Communicating with Data – Perception and Color

Dr. Ab Mosca (they/them)

Slides based off slides courtesy of Jordan Crouser (https://jcrouser.github.io/)

Notes on HW01

- Remember to note who you collaborated with or explicitly state that you collaborated with no one (per the syllabus)
- Consider working (and submitting) in groups! Lots of people did the exact same visualizations, and it's more fun to create an analyze when you have brainstorming buddies

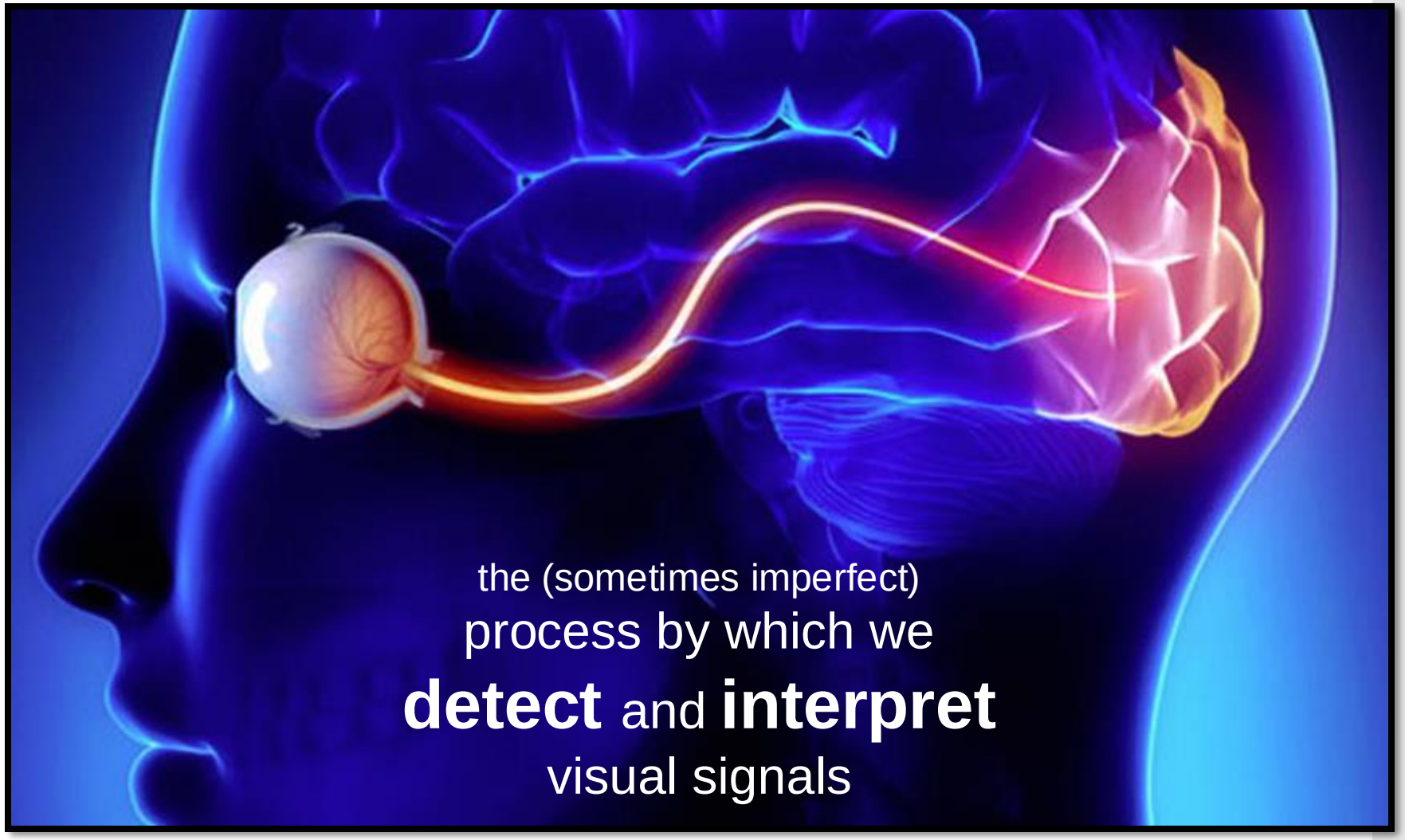
Plan for Today

- What is perception?
  - How does it work?
  - Pre-attentive processing
  - Gestalt Psychology
  - Attentive processing
- Color 101
  - How we see color
  - What this means for visualization
  - More perceptual problems
- Takeaways

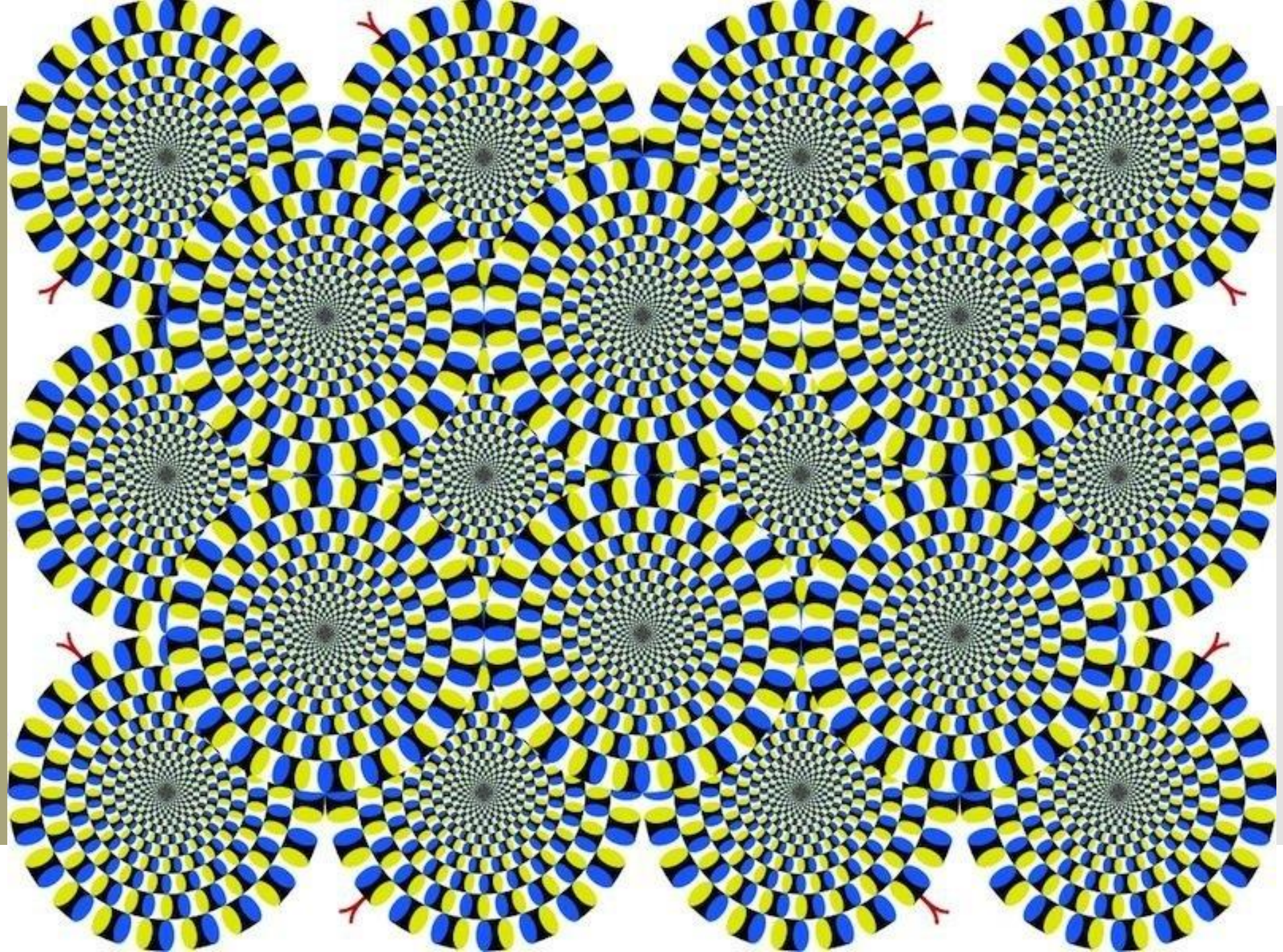
Note: I'm going to flash a bunch of slides quickly today. If that doesn't work for you, you are welcome to step out, close your eyes, etc.. (none of us will be offended and I will fill you in on anything crucial you missed!)

What is perception?

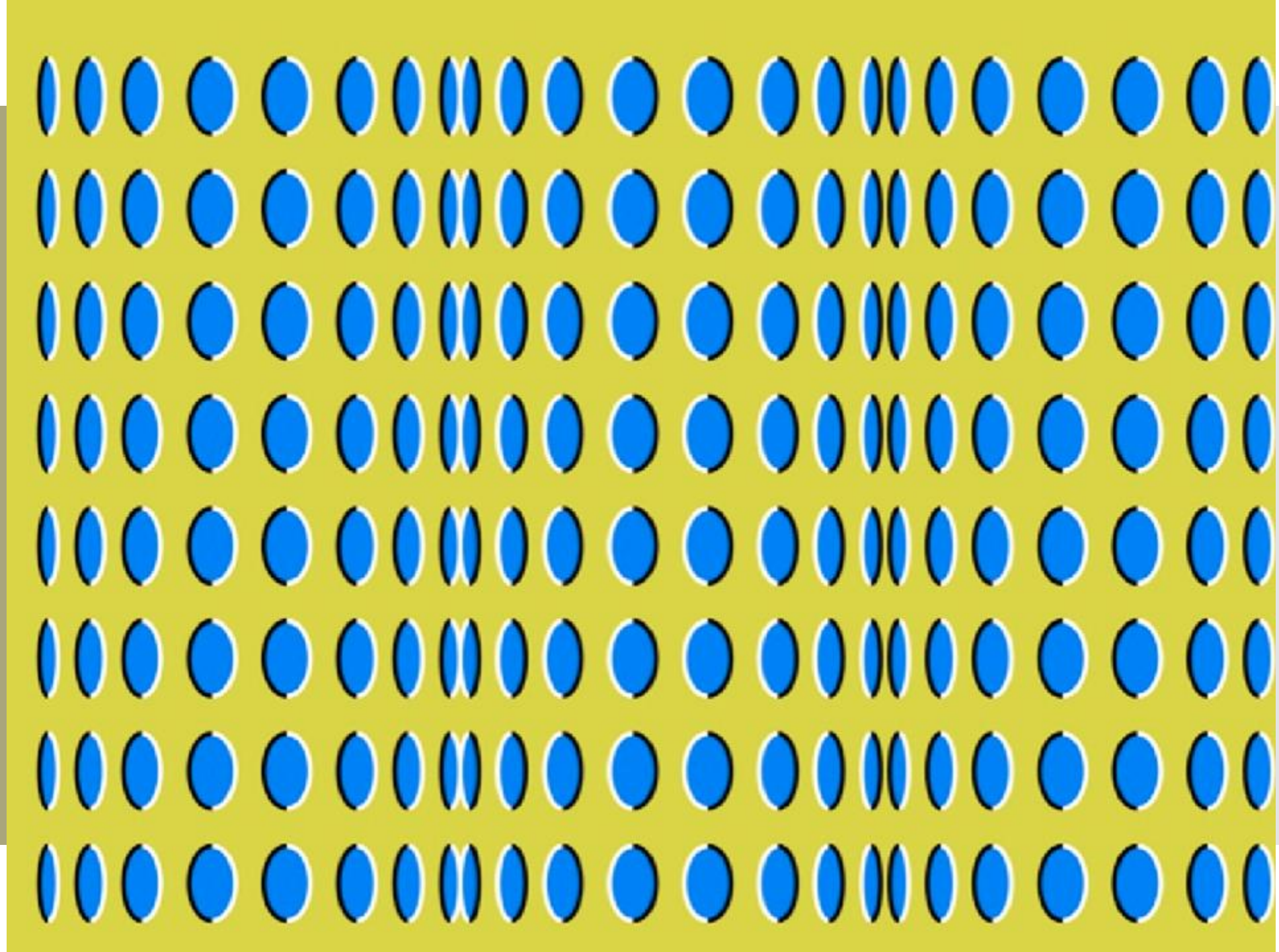
Visual perception (def.)



Do you see movement?

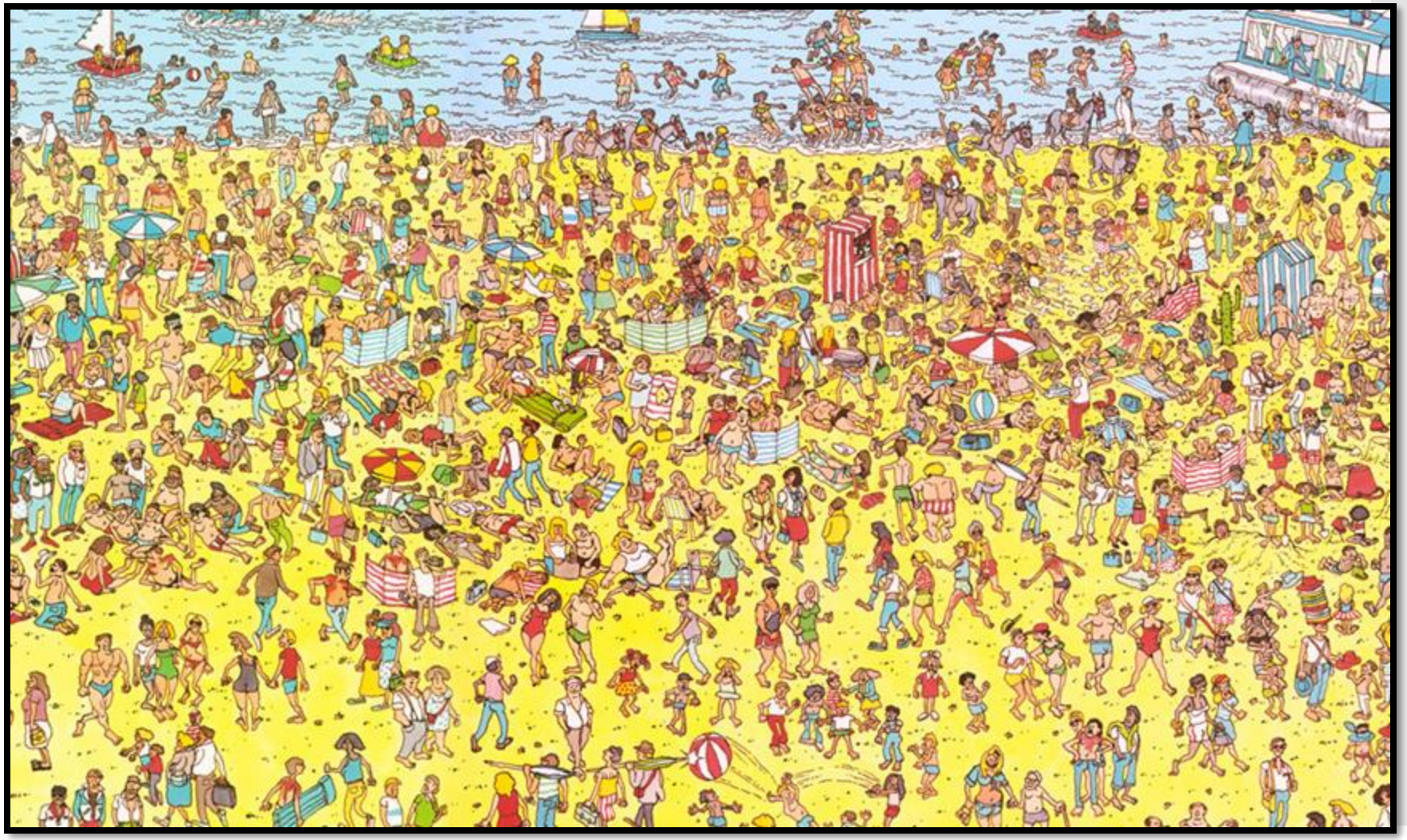


Do you see movement?



