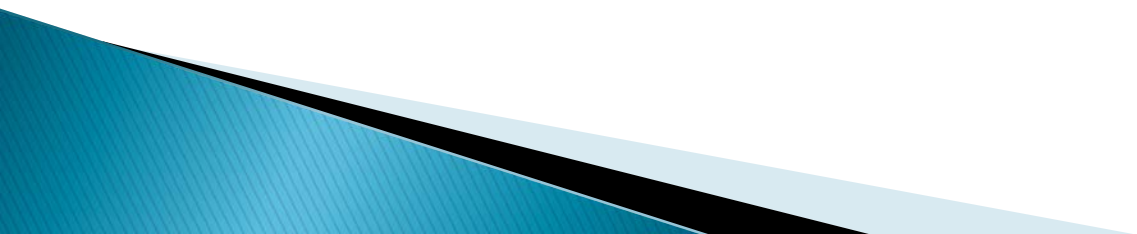
Professors d’IDI - UPC

IDI – Design with color



Design with color

- Color perception problems
- Tips for color selection

Human Vision

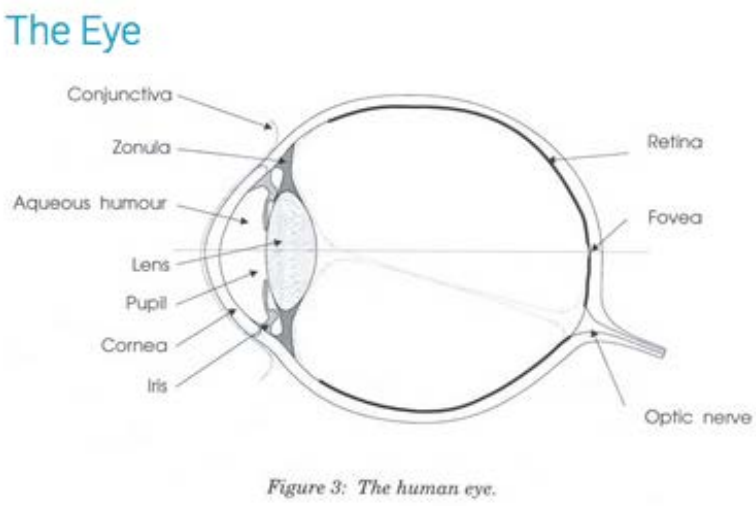
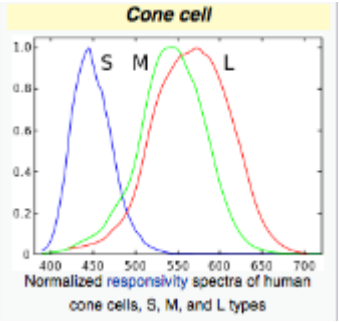


Figure 3: The human eye.

Source: Lilley, Lin, Hewitt, & Howard, "Colour in Computer Graphics", University of Manchester.

Photoreceptors:

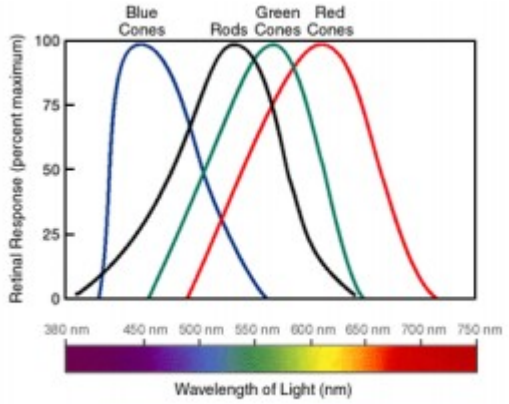
- Rods:
  - Only one kind (peak response in green wavelenghts)
  - Sensitives to low light, saturate at moderate light
- Cones:
  - Operate in brighter light
  - Three kinds: S (are weak, centered in Blue),
    M &L (more powerfull, overlapping frequencies,
    M centered in Green, L in Red)

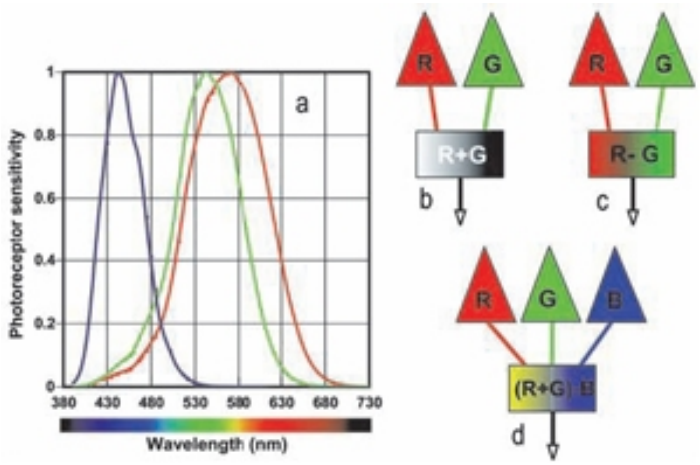


Human Vision

- Signals from Photoreceptors
  - Brightness (M+L+rods)
  - Red-Green difference (L-M)
  - Blue-yellow (S- (L+M))

- Contrasting colors:
  - Opponent colors: R/G, B/W, B/Y





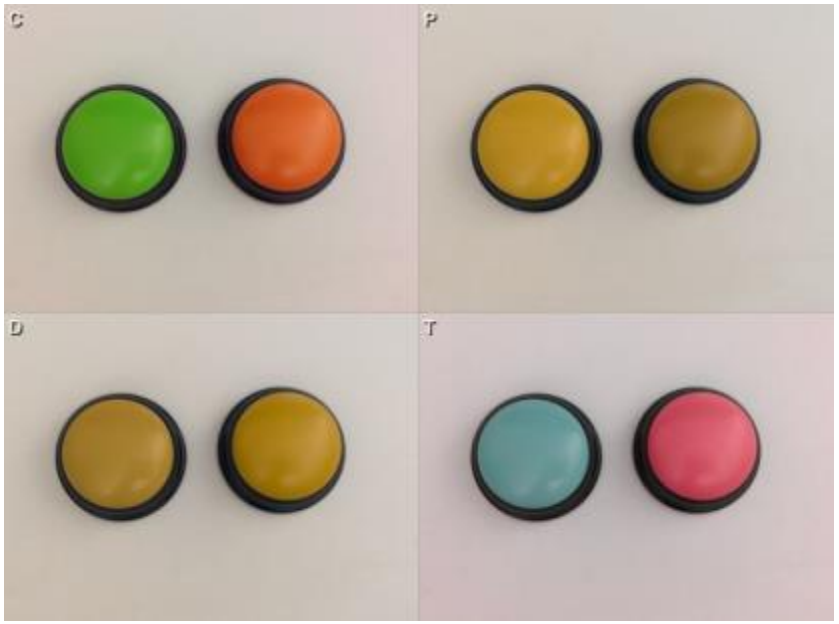
Color perception problems

- Color blindness:
  - Inability to distinguish the colors the same way than non-color impaired people
    - 5-10% of men
    - 1-2% of women
- Most common types of colour blindness are:
  - **Deuteranopia (M cones)**: Reduced sensitivity to green light (common).
  - **Protanopia (L cones)**: Reduced sensitivity to red light (rare).
  - **Tritanopia (S cones)**: Reduced sensitivity to blue light (very rare).
  - **Achromatopsia**: Cannot see any colour at all. Also not very common.

Color perception problems

- Color blindness simulation (affects the three channels):

Original



Protanopia (no L)
- Black with many shades of R
- Dark brown with dark G, orange and R
- Some B with some R, …
- Mid-G with some oranges

Deuteranopia (no M,…)

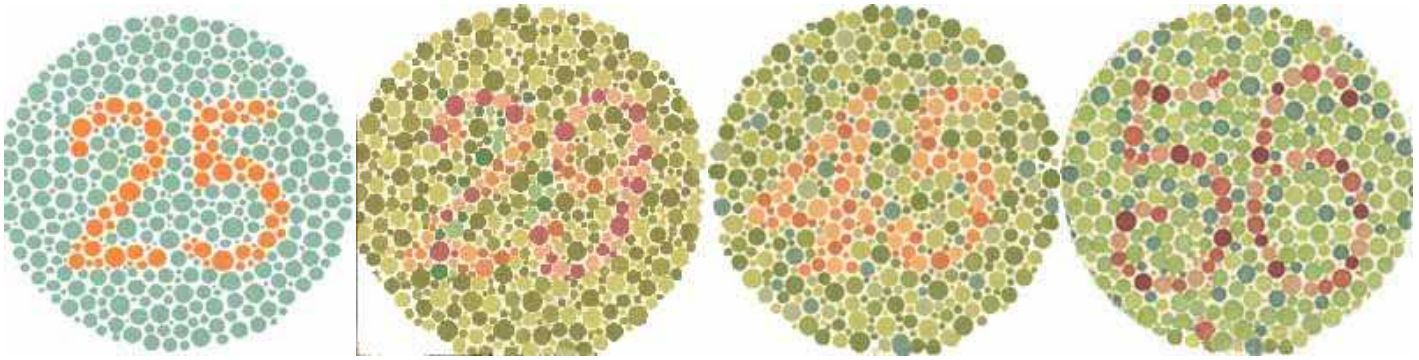
Tritanopia (no S,…)

