

DATA 230 Spring 2023

Week 4

Lecture 4:

Color (Hue, Luminance, Saturation)

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DATA 230: Data Visualization

Review: How to Visualize?

Complex visual encodings can be broken down into two components:

Mark and Channel

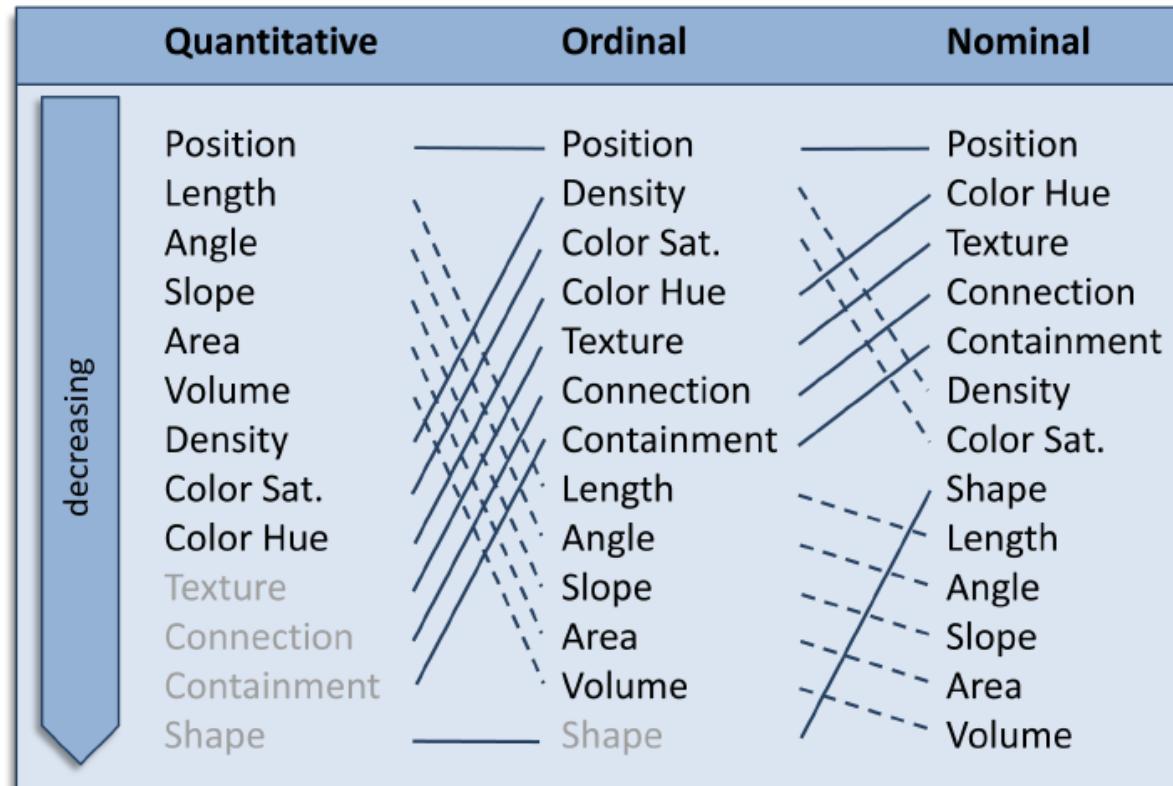
Mark: “basic” geometric elements.

Channel: control the appearance of marks to convey data.

Color/Hue

Good: high accuracy for ordinal or nominal (categorical) data. Easy option to add more features.

Bad: Color blindness/weakness, relative perception (e.g. background color, resolution)

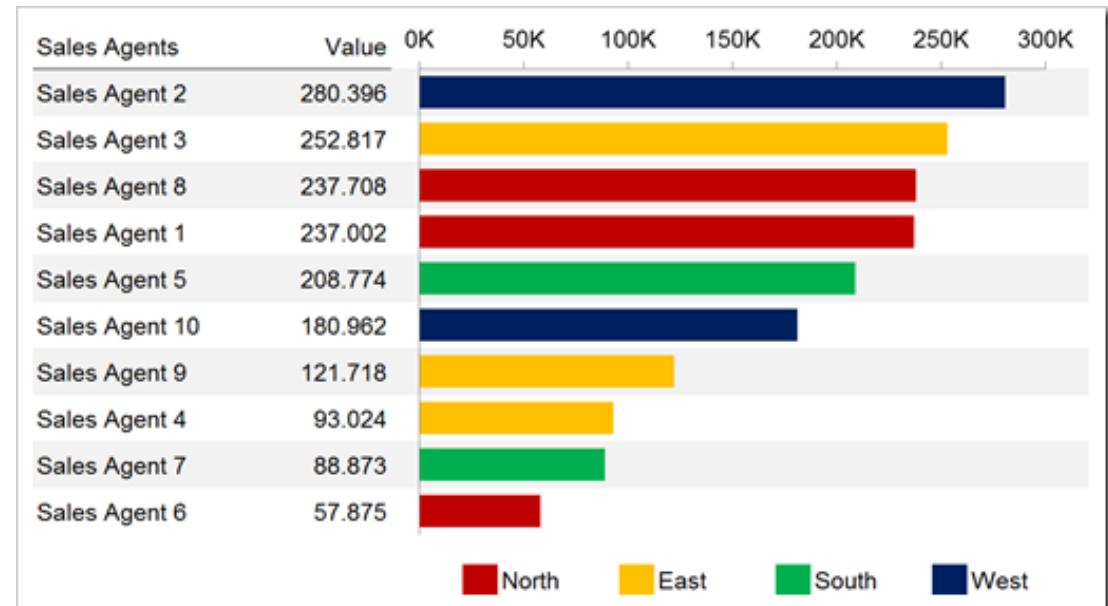
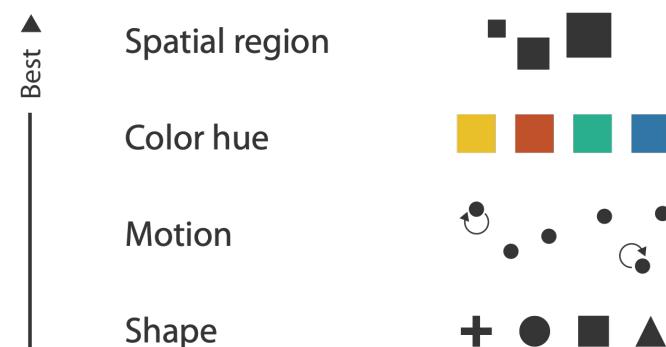


Color/Hue

④ Magnitude Channels: Ordered Attributes

Position on common scale	
Position on unaligned scale	
Length (1D size)	
Tilt/angle	
Area (2D size)	
Depth (3D position)	
Color luminance	
Color saturation	
Curvature	
Volume (3D size)	

⑤ Identity Channels: Categorical Attributes

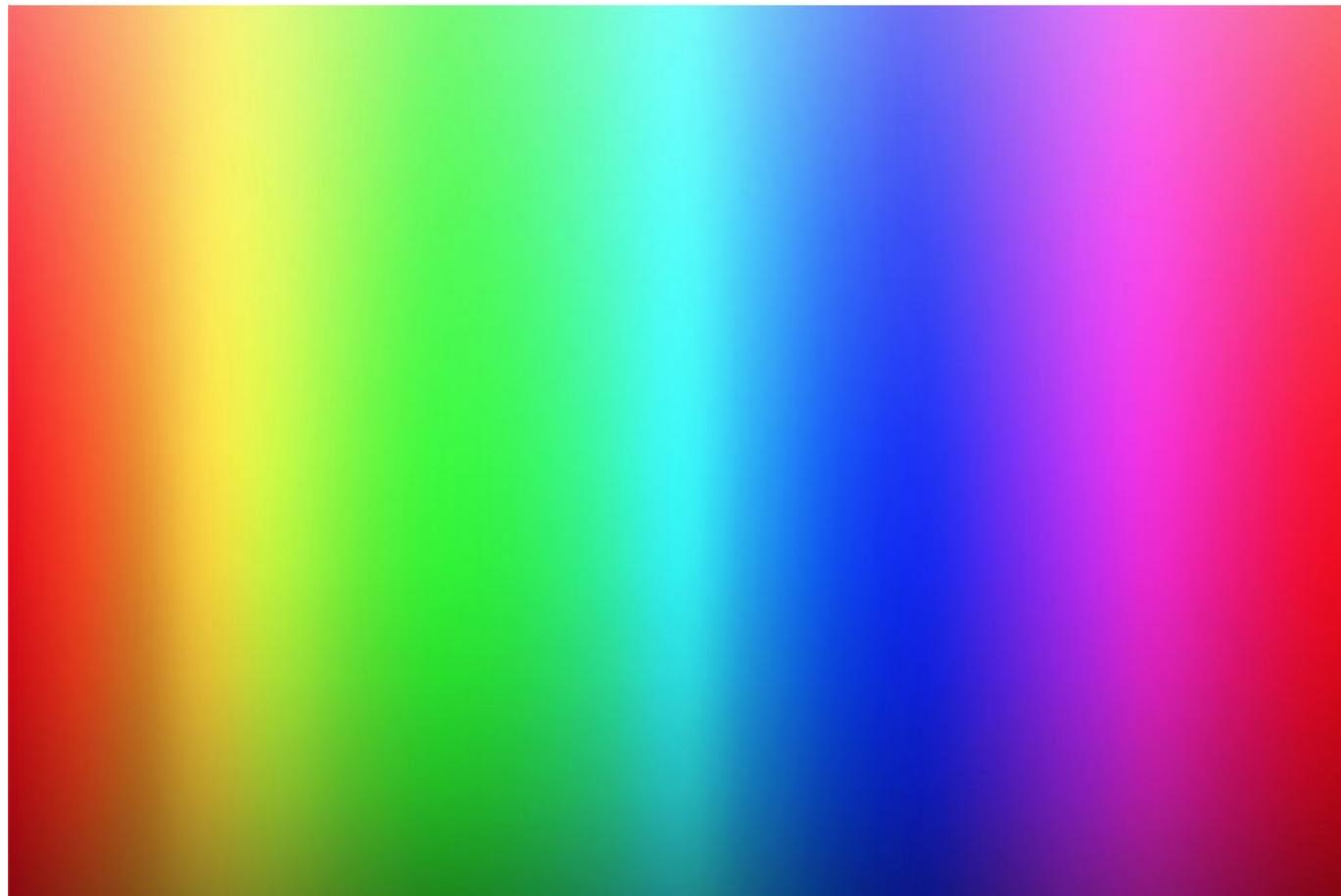


What color is this?

What color is this?

Color/Hue

Color is continuous quantity.



Color

Color is continuous quantity.



(a)



(b)



(c)

Color

Luminance: measured amount of (physical) light ... How bright?

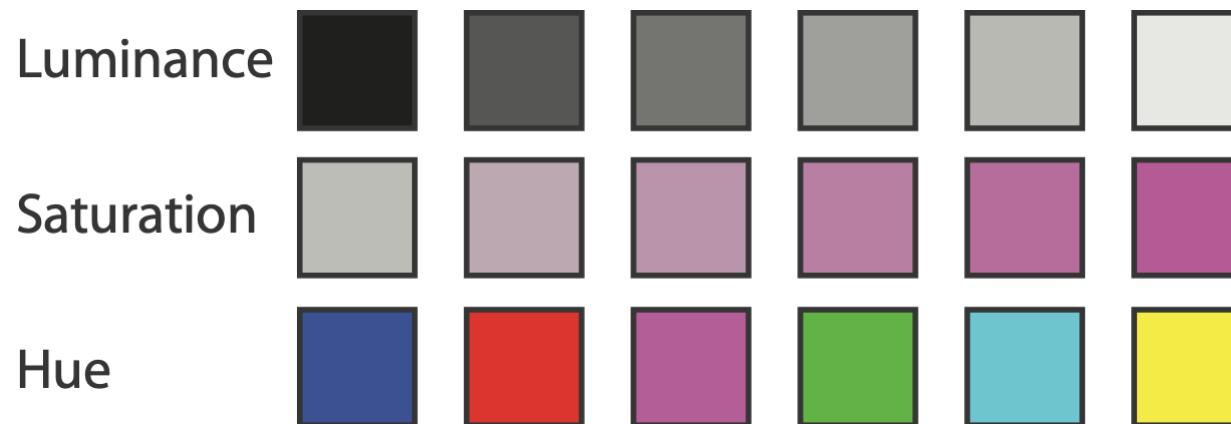
→ The amount of black mixed with that pure color.

Saturation: perceived reflectance of surface ... How colorful?

→ The amount of white mixed

Hue: What pure color?

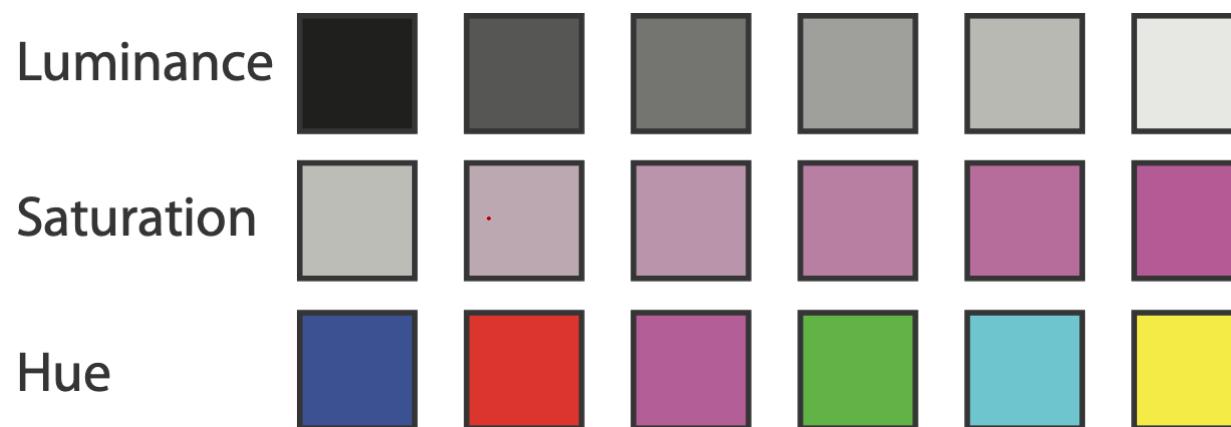
with that pure color



Luminance

Suitable for magnitude channel or ~~identity channel~~?

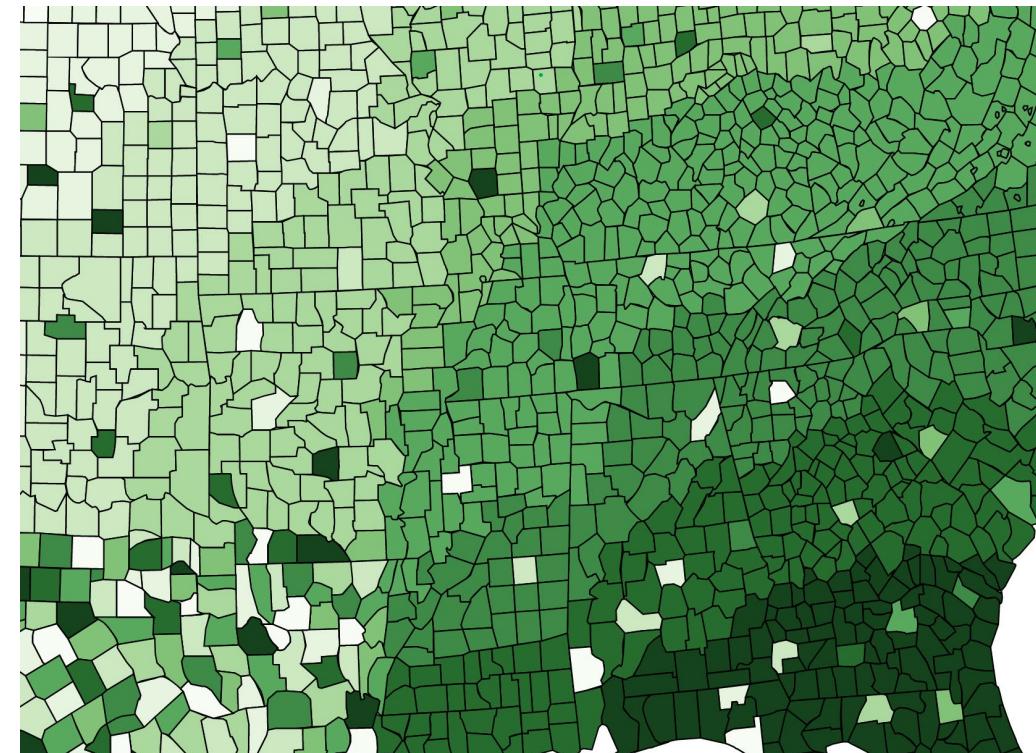
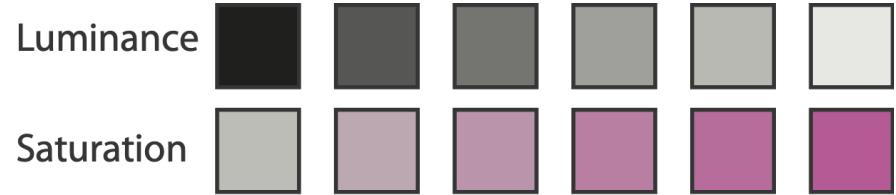
Suitable for ordered data or ~~categorical data~~?



Discriminability in Luminance

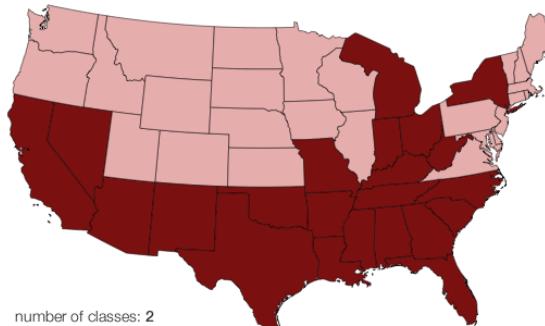
“Contrast effect: It is hard to perceive whether noncontiguous regions have the same luminance.

→ less than 5 levels (bins) when background is not uniform.

