Color

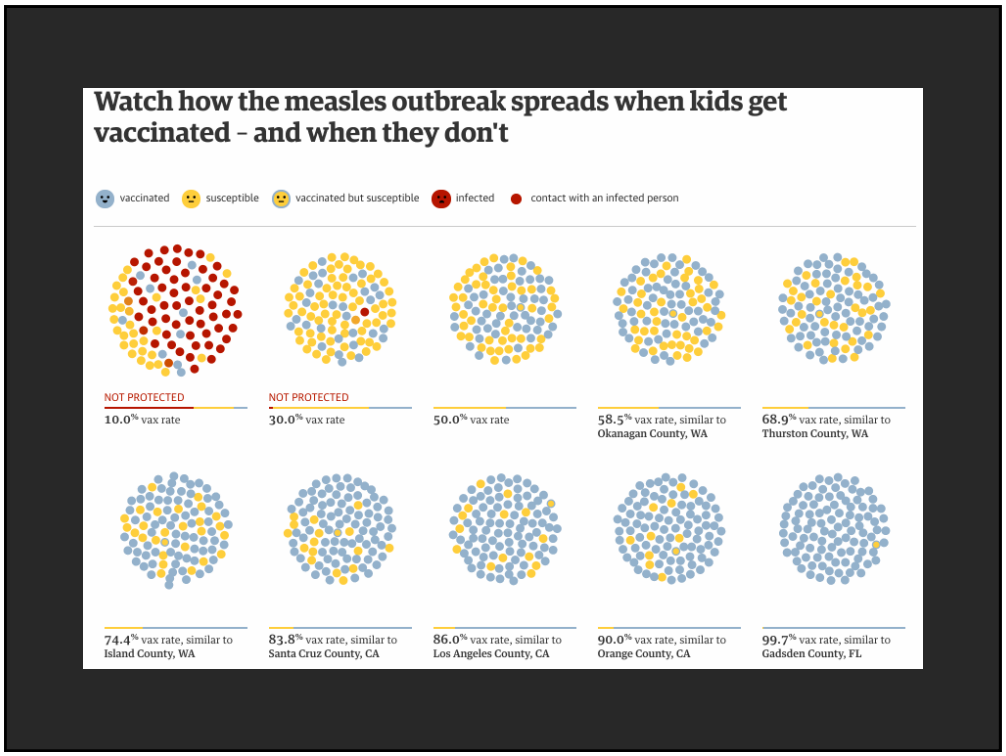
Maneesh Agrawala

CS 448B: Visualization
Fall 2020

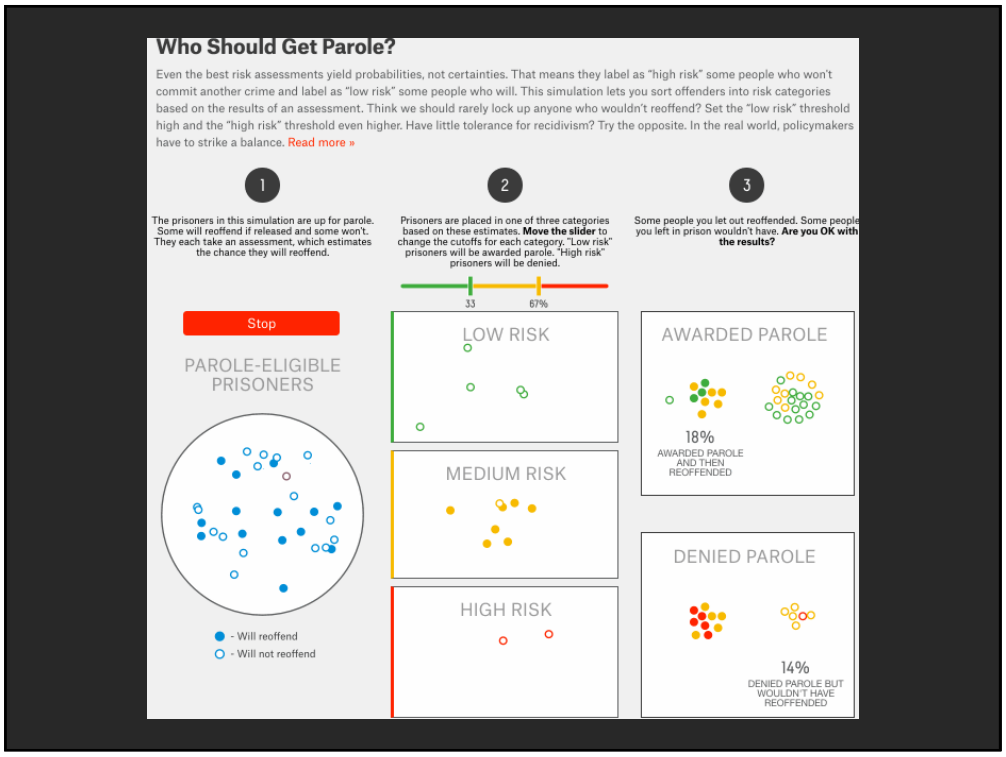
1

Last Time: Visual Explainers

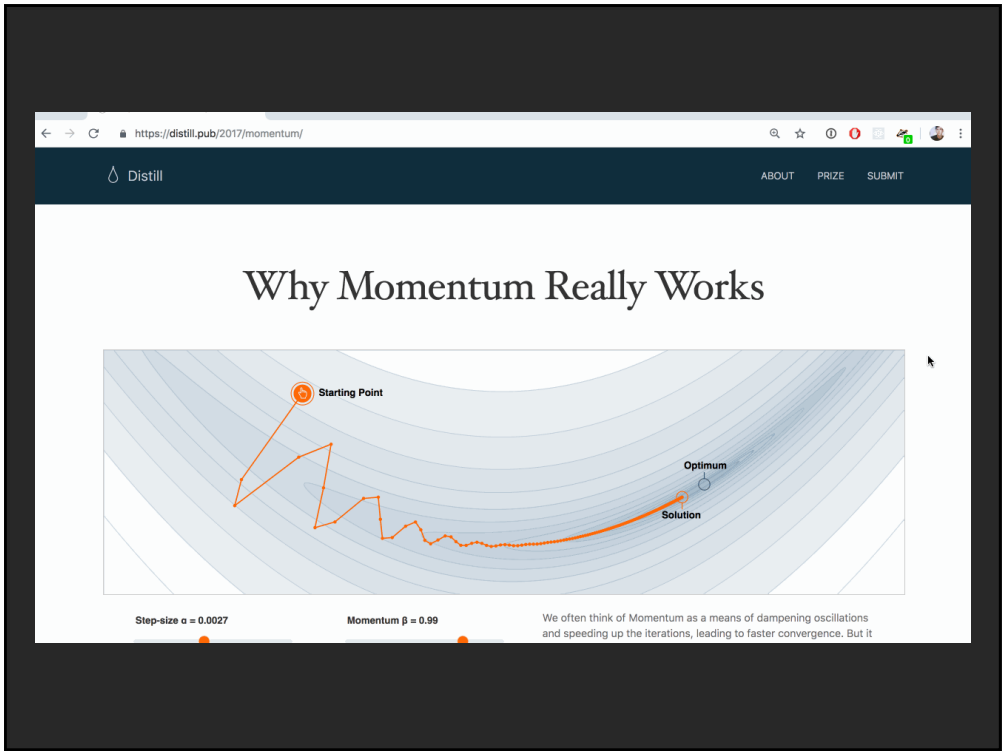
2


Watch how the measles outbreak spreads when kids get vaccinated – and when they don't
vaccinated
susceptible
vaccinated but susceptible
infected
contact with an infected person
NOT PROTECTED
10.0% vax rate
NOT PROTECTED
30.0% vax rate
50.0% vax rate
58.5% vax rate, similar to Okanagan County, WA
68.9% vax rate, similar to Thurston County, WA
74.4% vax rate, similar to Island County, WA
83.8% vax rate, similar to Santa Cruz County, CA
86.0% vax rate, similar to Los Angeles County, CA
90.0% vax rate, similar to Orange County, CA
99.7% vax rate, similar to Gadsden County, FL

