Perception & Color

COMP8503

Advanced Topics in Visual Analytics

What is Perception?

- Processing of sensory information
  - Recognizing (be aware of)
  - Organizing (gathering and storing)
  - Interpreting (binding to knowledge)

Why is something easier to find?

ehklhfdiyaiorywekIblkhockxlyhirhupw
lksajdhflkihqdaklljerlajesljselusdslfjsals
oufojrtopjhklghqlkshlkfhlkdshflymcvci

- Find the p's
- Find the q's

- What makes an object easy to find is how easily we can direct a rapid eye movement to focus our attention on it.

Eye Movement Planning

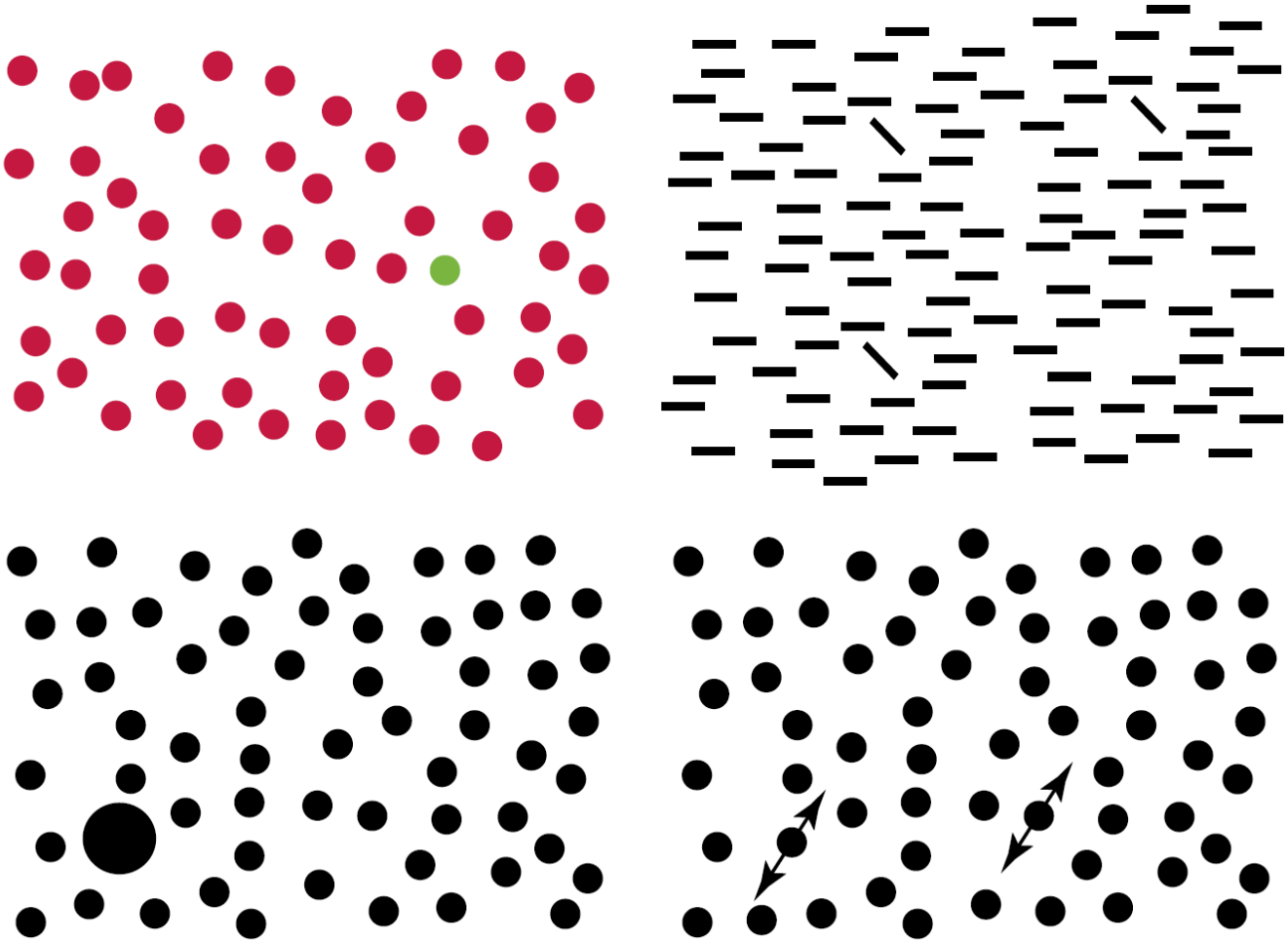
- When we are looking at something, we focus & process.

Find the tomatoes

Eye Movement Planning

- How to get our eyes focused at something in the absence of prior knowledge of where things are?
- How to draw one's attention? What will stand out in a graphic?

Eye Movement Planning

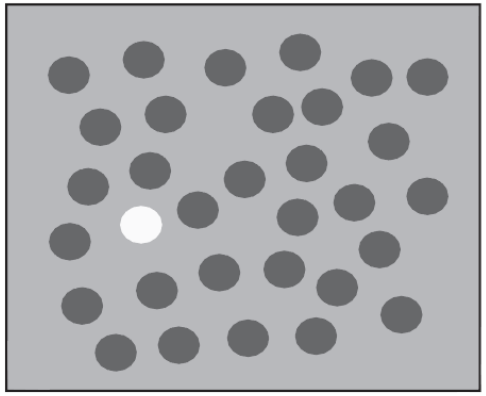


[Colin 2008]

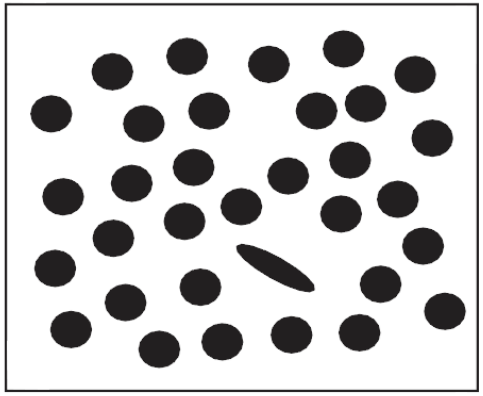
Preattentive Processing

- **Uncontrolled** perception that seems to take place prior to conscious attention
- The **fast** ability to detect features, usually within 200 ms or less

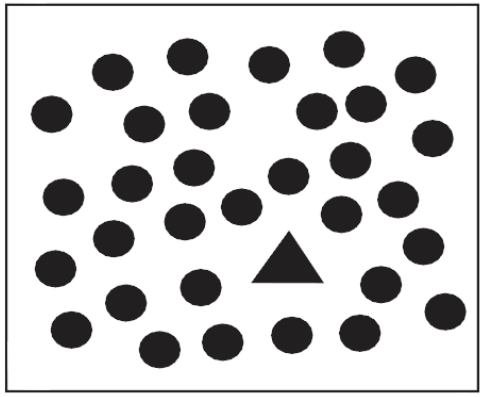
Preattentive Features



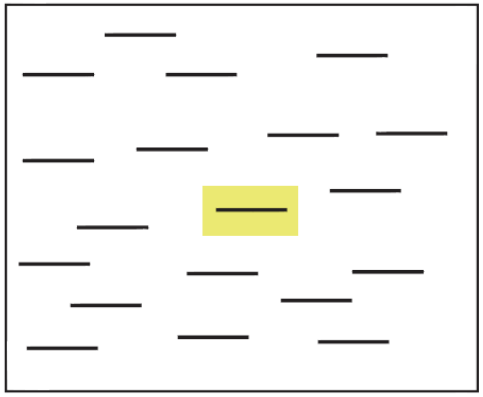
Grey value



Elongation



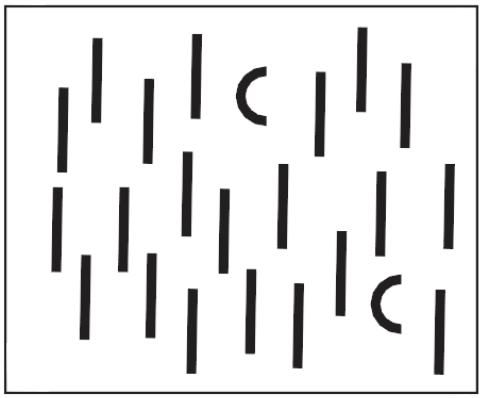
Shape



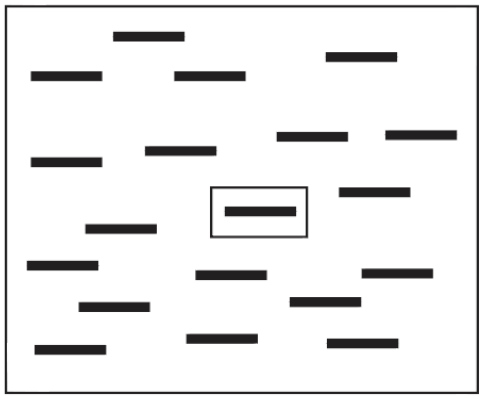
Surround Color

[Colin 2008]

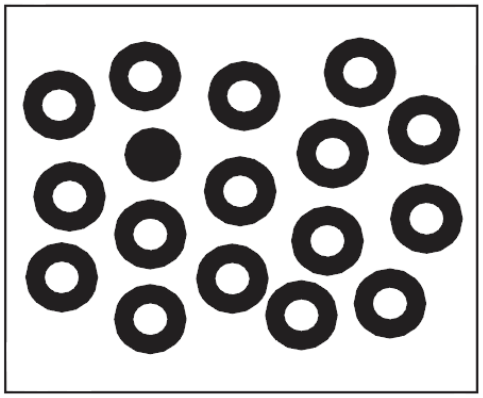
Preattentive Features



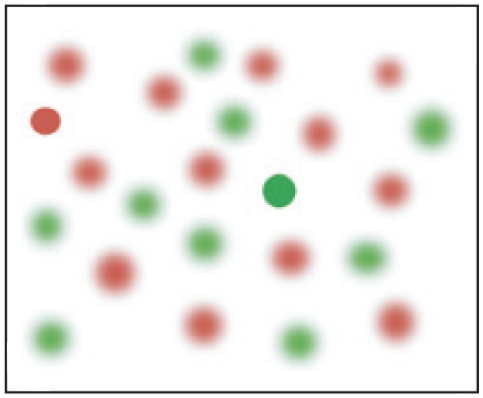
Curvature



Surround box



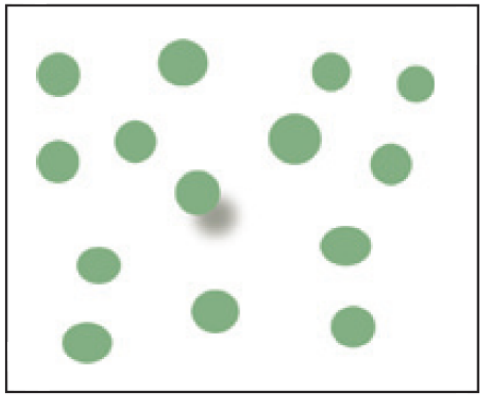
Filled



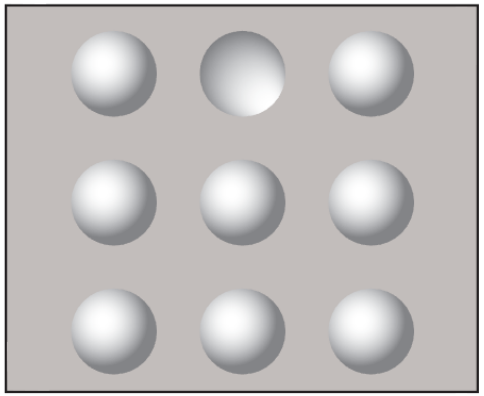
Sharpness

[Colin 2008]

