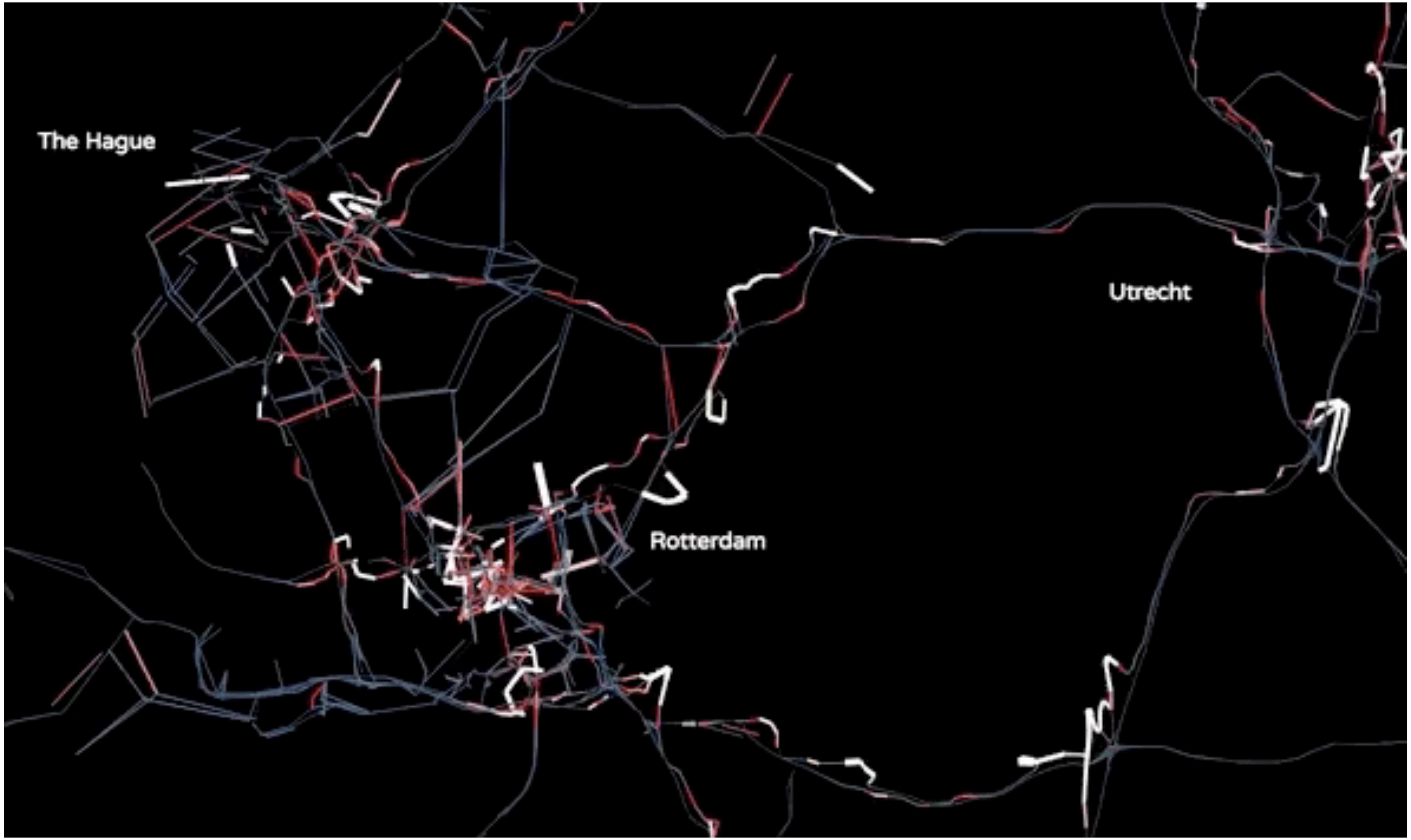
Data Visualization & Design

Week 3

Announcements

This week in **visualization** —



[Source]

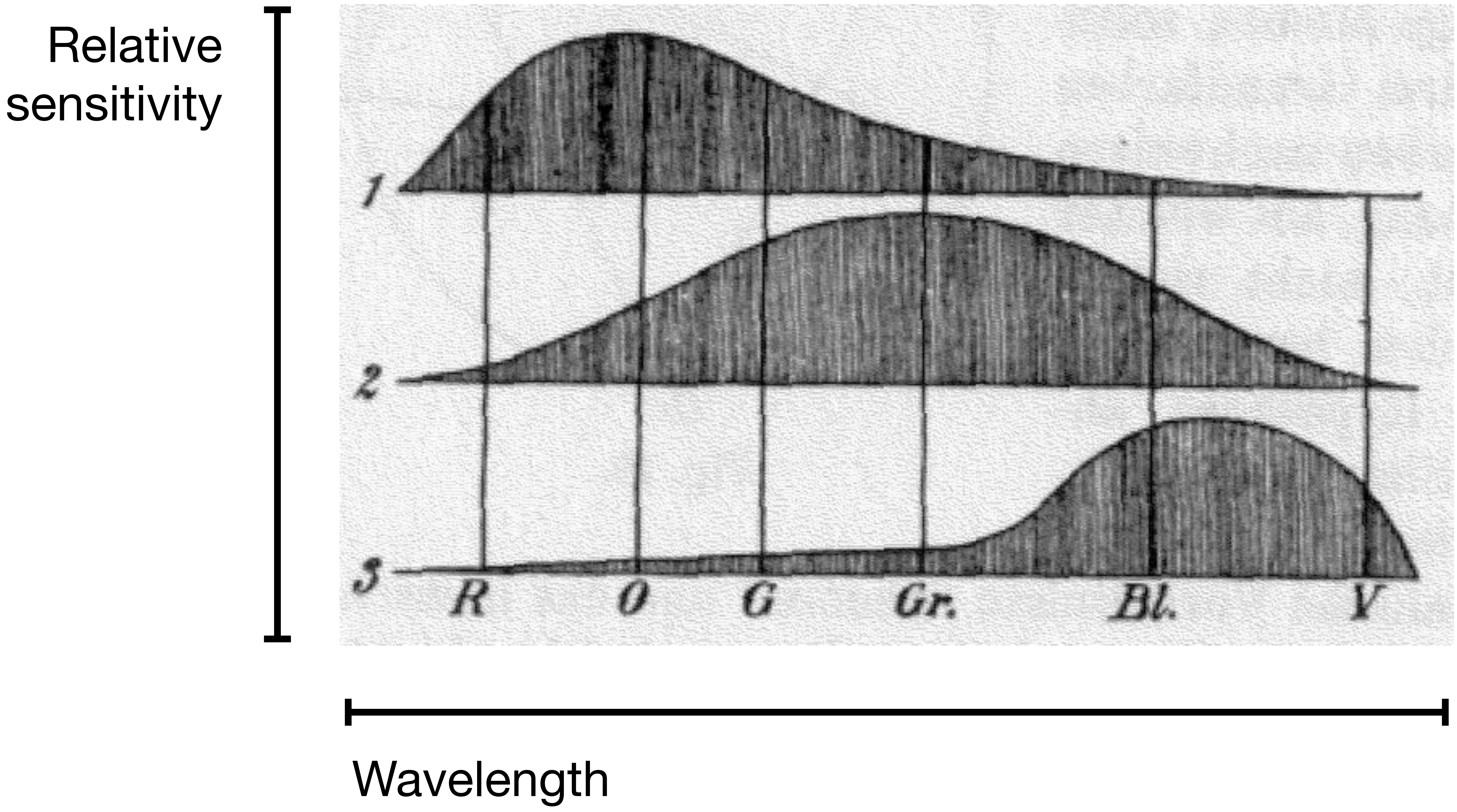
Assignment 1 — **Review**

Using **color** in visualization

When visualizing data, **color is a versatile tool** for encoding values and communicating difference.

Representing color digitally ties together both human perception and the physical properties of light.

- In 1801, scientist **Thomas Young** proposed that the retina of the human visual system contains three “kinds of fibers,” each sensitive to a different wavelength of light.
- This theory, referred to now as the ***“trichromatic theory of color vision,”*** informs the way computers display color images, and holds implications for human color perception.