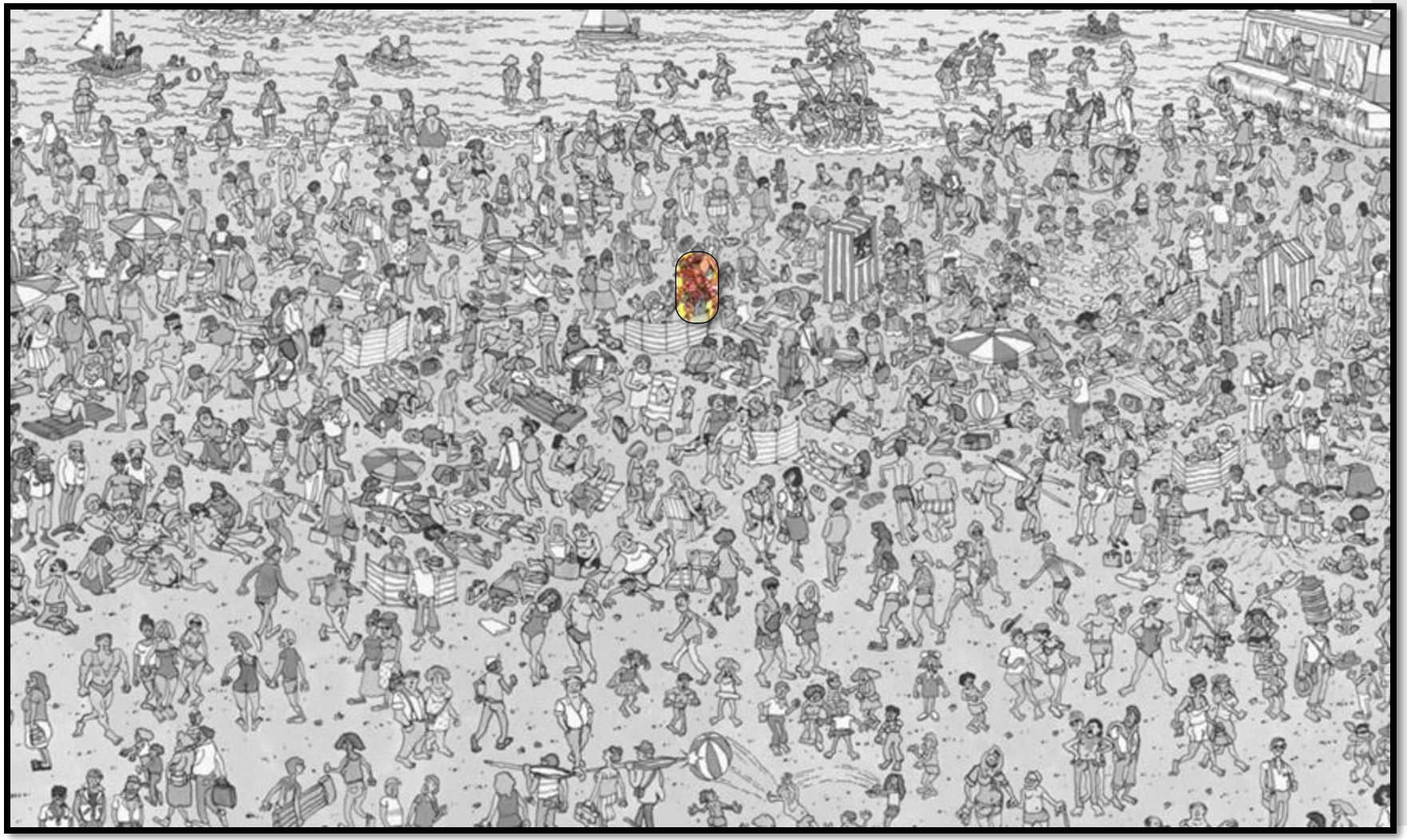
Visual perception

Some things are processed slowly



Visual perception

Others are incredibly fast

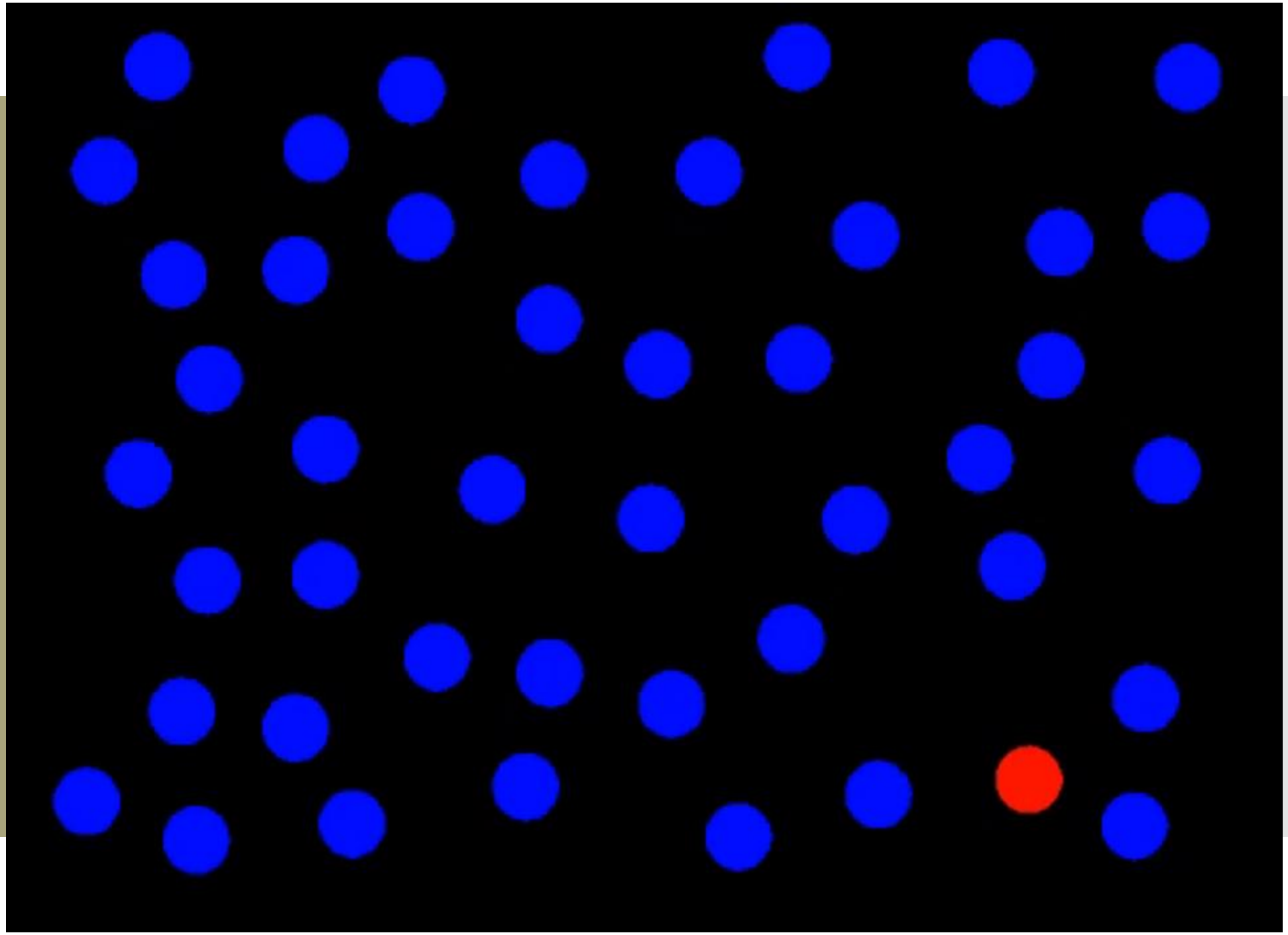


Pre-attentive processing

Fast = “pre-attentive processing”

- Things that happen in <200ms of visual stimulation
- Performed in parallel across the entire visual field
- Example…

Pre-attentive processing



Pre-attentive processing

What did you see?

Pre-attentive processing

"An understanding of what is processed pre-attentively is probably the **most important** contribution that visual science can make to data visualization" (Ware, 2004, p. 19)

Pre-attentive processing facilitates:

- Target detection (presence or absence)
- Boundary detection / grouping
- Region tracking
- Counting and estimation

Pre-attentive processing facilitates:

- Target detection (presence or absence)
- Boundary detection / grouping
- Region tracking
- Counting and estimation

- On the next slide I want you to count how many zeros you see as fast as you can. Raise your hand (do not shout the number) when you have the answer.

Attentive counting

128176875613897654698450698562498282676298098584582245198564589450984599859435859891330249945959595772564675750678974567884578981982167765487636496856091294968 6

How many zeros are there?

Attentive counting

We'll do the same on the next slide for threes.

Pre-attentive counting

1281768756138976546984506985604982826762

9809858458224509856458945098450980943585

9091030209905959595772564675050678904567

8845789809821677654876364908560912949686

How many threes are there?

Pre-attentive processing for visualization

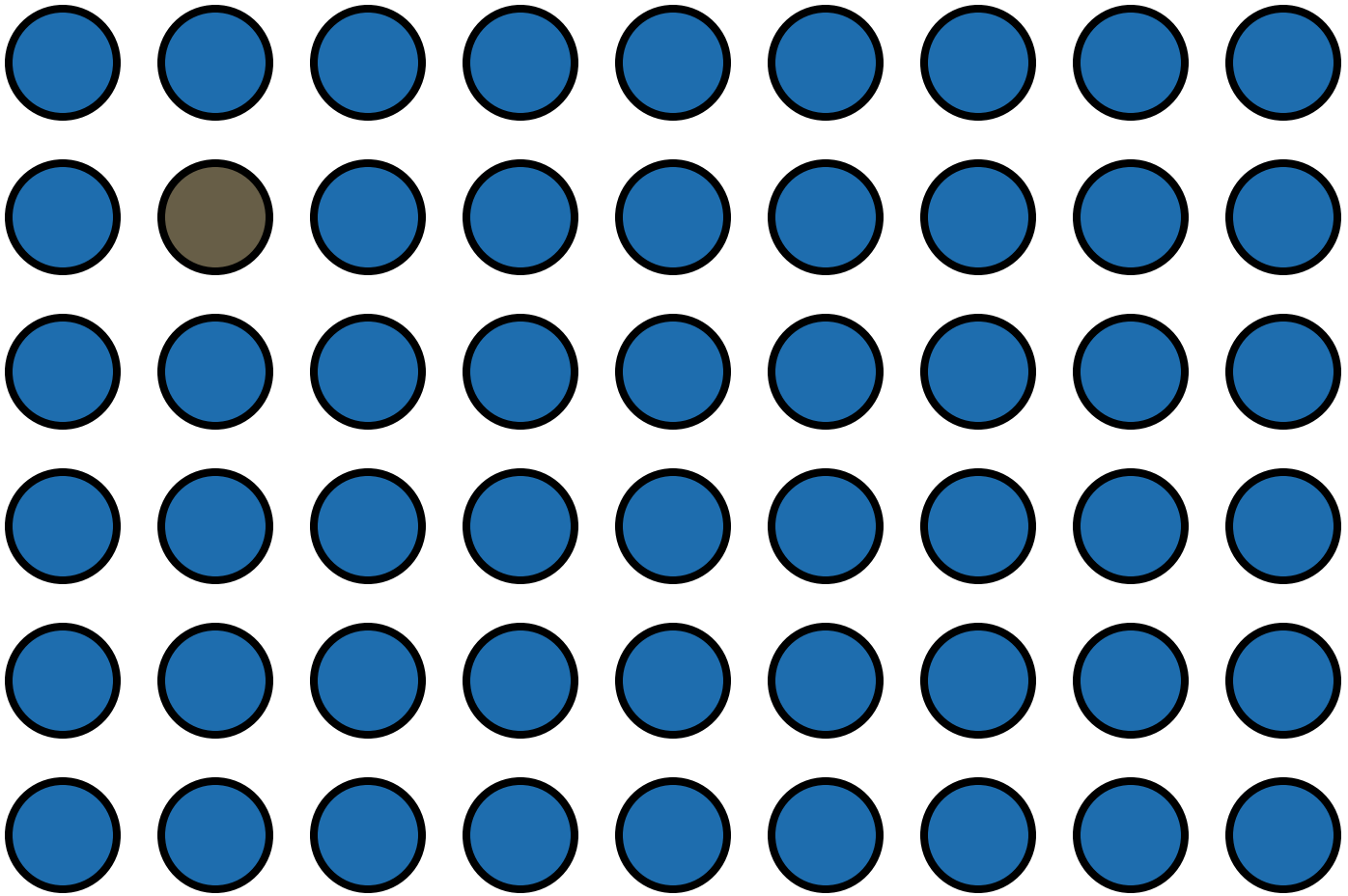
Question 1: how do we (vis designers) use pre-attentive processing to our advantage?

Question 2: what do we need to watch out for?

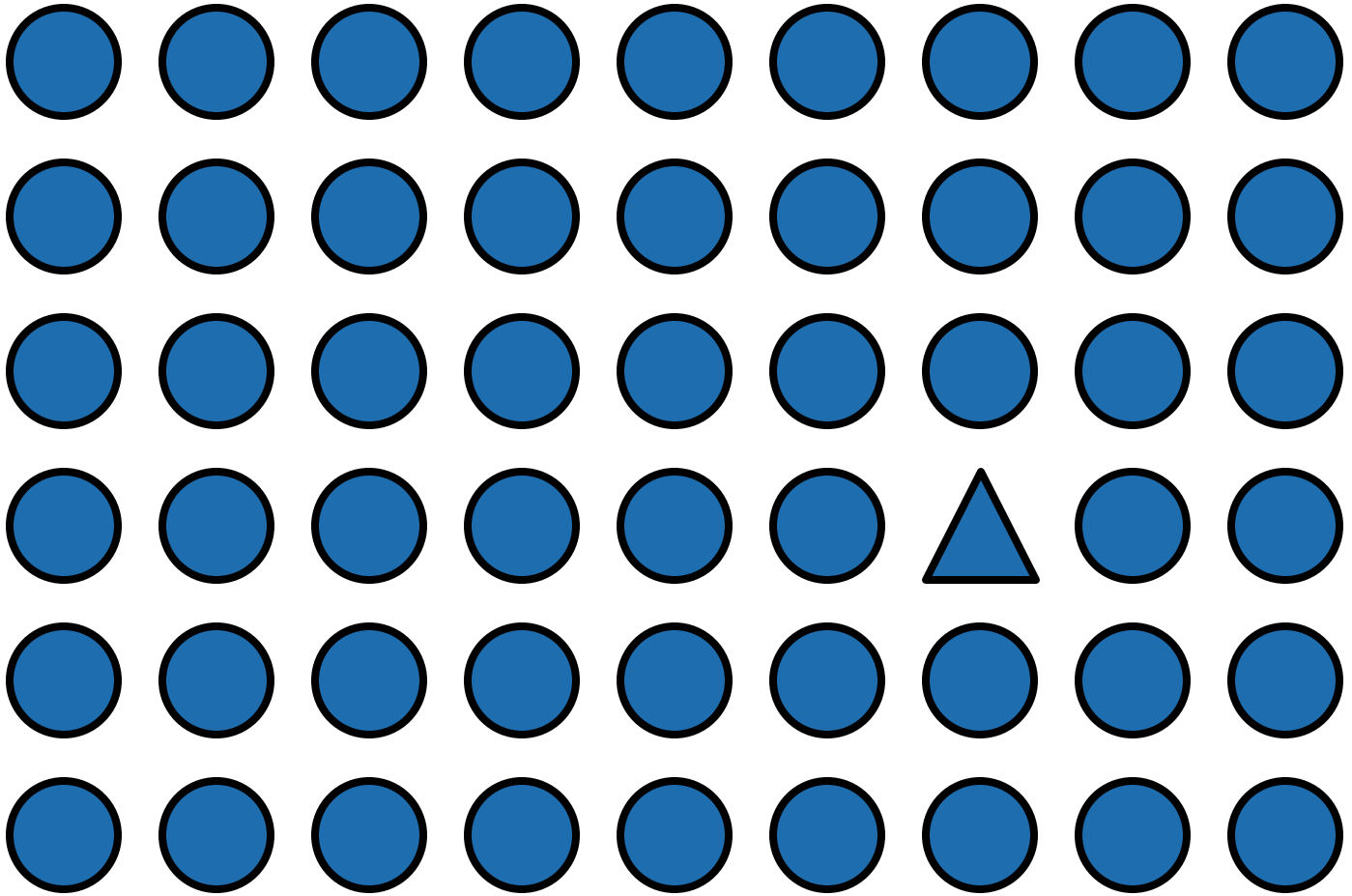
Pre-attentive processing for visualization

There’s only one instance of something on each of the next slides. What is it?