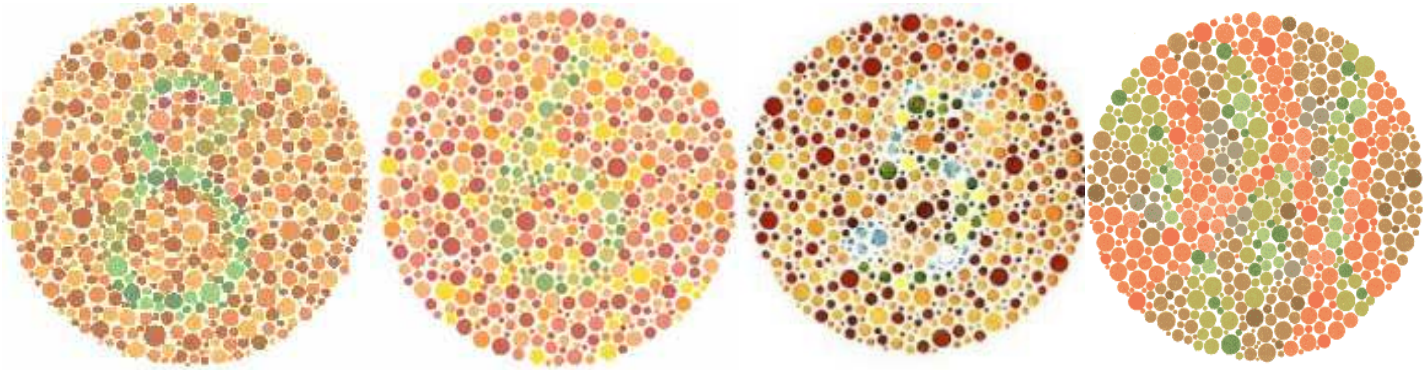
Color perception problems

- Color blindness:
  - Inability to distinguish the colors the same way than non-color impaired people
    - 5-10% of men
    - 1-2% of women
  - Relatively easy to detect
    - **Ishihara** tests

Color perception problems

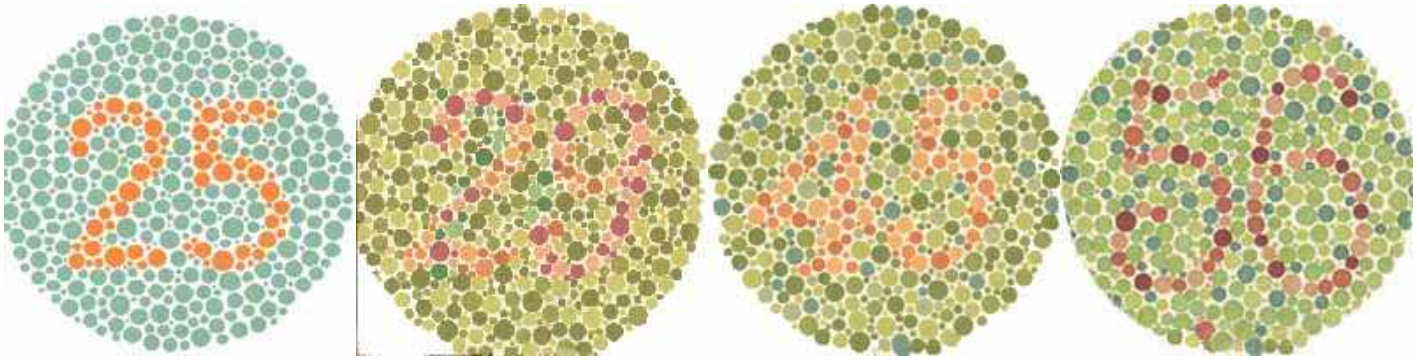
Ishihara test images





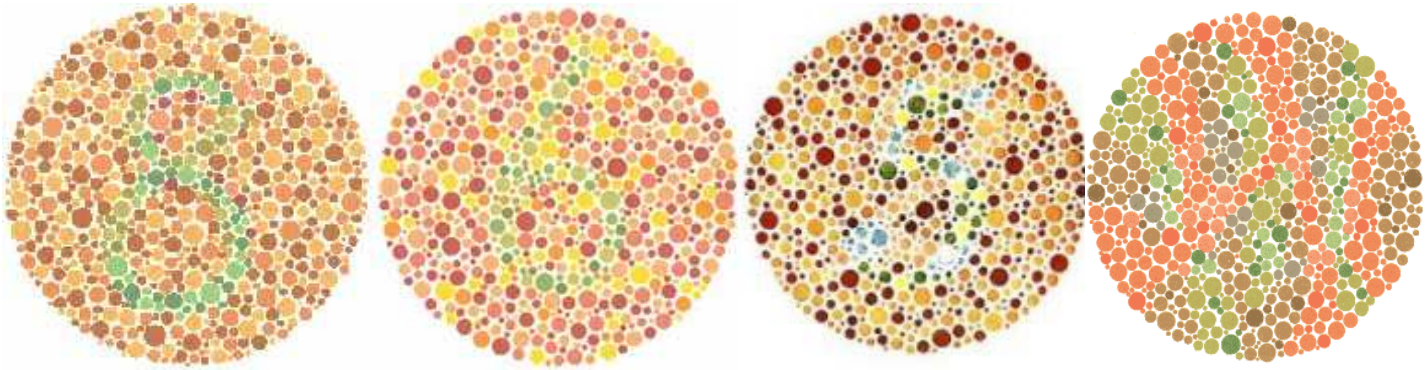
Color perception problems

Ishihara test images



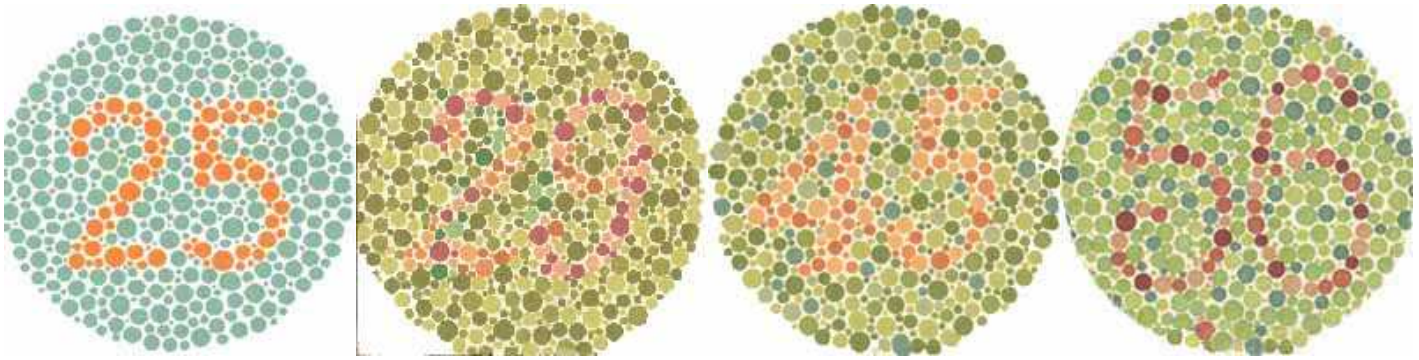
No color-blind: 25, 29, 45,56

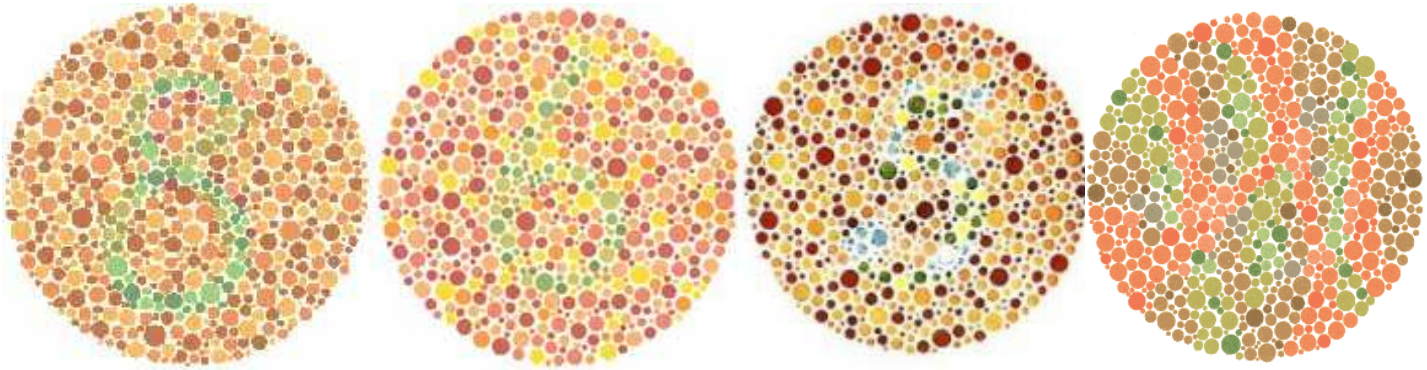
Red-green color-blindness: 25, nothing, nothing, 56



