Color and Perception

SSEP 2022 Afternoon Day 5

Dr. Ab Mosca (they/them)

Slides based on slides courtesy of Jordan Crouser: https://jcrouser.github.io/MassMutual-IntroR/, https://jcrouser.github.io/MassMutual-DataVis/, https://beanumber.github.io/sds192/

Perception

Recall

Principle 2: Effectiveness

Most effective channels should be used for most important data

Effectiveness = Based on a compilation of research, how well a channel supports:

- Perceptual accuracy
- Discriminability
- Separability
- Visual popout
- Grouping

Recall

Principle 2: Effectiveness

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Perception

Perception

Definition: the (sometimes imperfect) process by which we detect and interpret visual signals

- Understanding human perception helps us anticipate how people are likely to understand our visualizations
- We can leverage perception to make better visualization tools

Accuracy

Definition: how close human perceptual judgement is to an objective measurement of the stimulus

Accuracy

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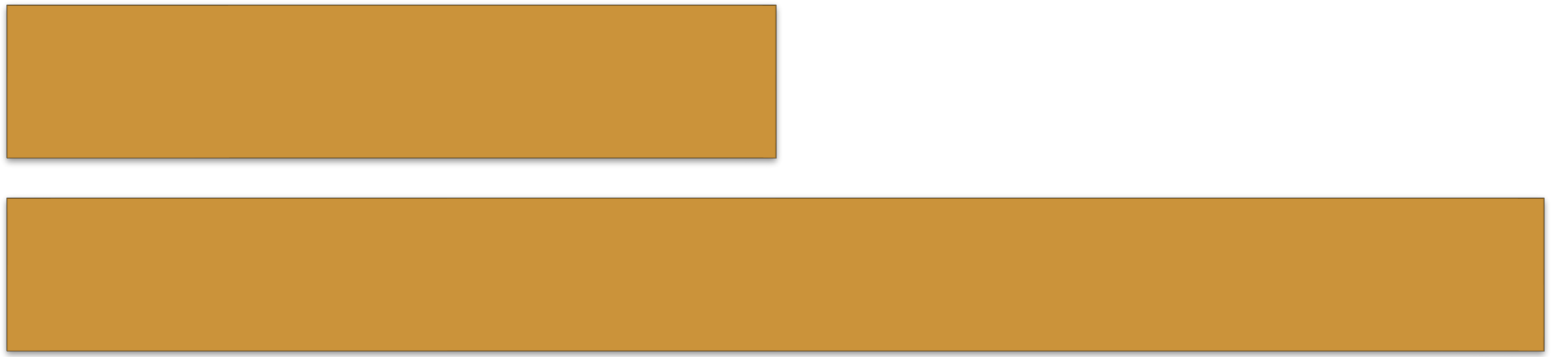
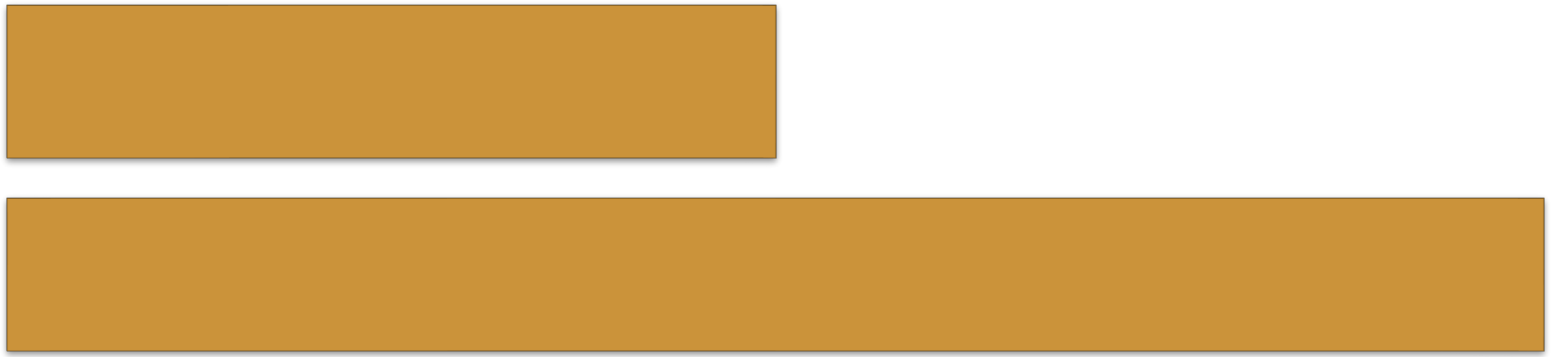


How much longer is the second bar?

Accuracy

Definition: how close human perceptual judgement is to an objective measurement of the stimulus

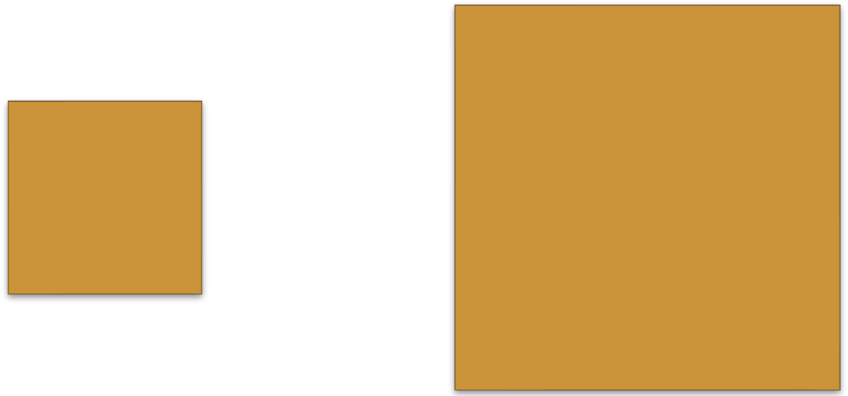


How much longer is the second bar?

2X

Accuracy

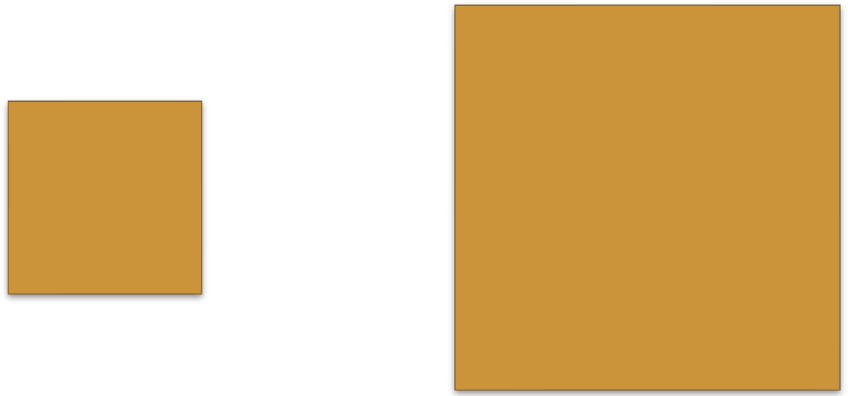
Definition: how close human perceptual judgement is to an objective measurement of the stimulus



How much bigger is the second square?

Accuracy

Definition: how close human perceptual judgement is to an objective measurement of the stimulus



How much bigger is the second square?

4X

Accuracy

Definition: how close human perceptual judgement is to an objective measurement of the stimulus

How much bigger is the second box?

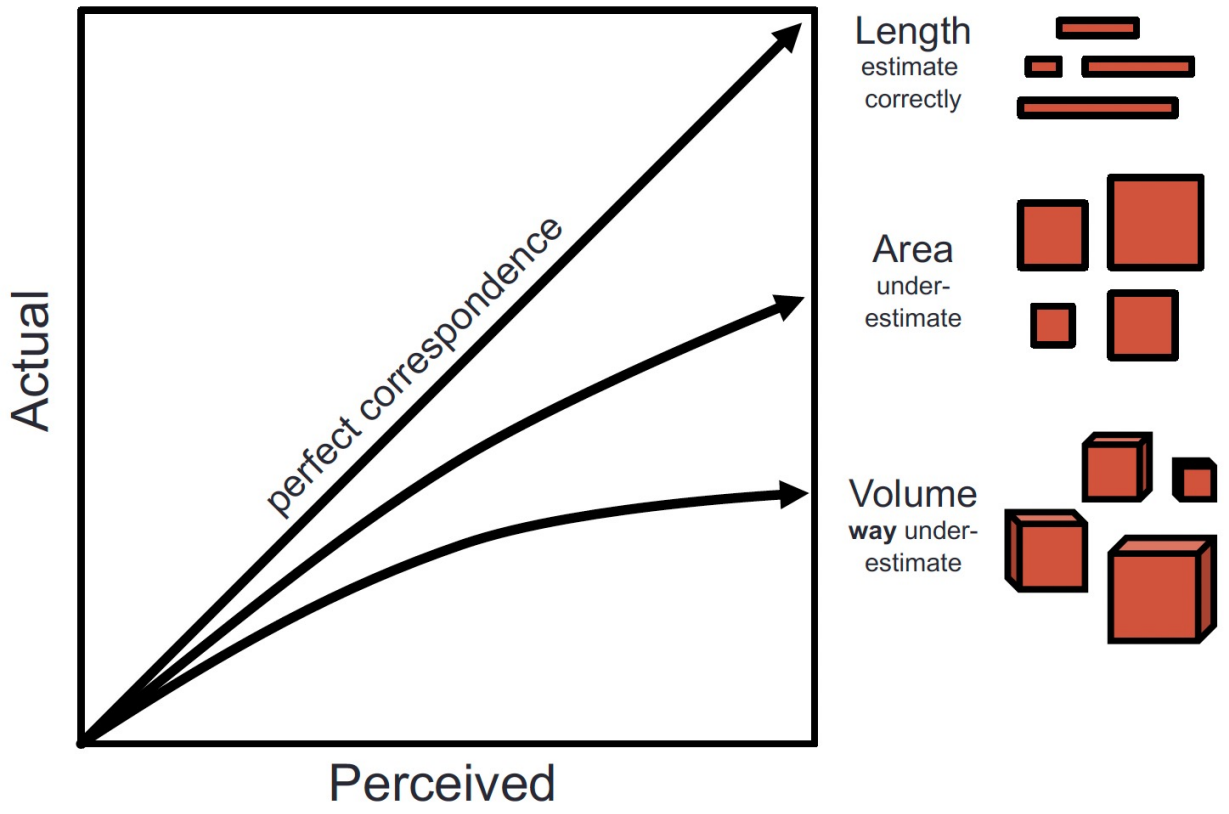
Accuracy

Definition: how close human perceptual judgement is to an objective measurement of the stimulus