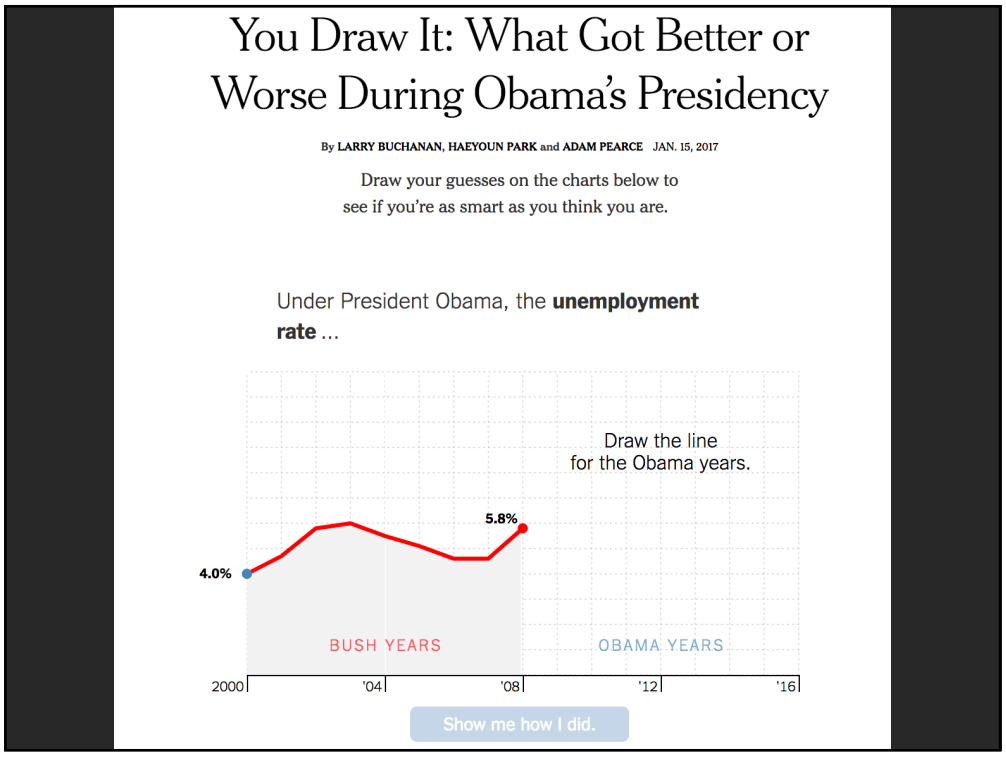
4


Who Should Get Parole?
Even the best risk assessments yield probabilities, not certainties. That means they label as "high risk" some people who won't commit another crime and label as "low risk" some people who will. This simulation lets you sort offenders into risk categories based on the results of an assessment. Think we should rarely lock up anyone who wouldn't reoffend? Set the "low risk" threshold high and the "high risk" threshold even higher. Have little tolerance for recidivism? Try the opposite. In the real world, policymakers have to strike a balance. Read more »
1
The prisoners in this simulation are up for parole. Some will reoffend if released and some won't. They each take an assessment, which estimates the chance they will reoffend.
2
Prisoners are placed in one of three categories based on these estimates. Move the slider to change the cutoffs for each category. "Low risk" prisoners will be awarded parole. "High risk" prisoners will be denied.
33
67%
3
Some people you let out reoffended. Some people you left in prison wouldn't have. Are you OK with the results?
Stop
PAROLE-ELIGIBLE PRISONERS
- Will reoffend
- Will not reoffend
LOW RISK
MEDIUM RISK
HIGH RISK
AWARDED PAROLE
18%
AWARDED PAROLE AND THEN REOFFENDED
DENIED PAROLE
14%
DENIED PAROLE BUT WOULDN'T HAVE REOFFENDED

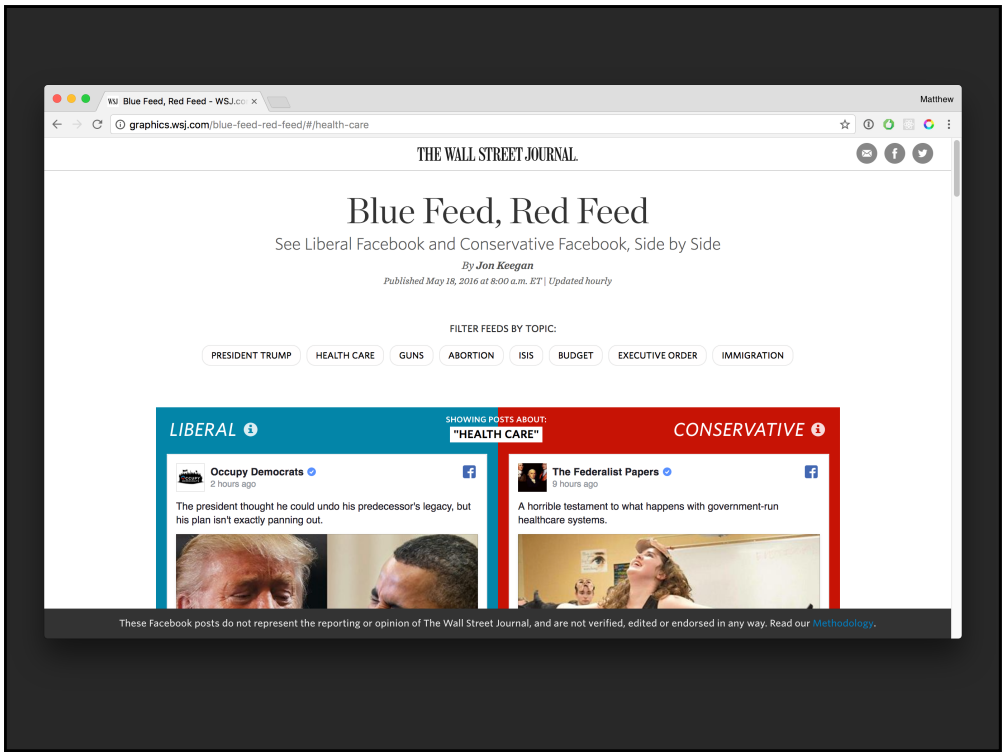
5


https://distill.pub/2017/momentum/
Distill
ABOUT
PRIZE
SUBMIT
Why Momentum Really Works
Starting Point
Optimum
Solution
Step-size α = 0.0027
Momentum β = 0.99
We often think of Momentum as a means of dampening oscillations and speeding up the iterations, leading to faster convergence. But it