Relative sensitivity
1
2
3
R
O
G
Gr.
Bl.
V
Wavelength

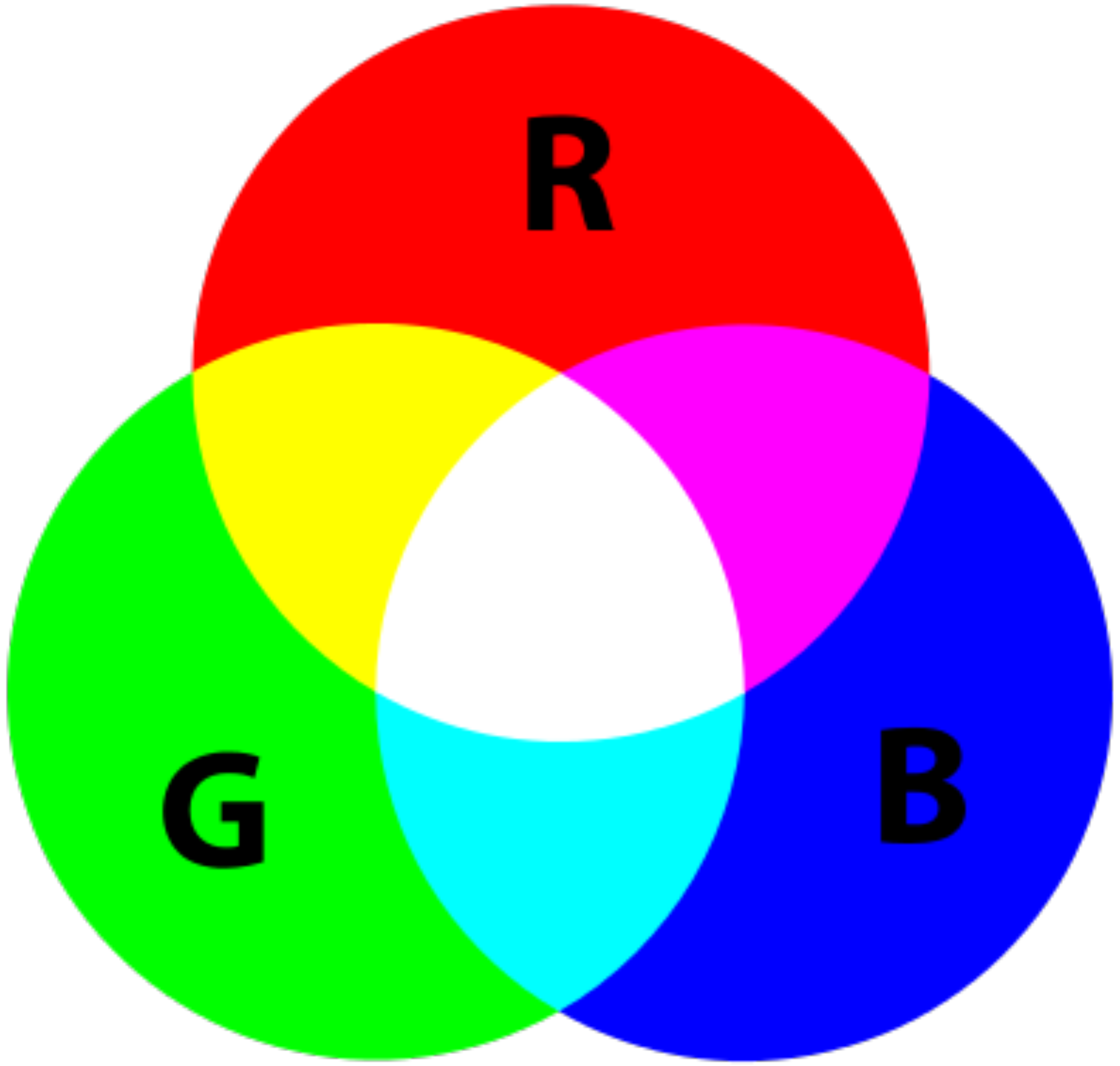
Concept — **Tristimulus theory**

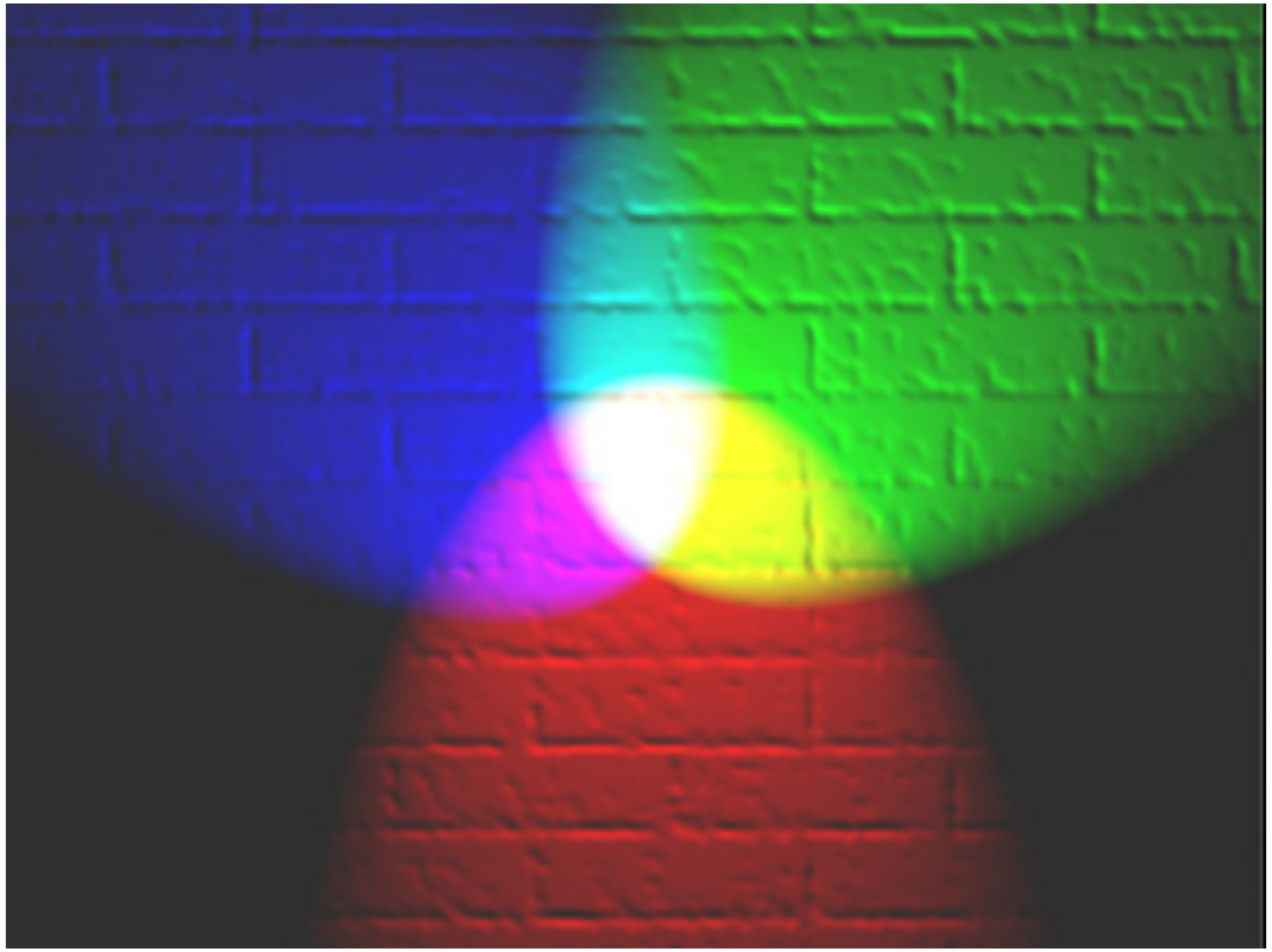
- There are exactly **three different types of color receptors** in the human eye
  - Sensitivity to ***long*** *wavelengths*
  - Sensitivity to ***medium*** *wavelengths*
  - Sensitivity to ***short*** *wavelengths*
- As such, any perceived color can be uniquely represented using **three values**
- Color is an inherently **three-dimensional space**

Concept — **Additive color space**

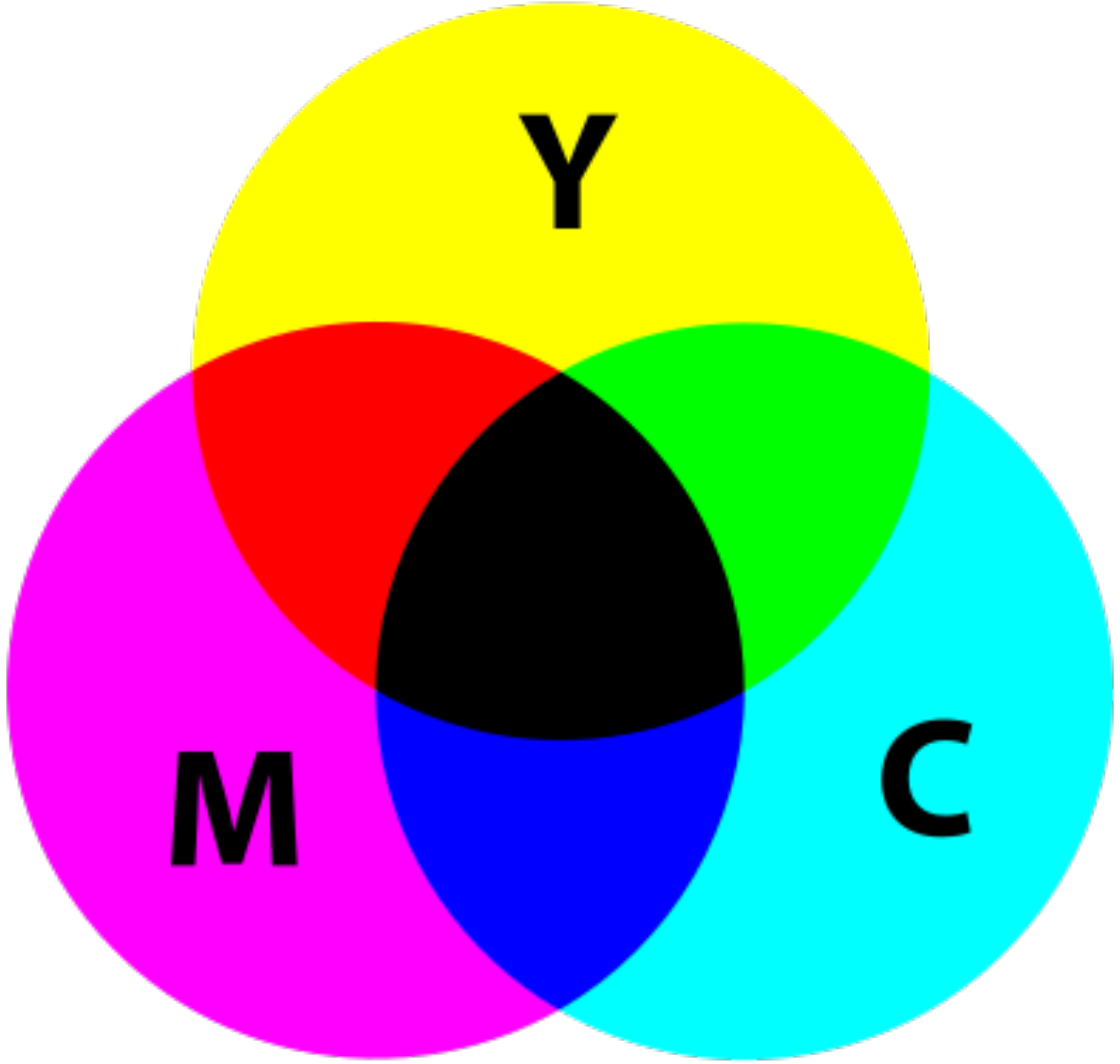
- Additive color is created by **mixing different light colors**
- **RGB (most common):** the three values in this space refer to the **intensity output** of the three light colors used in a monitor, television, or projector
  - **R** — Red
  - **G** — Green
  - **B** — Blue
- It’s convenient to specify colors in terms of their output medium