Color perception problems

Ishihara test images

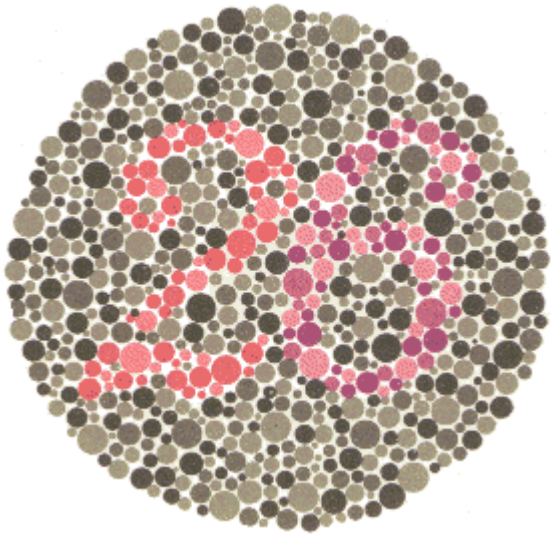




No color-blind: 8, 6, 5 (mixing colors), nothing
red-green color-blindness: nothing, nothing, 2, 45

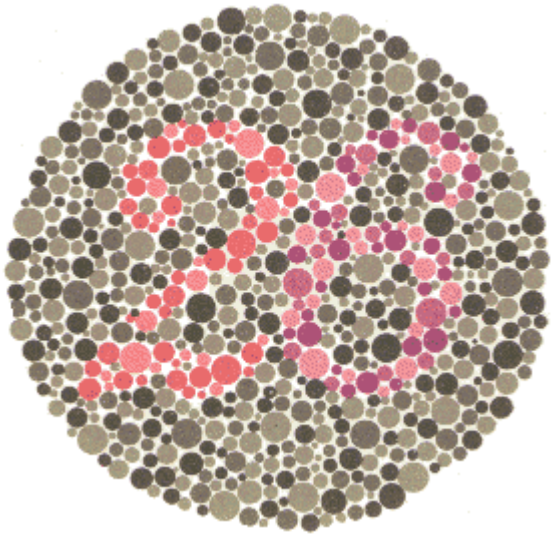
Color perception problems

Ishihara test images



Color perception problems

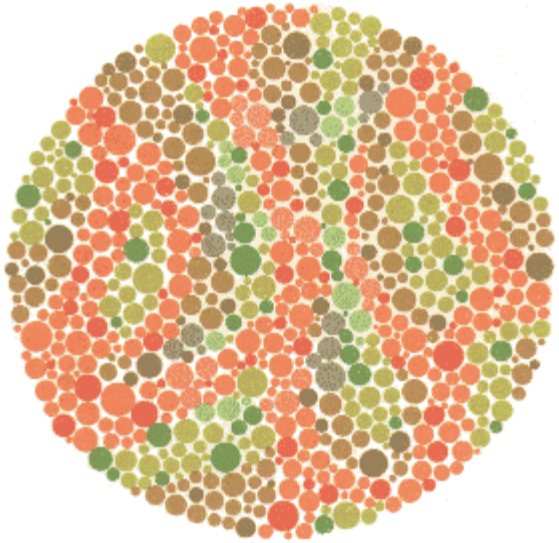
Ishihara test images



Normal vision: 26
Red color-blind (protanopia): 6
Green color-blind: 2
Both might see the other number faintly if not completely color-blind

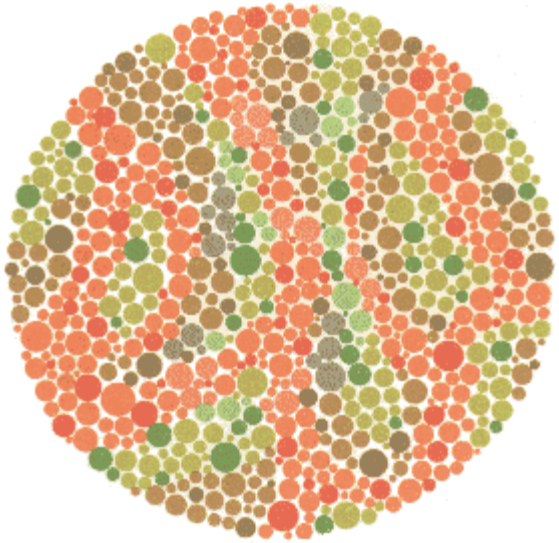
Color perception problems

Ishihara test images



Color perception problems

Ishihara test images



Normal vision: nothing
Red-green color-blindness: 5

Color perception problems

- Other vision problems:
  - About 4% of the population have low vision (0.6% are blind)
  - Low-vision conditions increase with age
    - Half of people over 50 have some degree of low-vision condition
  - Worldwide, the fastest-growing population is 60+ years
    - Over 40, almost everyone needs corrected vision to clearly see small objects or text
    - Age-related vision problems include macular degeneration, diabetic retinopathy, cataracts, and retinitis pigmentosa

Color perception problems

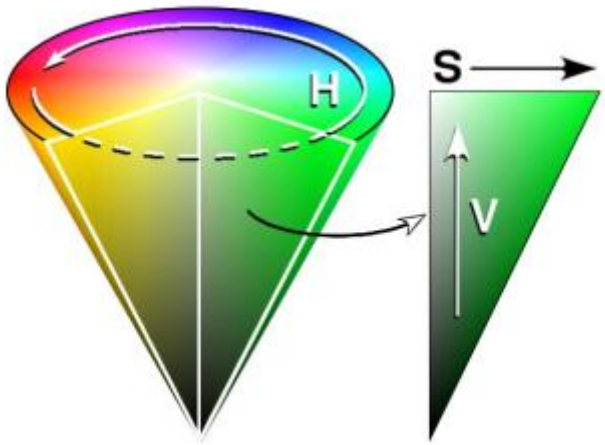
- Supporting packages and webpages:
  - **Colorblindor**: Color-blindness simulator. http://www.color-blindness.com/coblis-color-blindness-simulator/
  - **Color Oracle**: Color-blindness simulator https://colororacle.org/
  - **Chromatic Vision Simulator**: Simulates three forms of colour deficiencies: Protanopia, Deuteranopia and Tritanopia.
    - Available for Android and iOS
  - **VisionSim**: Developed by the Braille Institute. It simulates a variety of low-vision conditions.
    - Available for Android and iOS

Light color models (additive)

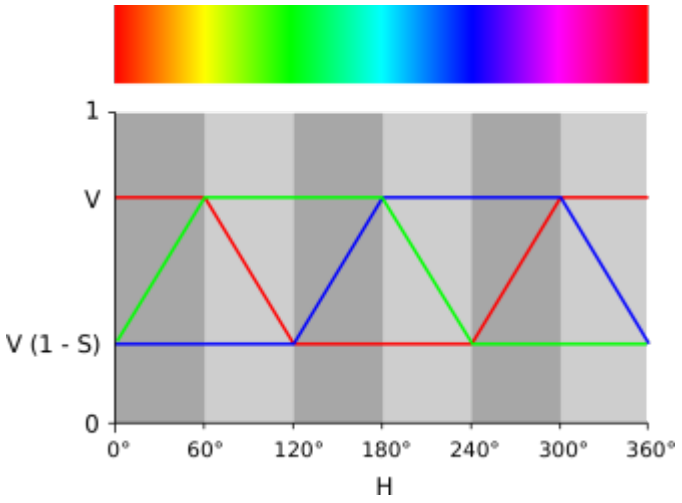
All the channels sum up to white light.