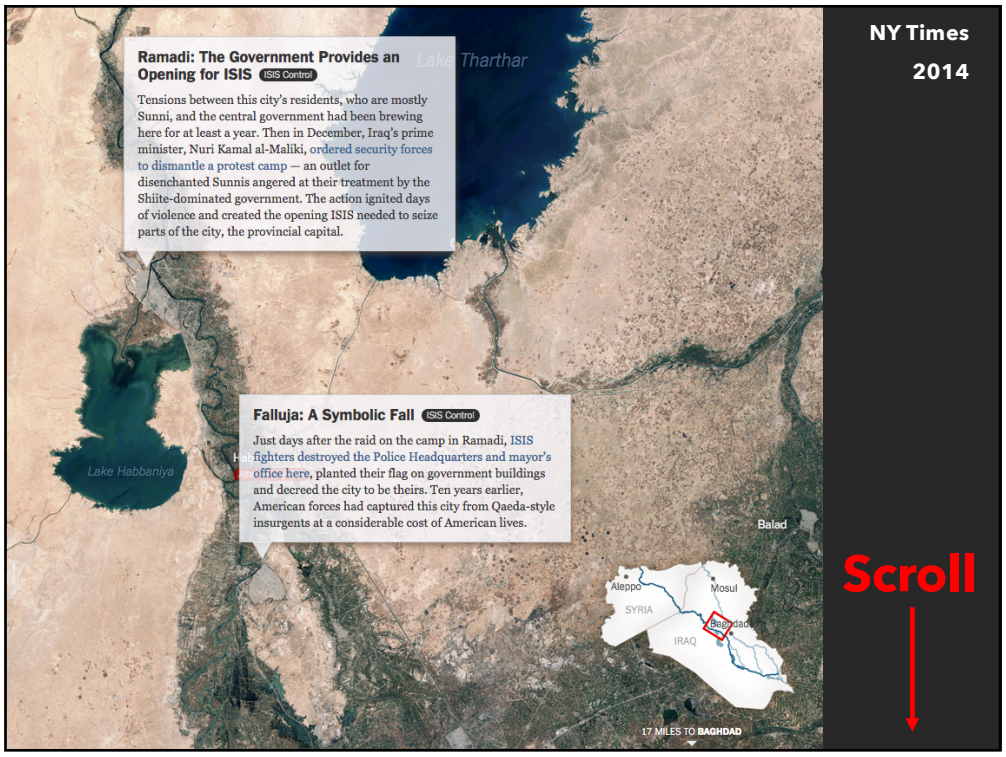
6


You Draw It: What Got Better or Worse During Obama's Presidency
By LARRY BUCHANAN, HAEYOUN PARK and ADAM PEARCE JAN. 15, 2017
Draw your guesses on the charts below to see if you're as smart as you think you are.
Under President Obama, the unemployment rate ...
Draw the line for the Obama years.
5.8%
4.0%
BUSH YEARS
OBAMA YEARS
2000
'04
'08
'12
'16
Show me how I did.

8


Blue Feed, Red Feed - WSJ
graphics.wsj.com/blue-feed-red-feed/#/health-care
THE WALL STREET JOURNAL.
Blue Feed, Red Feed
See Liberal Facebook and Conservative Facebook, Side by Side
By Jon Keegan
Published May 18, 2016 at 8:00 a.m. ET | Updated hourly
FILTER FEEDS BY TOPIC:
PRESIDENT TRUMP
HEALTH CARE
GUNS
ABORTION
ISIS
BUDGET
EXECUTIVE ORDER
IMMIGRATION
LIBERAL
SHOWING POSTS ABOUT:
"HEALTH CARE"
CONSERVATIVE
Occupy Democrats
2 hours ago
The president thought he could undo his predecessor's legacy, but his plan isn't exactly panning out.
The Federalist Papers
9 hours ago
A horrible testament to what happens with government-run healthcare systems.
These Facebook posts do not represent the reporting or opinion of The Wall Street Journal, and are not verified, edited or endorsed in any way. Read our Methodology.

11

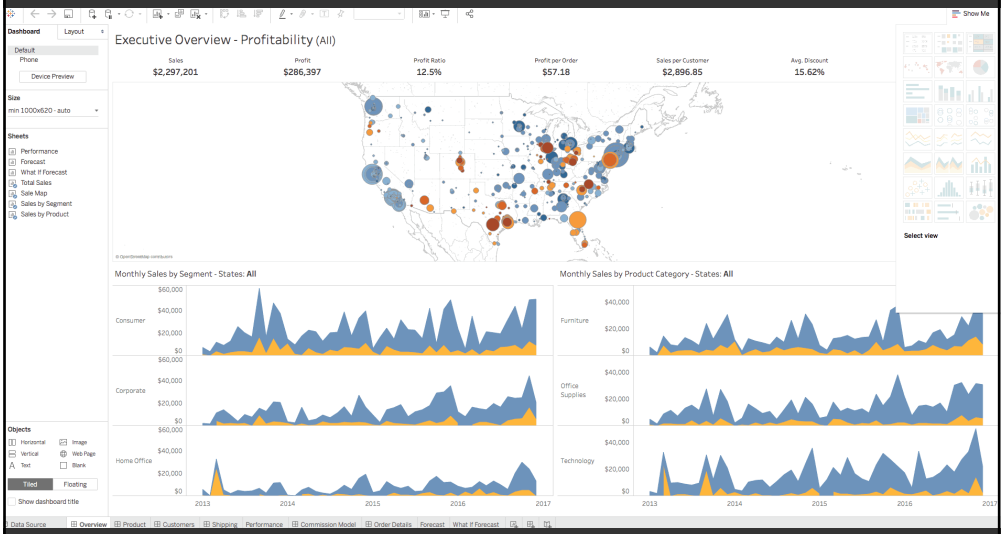

Ramadi: The Government Provides an Opening for ISIS
ISIS Control
Tensions between this city's residents, who are mostly Sunni, and the central government had been brewing here for at least a year. Then in December, Iraq's prime minister, Nuri Kamal al-Maliki, ordered security forces to dismantle a protest camp — an outlet for disenchanted Sunnis angered at their treatment by the Shiite-dominated government. The action ignited days of violence and created the opening ISIS needed to seize parts of the city, the provincial capital.
Lake Tharthar
Falluja: A Symbolic Fall
ISIS Control
Just days after the raid on the camp in Ramadi, ISIS fighters destroyed the Police Headquarters and mayor's office here, planted their flag on government buildings and decreed the city to be theirs. Ten years earlier, American forces had captured this city from Qaeda-style insurgents at a considerable cost of American lives.
Lake Habbaniya
Balad
Aleppo
Mosul
SYRIA
IRAQ
Baghdad
17 MILES TO BAGHDAD
NY Times
2014
Scroll

13

Chart Sequences

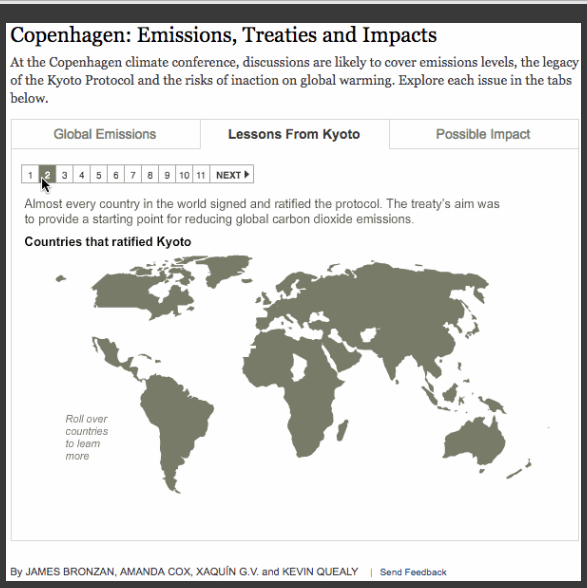
15

Multiple Charts in Data Analysis



16

Multiple Charts in Storytelling



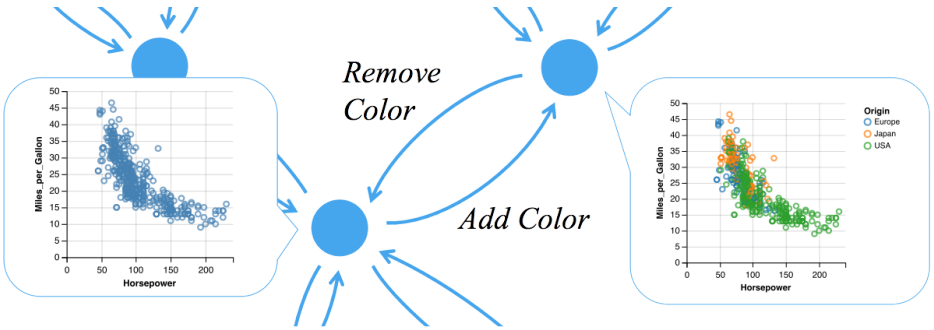
17

Chart Sequence Design [Hullman 2013]

Can we automatically identify sequences to recommend to a human designer?

18

GraphScape: A Directed Graph Model



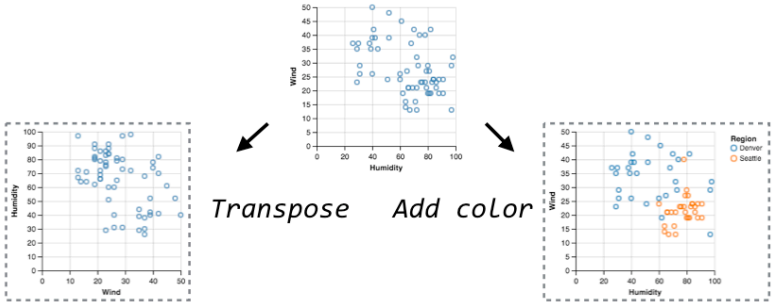
Nodes are **Vega-Lite specifications**. Edges represent **edit operations**, weighted by estimated **transition costs**.