How much bigger is the second box?
27X

Accuracy

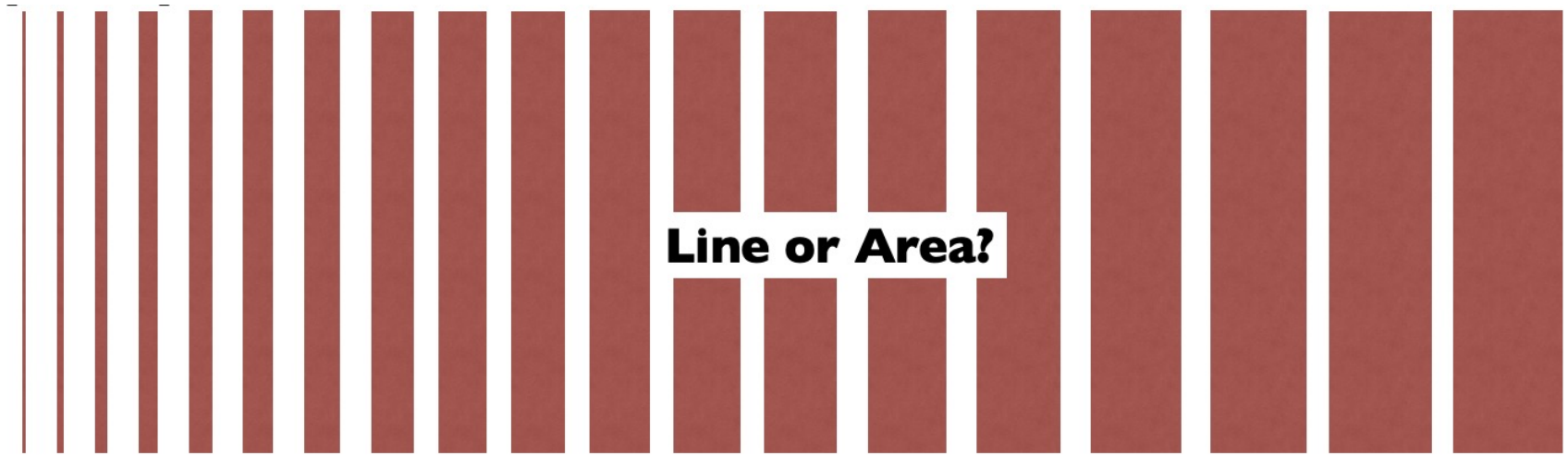
Definition: how close human perceptual judgement is to an objective measurement of the stimulus



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

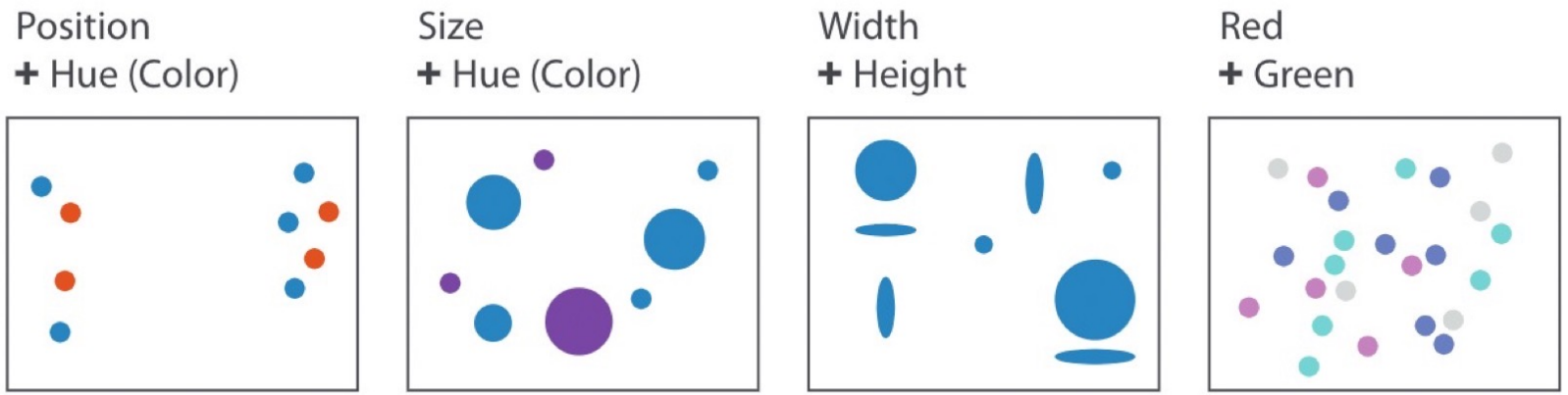
Discriminability

Definition: how differentiable different objects are



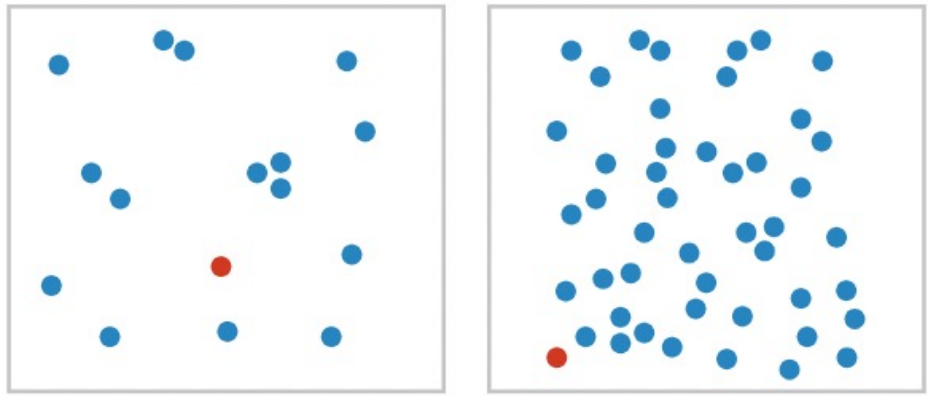
Separability

Definition: whether channels exist independently or integrally with others



Visual Popout

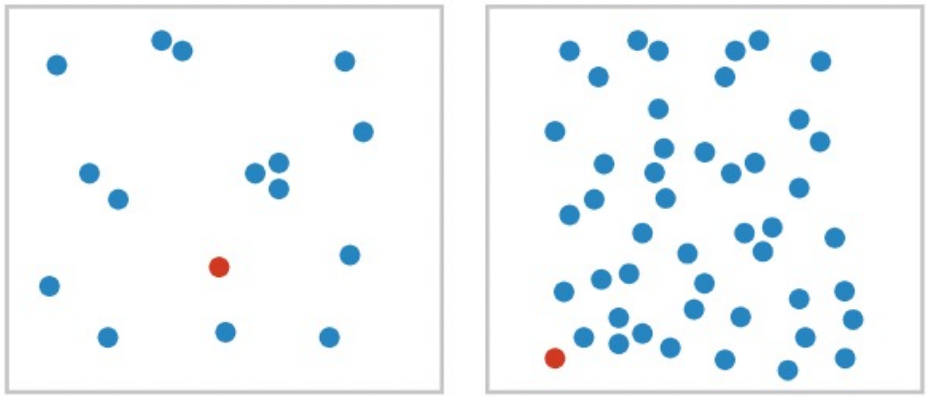
Definition: how well a distinct item stands out from others



(a) (b)

Visual Popout

Definition: how well a distinct item stands out from others

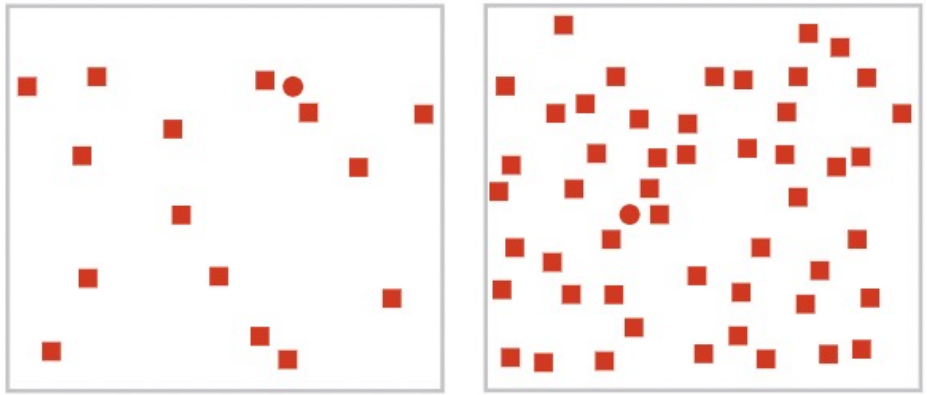


(a) (b)