- RGB:
  - Red,
  - Green
  - Blue
- The HSV color model:
  - H: Hue or chroma
  - S: Saturation (intensity of color)
  - V: Value (black to color)

HSV cone



Chroma from RGB

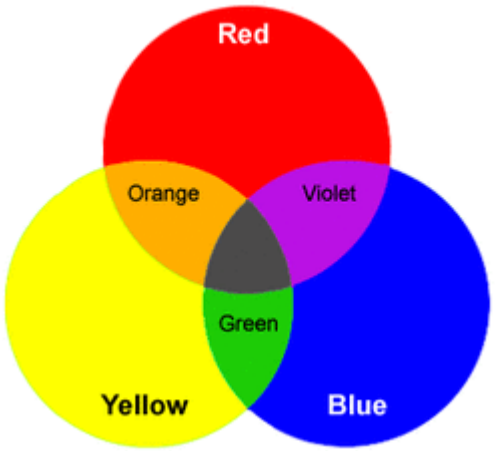


From Wikipedia, the free encyclopedia

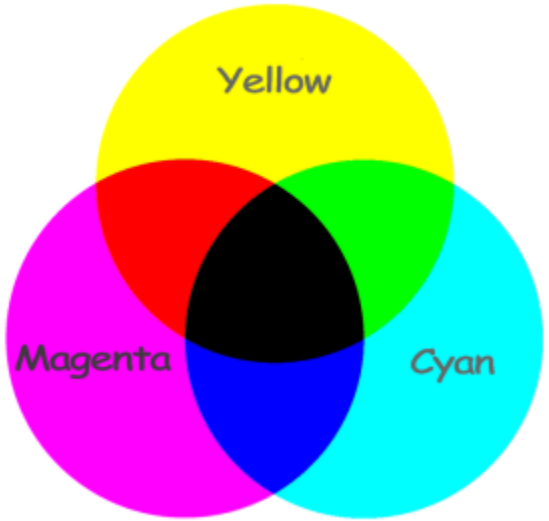
Pigment-based color models (substractive)

All the channels sum up to black color.

- RYB color model:



- CMYK color model:



Color perception problems

- Size and spatial frequency are also important in perception
  - The higher the spatial frequency the lower the saturation (e.g. chessboard)
- Chromatic adaptation:
  - Illumination changes affect the colours dramatically
    - Human perception adapts to changes
      - Does not perceive those changes *linearly*

Tips for color selection

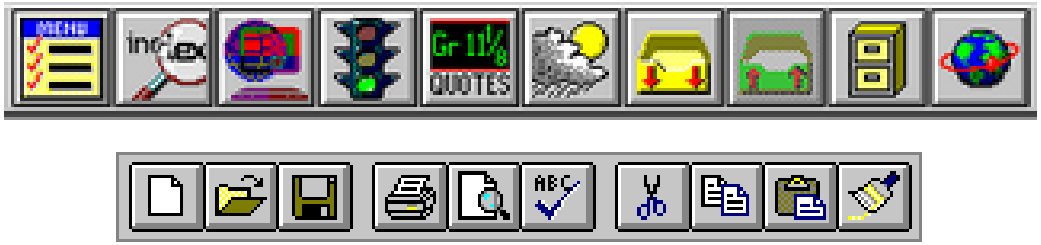
- Color friendly design (most concepts based on HSV model):
  - **Few colors.** Similar colors should infer a similarity among objects.
    - p.e. red for error, green for success, yellow for alert, blue information
  - Avoid using **adjacent strongly saturated** colors.
  - **Contrast** dark colors against light colors.
  - Content areas should be monochromatic with the font color and background at the opposite ends of the color saturation poles.
  - Elements of navigation, headers and sub-headers, require some extra visual enhancement.

Tips for color selection

- Color design rules:
  - Use color only when needed to serve a particular communication goal.

Tips for color selection

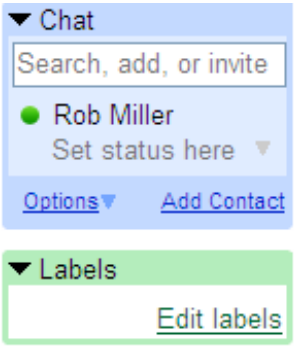
- Color design rules:
  - Use color only when needed to serve a particular communication goal.
  - Use small number of colors (hues).



- Many colors appears more complex
- More difficult perception
- More effective: one hue, weakly saturated and combined with black/white/gray

Tips for color selection

- Avoid strongly saturated colors

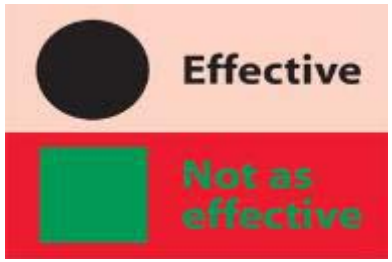


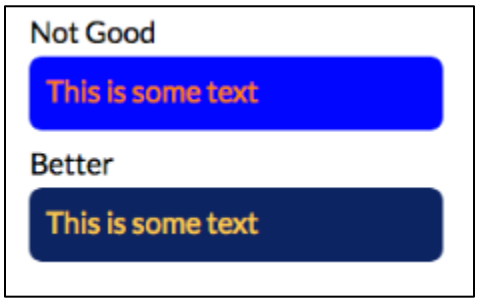
- They can cause visual fatigue
- More effective: “pastel” colors

Tips for color selection

- Color design rules:
  - If you want objects to be easily seen, use a background color that contrasts sufficiently with the object
  - For text is usually needed a combination of contrast of Hue+ V & S

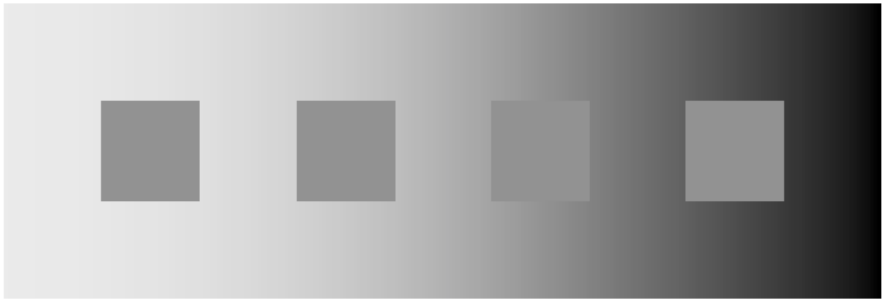
    Contrast “dark” (high S, Low V) with “light” colors (Low S, high V)





Tips for color selection

- Color design rules:
  - If you want different objects of the same color to look the same, make sure that the background--the color that surrounds them--is consistent



Tips for color selection

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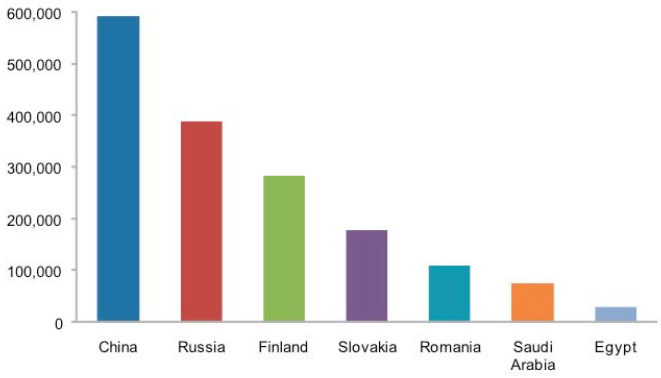
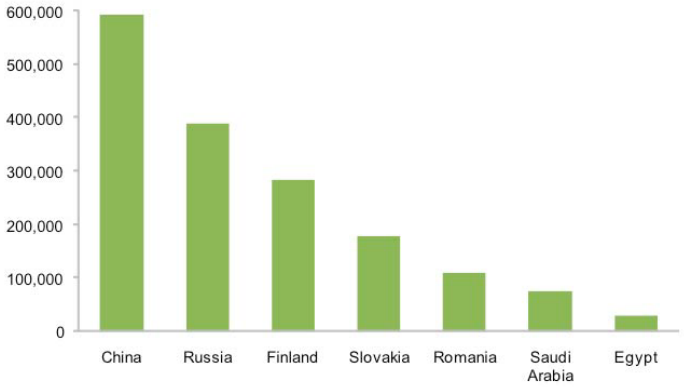
  - If you want different objects of the same color to look the same, make sure that the background--the color that surrounds them--is consistent

Tips for color selection

- Color design rules:
  - Use different colors only when they correspond to differences of meaning in the data.
    - Highlight particular data, group items, encode quantitative values…



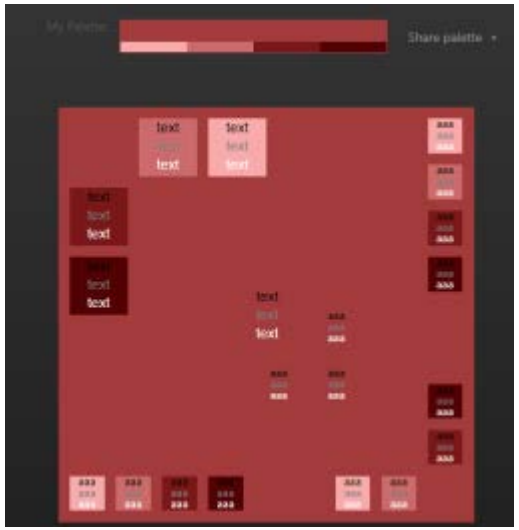


Tips for color selection

- Color design rules:
  - Use soft, natural colors to display most information and bright and/or dark colors to highlight information that requires greater attention.