[Kim, Wongsuphasawat, Hullman, Heer, 2017]

19

Constructing the Graph

After reading this chart,

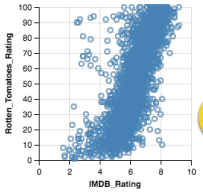


which chart is easier to follow?

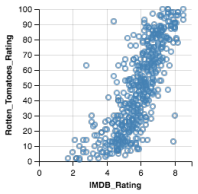
20

Design Alternatives

"Too many data points !"



Add Filter



Random Sample

Bin

Bin

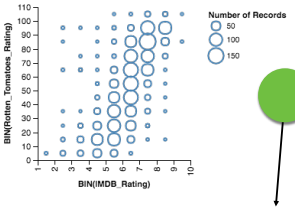
...

Add Size(count)

...

...

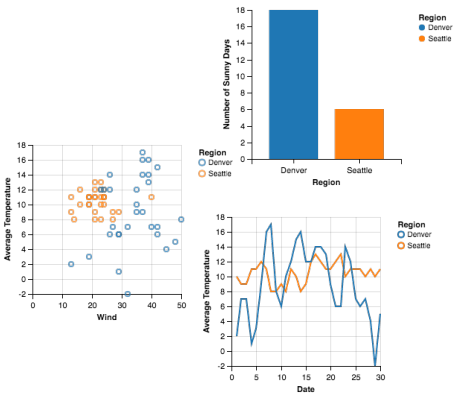
Binned Scatter Plot

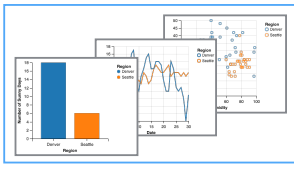


21

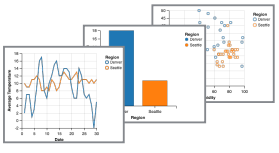
Sequence Recommendation

Sequence Cost





: 10



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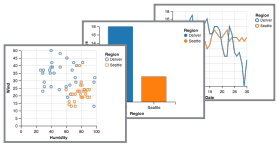


: 13

...

22

GraphScape [Kim, Wongsuphasawat, Hullman, Heer 2017]

Previously we've discussed approaches for automatic design of a single visualization (e.g. Mackinlay's APT)

GraphScape supports automated design methods for collections of visualizations.

Plenty of future work to do here!

23

Summary

Narrative visualizations blend communication via imagery and text with interaction techniques

Specific strategies can be identified by studying what expert designers make

Automating construction of effective explainers is an active area of Visualization research

24

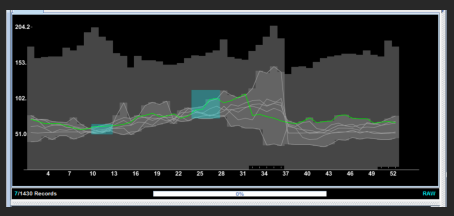
Announcements

25

Assignment 3: Dynamic Queries

Create a **small** interactive dynamic query application similar to TimeSearcher, but for top 100 personalities on Cable TV News.

1. Implement timeboxes interface
2. Submit the application and a short write-up on canvas



Can work alone or in pairs

Due before class on **Oct 20, 2020**

26

Grades and Regrades

The final grades will be curved

For regrades, send a private note on Piazza to us and explain why you think a regrade is in order

27

Final project

Data analysis/explainer or conduct research

- **Data analysis**: Analyze dataset in depth & make a visual explainer
- **Research**: Pose problem, Implement creative solution

Deliverables

- **Data analysis/explainer**: Article with multiple interactive visualizations
- **Research**: Implementation of solution and web-based demo if possible
- **Short video (2 min max)** demoing and explaining the project

Schedule

- Project proposal: Thu 10/29
- Design Review and Feedback: Tue 11/17 & Thu 11/19
- Final code and writeup: Sat 11/21 11:59pm

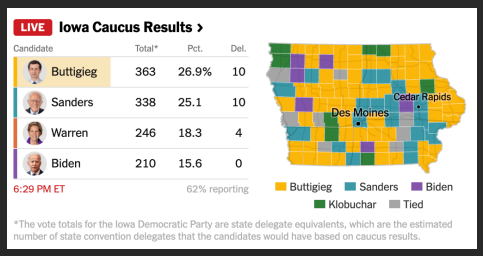
Grading

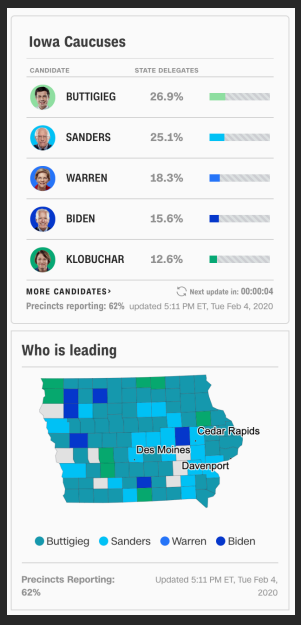
- Groups of up to 3 people, graded individually
- Clearly report responsibilities of each member

28

Color

29

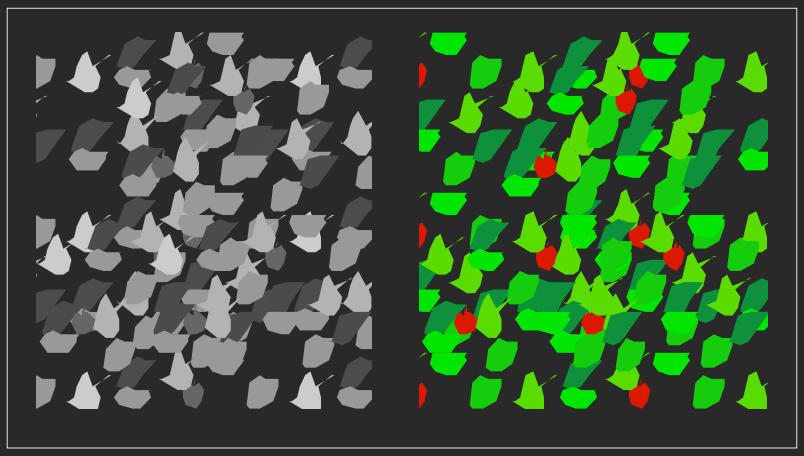

LIVE
Iowa Caucus Results ›
Candidate
Total*
Pct.
Del.
Buttigieg
363
26.9%
10
Sanders
338
25.1
10
Warren
246
18.3
4
Biden
210
15.6
0
6:29 PM ET
62% reporting
Cedar Rapids
Des Moines
Buttigieg
Sanders
Biden
Klobuchar
Tied
*The vote totals for the Iowa Democratic Party are state delegate equivalents, which are the estimated number of state convention delegates that the candidates would have based on caucus results.


Iowa Caucuses
CANDIDATE
STATE DELEGATES
BUTTIGIEG
26.9%
SANDERS
25.1%
WARREN
18.3%
BIDEN
15.6%
KLOBUCHAR
12.6%
MORE CANDIDATES›
Next update in: 00:00:04
Precincts reporting: 62% updated 5:11 PM ET, Tue Feb 4, 2020
Who is leading
Cedar Rapids
Des Moines
Davenport
Buttigieg
Sanders
Warren
Biden
Precincts Reporting: 62%
Updated 5:11 PM ET, Tue Feb 4, 2020

30

Color in Visualization

Identify, Group, Layer, Highlight



Colin Ware

31

Purpose of Color

To label
To measure
To represent and imitate
To enliven and decorate

"Above all, do no harm."