Color is a good channel for this

Visual Popout

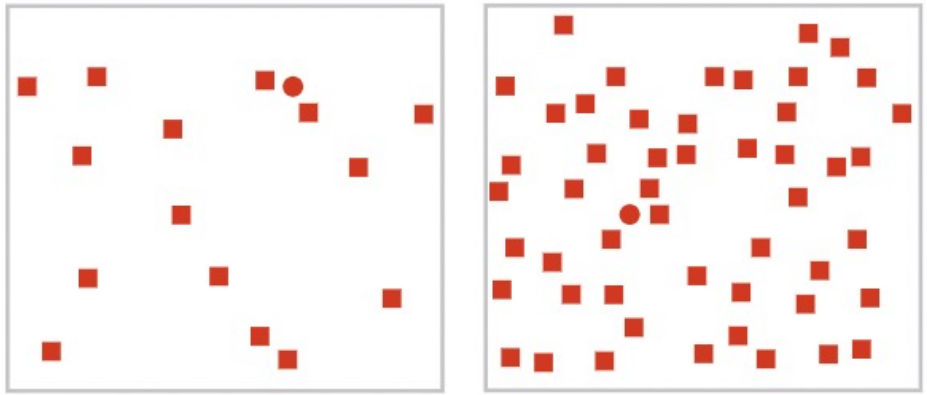
Definition: how well a distinct item stands out from others



(c) (d)

Visual Popout

Definition: how well a distinct item stands out from others



(c) (d)

Shape is not as helpful

Visual Popout

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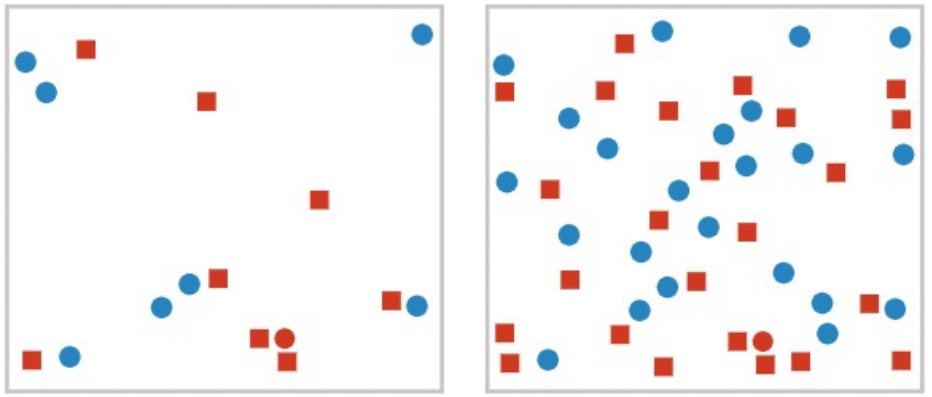

(e) (f)

Visual Popout

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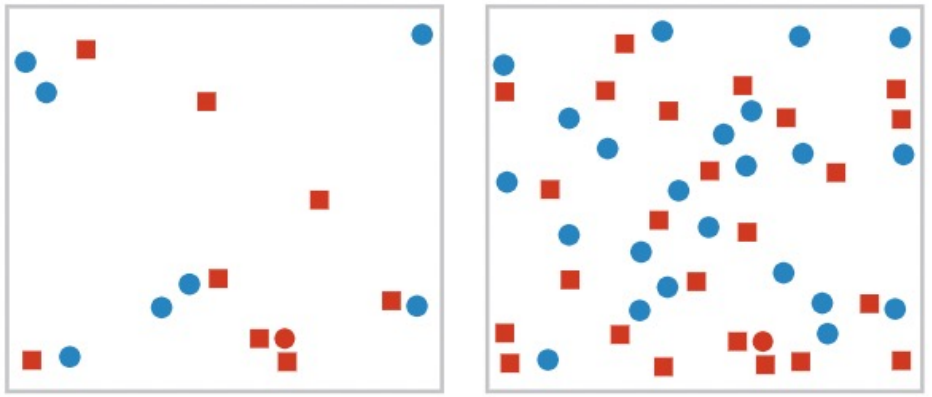
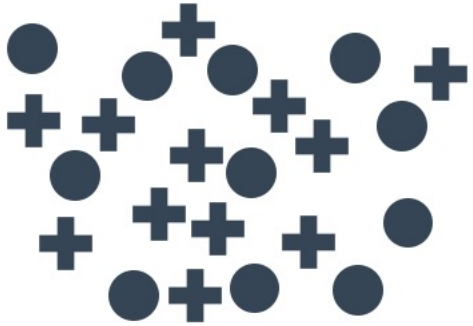


(e) (f)

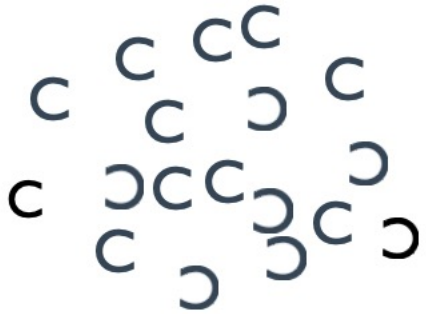
Combining color and shape causes "competition" – color is processed first

Grouping

Definition: how likely people are to infer differences as representing distinct groups



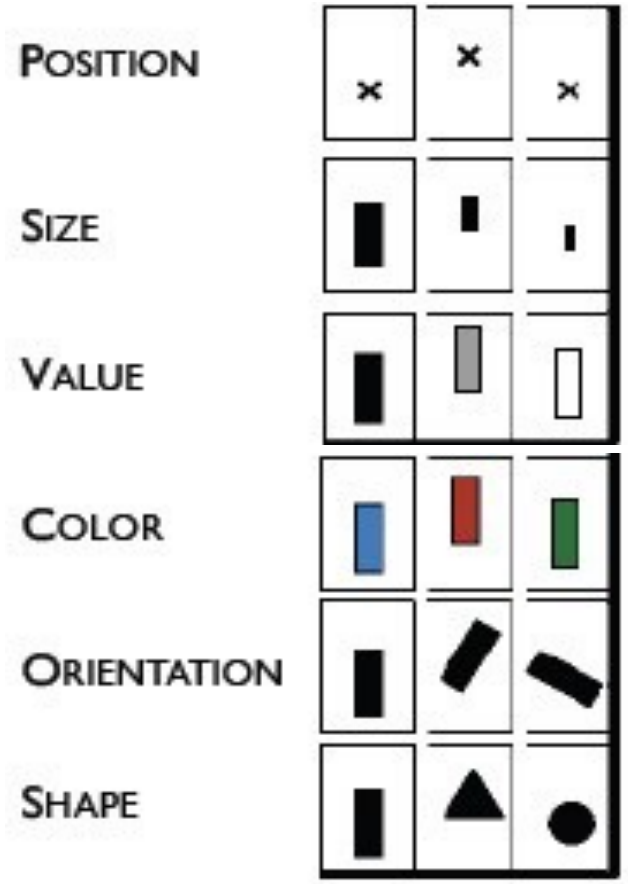
Circles and +’s



C’s and Ↄ’s

Grouping

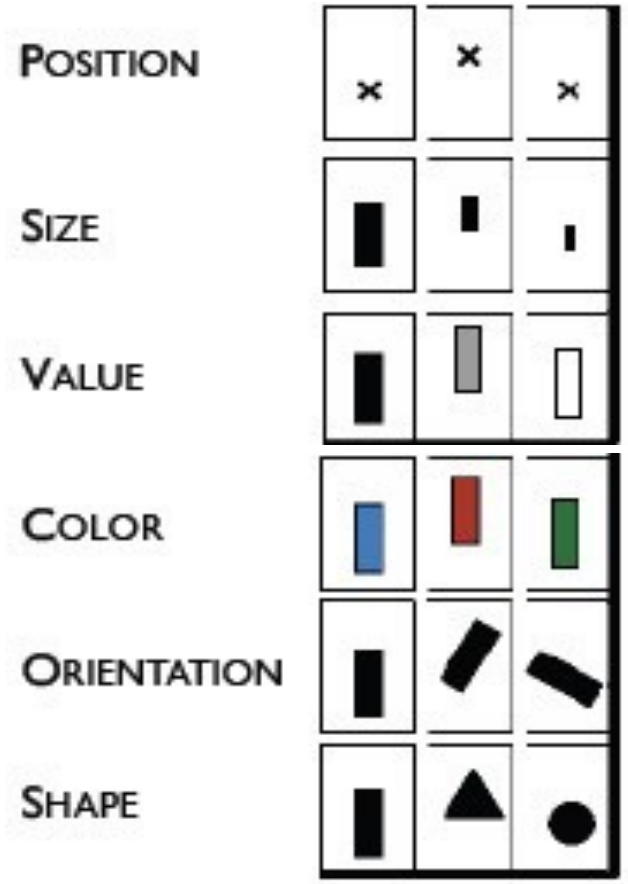
Definition: how likely people are to infer differences as representing distinct groups



Which of these channels are best for grouping?