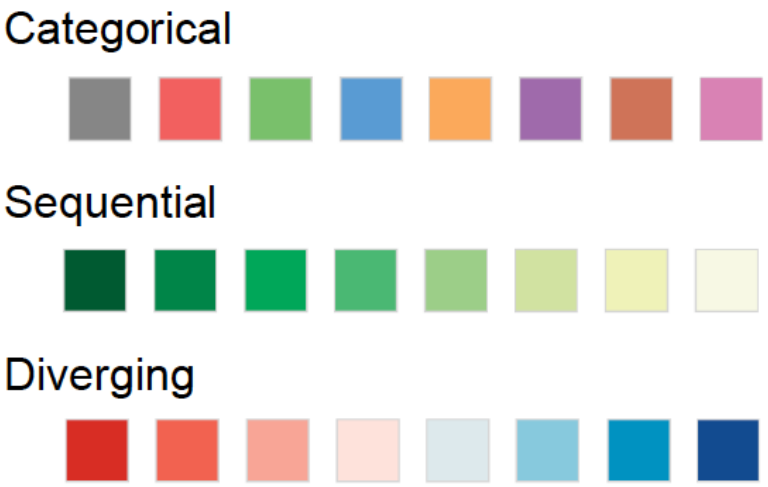
Tips for color selection

- Color design rules (palettes):
  - *When using color to encode a sequential range of quantitative values:*
    - Use a single hue (or a small set of closely related hues) and vary intensity ..
    - …from pale colors for low values …
    - ...to increasingly darker and brighter colors for high values



Tips for color selection

- Color design rules: Color palettes



No order required

Order required but no neutral value

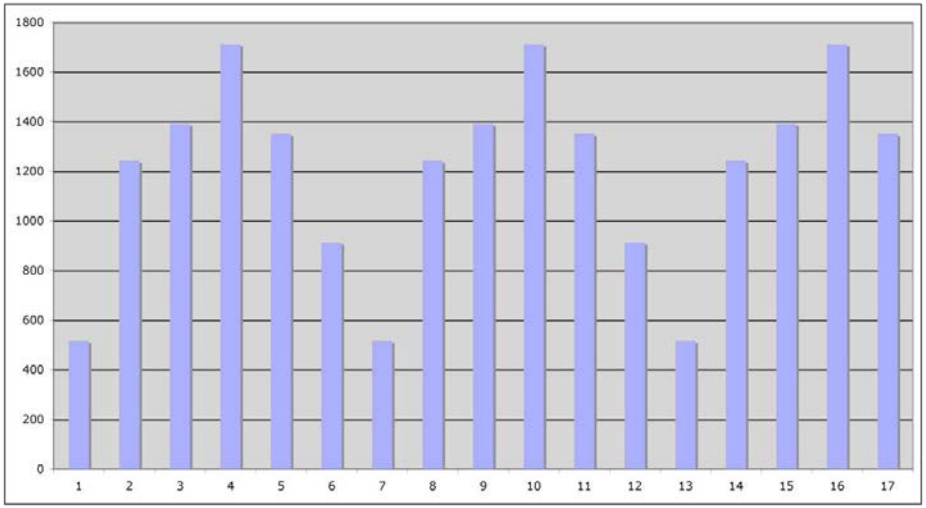
Order required **and** neutral value

Tips for color selection

- Color design rules (in charts/tables):
  - Non-data components of tables and graphs should be displayed just visibly enough to perform their role, but no more so, for excessive salience could cause them to distract attention from the data

Tips for color selection

- Color design rules:
  - De-emphasizing…



Tips for color selection

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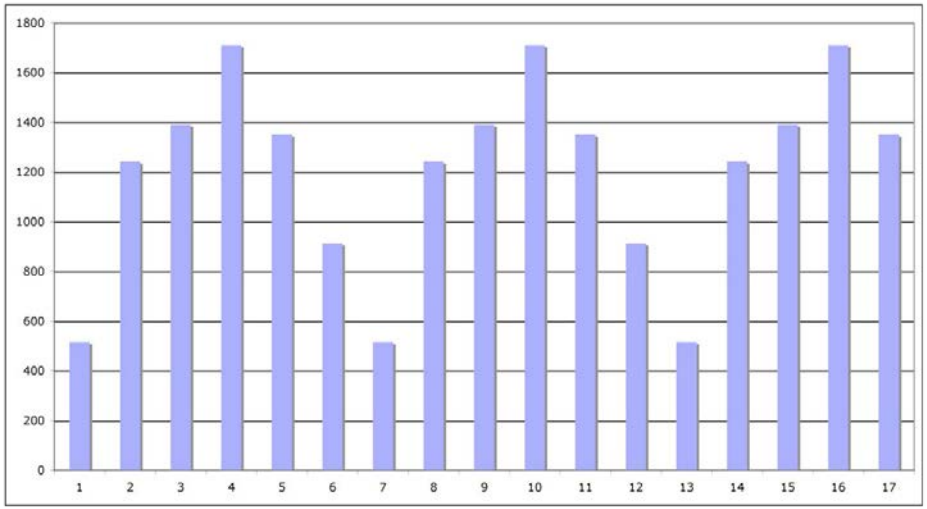

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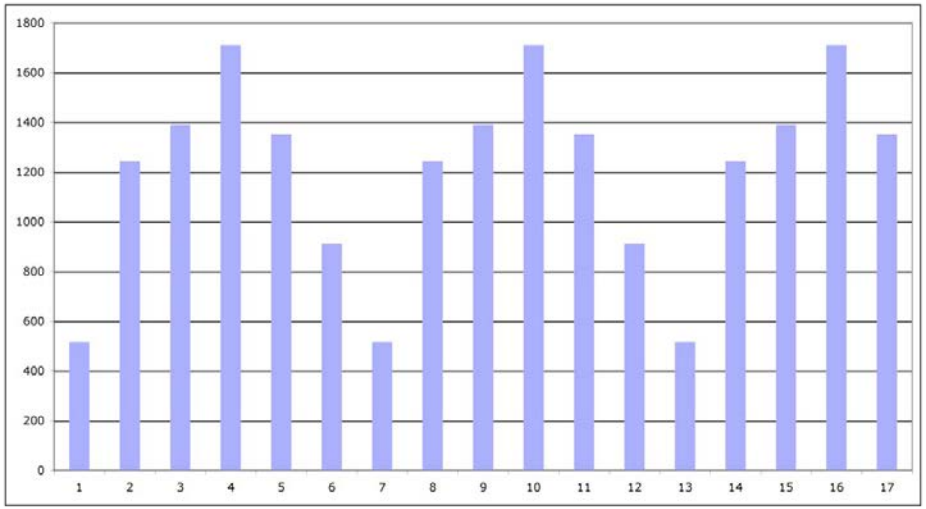

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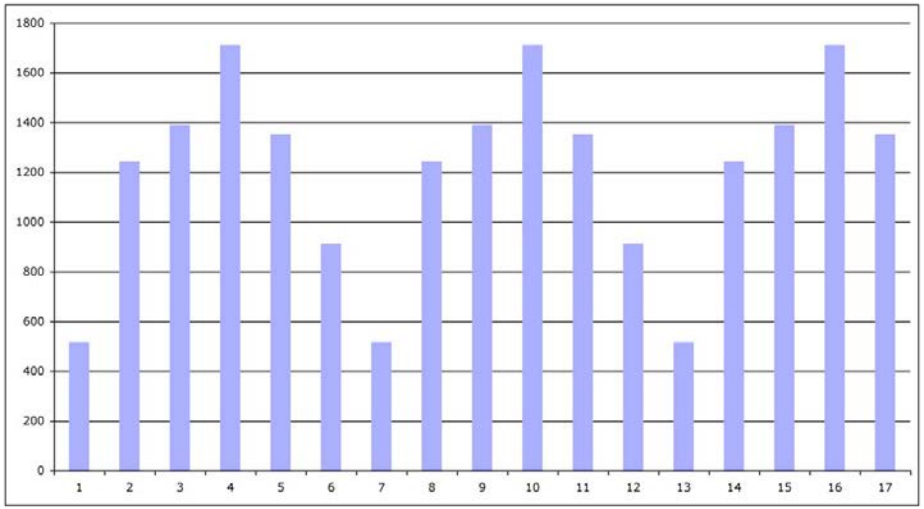