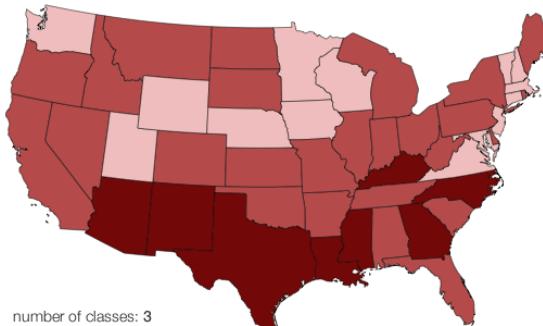


Discriminability in Luminance

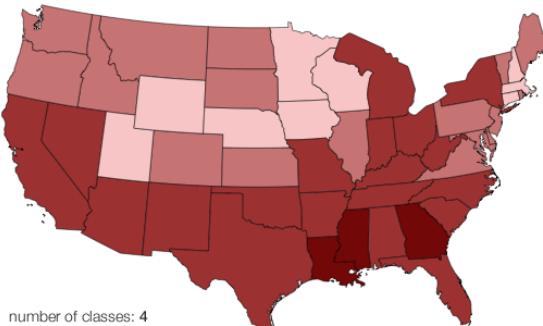
Up to 4 bins



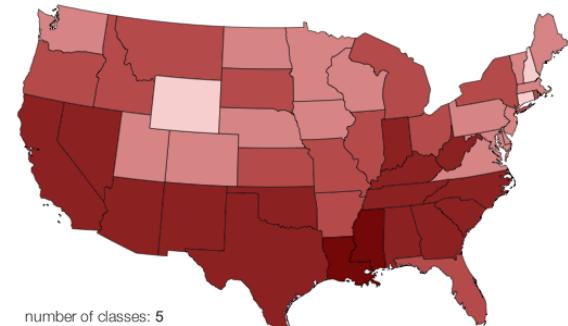
number of classes: 2



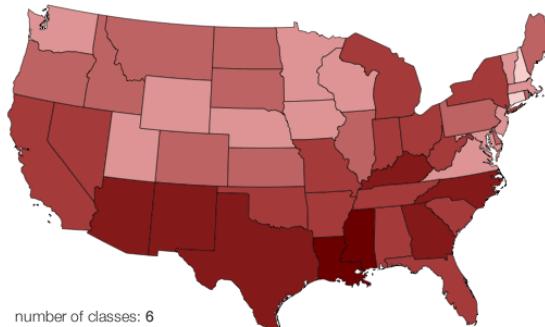
number of classes: 3



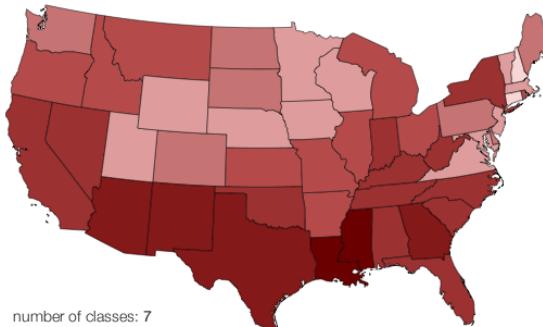
number of classes: 4



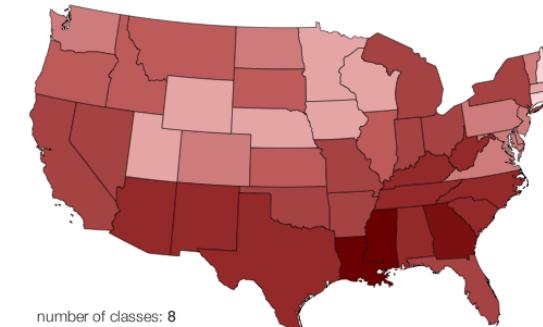
number of classes: 5



number of classes: 6



number of classes: 7

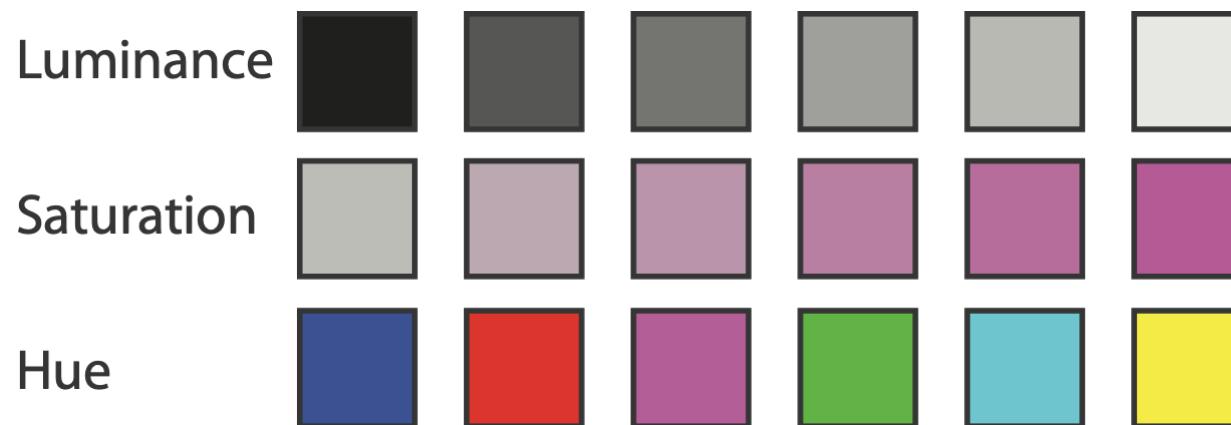


number of classes: 8

Saturation

Suitable for magnitude channel or identity channel?

Suitable for ordered data or categorical data?



Discriminability in Saturation

Low accuracy for noncontiguous regions.

→ Use less than 3 levels (bins).

Strongly interact with the size channel.

- size heavily affects salience.
- small regions need. bright and high saturation .
- large regions need. low saturation (pastel color)
- For (small) point mark or line mark

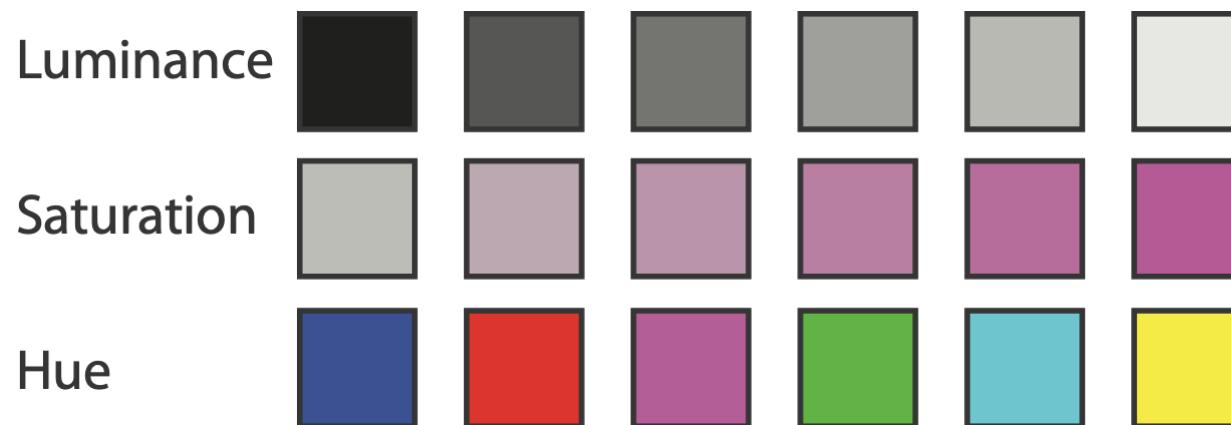
Use only two bins.



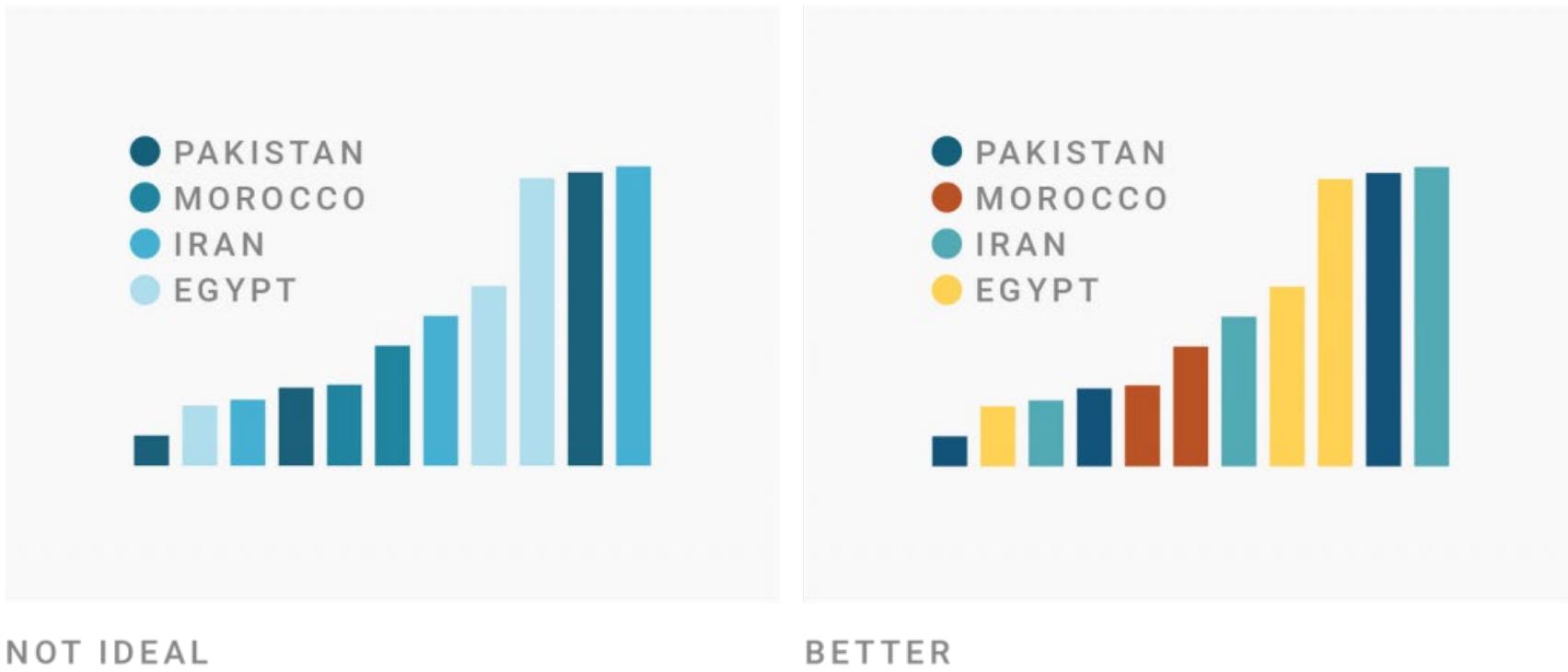
Hue

Suitable for ~~magnitude channel~~ or identity channel?

Suitable for ~~ordered data~~ or categorical data?

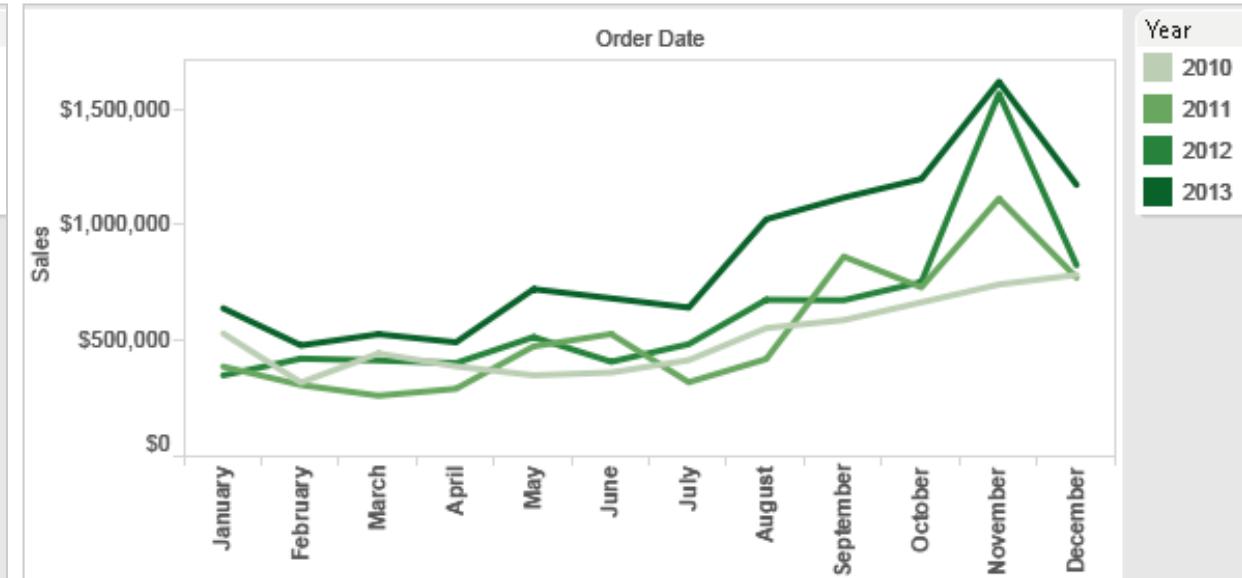
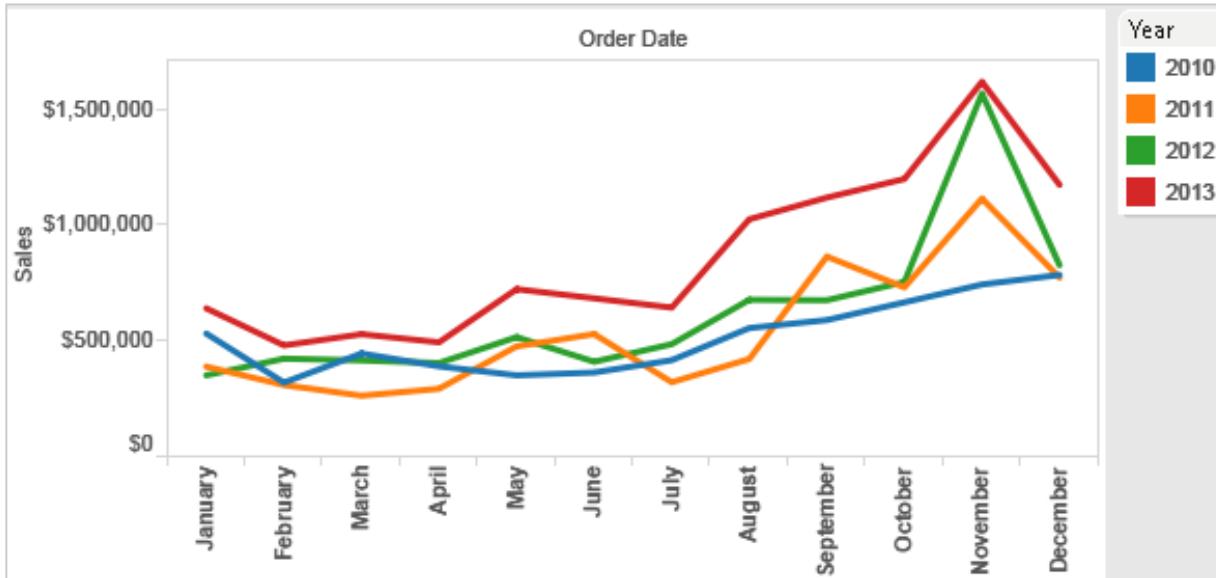


Hue in Ordered/Categorical Data



Hue in Ordered/Categorical Data

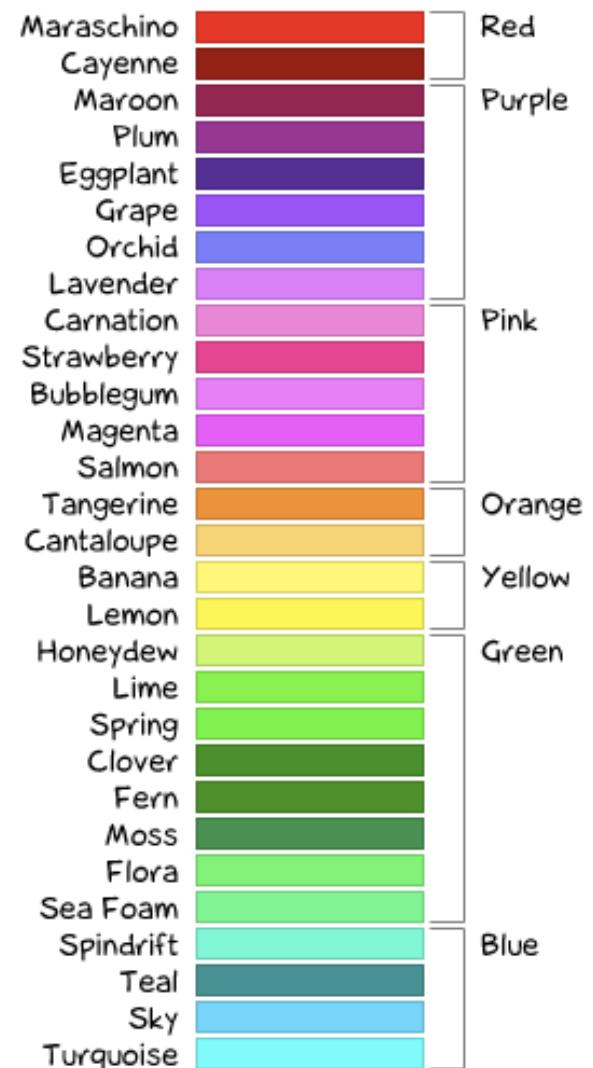
Hue does not have an implicit perceptual ordering (except rainbow or traffic lights).