Grouping

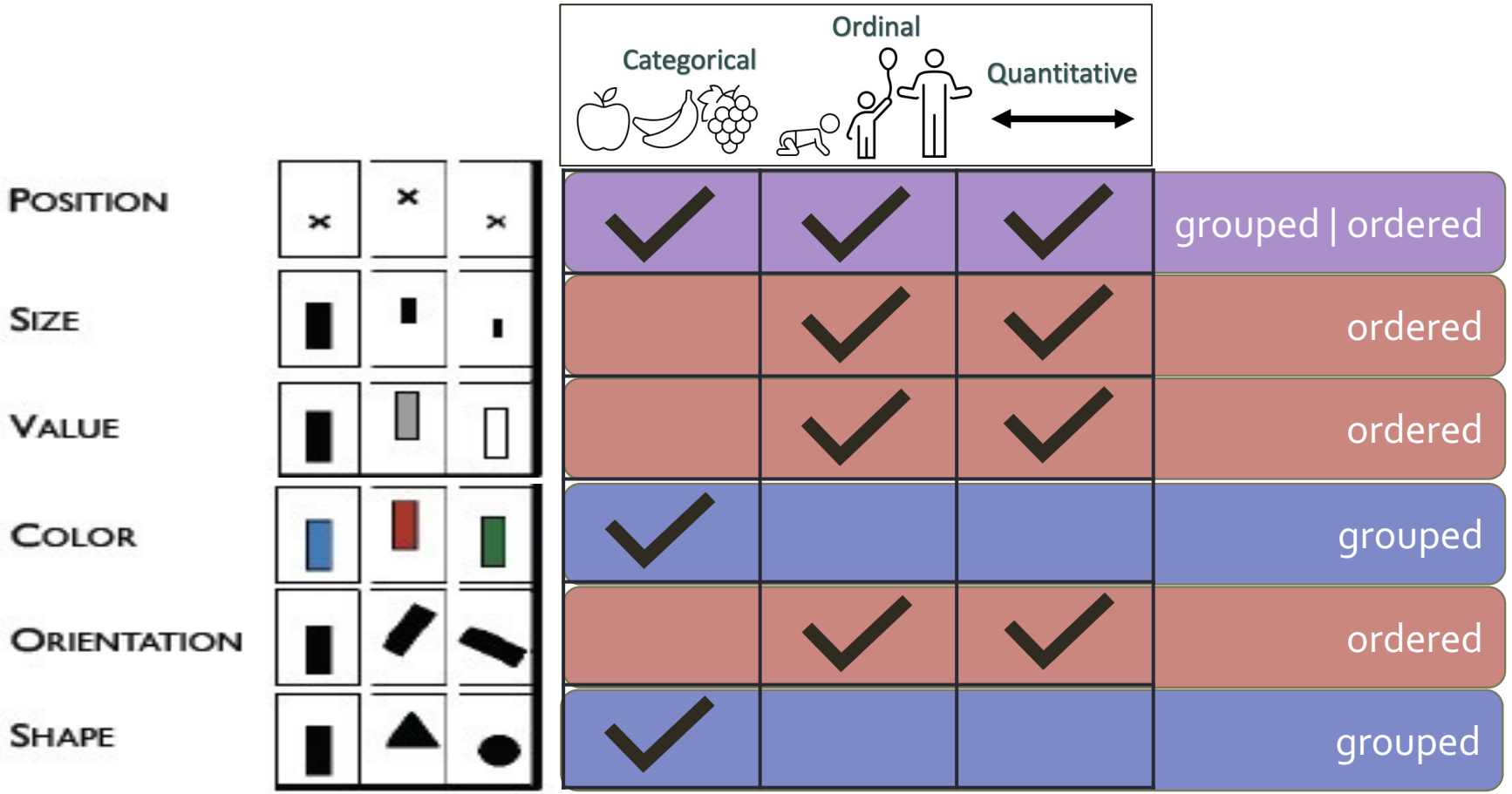
Definition: how likely people are to infer differences as representing distinct groups



Which of these channels are best for ordering?

Grouping

Definition: how likely people are to infer differences as representing distinct groups



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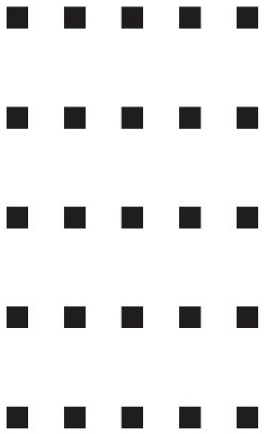

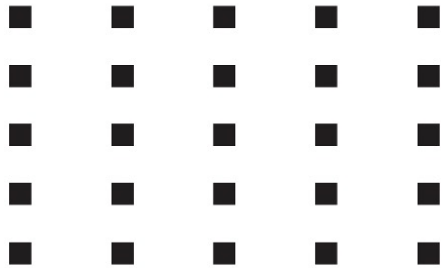

Bang Wong, "Gestalt principles (Part 1)" (Nature Methods)

Based on Slide by M. Meyer

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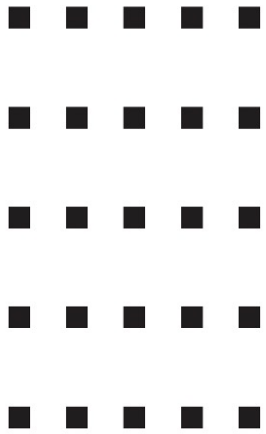
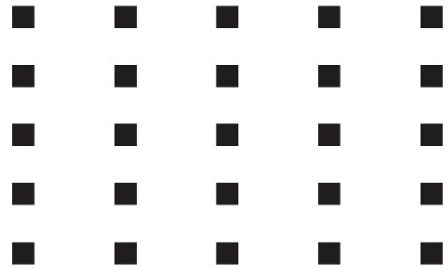




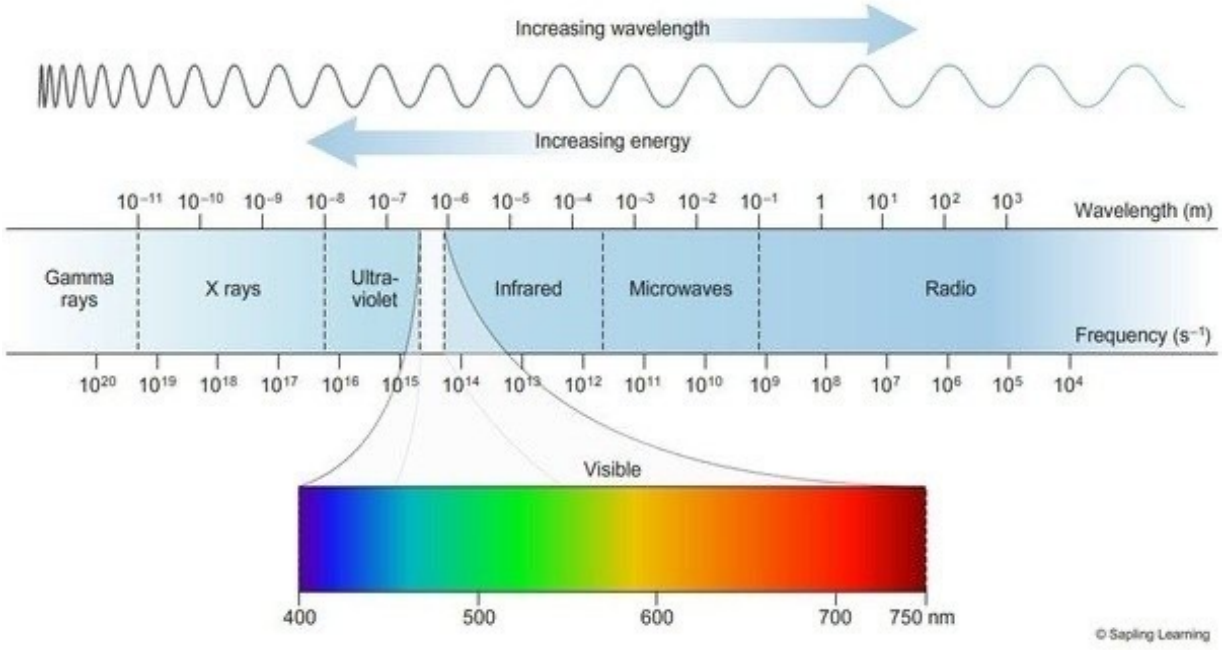
Bang Wong, "Gestalt principles (Part 1)" (Nature Methods)

Based on Slide by M. Meyer

Color (and perception)