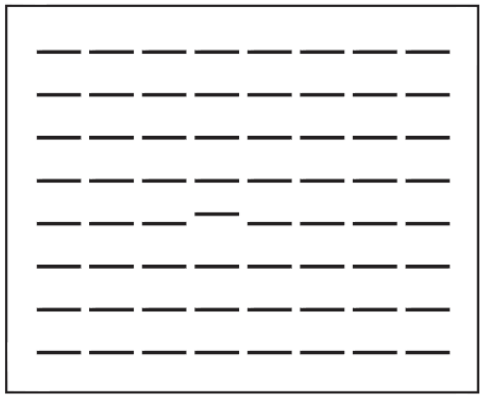
Preattentive Features



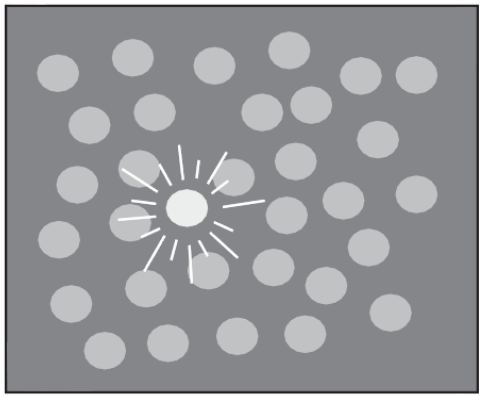
Shadow



Convex and concave



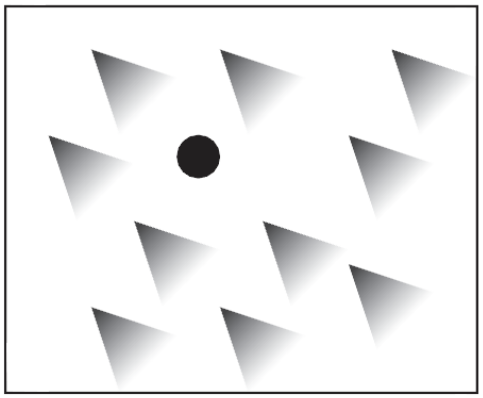
Alignment



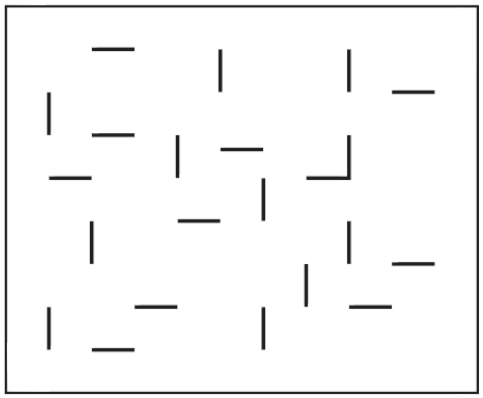
Blinking

[Colin 2008]

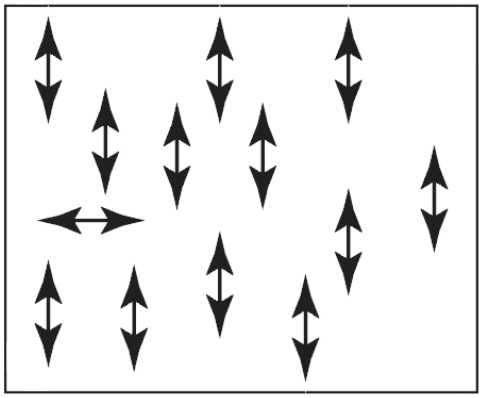
Preattentive Features



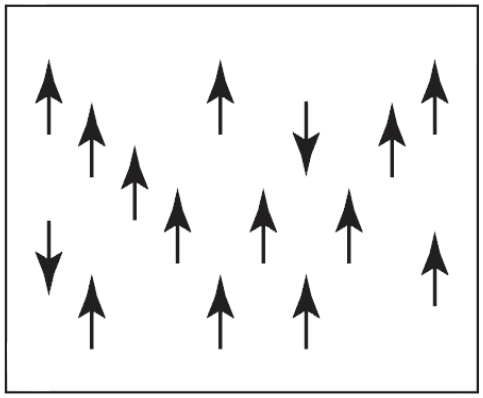
Sharp vertex



Joined lines



Motion direction

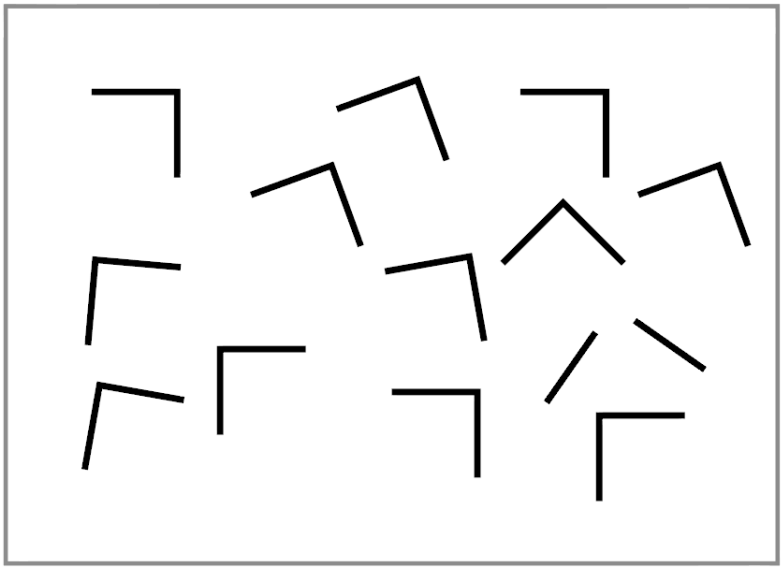


Phase of motion

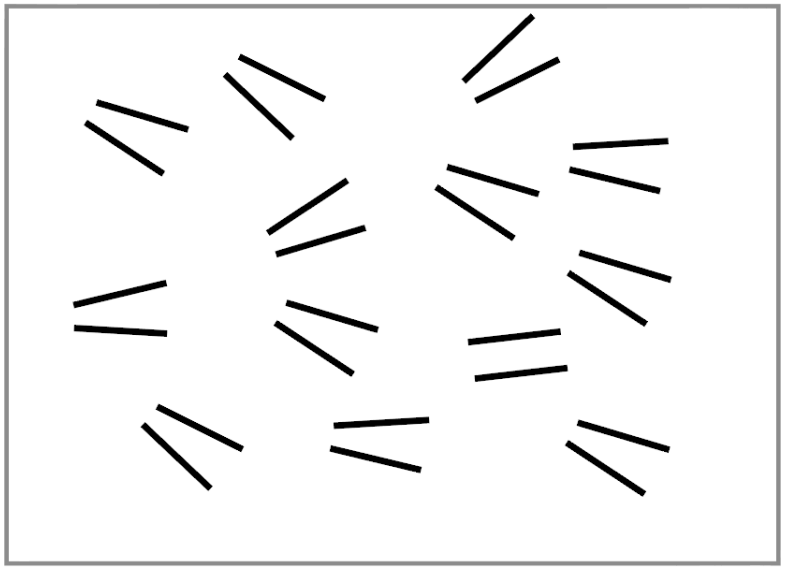
[Colin 2008]

Non-Preattentive Features

- Not all features are preattentive



Juncture



Parallelism

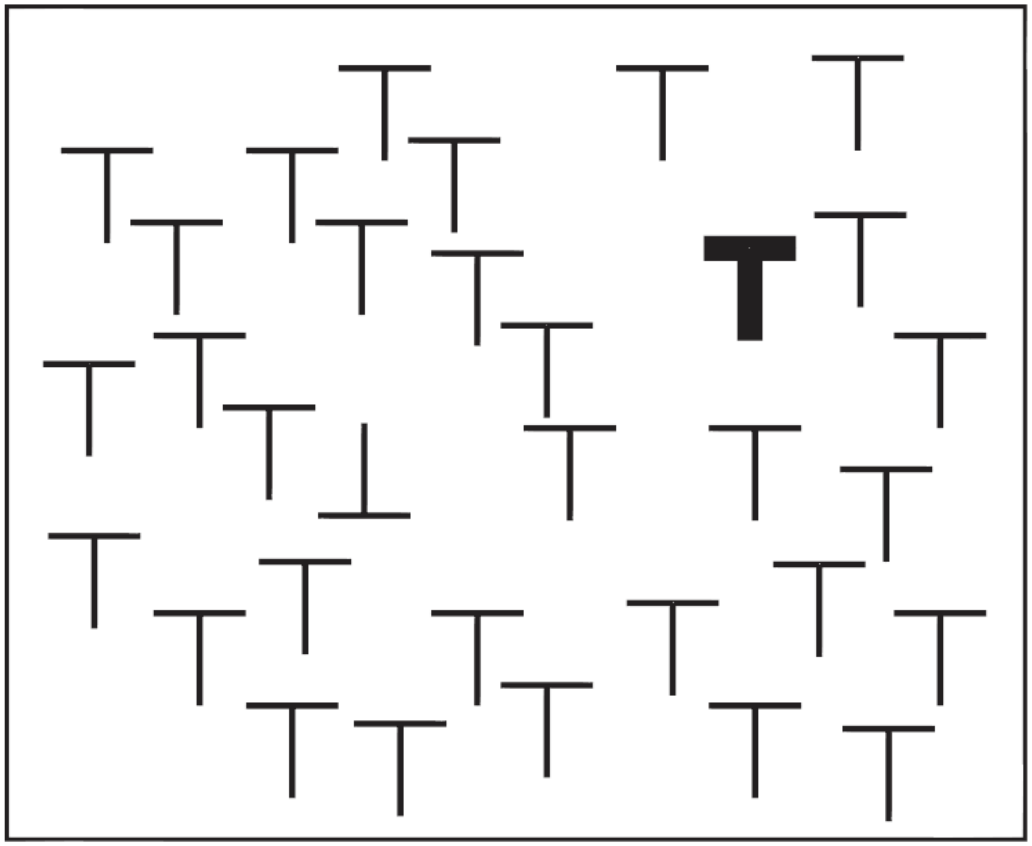
[Colin 2008]

Easy vs. Hard to Find

- Some features are easier to find:

Find 

Find 



[Colin 2008]

Easy vs. Hard to Find

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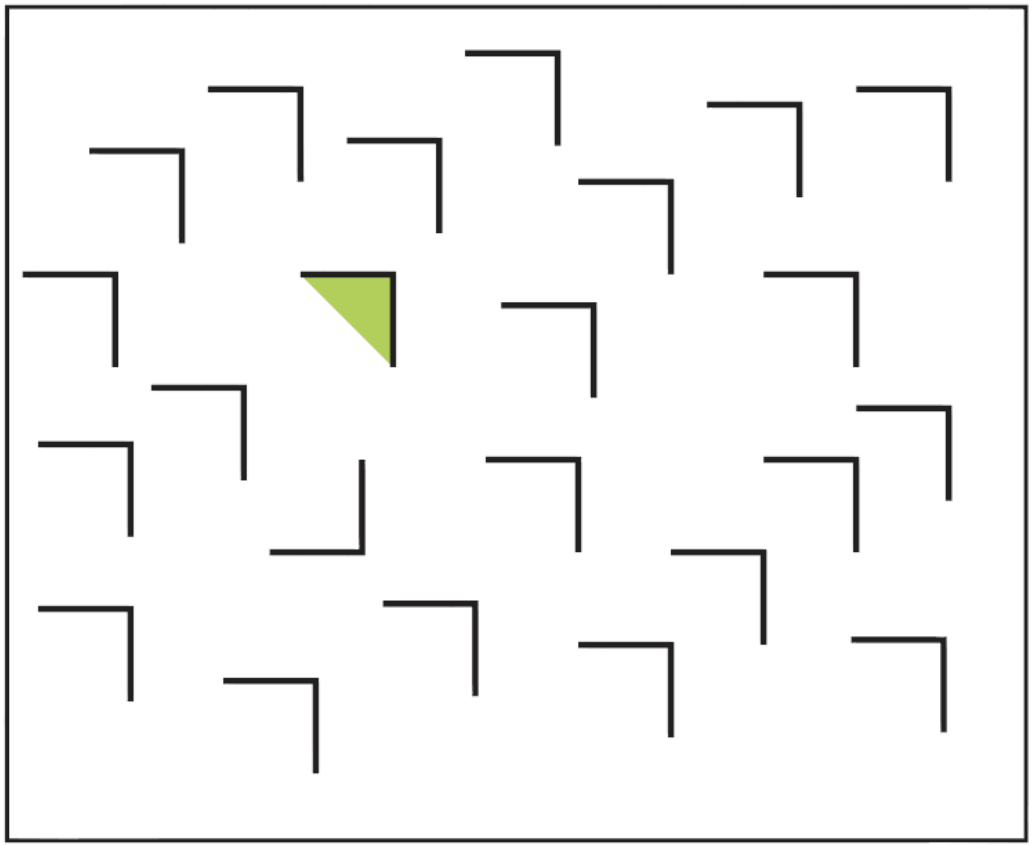
Find

