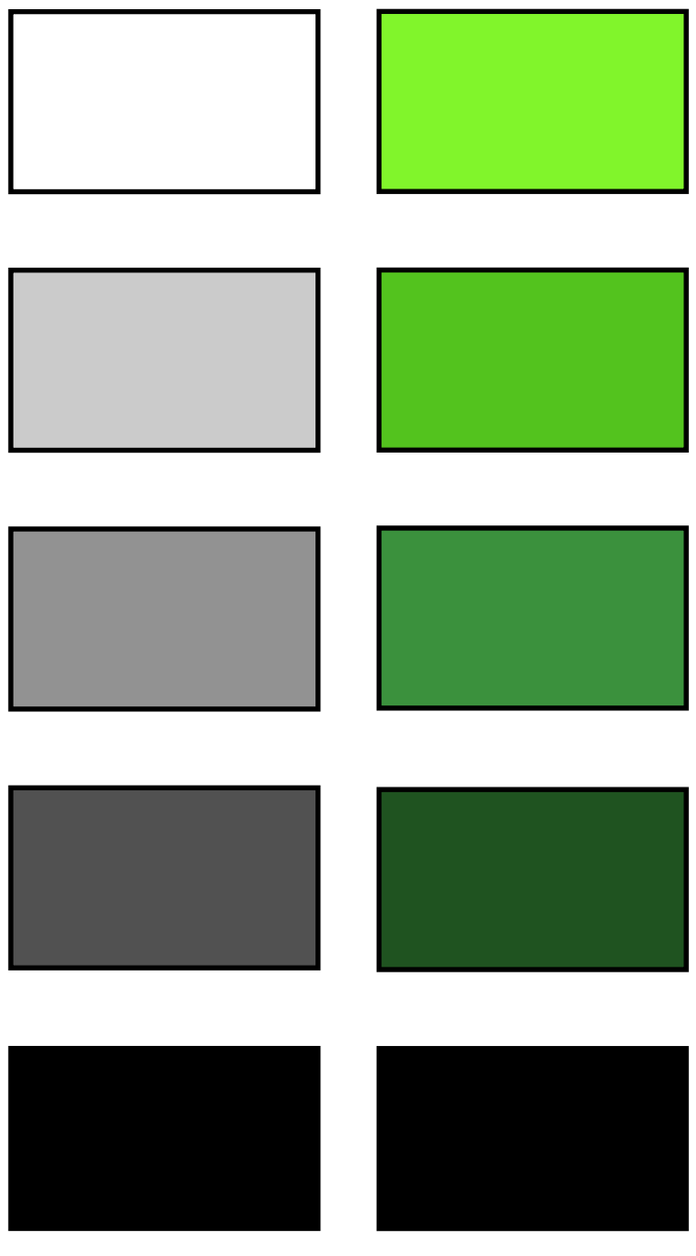
Hue



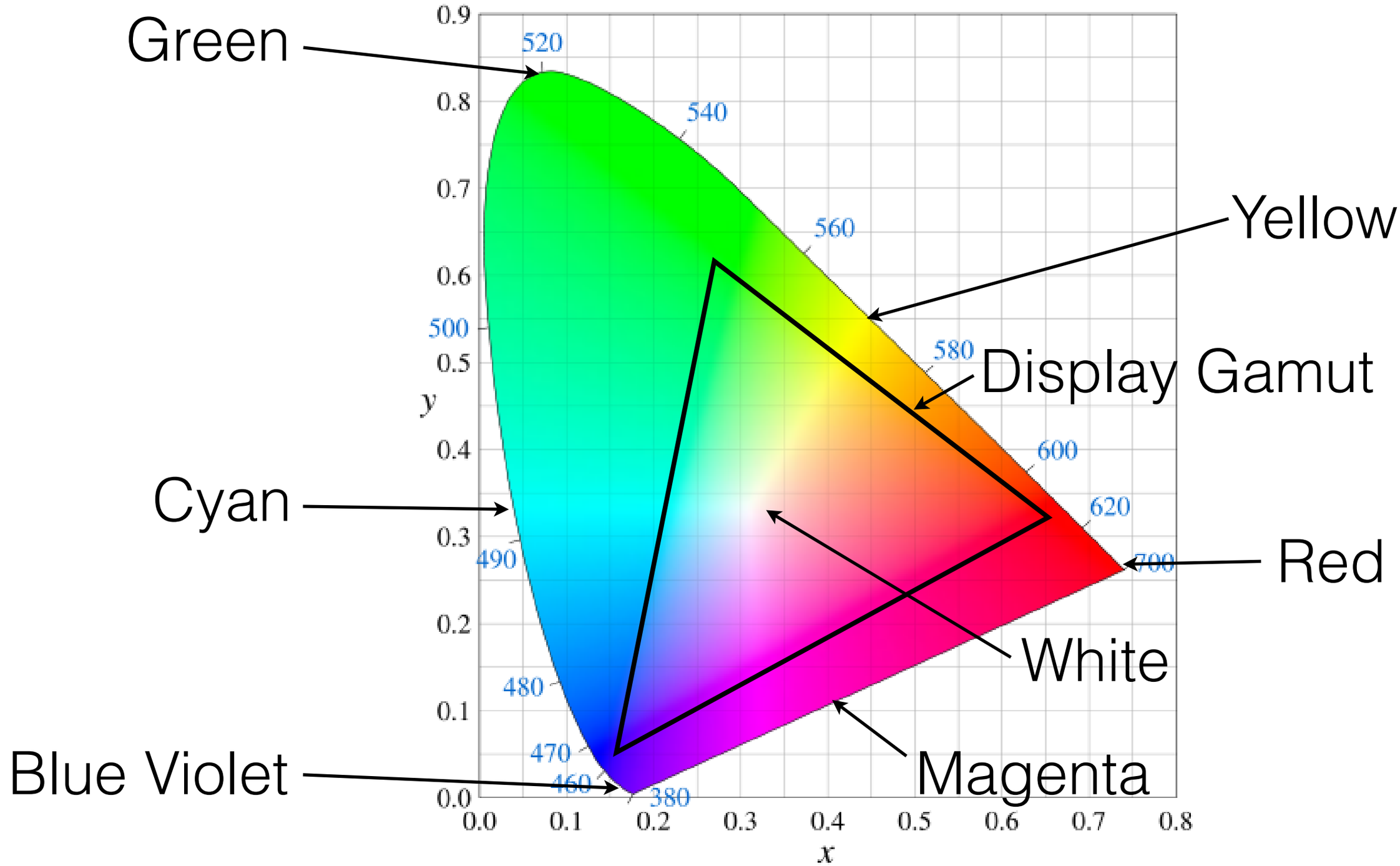
Saturation



Luminance

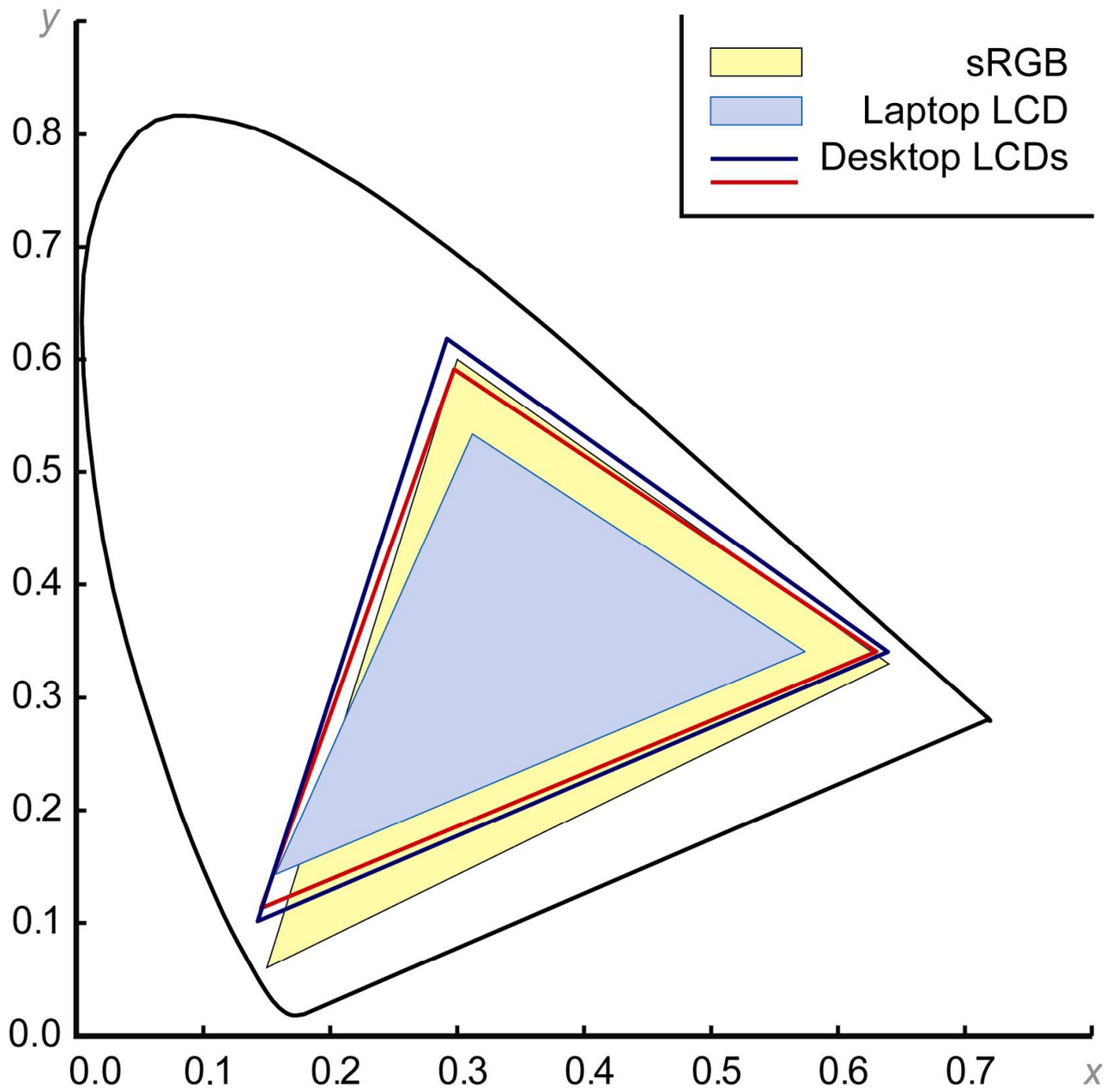