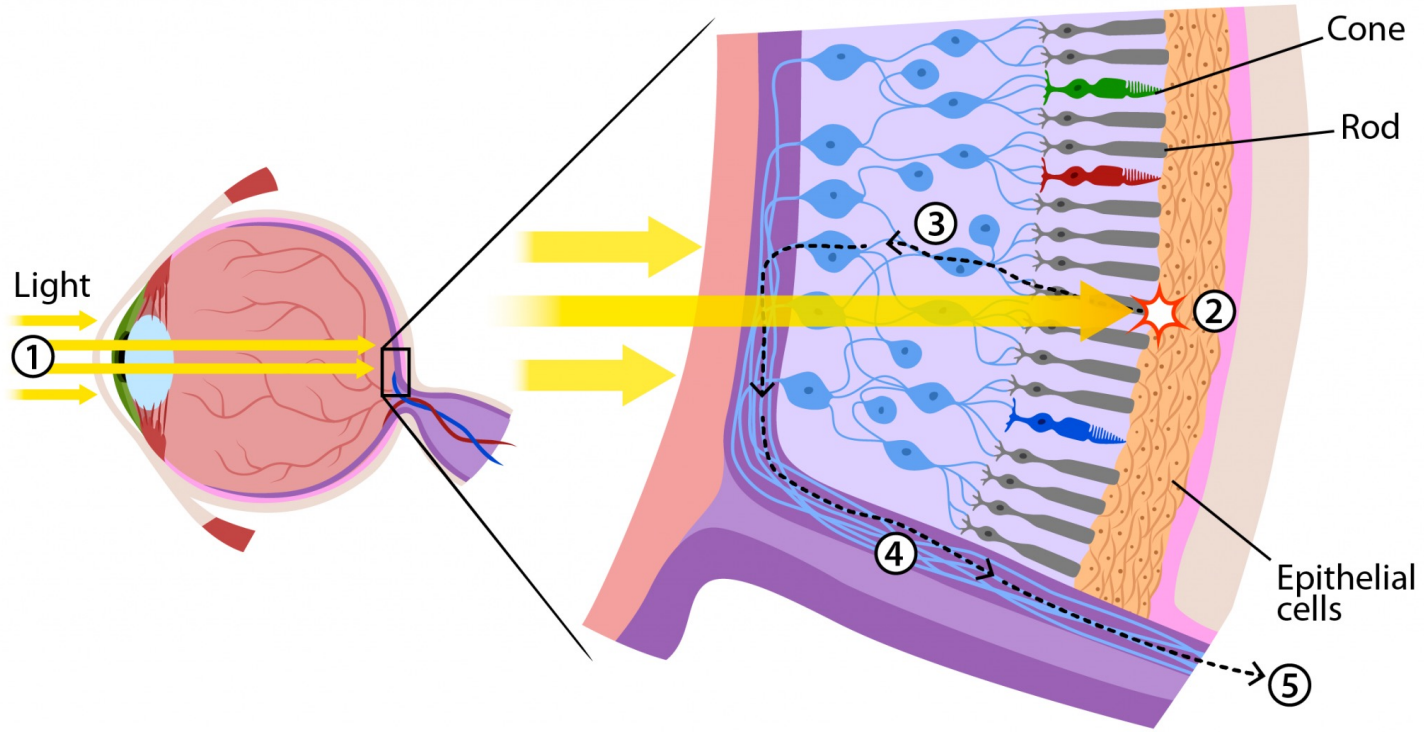
Color Perception

Color results from different wavelengths of light.



Color Perception

Your eye takes in light waves and translates them to lightness/darkness and color.



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

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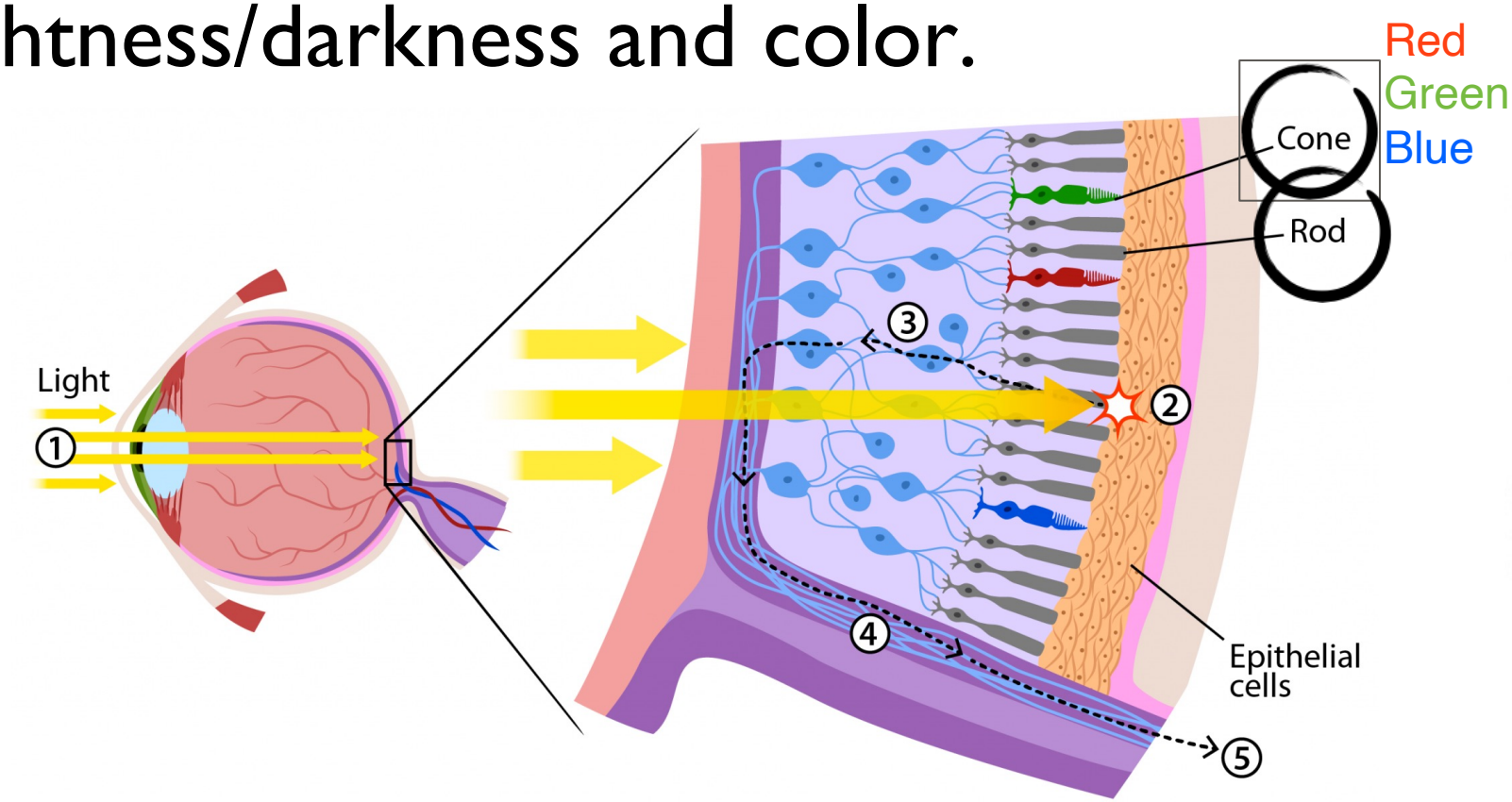

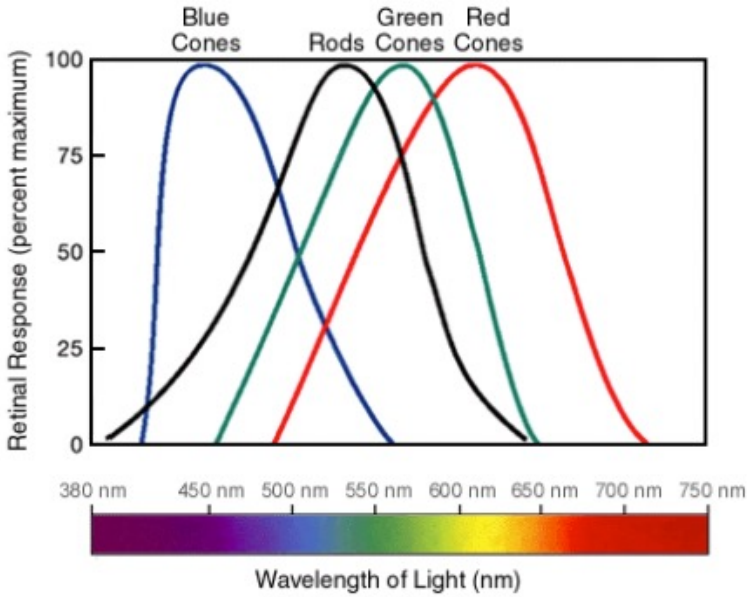

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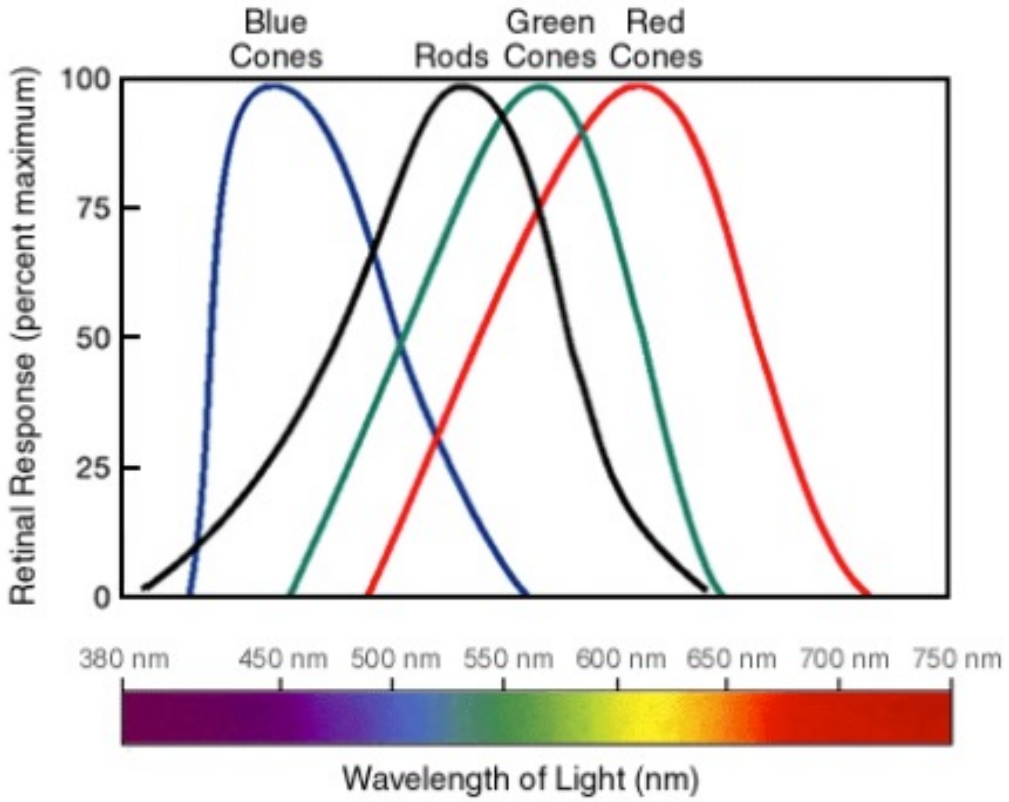
Color Perception



This is why lightness/darkness is an effective encoding channel!