Find



[Colin 2008]

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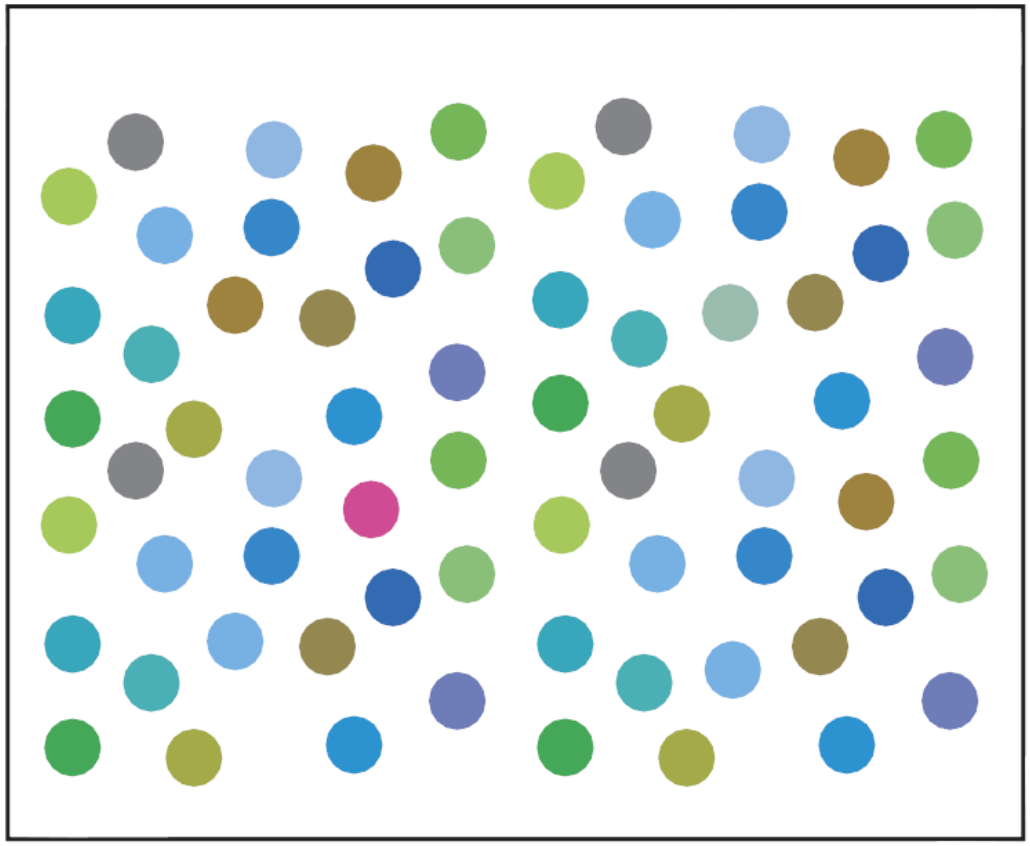

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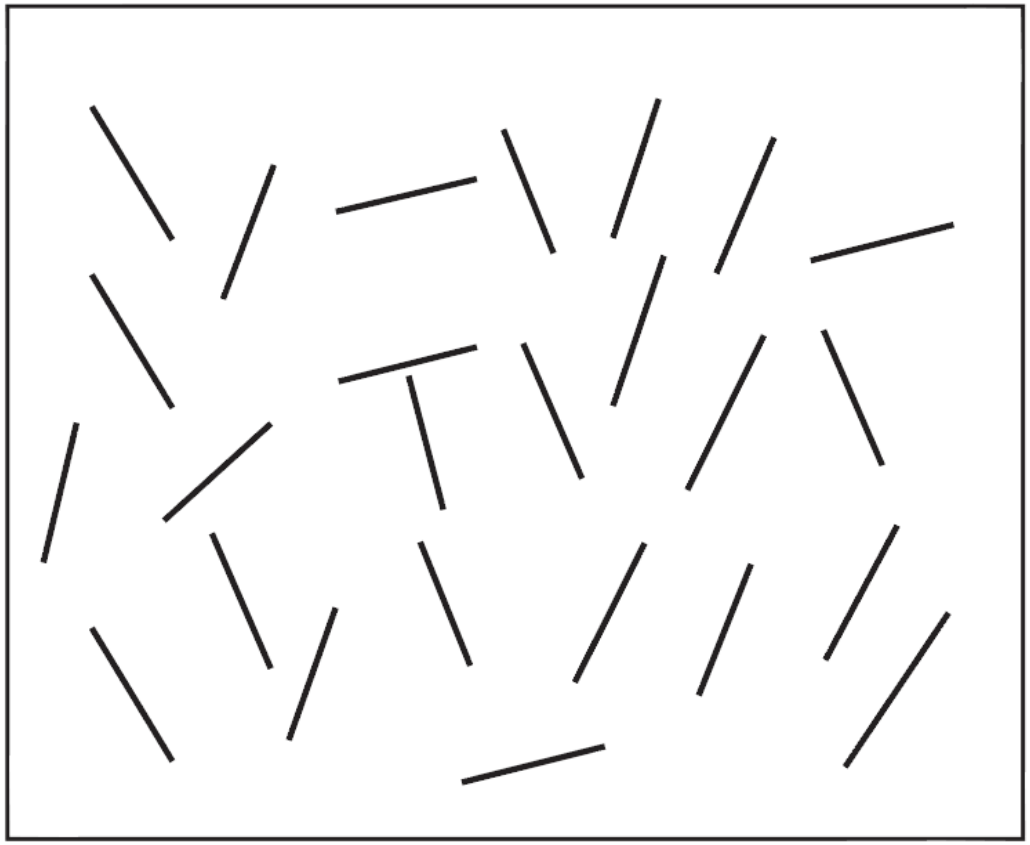
Find



[Colin 2008]

Words as Pattern

Aoccdrnig to a rscheearch at Cmabrigde Uinervtisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht the frist and lsat ltteer be at the rghit pclae. The rset can be a toatl mses and you can sitll raed it wouthit porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe.

Words as Pattern

According to a research at Cambridge University, it doesn't matter in what order the letters in a word are, the only important thing is that the first and last letter be at the right place. The rest can be a total mess and you can still read it without problem. This is because the human mind does not read every letter by itself, but the word as a whole.

Words as Pattern

Anidroccg to crad–cniyrrag lcitsiugnis planoissefors at an uemannd utisreviny in Bsitirh Cibmuloa, and crartnoy to the duoibus cmials of the ueticnd rcraeseh, a slpmie, macinahcel ioisrevnn of ianretnl cretcarahs araepps sneiciffut to csufnoe the eadyrevy oekoolnr.

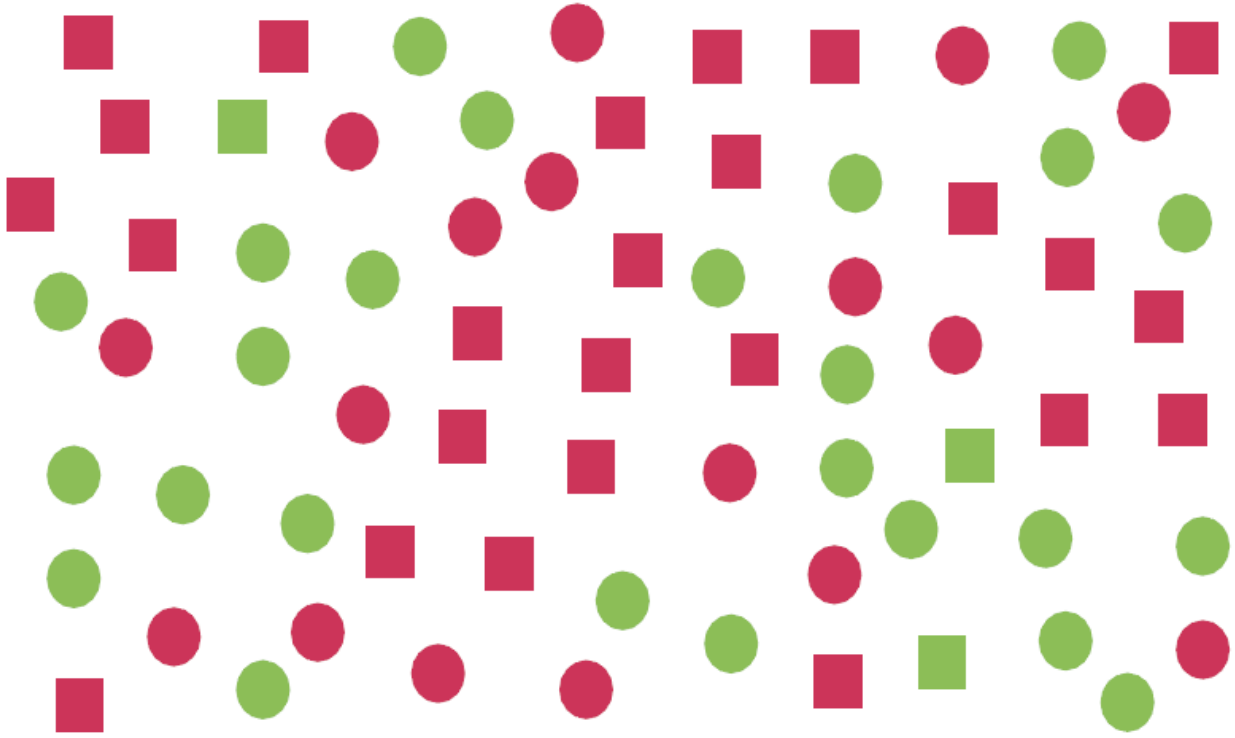
Words as Pattern

According to card-carrying linguistics professionals at an unnamed university in British Columbia, and contrary to the dubious claims of the uncited research, a simple, mechanical inversion of internal characters appears sufficient to confuse the everyday onlooker.

