

Sit together with your groupmates (Canvas->People->Groups) – new group!

▼ Week 4 - Group 1

4 students

Pooja Hegde	⋮
Naga Manohar Yelubandi	⋮

▼ Week 4 - Group 2

4 students

Shanthan Reddy Muddasani	⋮
Arvind Kumar Nalli Kuppu...	⋮

▼ Week 4 - Group 3

4 students

Kashmira Jitendra Golatka...	⋮
Jignesh Kirti Nagda	⋮

4 students

Nikhil Sai Dandamudi	⋮
Dhananjay Srivastava	⋮

▼ Week 4 - Group 5

4 students

Aniruddho Chatterjee (he...	⋮
Abhinav Krishna Narvaneni	⋮

⋮ Week 4 - Group 6

Sayali Pandhare	⋮
Piyush Chaudhari	⋮
Sreyas Anil Sawant	⋮

⋮ Week 4 - Group 7

Shanthan Reddy Muddasani	⋮
Arvind Kumar Nalli Kuppu...	⋮
Harini Sugumar (she/her/h...	⋮
Muhammad Siddiq Khan	⋮

⋮ Week 4 - Group 8

Sahithi Thummuri	⋮
Lakshmi Soujanya Taduru	⋮
Yerramsetti Dharma Teja .	⋮
Radhika Agarwal	⋮

⋮ Week 4 - Group 9

Nikhil Sai Dandamudi	⋮
Jait Mahawarkar	⋮
Mohit Mathrani	⋮
Subhranil Das (he/him/his)	⋮

⋮ Week 4 - Group 10

Aniruddho Chatterjee (he...	⋮
Shruti Houji (she/her/hers)	⋮
Lakshmi Pavani Kuncha (sh...	⋮
Sricharan Cheeti	⋮

Data visualization

W4-1

Quiz

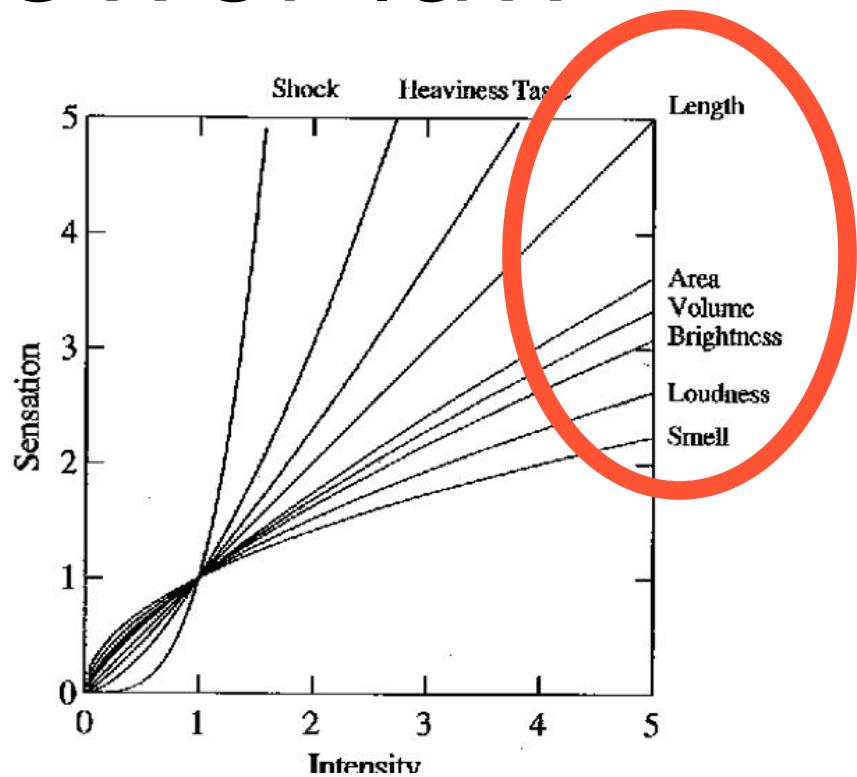
- What do you find interesting in today's VotW?
- What is Stevens' power law? What would be its most important implication for visualization?

Stevens's power law

Exponent (Empirically determined)

$$S = I^P$$

Stevens' power law



Relative magnitude estimation

Most accurate



Position (common) scale



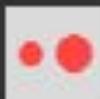
Position (non-aligned) scale



Length



Slope



Angle



Area



Volume

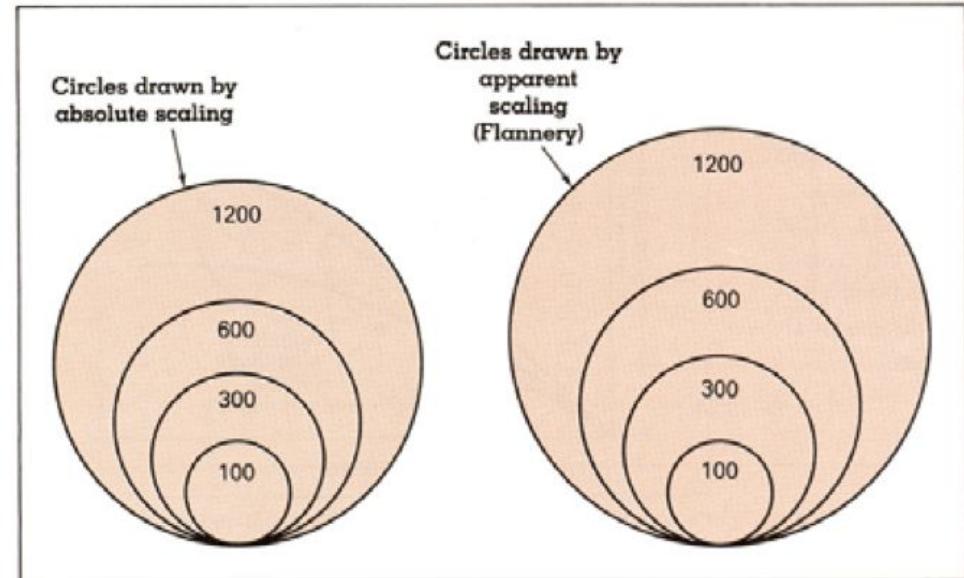
Least accurate



Color hue-saturation-density

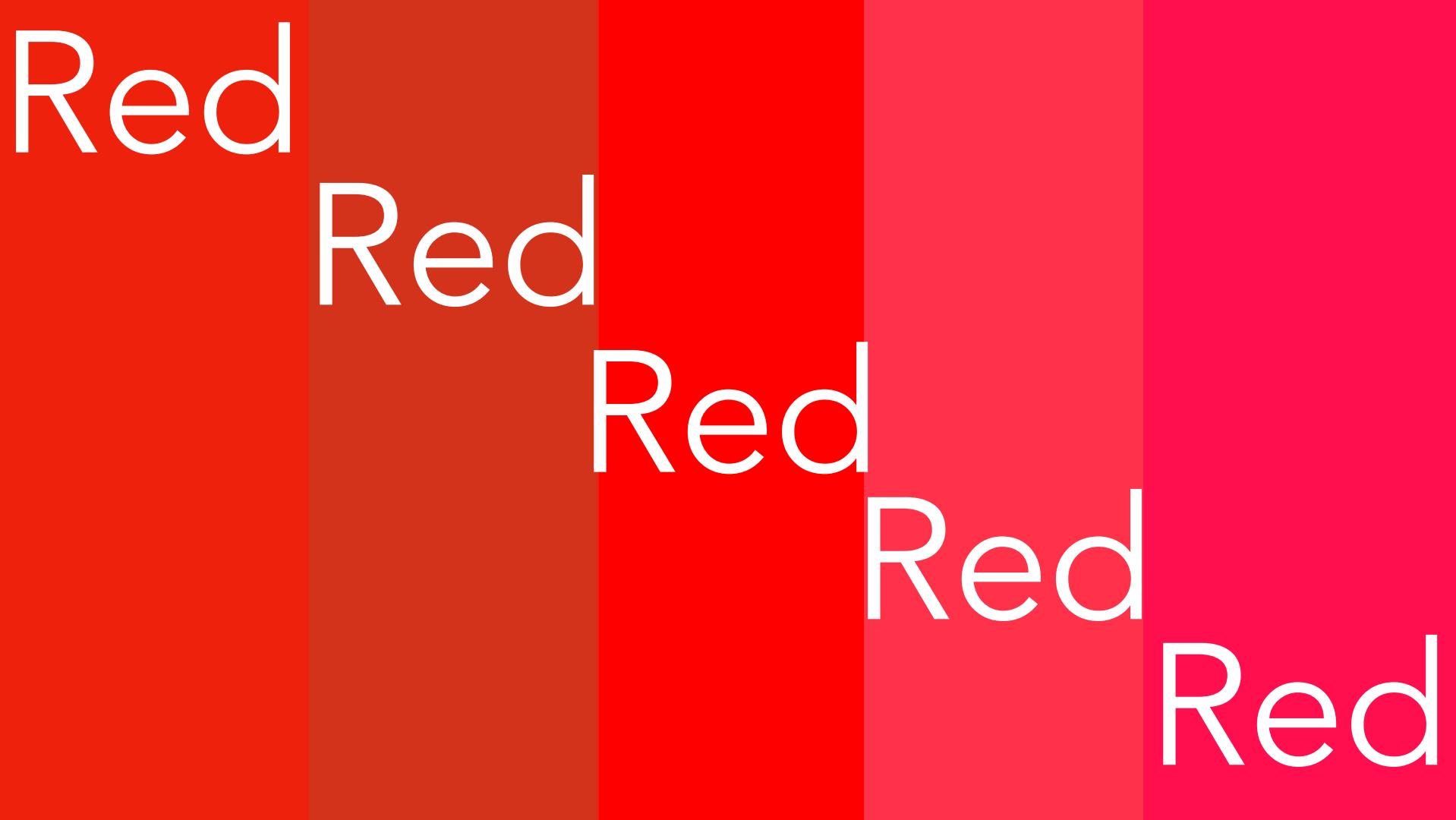
According to Stevens' power law, our perception of area is not accurate. Then why not rescale areas according to Stevens' power law?

I think I see that area B
is 3.14 times bigger than
area A. Is that correct?



Colors

Red



Color names if
you're a girl...

Maraschino	Red
Cayenne	Purple
Maroon	Purple
Plum	Purple
Eggplant	Purple
Grape	Purple
Orchid	Purple
Lavender	Pink
Carnation	Pink
Strawberry	Pink
Bubblegum	Pink
Magenta	Pink
Salmon	Orange
Tangerine	Orange
Cantaloupe	Yellow
Banana	Yellow
Lemon	Yellow
Honeydew	Green
Lime	Green
Spring	Green
Clover	Green
Fern	Green
Moss	Green
Flora	Green
Sea Foam	Blue
Spindrift	Blue
Teal	Blue
Sky	Blue
Turquoise	Blue

Color names if
you're a guy...



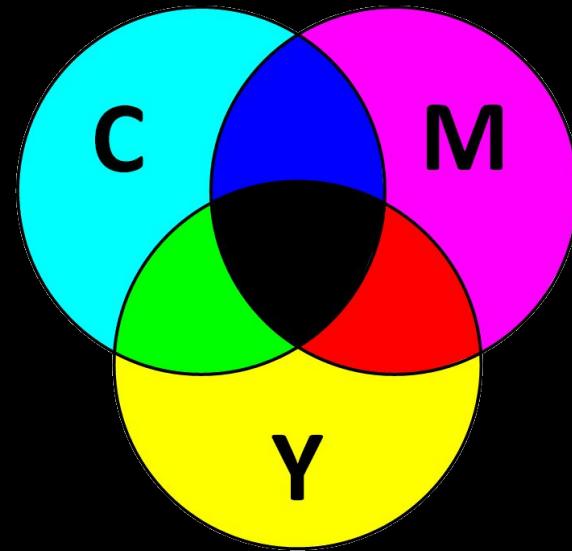
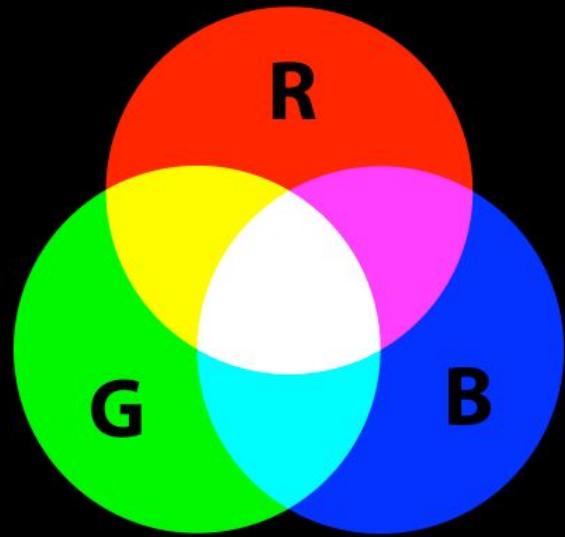
THIS CHART SHOWS THE DOMINANT COLOR NAMES OVER THE THREE FULLY-SATURATED FACES OF THE RGB CUBE (COLORS WHERE ONE OF THE RGB VALUES IS ZERO)