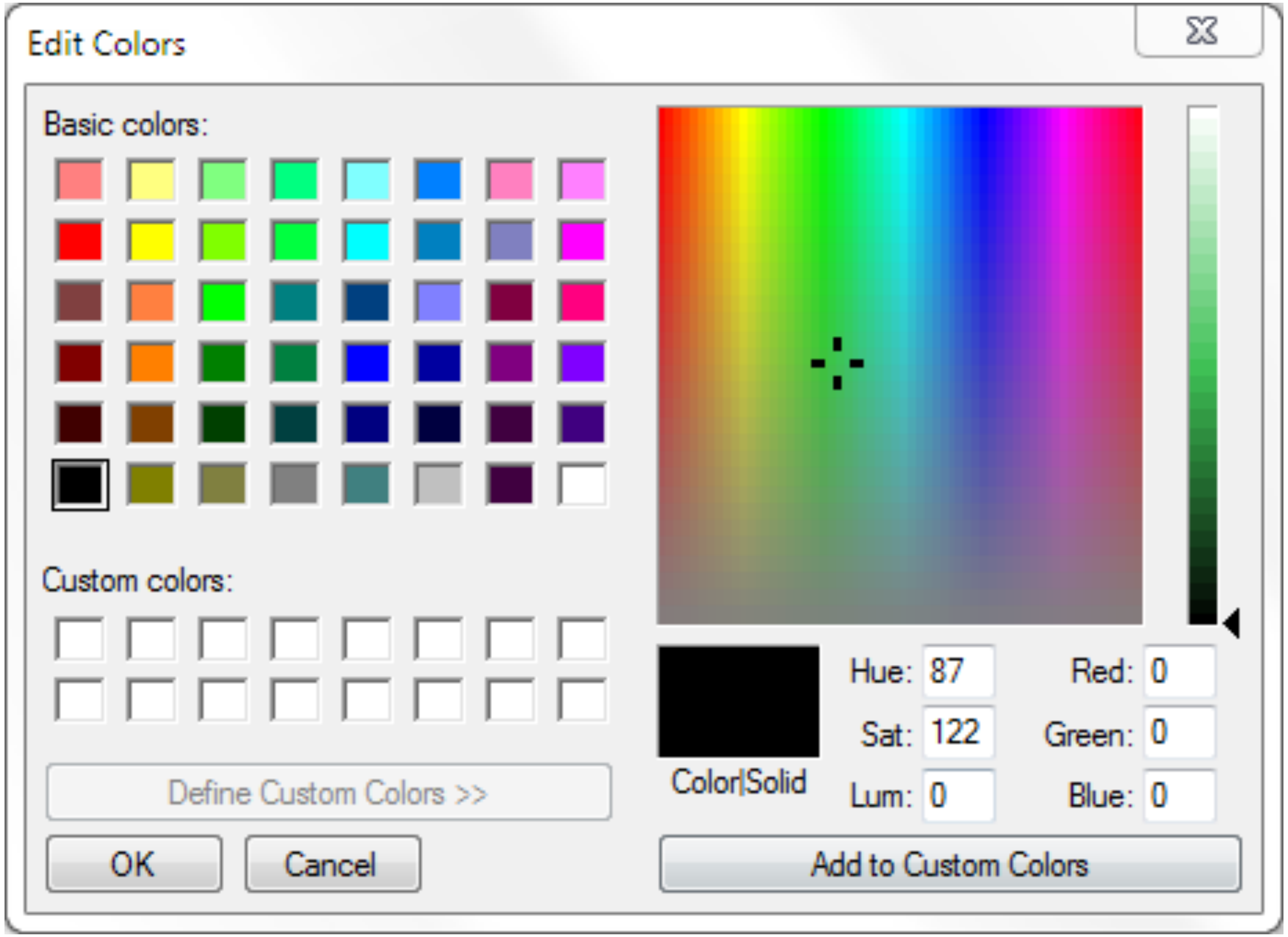
Additive



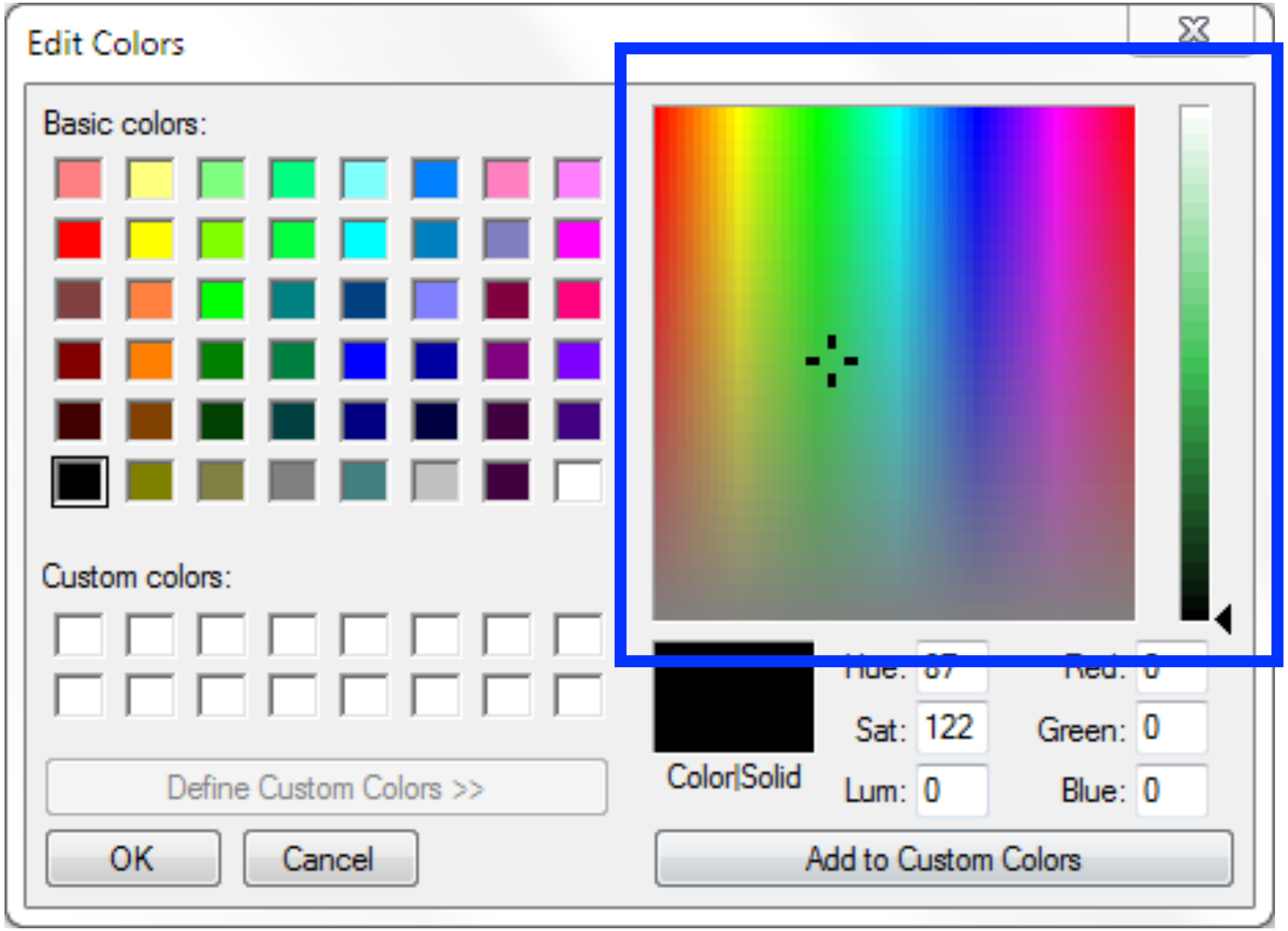


Subtractive (absorbs light)





Edit Colors
Basic colors:
Custom colors:
Define Custom Colors >>
OK
Cancel
Color|Solid
Hue: 87
Sat: 122
Lum: 0
Red: 0
Green: 0
Blue: 0
Add to Custom Colors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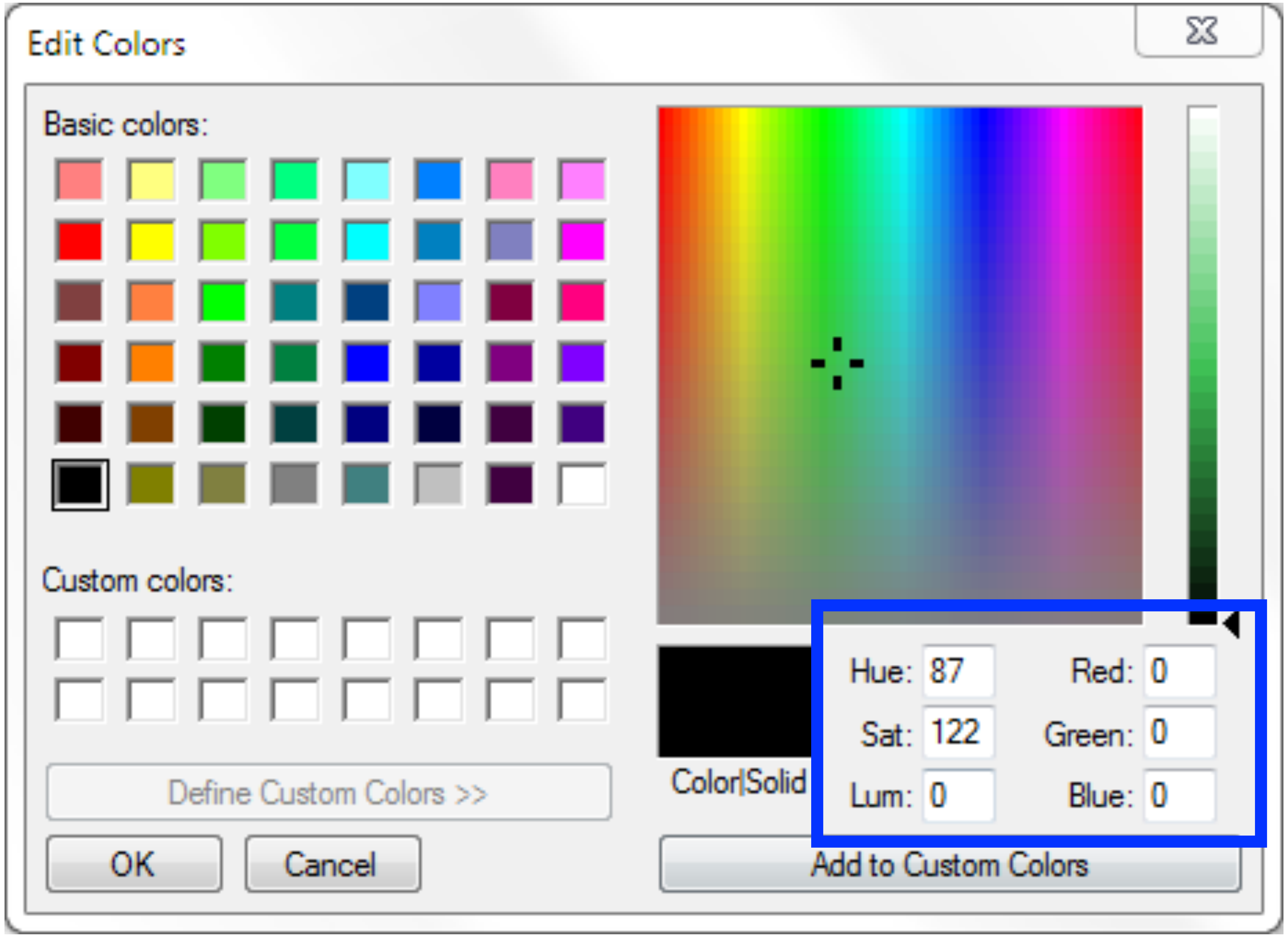

Edit Colors
Basic colors:
Custom colors:
Define Custom Colors >>
OK
Cancel
Color|Solid
Hue: 87
Sat: 122
Lum: 0
Red: 0
Green: 0
Blue: 0
Add to Custom Colors

For the purposes of visualization, we are more concerned with **how color is perceived** than how it is formed.

- Hue
- Saturation
- Luminance

- **Hue** — The actual color
- Saturation
- Luminance

- Hue
- **Saturation —** The amount of grey in a color
- Luminance

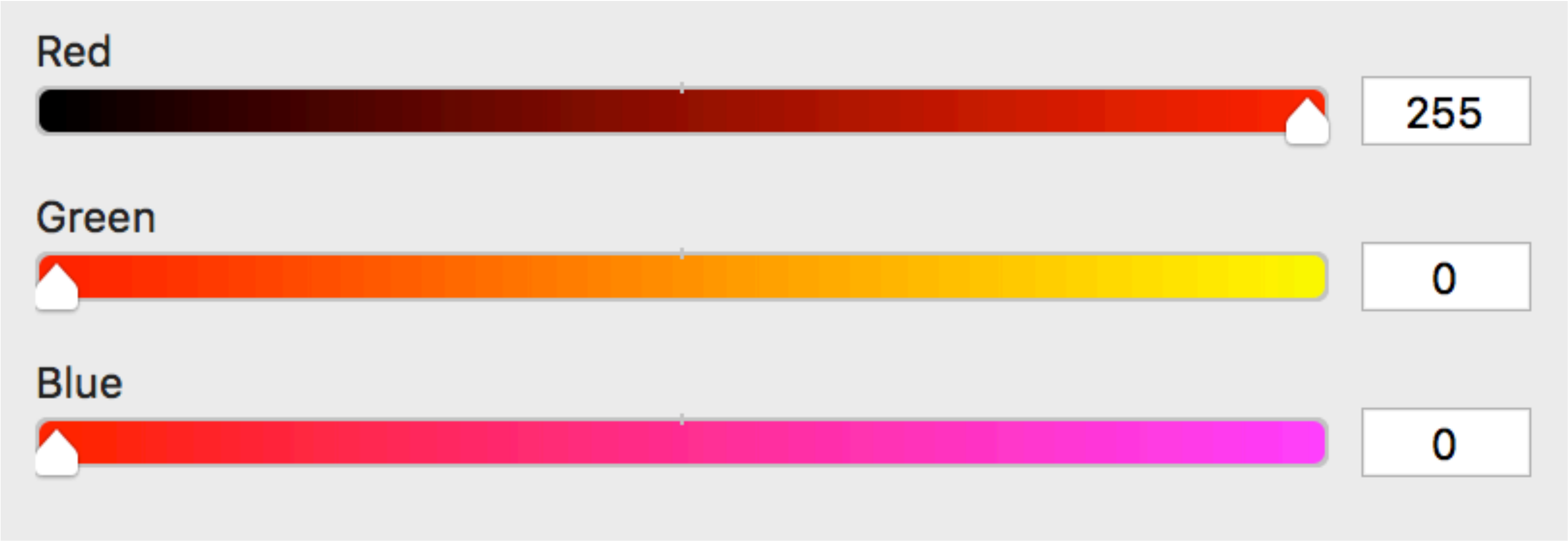
- Hue
- Saturation
- **Luminance —** The amount of white or black in a color

Color **syntax**

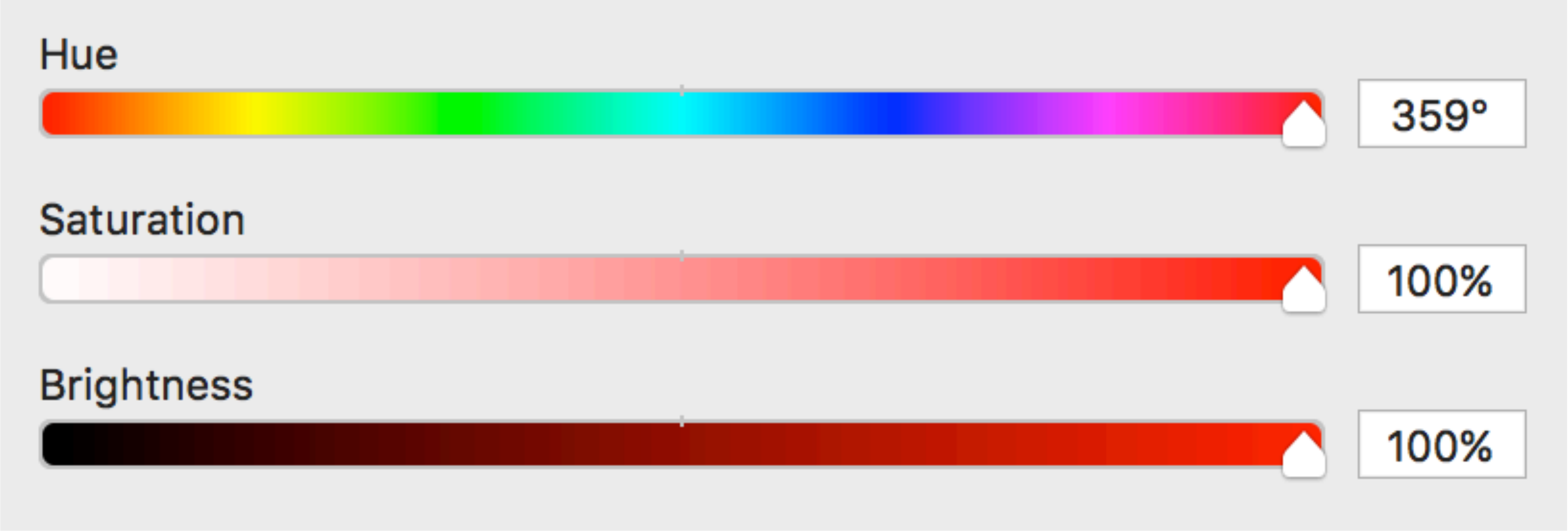
When working with color in a **digital context**, most color pickers allow you to specify values in RGB, CMYK, or HSL/HSB (+ more!).