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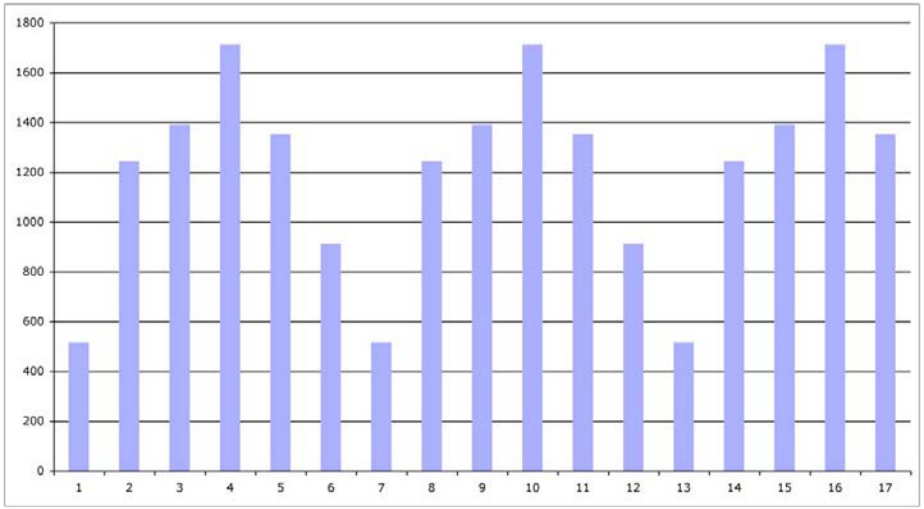

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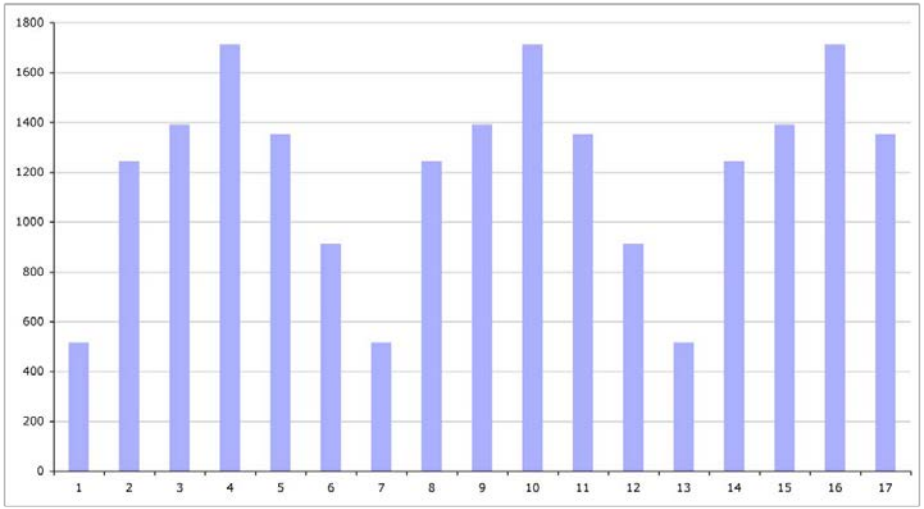

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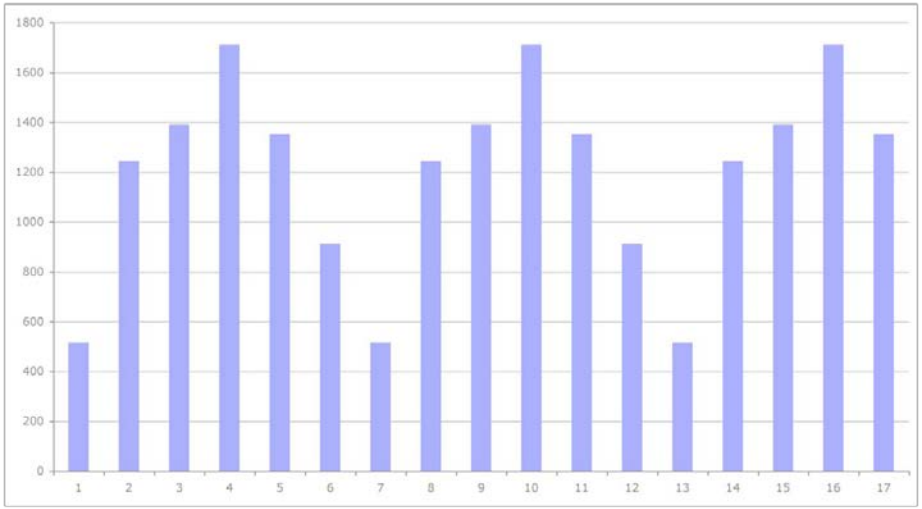

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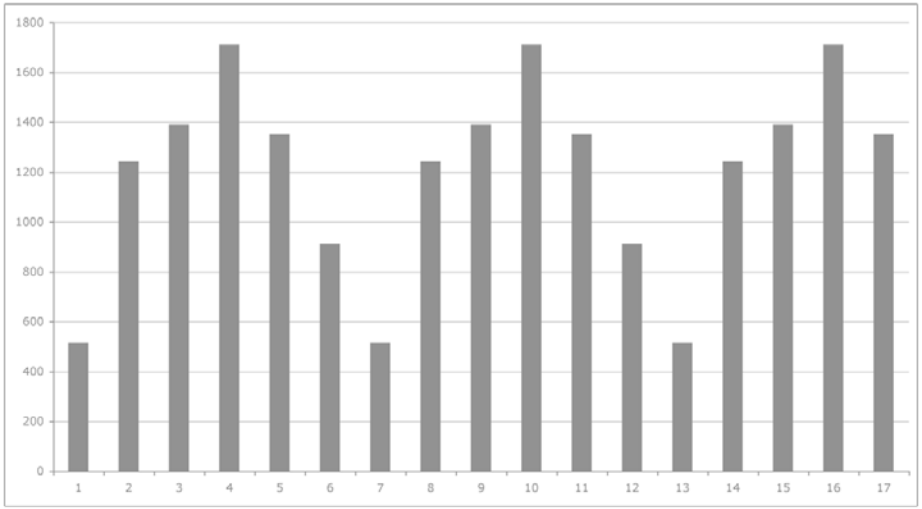

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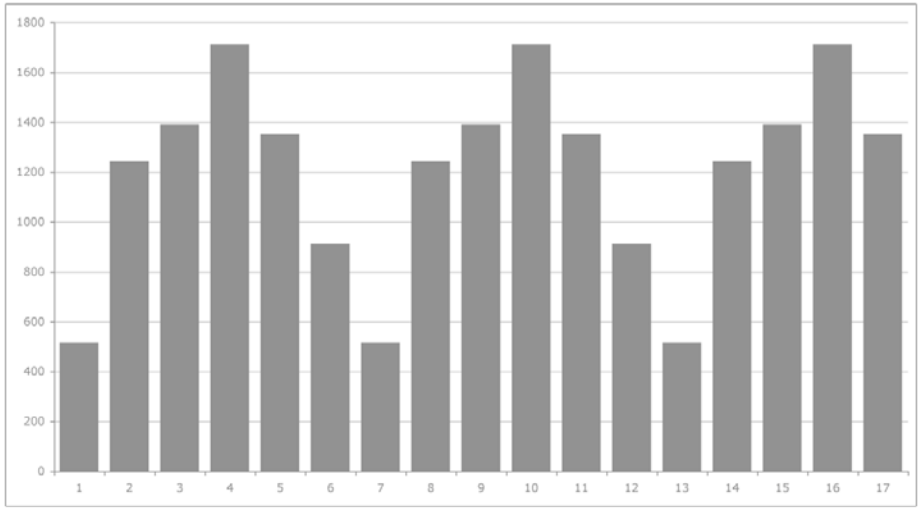

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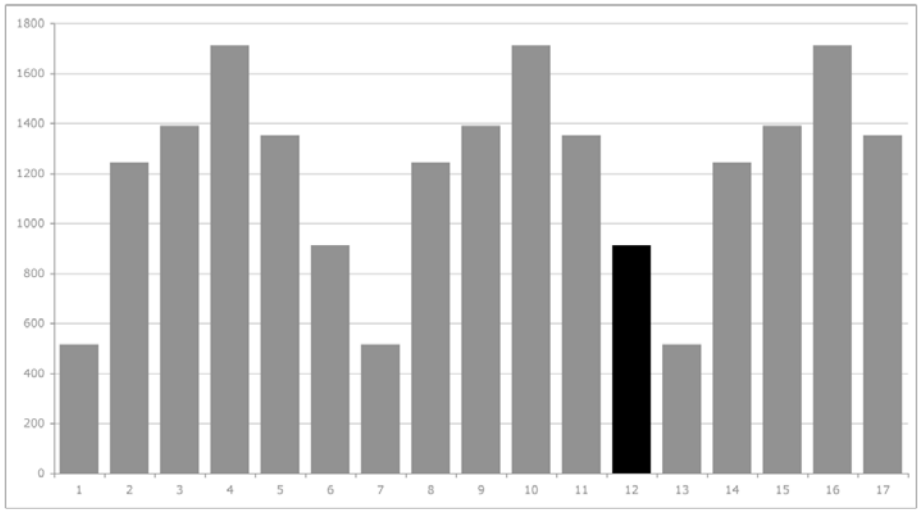