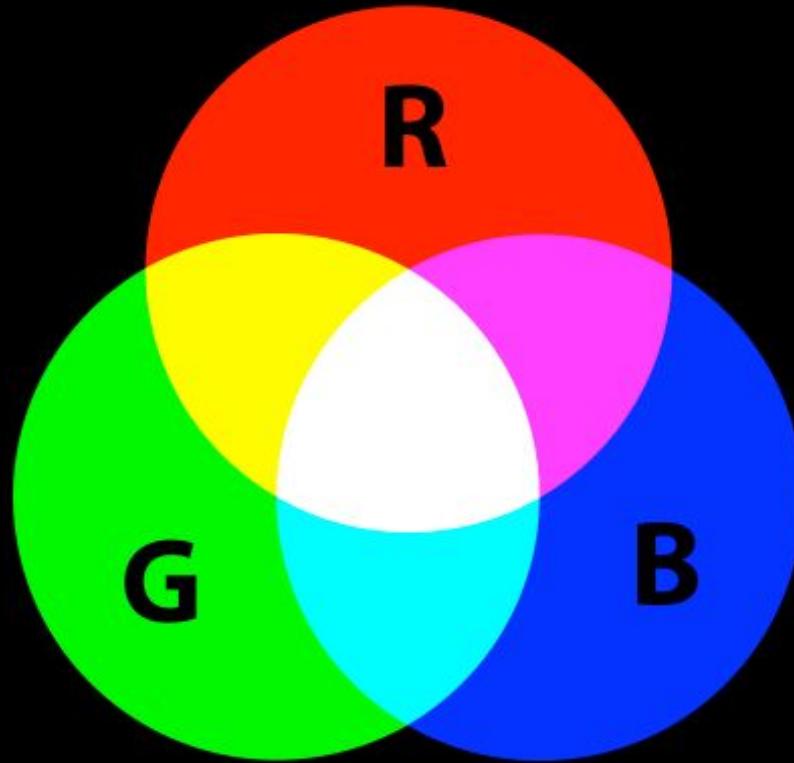
*Actual color names
if you're a girl ... Actual color names
if you're a guy ...*



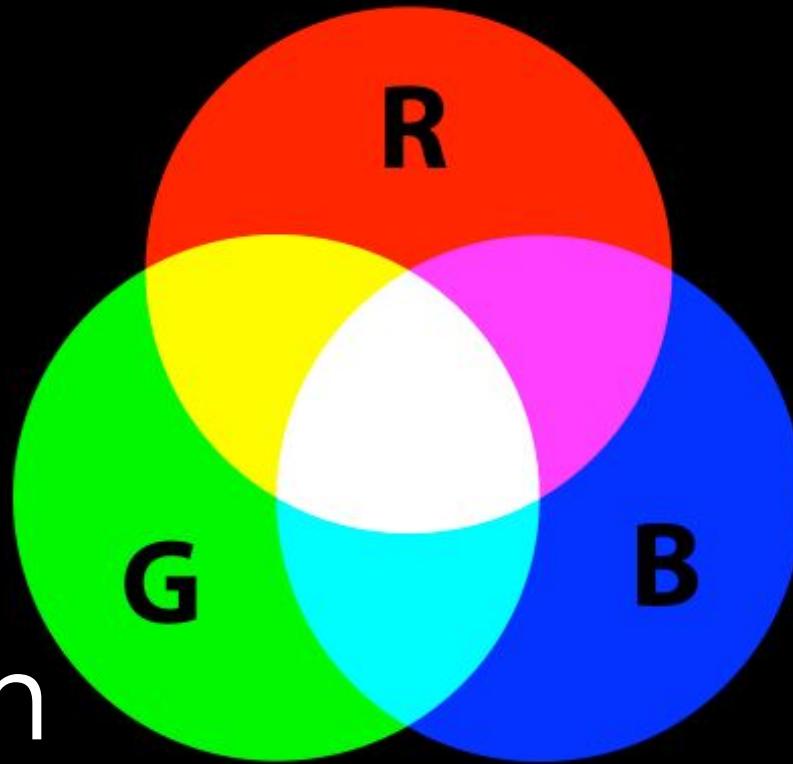
How can we quantitatively
represent colors?

Any “system” that you know of?





Red

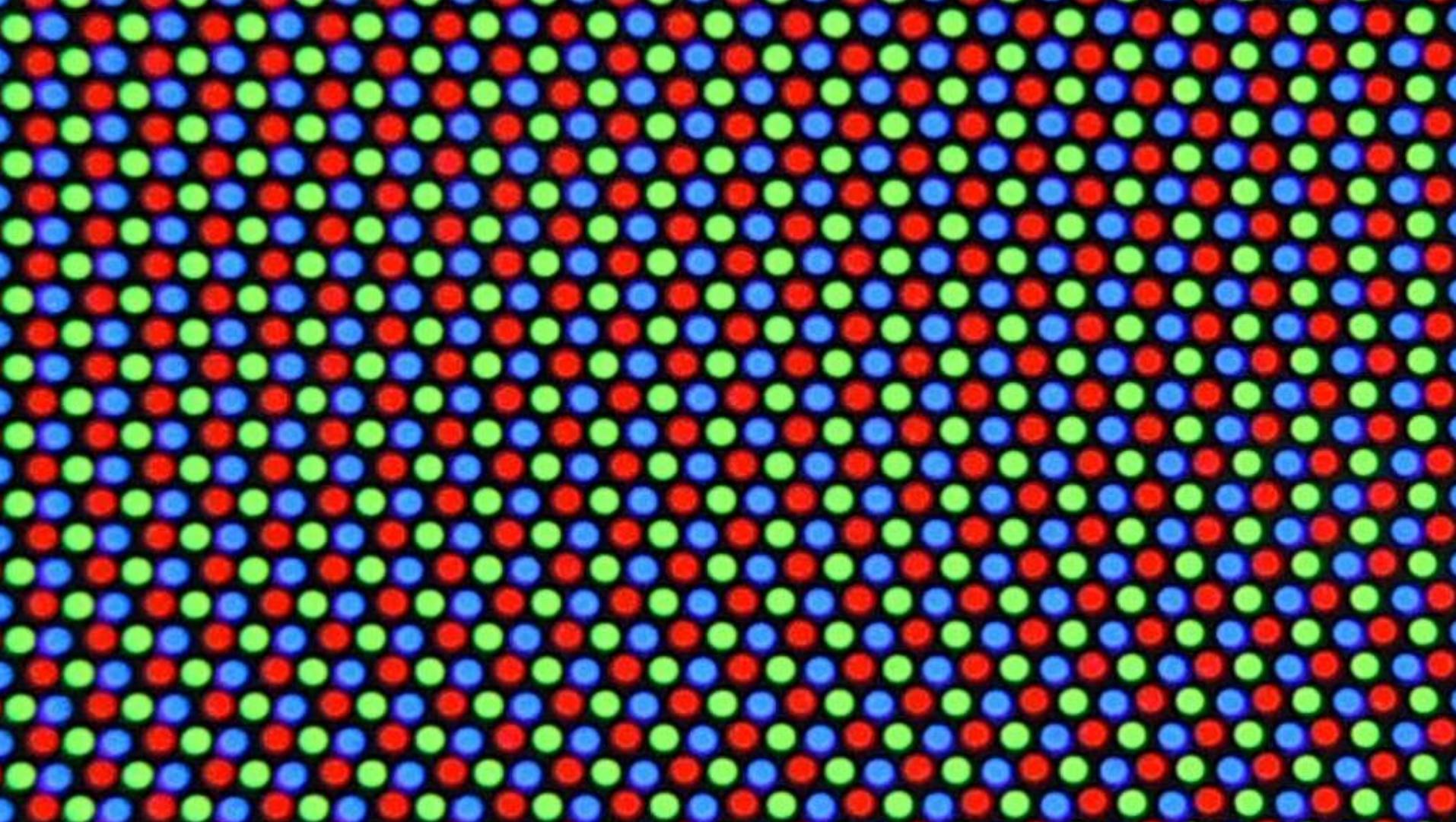


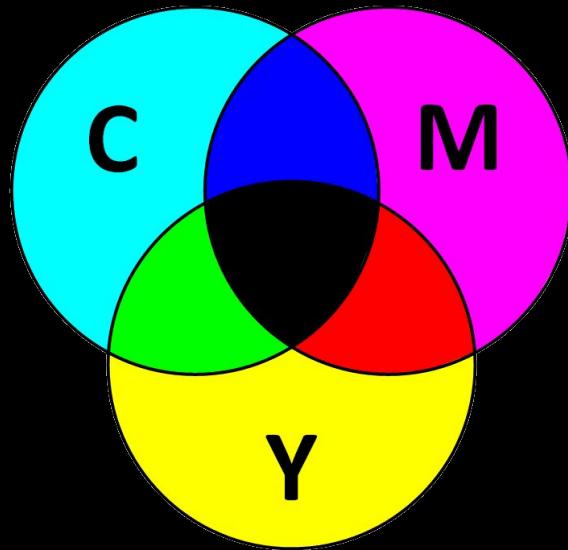
Green

Blue



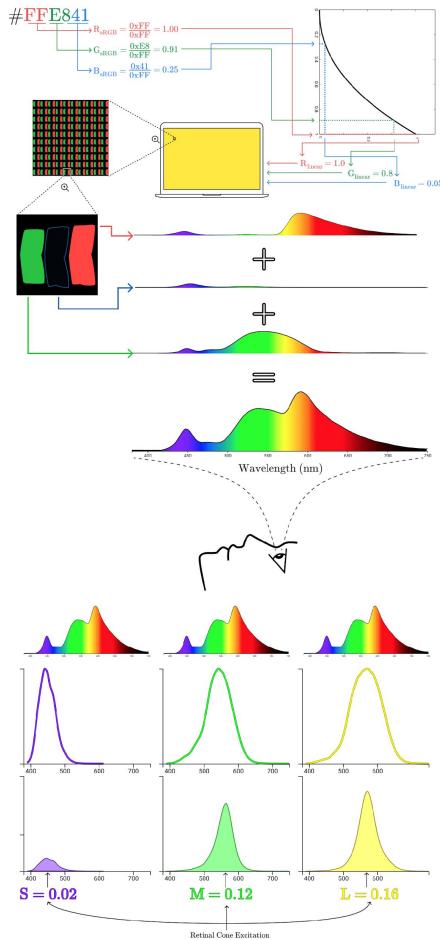
https://en.wikipedia.org/wiki/RGB_color_model#/media/File:RGB_illumination.jpg





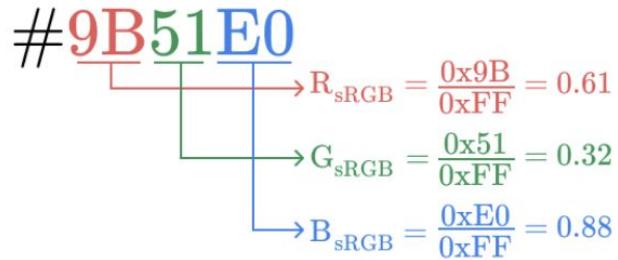
https://commons.wikimedia.org/wiki/File:CMYK_Subtractive_Model.gif



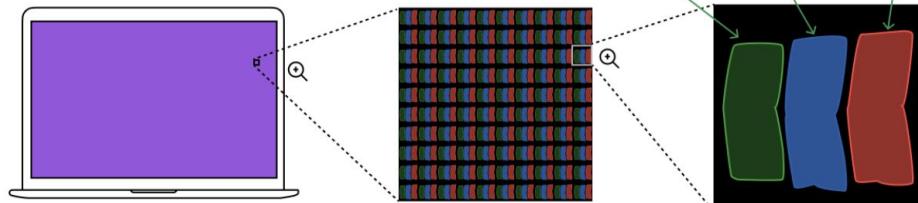


Zerø Wind
Jamie Wong
[Twitter](#) [GitHub](#)
April 3, 2018

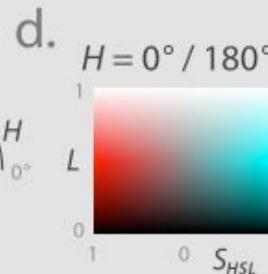
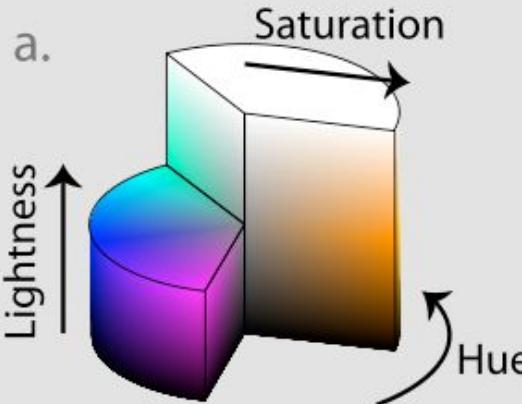
Color: From Hexcodes to Eyeballs



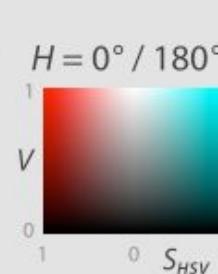
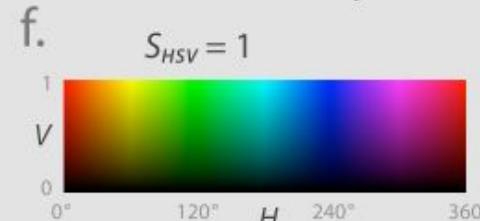
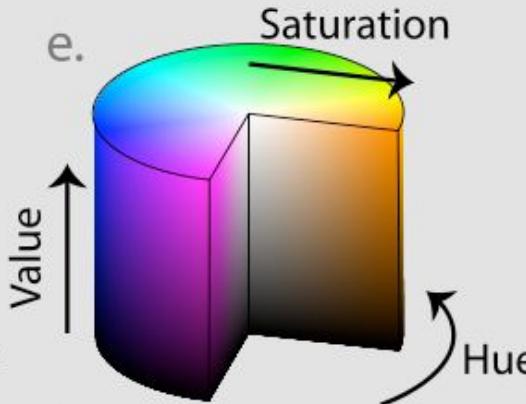
$G_{linear} = 0.08$ $B_{linear} = 0.75$ $R_{linear} = 0.33$



HSL

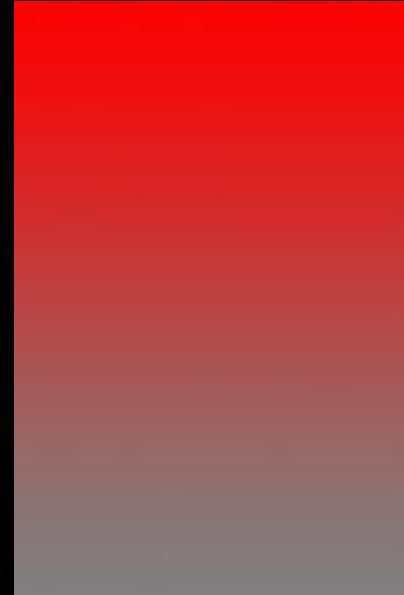


HSV



The background of the image is a vibrant, hand-painted rainbow gradient. It features horizontal wavy brushstrokes in various colors, transitioning from red at the top to orange, yellow, green, cyan, blue, and finally purple at the bottom. The colors are bright and slightly textured.