CIE Chromaticity Diagram



wikipedia.org

Display Gamuts



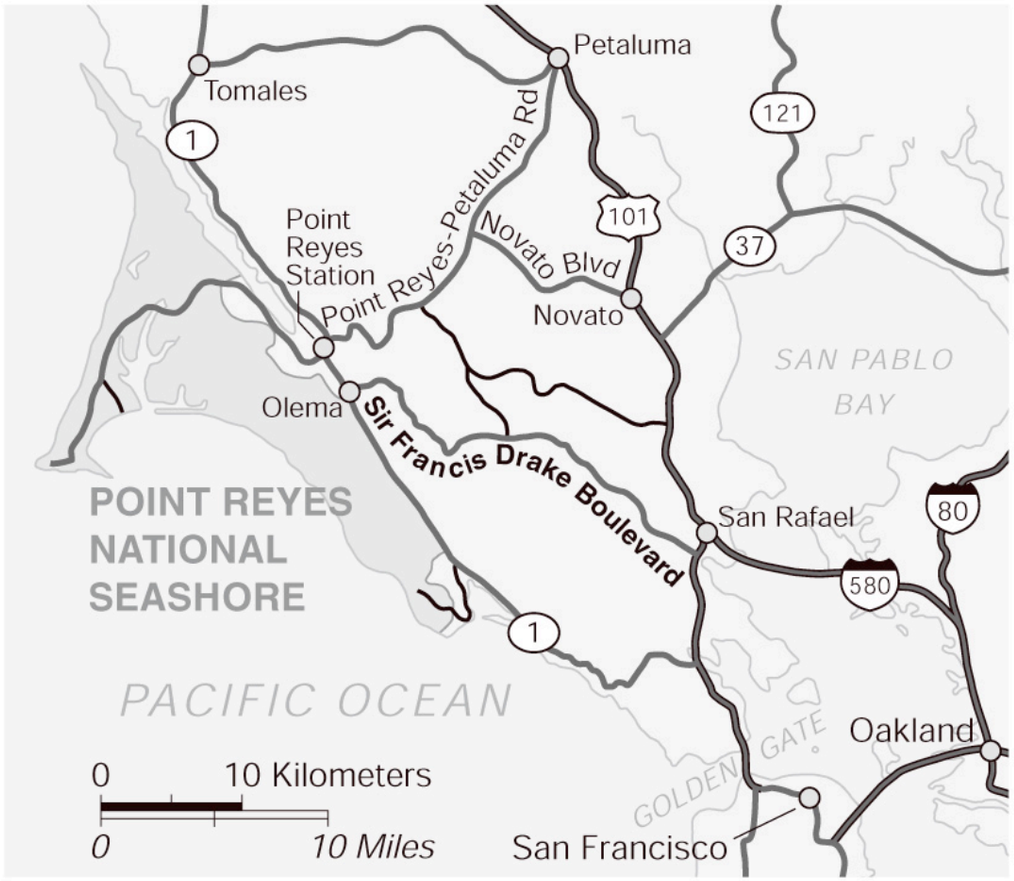
M. Stone, ‘A Field Guide to Digital Color’