- Edward Tufte

32

Topics

Color Perception
Color Naming
Using Color in Visualization

33

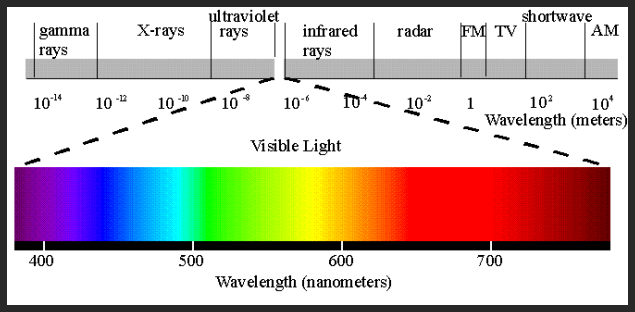
Color Perception

Physical World, Visual System, Mental Models

34

Physical World

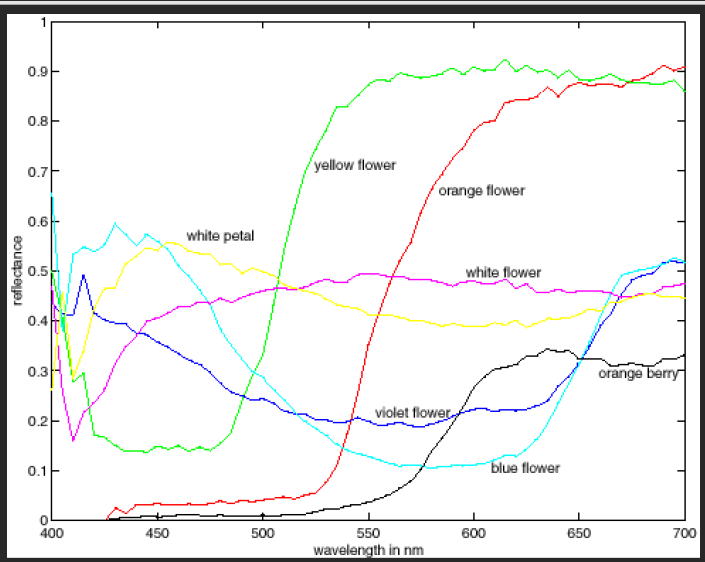
Light is radiation in range of wavelengths



Light of single wavelength is *monochromatic*

37

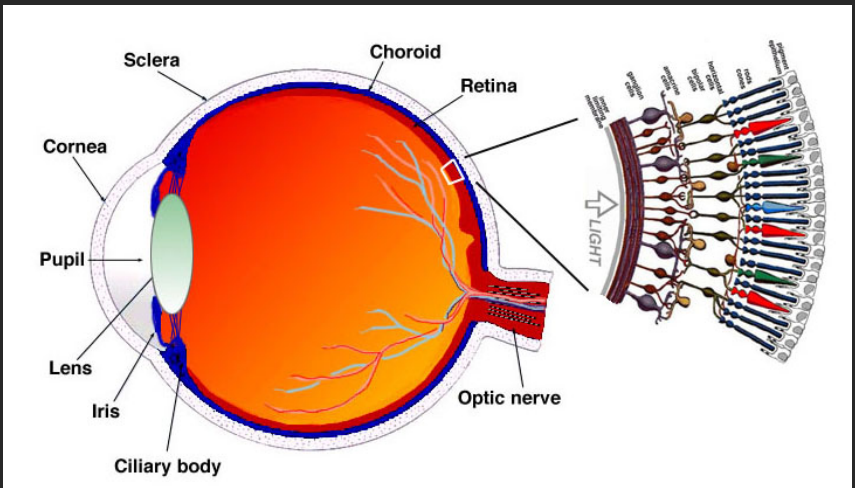
Most Colors not Monochromatic



Curves describe spectral composition $\Phi(\lambda)$ of stimulus

39

Retina

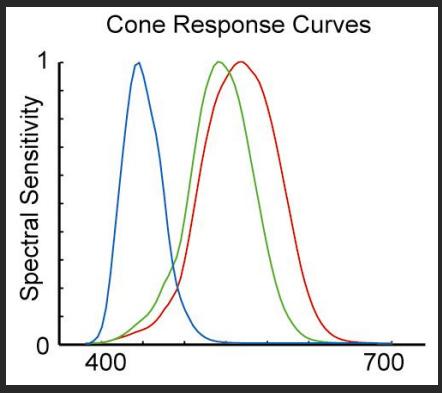


Simple Anatomy of the Retina, Helga Kolb

42

As light enters our retina...

LMS (Long, Middle, Short) Cones Sensitive to different wavelength

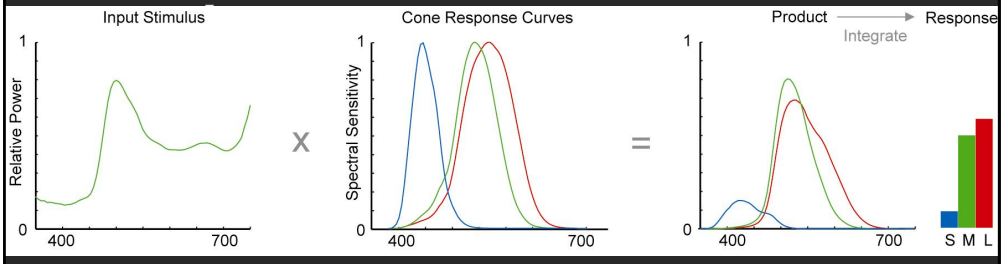


A Field Guide to Digital Color, Maureen Stone

45

Cone Response

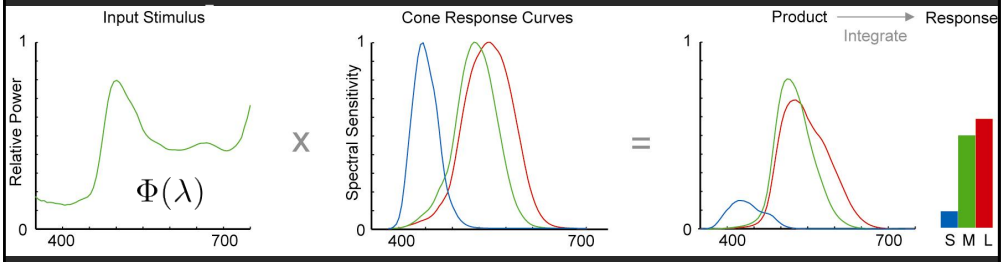
Integrate cone response with input



46

Computing Cone Response

Integrate cone response with input



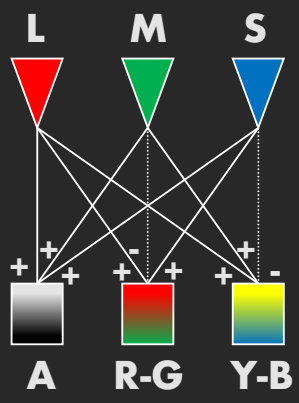
$$L = \int \Phi(\lambda) L(\lambda) \mathrm{d}\lambda$$
$$M = \int \Phi(\lambda) M(\lambda) \mathrm{d}\lambda$$
$$S = \int \Phi(\lambda) S(\lambda) \mathrm{d}\lambda$$

47

Opponent processing

LMS are linearly combined to create:

- Lightness
- Red-green contrast
- Yellow-blue contrast



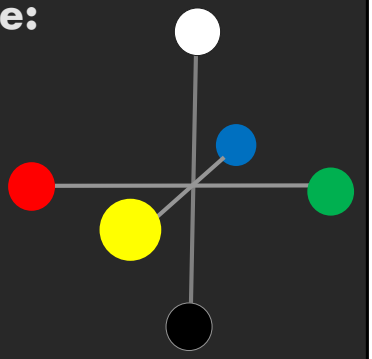
Fairchild

51

Opponent processing

LMS are combined to create:

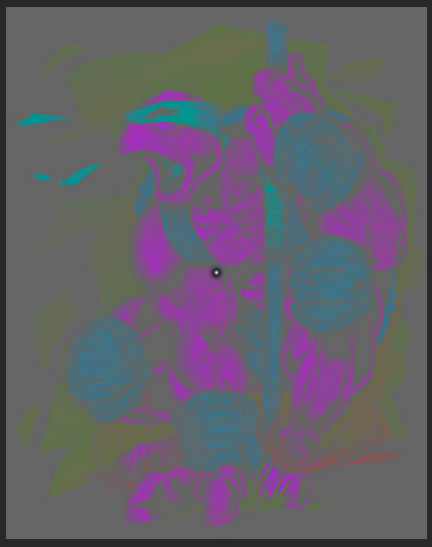
- Lightness
- Red-green contrast
- Yellow-blue contrast