Hue
(What color)



Saturation
(How colorful)

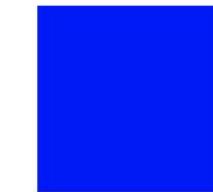
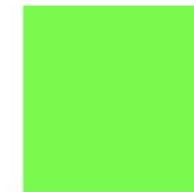
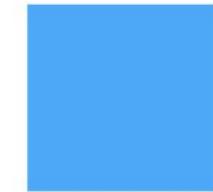
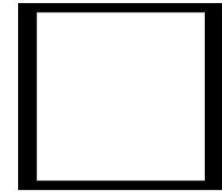
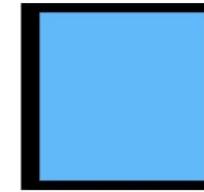
Low

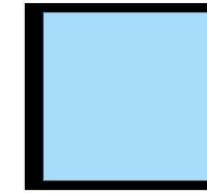
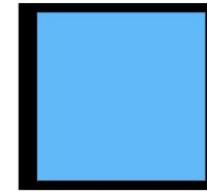


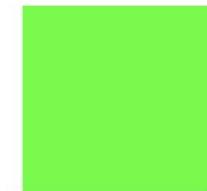
High

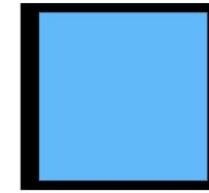


Value / lightness
(How bright)



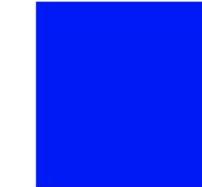
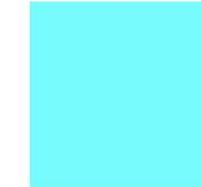
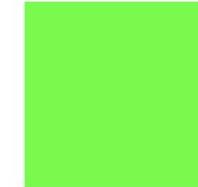






Ordered channels - magnitude

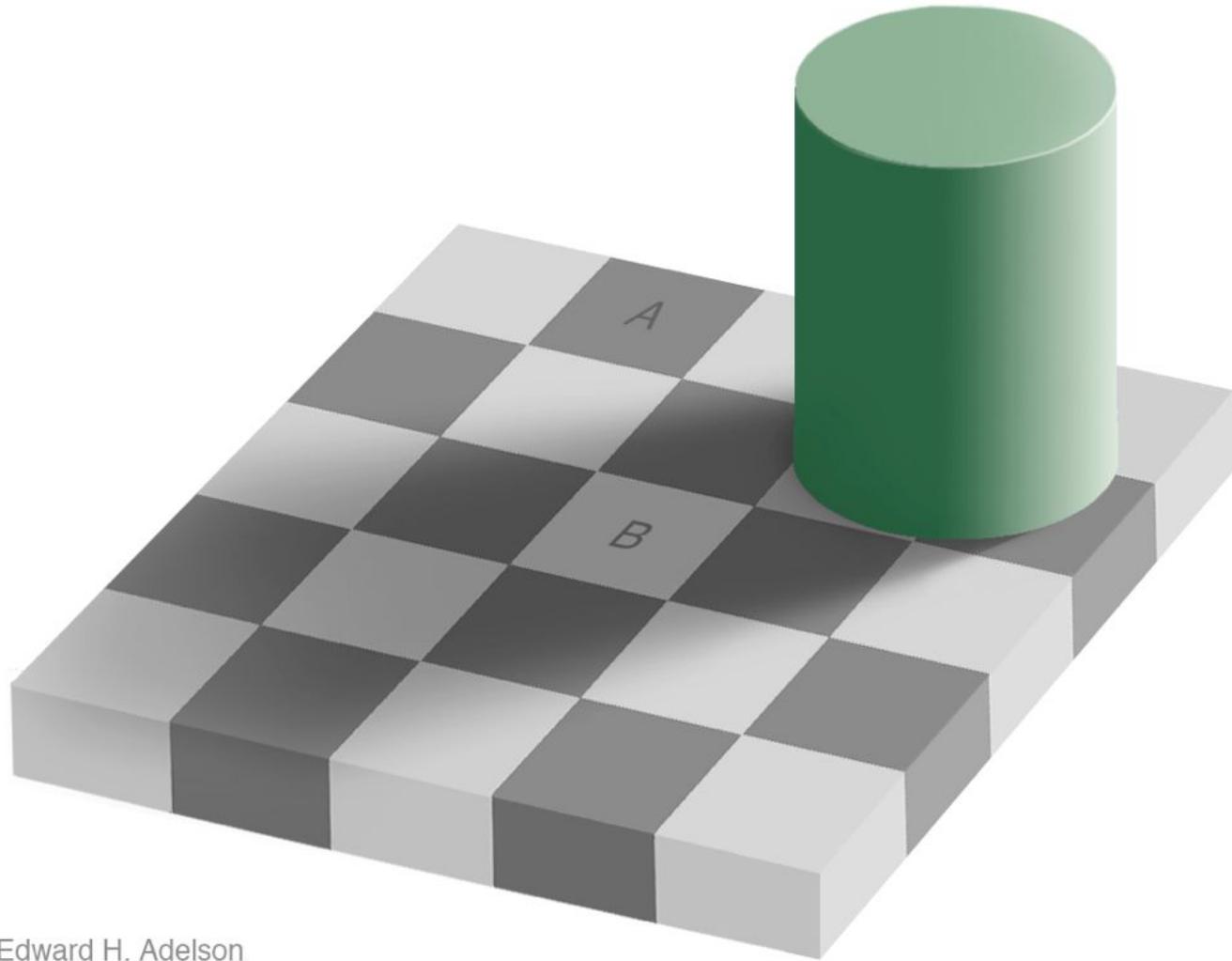
Categorical channels - identity



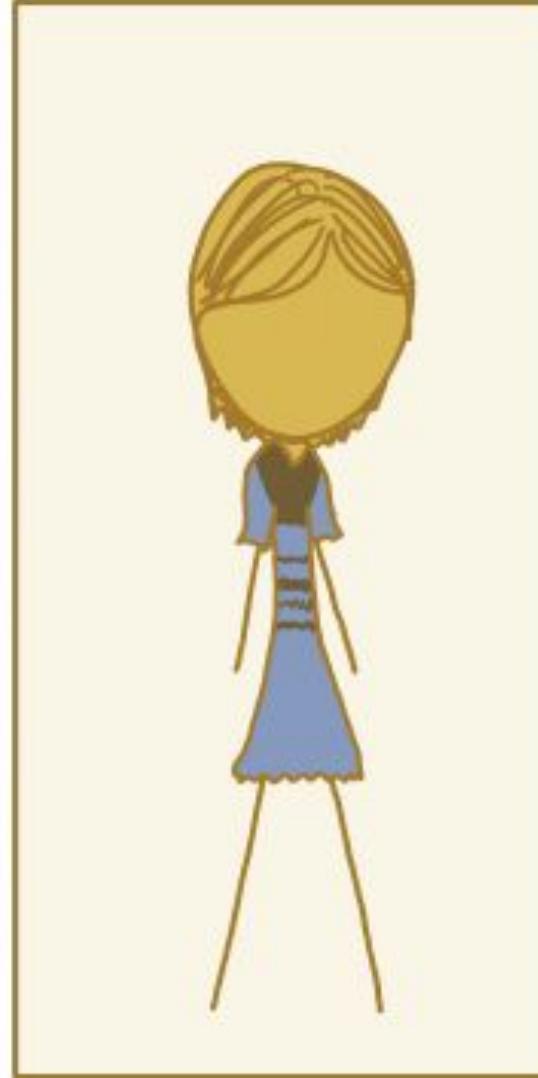
Hands-on activity

Why do we need to
understand color perception?

1. Context



Edward H. Adelson



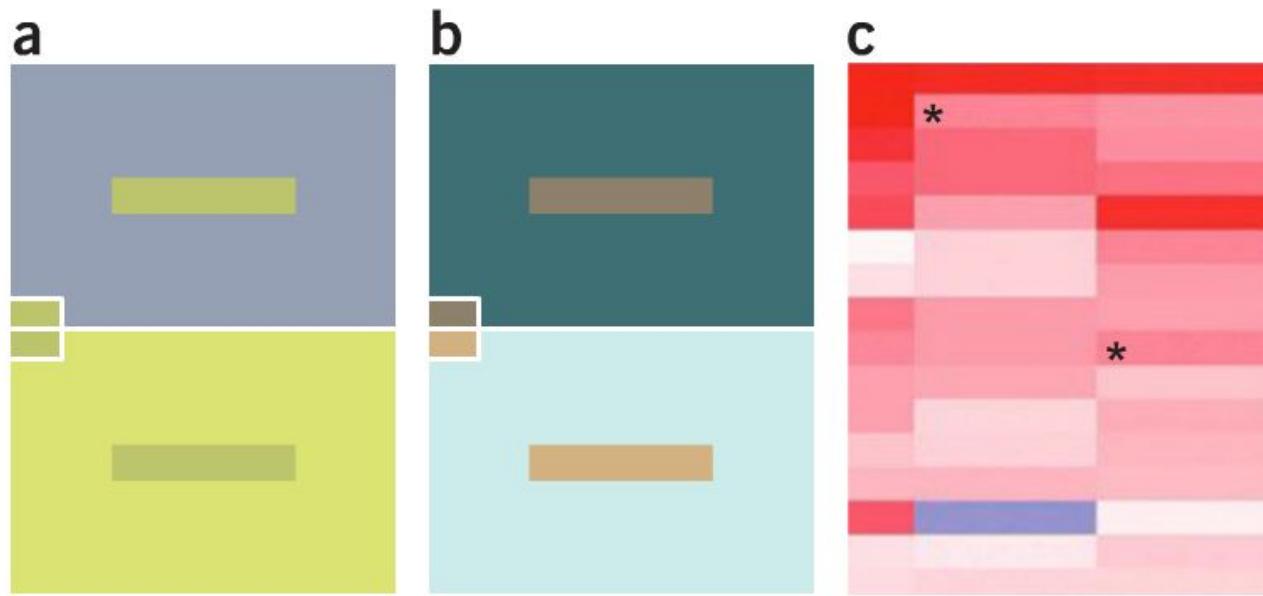
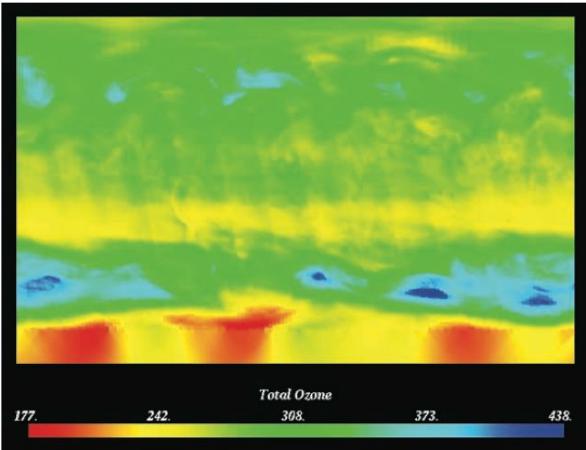
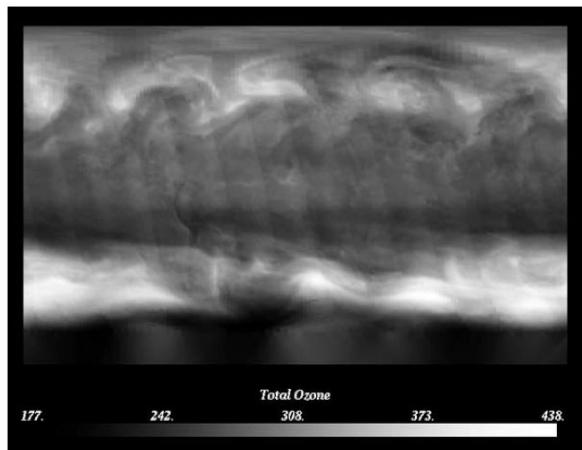
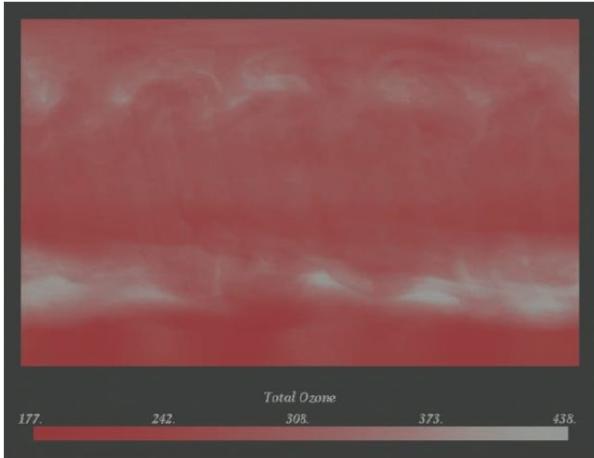


Figure 1 | Perception of color can vary. (a,b) The same color can look different (a), and different colors can appear to be nearly the same by changing the background color (b)¹. (c) The rectangles in the heat map indicated by the asterisks (*) are the same color but appear to be different.

2. Artifacts



Saturation



Total Ozone

177.