This color may be specified in any of **these** ways.

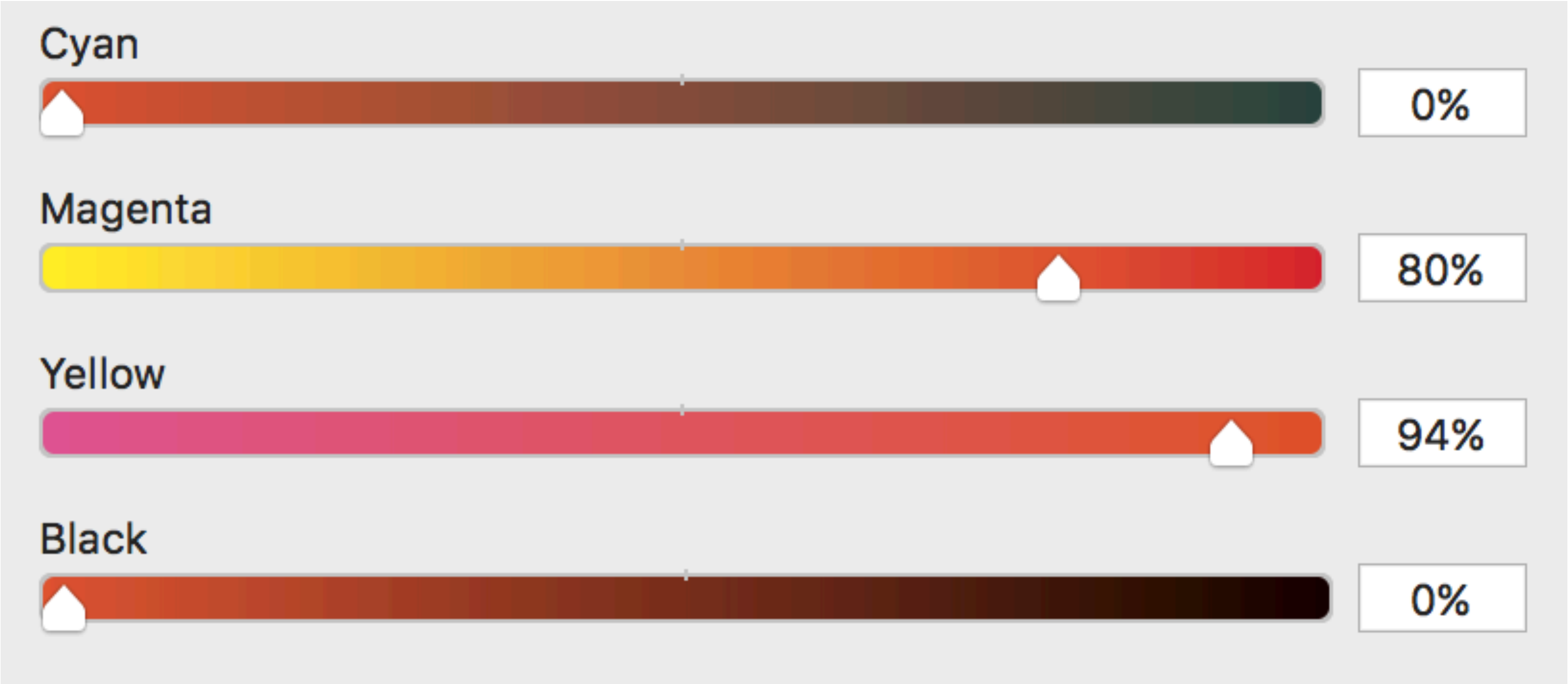
- RGB(255, 0, 0)
- HSL(9, 100, 100)
- CMYK(0, 80, 94, 0)



- **RGB(255, 0, 0)**
- HSL(9, 100, 100)
- CMYK(0, 80, 94, 0)



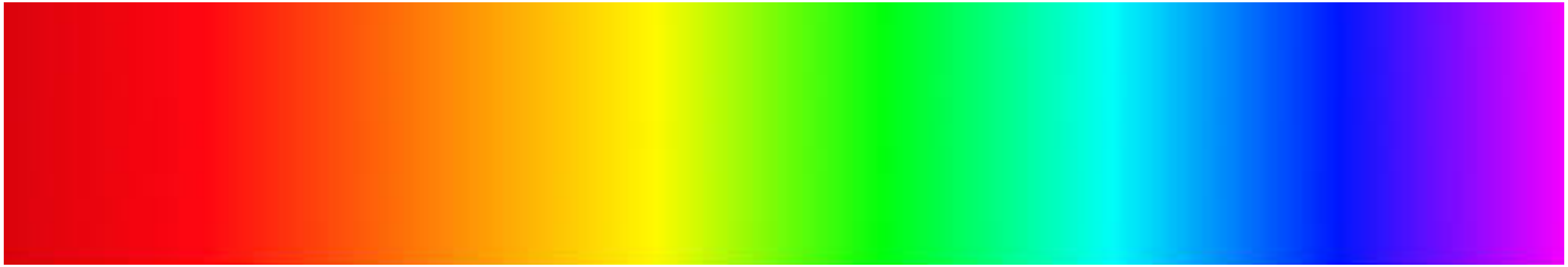
- RGB(255, 0, 0)
- **HSL(9, 100, 100)**
- CMYK(0, 80, 94, 0)



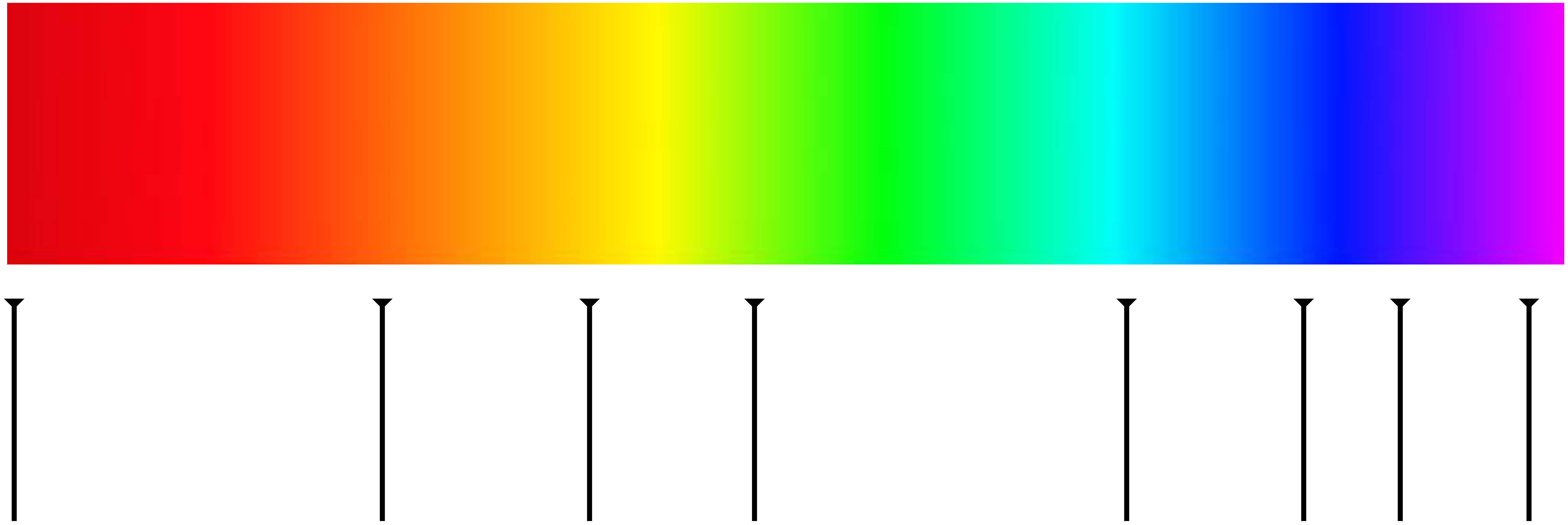
- RGB(255, 0, 0)
- HSL(9, 100, 100)
- **CMYK(0, 80, 94, 0)**

Working with color becomes challenging when trying to create **scales that appear to have even increments** *(perceptual uniformity)*.

Why not use a rainbow?

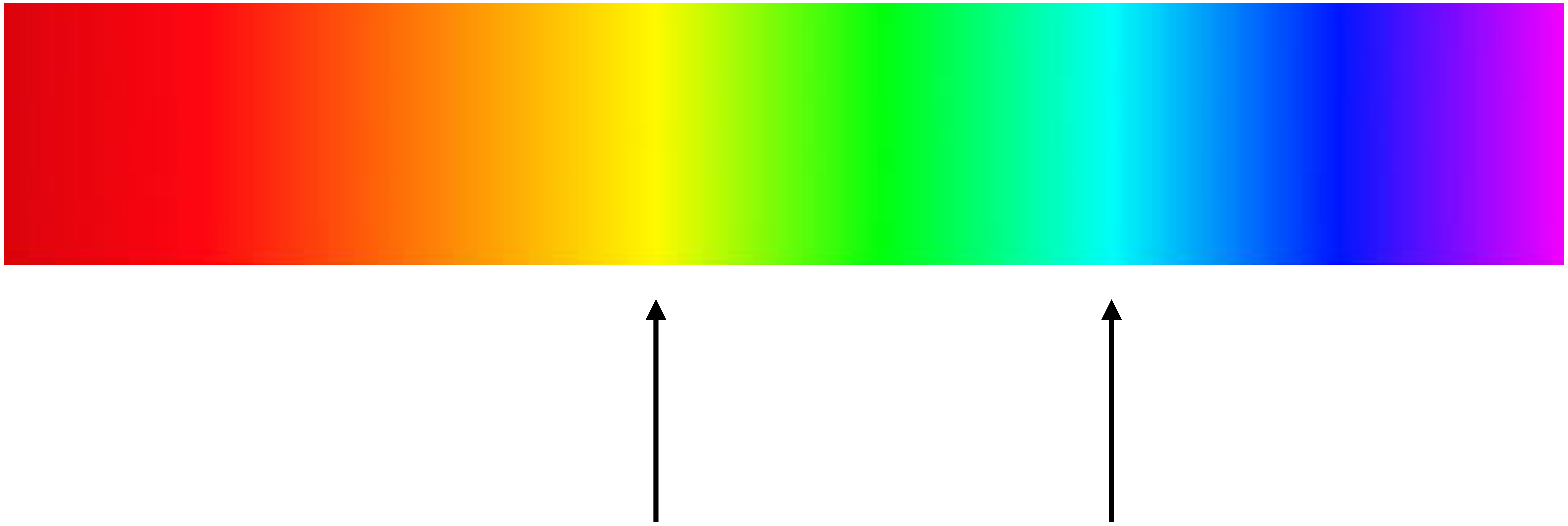


Why not use a rainbow?