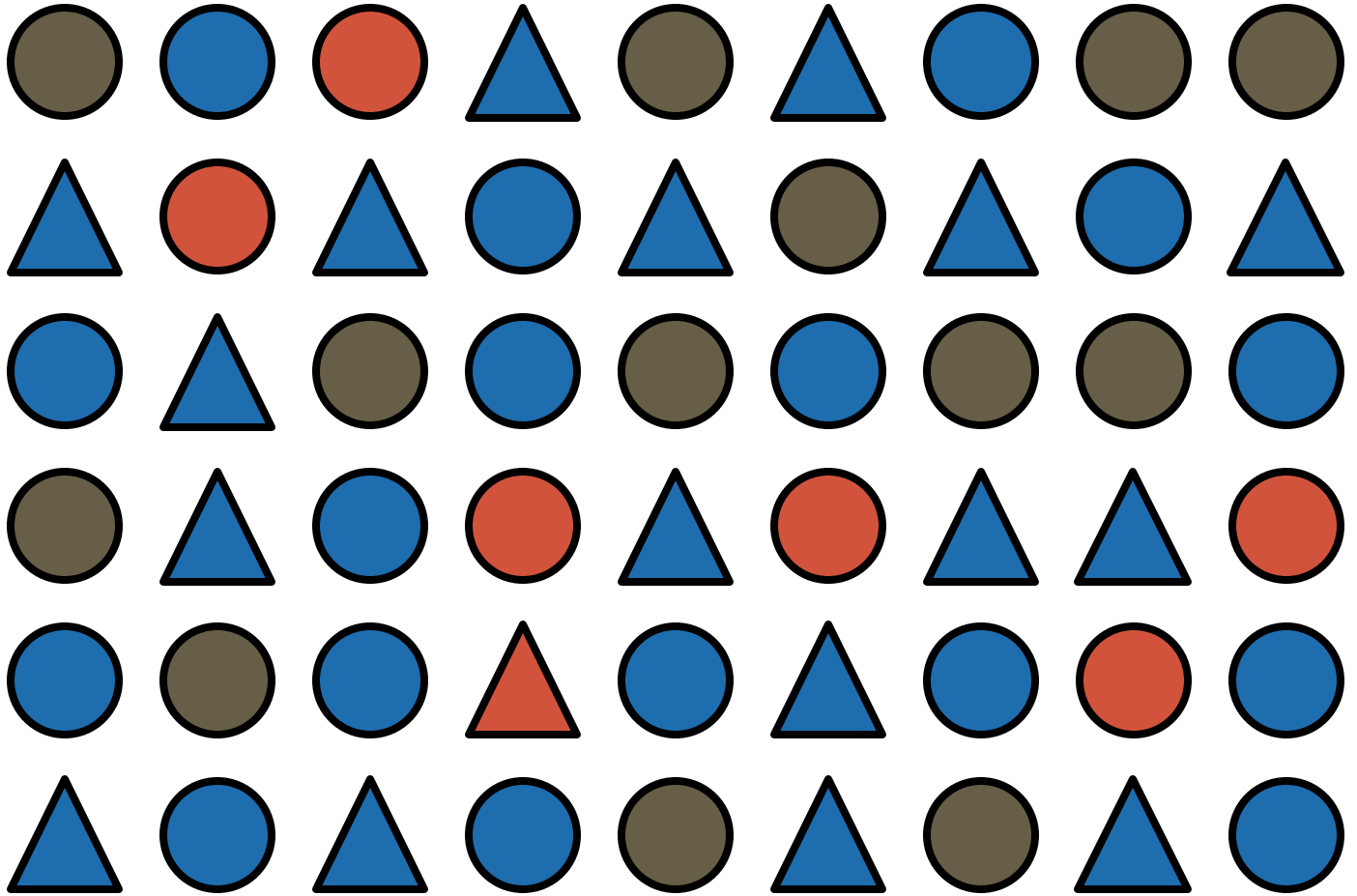
Pre-attentive processing: hue



Pre-attentive processing: shape (curvature)



Pre-attentive processing: shape + hue?



Discussion: what's going on here?

Answer: this is called "conjunction"

- If you search for red things, you get a bunch of red circles (as well as the red **triangle**).
- Similarly, if you search for search for **triangles**, you get a bunch of blue **triangles** (as well as the red **triangle**).
- Either way, you have to search through them all one by one!

Pre-attentive processing for visualization

For each of the next slides, is there a boundary (i.e. are there multiple regions)? If yes, what are the regions?

Pre-attentive processing: hue

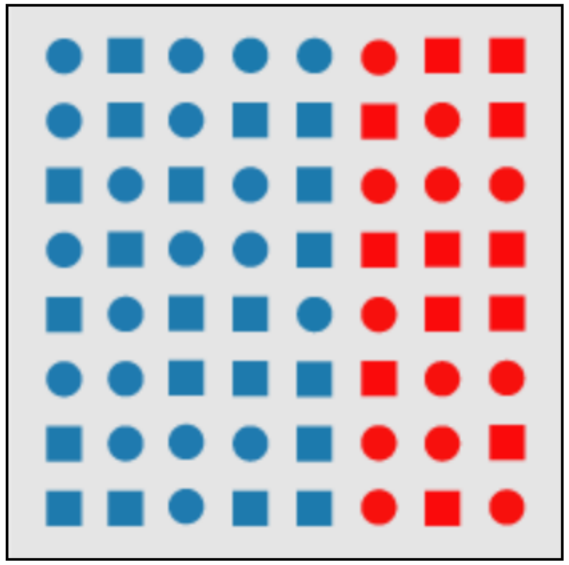
Pre-attentive processing: shape (curvature)

Pre-attentive processing: hue + shape

Discussion: what's going on here?

Answer: this is called "feature hierarchy"

- During boundary detection, the visual system favors hue over shape



(b)

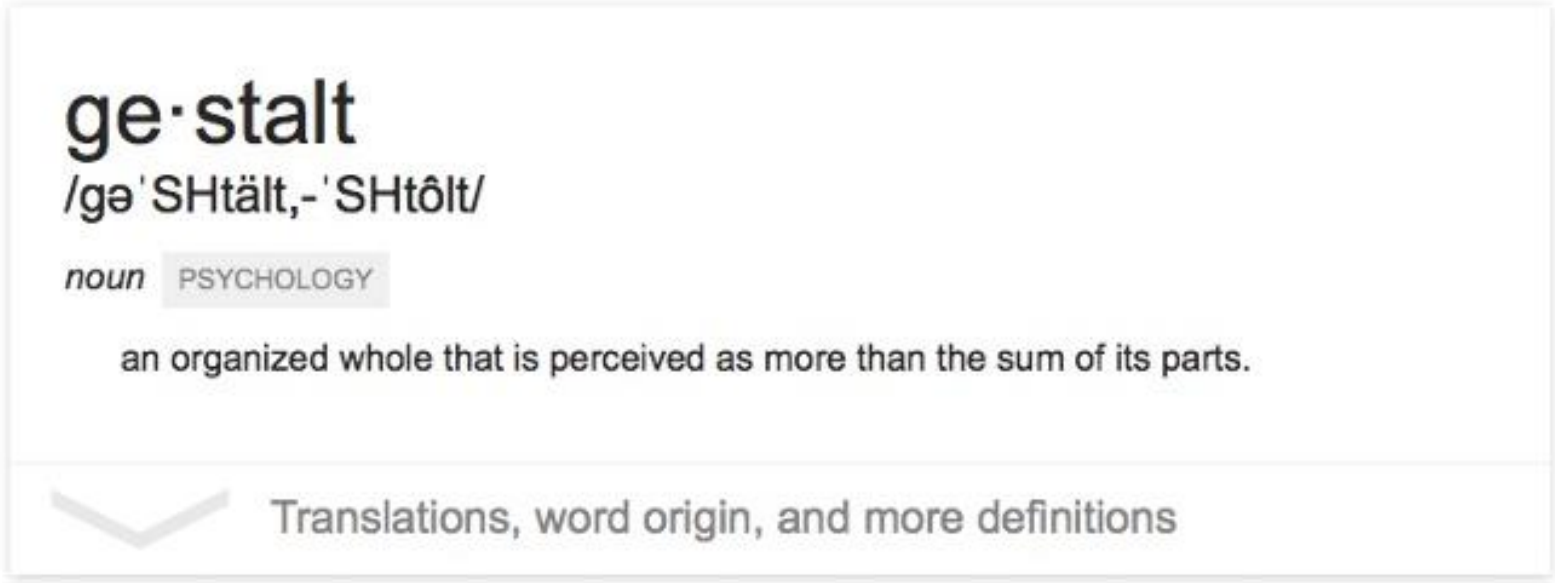
Pre-attentive processing for visualization

- Whatever draws our eyes draws our attention
- This can be useful
- It can also be problematic:

Pre-attentive processing for visualization: The downsides

Ex. flicker can cause change blindness

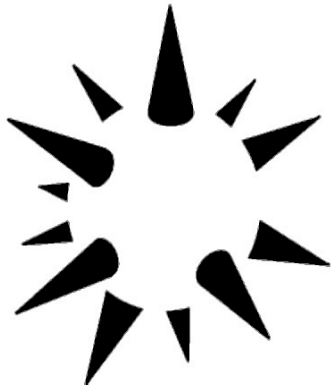
The “gestalt effect”



Our brain’s ability to generate whole forms, instead of just collections of unrelated elements

Gestalt effects

Reification

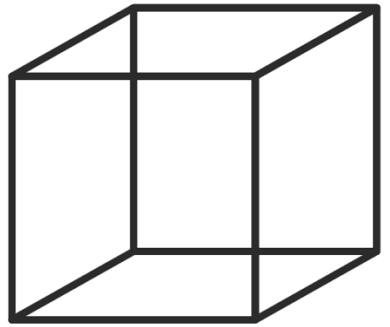


Demonstration of reification in perception from Lehar S. (2003) The World In Your Head, Lawrence Erlbaum, Mahwah, NJ. p. 52, Fig. 3.3

Emergence

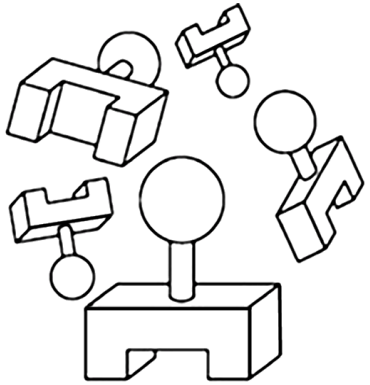
https://www.interaction-design.org/literature/topics/gestalt-principles#docs-internal-guid-f7074e47-7fff-b4dc-f0f5-966e09f6b4e7

Multistability



https://www.interaction-design.org/literature/topics/gestalt-principles#docs-internal-guid-f7074e47-7fff-b4dc-f0f5-966e09f6b4e7

Invariance

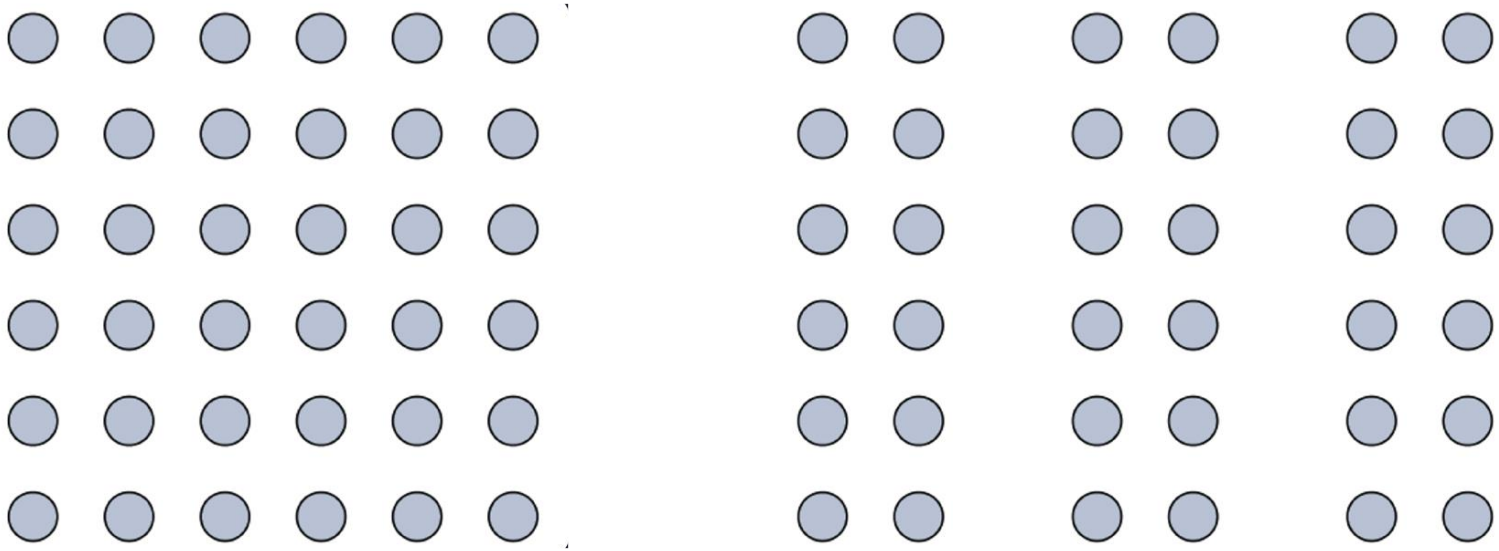


Demonstration of invariance in perception from Lehar S. (2003) The World In Your Head, Lawrence Erlbaum, Mahwah, NJ. p. 53, Fig. 3.5

→ 6 “Laws of Grouping”