Experiments:

- No reddish green, no bluish yellow
- Color after images

53



55

56

Axes of CIE LAB

Correspond to opponent signals

L* = Luminance

a* = Red-green contrast

b* = Yellow-blue contrast

Scaling of axes to represent "color distance"

JND = Just noticeable difference (~2.3 units)

61

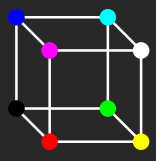
Psuedo-Perceptual Models

HLS, HSV, HSB

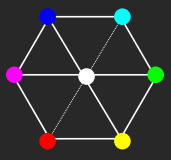
NOT perceptual models

Simple re-notation of RGB

- View along gray axis
- See a hue hexagon
- L or V is grayscale pixel value



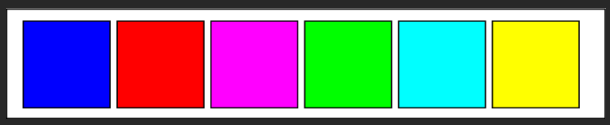
Cannot predict perceived lightness



68

Perceptual brightness

Color palette



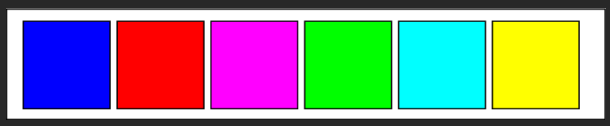
HSL Lightness

(Photoshop)

69

Perceptual brightness

Color palette



Munsell Value

L* (CIE LAB)

71

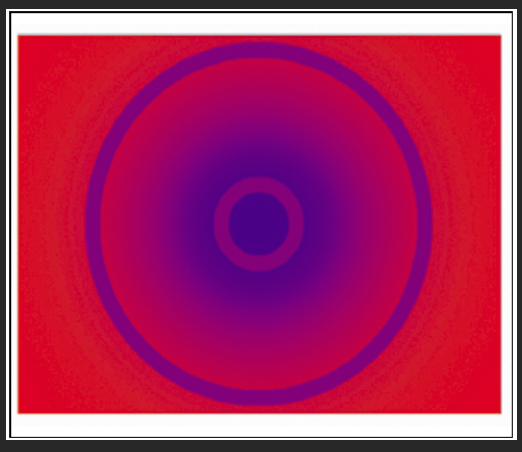
"In order to use color effectively it is necessary to recognize that it deceives continually."