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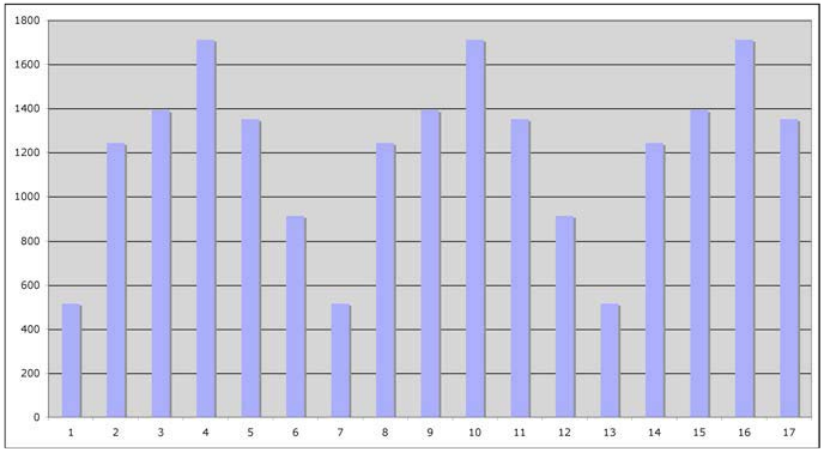
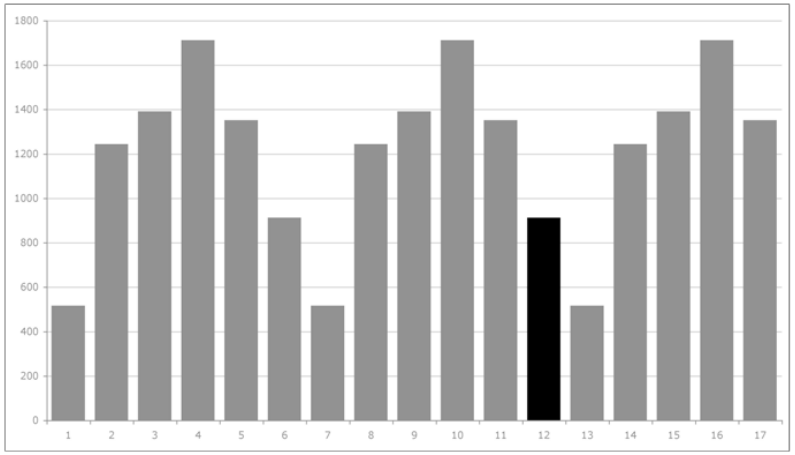
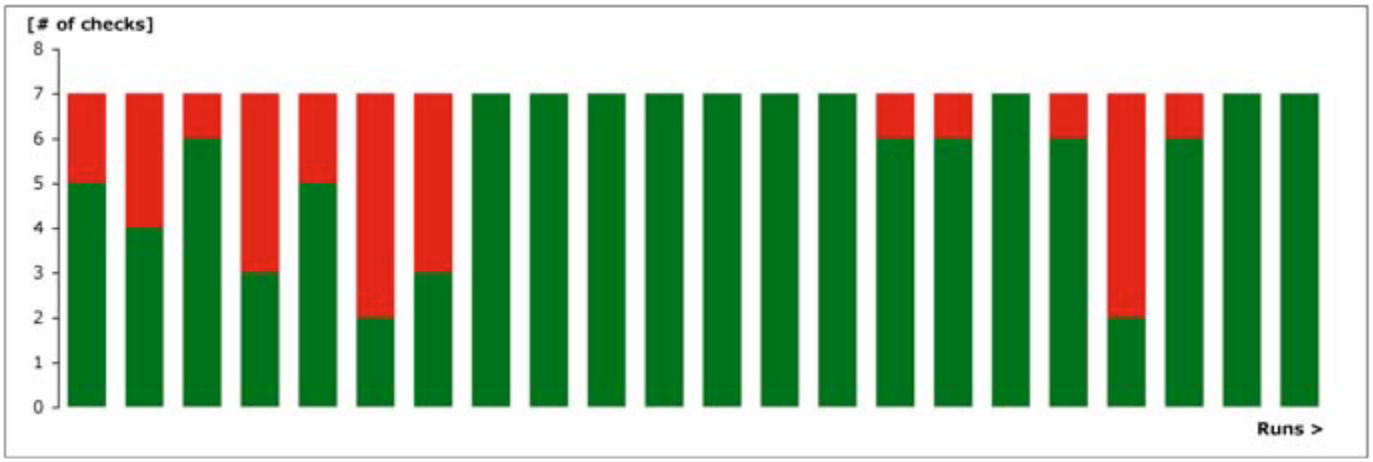




Tips for color selection

- Color design rules:
  - Avoid using a combination of red and green in the same display



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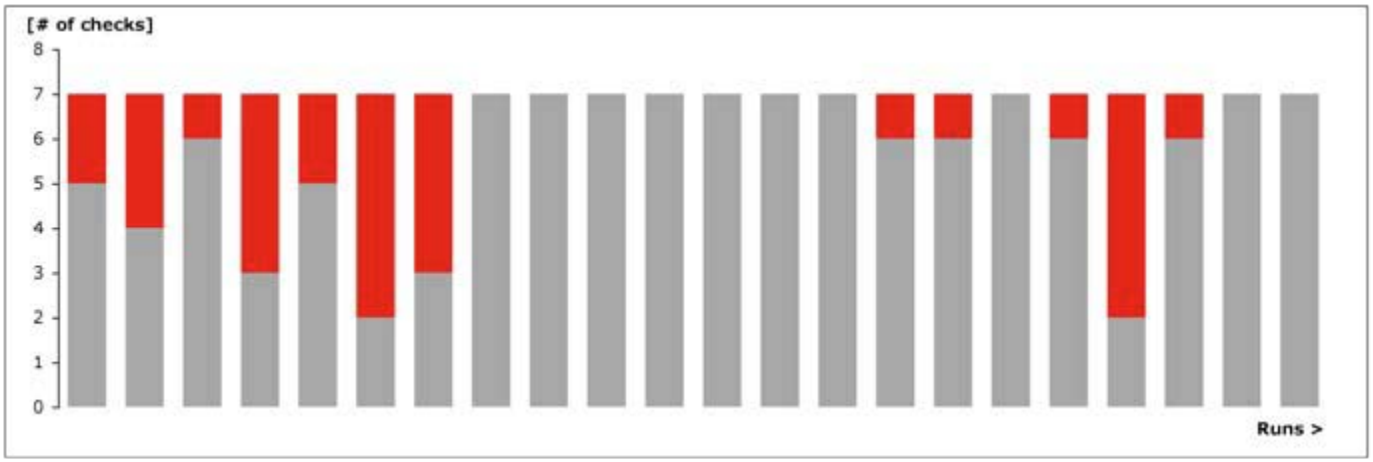