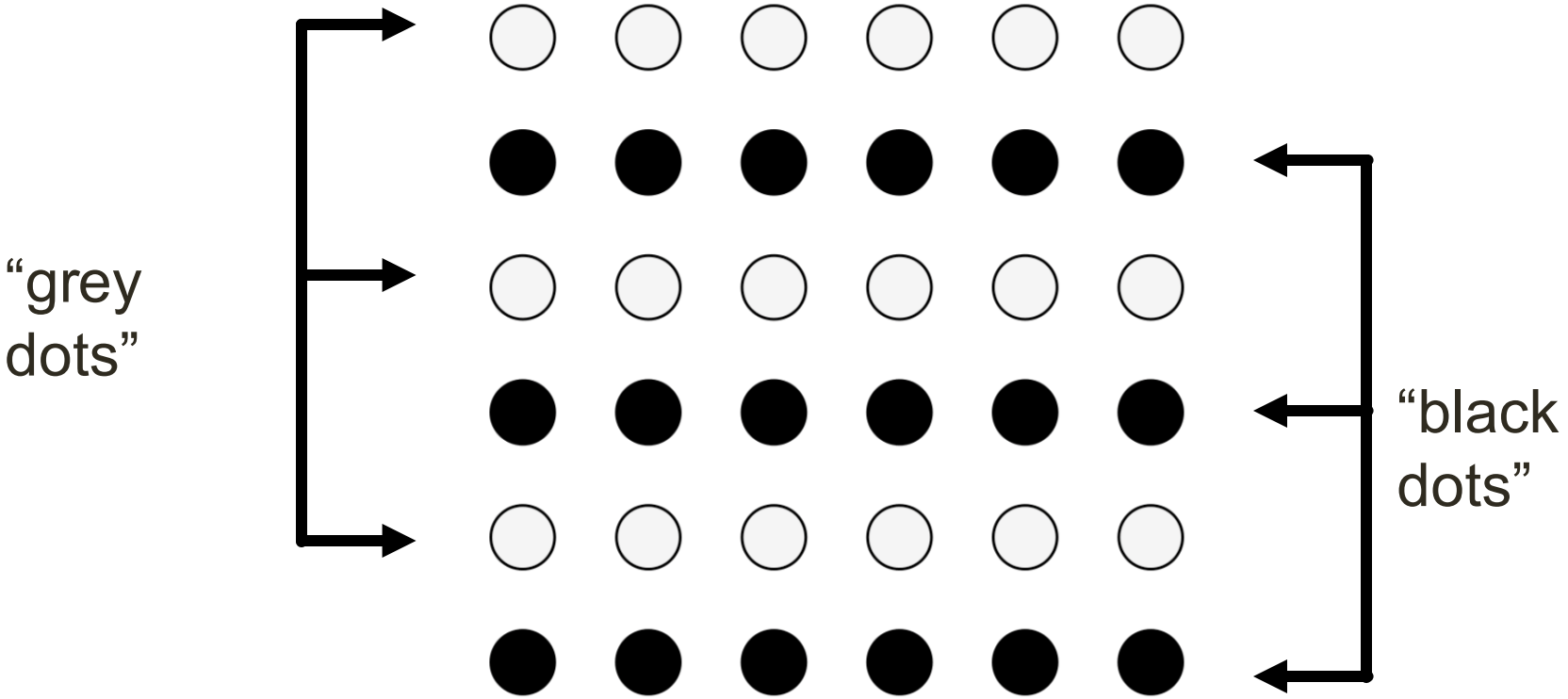
Law of Proximity

We interpret objects that are **close** to each other as a group



Law of Similarity

We interpret objects that are **visually similar** to each other as a group



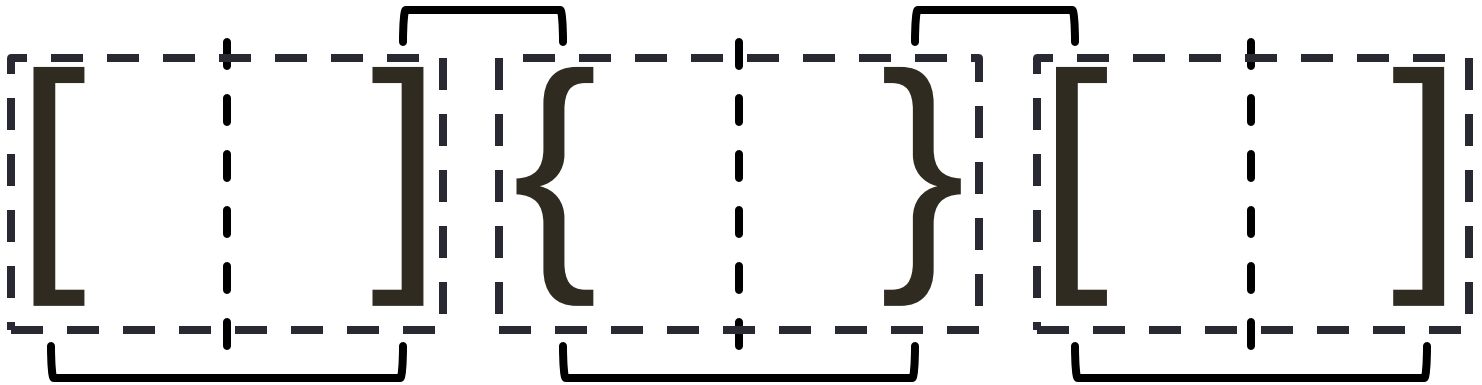
Law of Closure

When parts of a picture are missing, we fill in the visual gap

Law of Symmetry

We perceive objects as being symmetrical, arranged around a center point

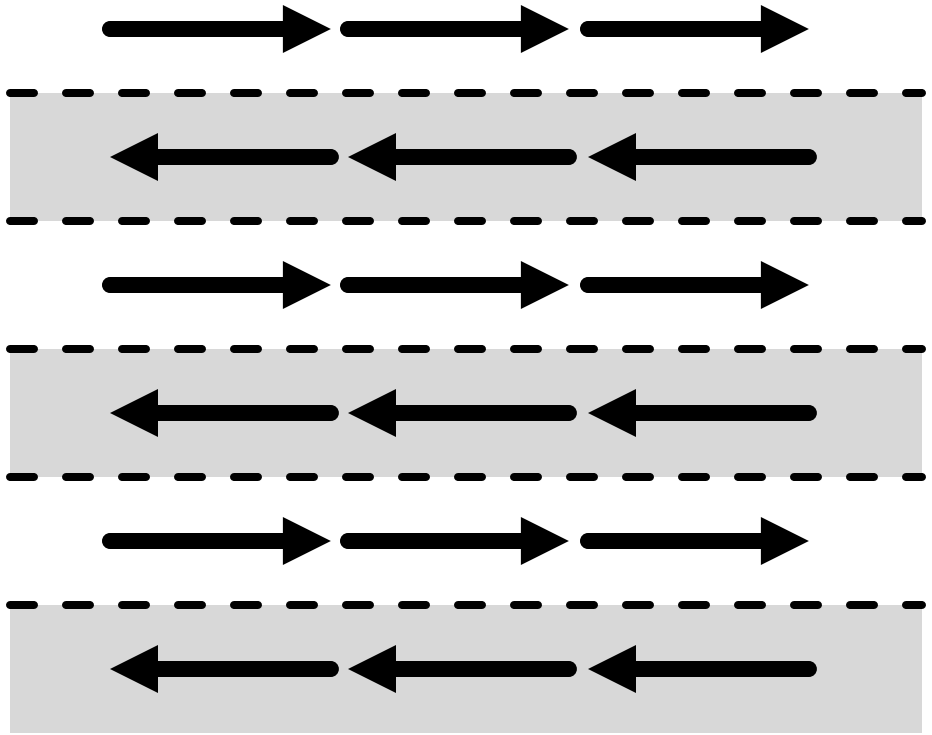
law of proximity



law of symmetry + law of similarity

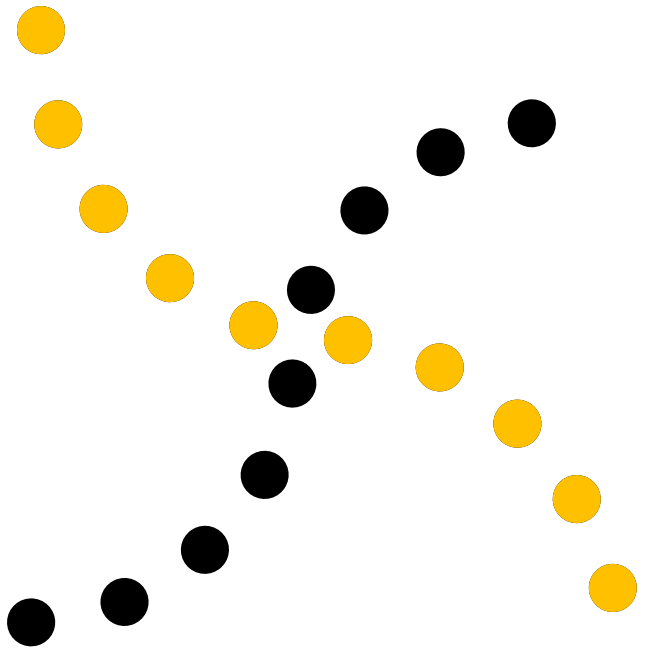
Law of Common Fate

We group objects that we perceive to be moving along the same path



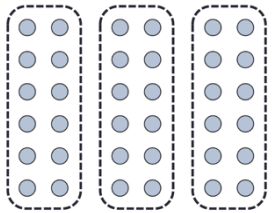
Law of Continuity

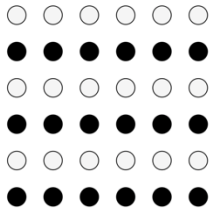
We tend to group objects along the **smoothest path**



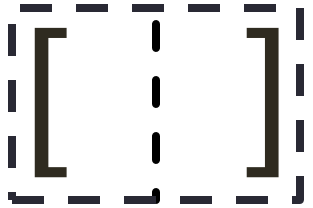
Let's Practice ~10 minutes

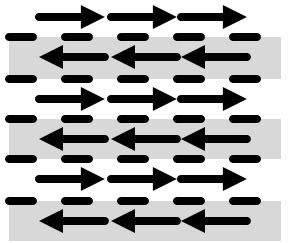
- Break into teams of 3
- Choose a visualization from the Tableau Vis of the Day collection: https://public.tableau.com/app/discover/viz-of-the-day
- **Goal:** identify as many examples of the Laws of Grouping (Gestalt Principles) in action in your sample visualization as you can
- Be prepared to present your findings to the class

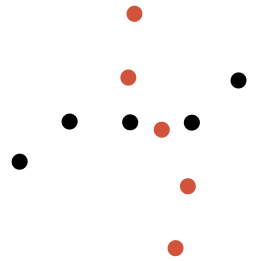

proximity


similarity


closure

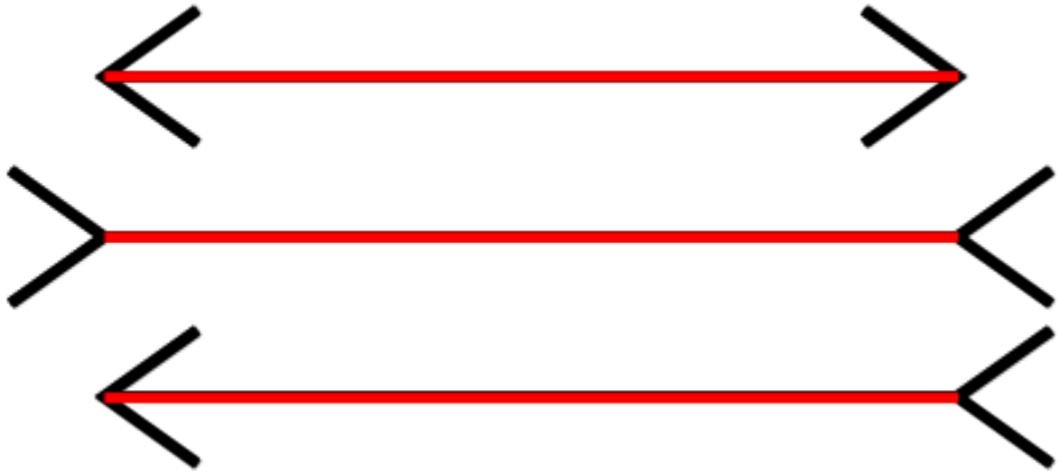

symmetry


common fate


continuity

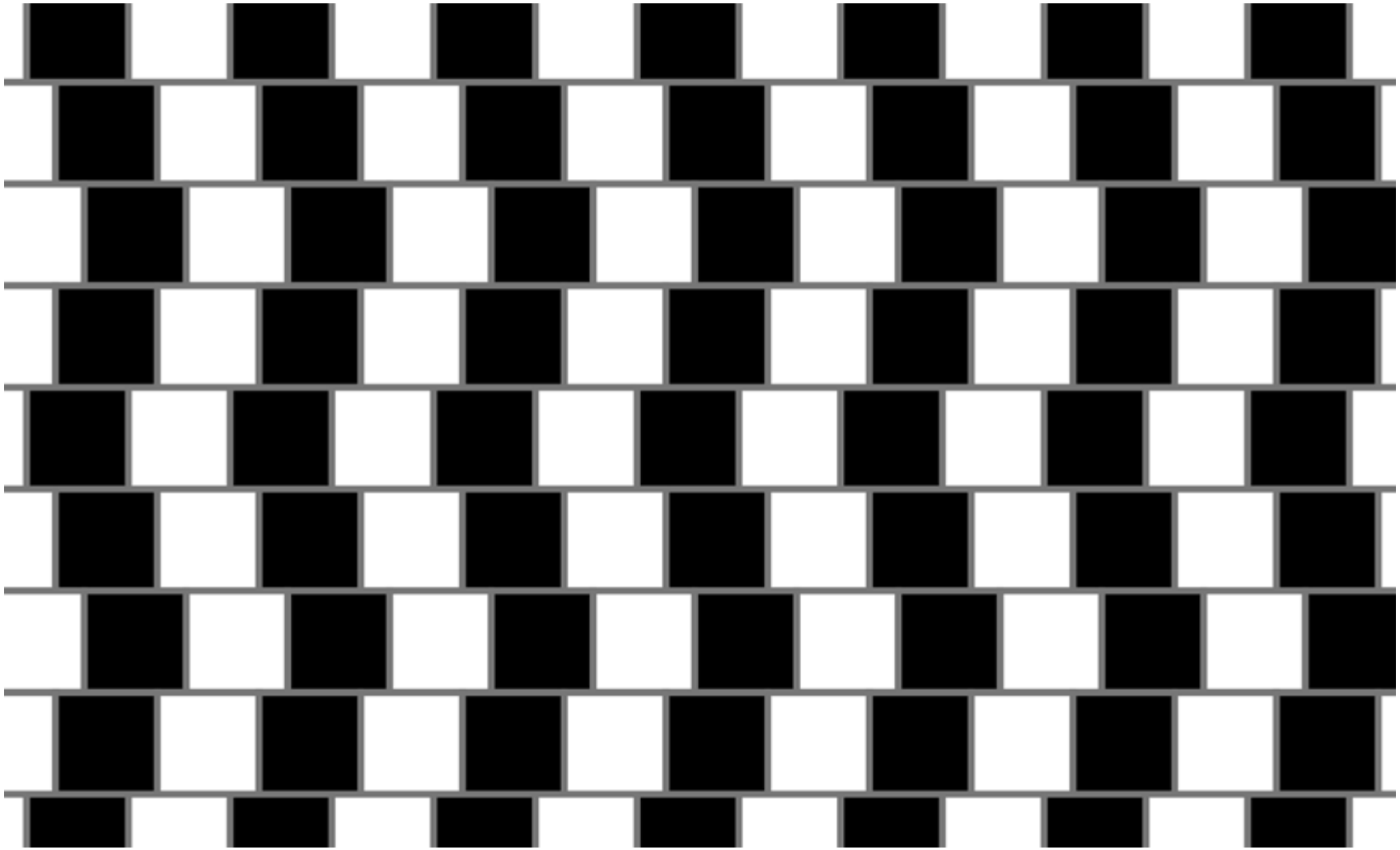
Pre-attentive processing for visualization: The downsides

Sometimes gestalt & pre-attention compete



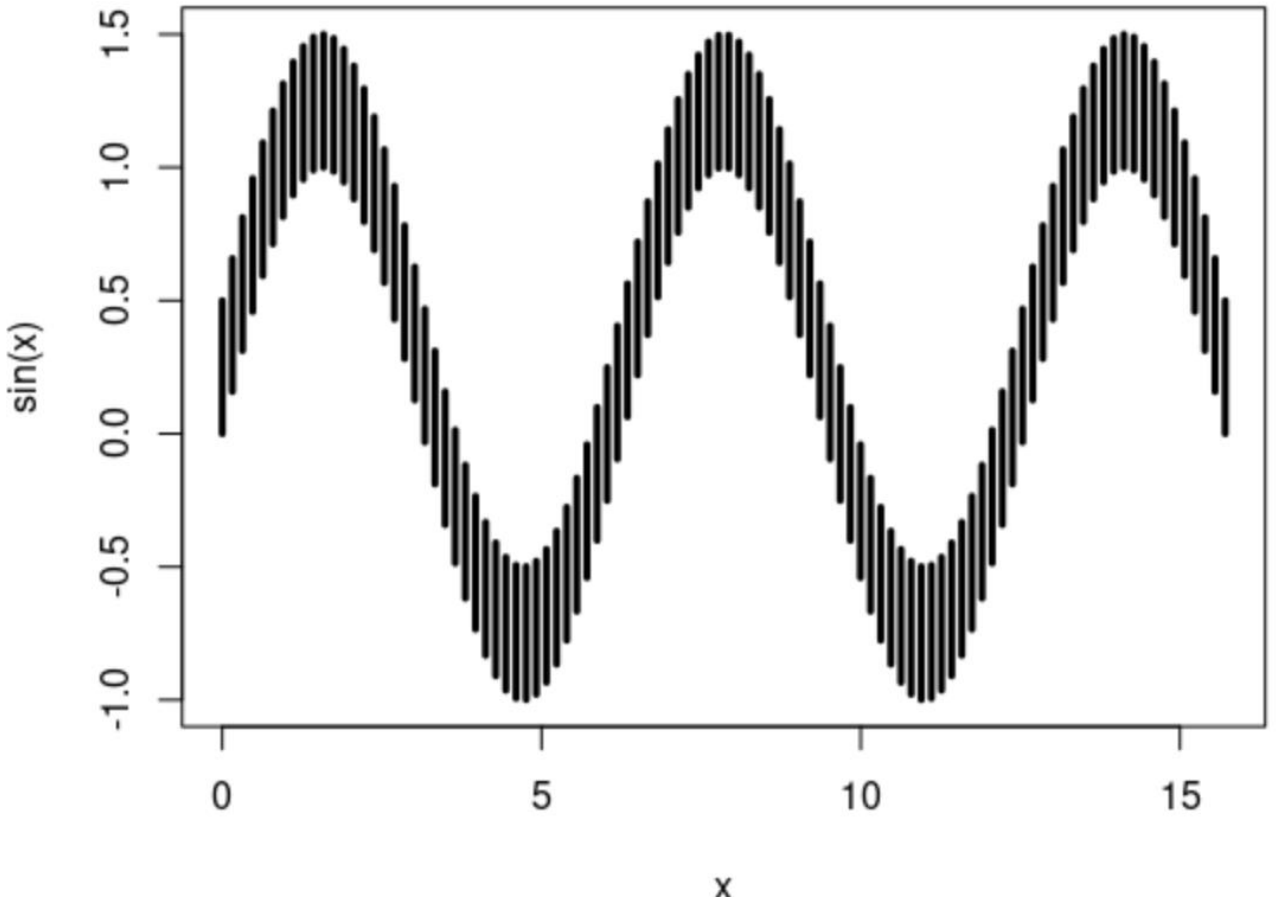
Pre-attentive processing for visualization: The downsides