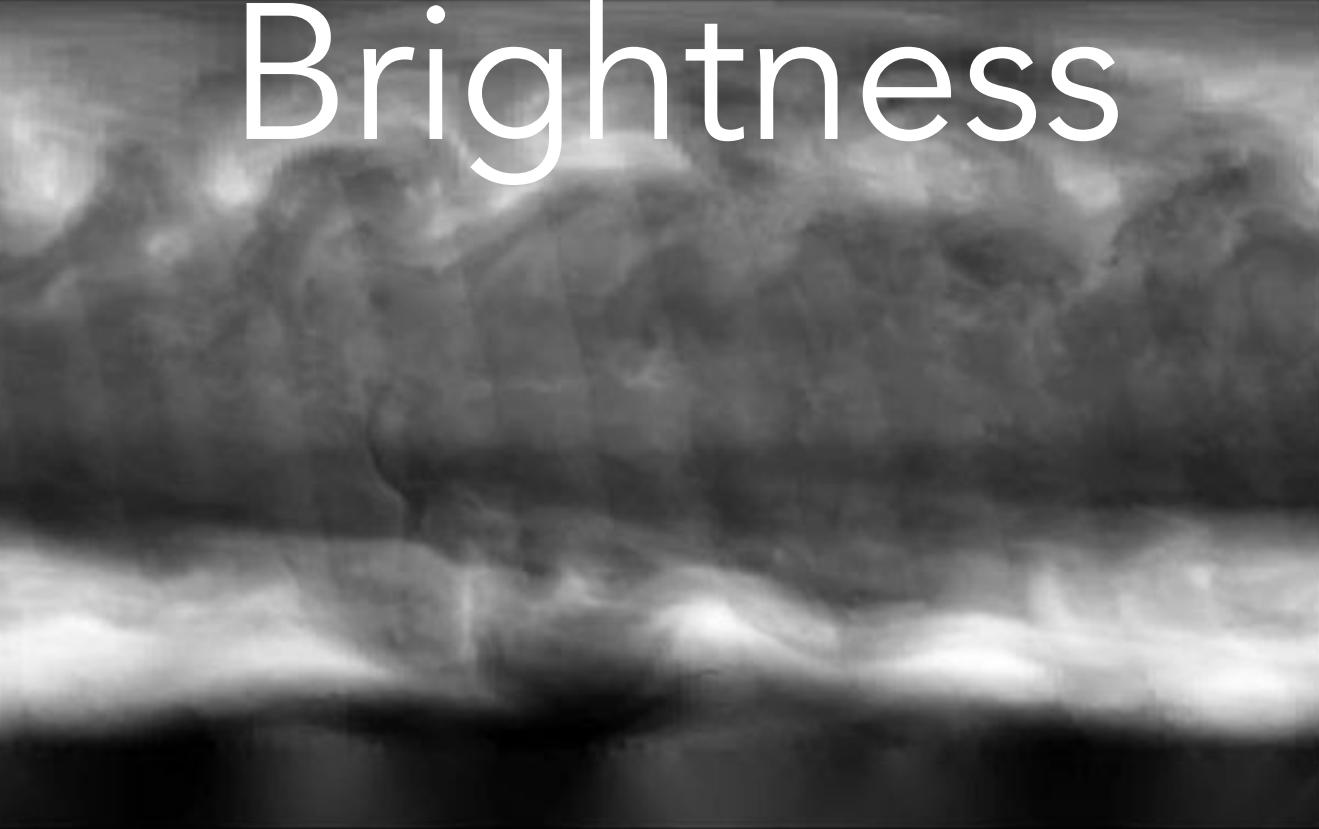
242.

308.

373.

438.

Brightness



Total Ozone

177.

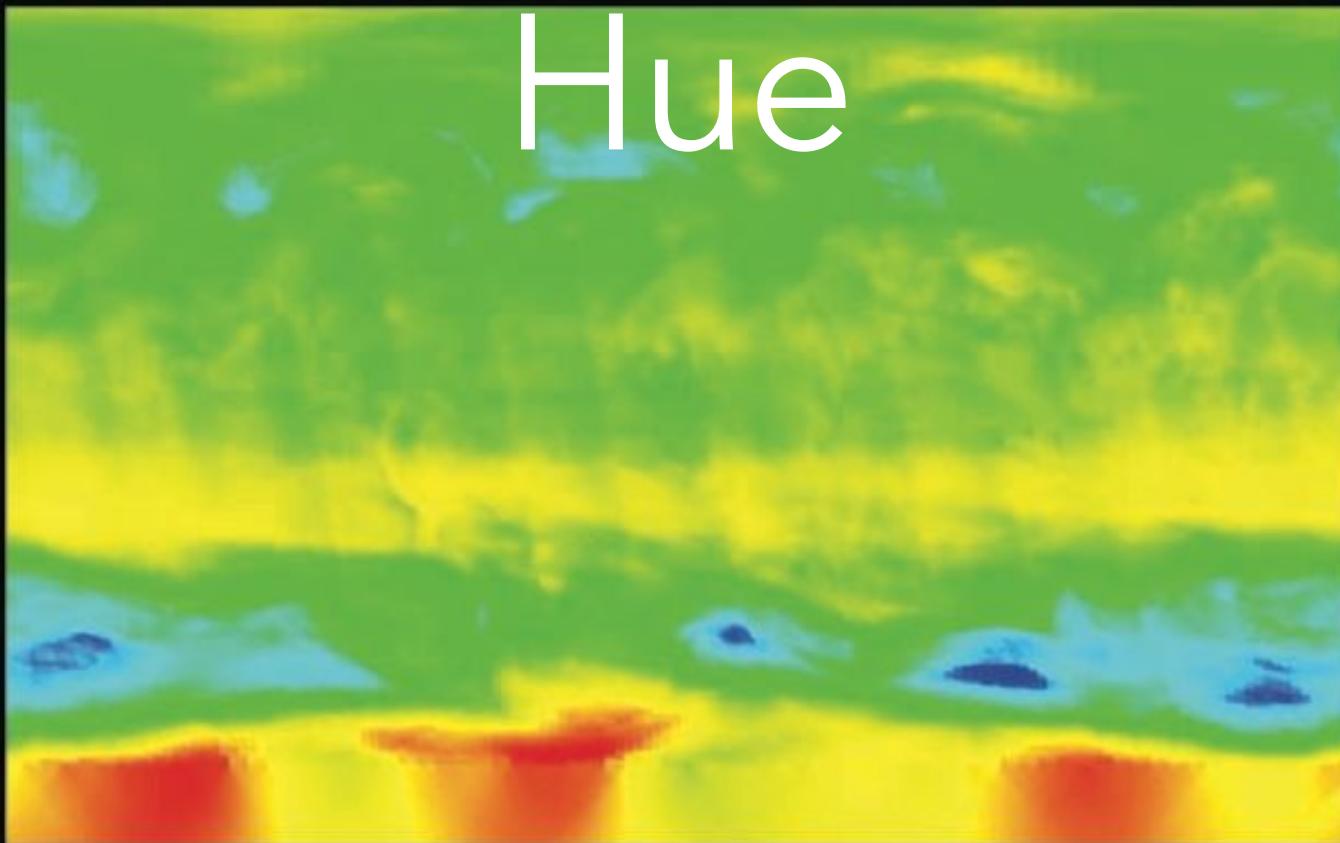
242.

308.

373.

438.

Hue



Total Ozone

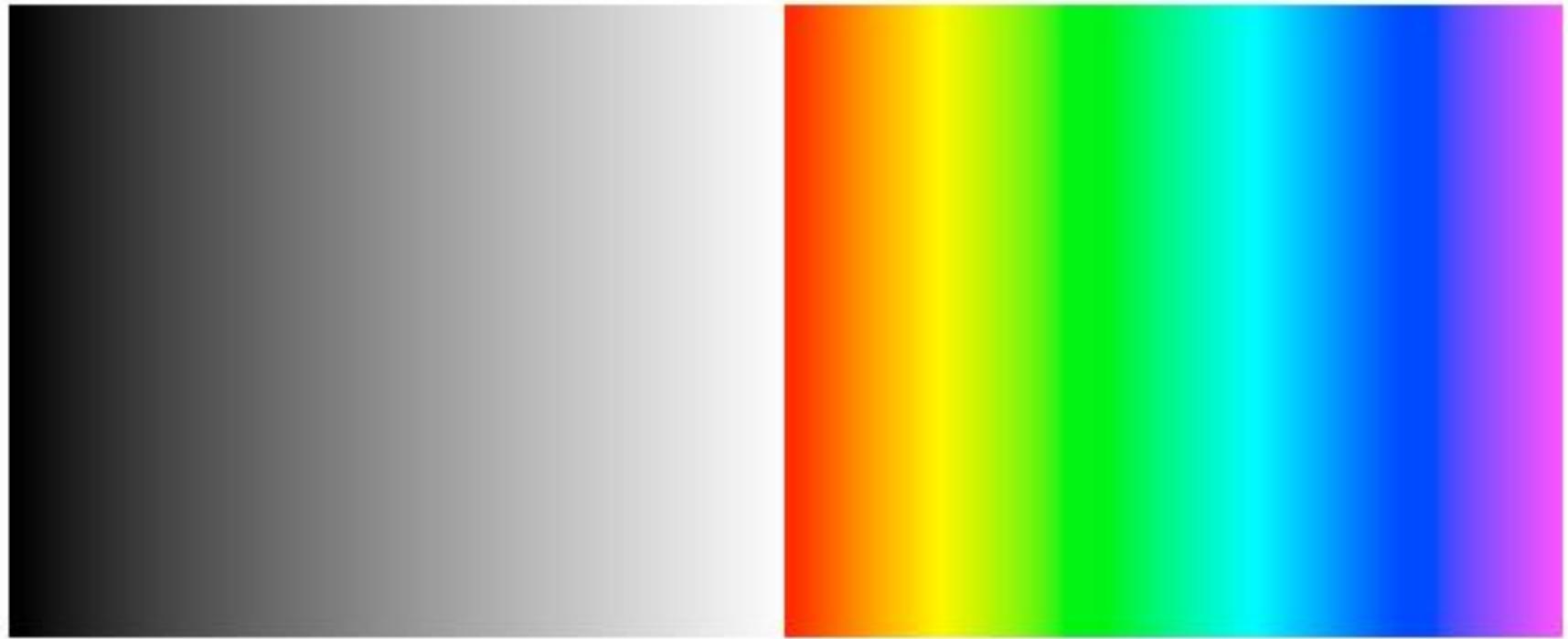
177.

242.

308.

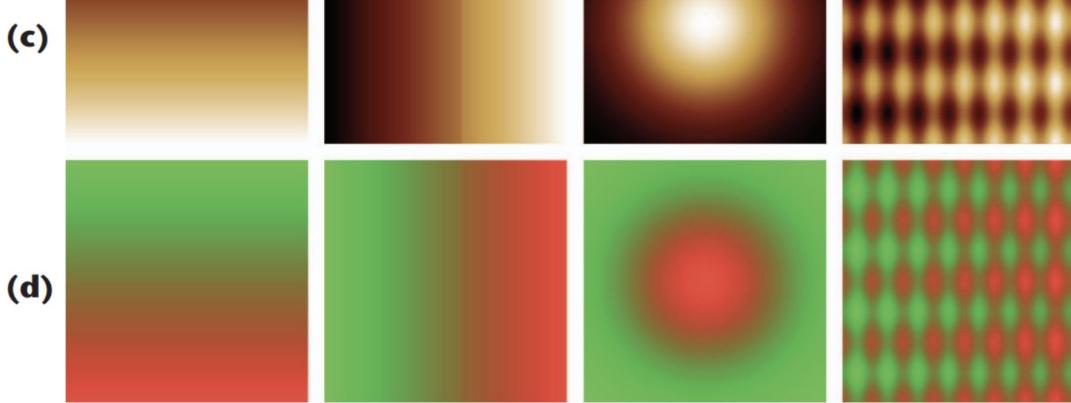
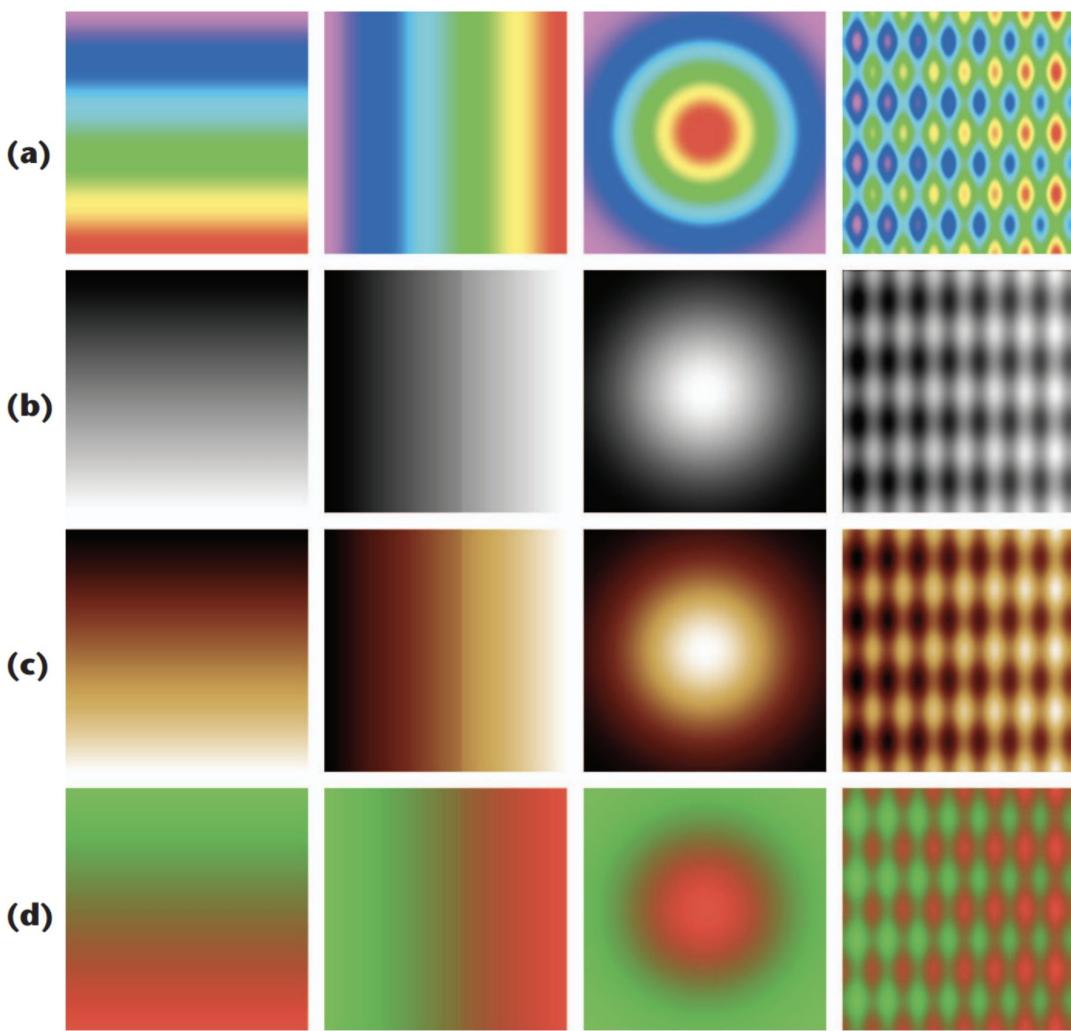
373.