- **Typoglycemia:** concerns about the cognitive process behind reading written text

Visual Conjunctions

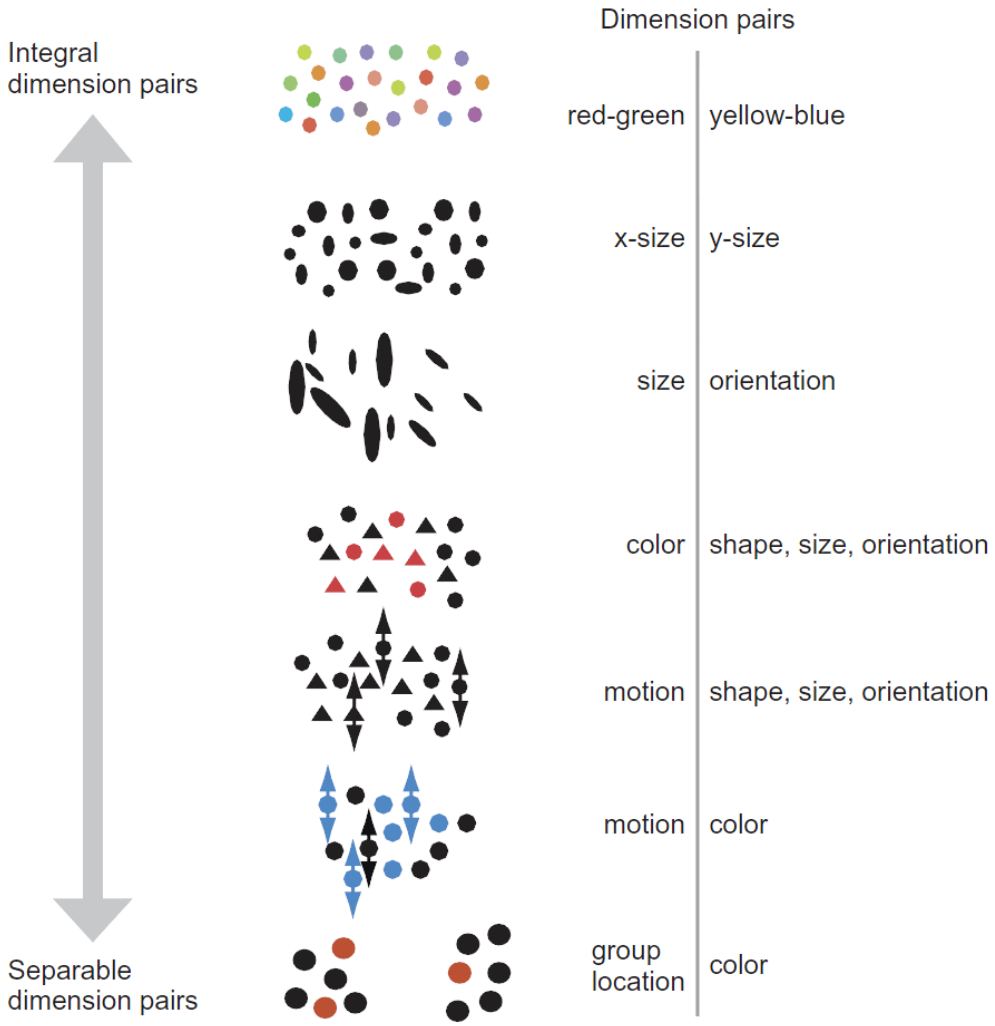
- A combination of non-unique features



Find the green square

[Colin 2008]

Effective Use of Conjunctions



[Colin 2013]

Preattentive Salience

- Stronger effects:
  - Color, orientation, size, contrast, motion/blinking
- But depends also on degrees of differences
  - E.g. large vs. small color differences

Use strong preattentive features/cues before weak ones to facilitate ease of search

Preattentive Salience

- Factors determining if a feature **stands out** preattentively:
  - Degree of difference of the nontargets from each other
  - Degree of difference of the target from the nontargets (distractors)

Preattentive Salience

[Colin 2008]

d: distractor t: target

Preattentive Salience

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Preattentive Salience

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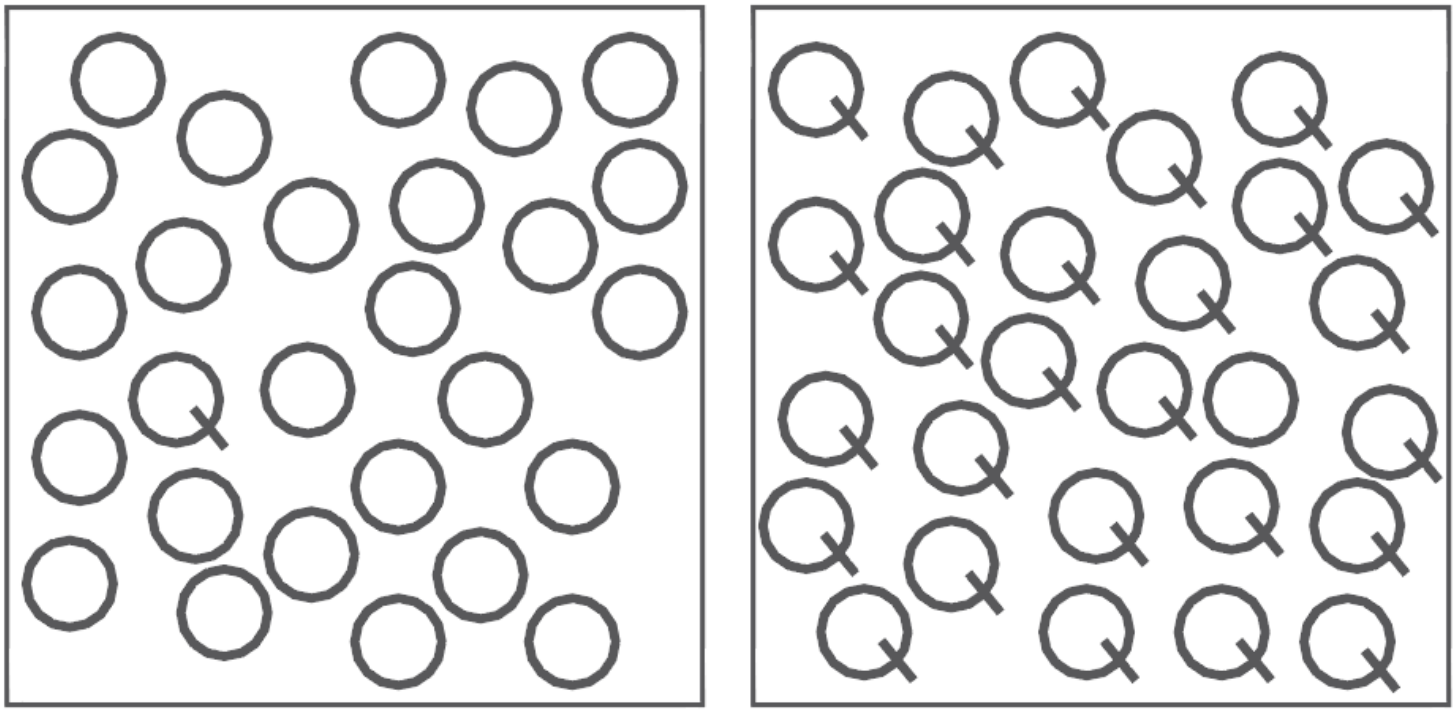
Asymmetric Preattentive Cues

- The “reverse” of a preattentive feature is not necessary preattentive.



Asymmetric Preattentive Cues

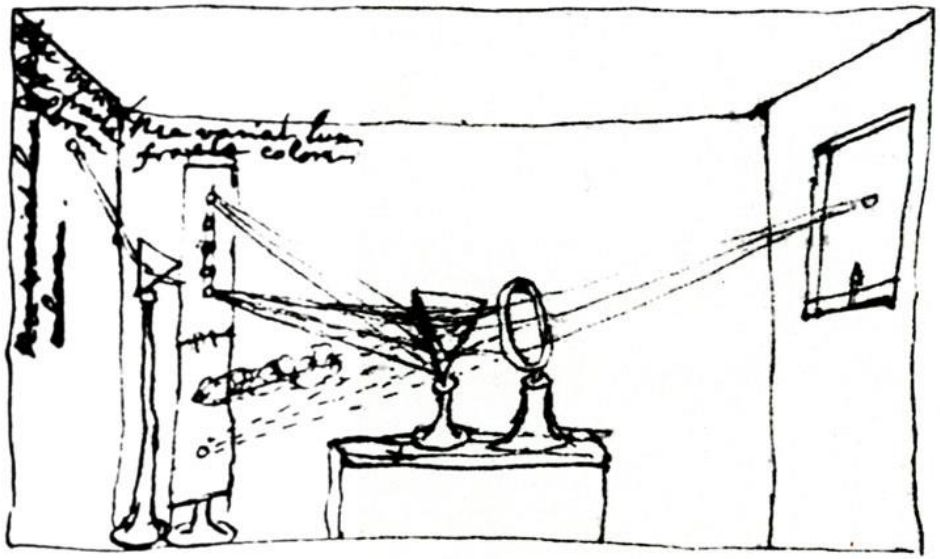
- Examples
  - Underlining words in a paragraph
  - Big targets surrounded by small ones

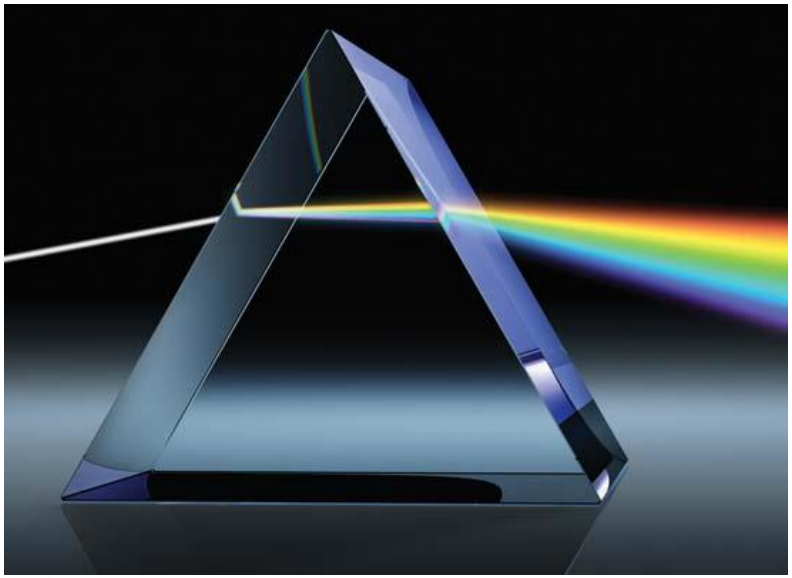
- Use **positively** asymmetric preattentive cues for highlighting

Color

Some Physics

- light is a composition of different colors.
  - by Issac Newton using a prism to disperse light

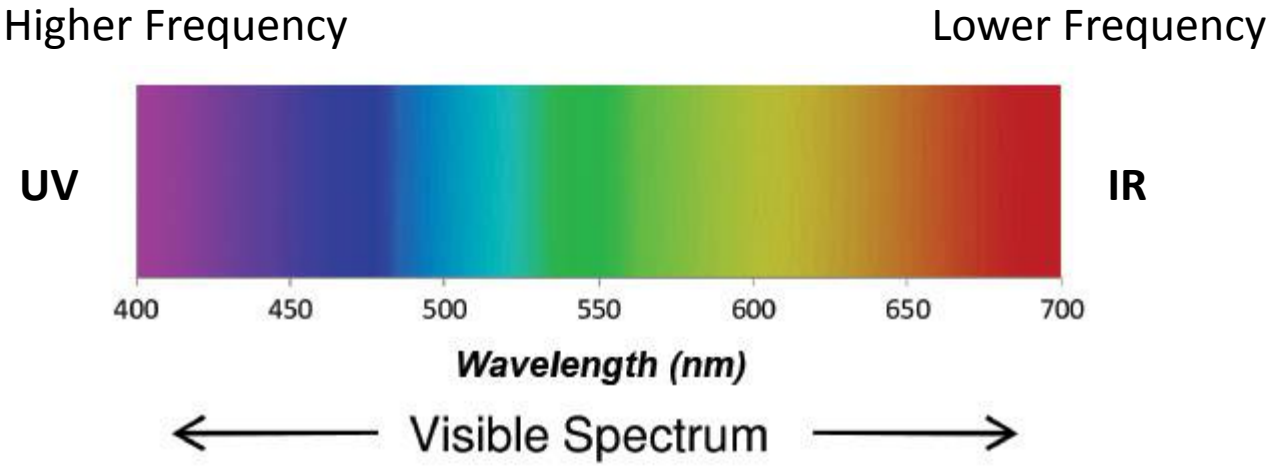




[*refraction; prism*. Photograph. *Encyclopædia Britannica Online*]