Discriminability in Hue

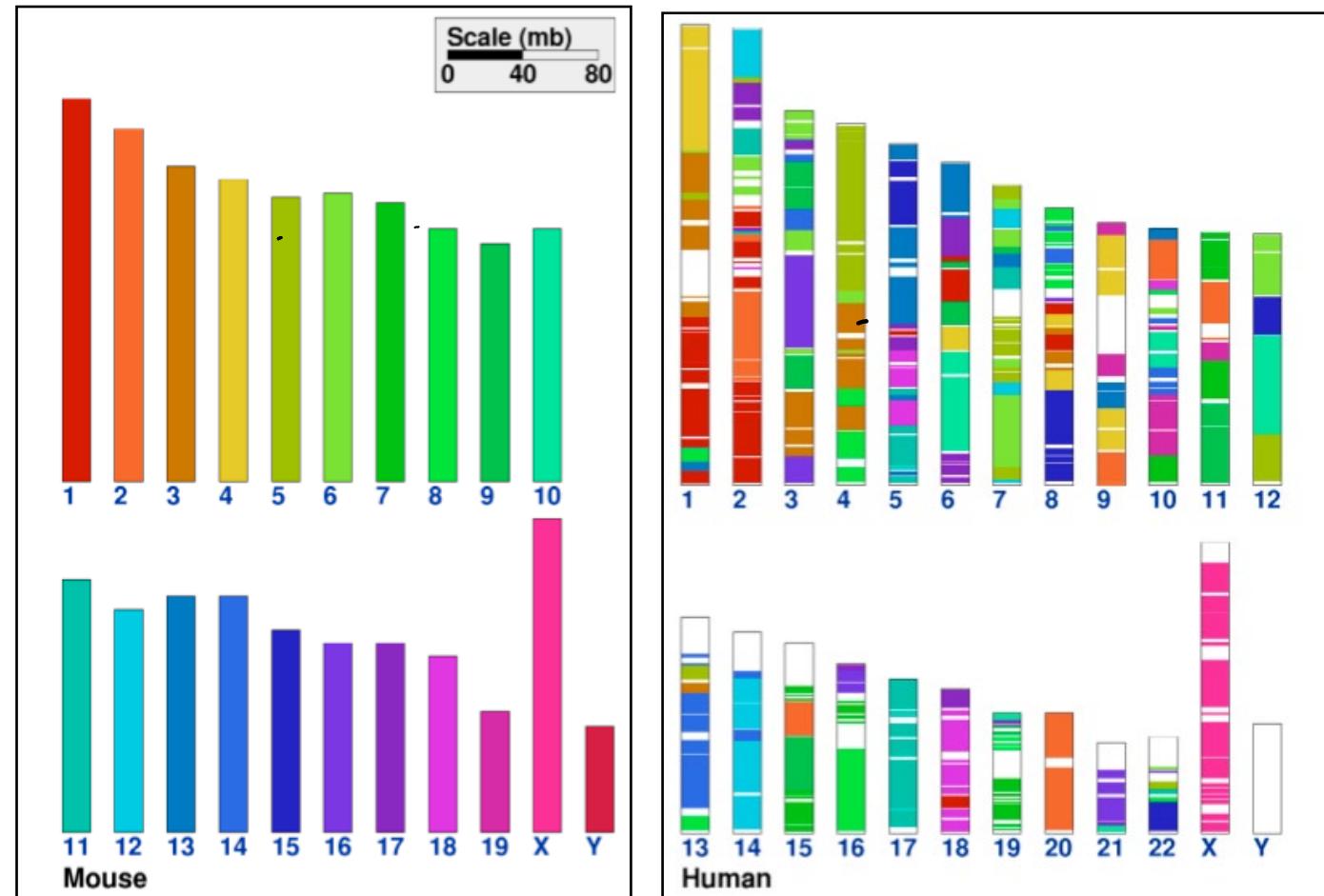
How many discriminable bins can we use?

- Everybody has a different sensitivity.
- display resolution.
- Environment.

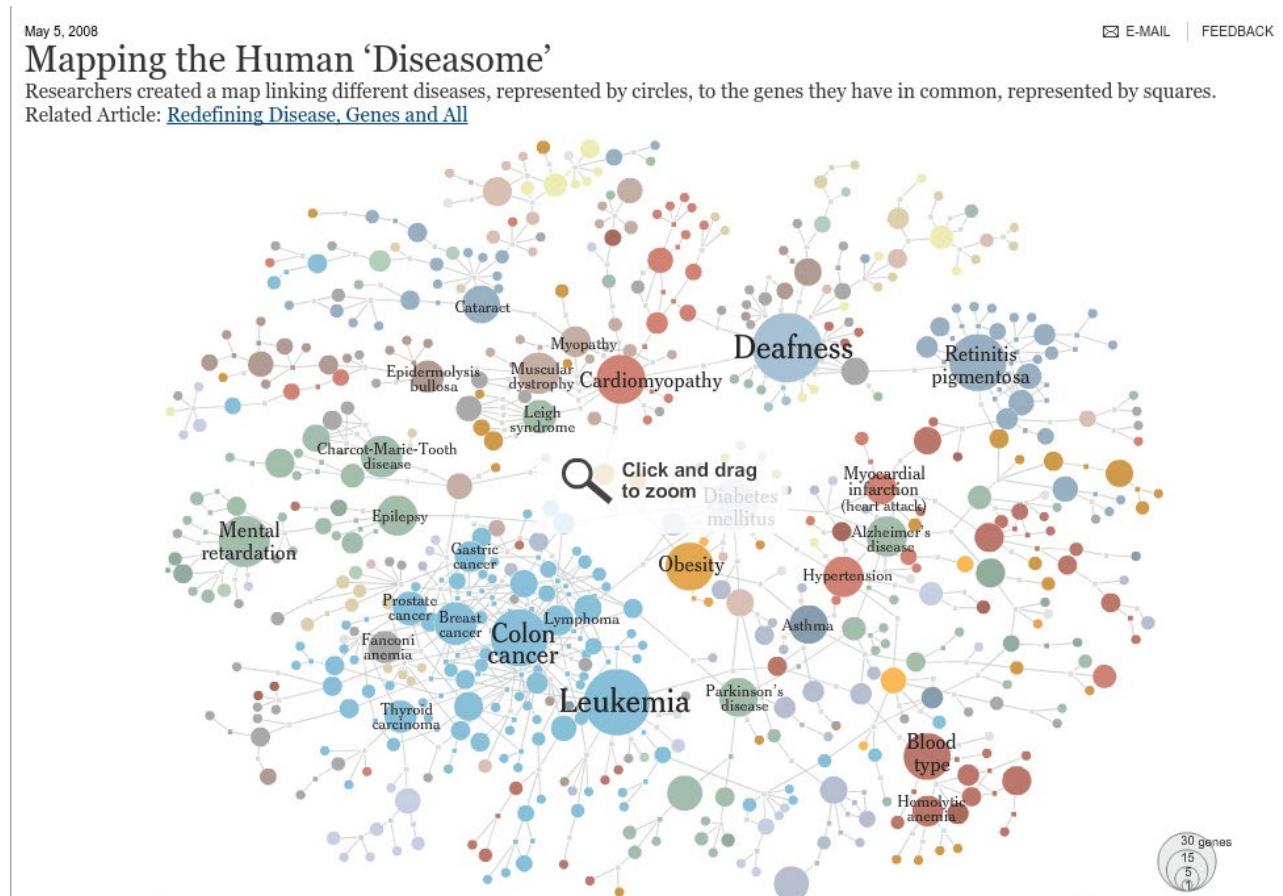
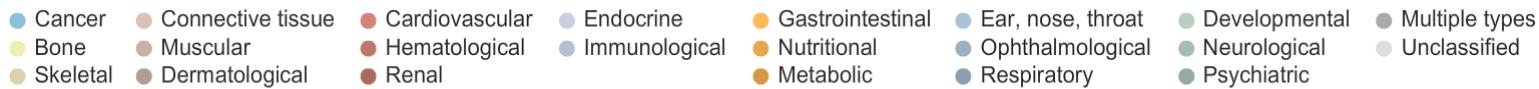


Discriminability in Hue

- Human perception built on relative comparisons
 - great if color contiguous.
 - surprisingly bad for absolute comparisons
- Noncontiguous small regions of color
 - fewer bins than you want.
 - rule of thumb: 6-12 bins, including background and highlights.



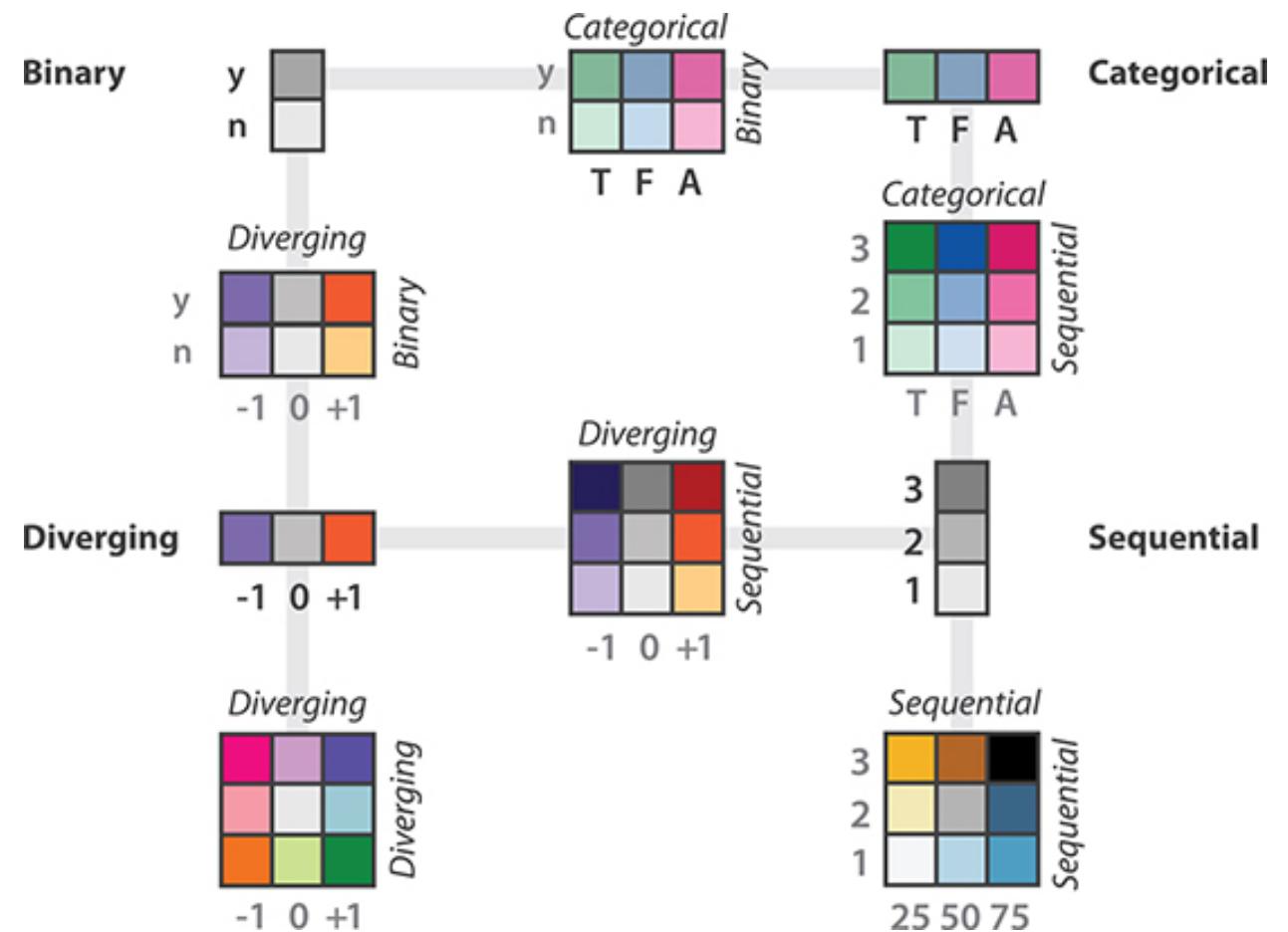
Discriminability in Hue (and Saturation)



Colormap

Expressiveness:

- Ordered data: magnitude channels.
(luminance and saturation).
- Segmented colormap for categorical data.
- Bivariate: better if one channel is binary.

Categorical Colormap

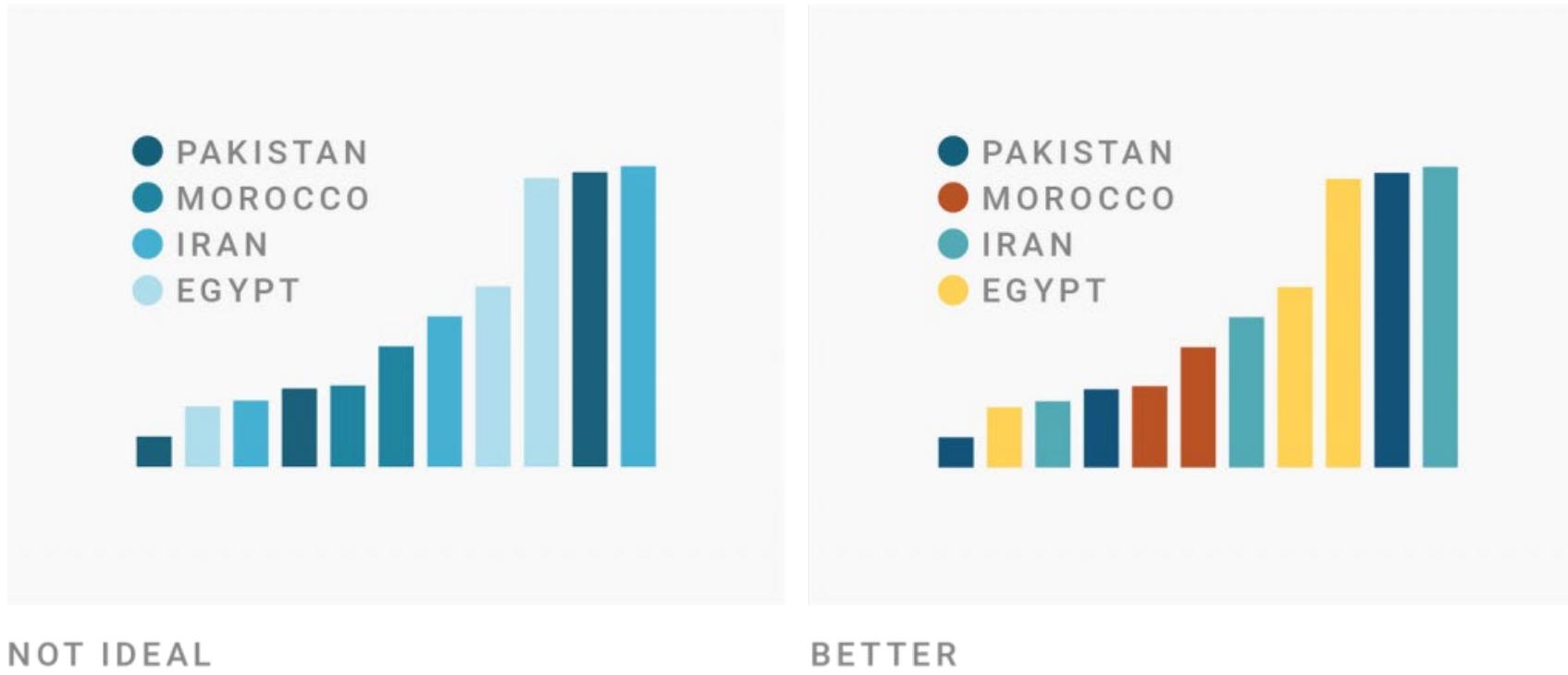
Normally segmented.

Hue is the second best channel for categorical data.

- * Consider print/display/environment.
- * Use easily nameable colors for memorability and the ability to discuss.



Categorical Colormap

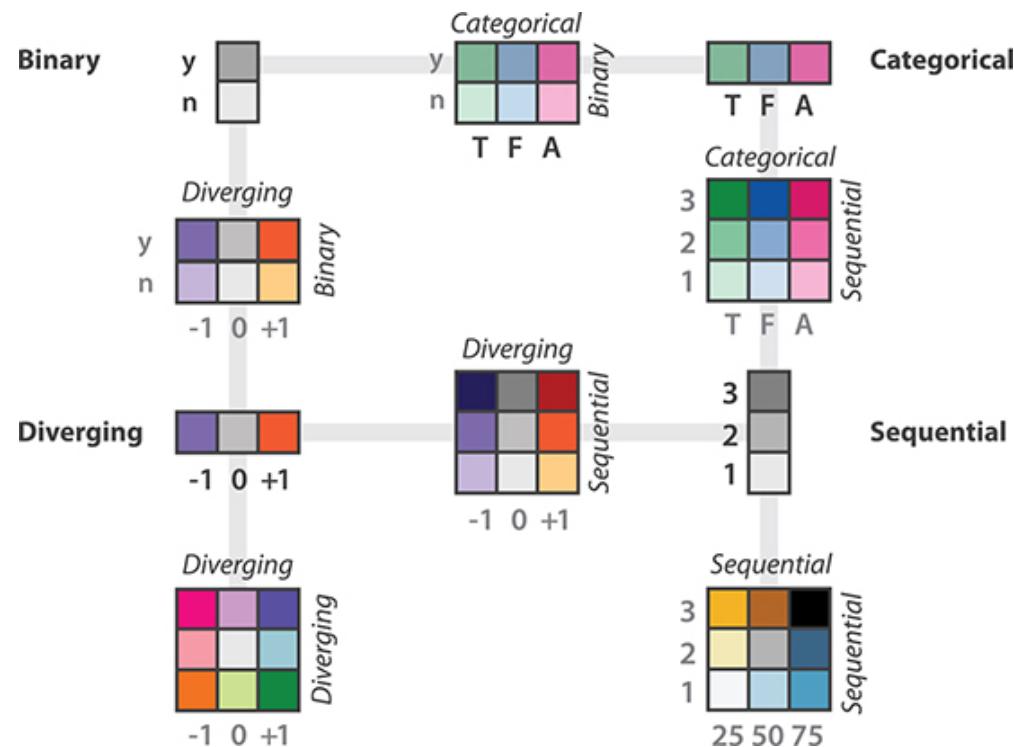


Ordered Colormap

Ordinal features.

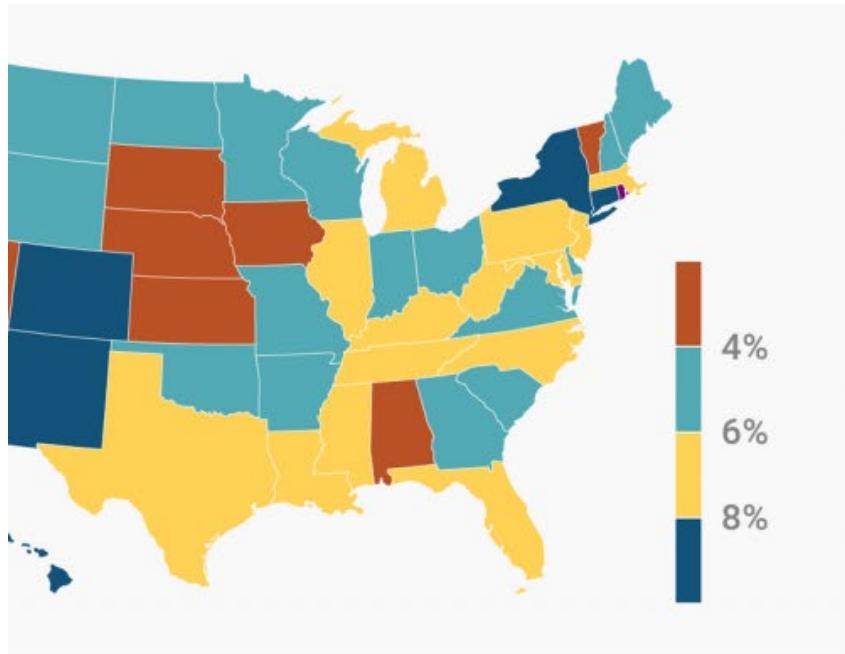
- Sequential: ranges from a min to max.
- Diverging: the hues at the endpoints and a neutral color as a midpoint. (**gray**, white, yellow)

Quantitative features.