438.



http://www.jwave.vt.edu/~rkriz/Projects/create_color_table/color_07.pdf

<http://www.sci.utah.edu/~miriah/cs6964/lectures/L05-encoding.pdf>



3. Legibility and Media dependency

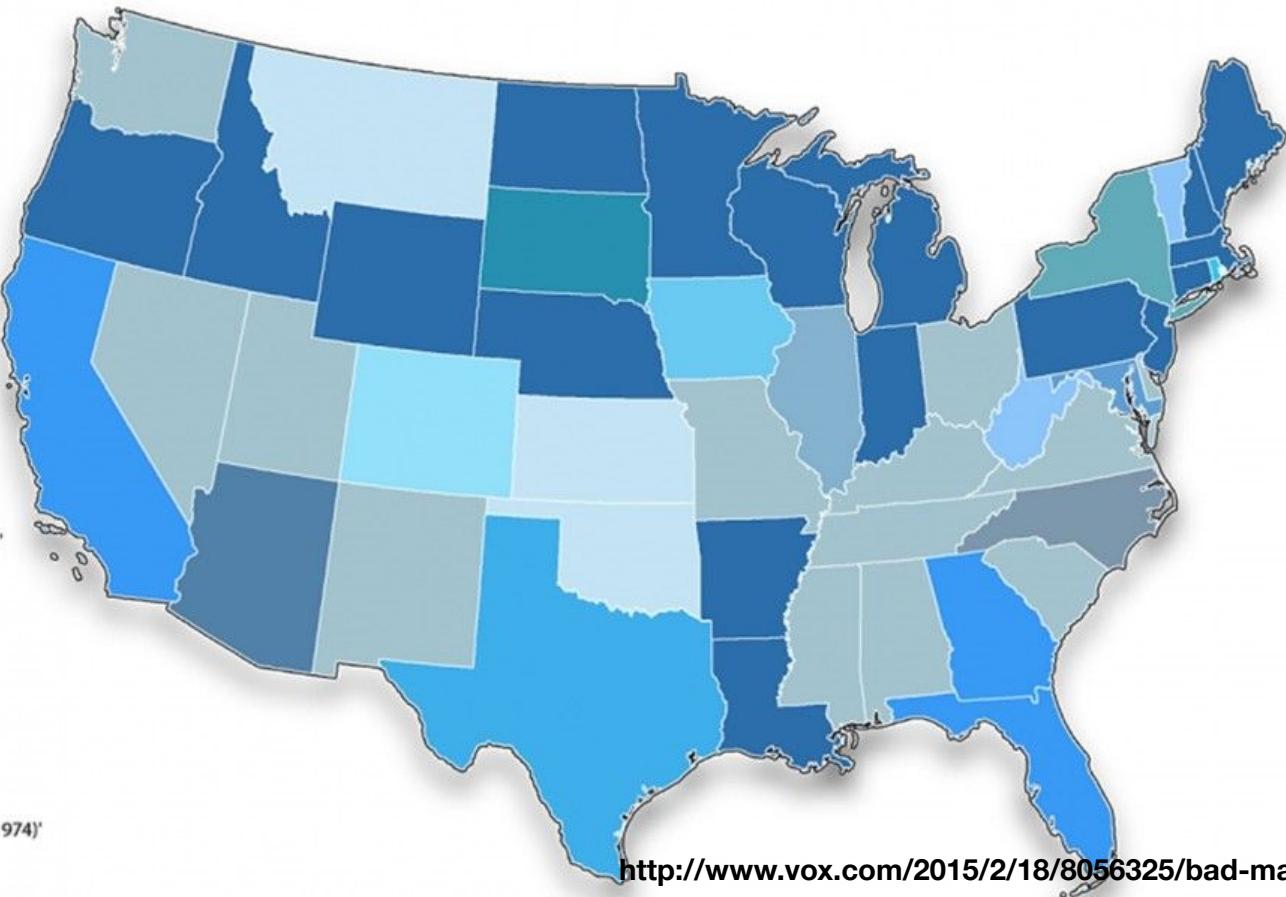
Obama's Divided Nation

ma presides over a more divided country than at any time in 50 years. A country that was riven by racial lines gathered in 2008 to elect its first black president. That president spent four years dividing the nation on the basis of economic class. The campaign revealed no evidence that Mr. Obama will close the chasm he has created between his voters and



- R.I.
- Conn.
- Del.
- D.C.

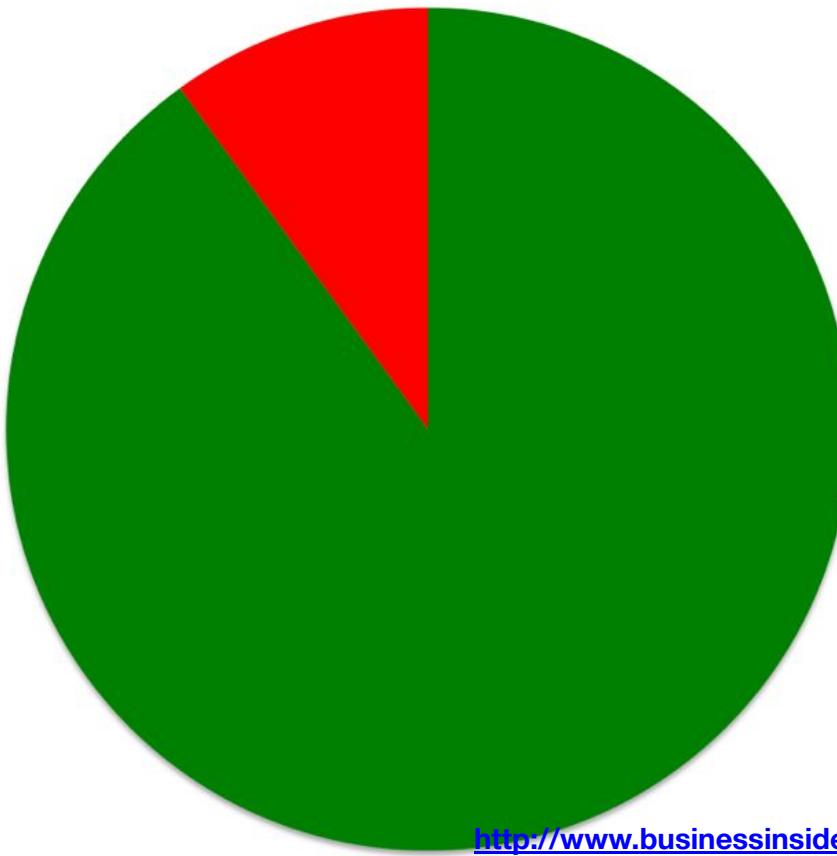
- 'Are We Faded'
by Keys N Krates
- 'Breath'
by Croquet Club
- Classic (Feat. Powers)
by The Knocks
- 'Desert Night'
by RUFUS DU SOL
- 'Don't Ask Why (Feat. Kyiki) (Radio Edit)'
by Moon Boots
- 'Favourite Addiction (Feat. Clarian)'
by Digitaria
- 'Forever'
by Majid Jordan
- 'Heroes (We Could Be) (Feat. Tove Lo)'
by Alesso
- 'I Lived (Arty Remix)'
by OneRepublic
- 'Lovers On The Sun (Feat. Sam Martin) (Extended)'
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by Kraak & Smaak
- 'Right For You (Feat. Banks)'
by Lil Silva
- 'Take Me'
by RUFUS DU SOL
- 'Tell You Why'
by Route 94
- 'When We Were Young (Feat. The Chain Gang Of 1974)'
by Dillon Francis & Sultan & Ned Shepard



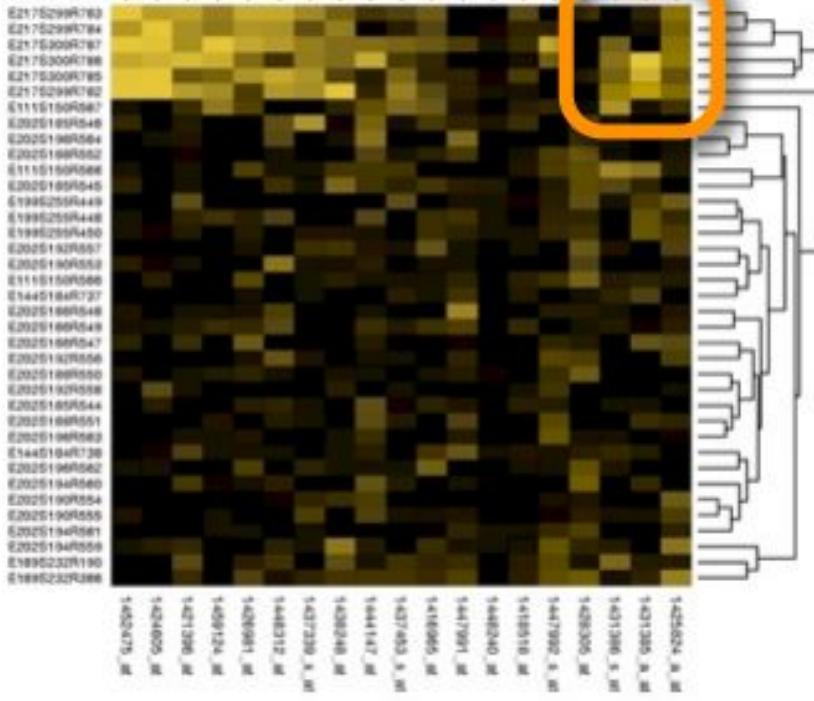
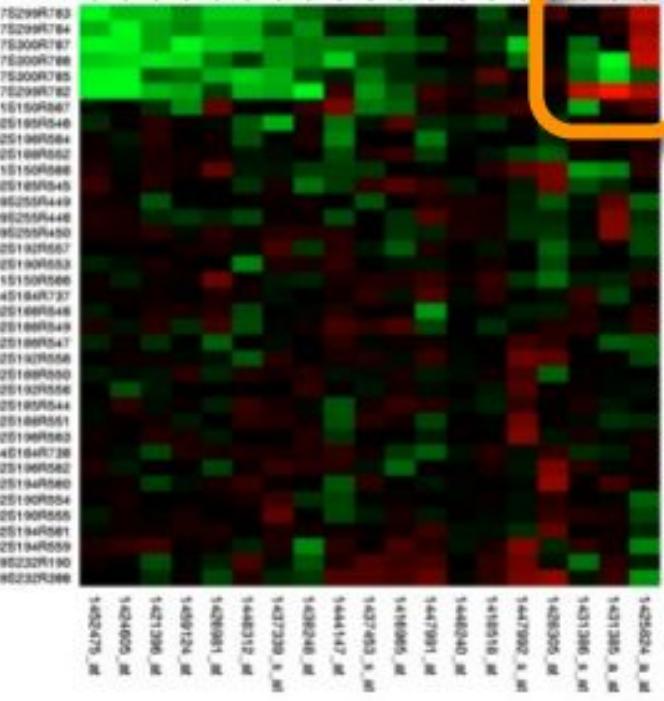
4. Some colors are
worse than others

Red-green colorblindness in men

■ Don't have it ■ Have it



More common



Colors for categorical data

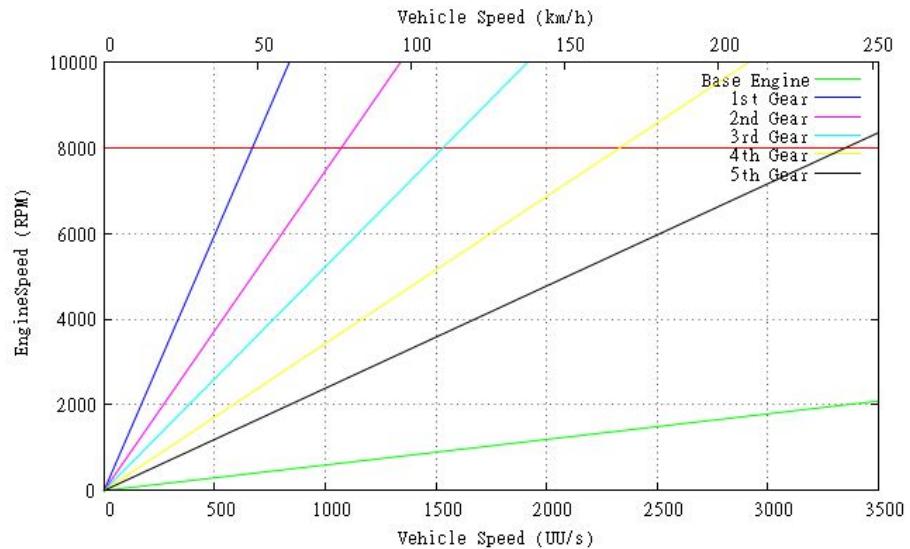
#1 Colors should be
visible

**Showing small yellow text on a white background is a bad idea.
There is insufficient luminance contrast.**

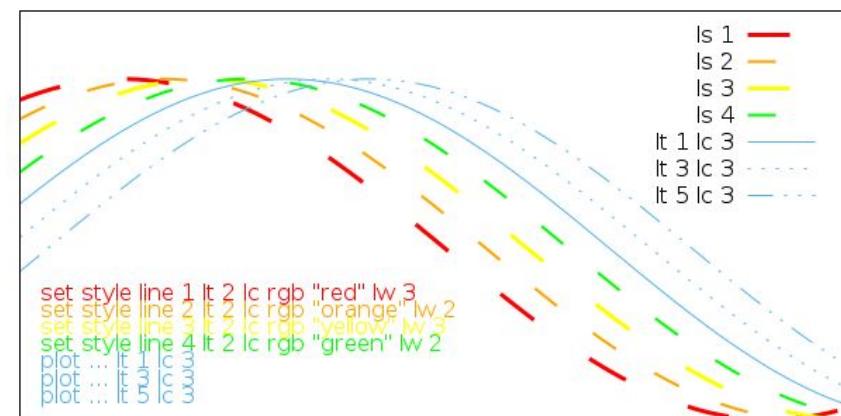
**Showing small yellow text on a white background is a bad idea.
There is insufficient luminance contrast.**