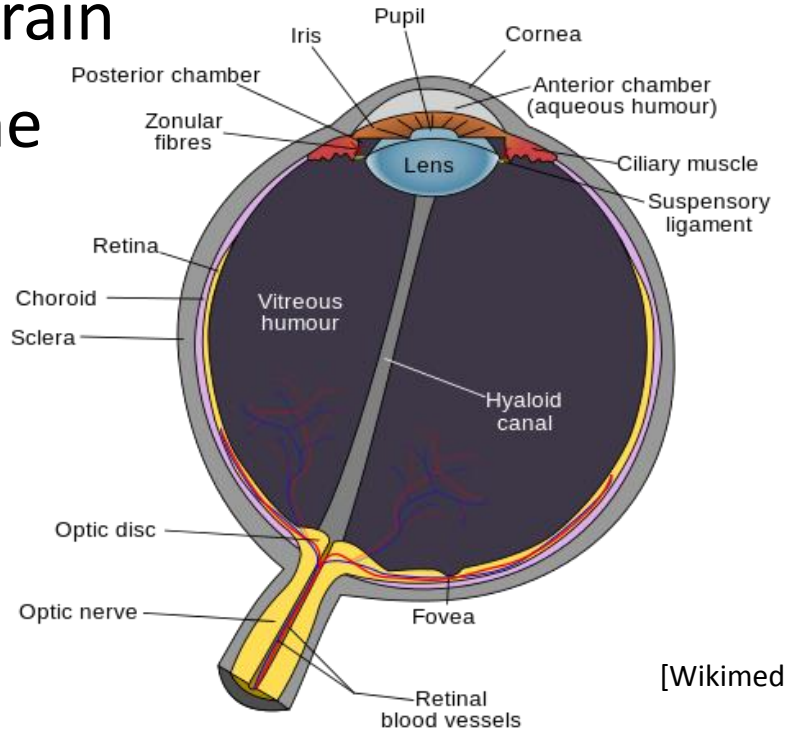
Visible Light Spectrum

- A spectrum of wavelengths from 370 to 730 nanometers (nm)



The Visual System

- How do we see?
  - Light travels through cornea, pupil, lens, retina, optical nerves, then brain
  - Imaging sensors on the retina: rods & cones



[Wikimedia Commons]

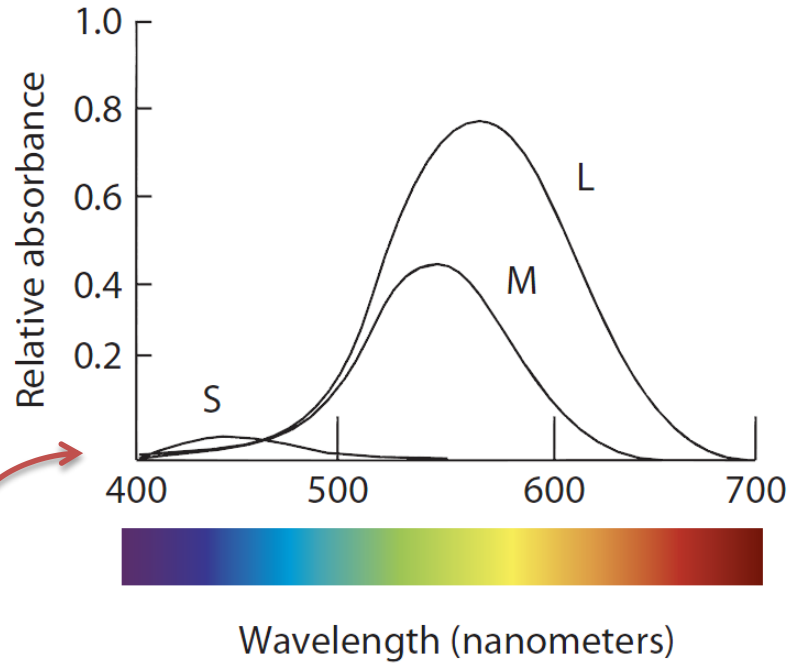
Rods and Cones

- Cones
  - active at normal light levels
  - color vision involves cone only
- Rods
  - sensitive at low light levels
  - not sensitive to color
  - responsible for our dark-adapted vision
  - Low influence on color perception
- There is an uneven distribution of cones and rods in the retina

Cone Response

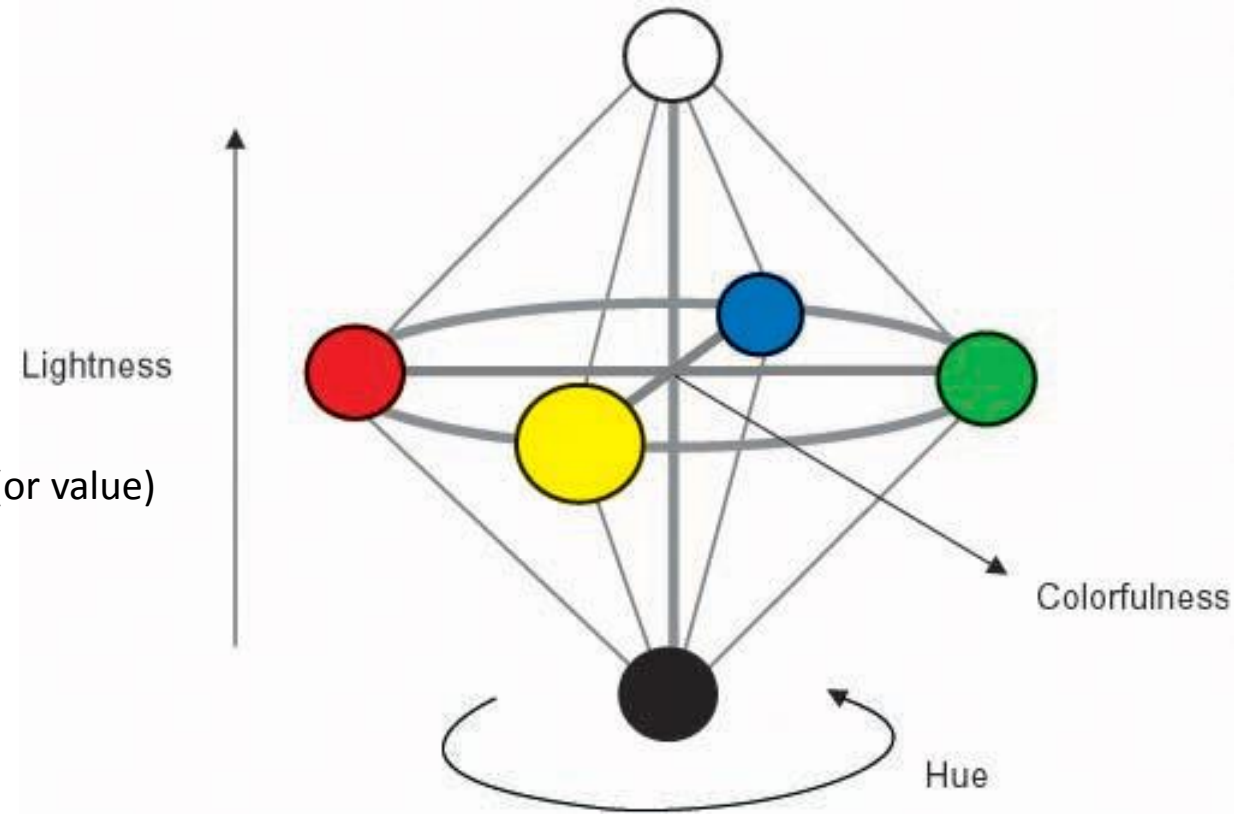
- Sensitivity functions for the three classes of cone receptors—long(L), medium(M), and short(S) wavelength-sensitive cones.
- **Trichromacy**: to match a particular colored light with 3 primary colors.

This is why we should not show blue over a dark background since S cone receptors are much less sensitive.



[Ware, 2008]

Perceptual Color Spaces

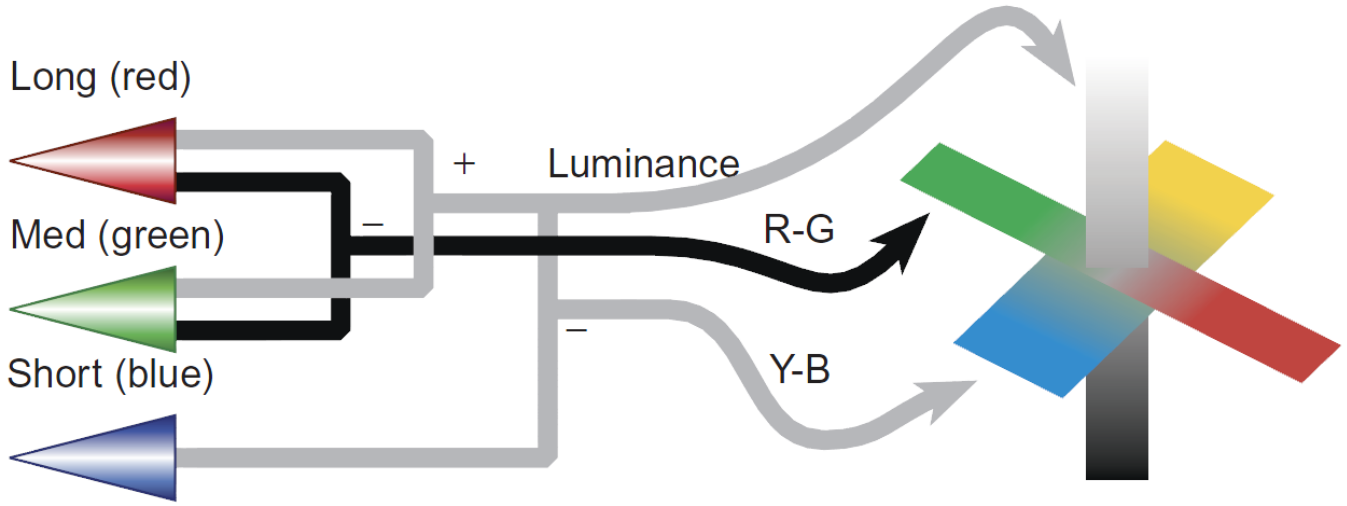


[Stone]

- How human perceive a color:
  hue, **lightness** and **colorfulness (color saturation)**

Opponent Color

- Input from the cones is processed into 3 distinct channels: **luminance** (black-white), **red-green**, and **yellow-blue**.
- Explain how we perceive some of the color effects, e.g., brightness contrasts or chromatic contrasts.



[Ware, 2013]

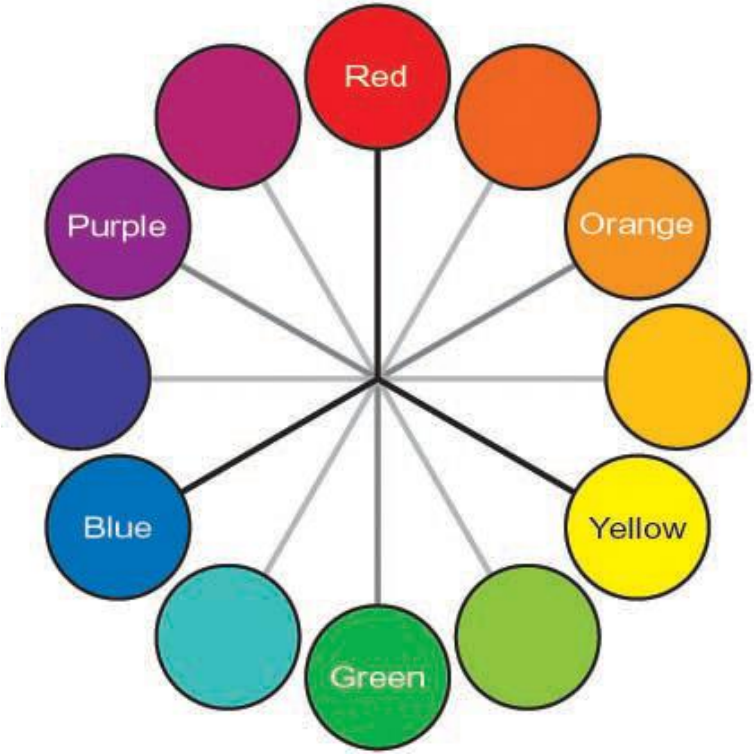
Color Selection & Design

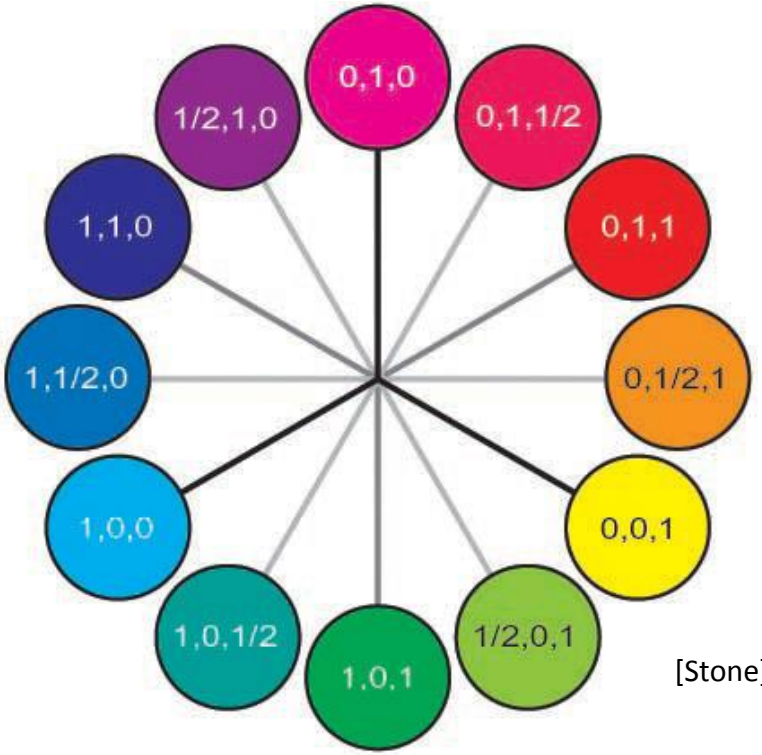
- Guided by the basic principle: **color harmony**
  - **Contrasts**: focus attention
  - **Analogy**: unify design
  - "please the eyes by using analogous colors, excite the eyes with contrasts" – *Wucius Wong*
- Be careful about perceptual & contextual effects