Rods: 120 million

Cones: 5-6 million

This is why we are so sensitive to red!

Cones:

64% red-sensitive

32% green-sensitive

2% blue-sensitive.

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

Colors - Beware

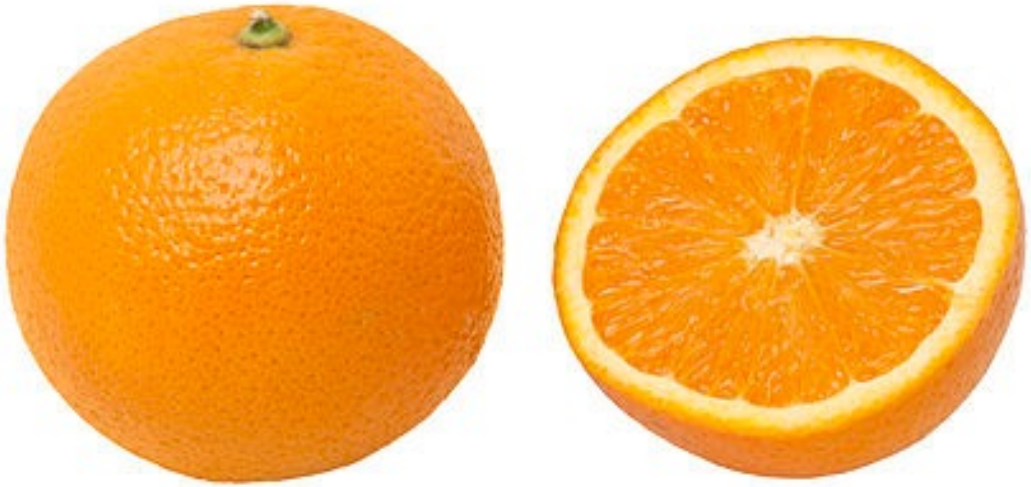
- For categorical attribute-color mapping, aim to maximize discriminability

vs.

Colors - Beware

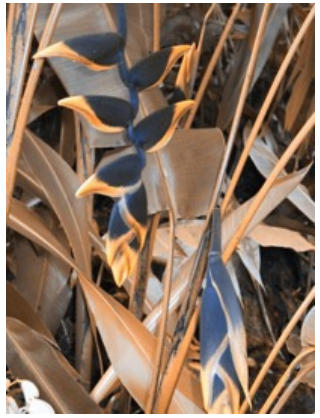
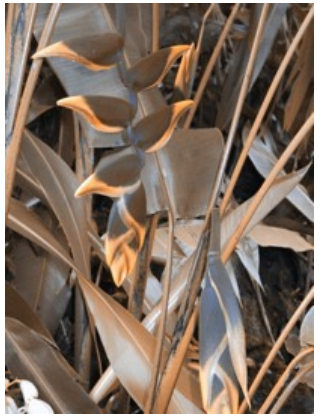
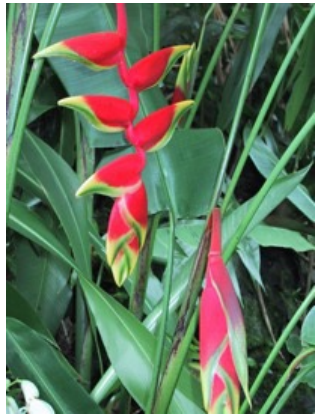
- When possible, use semantically meaningful colors
  (ex. red=hot, blue=cold)

- Be aware of cultural differences
  (ex. red in Chinese Culture vs Red in US culture)



Colors - Beware

- Use colorblind safe pallets.

Colors - Beware

- Saturation can cause illusions

High Saturation

→ Participants reported more red than green

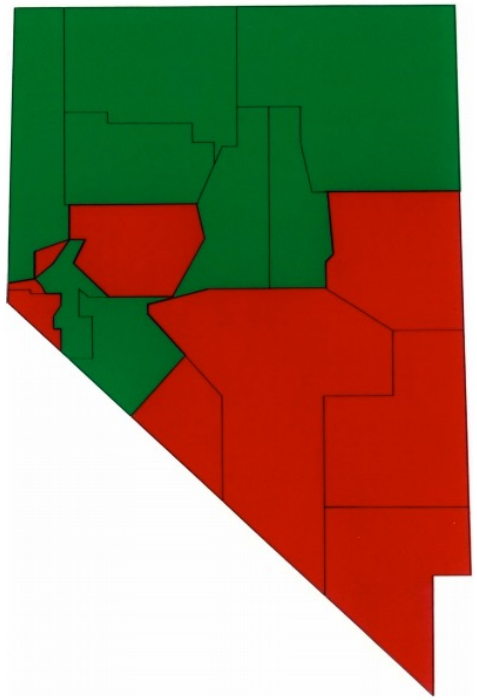


Figure 1. Stimulus From the High-Saturation Group

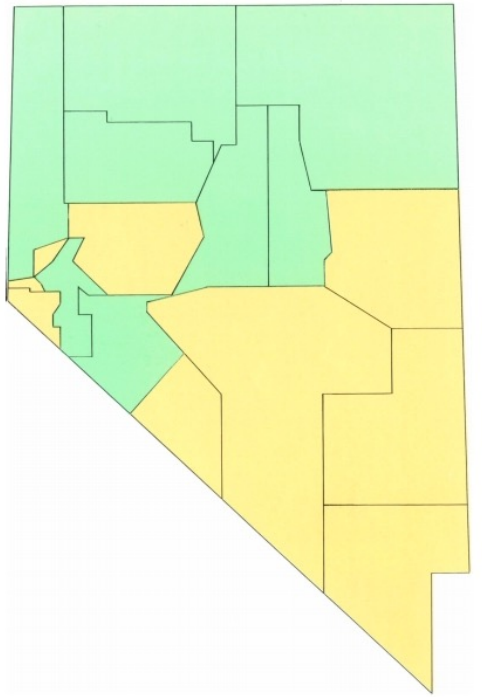


Figure 2. Stimulus From the Low-Saturation Group

Low Saturation

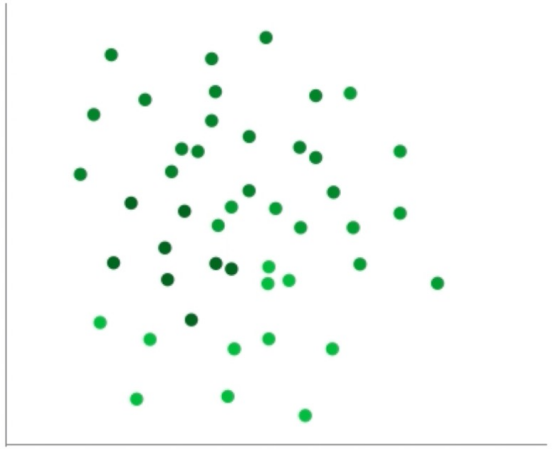
→ Participants reported equal proportions (which is correct)

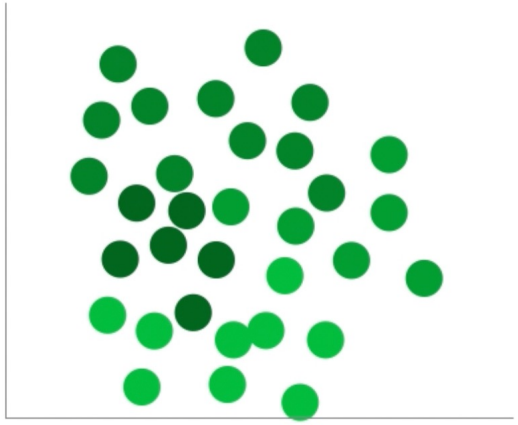
Cleveland & McGill, "A Color-Caused Optical Illusion on a Statistical Graph", 1983

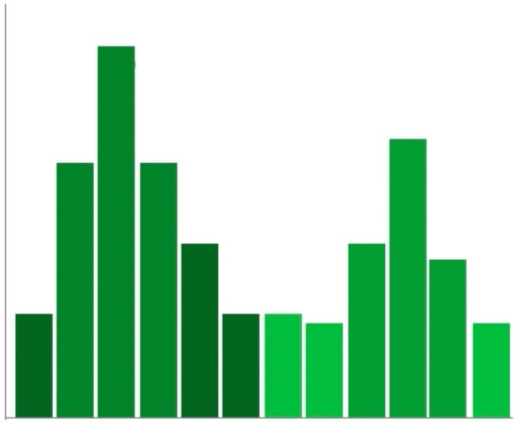
Colors - Beware

- Mark type and size effects how we perceive color

How many categories?