Color Blindness

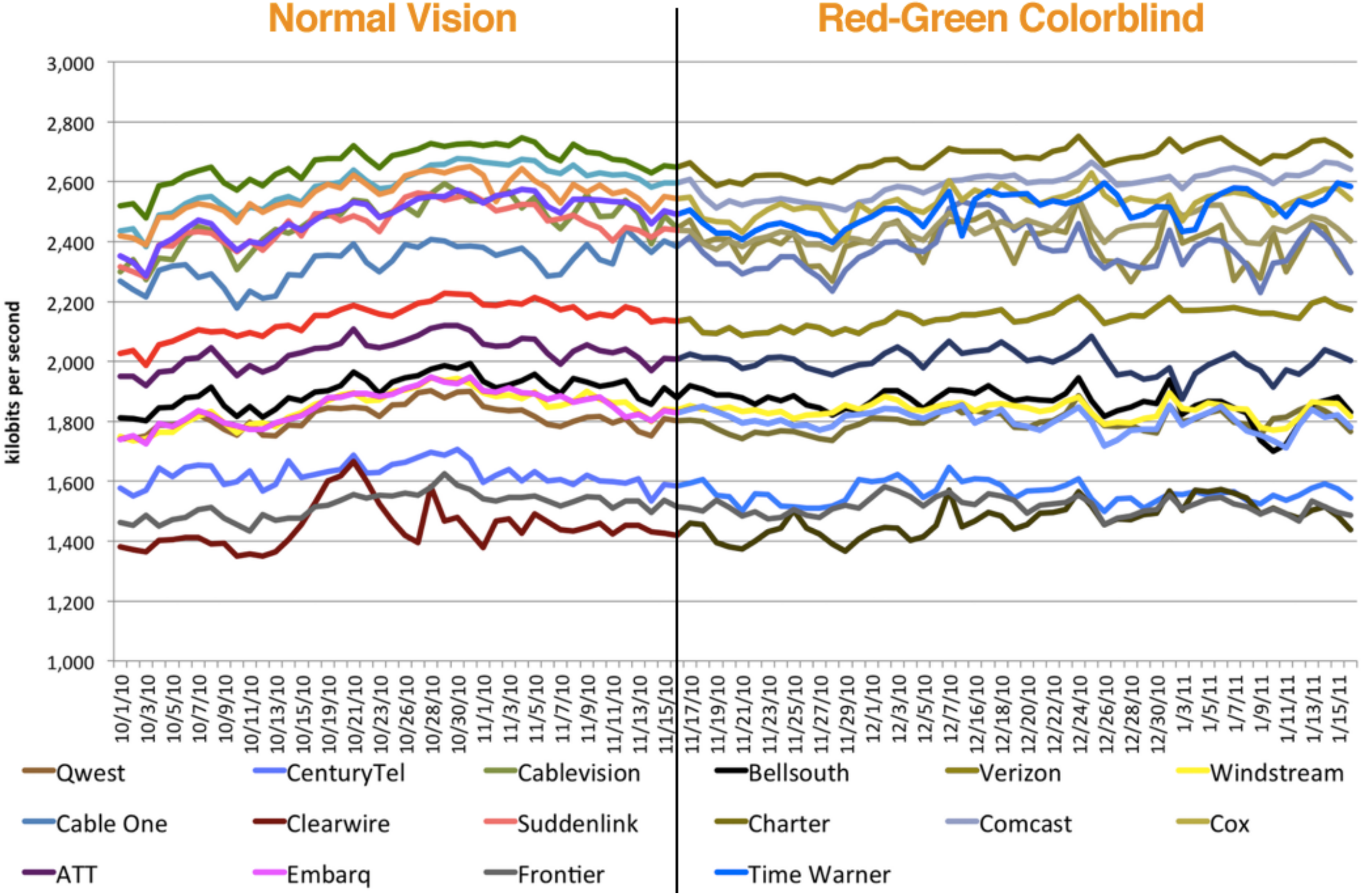
Based on slide from Stone

“Get It Right in Black and White”

M. Stone



National Park Services (www.nps.gov)


Normal Vision
Red-Green Colorblind
kilobits per second
3,000
2,800
2,600
2,400
2,200
2,000
1,800
1,600
1,400
1,200
1,000
10/1/10
10/3/10
10/5/10
10/7/10
10/9/10
10/11/10
10/13/10
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Qwest
CenturyTel
Cablevision
Bellsouth
Verizon
Windstream
Cable One
Clearwire
Suddenlink
Charter
Comcast
Cox
ATT
Embarq
Frontier
Time Warner

Andy Baio

https://uablogs.missouri.edu/interface/2011/05/is-your-site-color-blind-accessible/

Check your site design

Color Oracle

An application that will simulate the different types of color blindness on your computer. I like this option because you can test your design at the Photoshop mock-up stage before you begin to code.

Photoshop CS5

Under the View/Proof Setup menu, you can now simulate a few different types of color blindness on your document.

Colorblind Web Page Filter

A Web-based service where you submit your site URL and it will return a version as it appears to a color blind person. It?s a bit slow, but easy.

More color blind resources

Are Your Web Pages Color Sensitive?

This site has a few good tips on designing your site. One tip I?d add is making sure your embedded links are distinguishable from the rest of the text by using something other than a different color, like underlines.

As Seen By The Color Blind

A good article that explains color blindness and gives plenty of examples.

https://michelf.ca/projects/sim-daltonism/

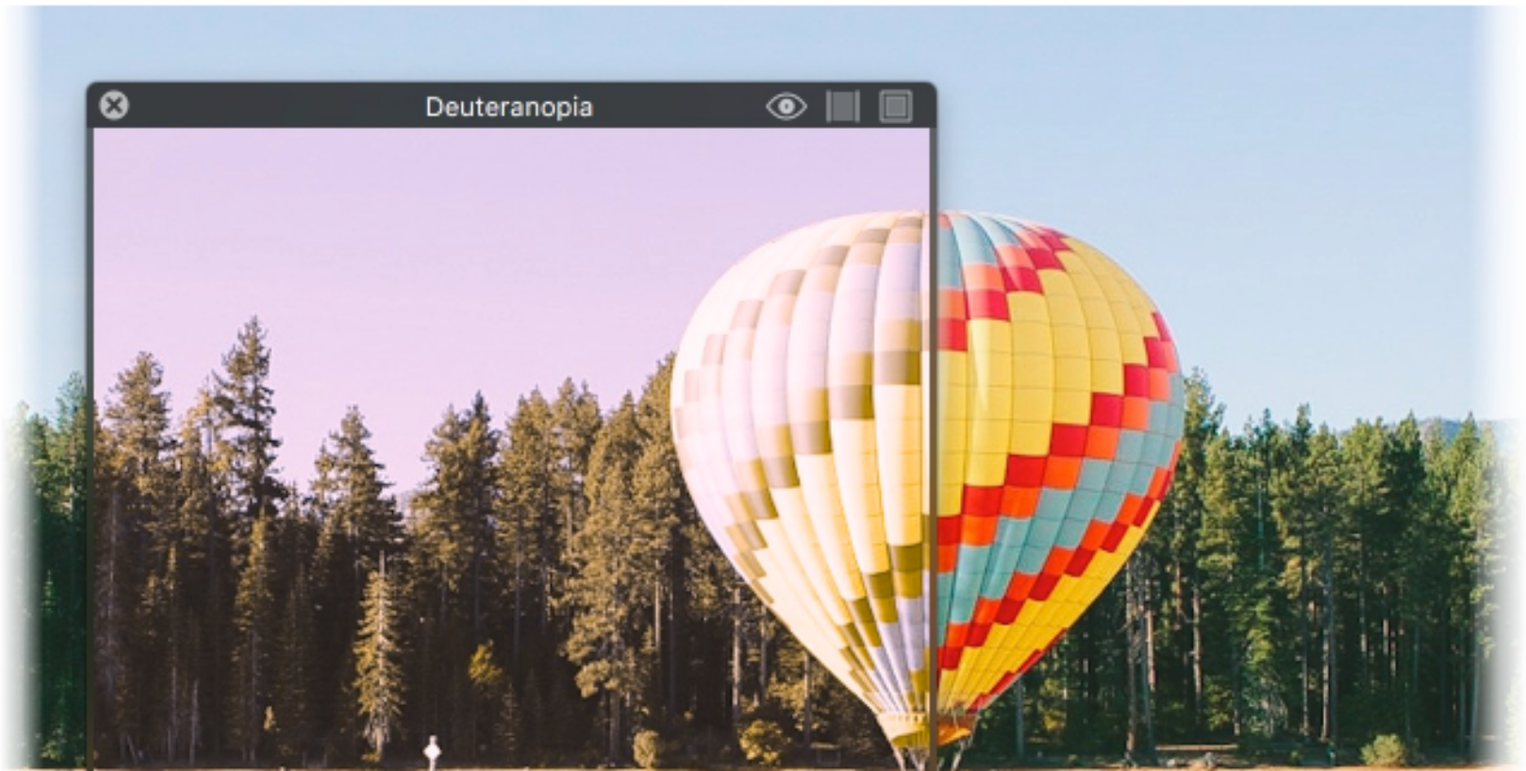
Sim Daltonism for Mac What's new? Download