[Stone]

Color Wheel

- Analogous colors lie close and contrasting colors lie opposite.

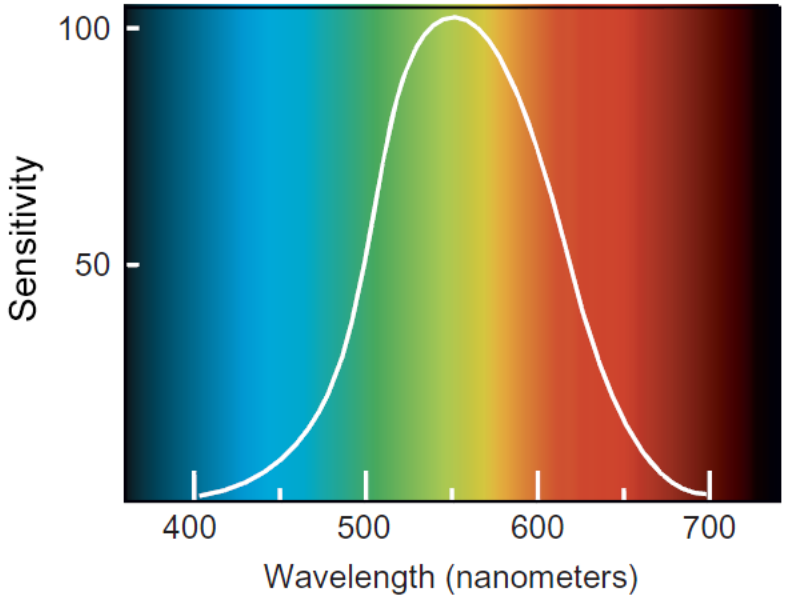




[Stone]

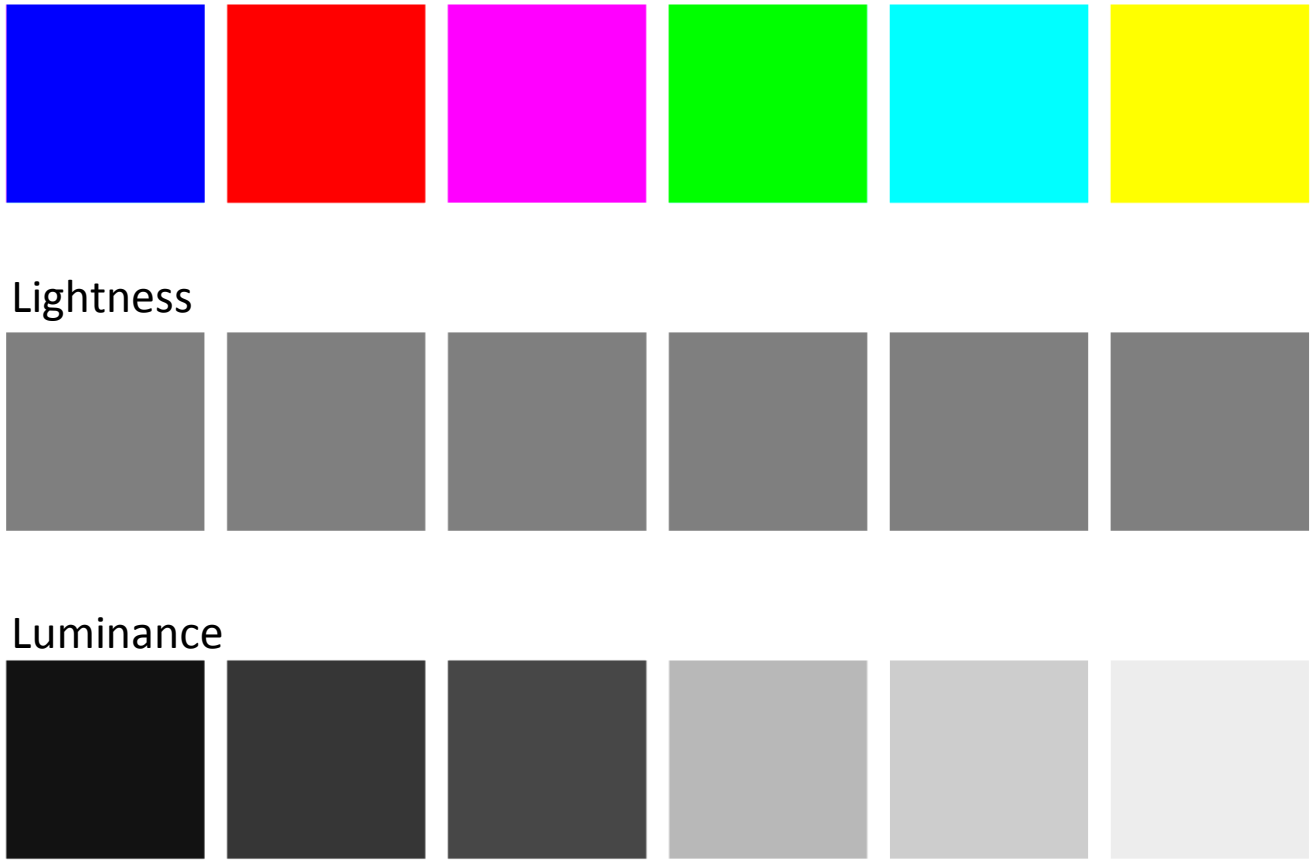
Lightness Scales

- **Lightness/Brightness** – (qualitative) perceived reflectance of a surface
- **Luminance –** (quantitative) measured amount of light relative to the eye's spectral sensitivity



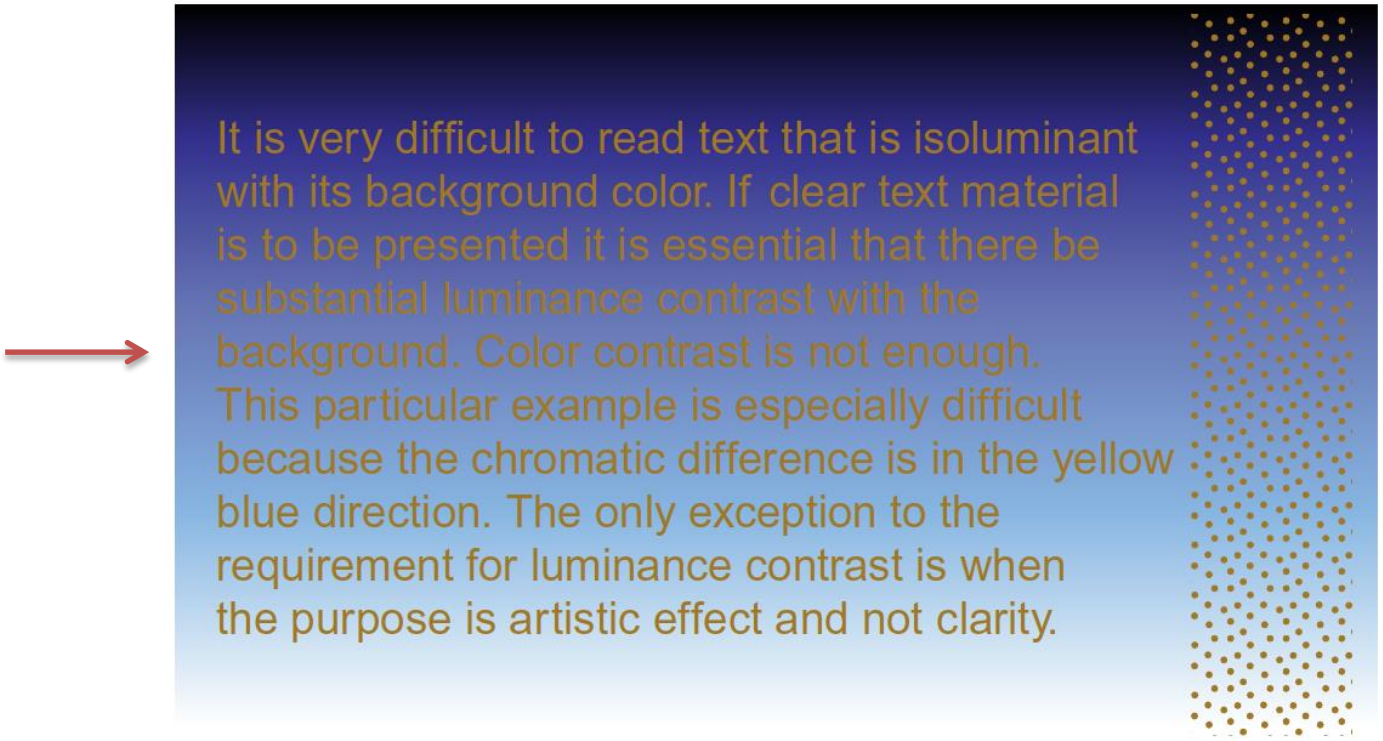
[Ware, 2013]

Lightness vs. Luminance

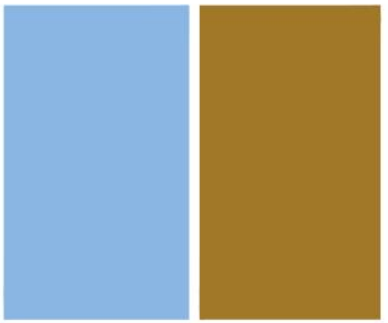


Contrast in Luminance

- Determines legibility and sharpness

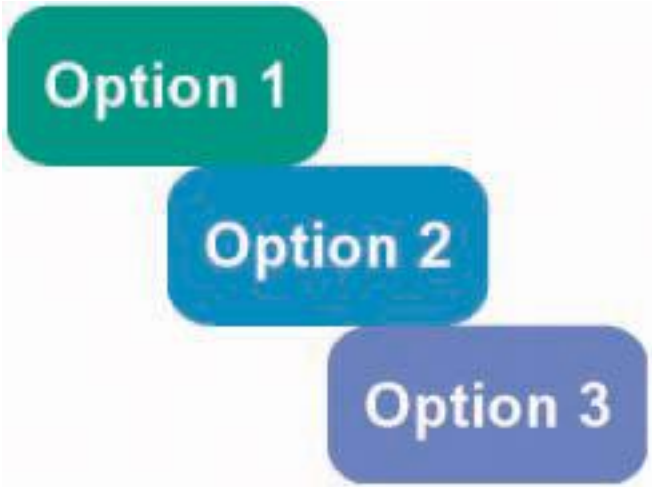


Brown text on a blue gradient



[Ware, 2013]