Szafir. Modeling Color Differences for Visualization Design

Colors - Beware

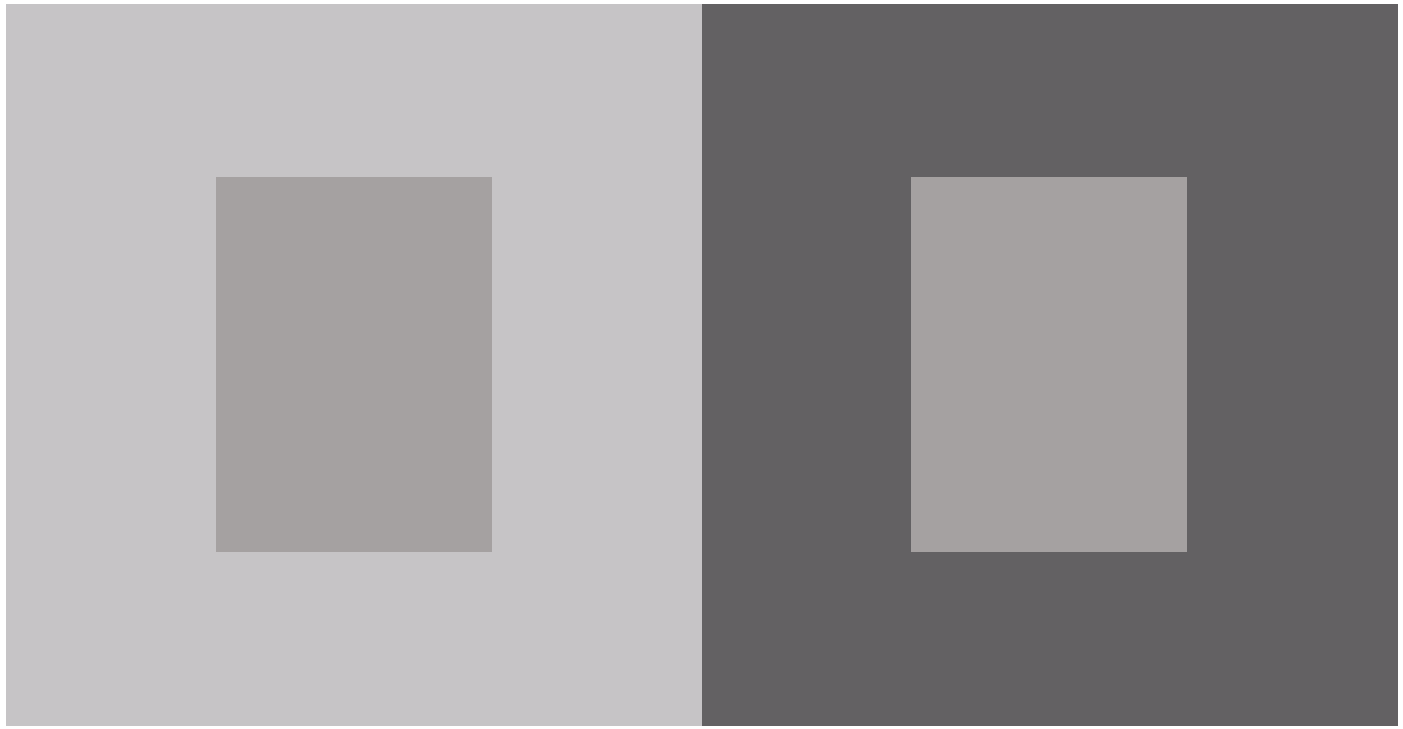
Is the smaller rectangle a solid color or gradient?

Colors - Beware

- SIMULTANEOUS CONTRAST – using a gradient as a background can distort how we see the foreground

  → Avoid using gradients as backgrounds

Colors - Beware



Are the smaller rectangles the same color or different colors?

Colors - Beware

- SIMULTANEOUS CONTRAST – solid backgrounds can distort how we see foreground shapes

Colors - Beware

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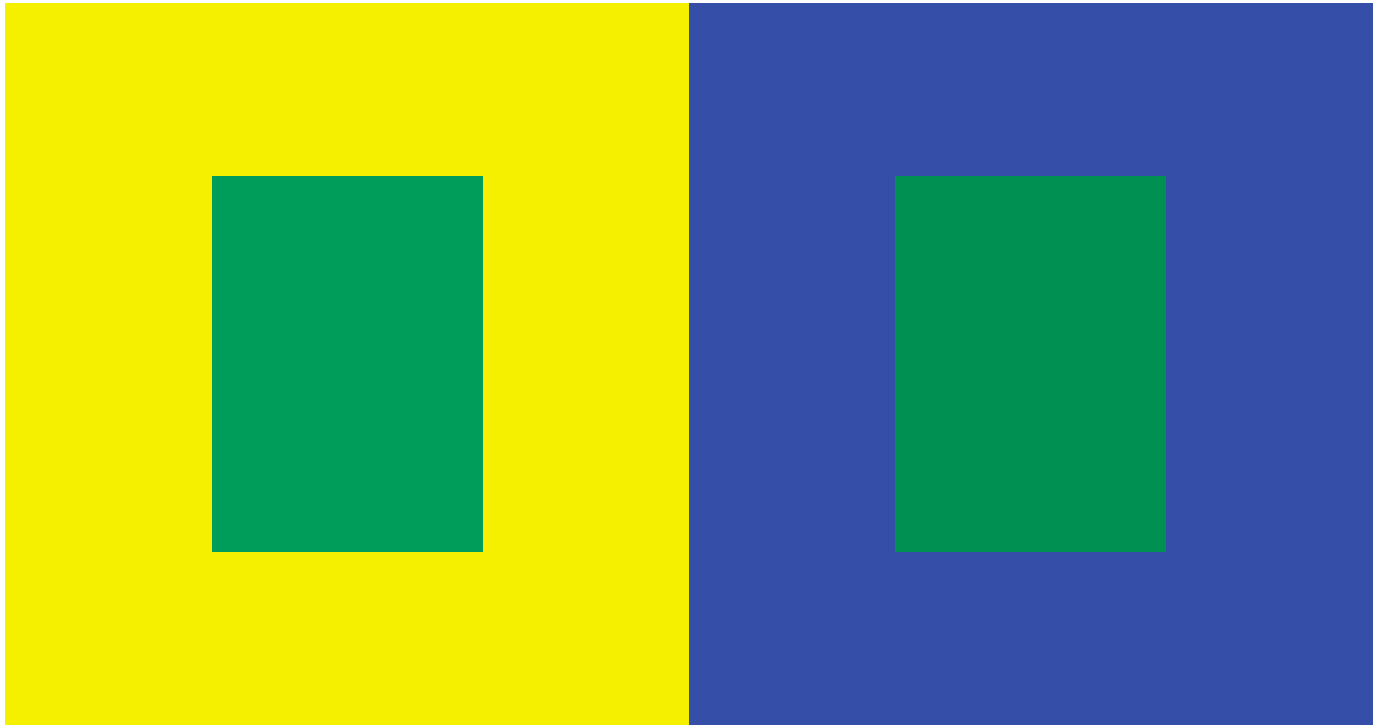
Colors - Beware



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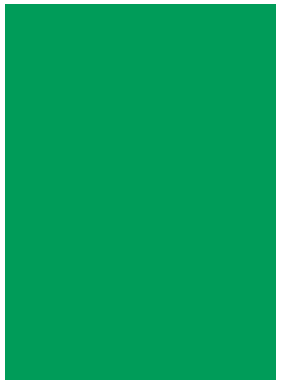
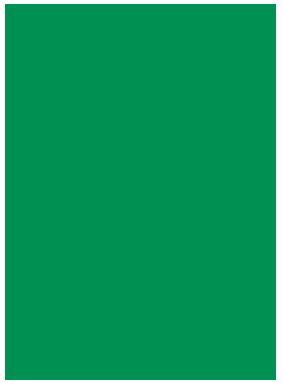
Colors - Beware



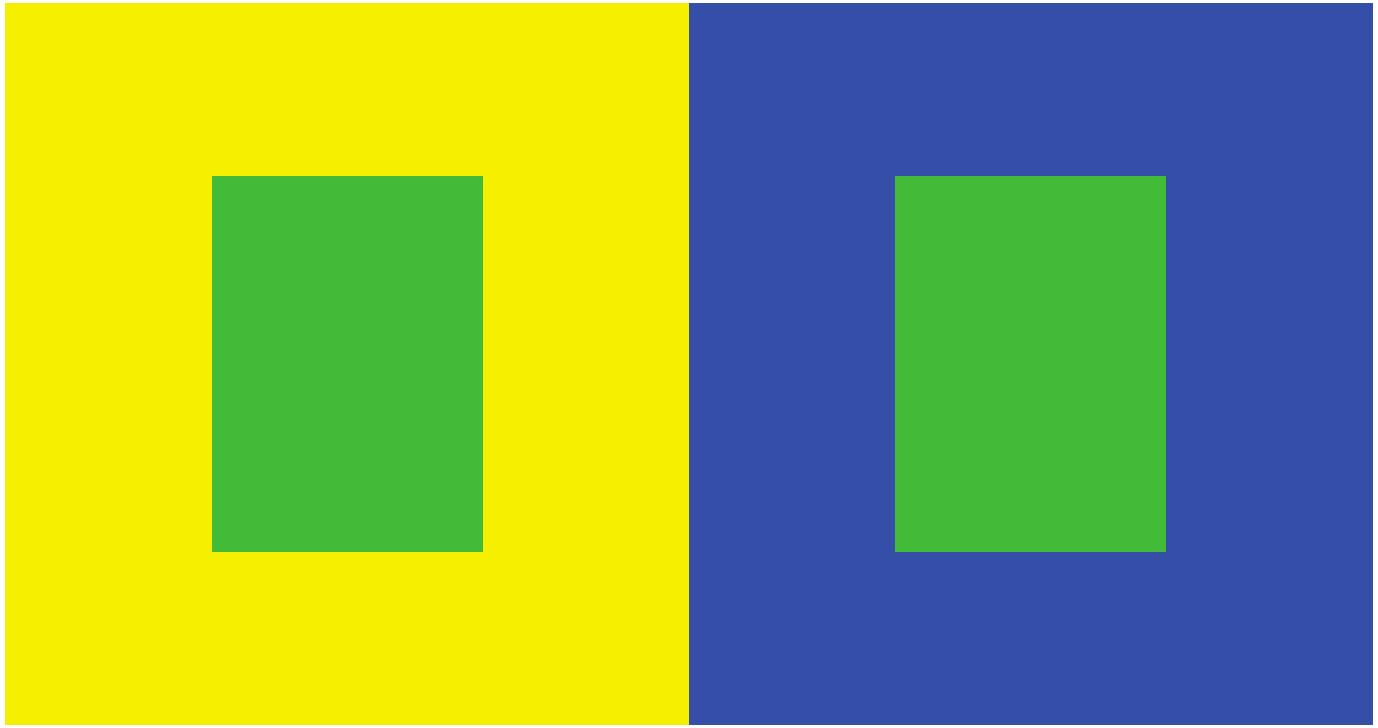
#009C59



#009051

Different!