Tips for color selection

- Use opposite colors

PEPPER POWERED

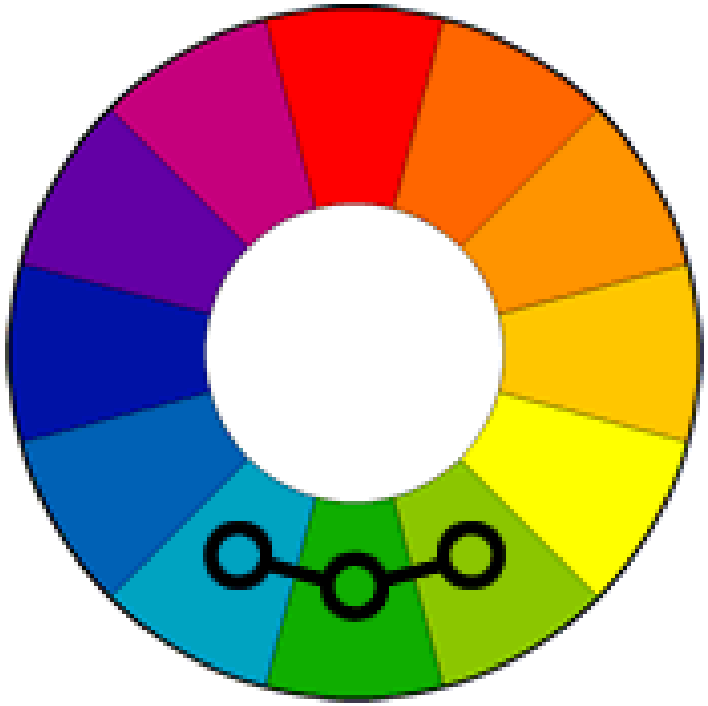
RYB color wheel – designed for painters

Tips for color selection

- Color Wheels

Tips for color selection

- Analogous colors

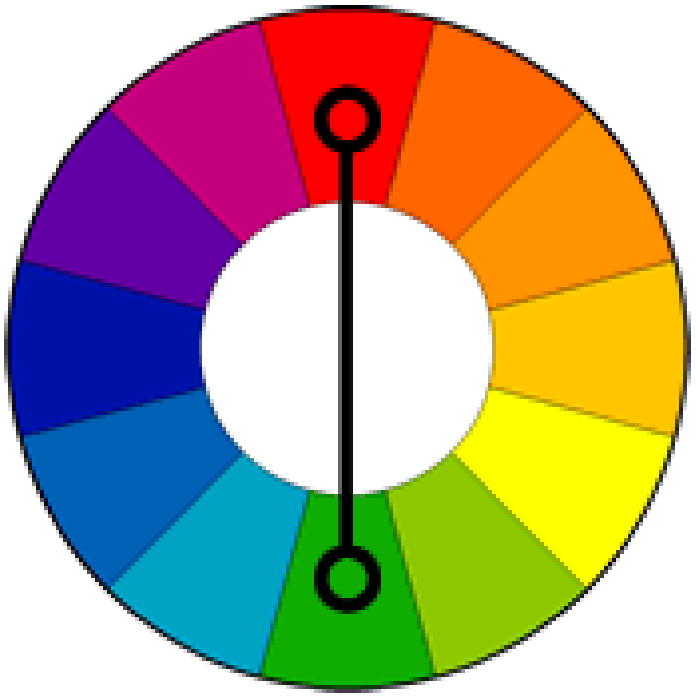


Tips for color selection

- Analogous colors

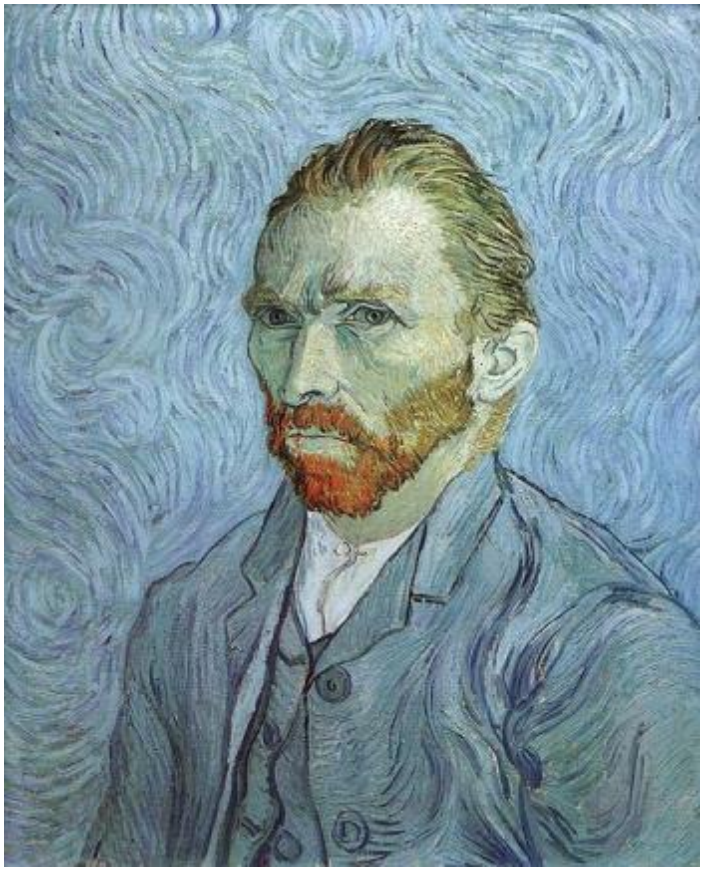
Tips for color selection

- Complementary colors



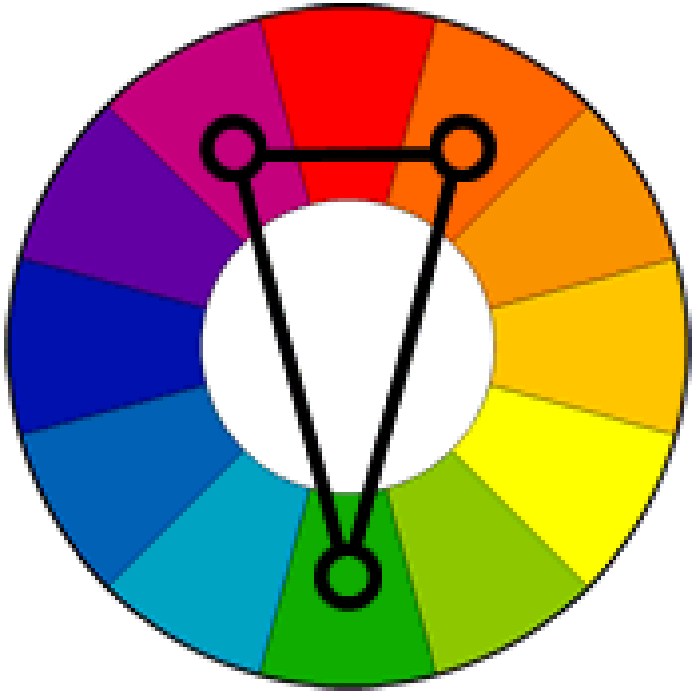
Tips for color selection

- Complementary colors



Tips for color selection

- Split-complementary colors

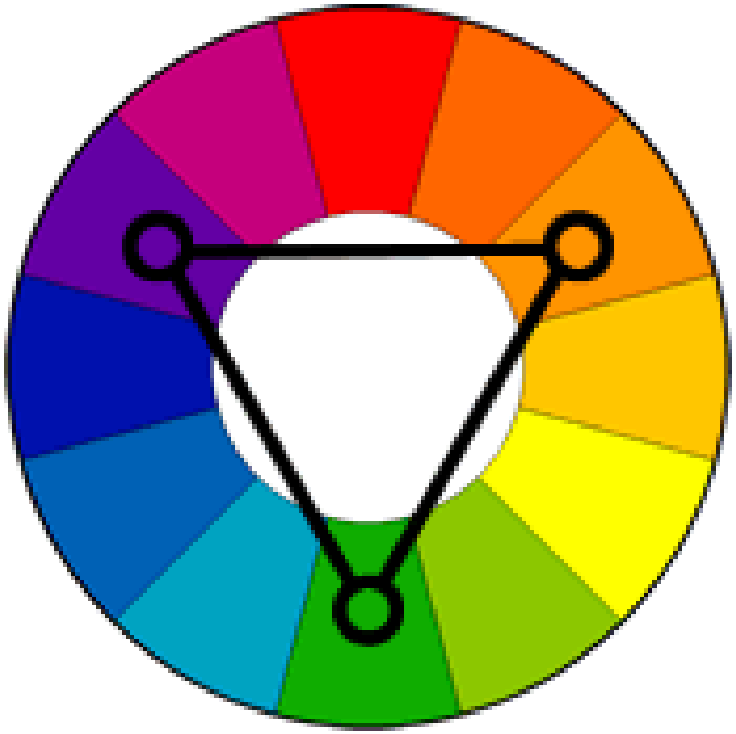


Tips for color selection

- Complementary colors

Tips for color selection

- Triad relationship



Tips for color selection

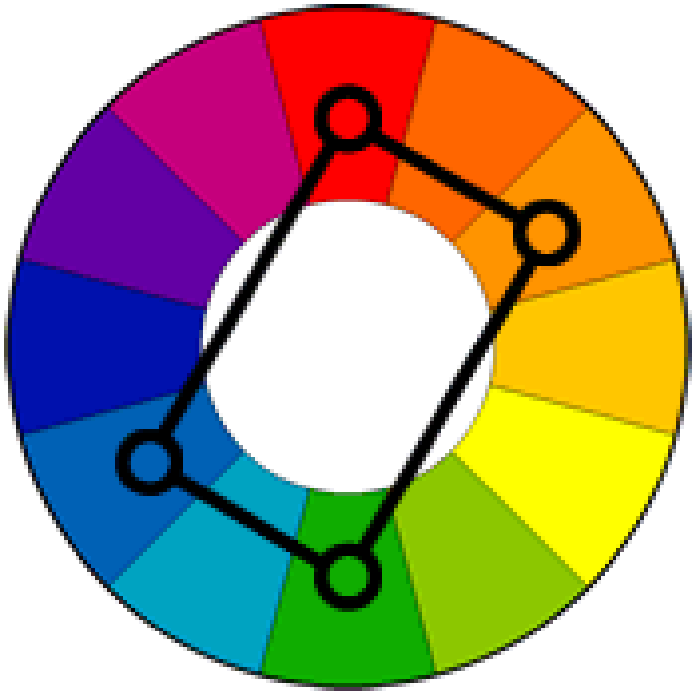
- Triad relationship

Tips for color selection

- Triad relationship

Tips for color selection

- Tetrad relationship



Tips for color selection

- Tetrad relationship

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