Weirdly spaced differences

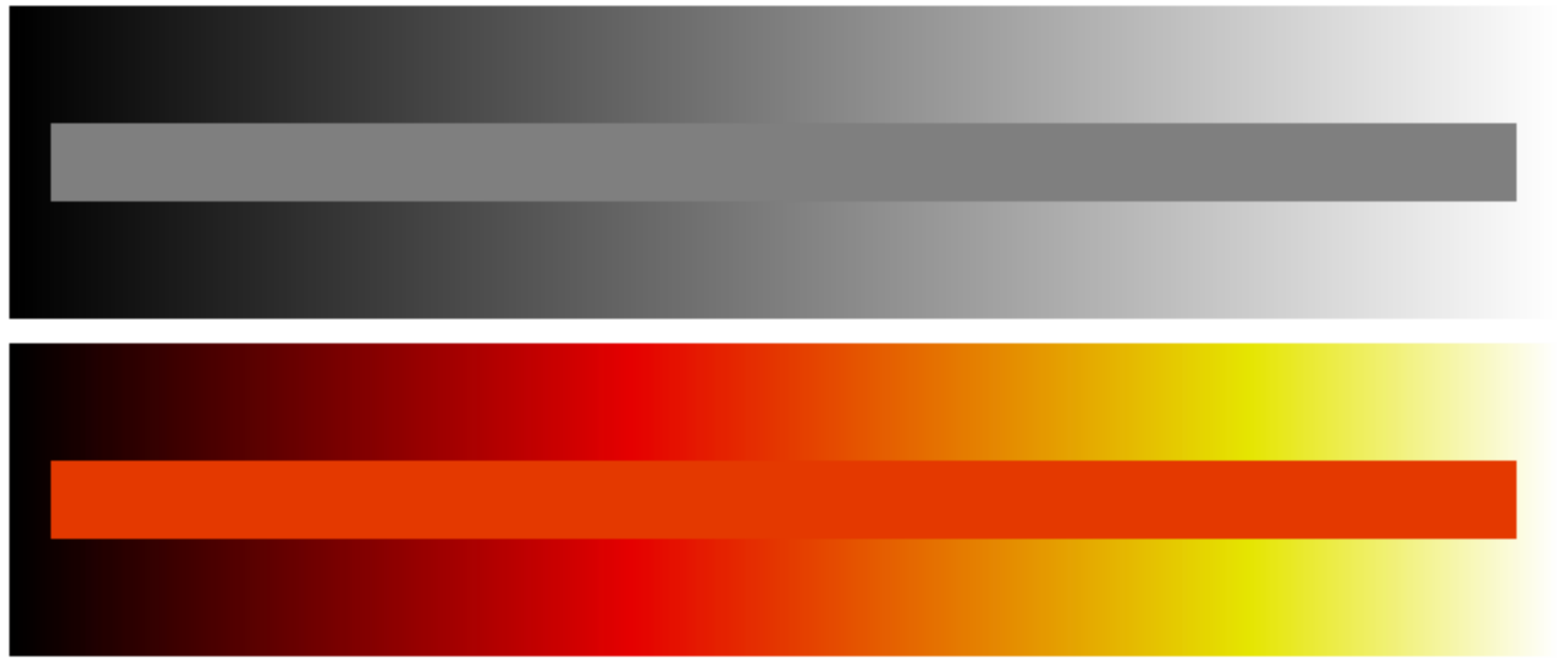
Why not use a rainbow?



Mach color bands

Even though rainbow scales are the default in many visualization applications, they produce undesirable **perceptual effects that distort the underlying data**.

Why not use a **grayscale** (luminance only)?



Pixel appearance is affected by surrounding pixels

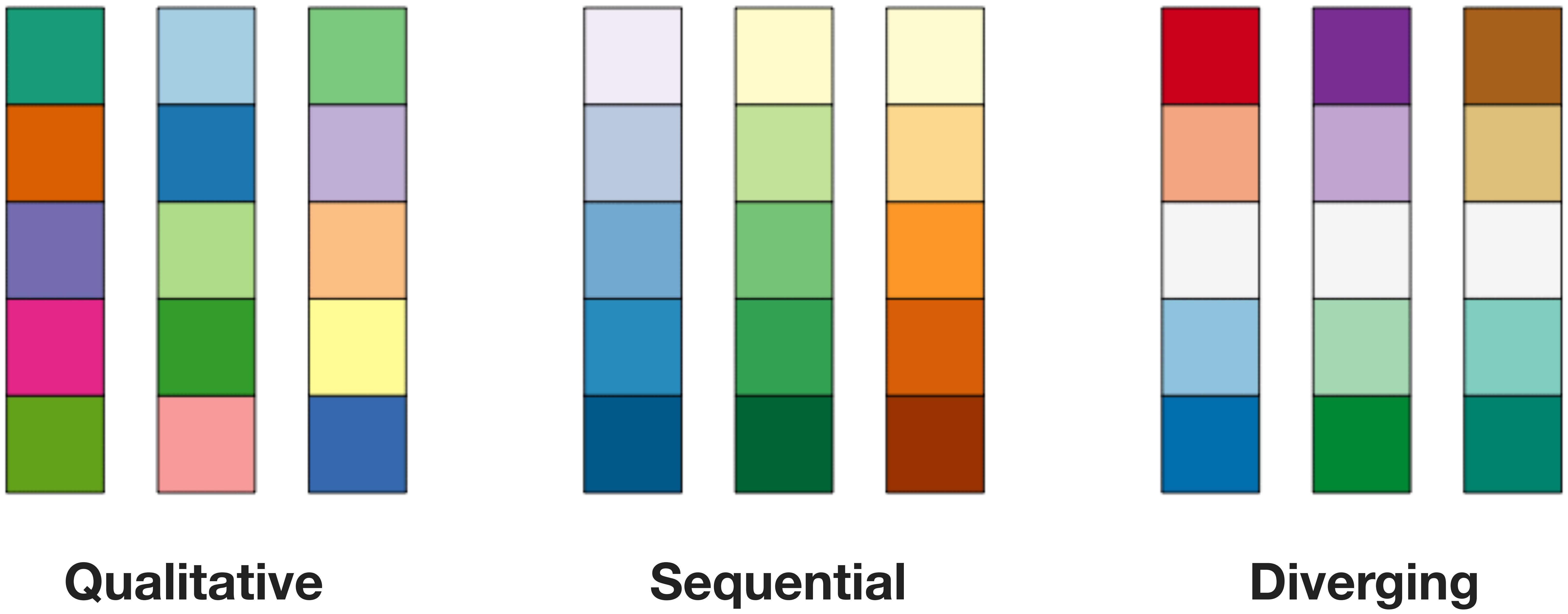
Detail lost

Why not use an **isoluminant map** (chromatic shifts)?

- Humans are more sensitive to changes in luminance
- Limits the number of colors represented, which can lead to lower-fidelity graphics

The right color scale **controls changes in hue** with shifts in saturation and luminance.

Cynthia Brewer — **Color Scales**



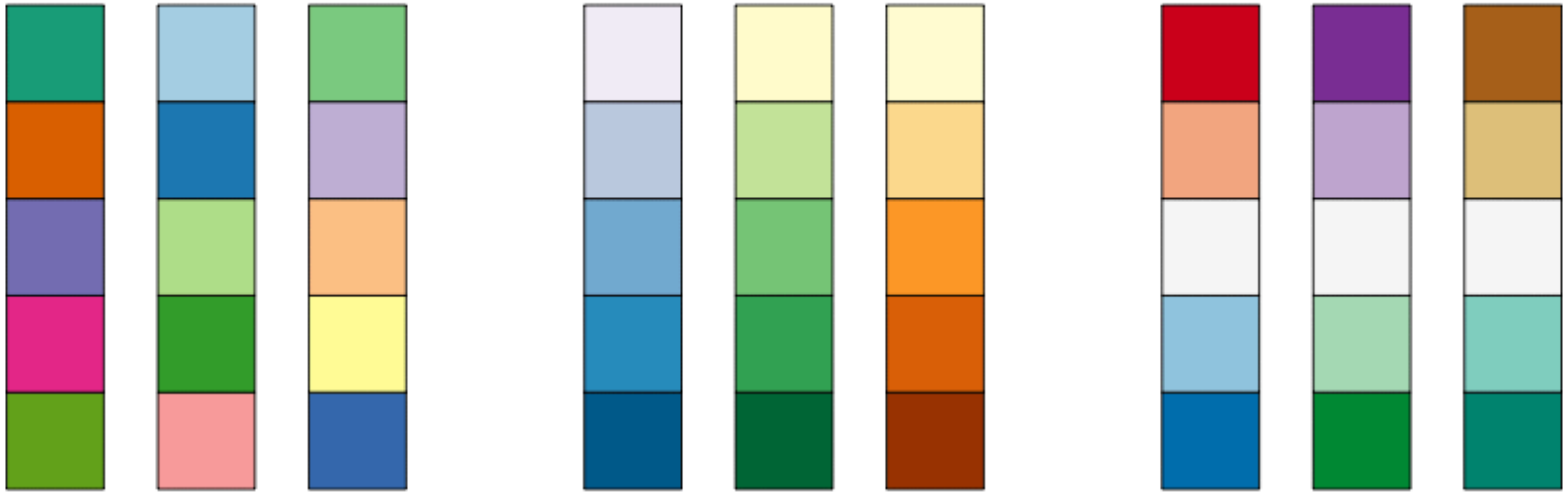
Qualitative

- Nominal
- Ordinal

Quantitative

- Interval
- Ratio

Cynthia Brewer — **Color Scales**



Qualitative
(Nominal)

Sequential
(Ordinal, interval, ratio)

Diverging
(Ordinal, interval, ratio)

Introduction to **visual variables**

Jacques Bertin

The Semiology of Graphics (1967)

Semiotics –

A study of signs and the cultures that use them

Sign –

Anything that stands for something other than itself

People understand a given set of signs **differently**

- A message is made up of signs, which are then interpreted
- Reading becomes an **active process**
- Different readings are not only possible, but probable

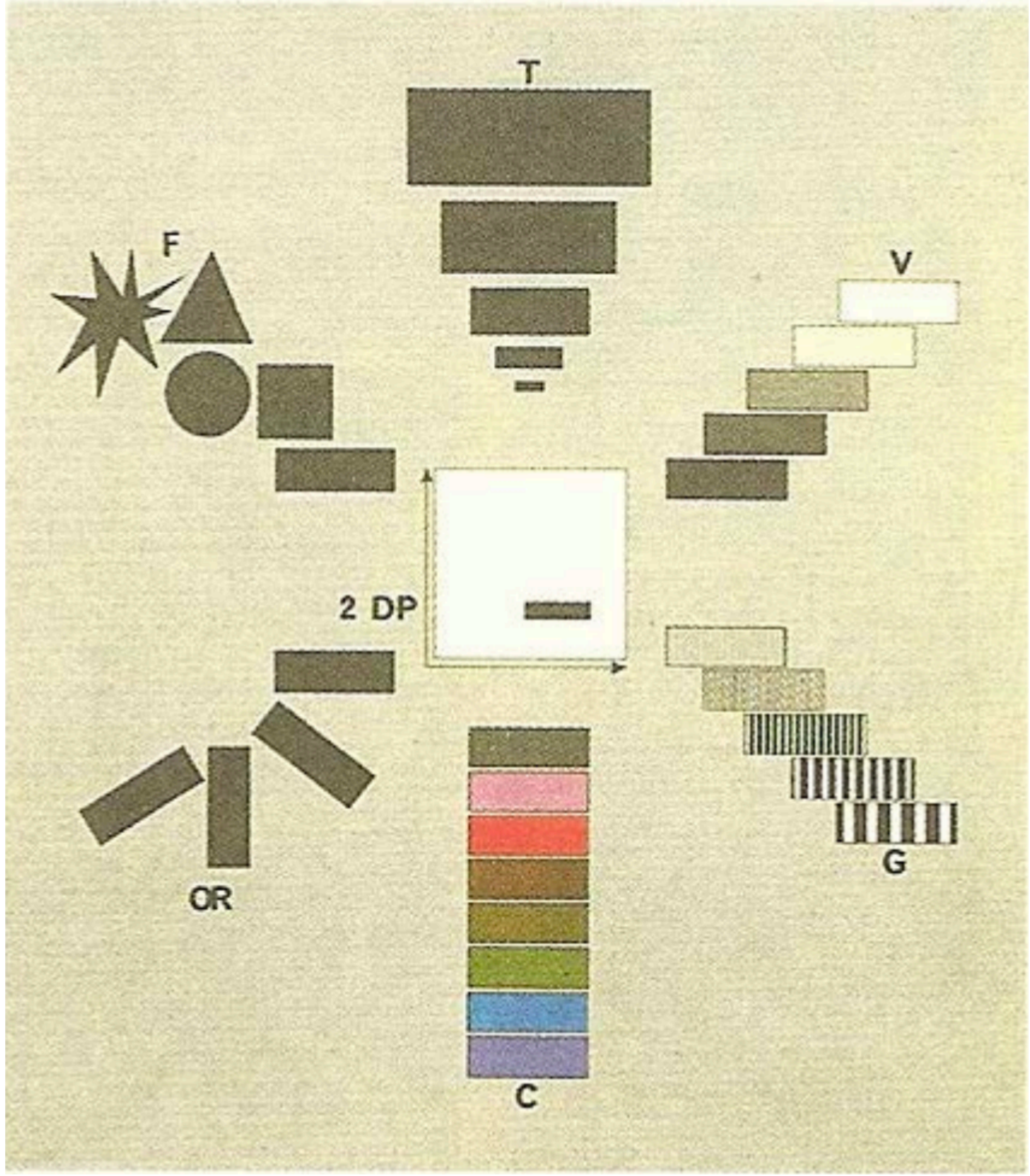
Bertin's **retinal variables** capture a number of ways to visually differentiate signs.