**Showing small blue text on a black background is a bad idea.
There is insufficient luminance contrast.**

**Showing small blue text on a black background is a bad idea.
There is insufficient luminance contrast.**

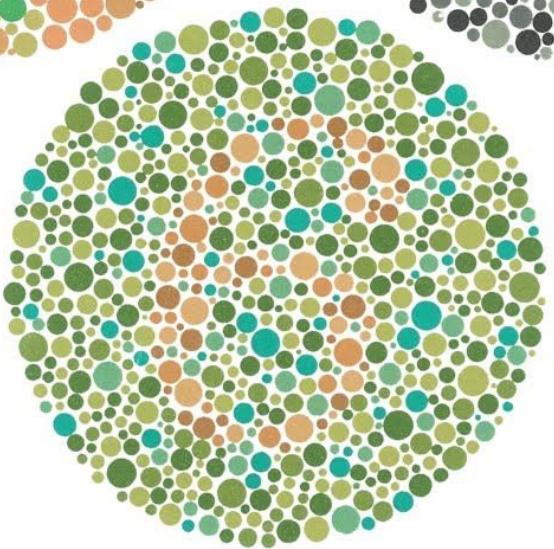
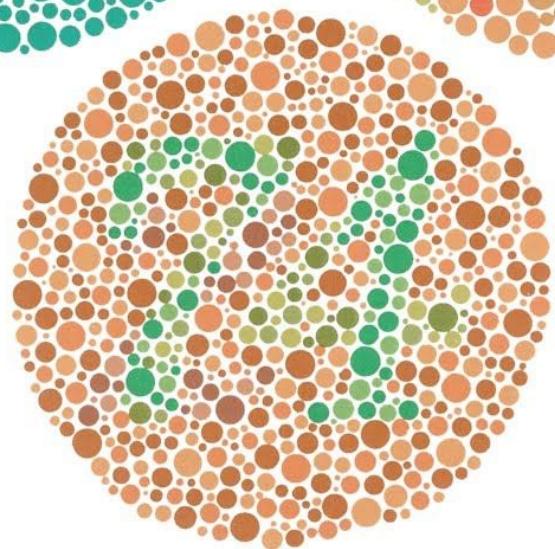
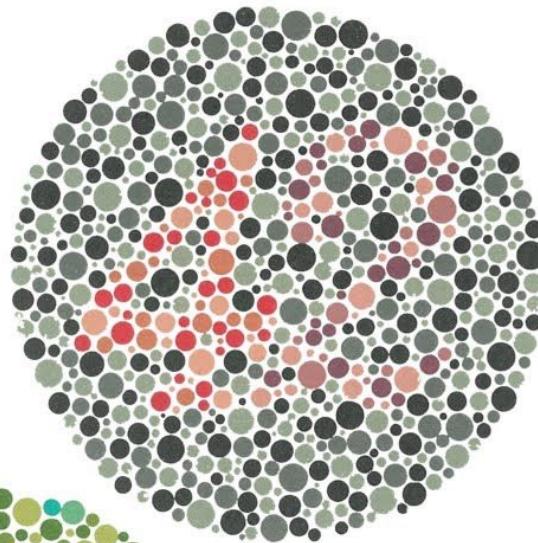
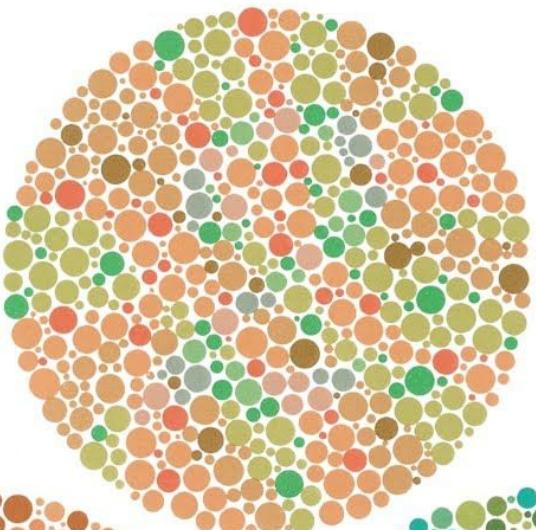
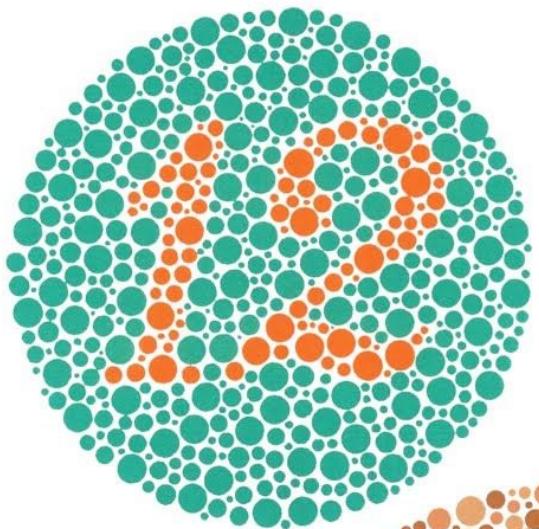


Independent colors and dot/dash styles



You will only see dashed lines if your current terminal setting permits it

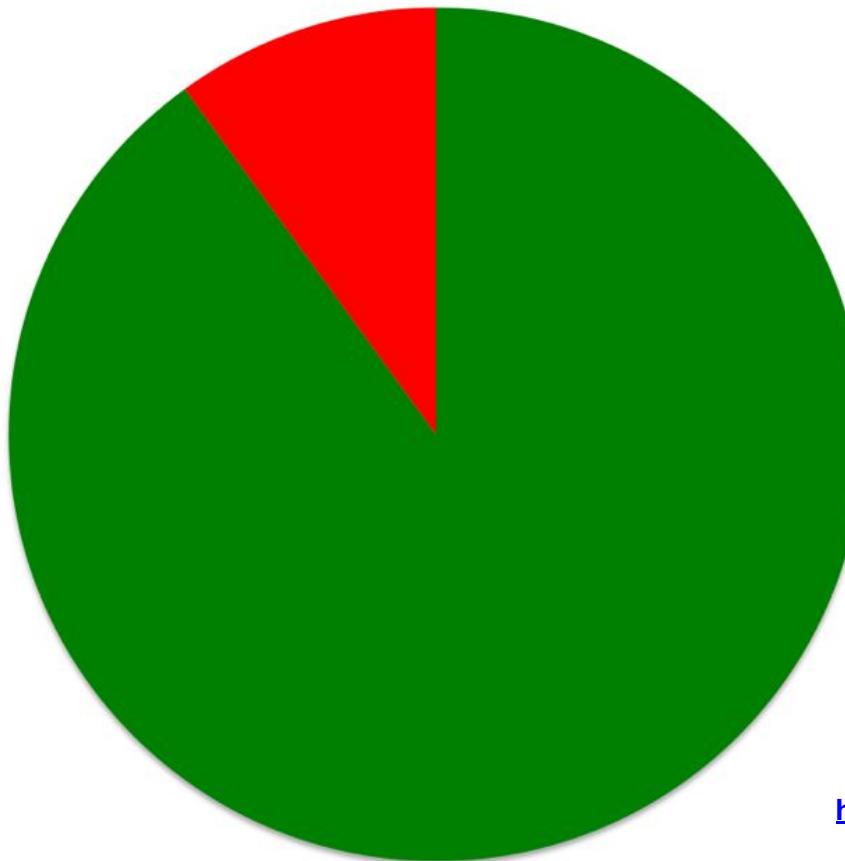
#2 Colors should
be distinguishable





Red-green colorblindness in men

■ Don't have it ■ Have it







Let's get color blind

Add to Chrome

Featured

★★★★★ 17 ⓘ | Accessibility | 5,000+ users

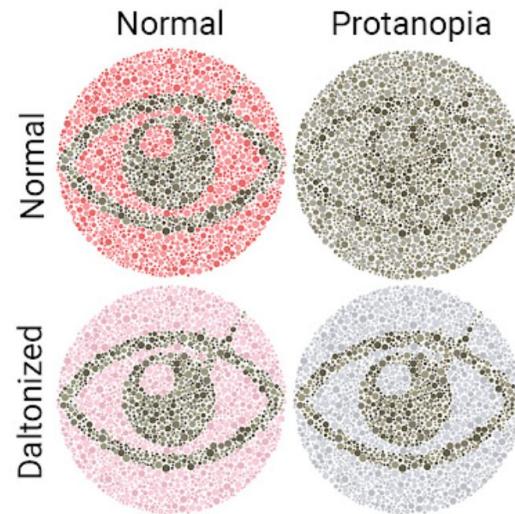
Overview

Privacy practices

Reviews

Support

Related



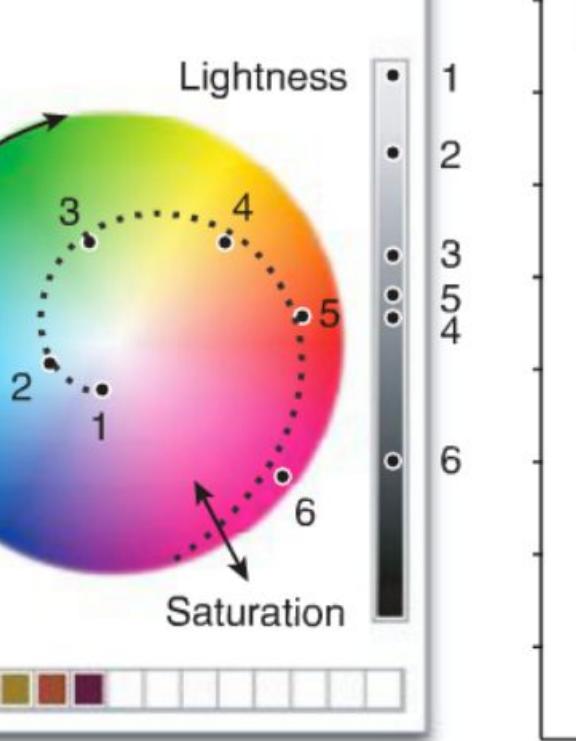
Media



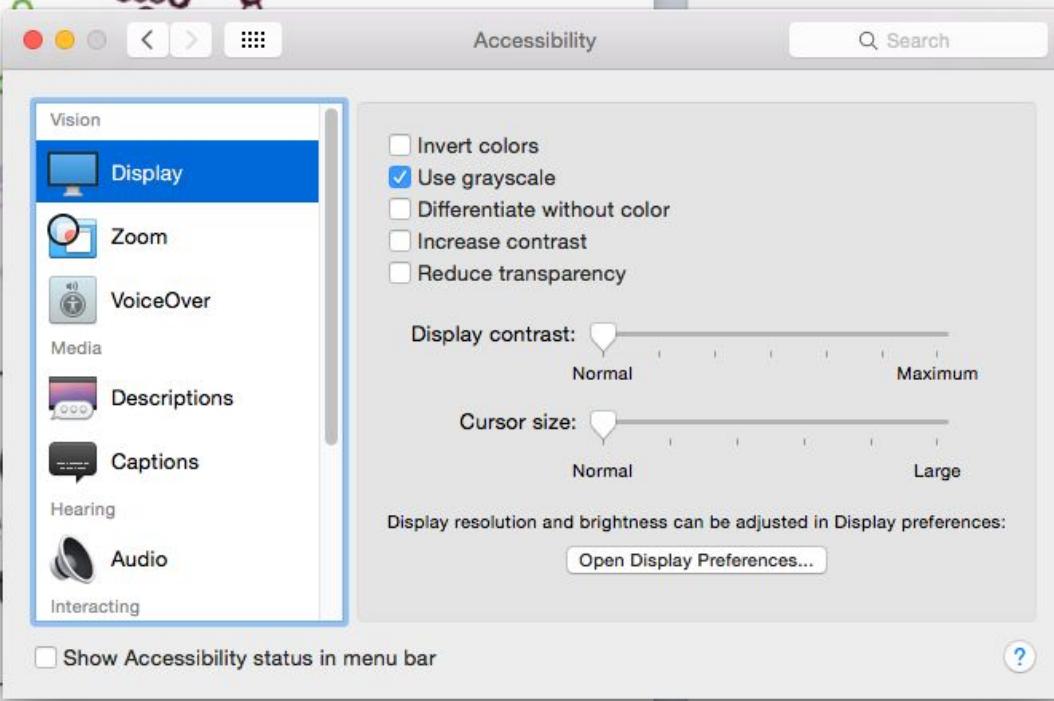
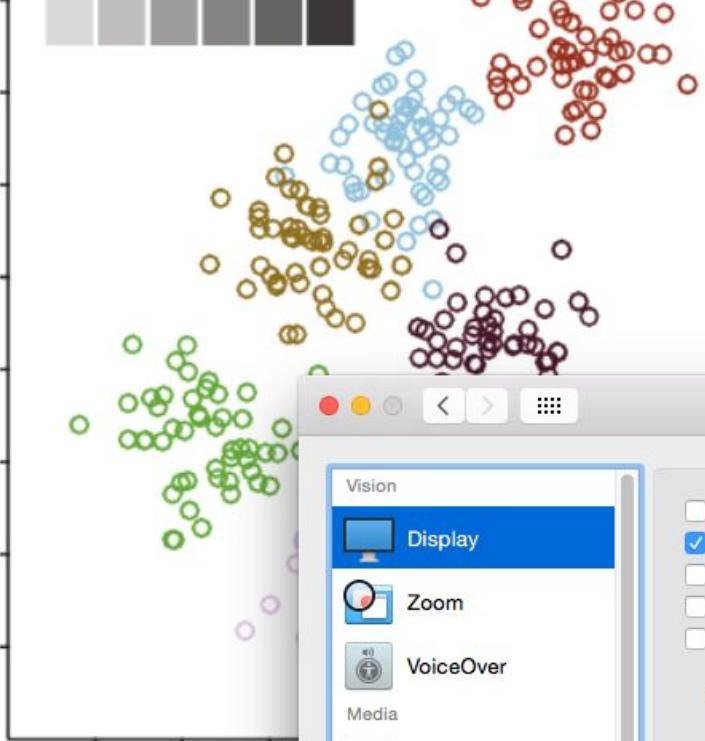
Obama's Divided Nation