Sometimes gestalt & pre-attention compete



Pre-attentive processing for visualization: The downsides

Sometimes gestalt & pre-attention compete

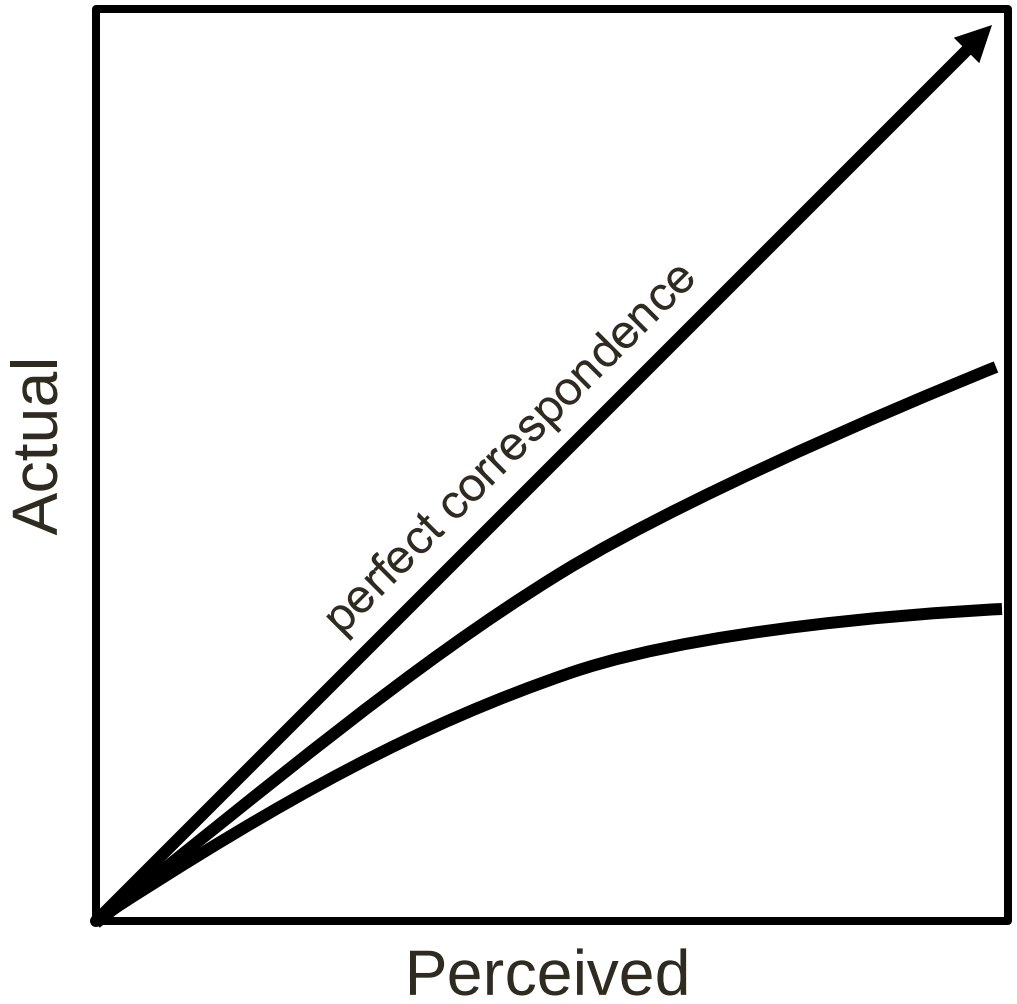


Attentive processing

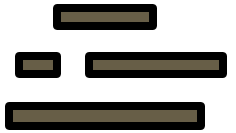
Okay, what about **attentive** processing?