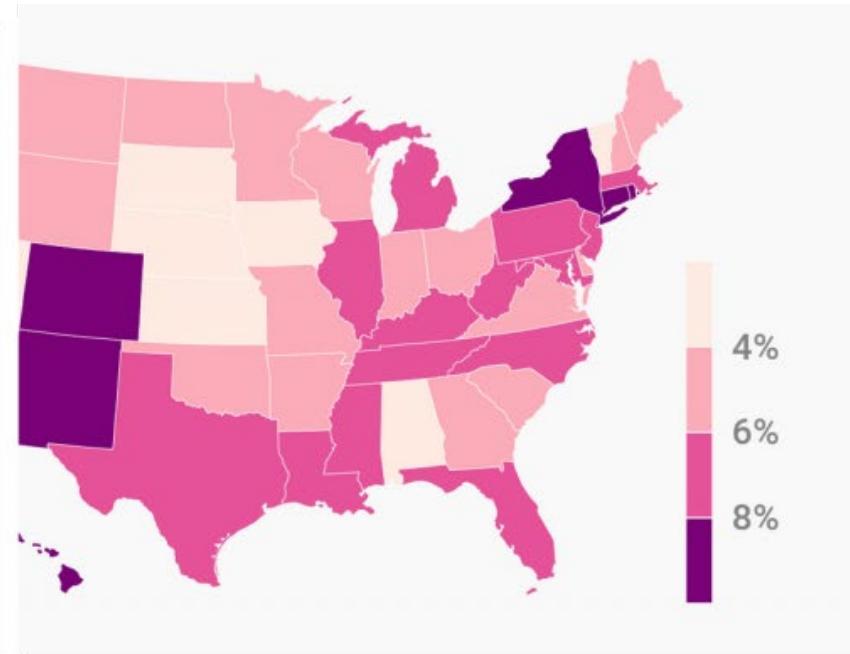


Ordered Colormap: Sequential

Sequential data: Luminance is good!



NOT IDEAL

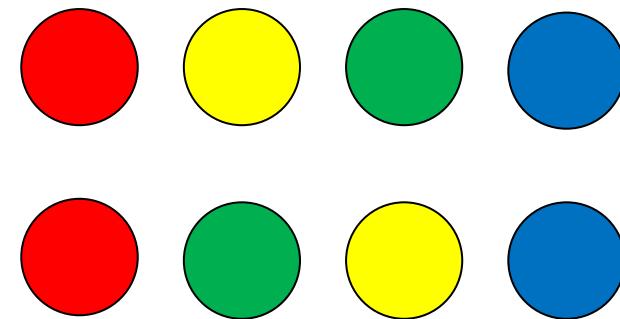
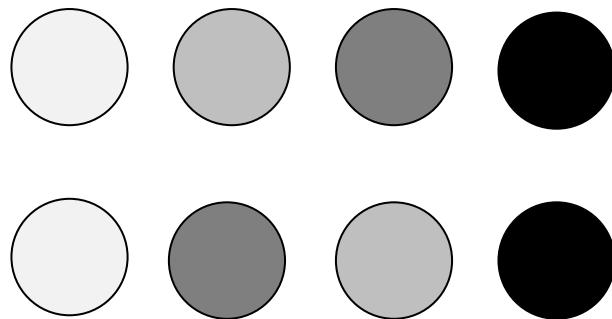


BETTER

Ordered Colormap: Sequential

No Rainbow!!

- perceptually unordered.
- perceptually nonlinear.



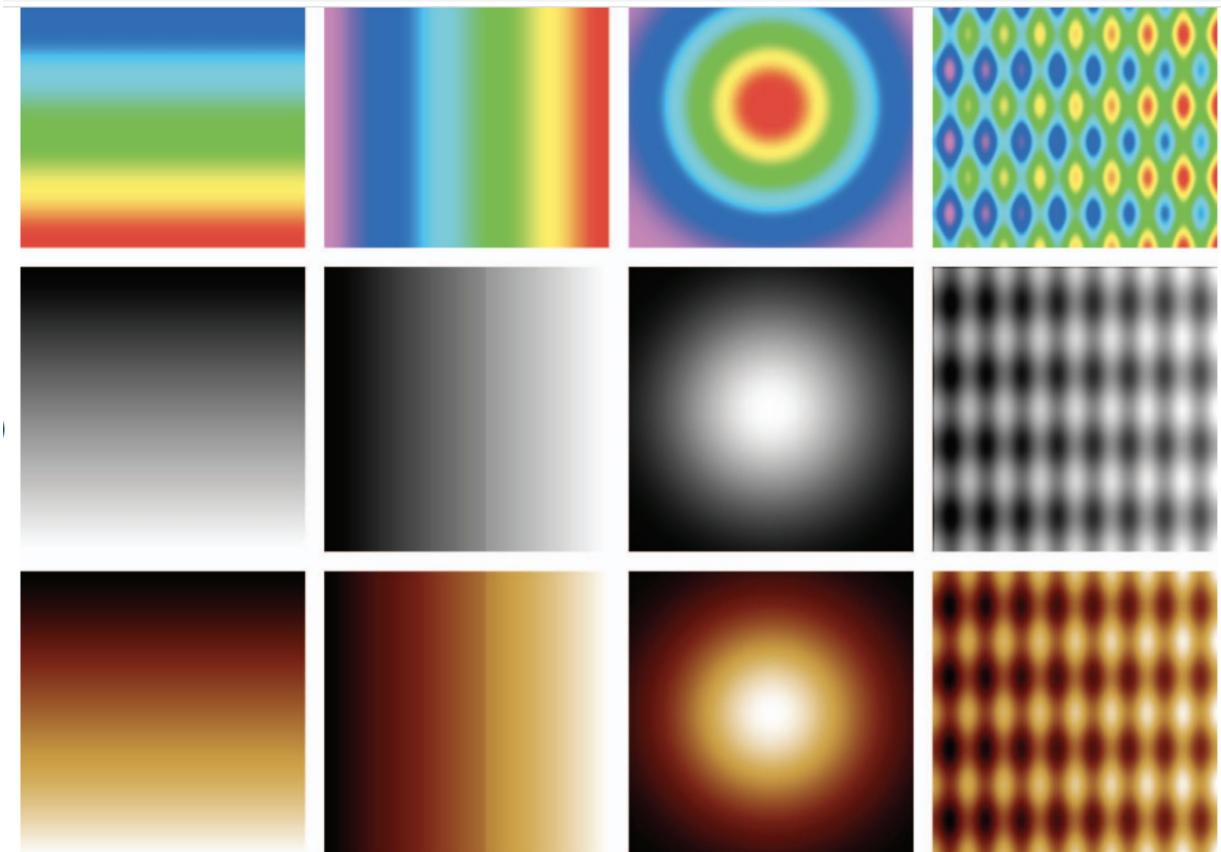
Ordered Colormap: Sequential

No Rainbow!!

- perceptually unordered.
- perceptually nonlinear.

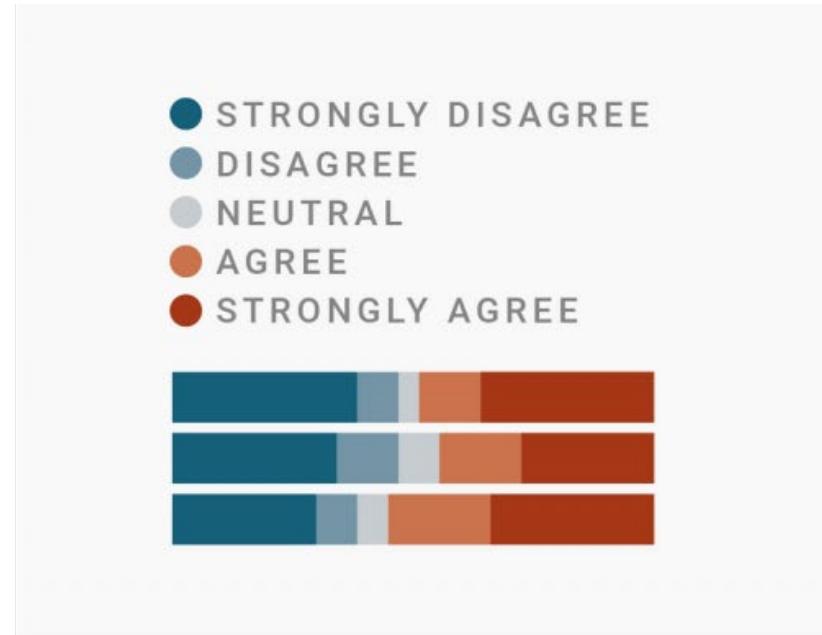
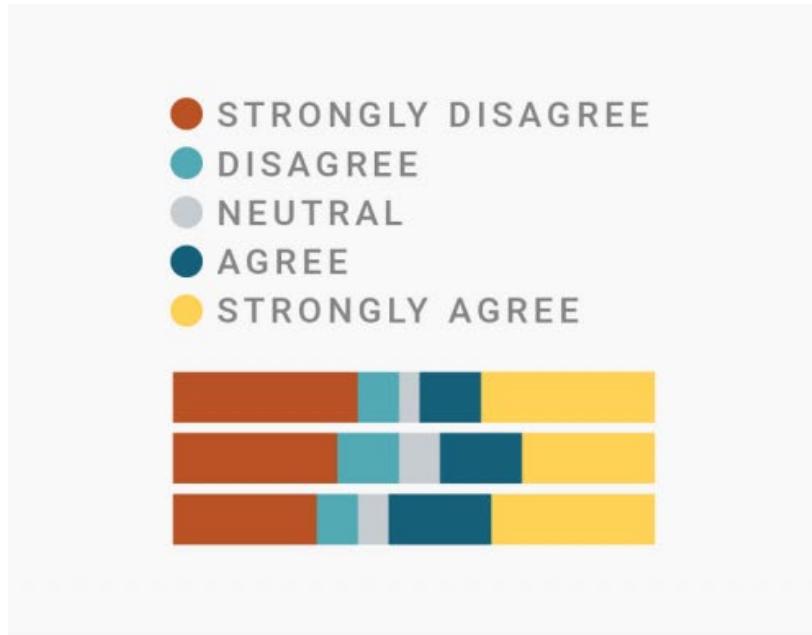


for only categorical data (but that is
not good.)



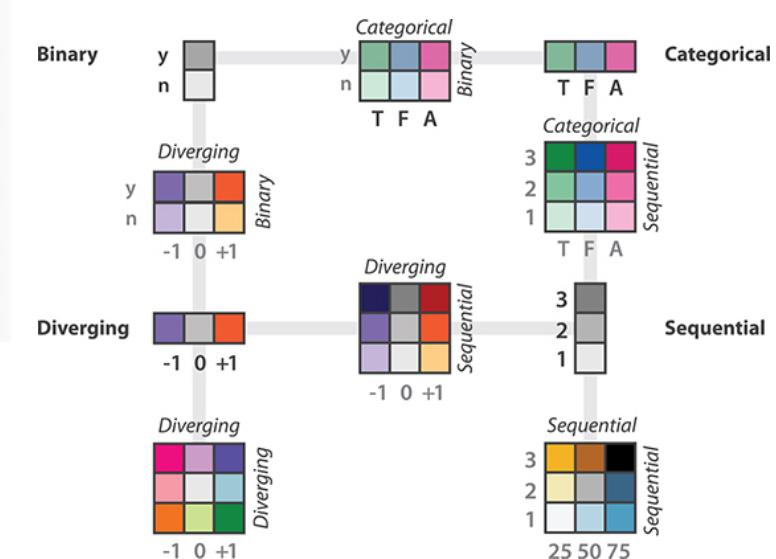
Ordered Colormap: Diverging

Diverging (-1, 0, 1) → need two colors with **saturation**.
(hue)



NOT IDEAL

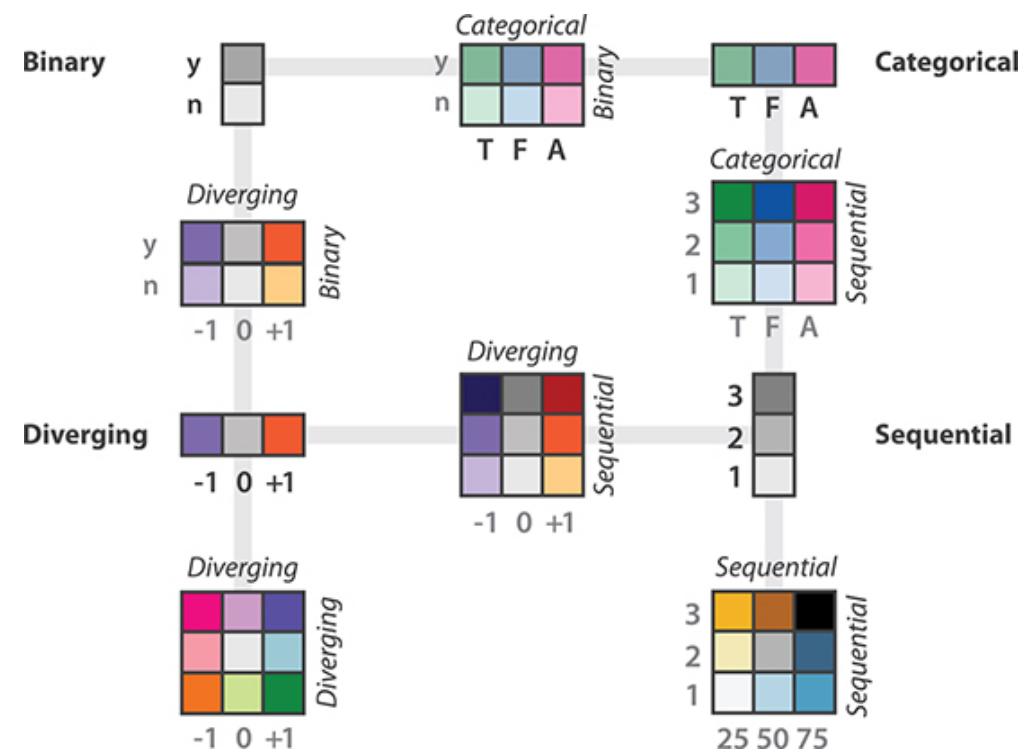
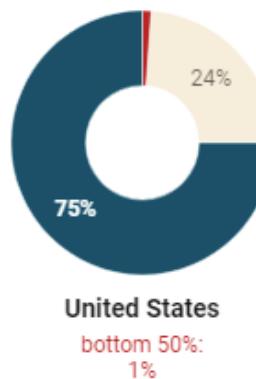
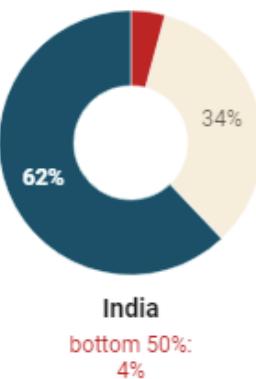
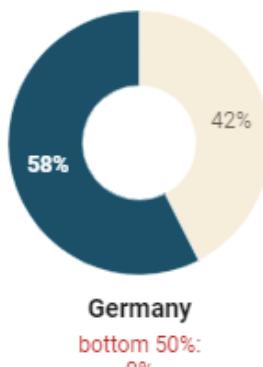
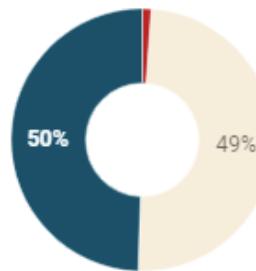
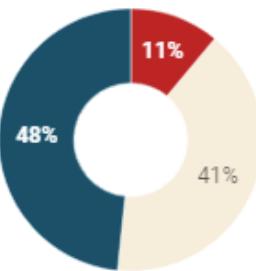
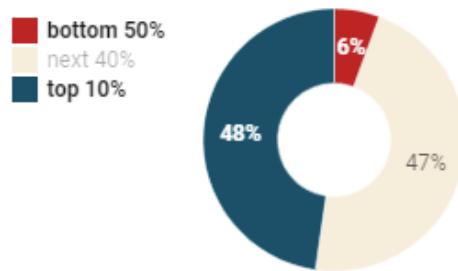
BETTER



Ordered Colormap: Diverging

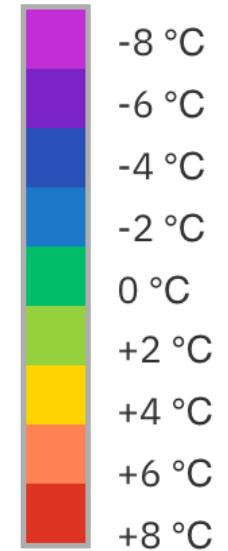
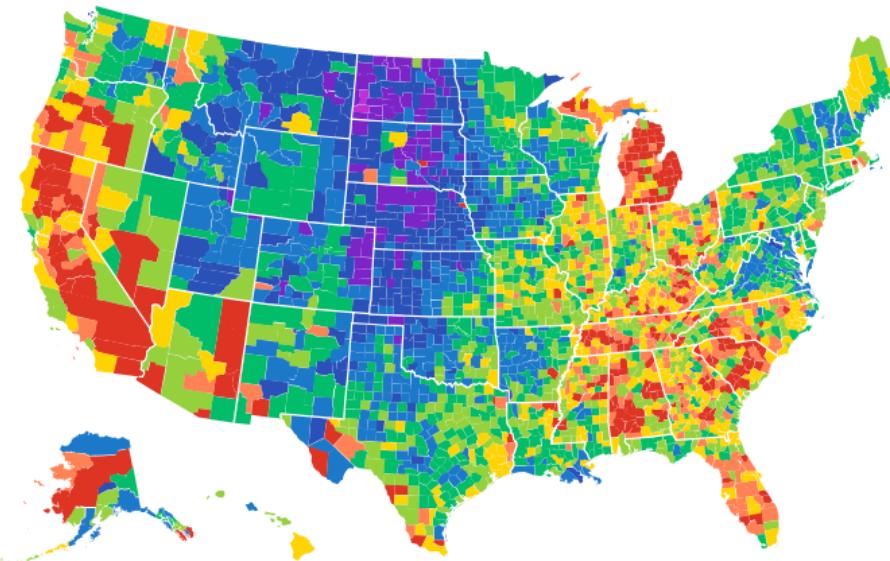
Who gets which slice of the pie?