Equal Luminance Value

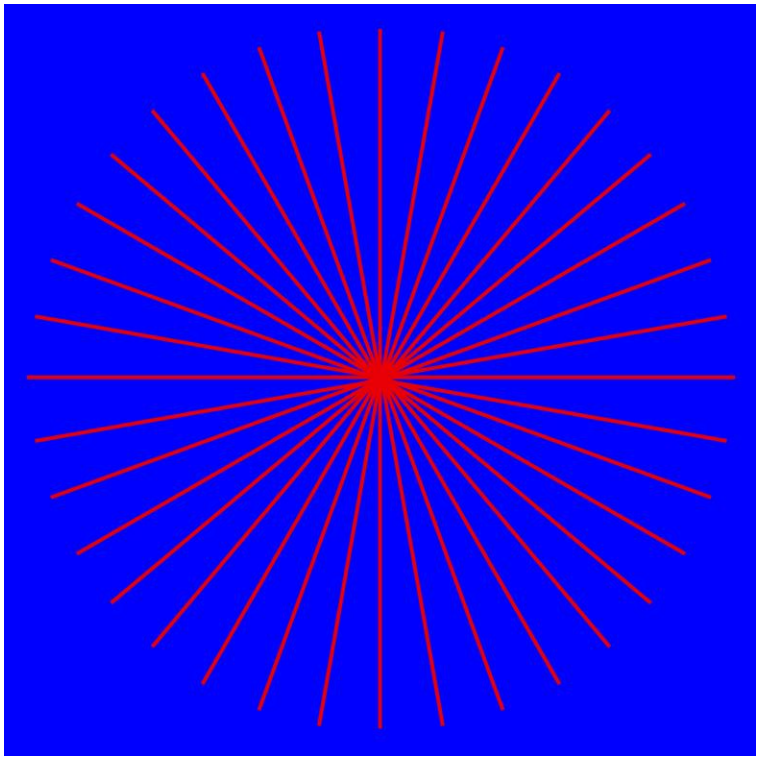


[Stone]

- Gives same importance or emphasis

Color on Color

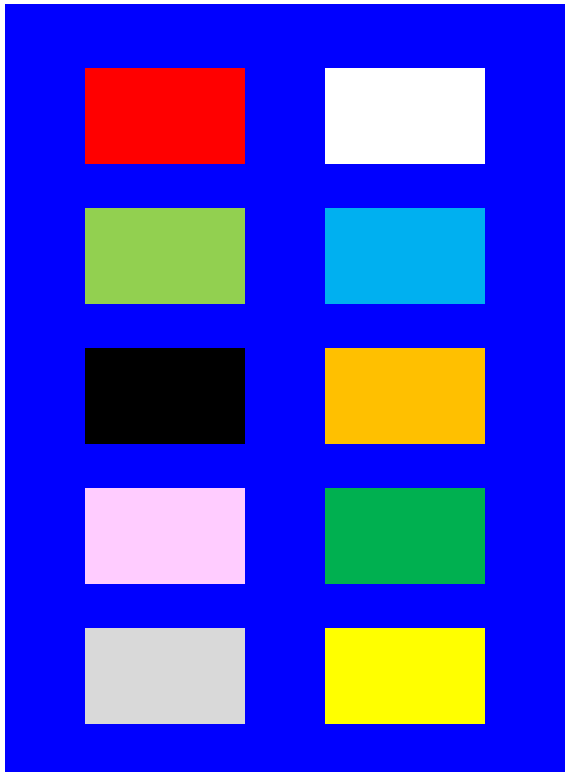
- Chromatic aberration – different colors focus at a different depth in the eye

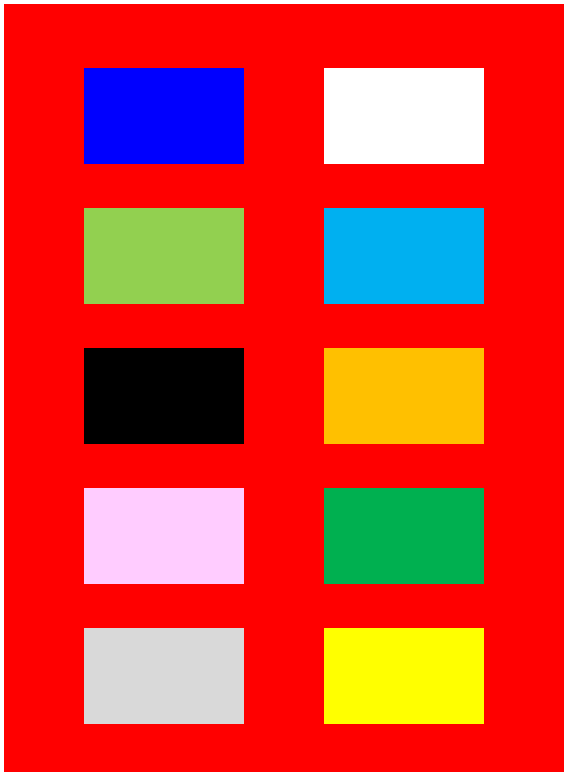


Difficult to focus on both red lines and blue background

Color on Color

- Chromatic aberration





Color on Color

- Blue-sensitive cones are few and weak.

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Lorem ipsum dolor sit amet, consectetur adipiscing elit. Pellentesque ornare nisi erat, eget luctus magna faucibus eu.

Color on Color

- Yellow is the lightest of all pure hues.

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Pellentesque ornare nisi erat, eget luctus magna faucibus eu.

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Pellentesque ornare nisi erat, eget luctus magna faucibus eu.

Color on Color

- How to reduce unpredictable effect of color on color?
  - Avoid doing this entirely
  - Layering colors only with neutral colors

- Ensure that edges are visible and text is legible

Purpose of Color

- Purpose of color in information design:
  - To label (color as noun)
  - To measure (color as quantity)
  - To represent or imitate reality (color as representation)
  - To enliven or decorate (color as beauty)
- Most important of all is that color should do no harm

[Tufte, Envisioning Information]

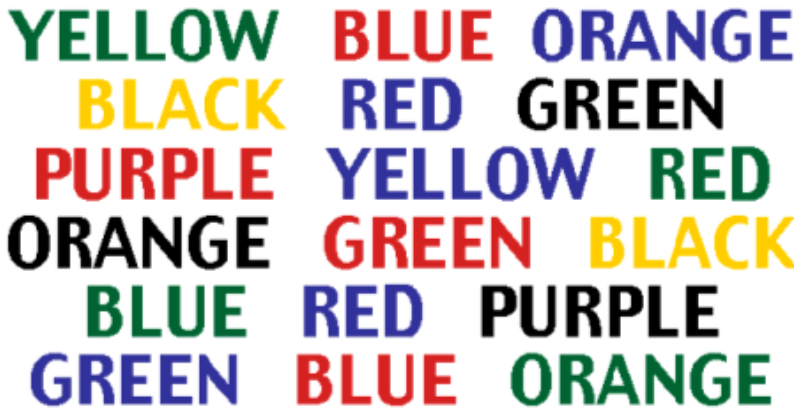
To Label

- Color's ability to label is preattentive process

[Stone]

To Label

- Stroop effect: your right brain is trying to say the color, while your left brain insists in saying the word

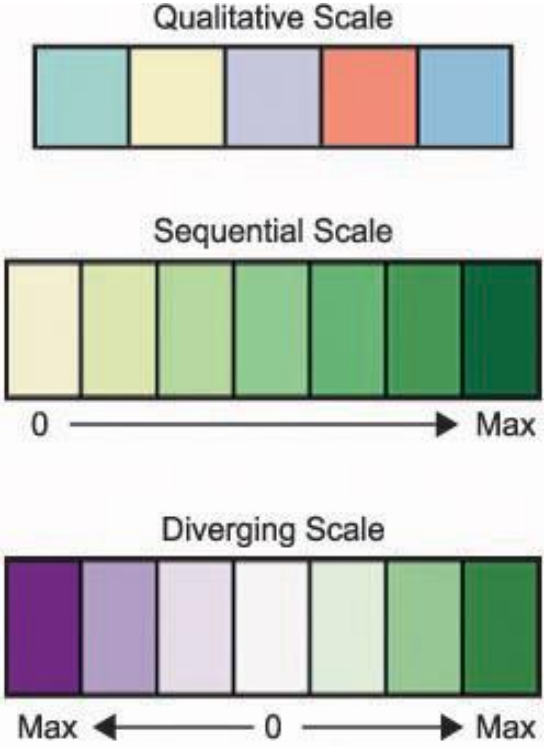


Name the color of each word

- Strong pre-attentive cues by text than by color
- Avoid color labeling that conflicts with convention

To Quantify

- Color scales: sequences of color values to indicate relative quantity



For labeling

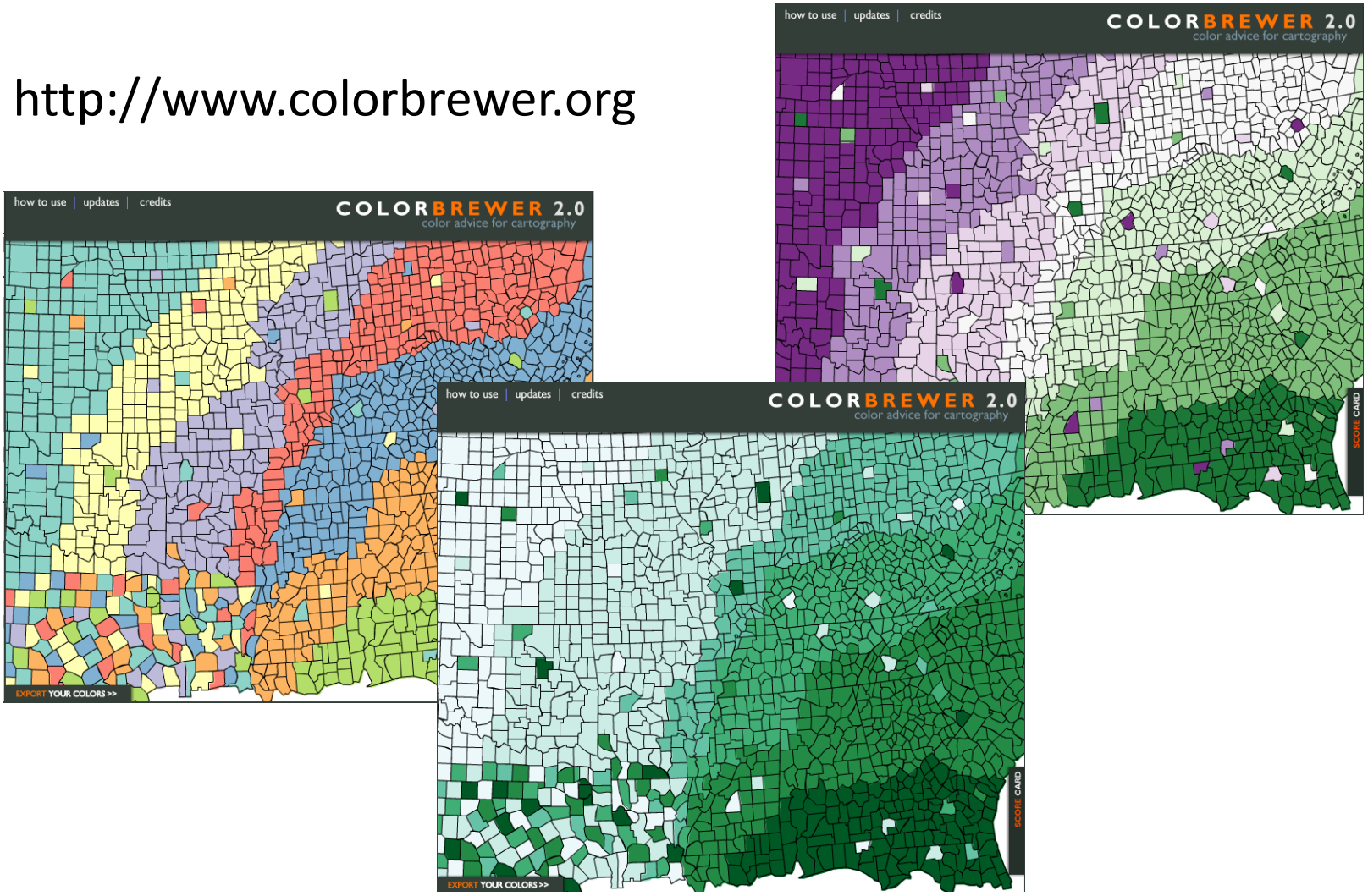
For indicating quantity

Two sequential scales cross-fade through a neutral color

[Stone]