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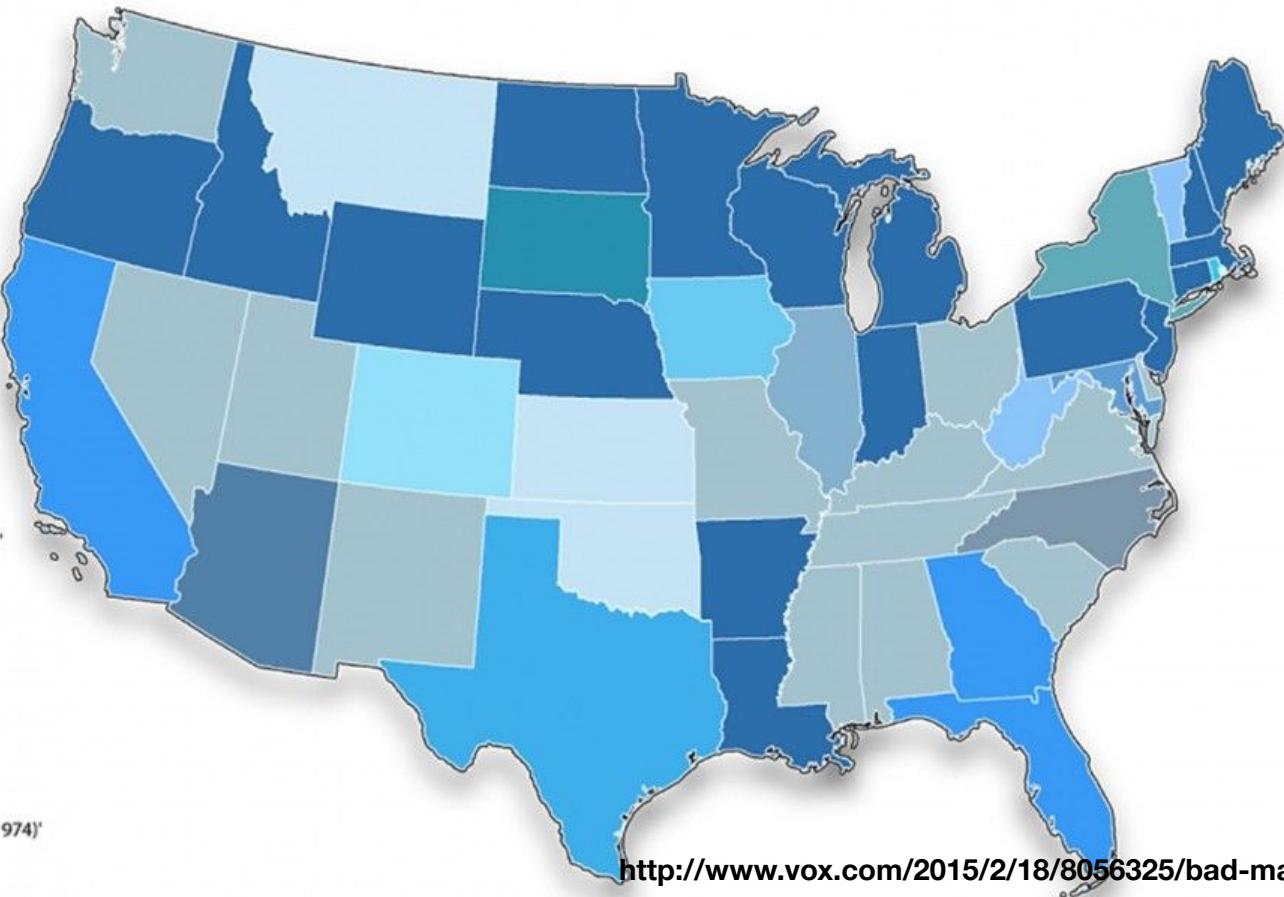


Color has hue, saturation and brightness. Using a color picker (a). Spiraling through hue and brightness can generate a discernible color set (points labeled 1–6).



Number of
colors

- 'Are We Faded'
by Keys N Krates
- 'Breath'
by Croquet Club
- Classic (Feat. Powers)
by The Knocks
- 'Desert Night'
by RUFUS DU SOL
- 'Don't Ask Why (Feat. Kyiki) (Radio Edit)'
by Moon Boots
- 'Favourite Addiction (Feat. Clarian)'
by Digitaria
- 'Forever'
by Majid Jordan
- 'Heroes (We Could Be) (Feat. Tove Lo)'
by Alesso
- 'I Lived (Arty Remix)'
by OneRepublic
- 'Lovers On The Sun (Feat. Sam Martin) (Extended)'
by David Guetta
- 'Mountain Top (Radio Edit)'
by Kraak & Smaak
- 'Right For You (Feat. Banks)'
by Lil Silva
- 'Take Me'
by RUFUS DU SOL
- 'Tell You Why'
by Route 94
- 'When We Were Young (Feat. The Chain Gang Of 1974)'
by Dillon Francis & Sultan & Ned Shepard



When you use colors for categorical data...

1. Are there enough **contrast**? Can you actually see the data?
2. Are your colors clearly **distinguishable**?
 - How about for **colorblind** people?
 - How about in **greyscale**?
3. Do you have **too many categories**?
 - How can you reduce the number of categories or colors?

More practical
tips

Tip #1

Print your
visualizations

Obama's Divided Nation

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The image displays a color picker interface on the left, featuring a circular color wheel with points labeled 1 through 6, a vertical brightness slider, and a grayscale bar. Below it is a small color calibration strip. In the center is a scatter plot with colored data points. On the right is a Mac OS X Accessibility settings window titled "Vision".

Slide Number

Background

[Edit Master Slide](#)

Lightness

Saturation

1 2 3 4 5 6

1 2 3 4 5 6

Accessibility

Search

Vision

Display

Zoom

VoiceOver

Media

Descriptions

Captions

Hearing

Audio

Interacting

Invert colors

Use grayscale

Differentiate without color

Increase contrast

Reduce transparency

Display contrast:

Normal Maximum

Cursor size:

Normal Large

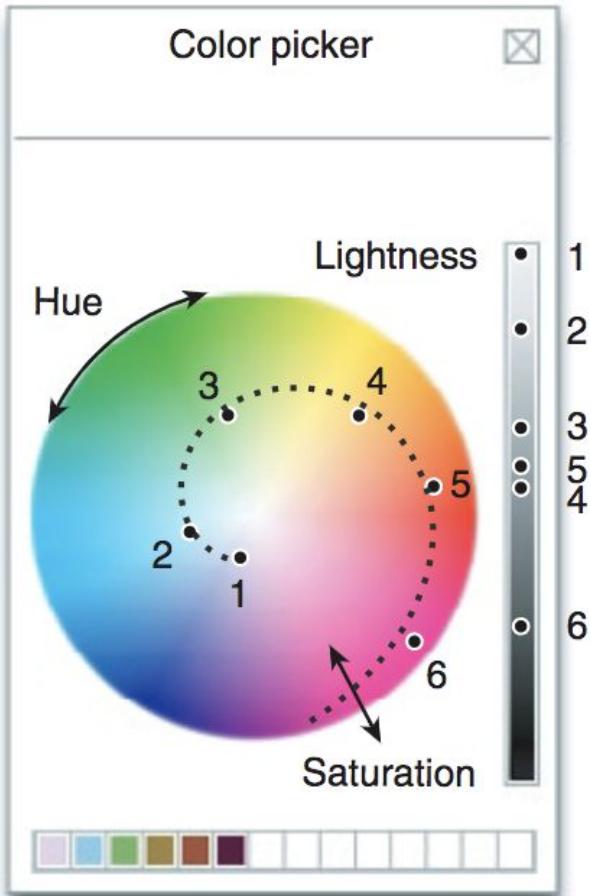
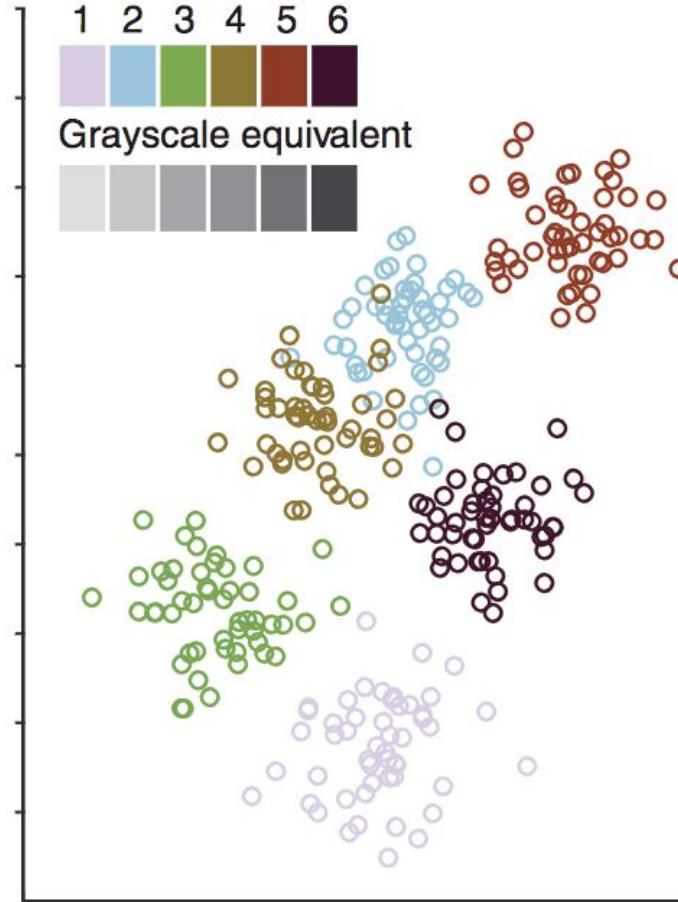
Display resolution and brightness can be adjusted in Display preferences:

[Open Display Preferences...](#)

Show Accessibility status in menu bar

Tip #2

Vary more aspects
together

a**b**

Tip #3

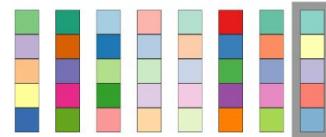
Use existing
colorschemes that
work

Number of data classes: **3**

Nature of your data:

sequential diverging qualitative

Pick a color scheme:



Only show:

- colorblind safe
- print friendly
- photocopy safe

Context:

- roads
- cities
- borders

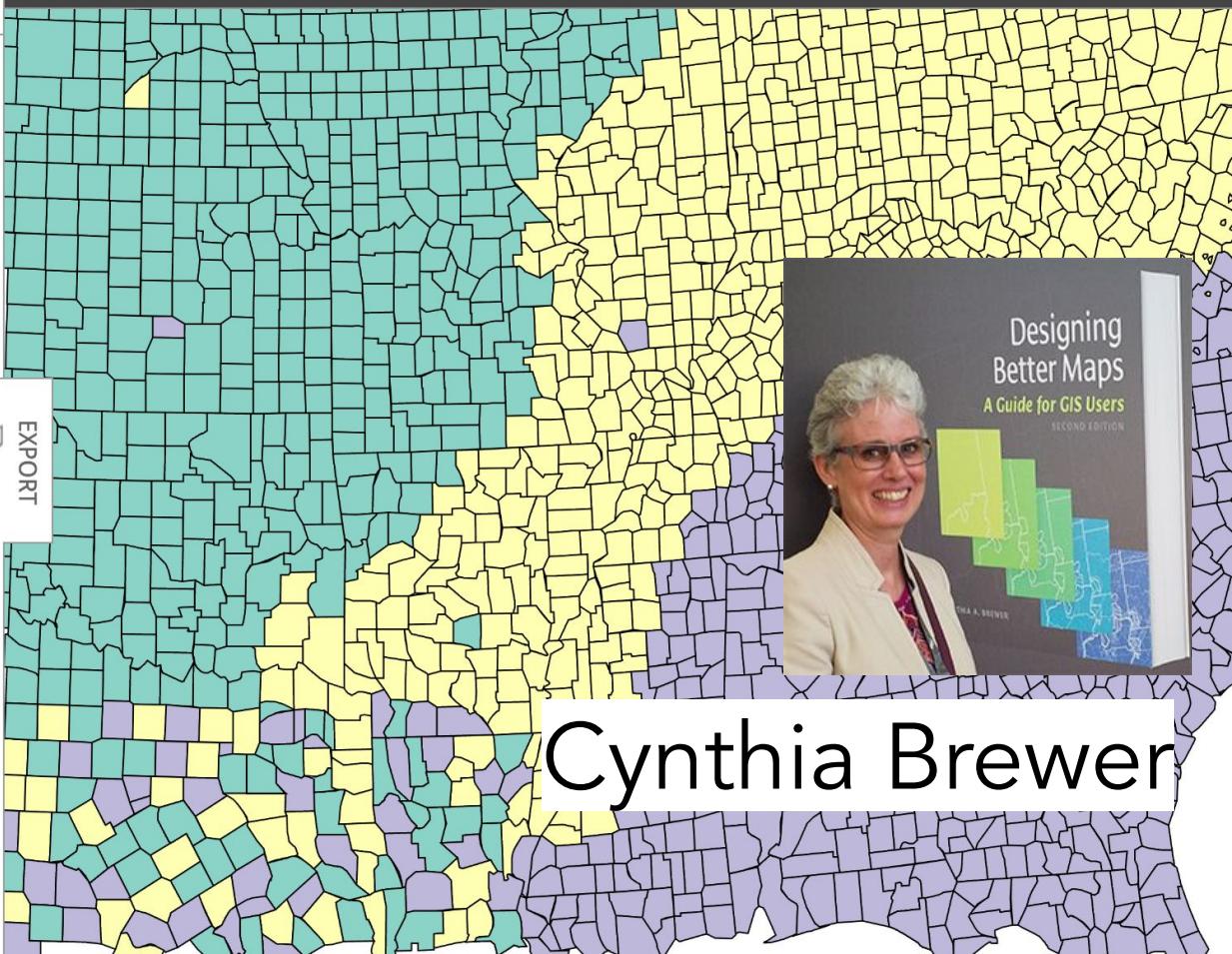
Background:

- solid color
- terrain

color transparency

[how to use](#) | [updates](#) | [downloads](#) | [credits](#)

COLORBREWER 2.0
color advice for cartography



Colors for quantitative data

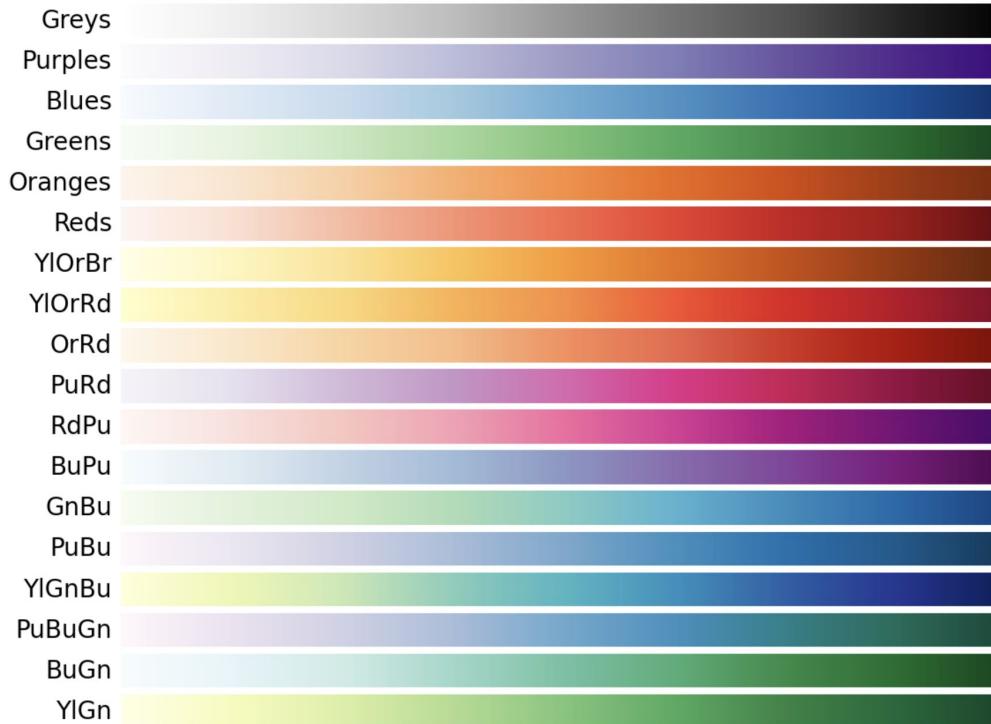
What are the
challenges?

#1 Colors should be
visible

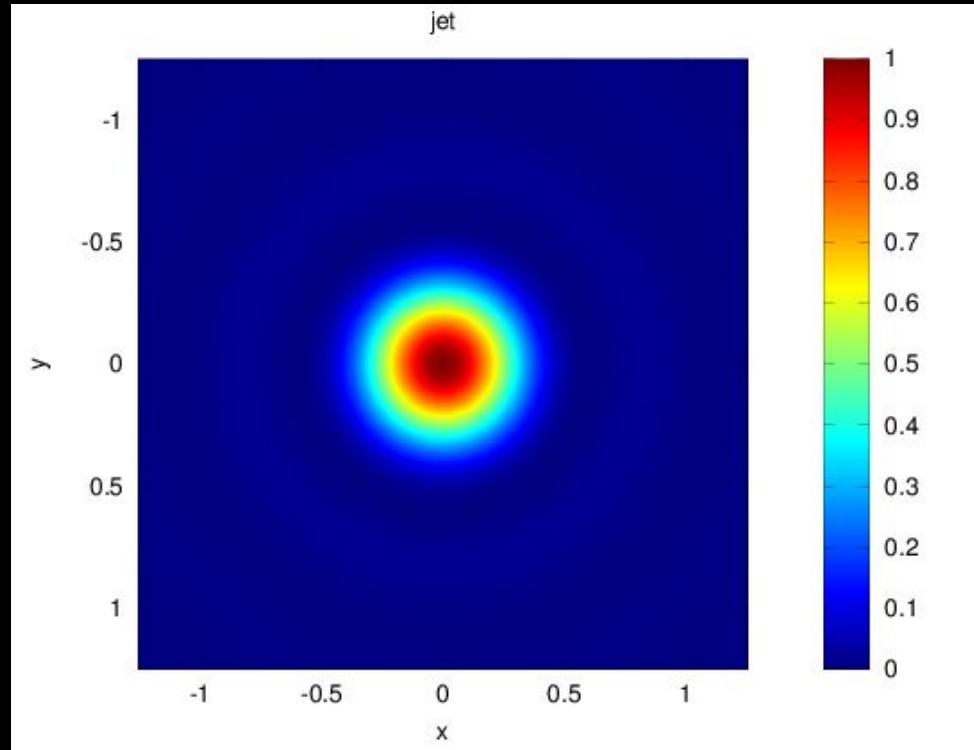
#2 Colors should be
distinguishable

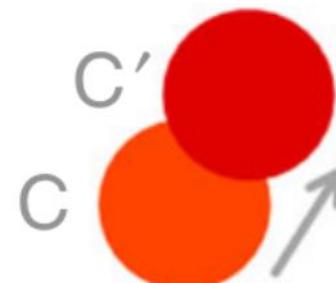
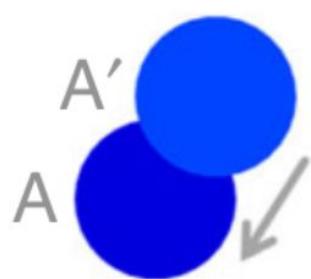
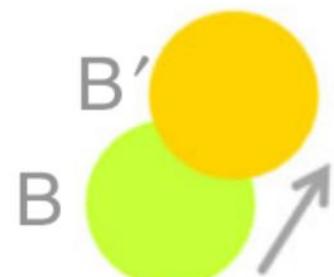
(But, how many colors do we
need?)

“Color map”



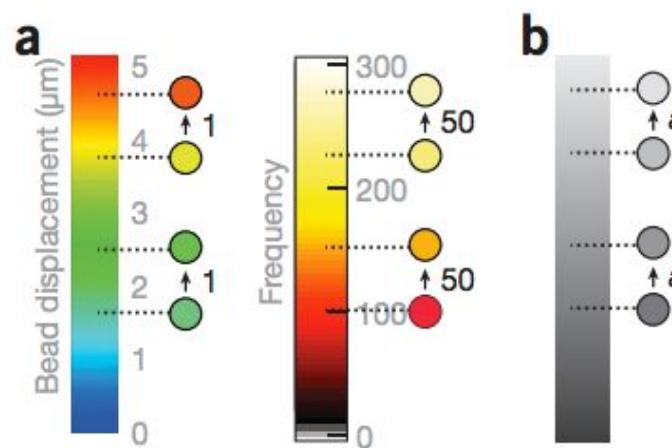
Example: “Jet” colormap





Many colormaps tend to be perceptually non-uniform

Figure 2 | Color is not ideal for presenting quantitative data. (a) Shifts in color scales (circles) are not visually commensurate with change in value. Reprinted from *Nature Methods*^{2,5}. (b) A gradation from 10–90% black produces even transitions.



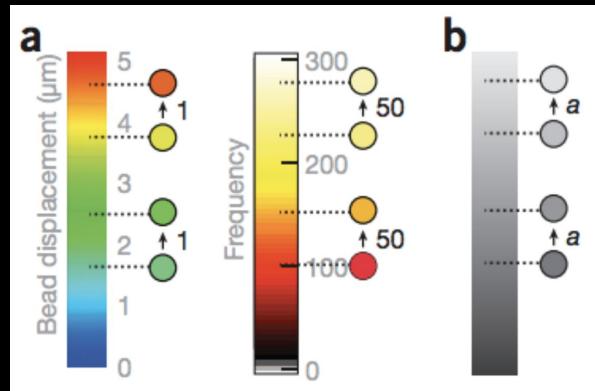
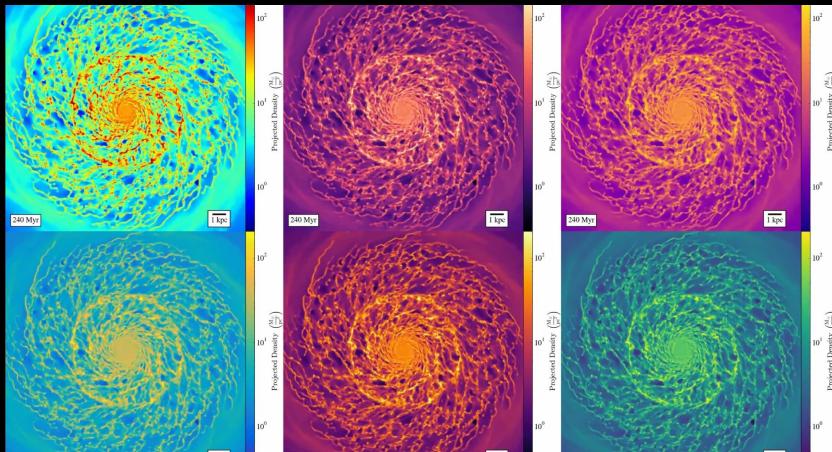
But excellent colormaps
exist!



 SciPy2015

<https://www.youtube.com/watch?v=xAoIjeRJ3IU>

“perceptually uniform colormap”: If data changes by a certain amount, the corresponding perceptual change in colormap is proportional to the amount, regardless of the location in the colormap.





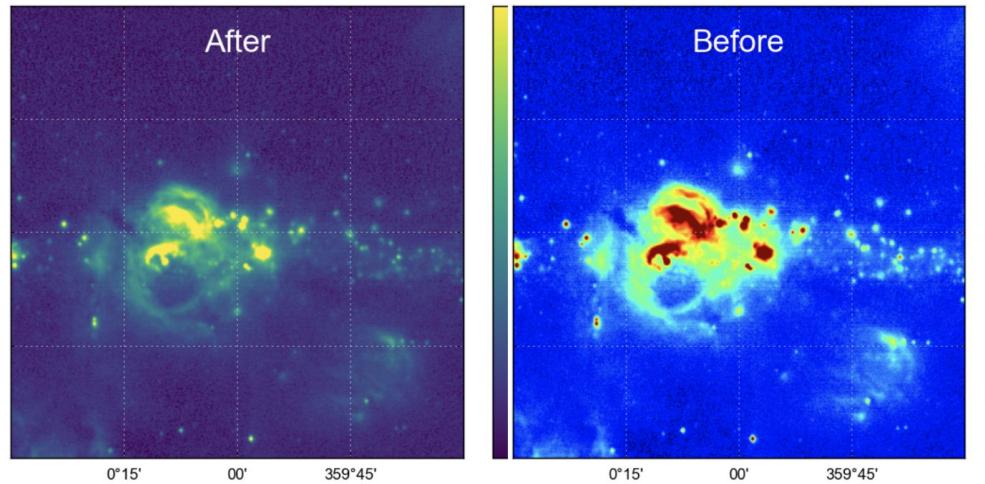
Thomas Robitaille

@astrofrog

Follow



VERY happy with the future default
#matplotlib colormap. Down with jet, long
live viridis! #python #visualization



7:14 AM - 20 Jul 2015

Colour-vision deficient (CVD)

Colour-blind



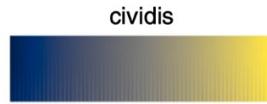
Deutanopia

Protanopia

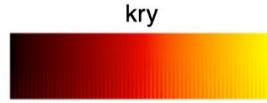
Tritanopia

Grey scale

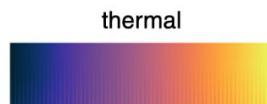
✓



✓



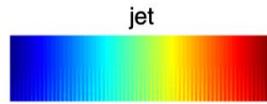
✓



✓



✓

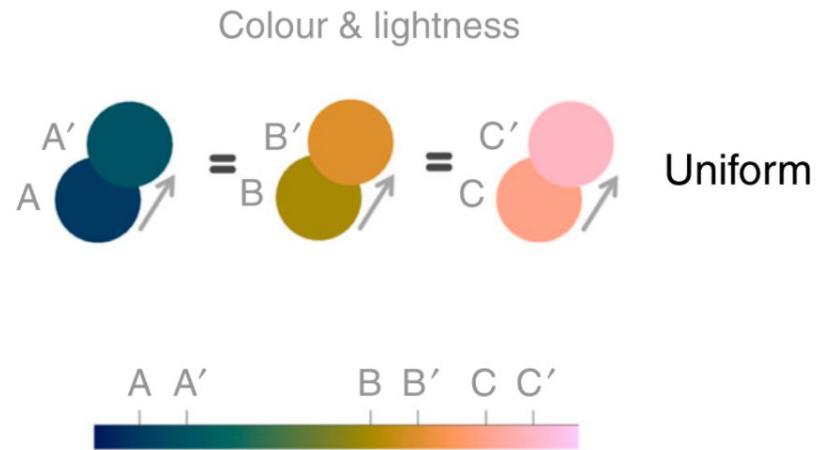


X

CVD-friendly

Incremental contrast

b



Intuitive order

d



More considerations

Intuitive colors?
(conventions)

Meaningful
middle point?

Brewer Sequential
Segmented



Brewer Divergent
Segmented