- **Position** Changes in the x, y, or z location
- **Size** Change in length or area
- **Shape** (Infinite number of shapes)
- **Value** Changes from light to dark
- **Color** Changes hue at a given value
- **Orientation** Changes in alignment
- **Texture** Variation in pattern

Size

Shape

Value



Orientation

Texture

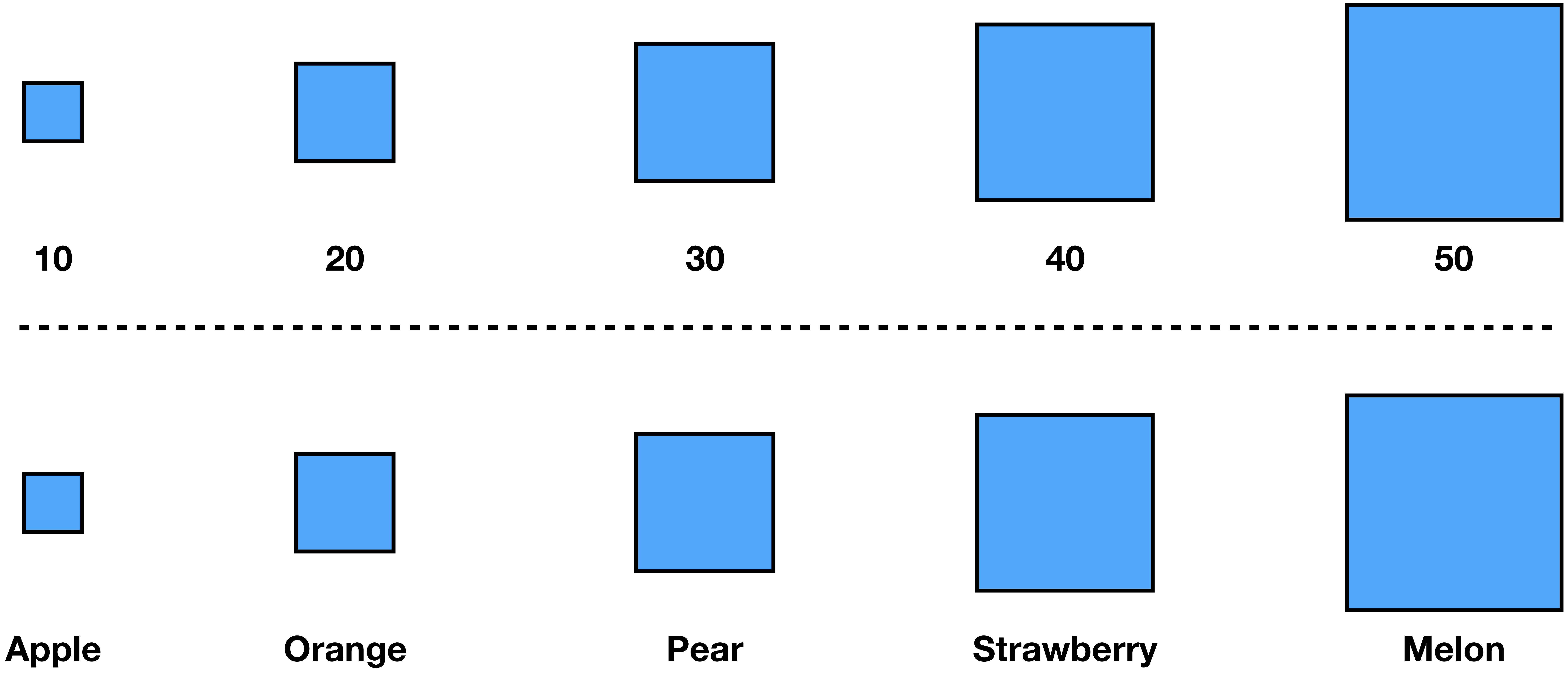
Color

The process of mapping data to visual variables is called **visual mapping**.

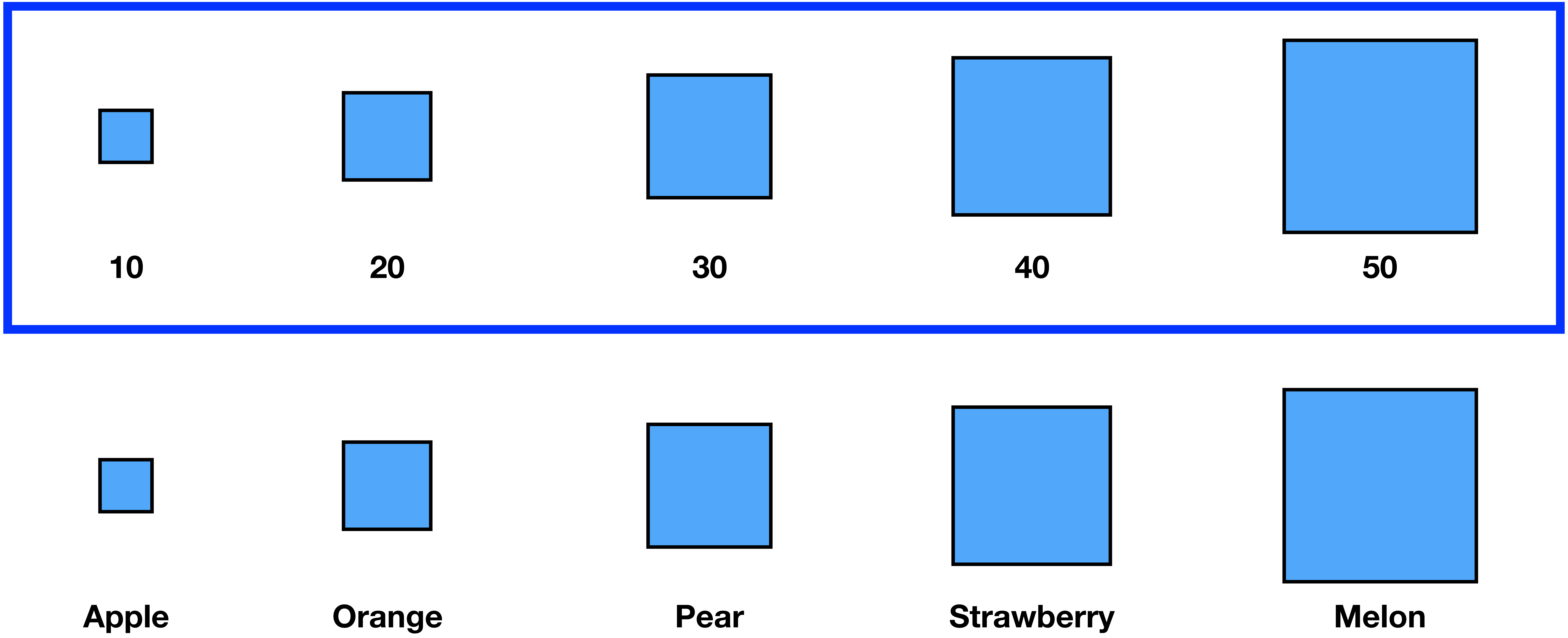
Selecting visual variables to represent different aspects of the same information can greatly influence the **perception and understanding** of the presented information.

Not all retinal variables work for all types of data. Think about what best corresponds to what you're working with.