How much of the wealth of a country do the poorest 50% own? How much do the top 10% own?



Ordered Colormap: Diverging

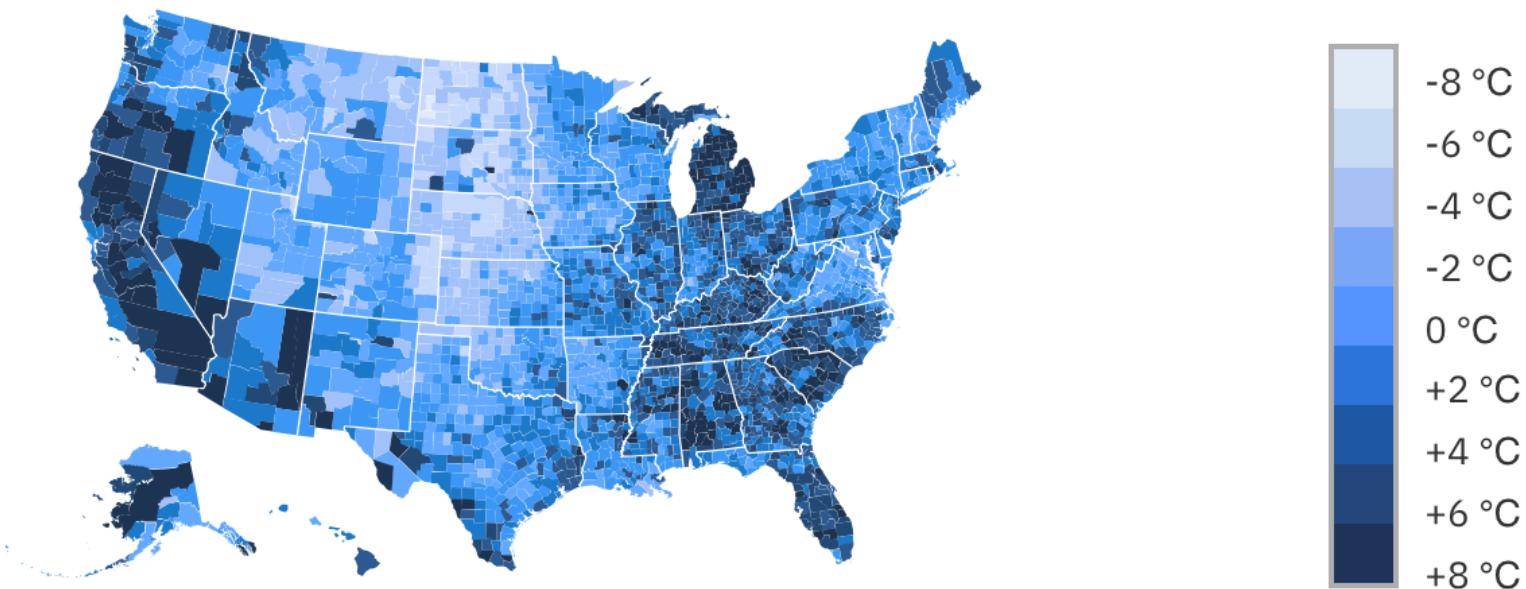
Temperatures variations in USA



Check blue and purple

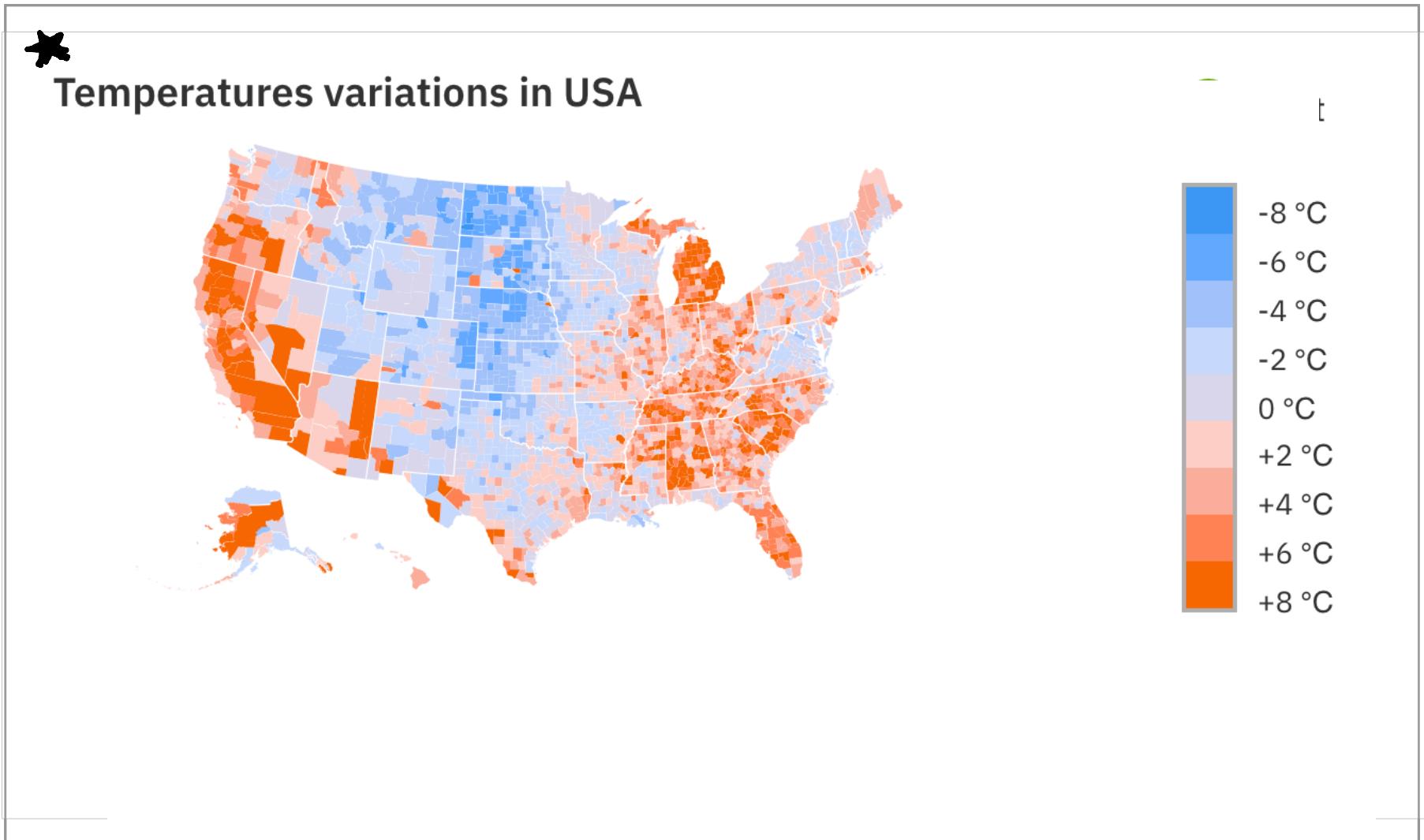
Ordered Colormap: Diverging

Temperature variations across the USA



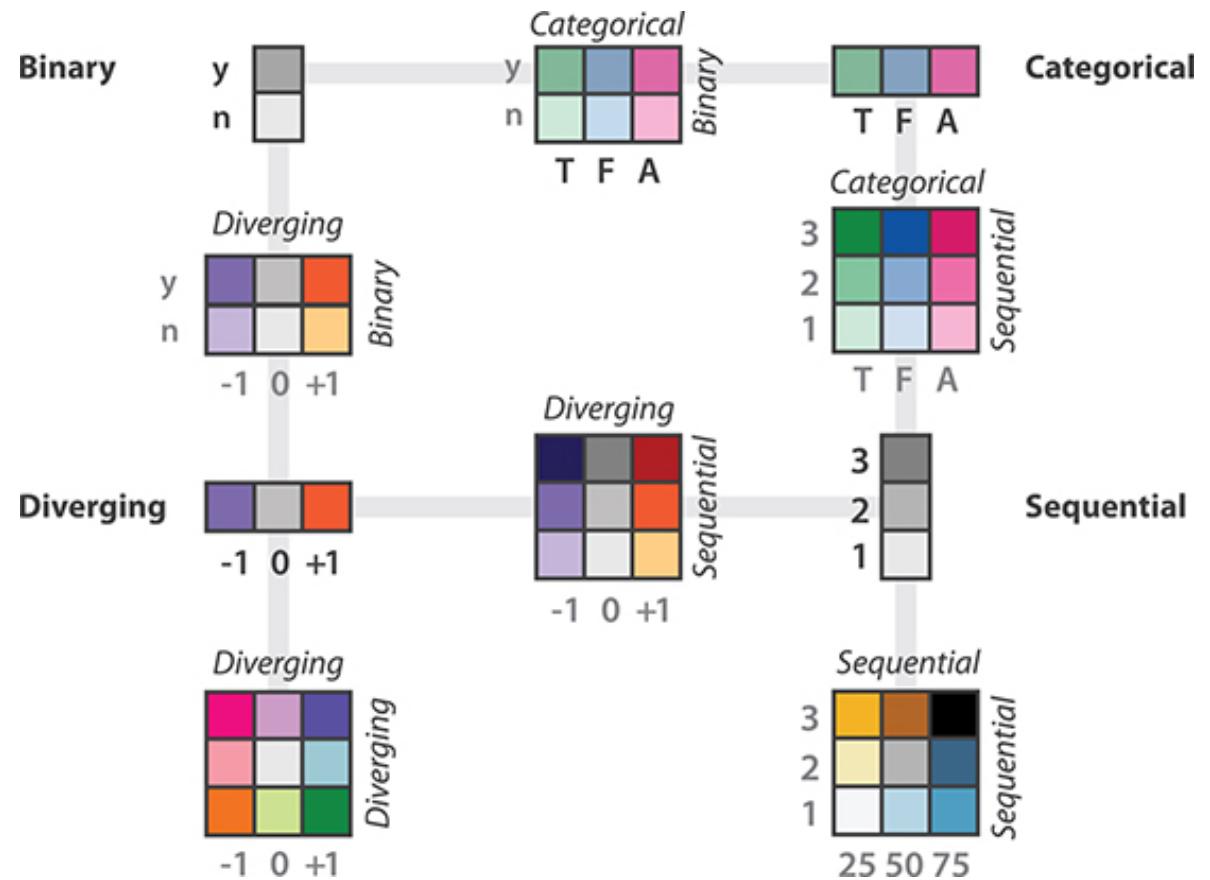
Not effective for negative and positive

Ordered Colormap: Diverging



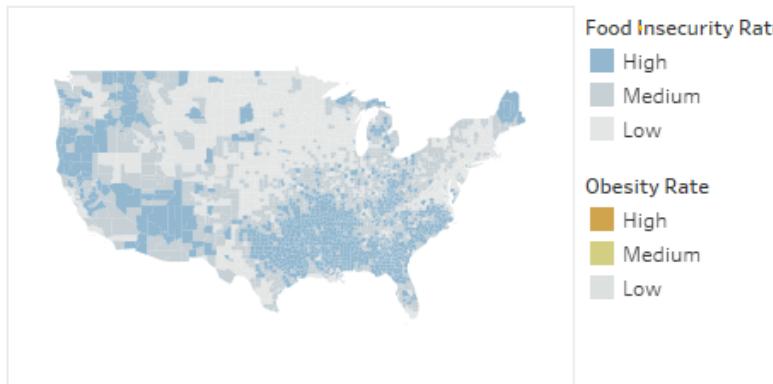
Bivariate Colormap

- Better if one channel is binary.
- Both are multinomial, carefully use.
- User-interactive visualization will be better!