- Josef Albers, *Interaction of Color*

76

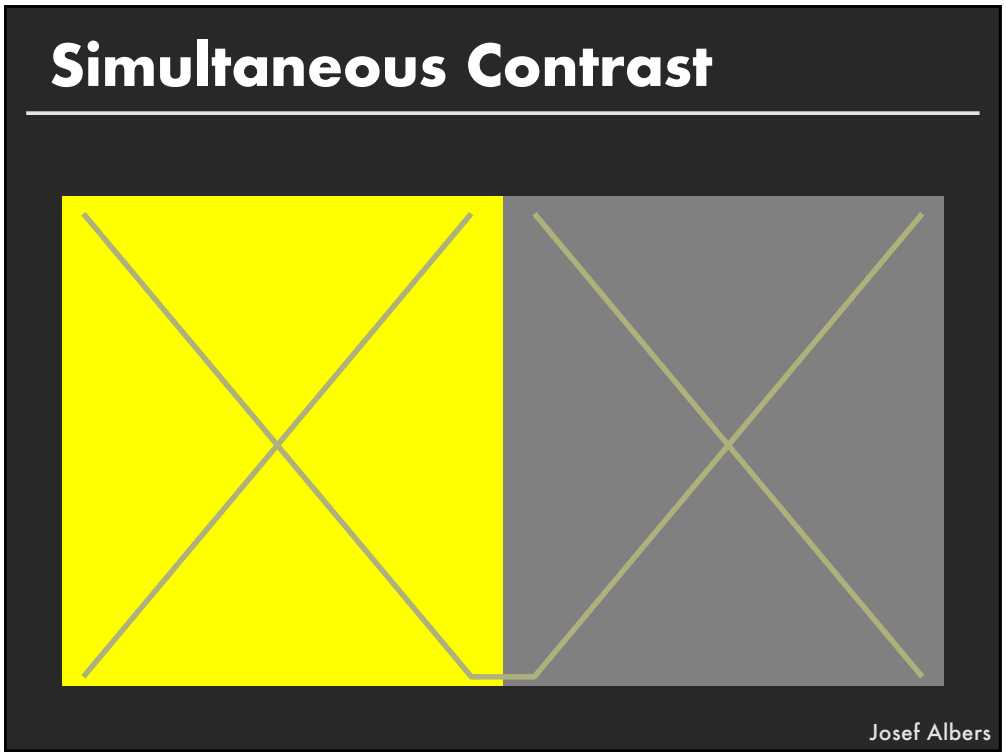
Simultaneous Contrast

The inner and outer thin rings are the physical purple

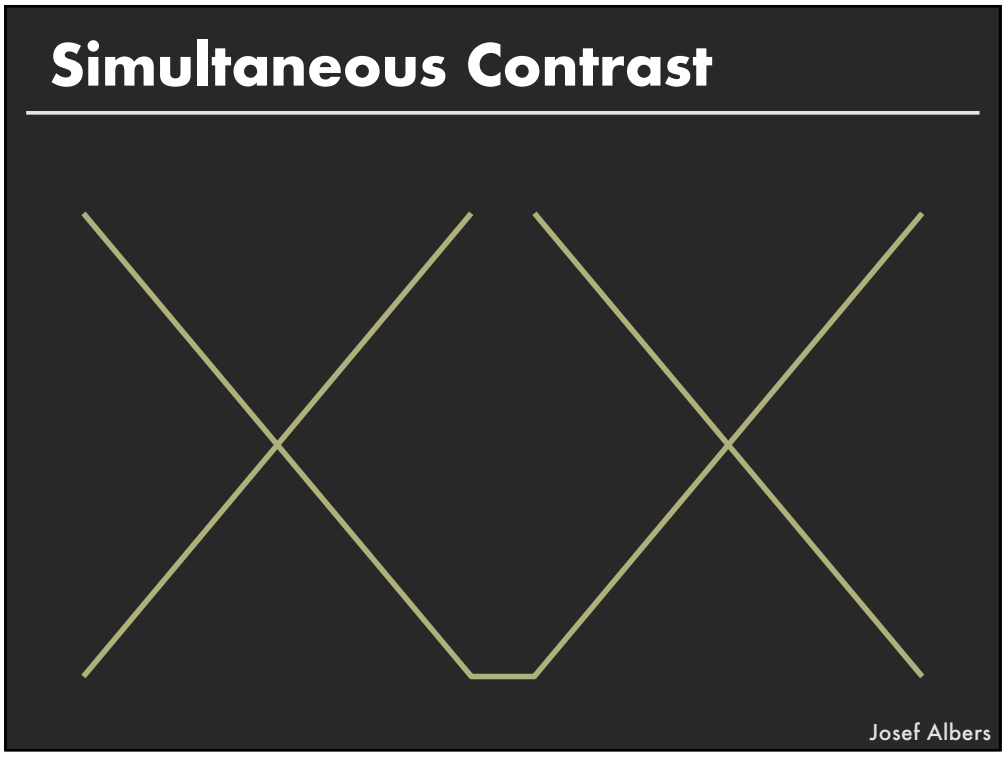


Donald MacLeod

77

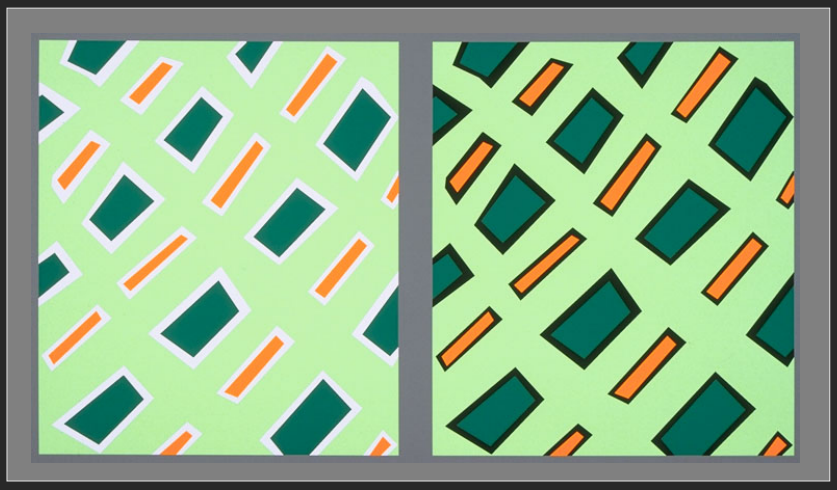

Simultaneous Contrast
Josef Albers

80


Simultaneous Contrast
Josef Albers

81

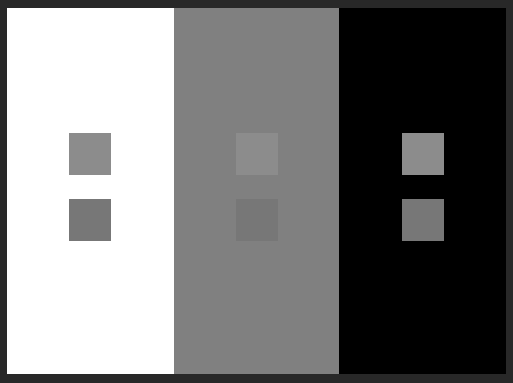
Bezold Effect



89

Crispening

Perceived difference depends on background



From Fairchild, *Color Appearance Models*

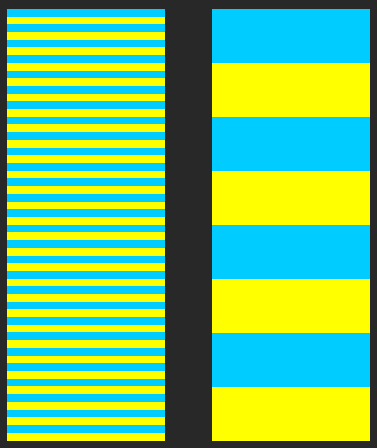
90

Spreading

Adjacent colors blend

Spatial frequency

- **The paint chip problem**
- **Small text, lines, glyphs**
- **Image colors**



Redrawn from *Foundations of Vision*

91

Color Naming

92

What color is this?

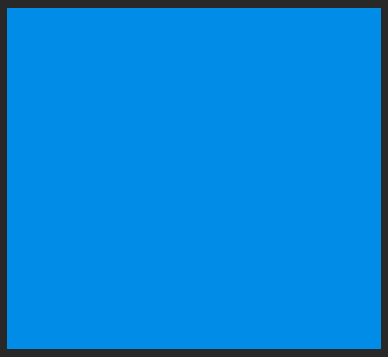
93

What color is this?

"Yellow"

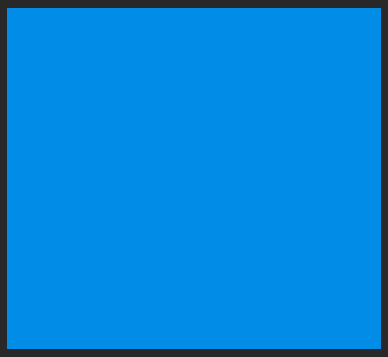
94

What color is this?



95

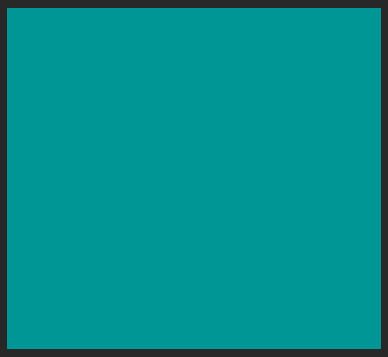
What color is this?



"Blue"

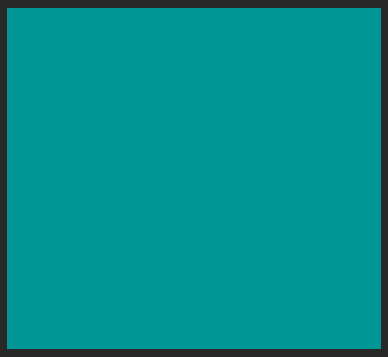
96

What color is this?



97

What color is this?



"Teal" ?

98

Colors according to XKCD...

99

Basic color terms

Chance discovery by Brent Berlin and Paul Kay

100

Basic color terms

Chance discovery by Brent Berlin and Paul Kay

101

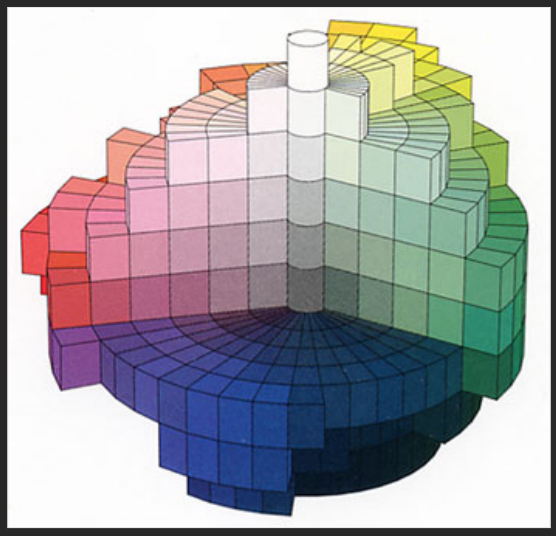
Basic Color Terms

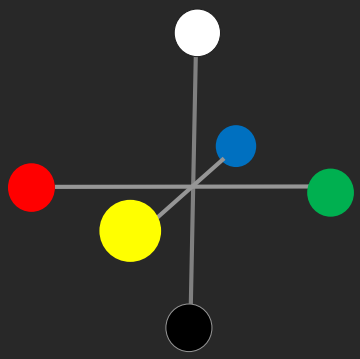
Chance discovery by Brent Berlin and Paul Kay

Initial study in 1969
Surveyed speakers from 20 languages
Literature from 69 languages