Sim Daltonism for Mac

A window to color blindness.

Download Sim Daltonism (2.0)

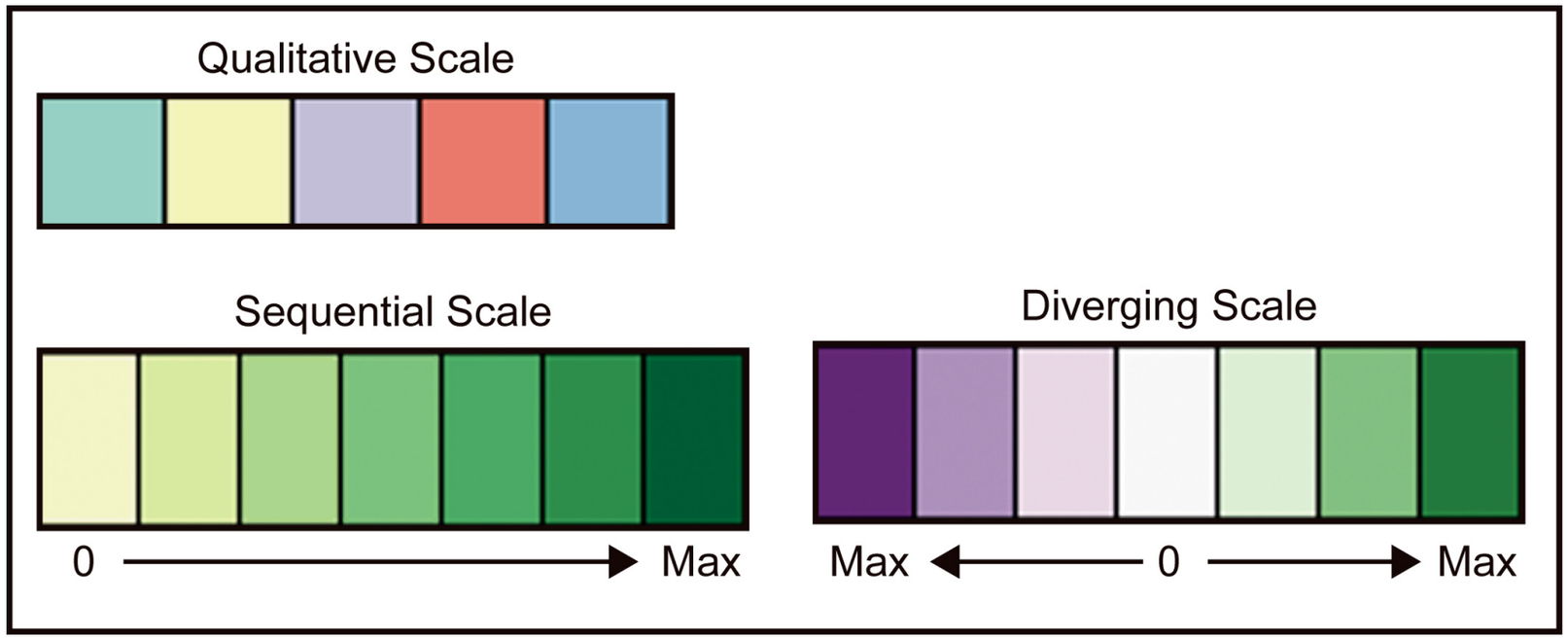
From the perspective of a color blind person, some colors are impossible to distinguish. Sim Daltonism lets you visualize colors as they are perceived with various types of color blindness.



Color Brewer

Nominal

Ordinal



Cynthia Brewer, Color Use Guidelines for Data Representation

how to use | updates | credits

COLORBREWER 2.0

color advice for cartography

number of data classes on your map

3 | learn more >

the nature of your data

sequential | learn more >

pick a color scheme: GnBu

multihue | single hue

(optional) only show schemes that are:

- [x] colorblind safe
- [ ] print friendly
- [ ] photocopy-able

learn more >

pick a color system

224, 243, 219
168, 221, 181
67, 162, 202

(•) RGB ( ) CMYK ( ) HEX

adjust map context

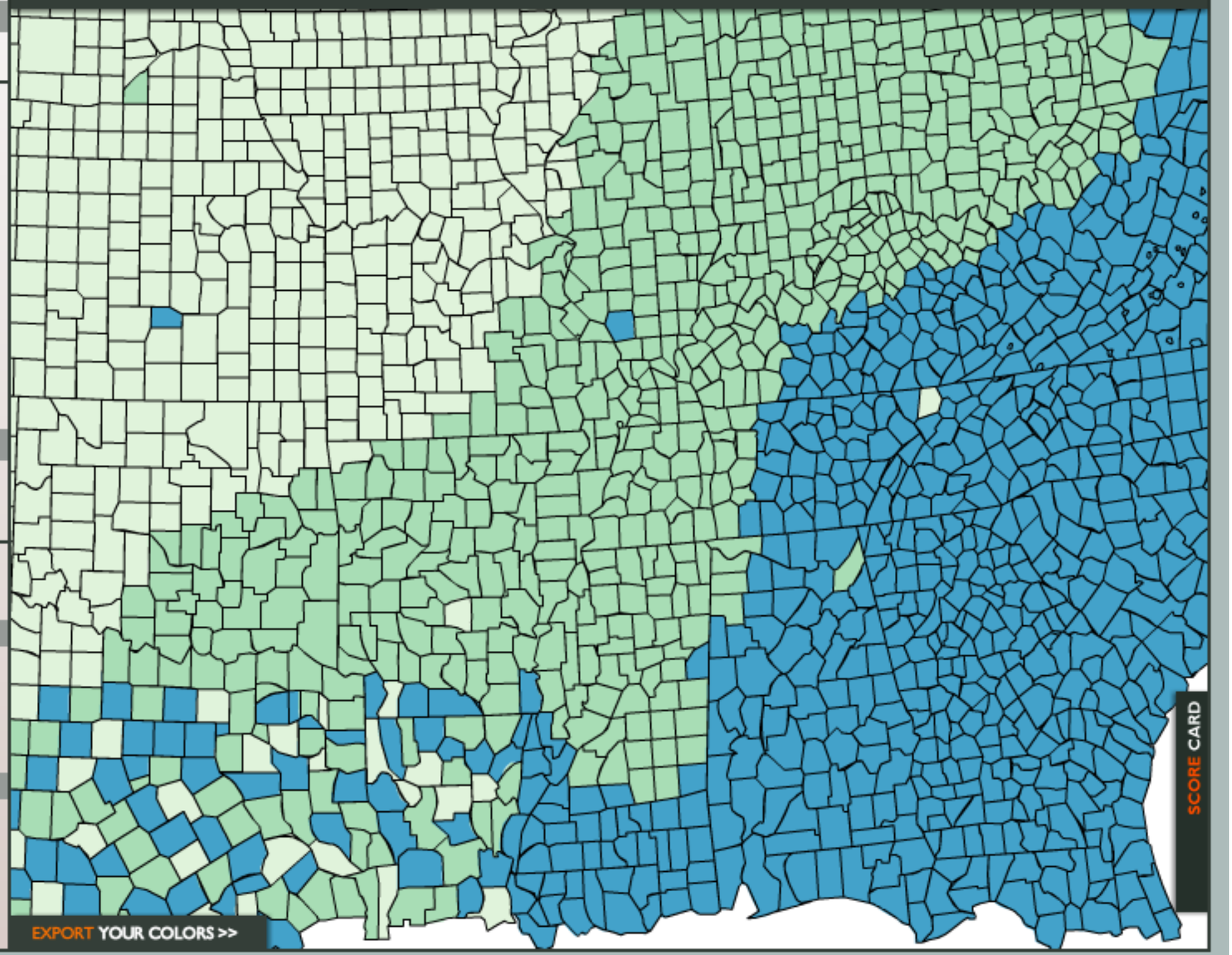
- [ ] roads
- [ ] cities
- [x] borders

select a background

(•) solid color
( ) terrain

color transparency

learn more >



Support

Back to ColorBrewer 1.0

axm

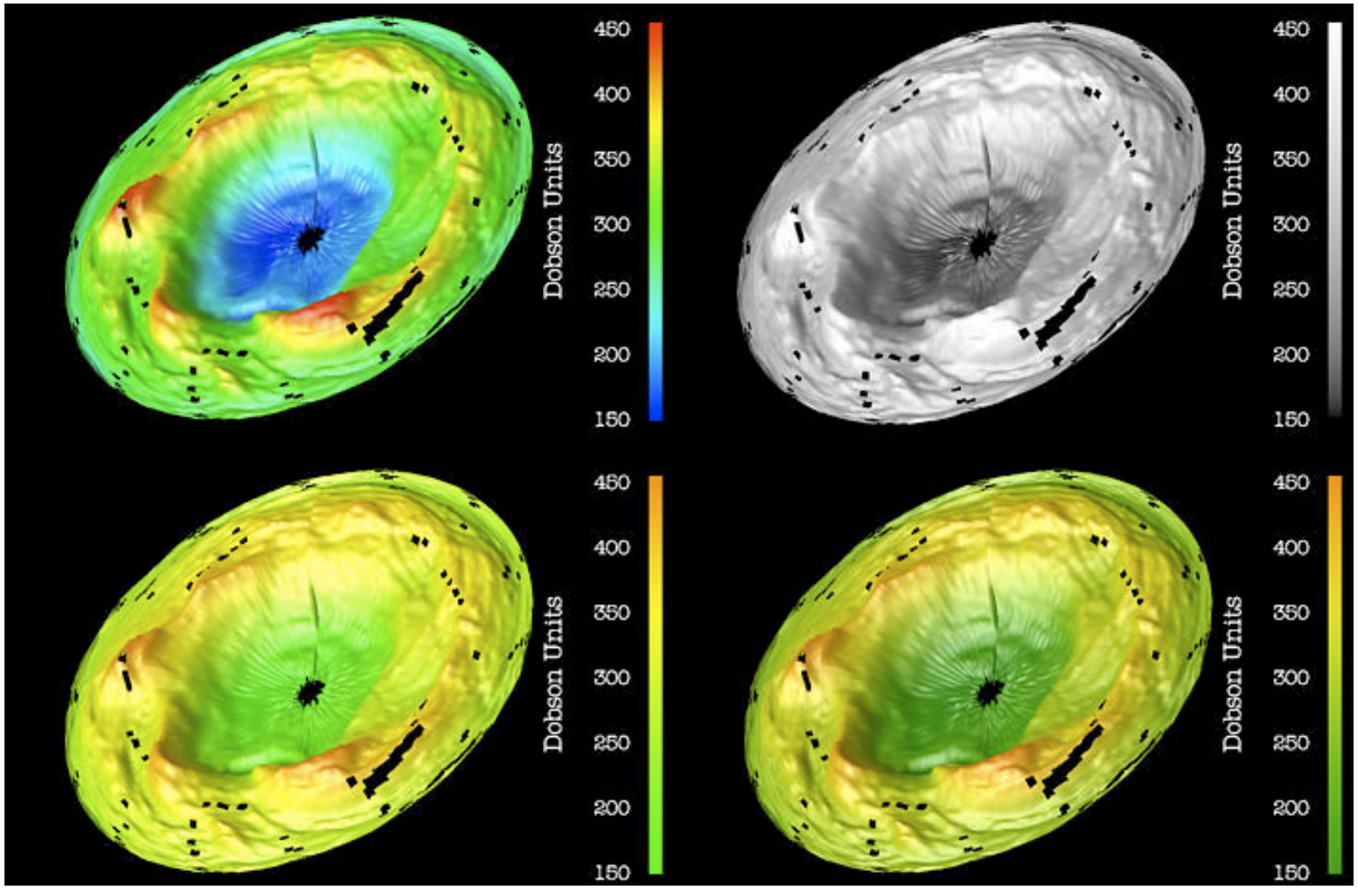
Colormaps

CS 171

Colors for Quantitative Data

Hue
(Rainbow)