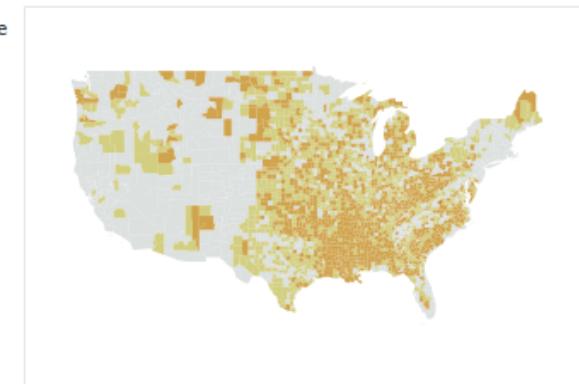


Bivariate Colormap

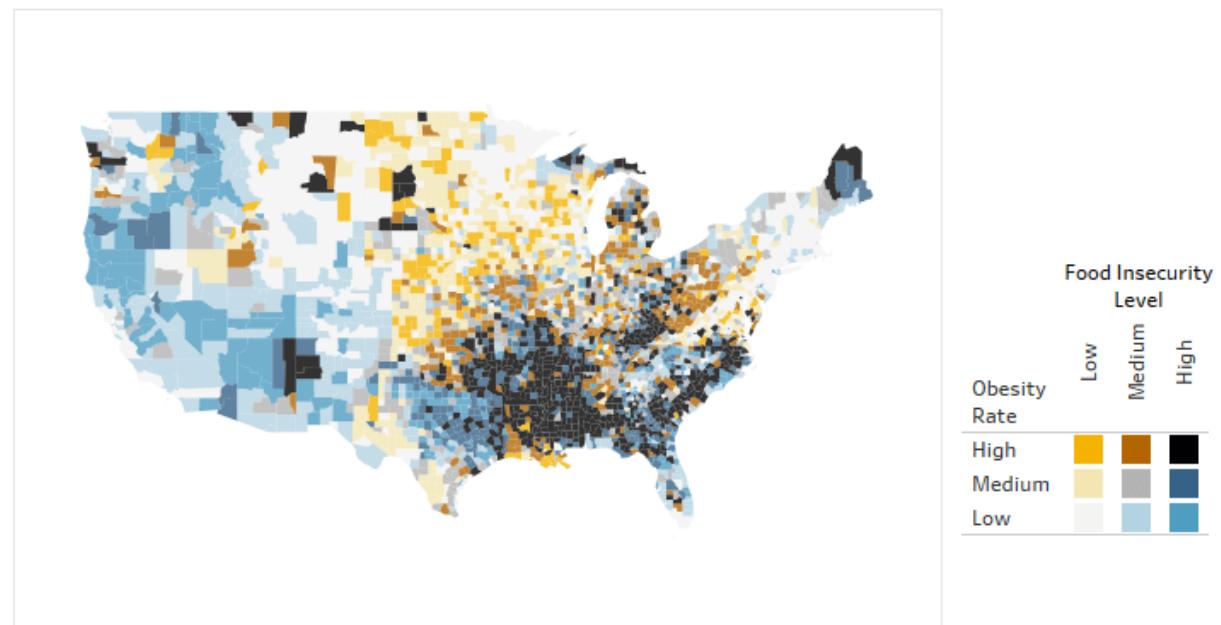
Food Insecurity Rate



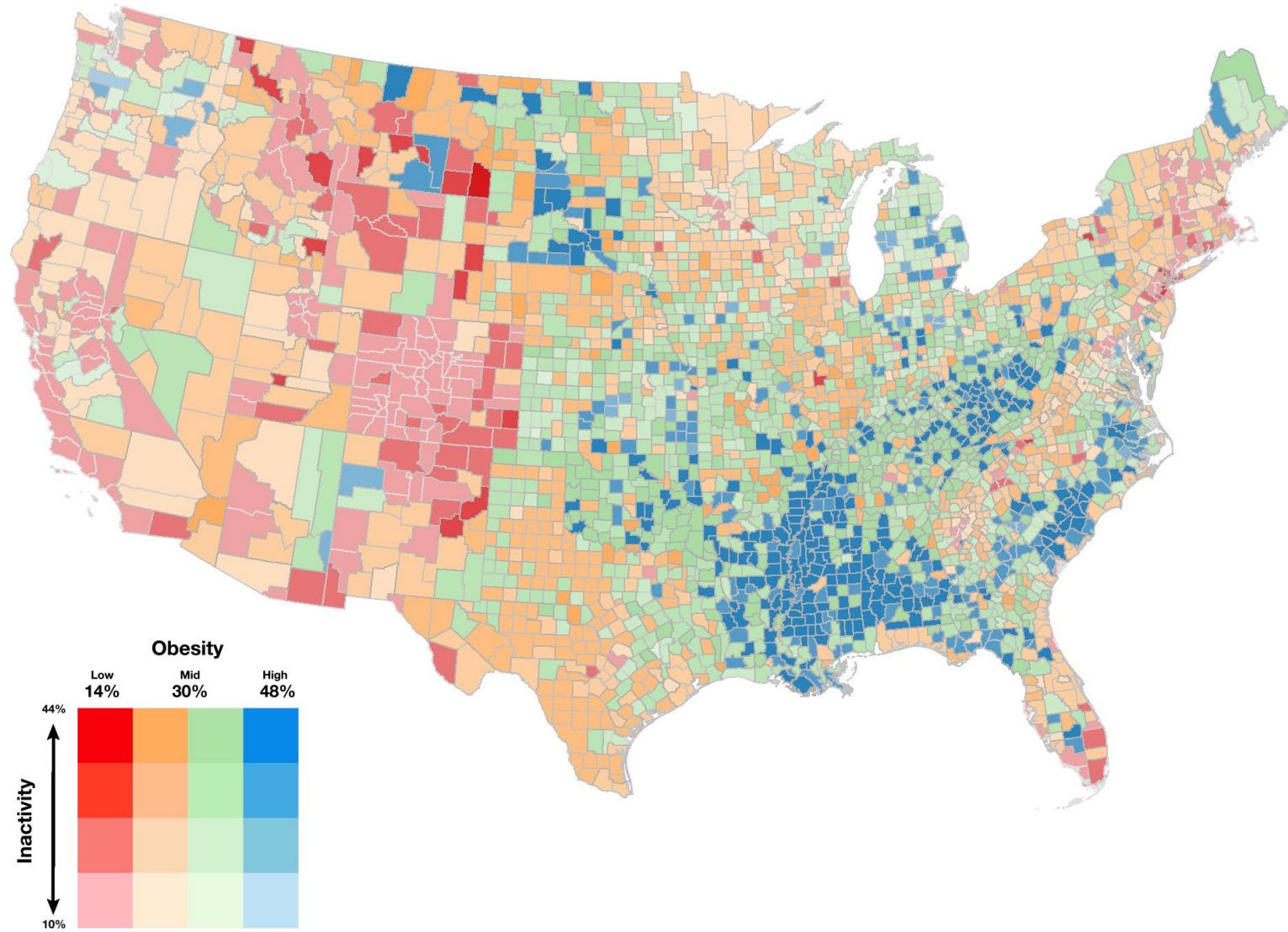
Obesity Rate



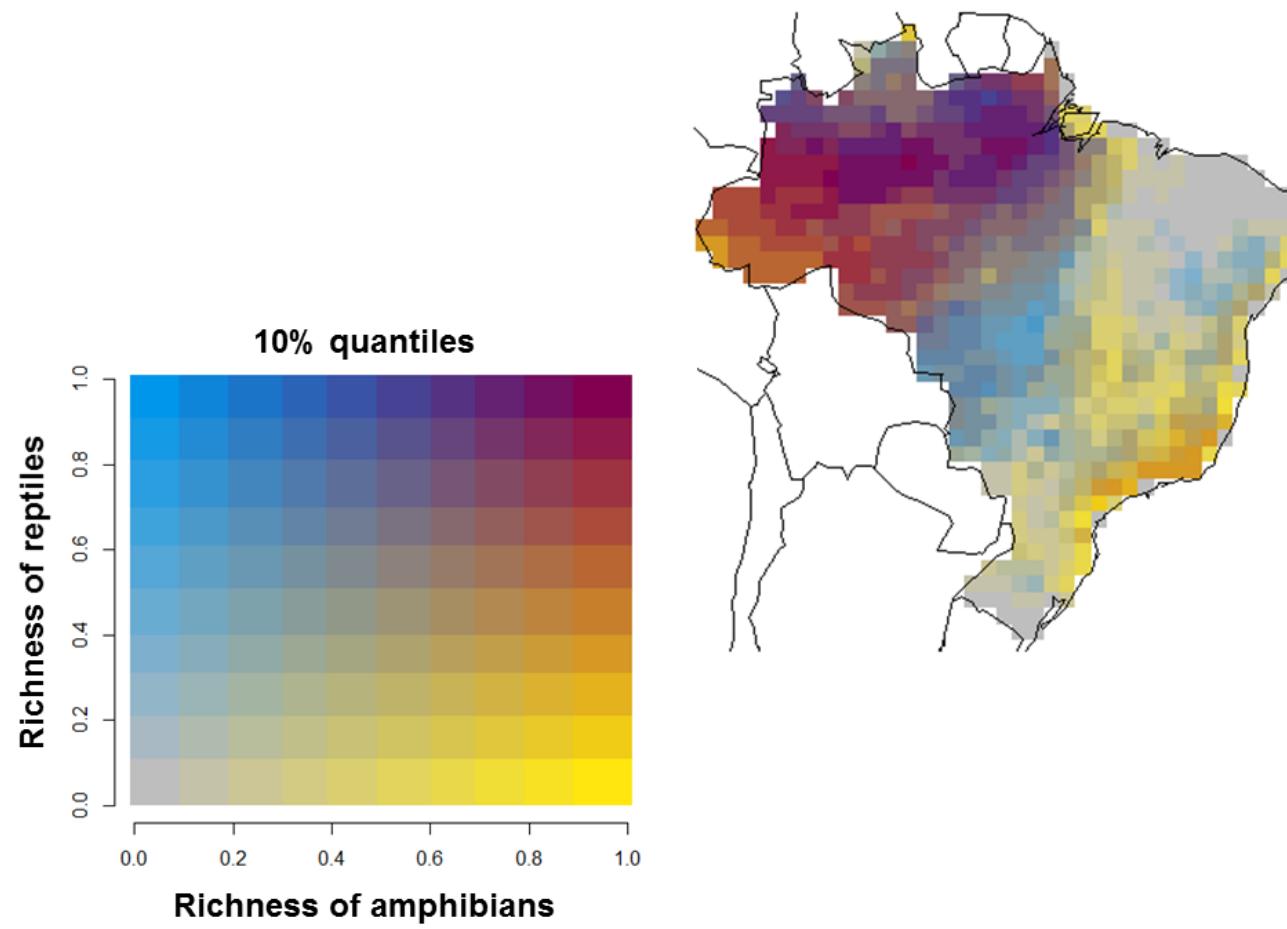
Food insecurity vs. Obesity



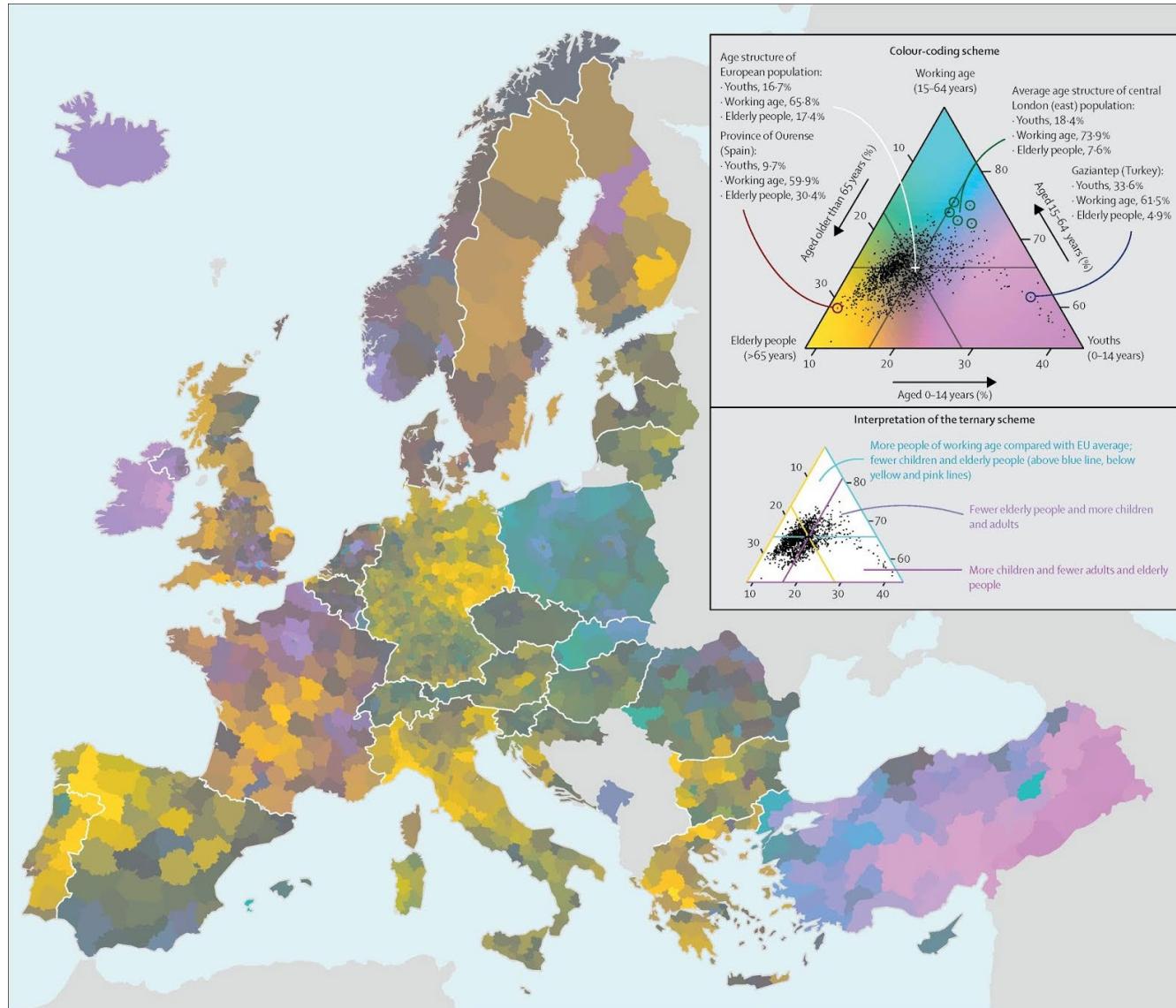
Bivariate Colormap



Bivariate Colormap



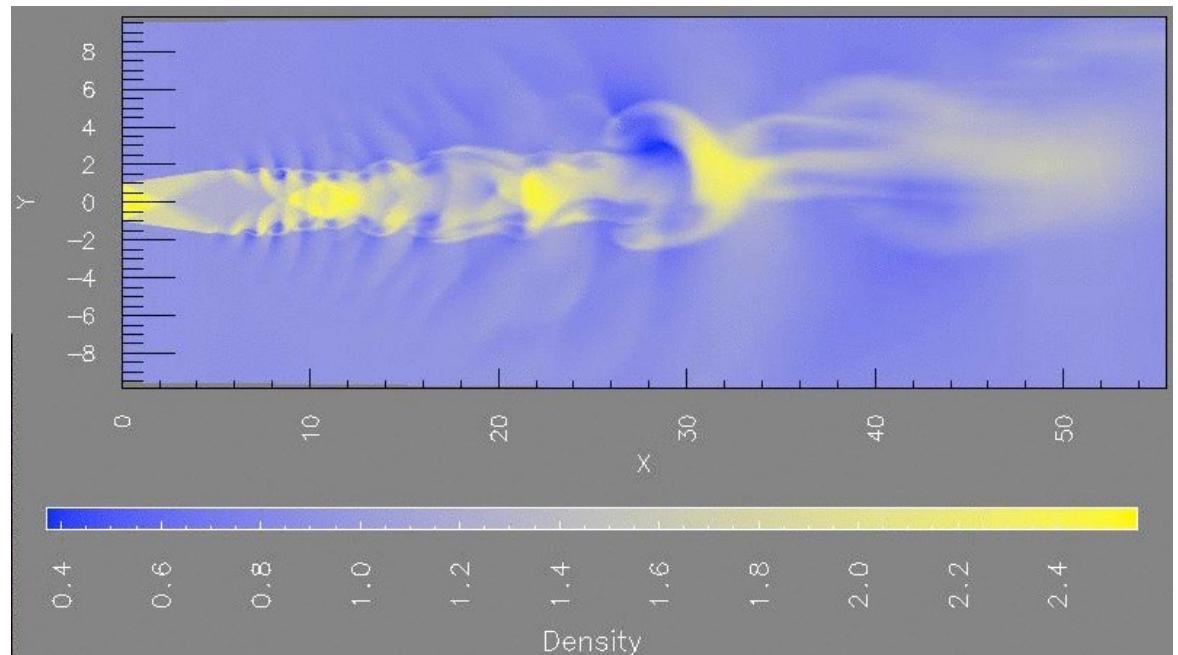
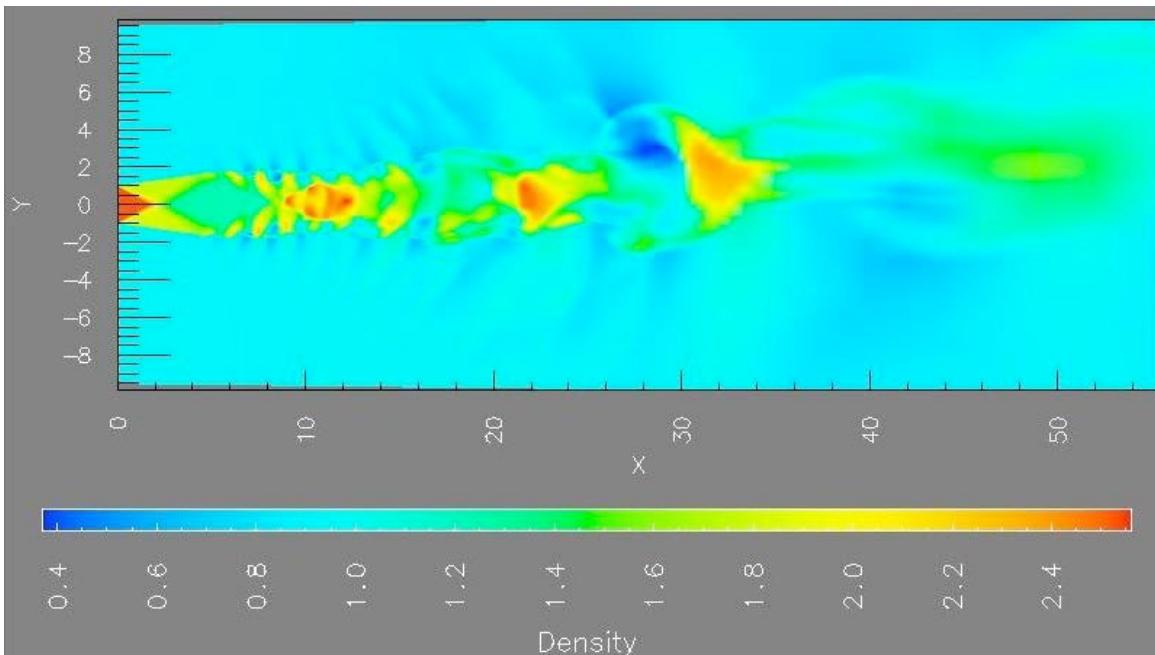
Bivariate Colormap



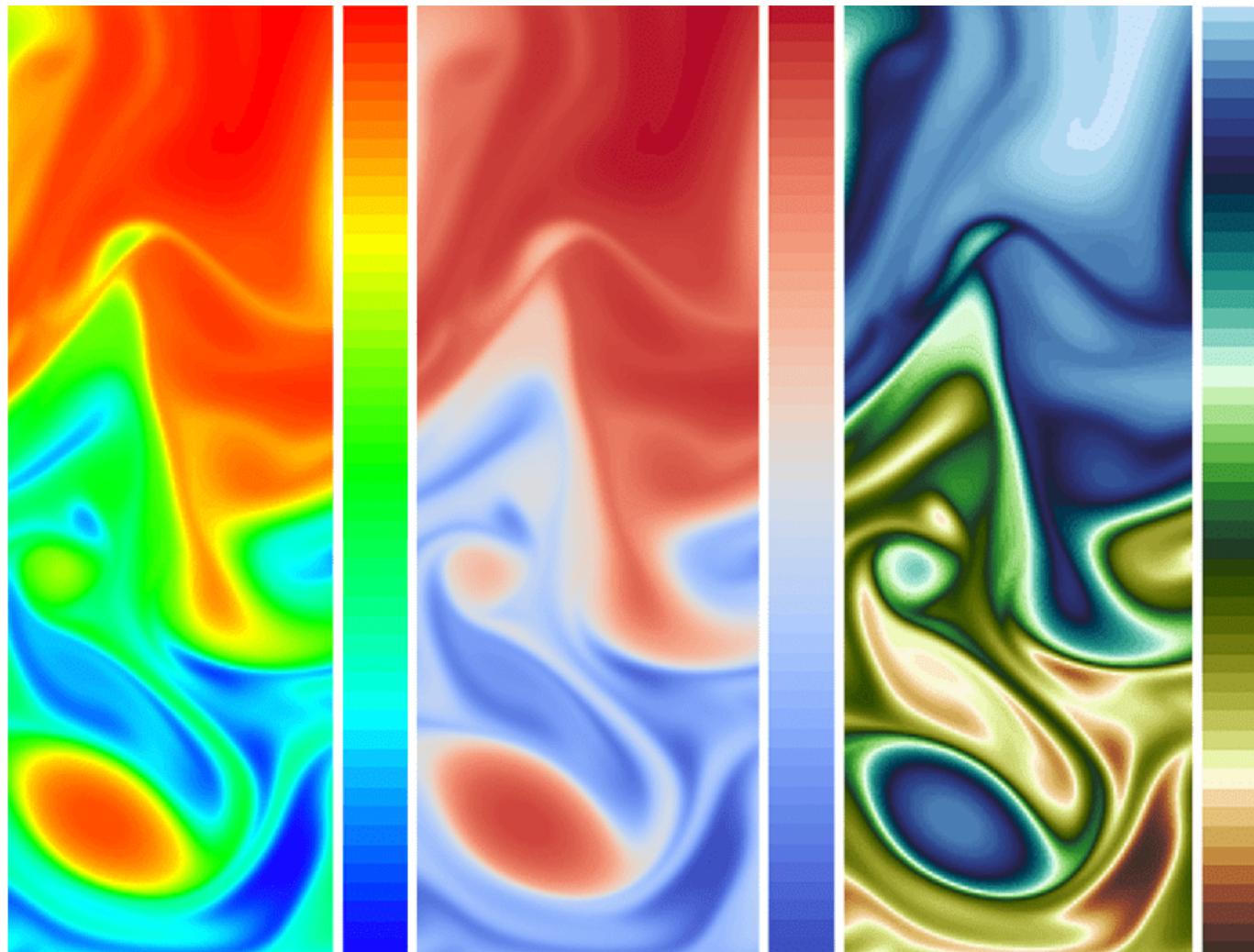
Ordered Colormap: Quantitative

No Rainbow!!

- Not easy to capture middle range.