Attentive processing

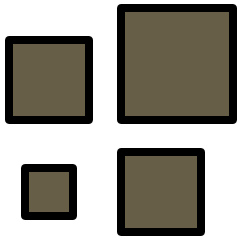
"Apparent" magnitude



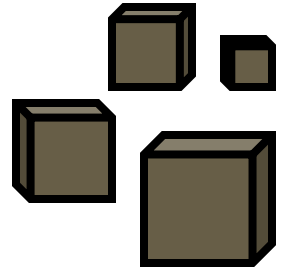
Length
estimate correctly



Area
under-estimate



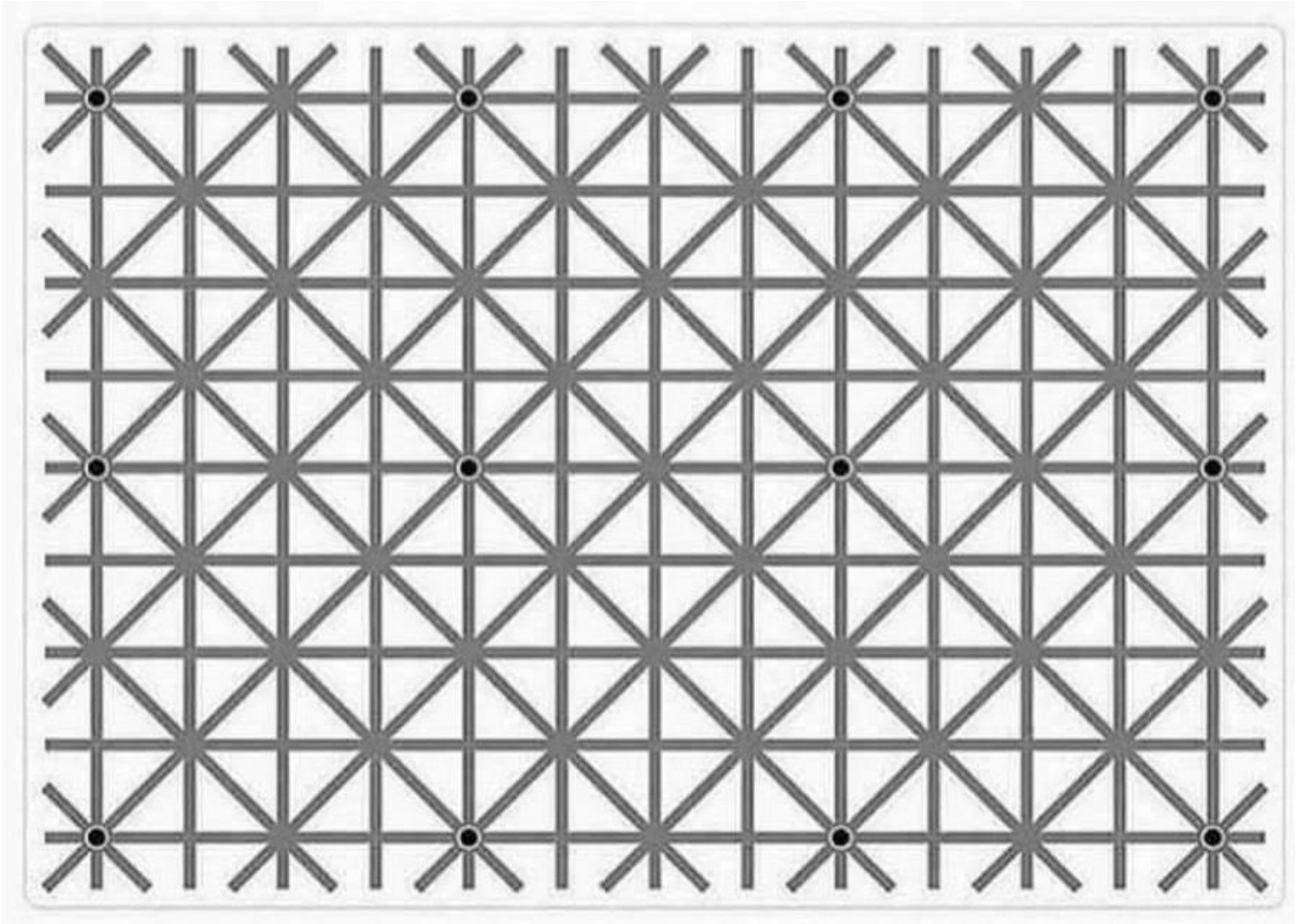
Volume
way under-estimate



http://makingmaps.net/2007/08/28/perceptual-scaling-of-map-symbols/

Attentive processing

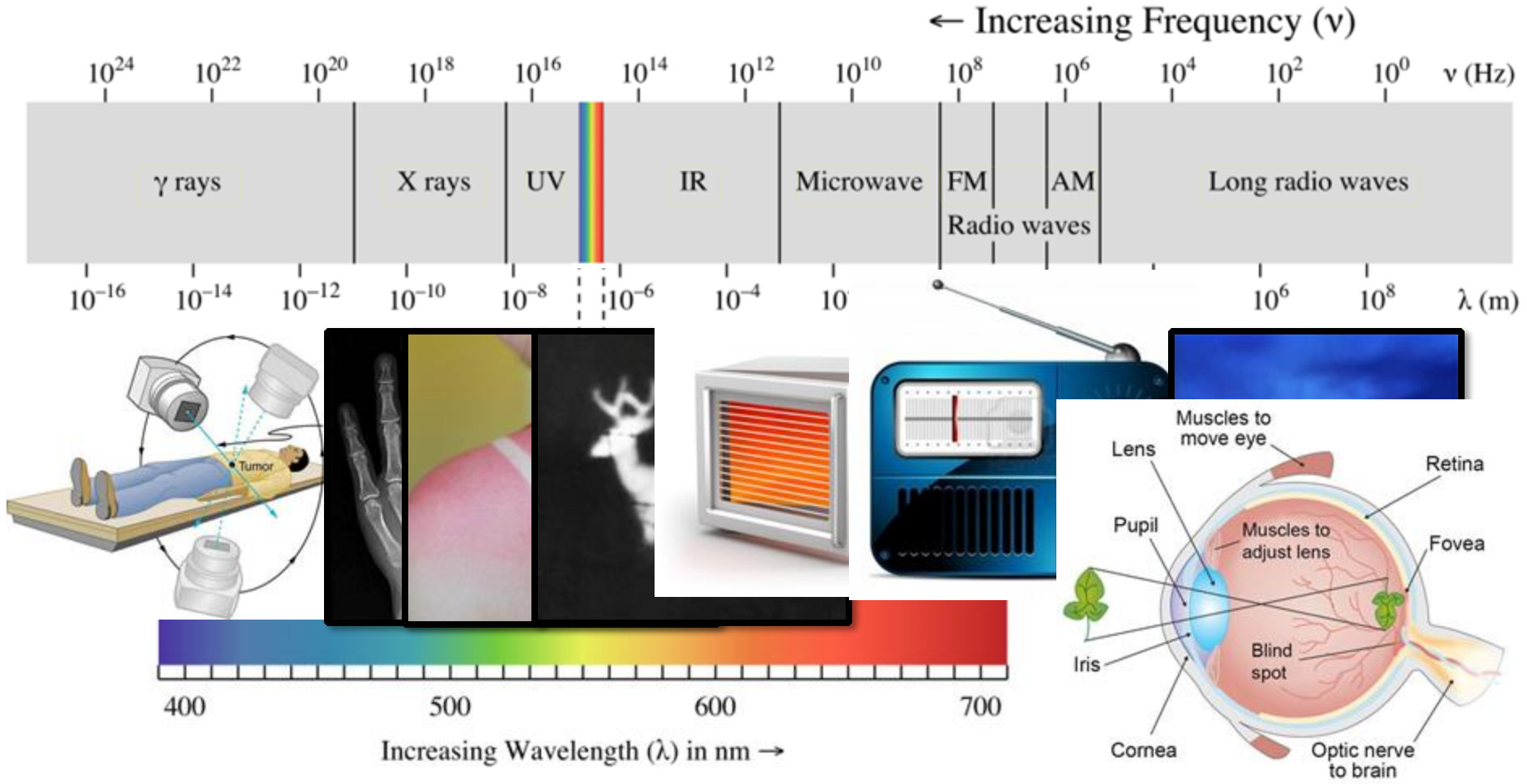
Short term "working" memory is limited



https://homepage.divms.uiowa.edu/~luke/classes/STAT4580/percep.html

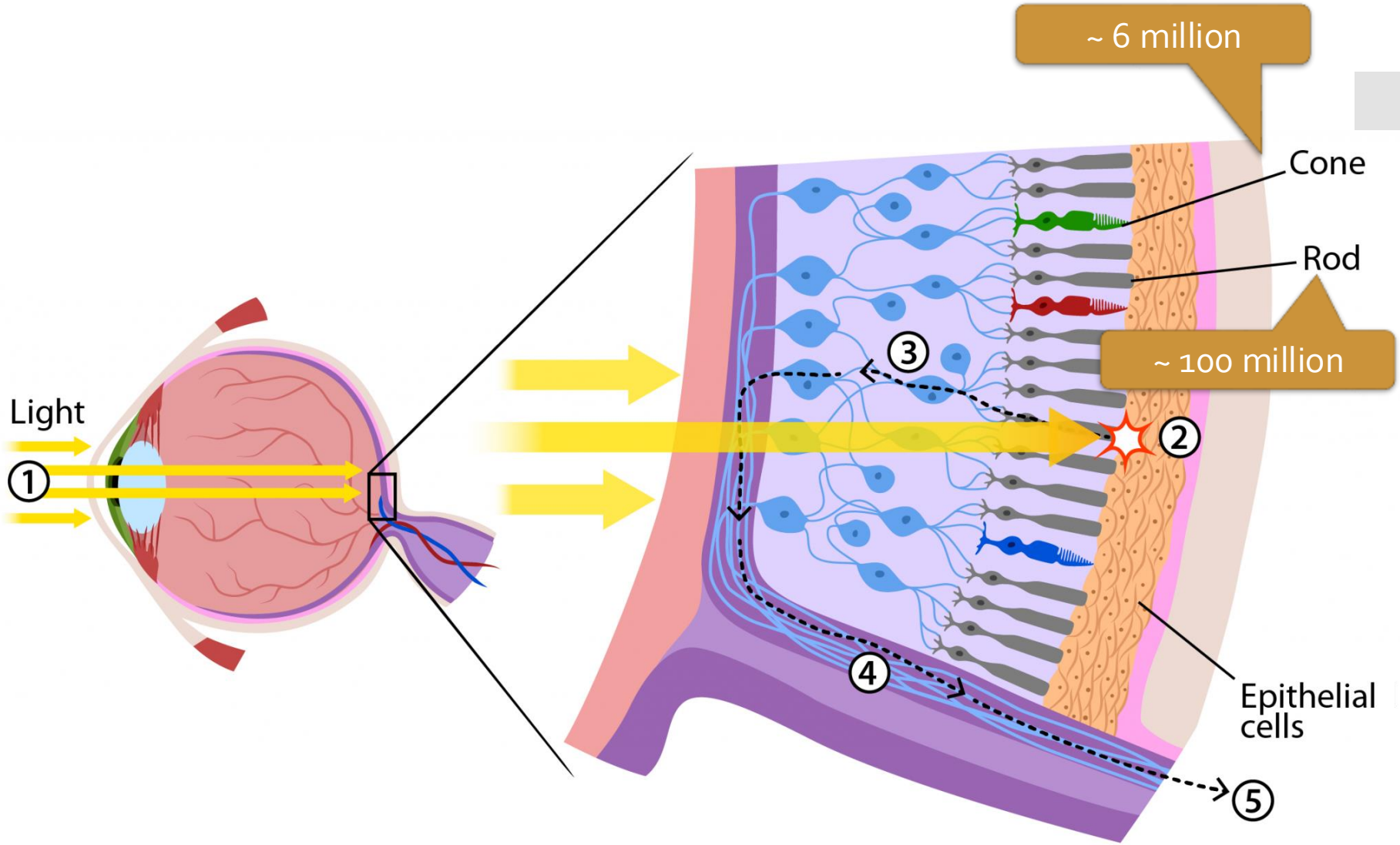
Color 101

Kinds of light



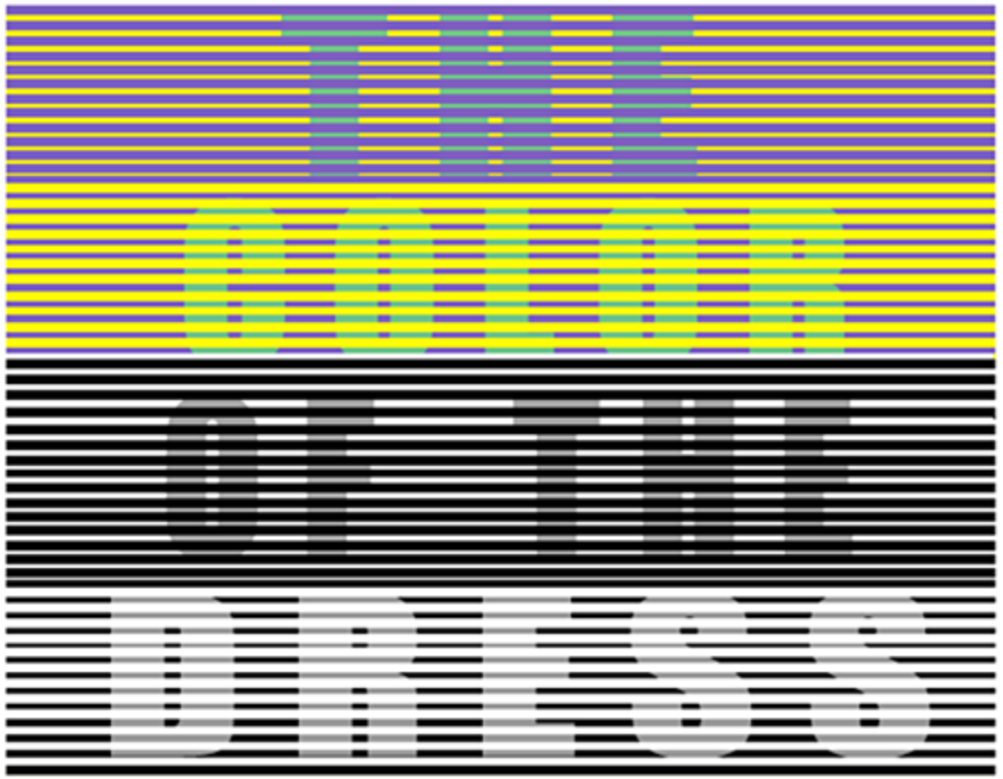
Eye diagram courtesy ASU

How we see color



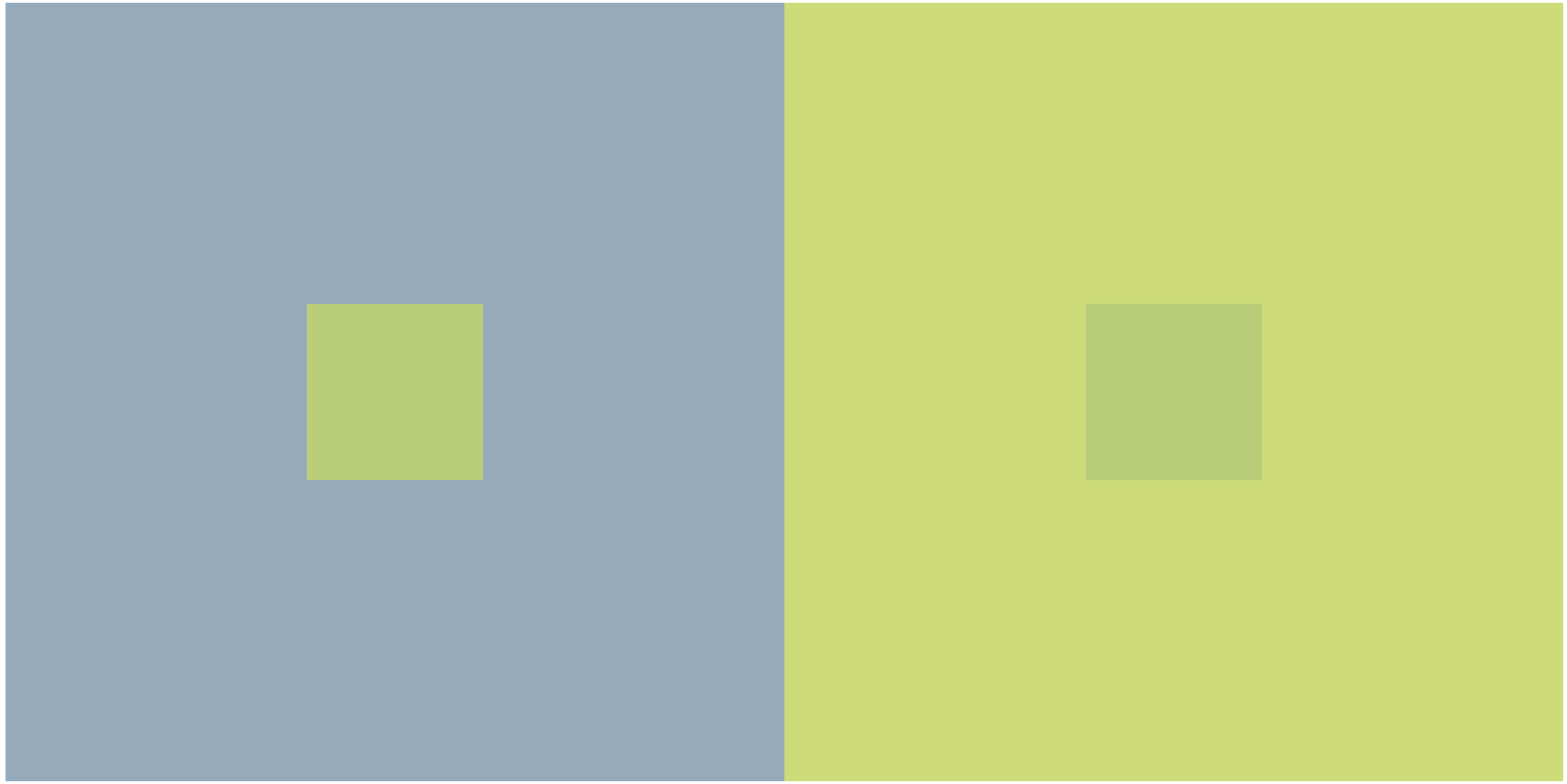
https://askabiologist.asu.edu/rods-and-cones

Color phenomena



Color phenomena

Caveat 1: color is perceived in context



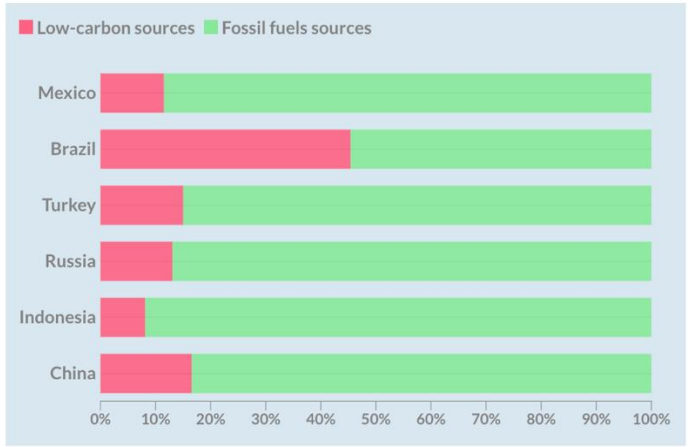
Which small square is **darker green**?

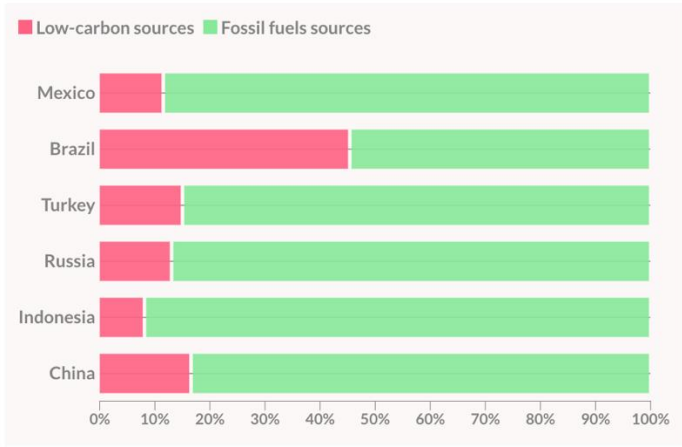
Color phenomena

Caveat 2: difference is relative

Color phenomenon

- Be careful when layering colors

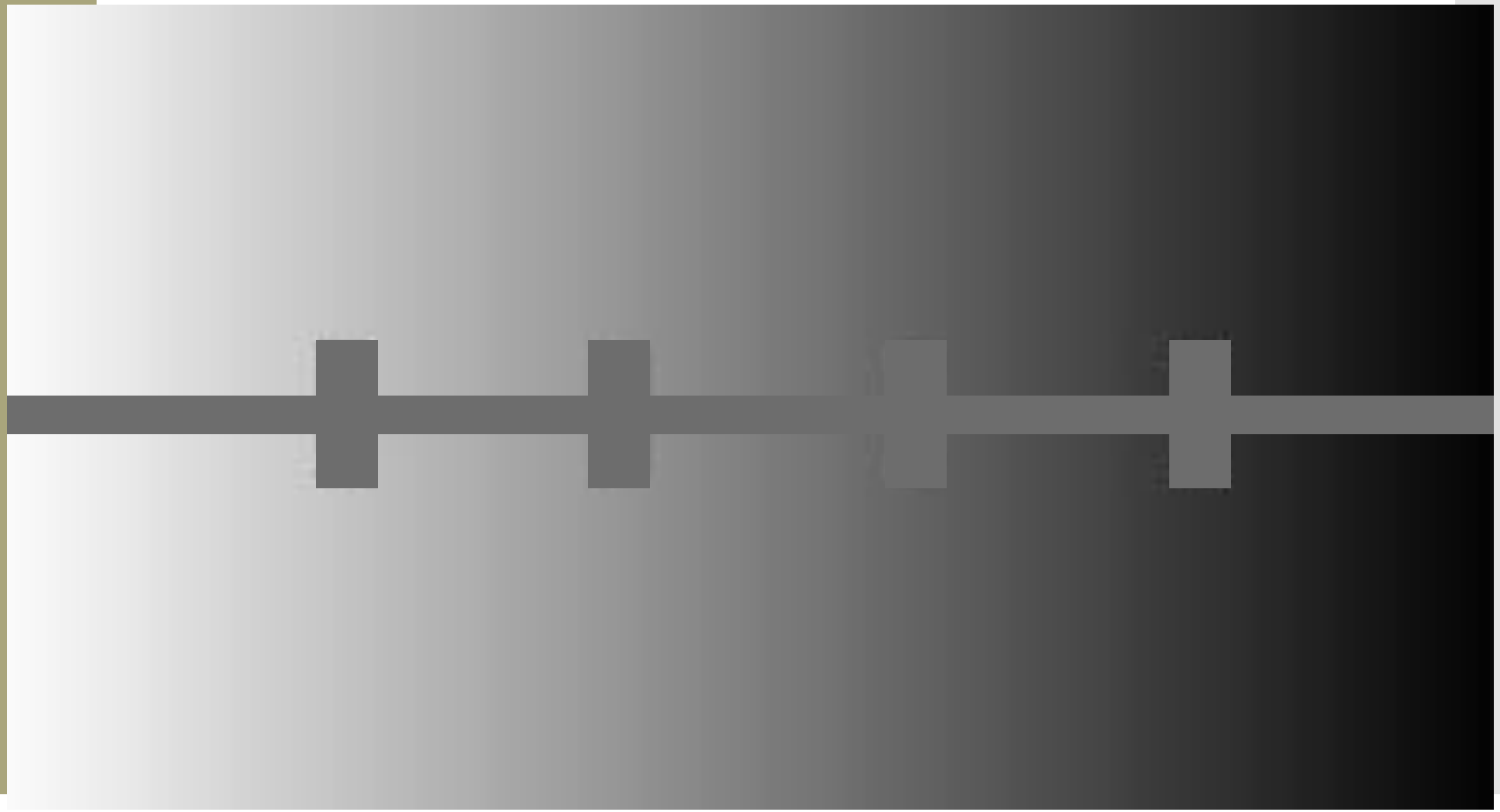




https://clauswilke.com/dataviz/color-basics.html

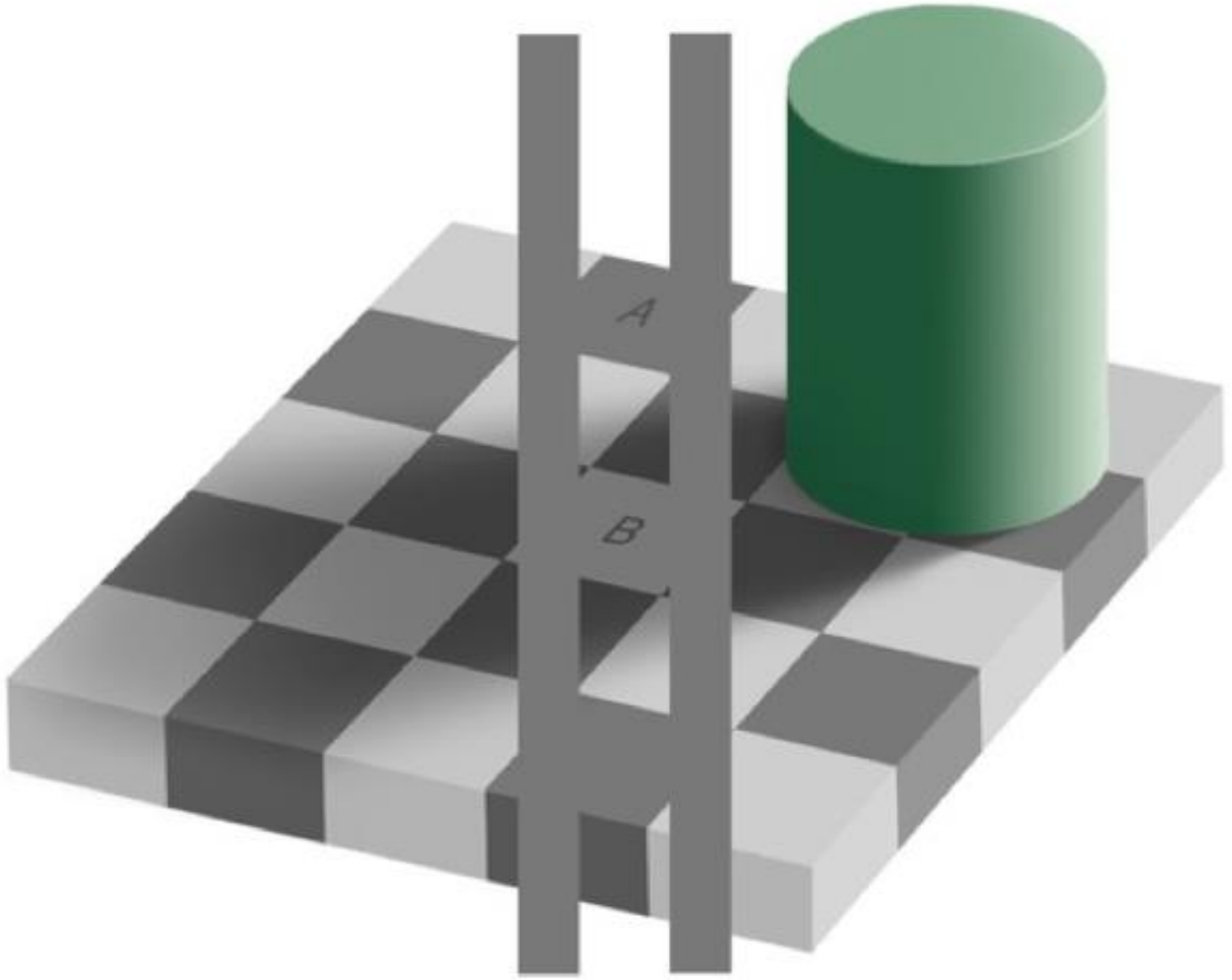
Caveat 2a: so are brightness and contrast