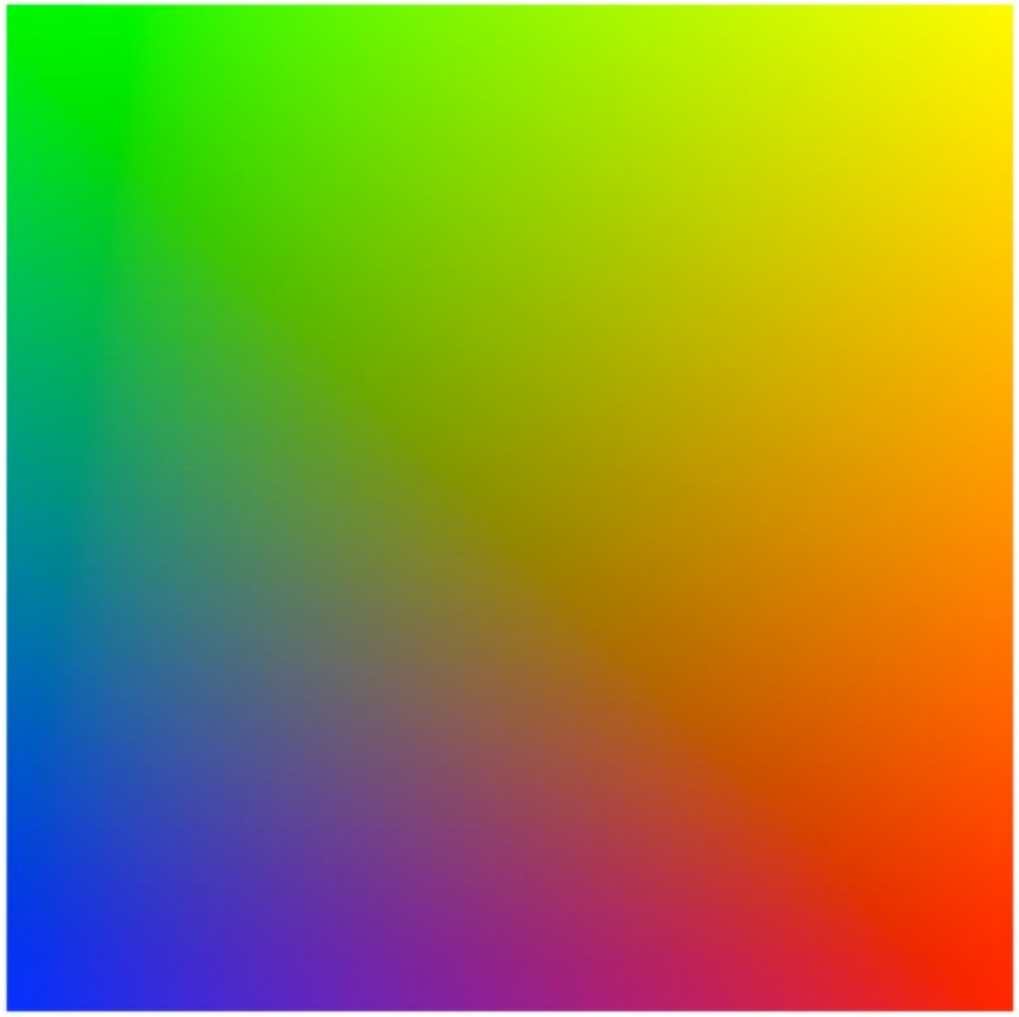
Luminance
& Hue

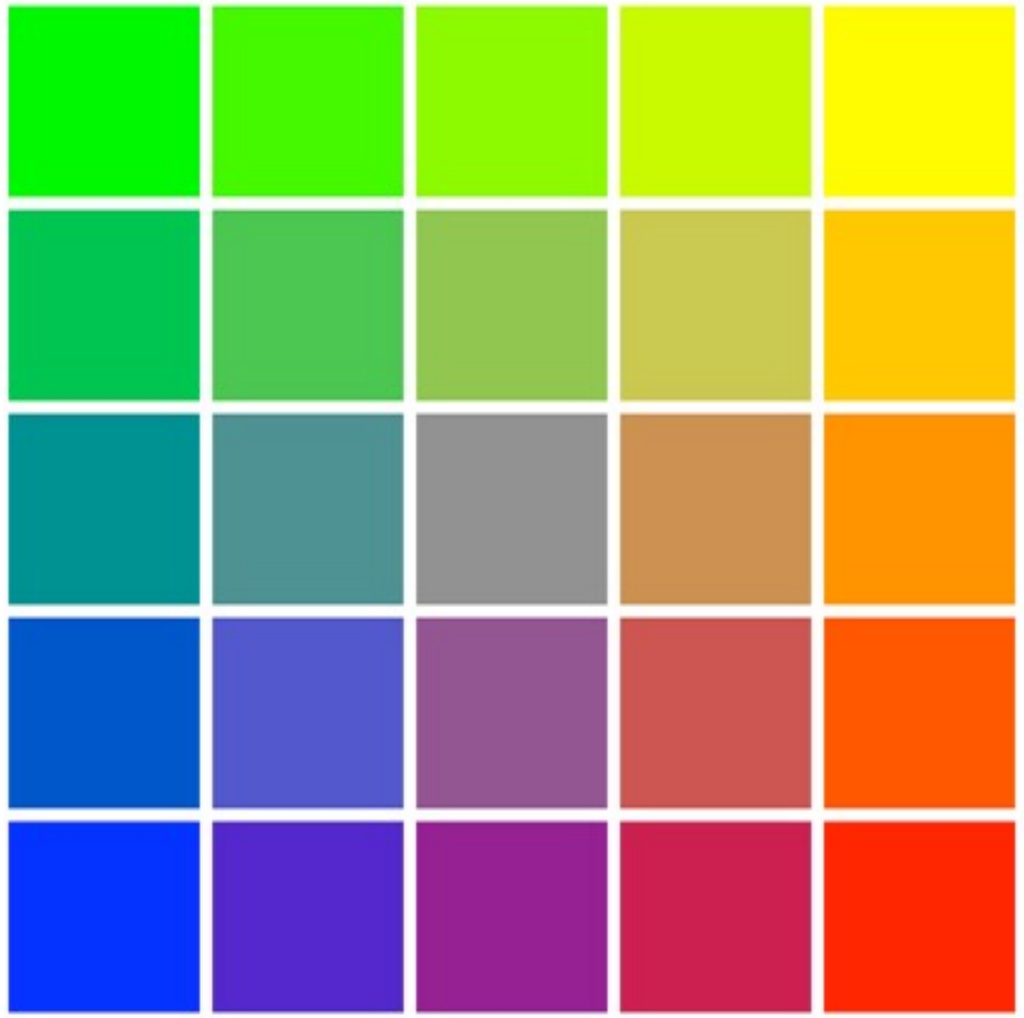


Luminance

Rogowitz and Treinish, Why should engineers and scientists be worried about color?