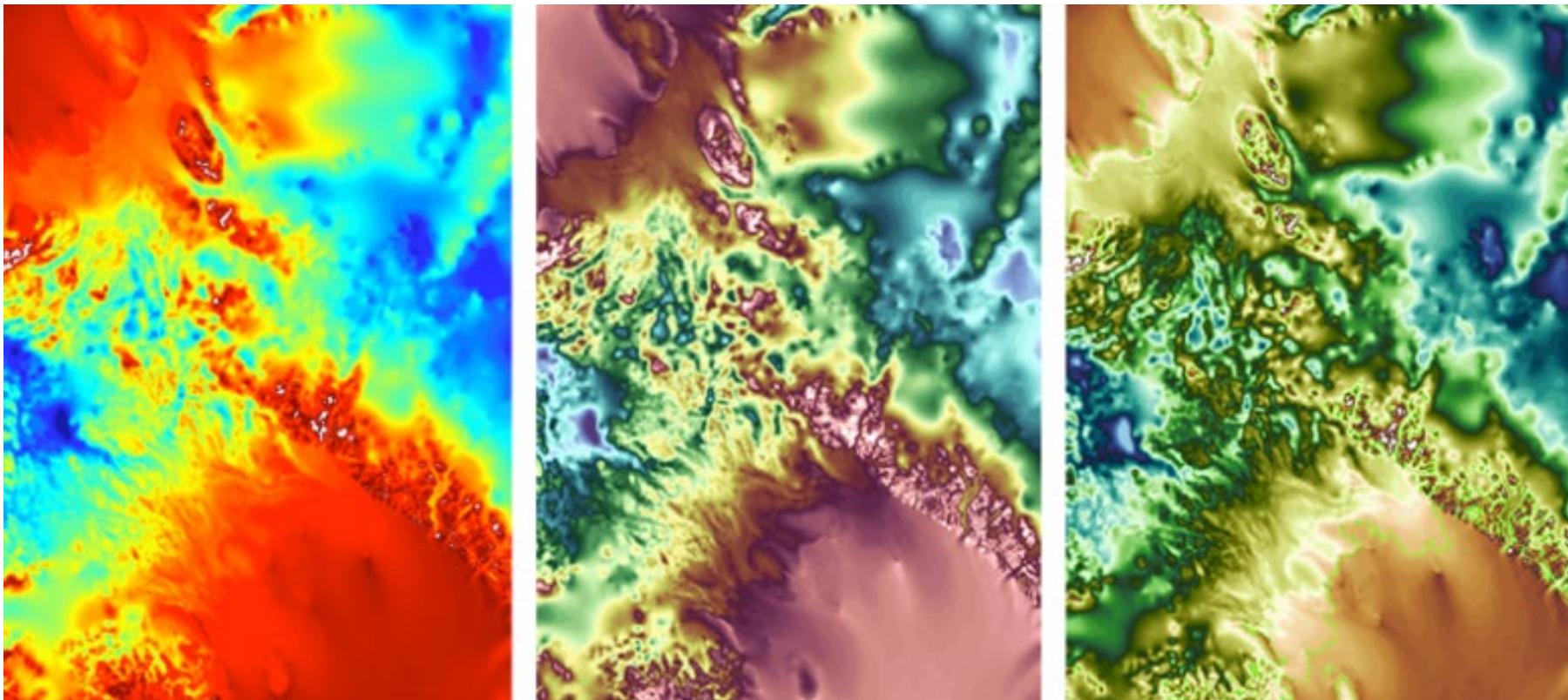


Ordered Colormap: Quantitative



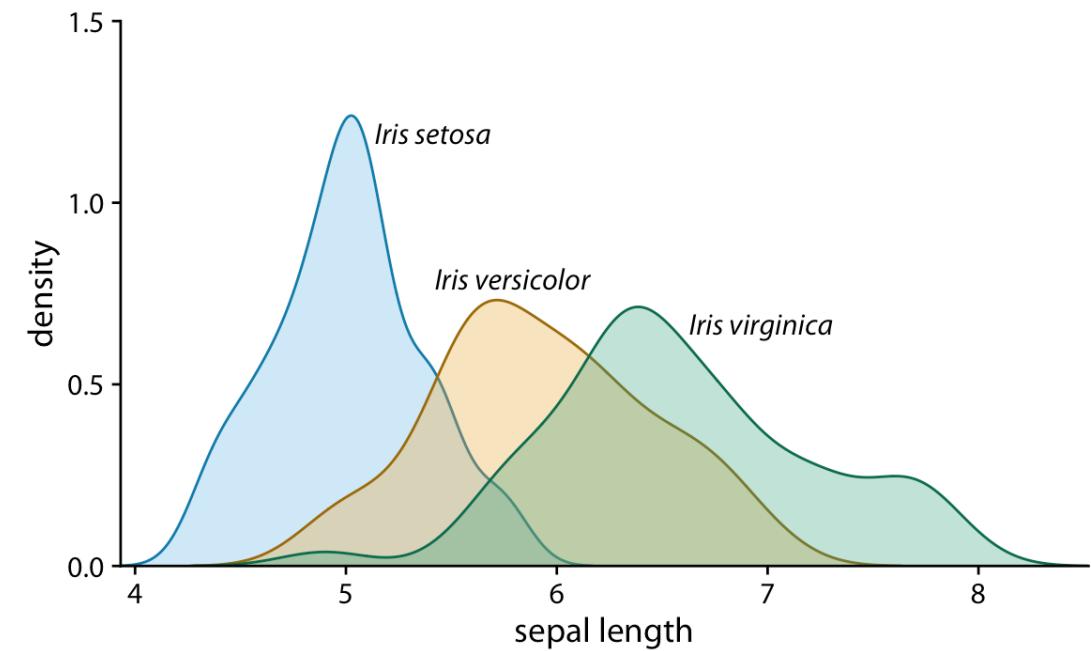
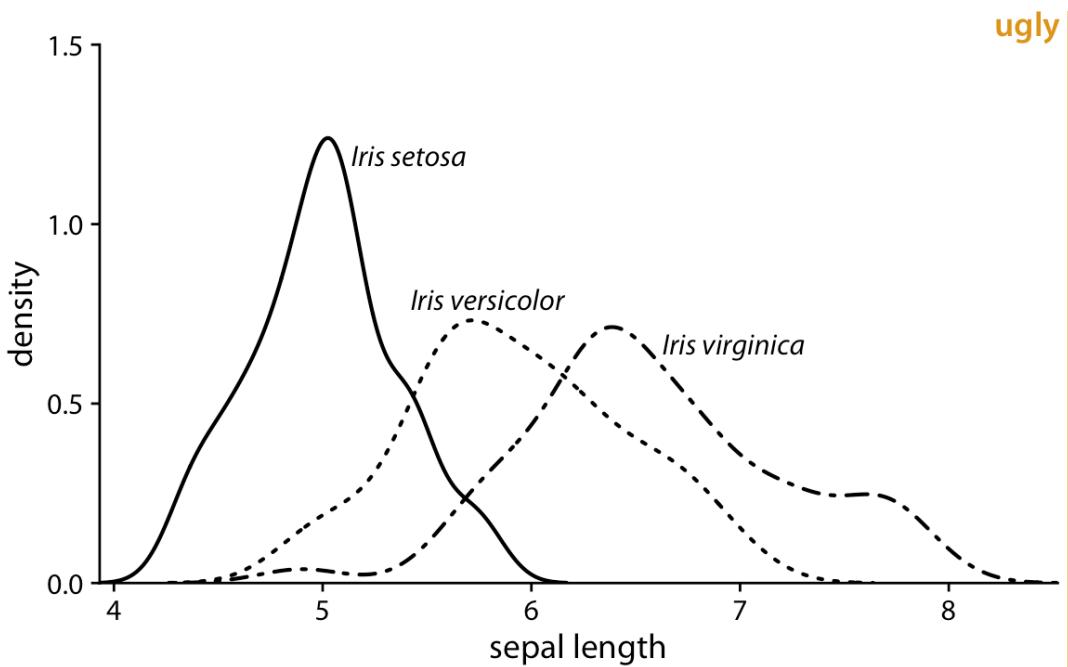
your own
Colormap.

Ordered Colormap: Quantitative



Transparency

- Cannot use independently.
- For superimposed layers.
- Check redundancy.



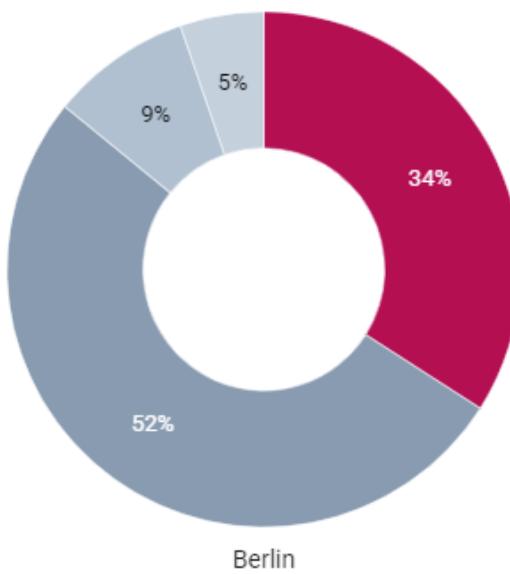
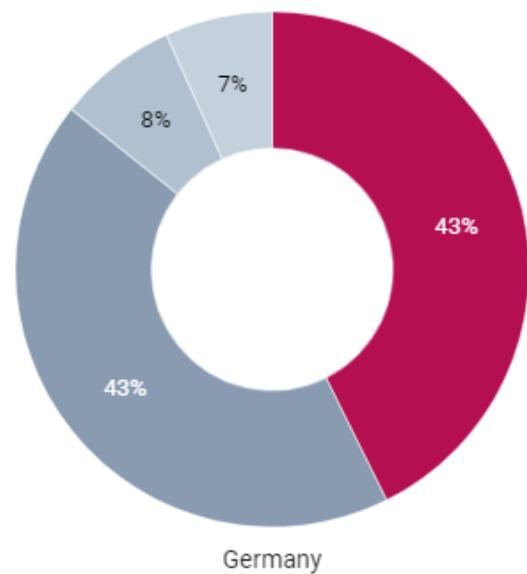
Color Combination

Hue: Target data (visual popout).

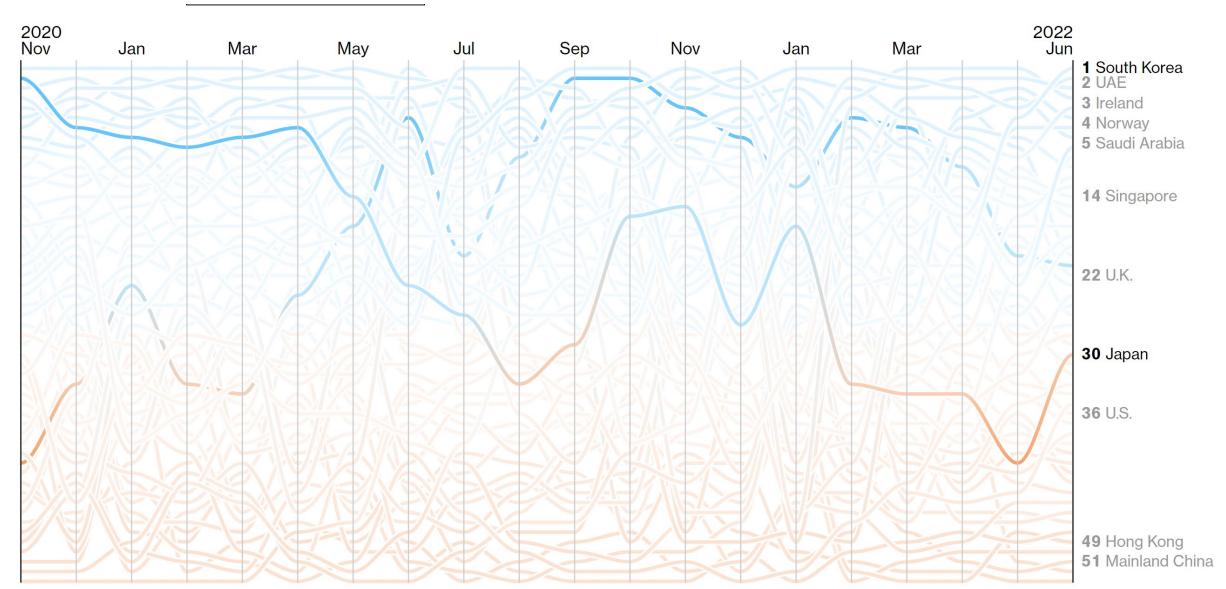
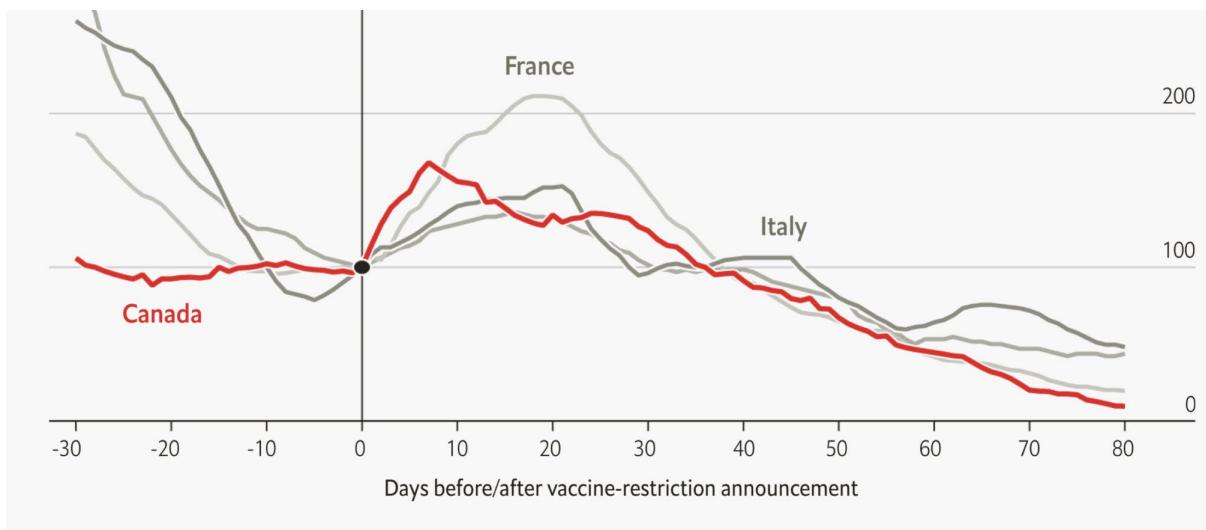
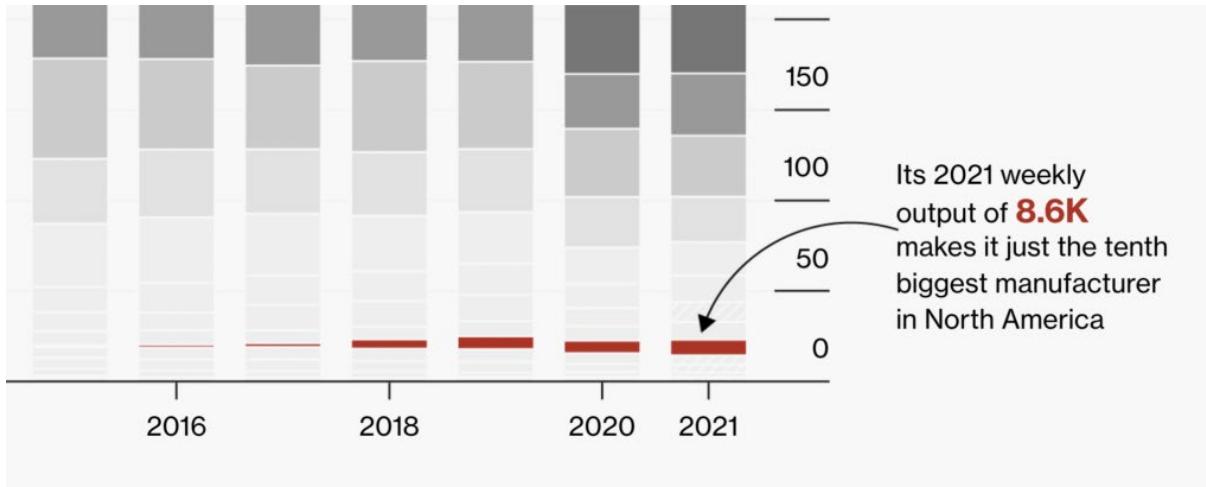
Luminance or saturation: quantitative, nominal or categorical.

43% of Germans are married, but only 34% of Berliners

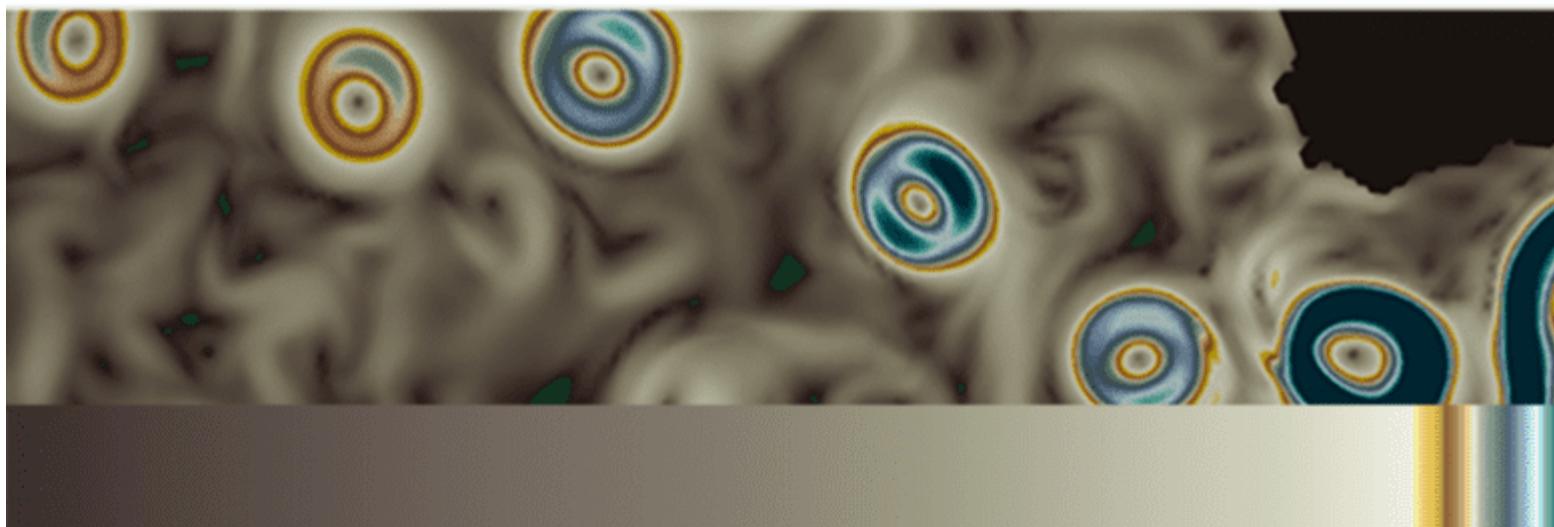
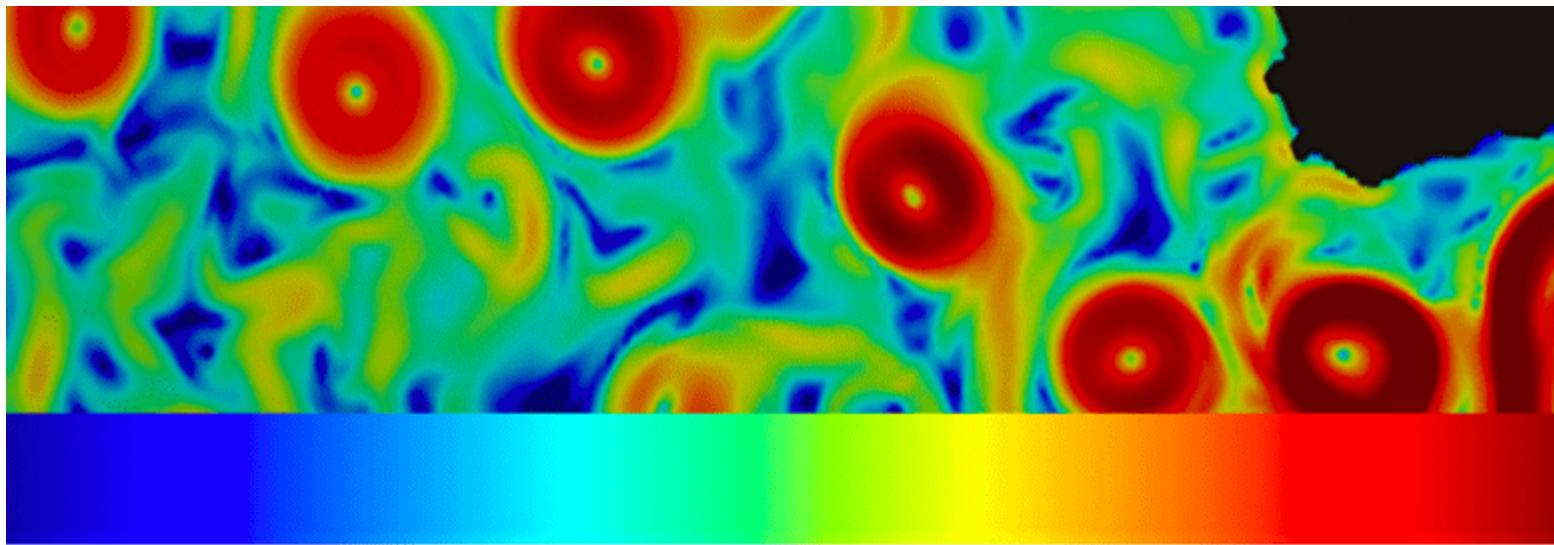
■ Married & civil union ■ Single ■ Divorced ■ Widowed