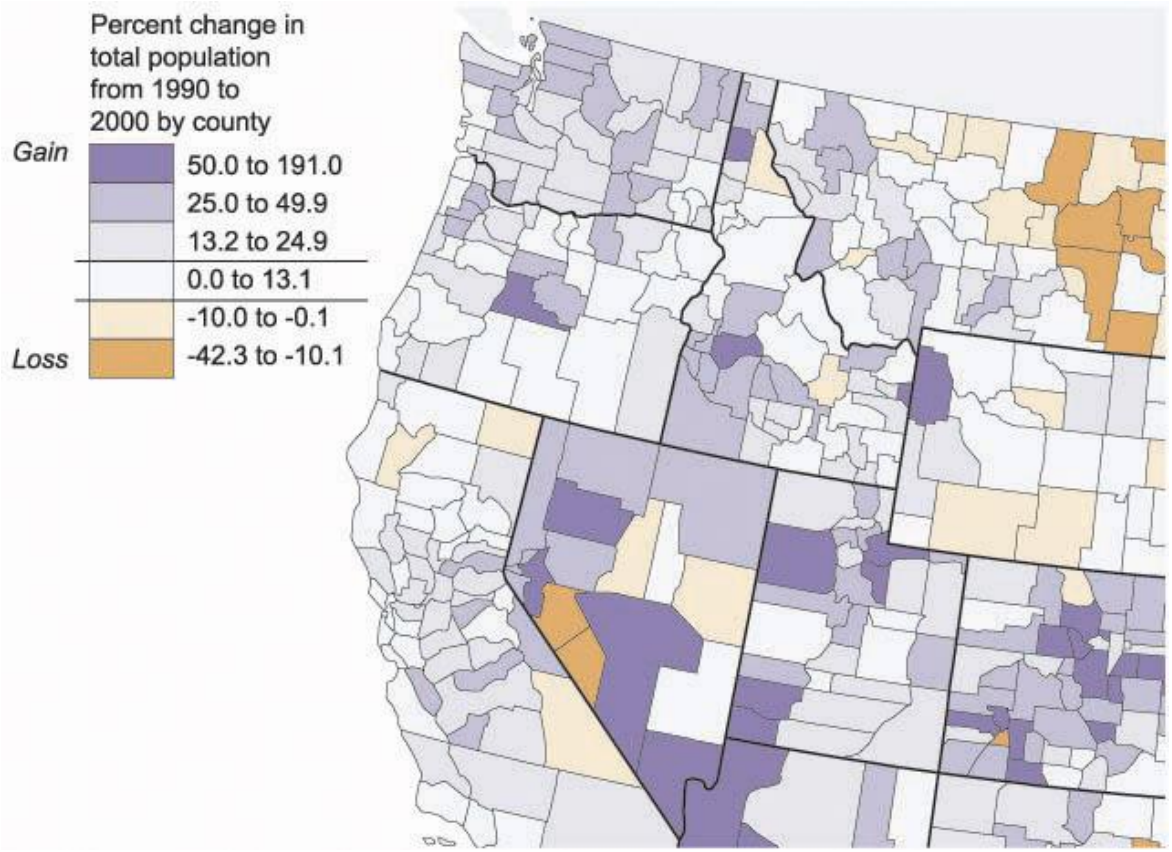
To Quantify

- http://www.colorbrewer.org



To Quantify

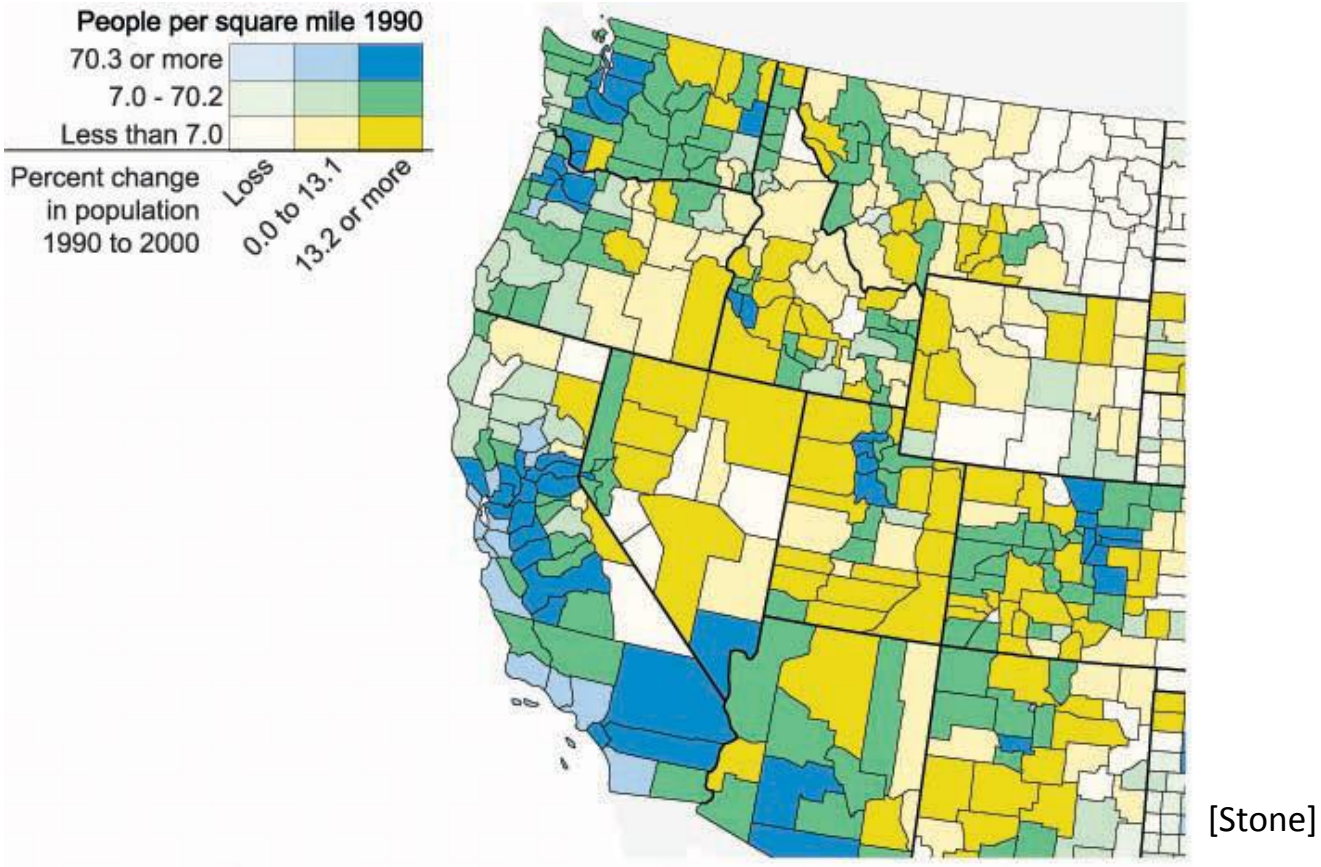
- Univariate data



[Stone]

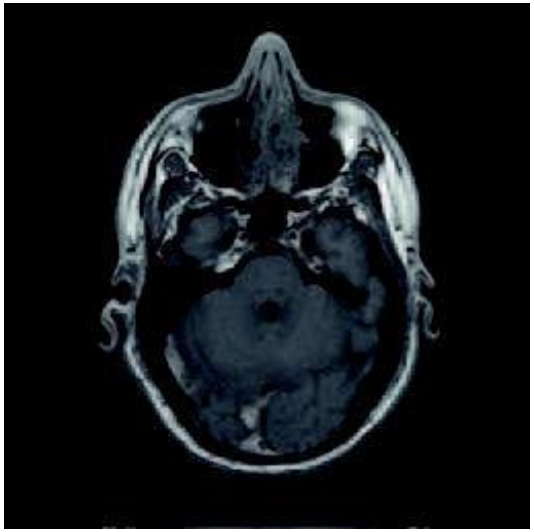
To Quantify

- Multivariate scale

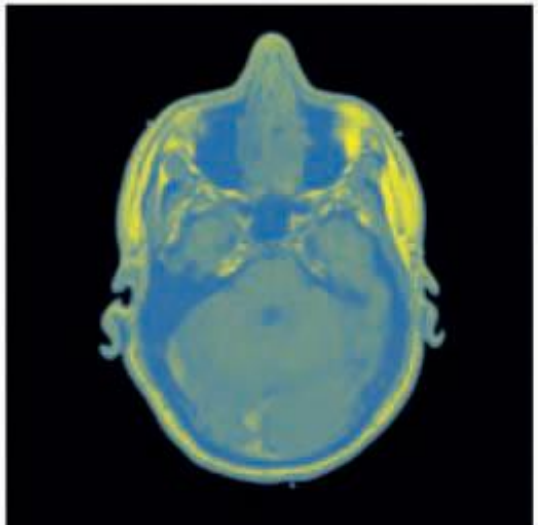


[Stone]

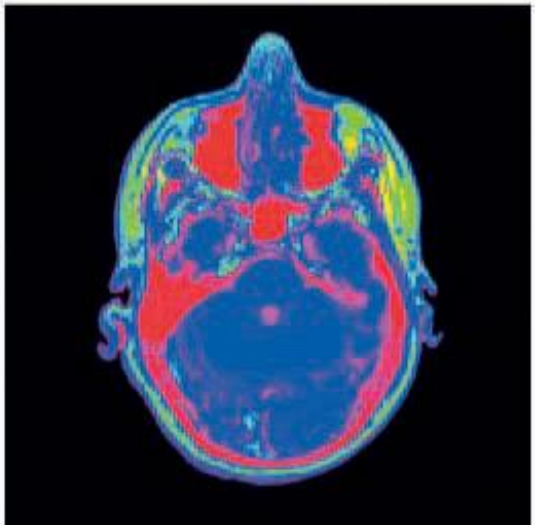
Bad Use of Color



Original MRI data



Pseudocolor
blue-yellow gradient



Pseudocolor
rainbow color

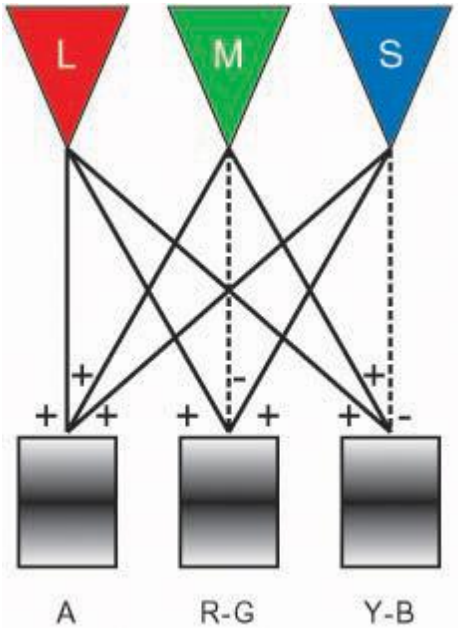
Similar lightness scale

Obscures the original data

[Stone]

Color Blindness

- About 10% of people (mostly men) has color vision deficiencies.
- Most have problems in processing red-green variations.
- Most have no problem in processing luminance information.
- **Rule 1**: maintain sufficient value contrast when reduce to shades of gray
  Rule 2: reinforce color encoding with position, size, shape



[Stone]

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