Color Segmentation

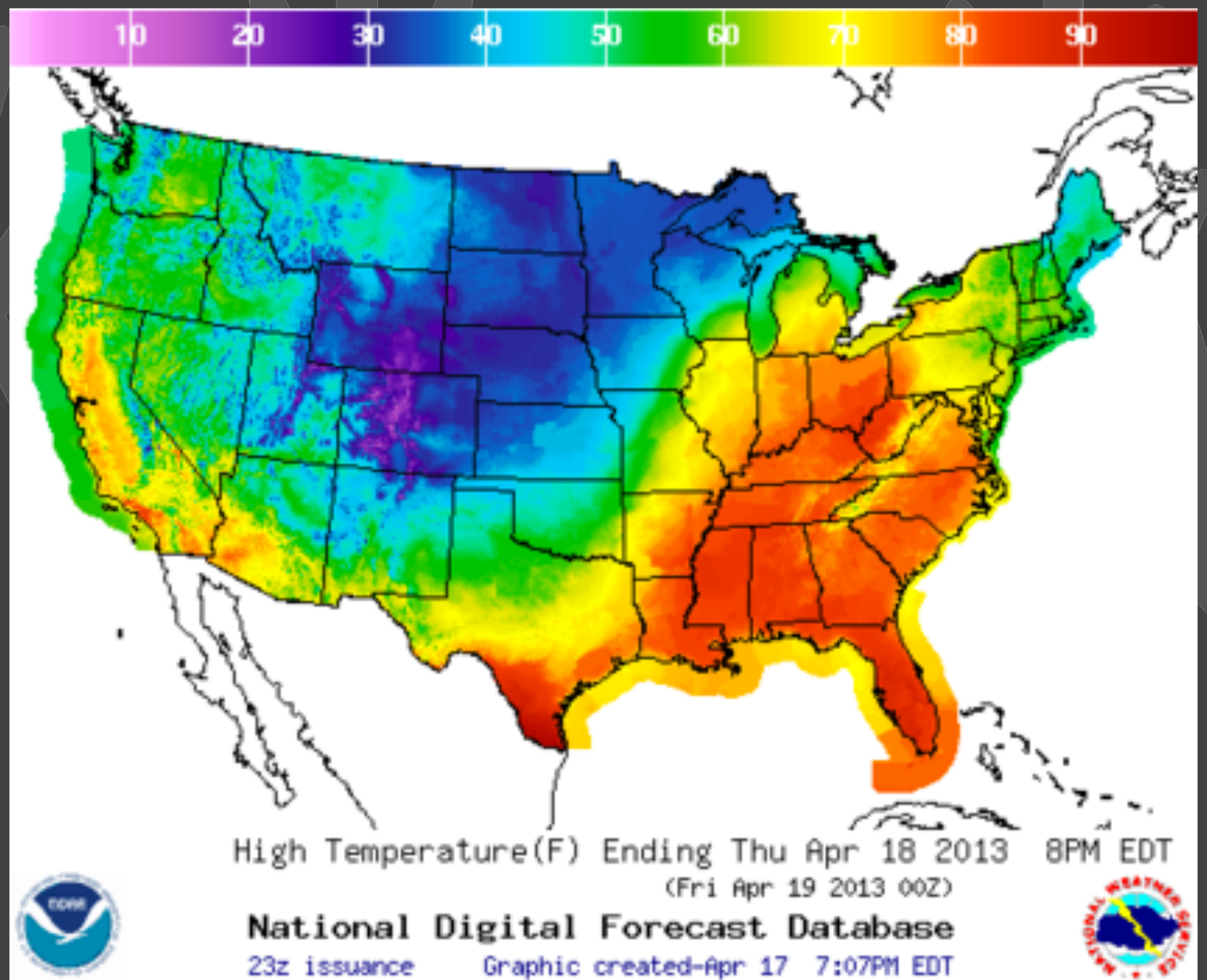




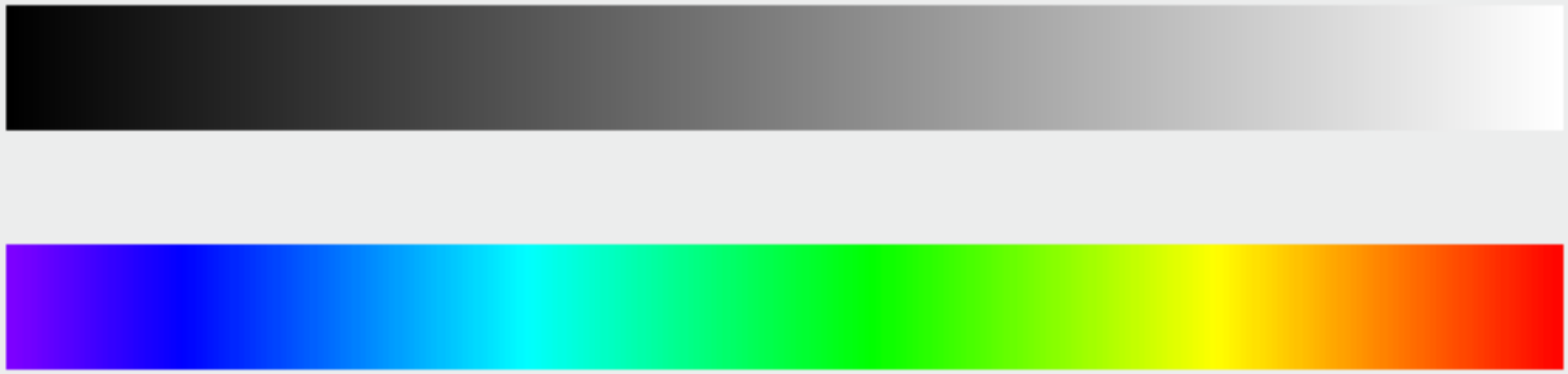
C. Ware, ‘Visual Thinking for Design’