Color phenomena



Color phenomena

Caveat 3: mental models > perception

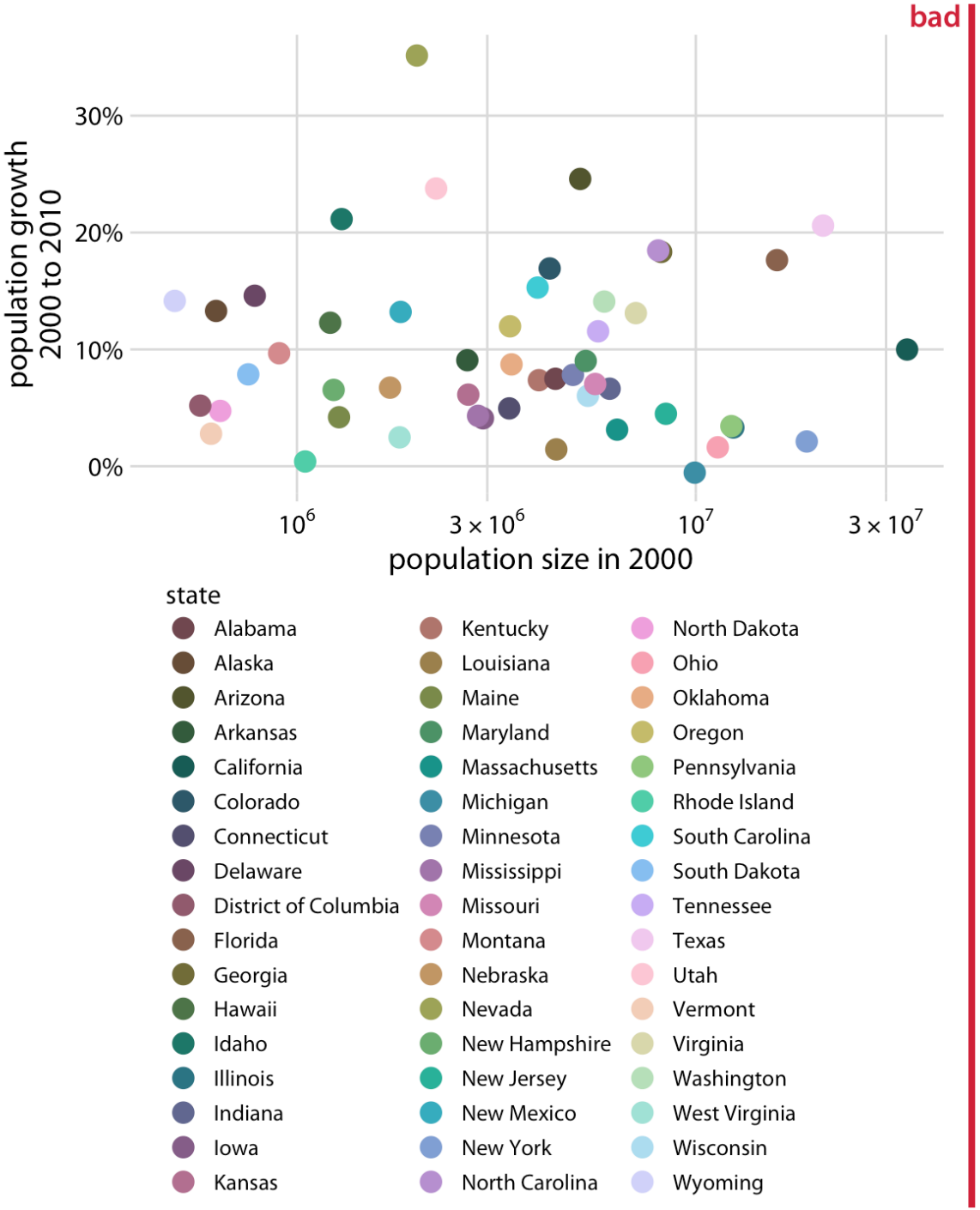


Color Problems

- Using a poor color scheme can also cause issues with your visualization

Color Problems

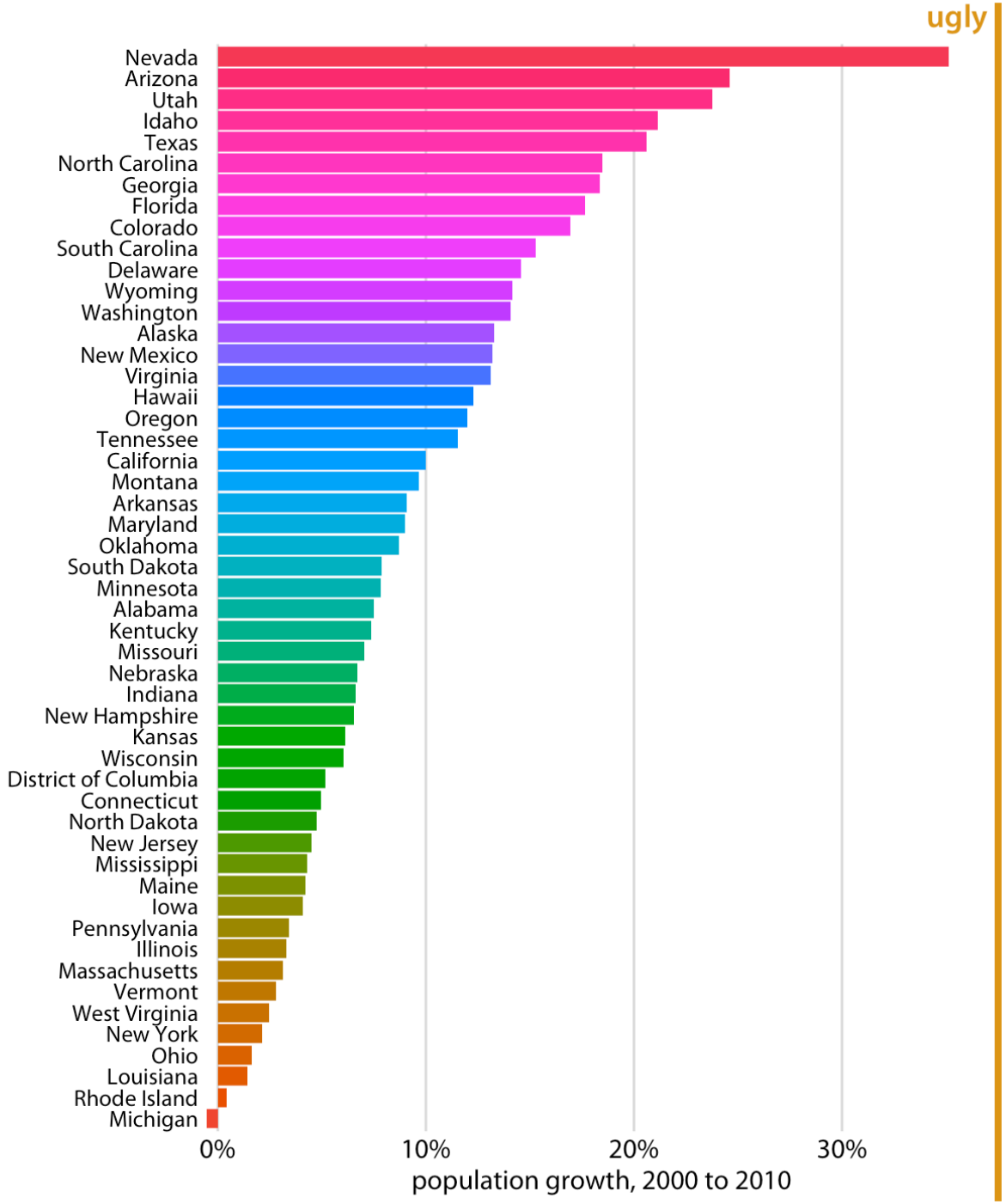
- Hue mapped to too many categories



https://clauswilke.com/dataviz/color-basics.html

Color Problems

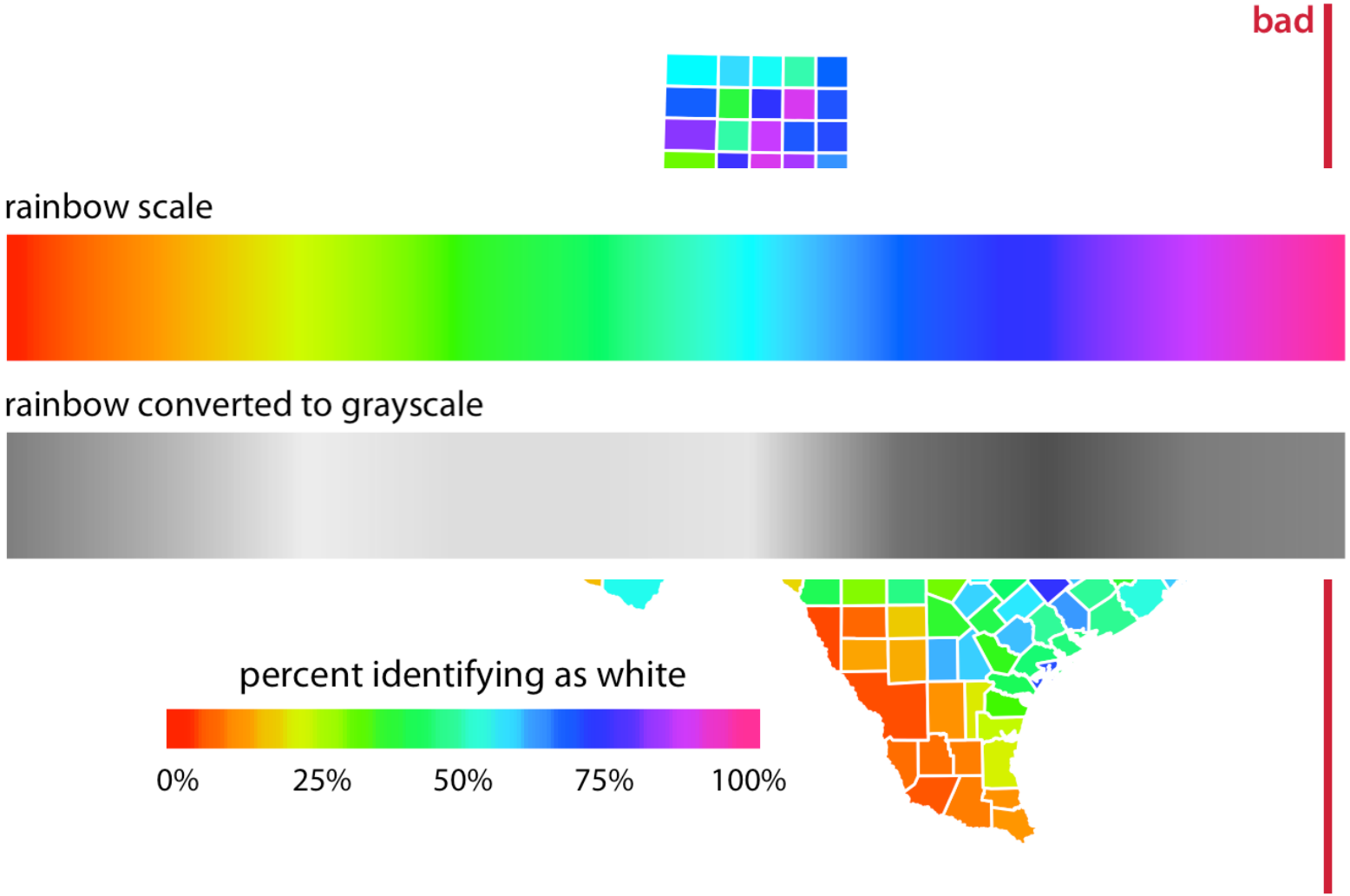
- Hue not mapped to data



https://clauswilke.com/dataviz/color-basics.html

Color Problems

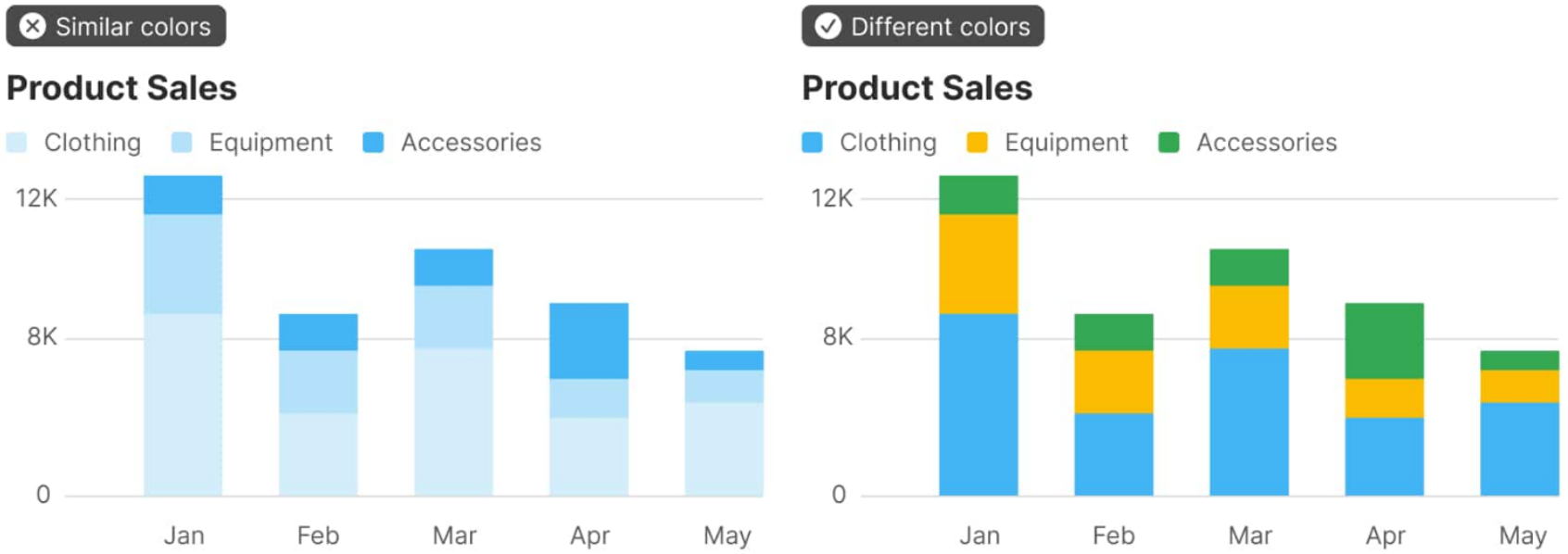
- Rainbow obscures real patterns (it is not monotonic)



https://clauswilke.com/dataviz/color-basics.html

Color Problems

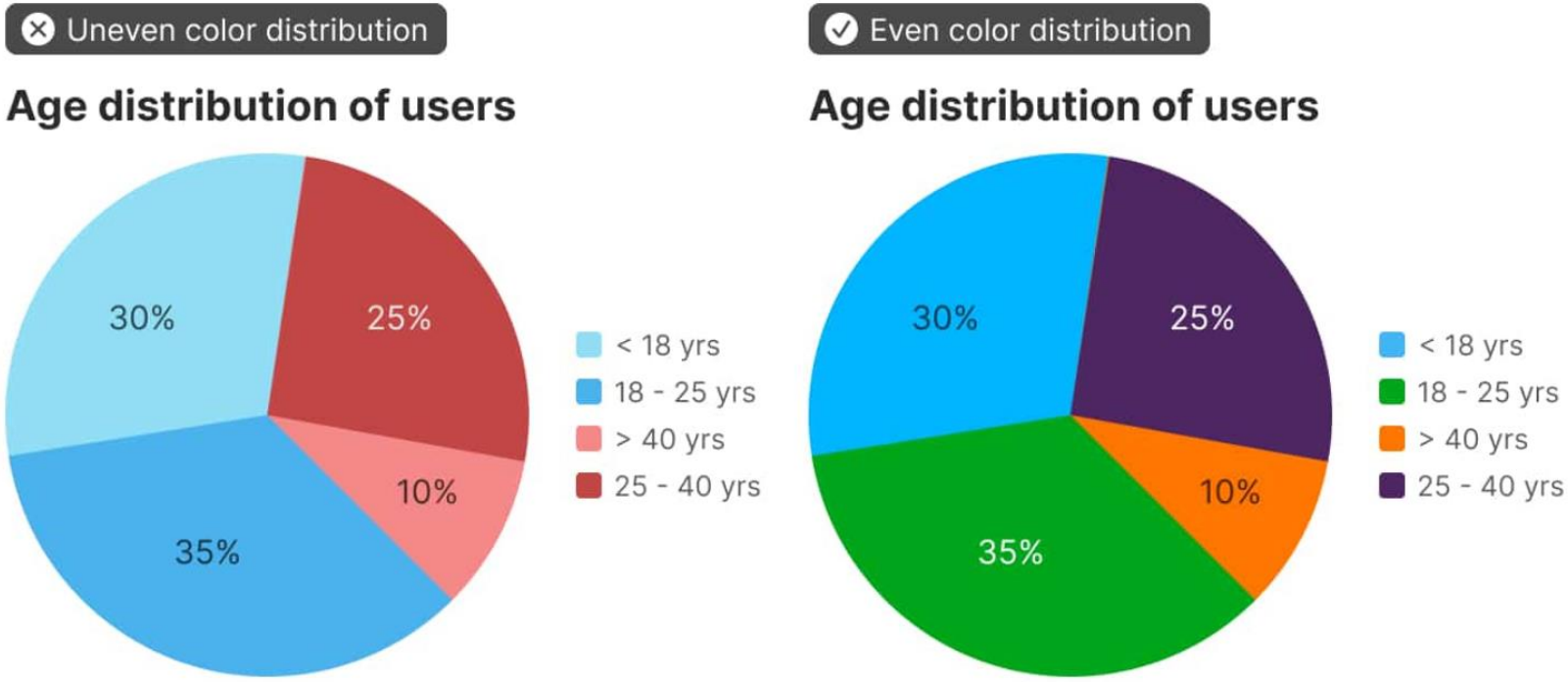
- Similar colors are hard to differentiate