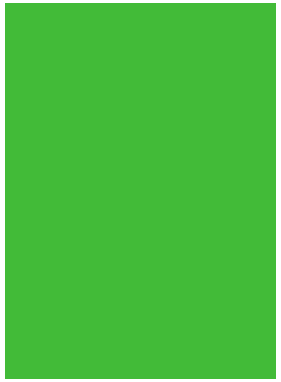
Colors - Beware

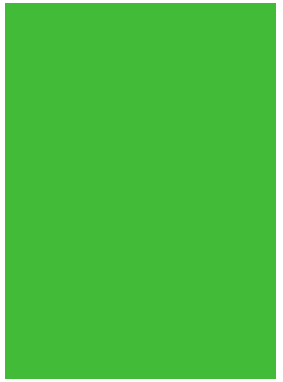


Are the smaller rectangles the same color or different colors?

Colors - Beware

- SIMULTANEOUS CONTRAST – solid backgrounds can distort how we see foreground shapes





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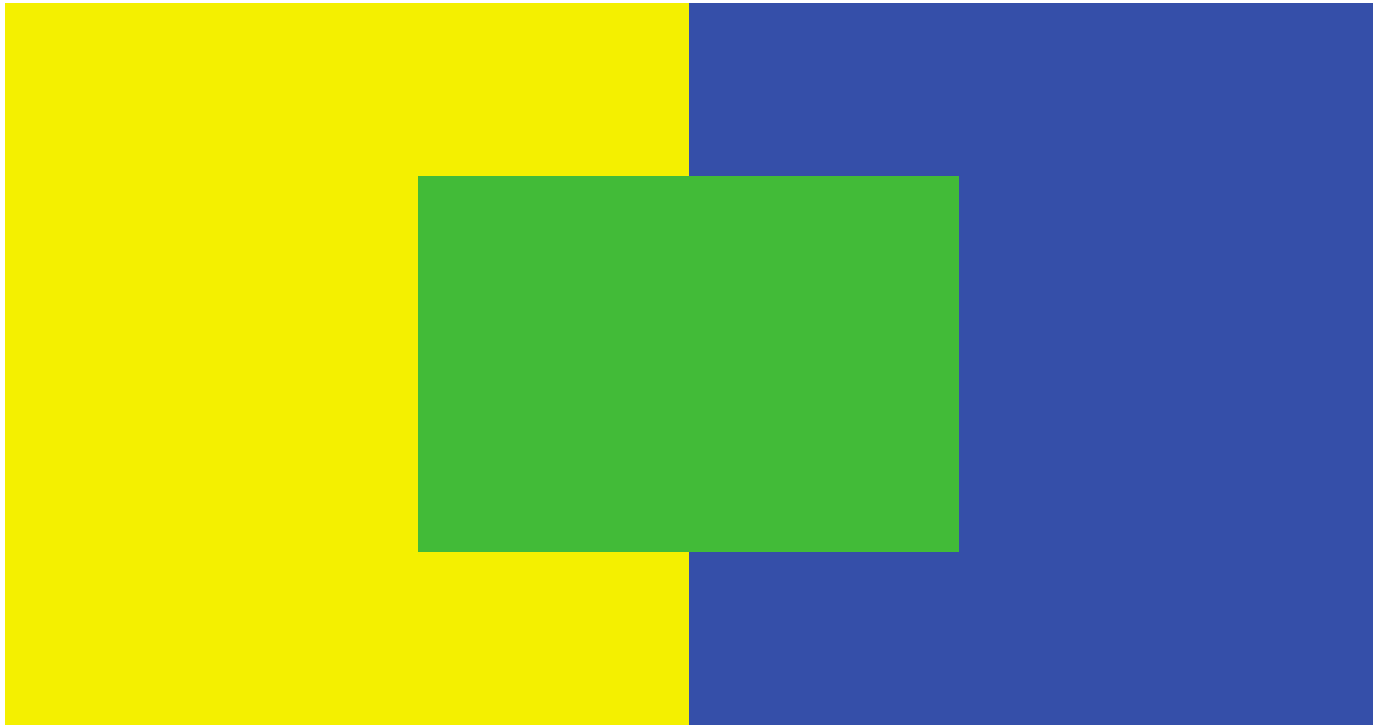
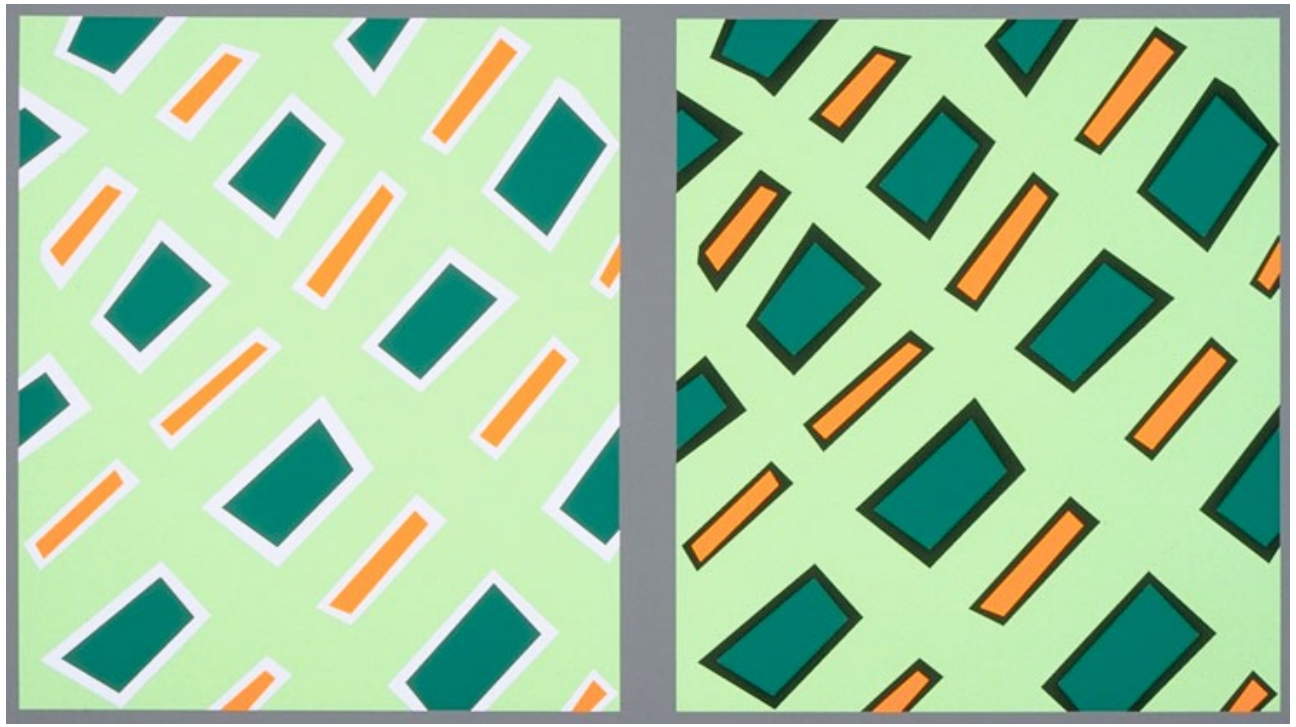


Colors - Beware

- VON BEZOLD SPREADING EFFECT – borders can change the appearance of shape's colors



Colormaps

Help us choose the correct colors to represent different data types

Categorical

Sequential

Divergent

Categorical

- Different color = different category
- Protip #1: choose colors that are perceptually distant
- Protip #2: choose colors that are roughly the same saturation and value

- Work with the person next to you to find an example of a visualization with a categorical color scheme
- You can look anywhere you want, but here are some potential sources: FiveThirtyEight, New York Times, Wall Street Journal, Tableau Viz of the Day
- Add your example to the appropriate page of the Jamboard here: Colormap Examples

Sequential

- Saturation indicates difference in the amount of the phenomenon
- Protip #1: no more than 5-6 levels
- Protip #2: people interpret darker as meaning more

- Work with the person next to you to find an example of a visualization with a sequential color scheme
- You can look anywhere you want, but here are some potential sources: FiveThirtyEight, New York Times, Wall Street Journal, Tableau Viz of the Day
- Add your example to the appropriate page of the Jamboard here: Colormap Examples

Divergent

- Two colors used to indicate extremes of a range
- Protip #1: neutral color in the middle
- Protip #2: differentiate between "average" or midpoint and "no data"

- Work with the person next to you to find an example of a visualization with a divergent color scheme
- You can look anywhere you want, but here are some potential sources: FiveThirtyEight, New York Times, Wall Street Journal, Tableau Viz of the Day
- Add your example to the appropriate page of the Jamboard here: Colormap Examples