102

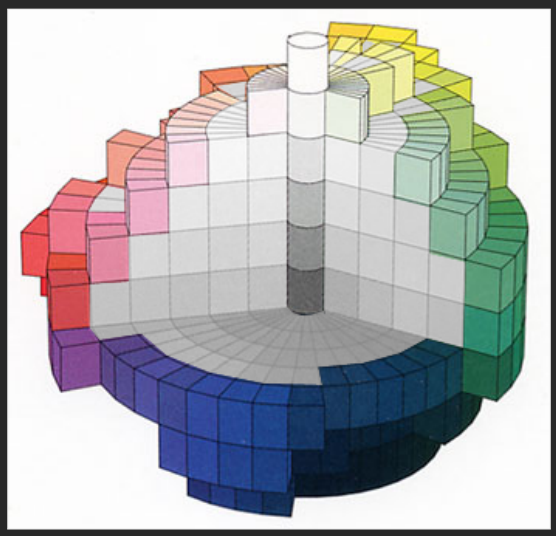
World color survey





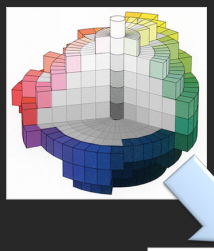
103

World color survey

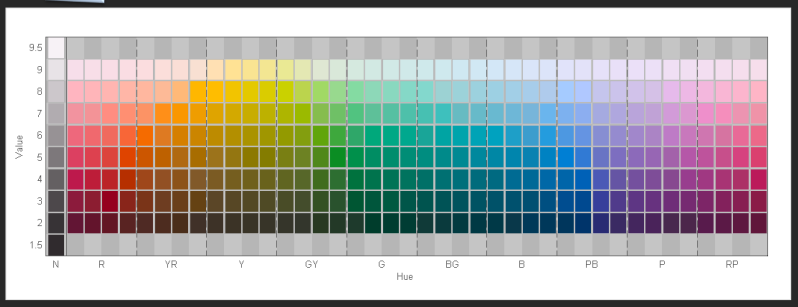


104

World color survey

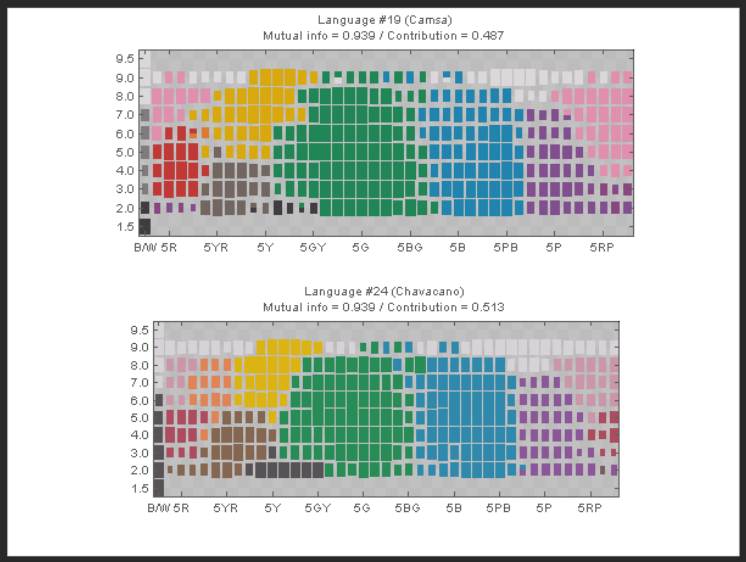


Naming information from 2616 speakers from 110 languages on 330 Munsell color chips



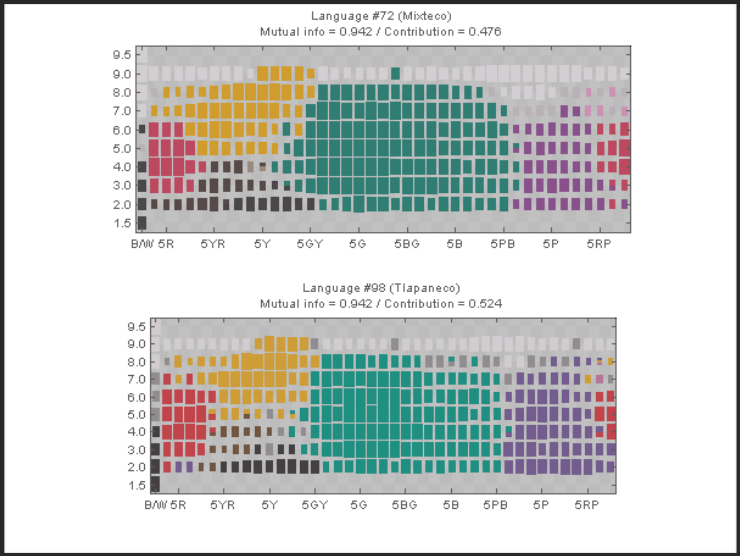
105

Results from WCS (South Pacific)



106

Results from WCS (Mexico)



107

Universal (?) Basic Color Terms

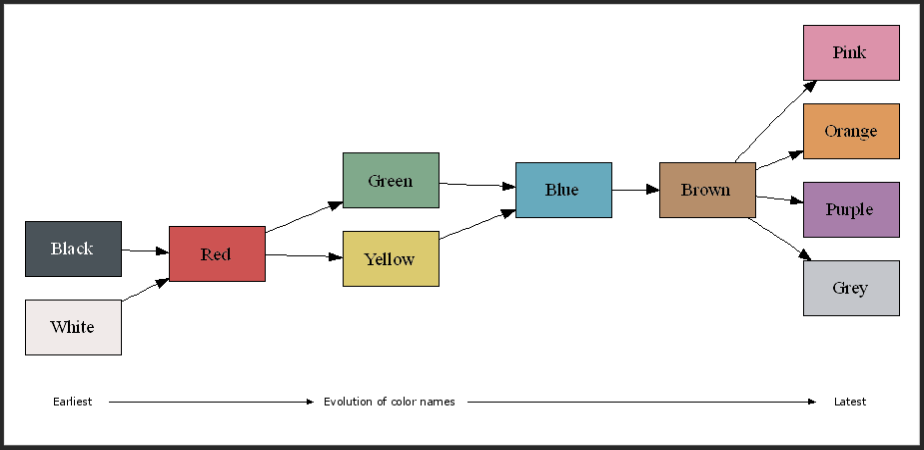
Basic color terms recur across languages

White
Red
Pink
Grey
Yellow
Brown
Black
Green
Orange
Blue
Purple

108

Evolution of Basic Color Terms

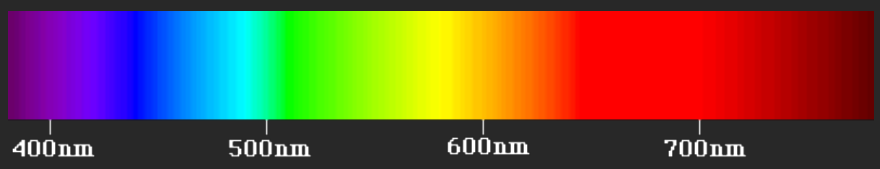
Proposed universal evolution across languages



109

Rainbow color ramp

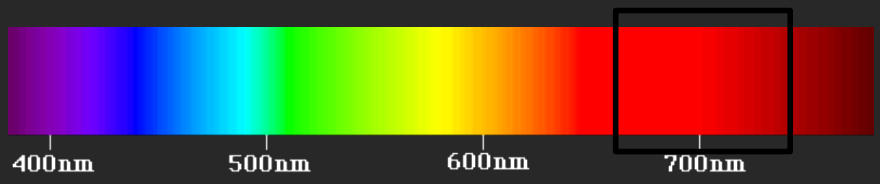
We associate and group colors together, often using the name we assign to the colors



110

Rainbow color ramp

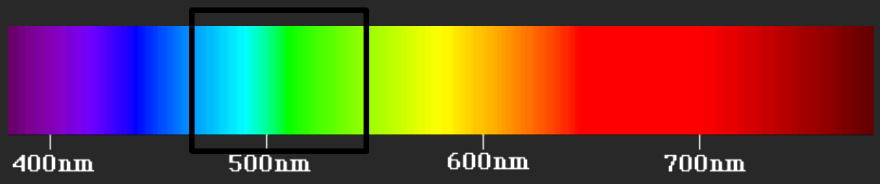
We associate and group colors together, often using the name we assign to the colors



111

Rainbow color ramp

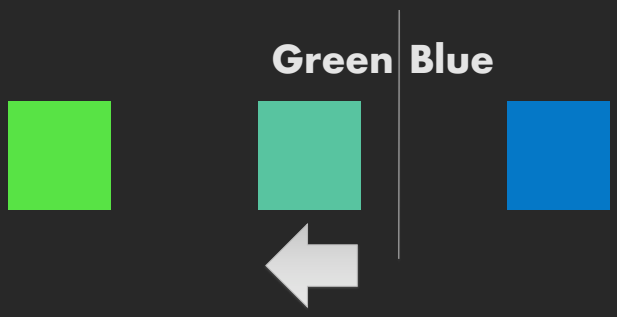
We associate and group colors together, often using the name we assign to the colors



112

Naming affects color perception

Color name boundaries



113

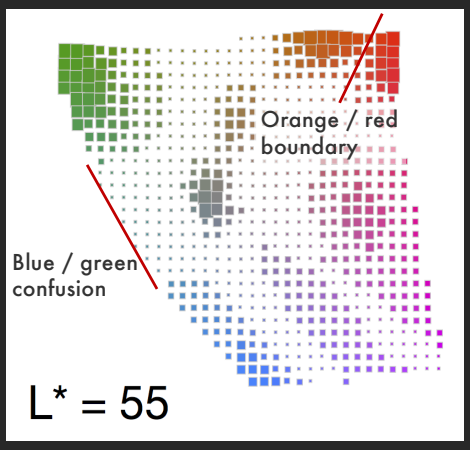
Color naming models

[Heer & Stone]

Model 3 million responses from XKCD survey

Bins in LAB space sized by *saliency*:
How much do people agree on color name?

Modeled by entropy of *p(name | color)*



114