https://matthewstrom.com/writing/how-to-pick-the-least-wrong-colors/

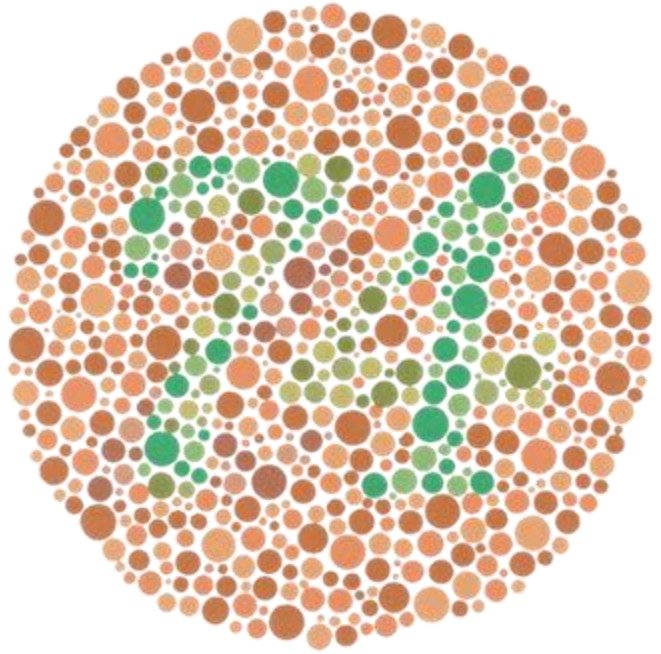
Color Problems

- Similar colors imply relationships



https://matthewstrom.com/writing/how-to-pick-the-least-wrong-colors/

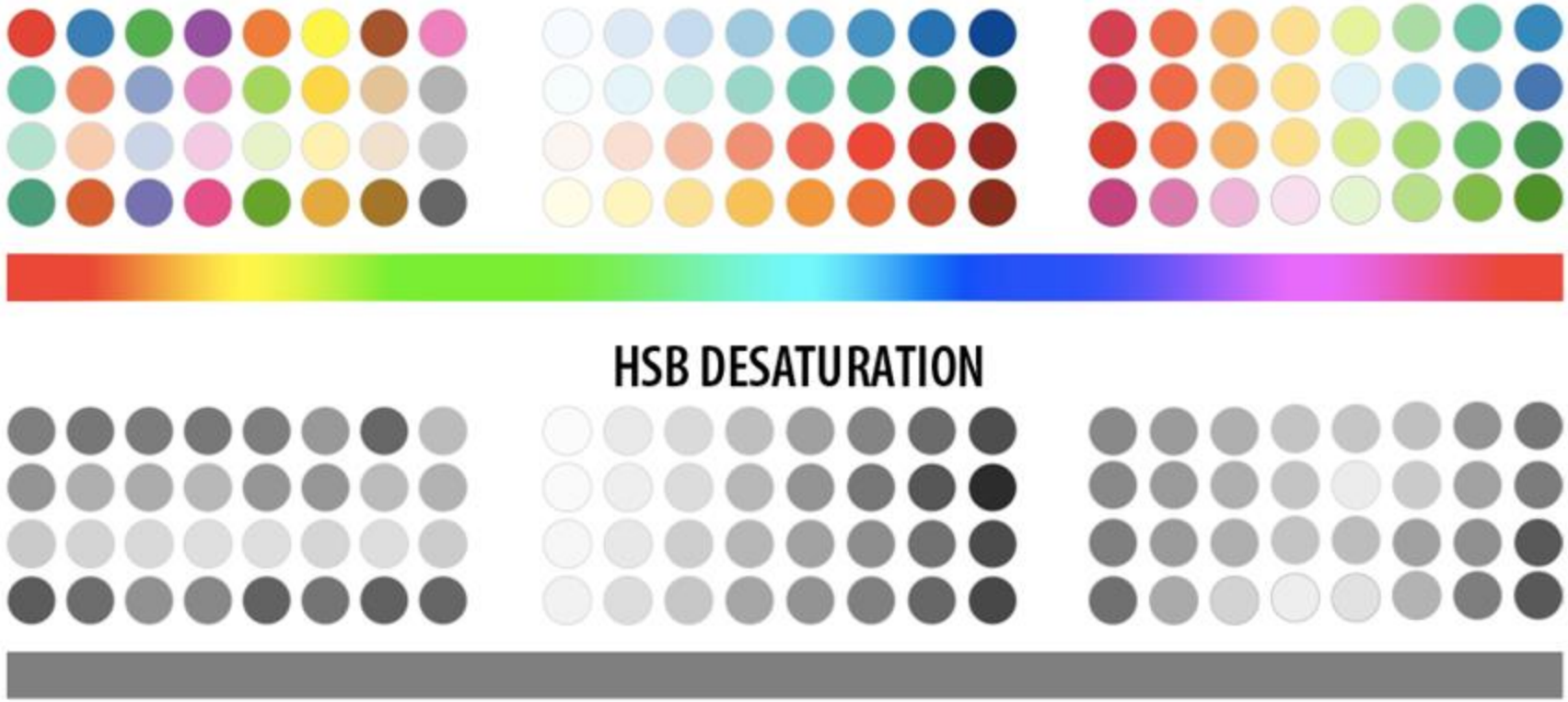
“colorblindness”



1 out of every 8 people has just 2 types of color receptors (rather than 3)

What happens when you print?

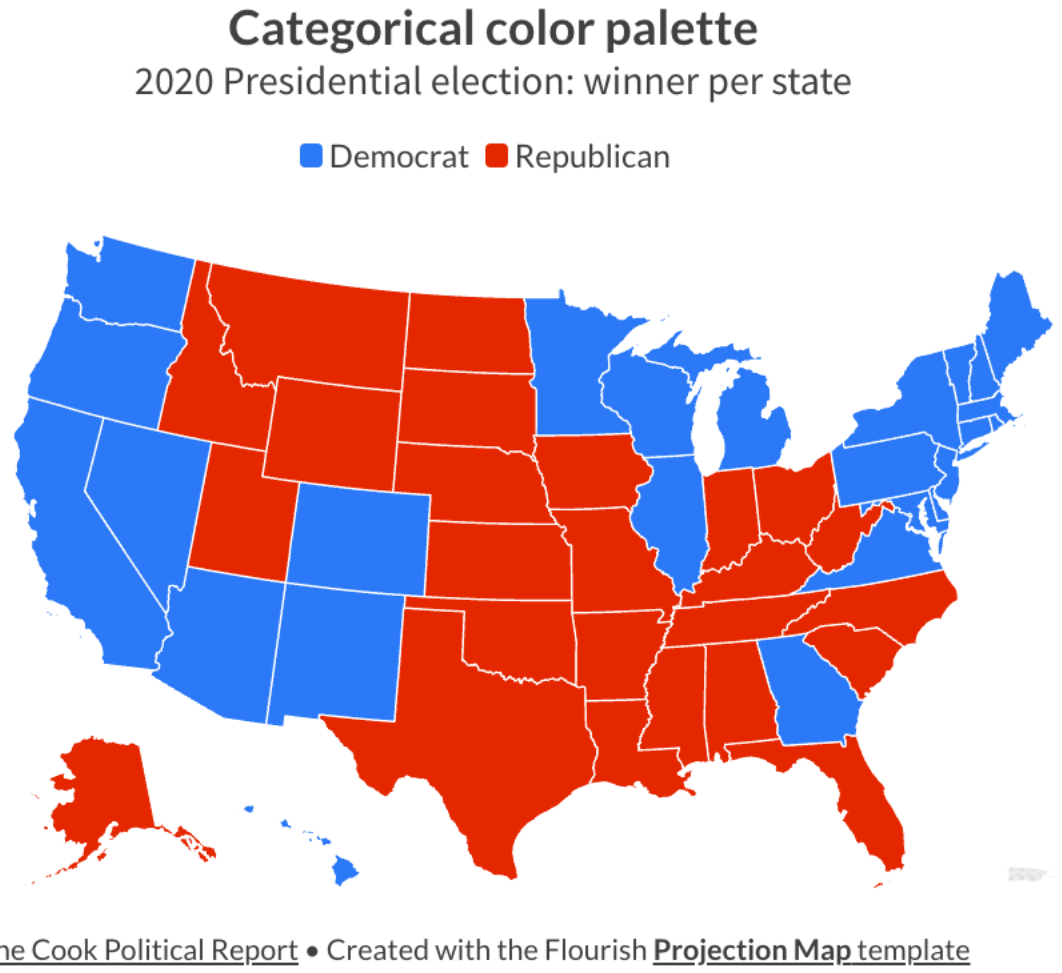
- Need color scheme that converts well to grey scale



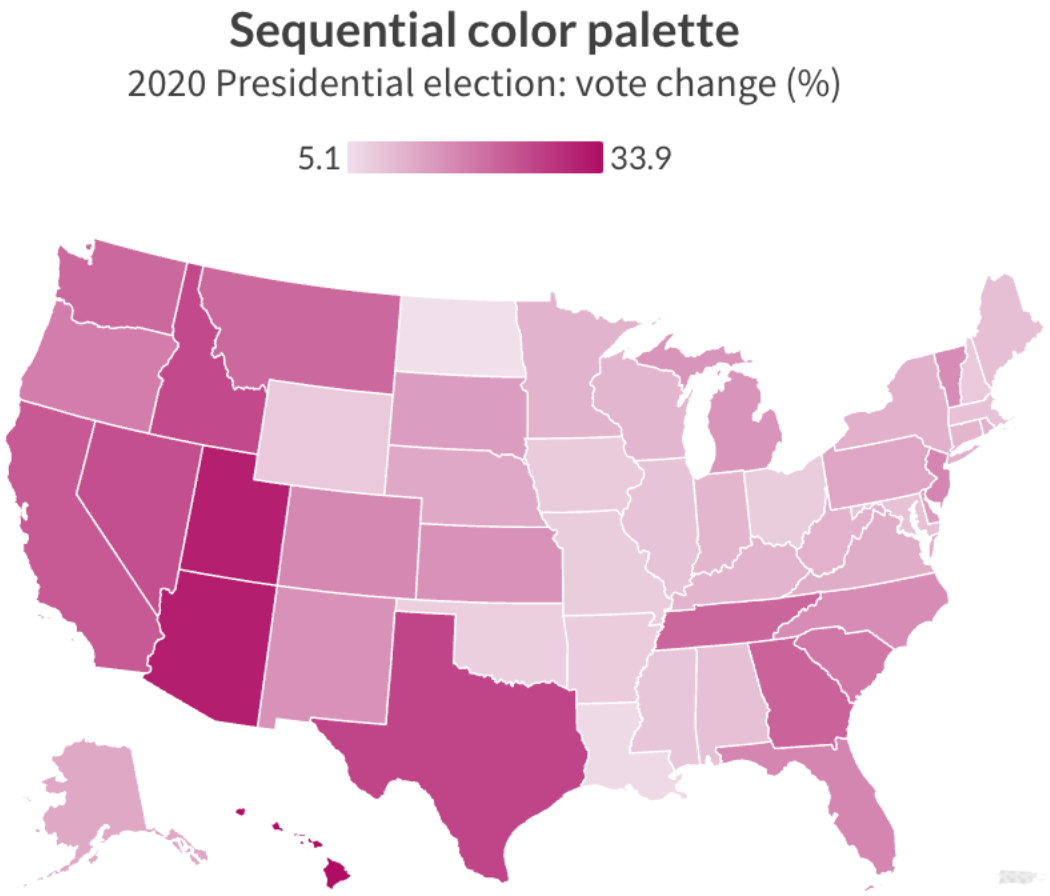
Colorbrewer palettes

- colorbrewer.org provides a whole bunch of palettes that can help us avoid these issues
- This makes life a lot easier for us!

Colorbrewer palettes

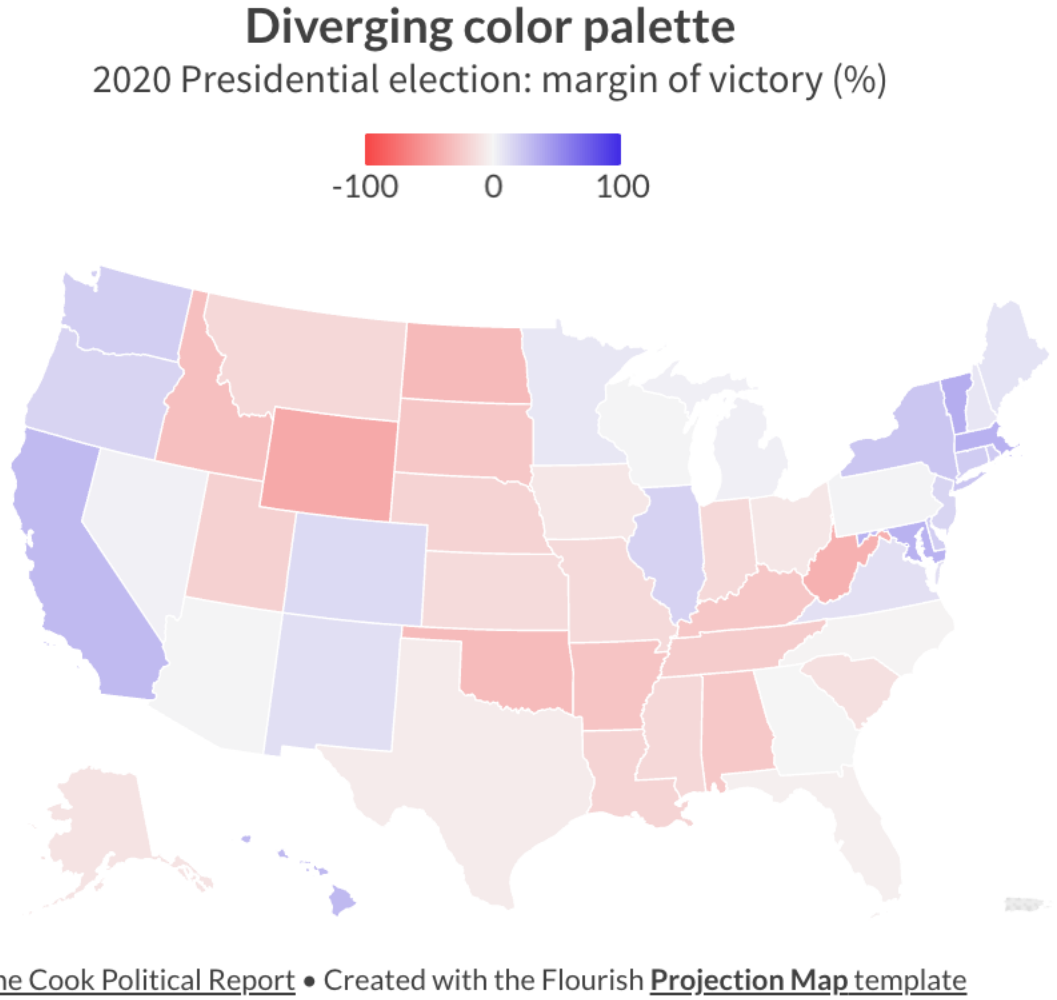


Colorbrewer palettes



Source: The Cook Political Report • Created with the Flourish **Projection Map** template

Colorbrewer palettes



Takeaways: Perception

- Visualization is about more than just aesthetics
- There are compelling **cognitive reasons** why some visualization techniques are helpful and others aren't
- The choices we make about **visual mappings** can have a significant effect on performance

Your turn!

- Find a partner and open Tableau
- Choose a dataset from the course website
- Create a visualization that shows an interesting trend using one of the three color channels
- Modify color usage in your visualization so that the interesting trend is lost

Discussion

- What did you try?
- What did you learn about the data?
- Can you imagine a scenario that might incline someone to choose your “bad” visualization instead of a better one?