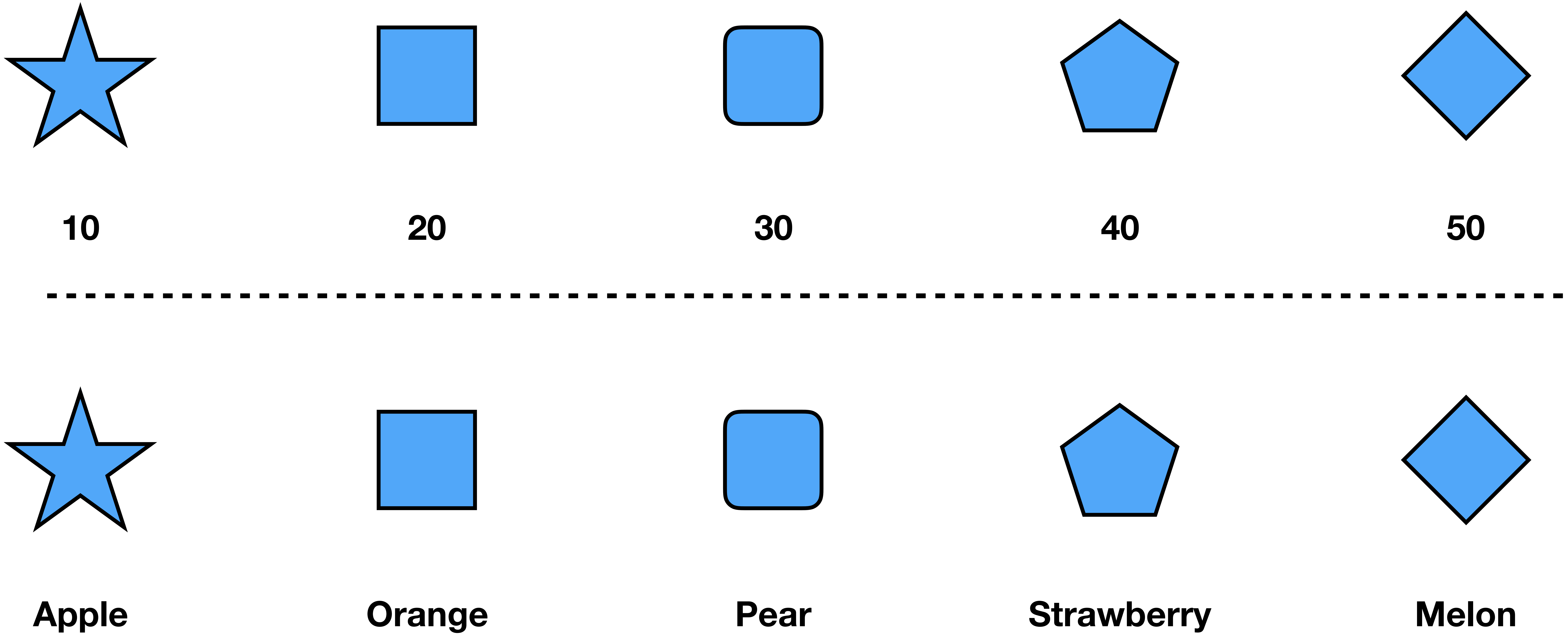
Retinal variable: **Size**



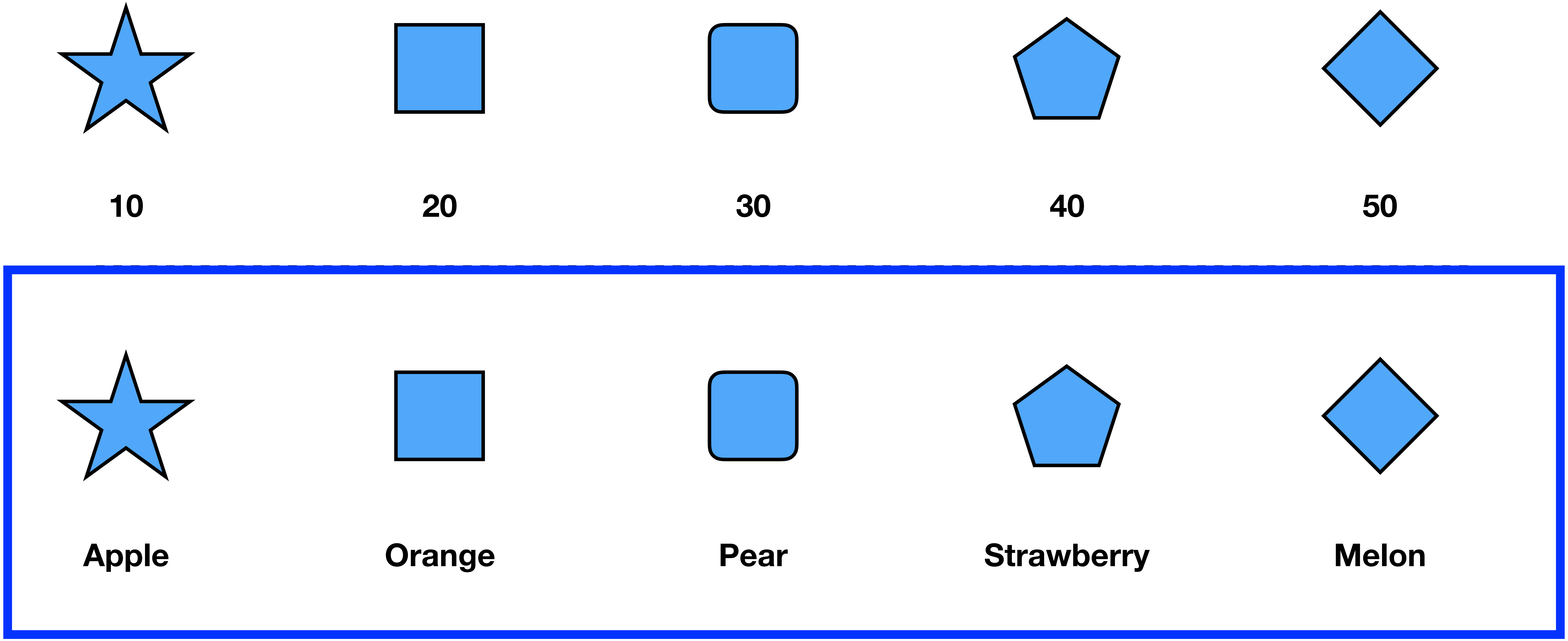
Retinal variable: **Size**



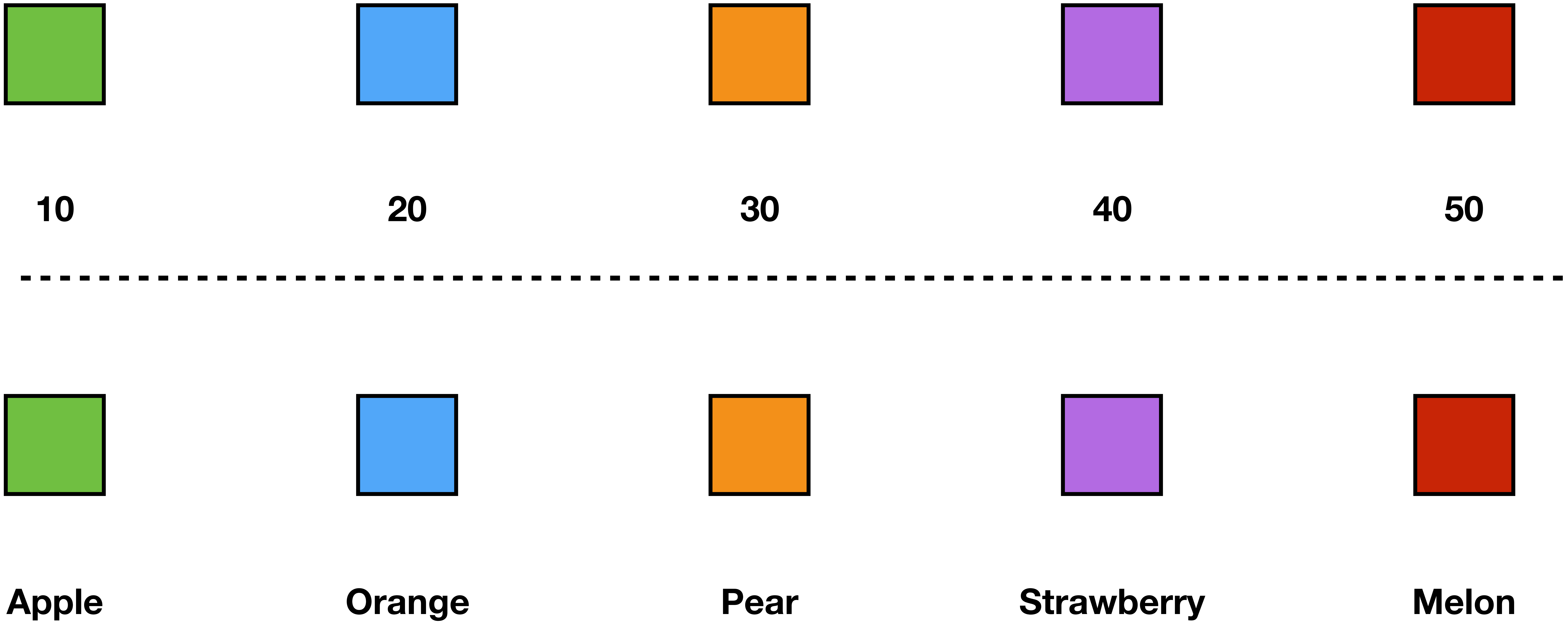
Retinal variable: **Shape**



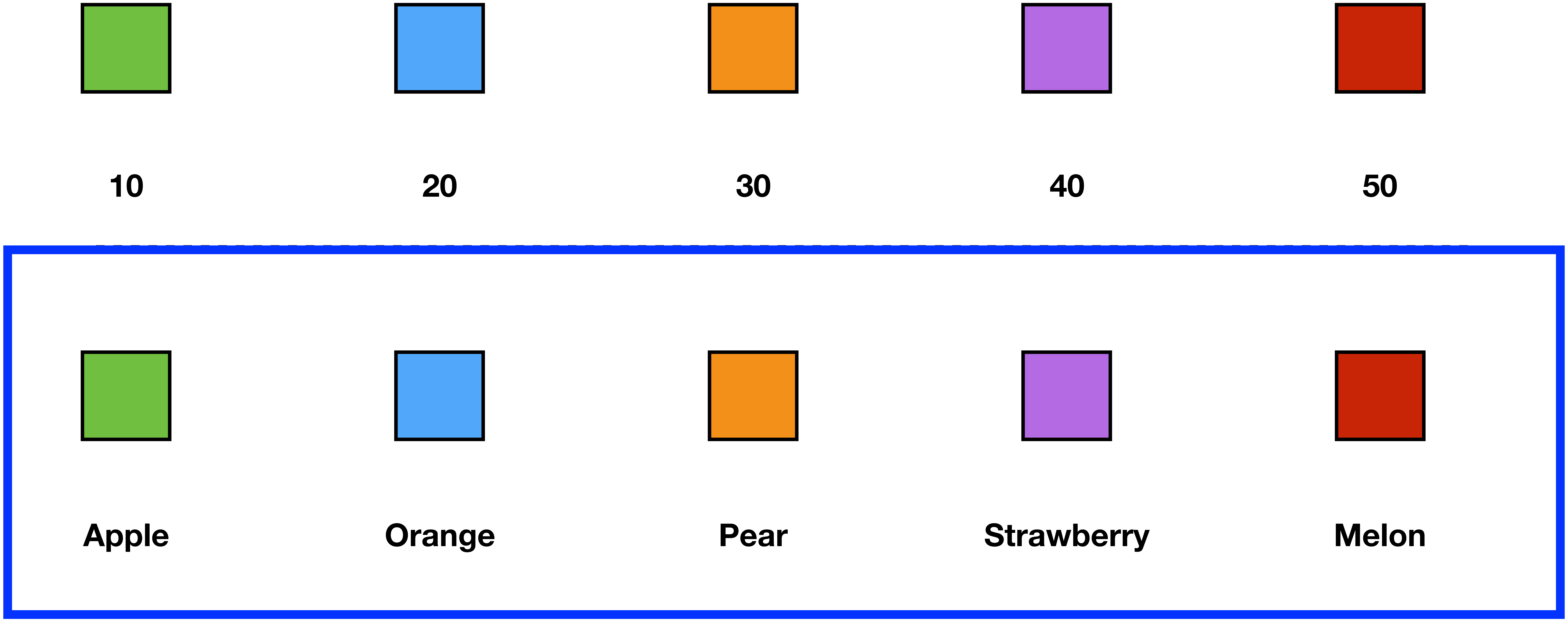
Retinal variable: **Shape**



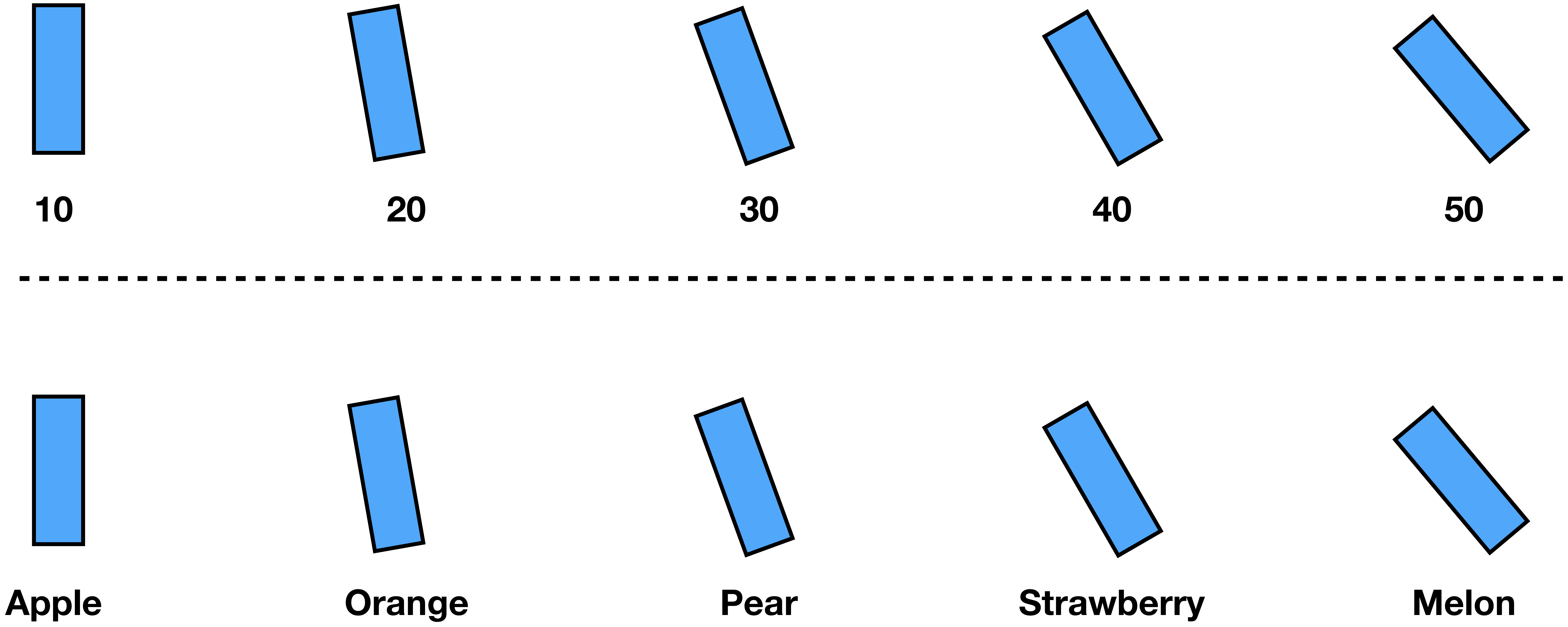
Retinal variable: **Color**



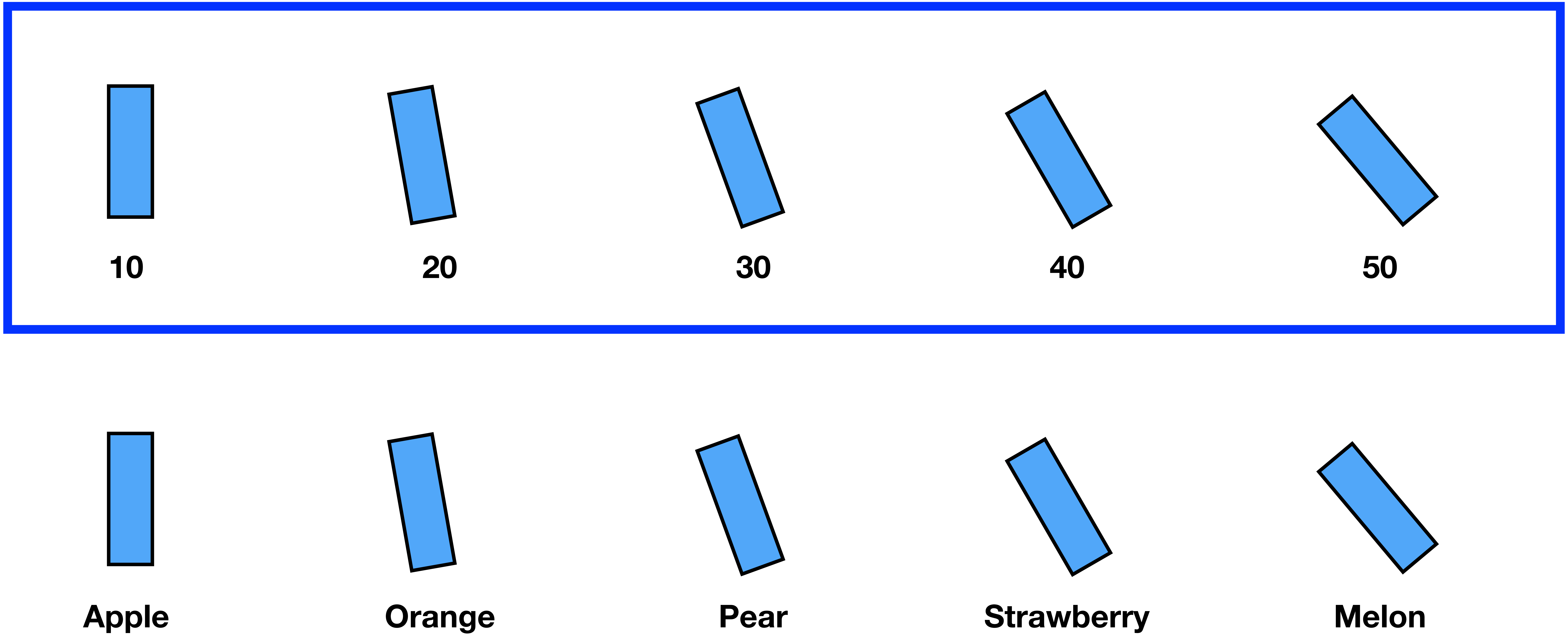