Activity

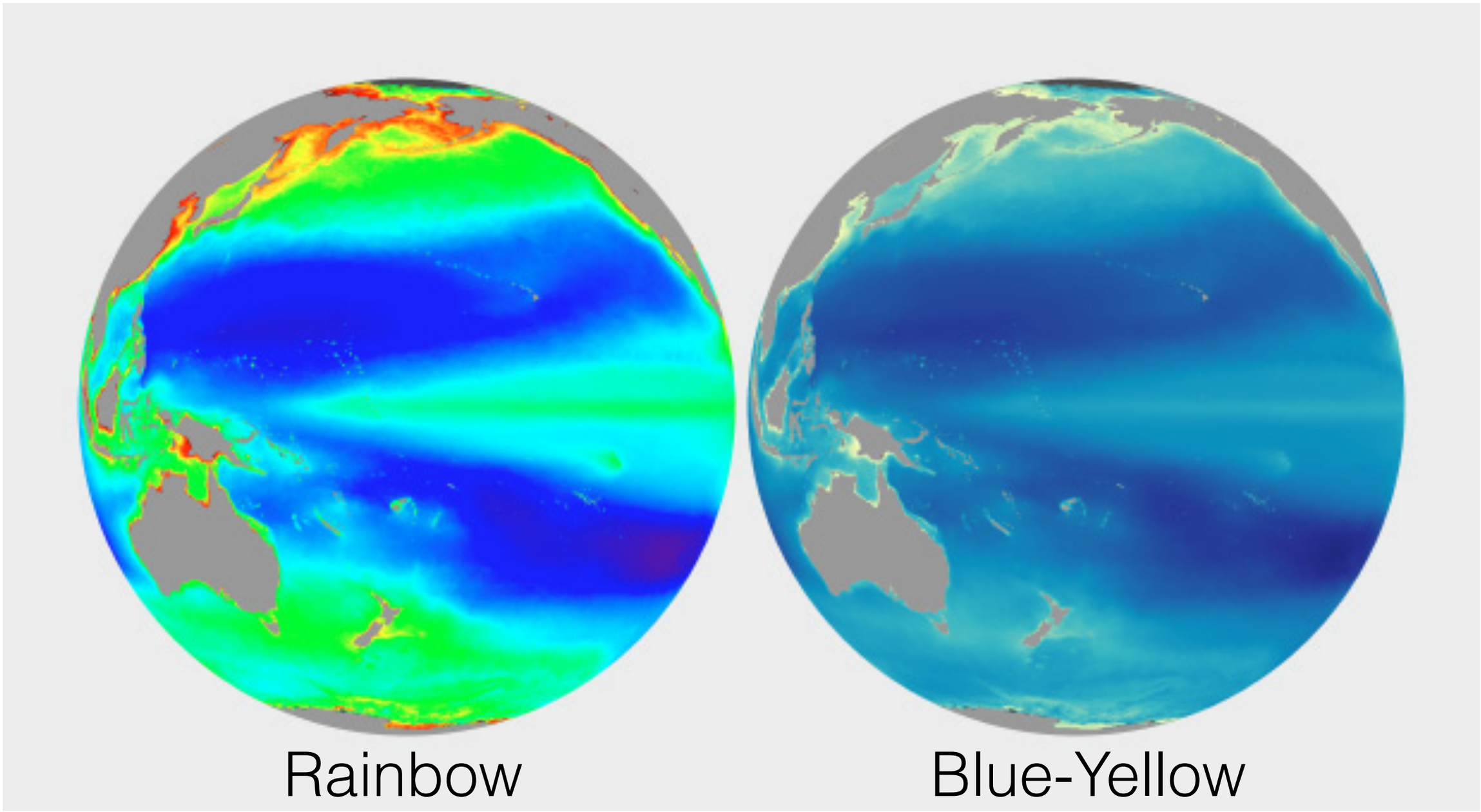
What do you think of this particular color scheme? Is it effective?



Rainbow Colormap



R. Simmon



R. Simmon

Contrast

Pop-Out

Separable-Integral

Motion

Variable

Transition

Time

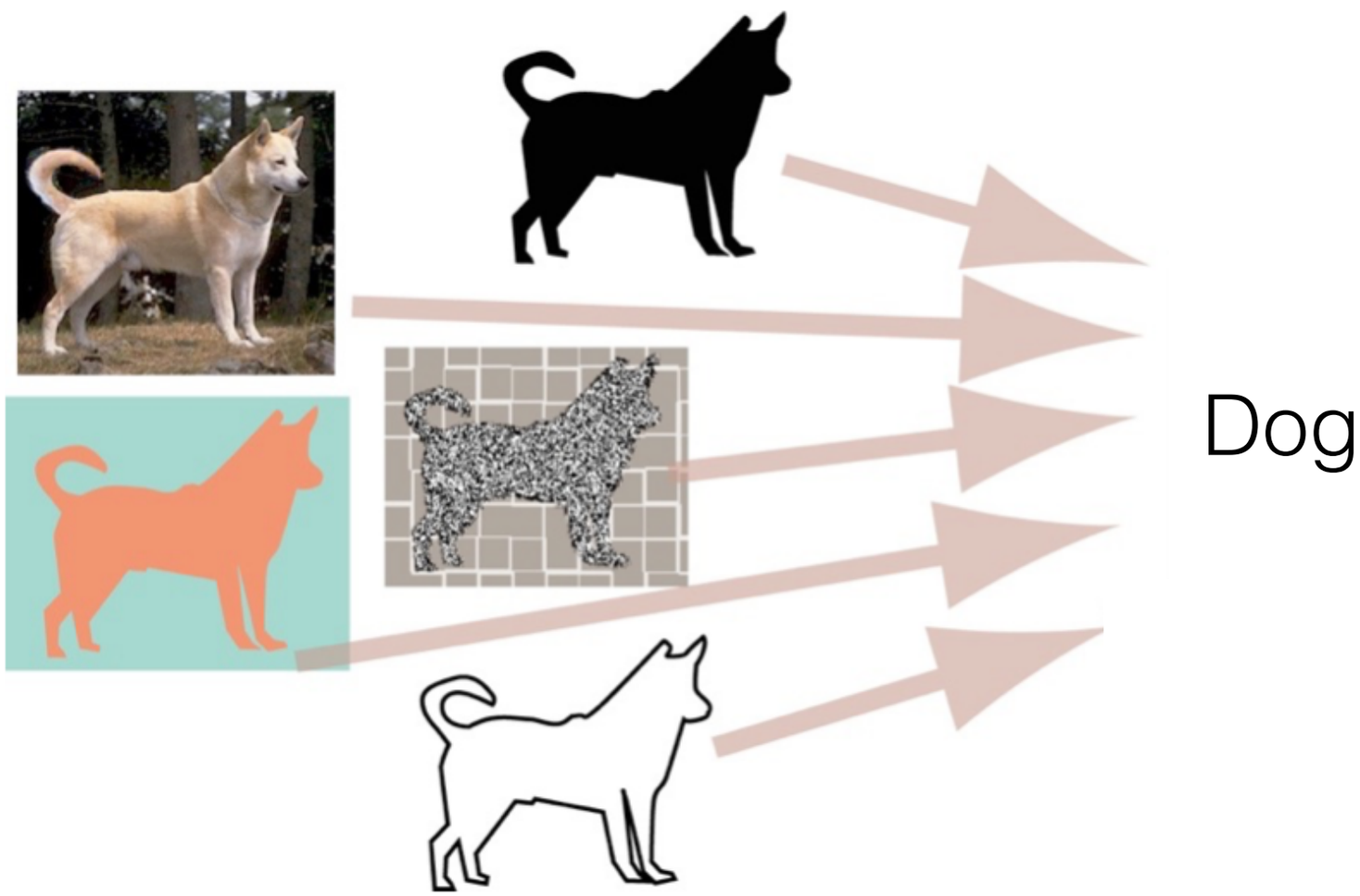
Color

Categorical

Ordinal

Quantitative

How?



C. Ware, ‘Visual Thinking for Design’

This Thursday…

- Introduction to SVG and D3
- Reading: Ch. 3 (p. 49-57), Ch. 5 (p. 67-72, p. 76-84)

Next Tuesday…

- Cognition (Higher level visual processing)
- Reading: Ware, Chapter 3 (optional: 6)

Homework (due Monday)…

- Homework 3
- Lab 3

One-Minute Paper

Remember the picture

CS 171