Color Combination

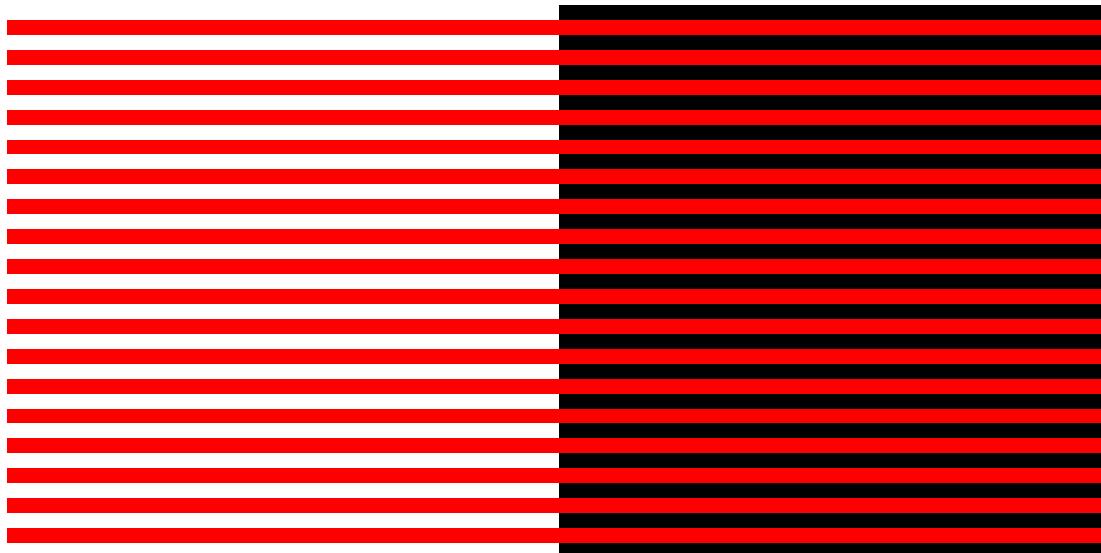


Color Combination



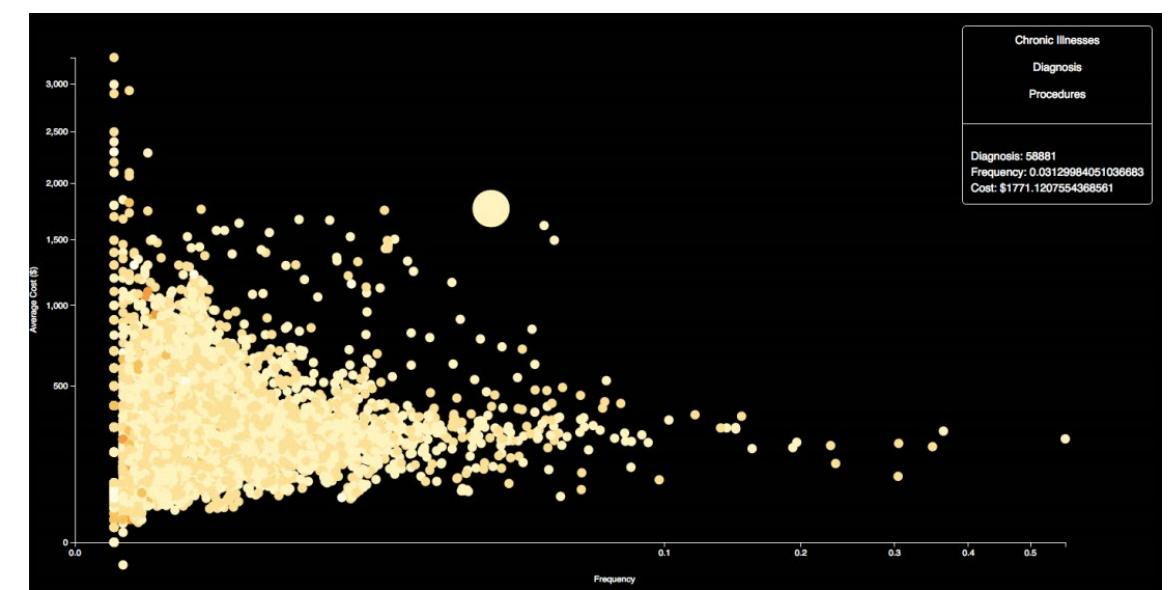
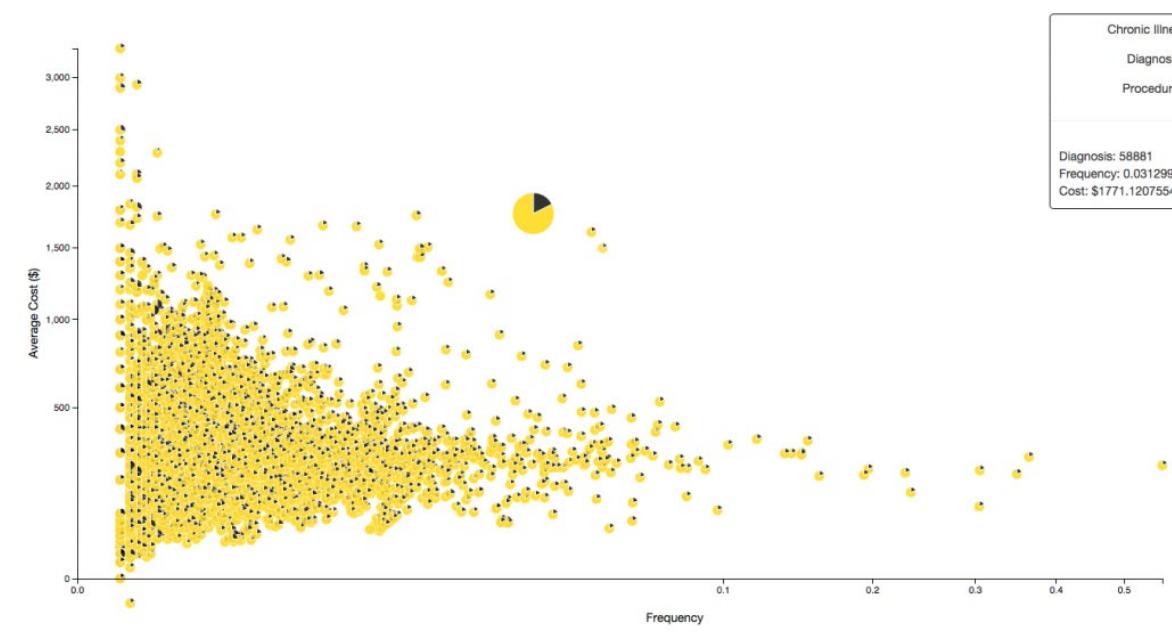
Interaction with the Background

Outlines (surrounding) matter.

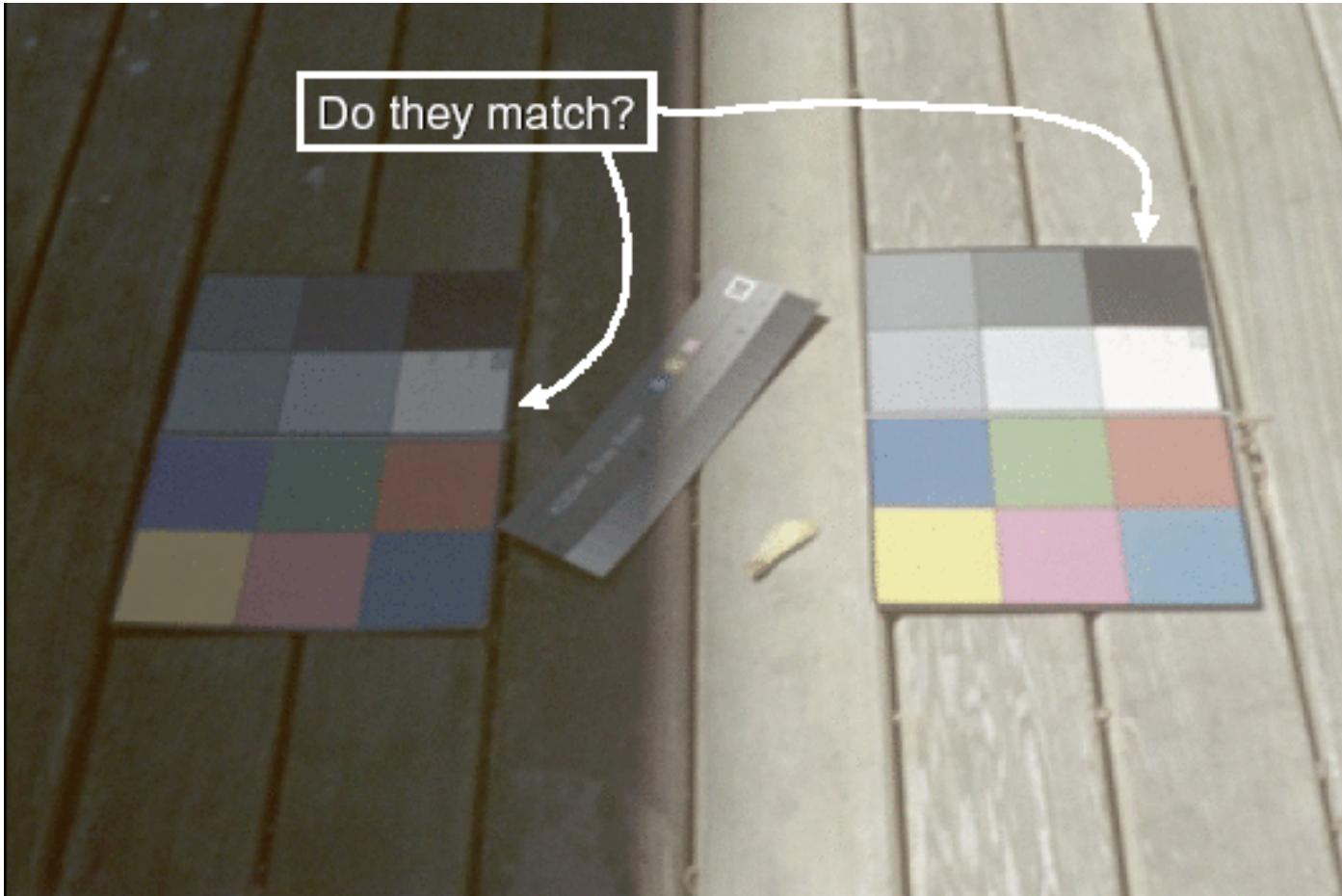


Interaction with the Background

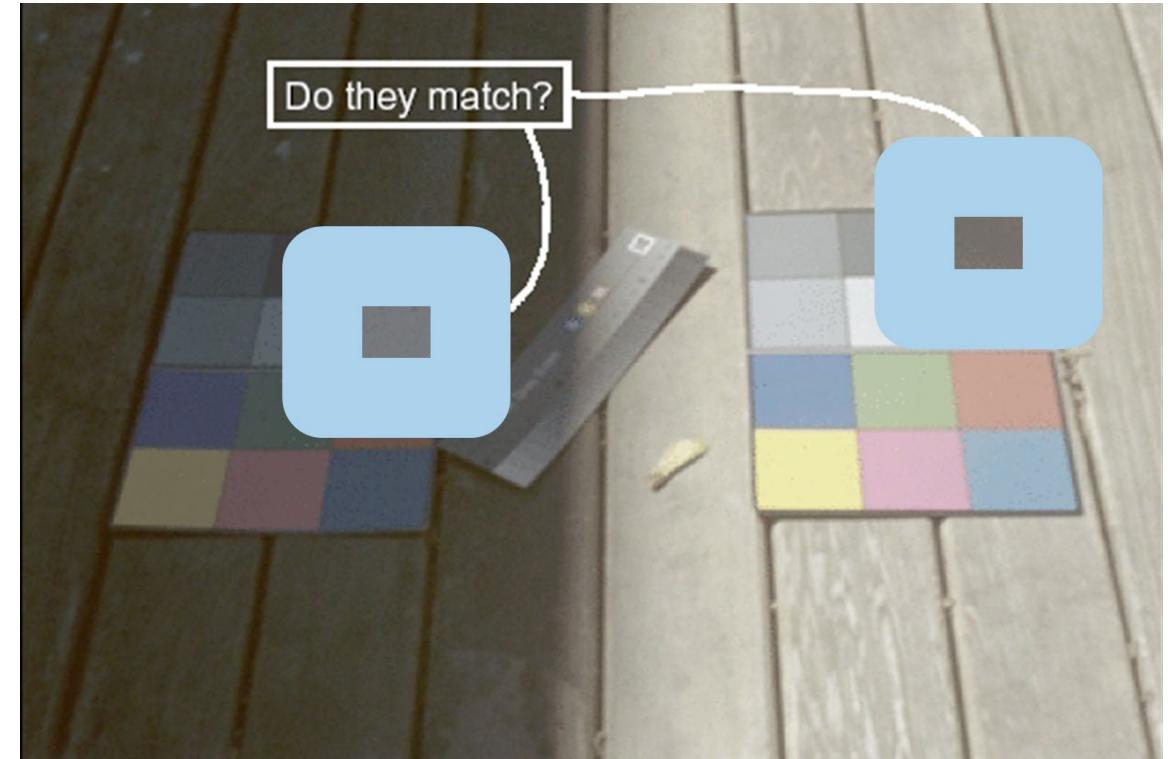
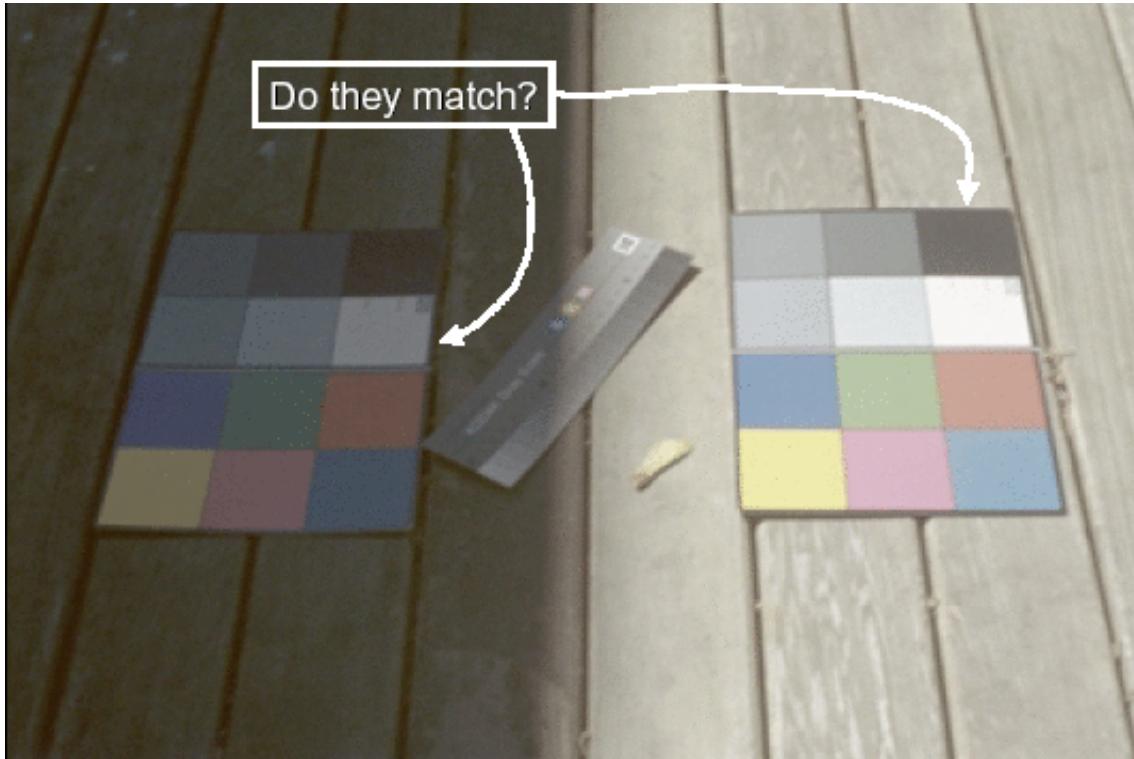
Outlines (surrounding) matter.



Interaction with the Background



Interaction with the Background



Interaction with the Background