Retinal variable: **Color**



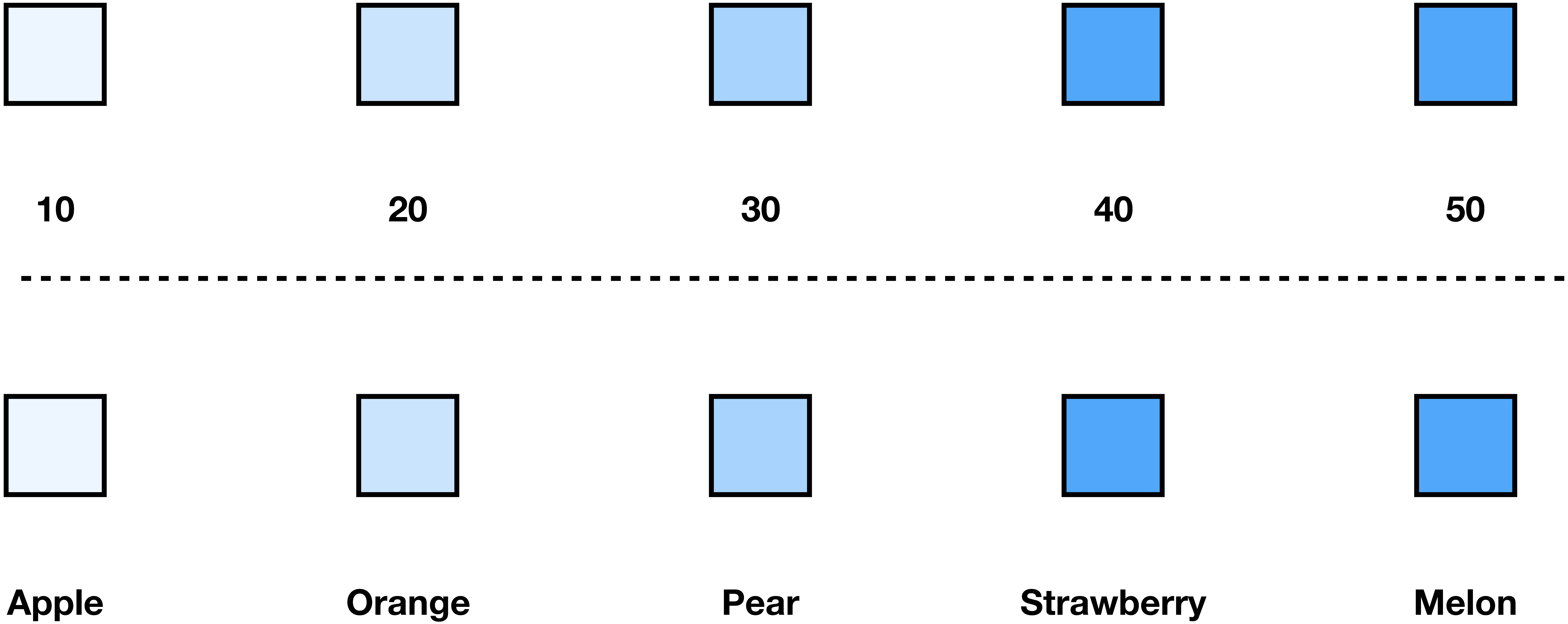
Retinal variable: **Orientation**



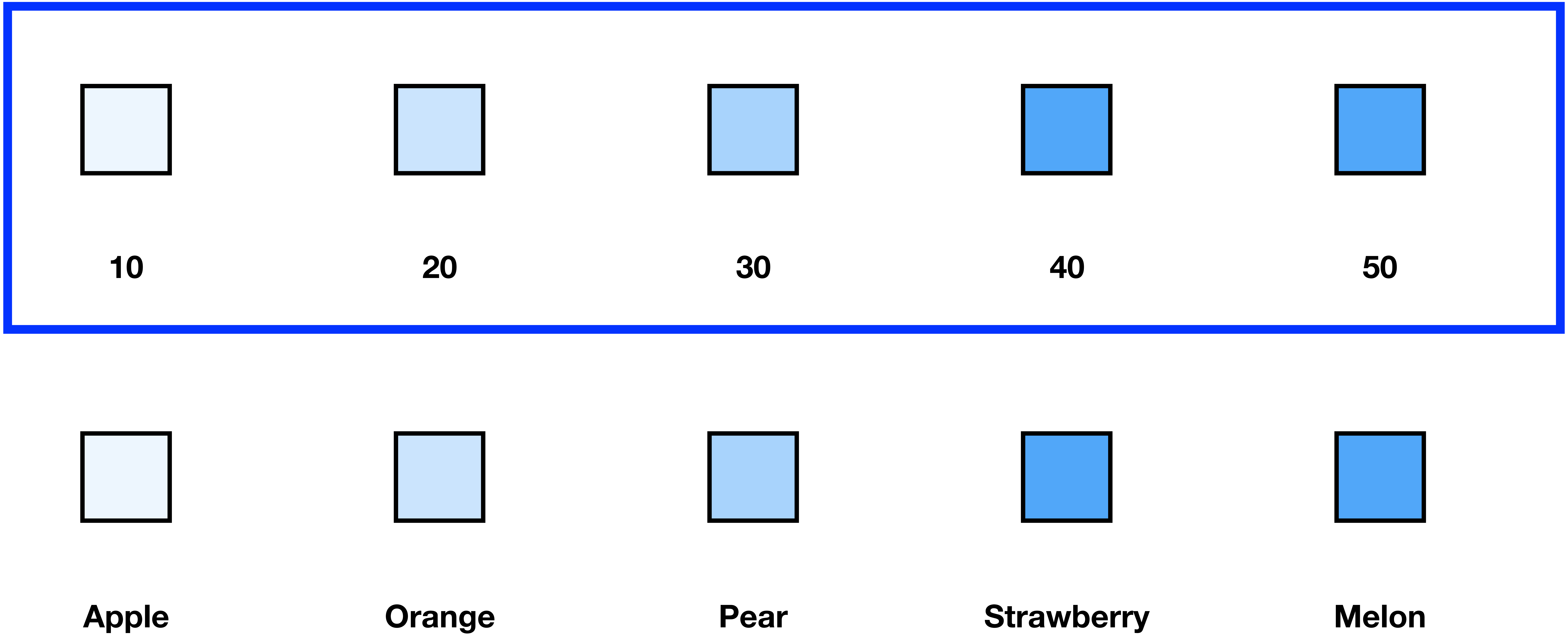
Retinal variable: **Orientation**



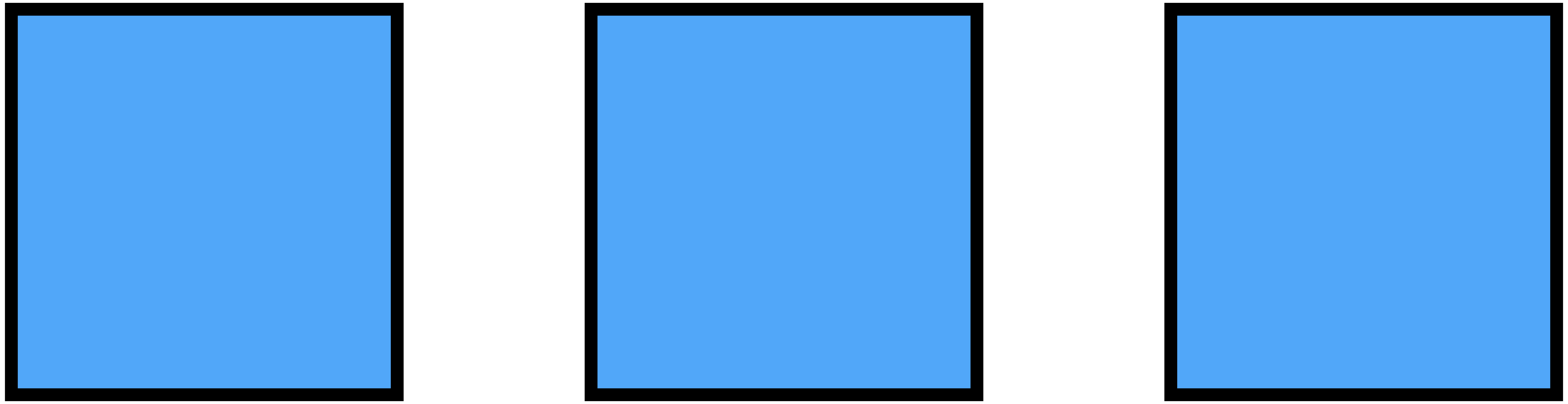
Retinal variable: **Value**



Retinal variable: **Value**

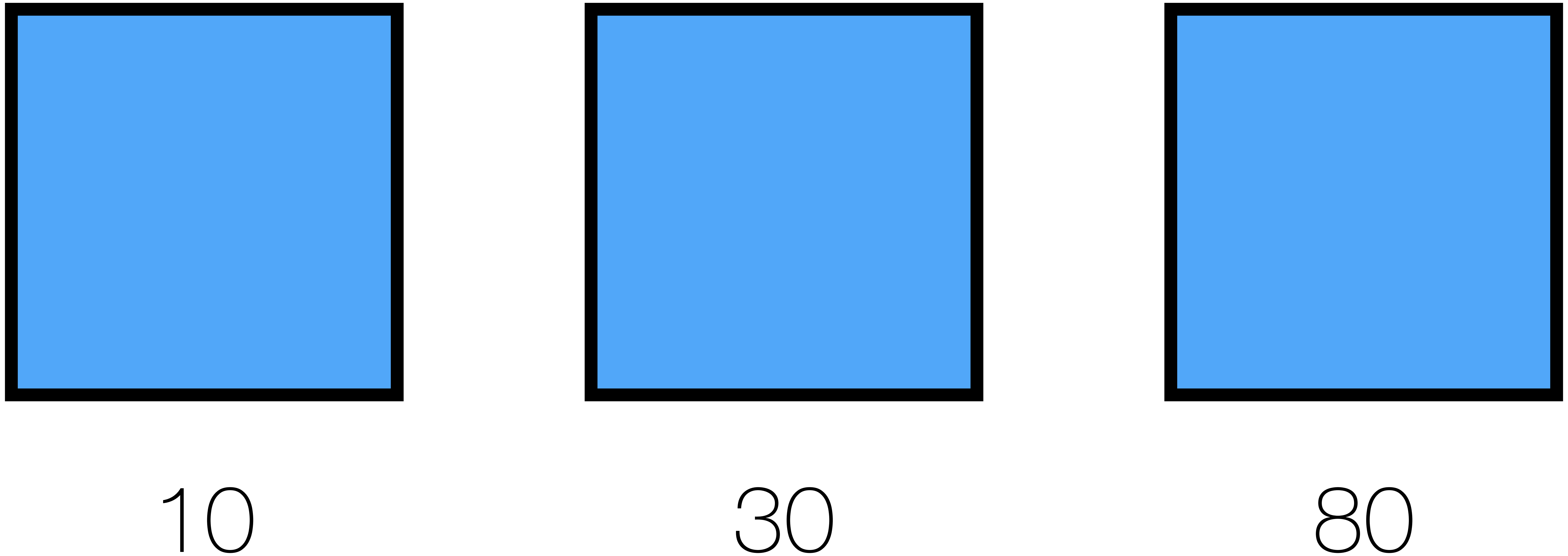


Example — **Three Squares**

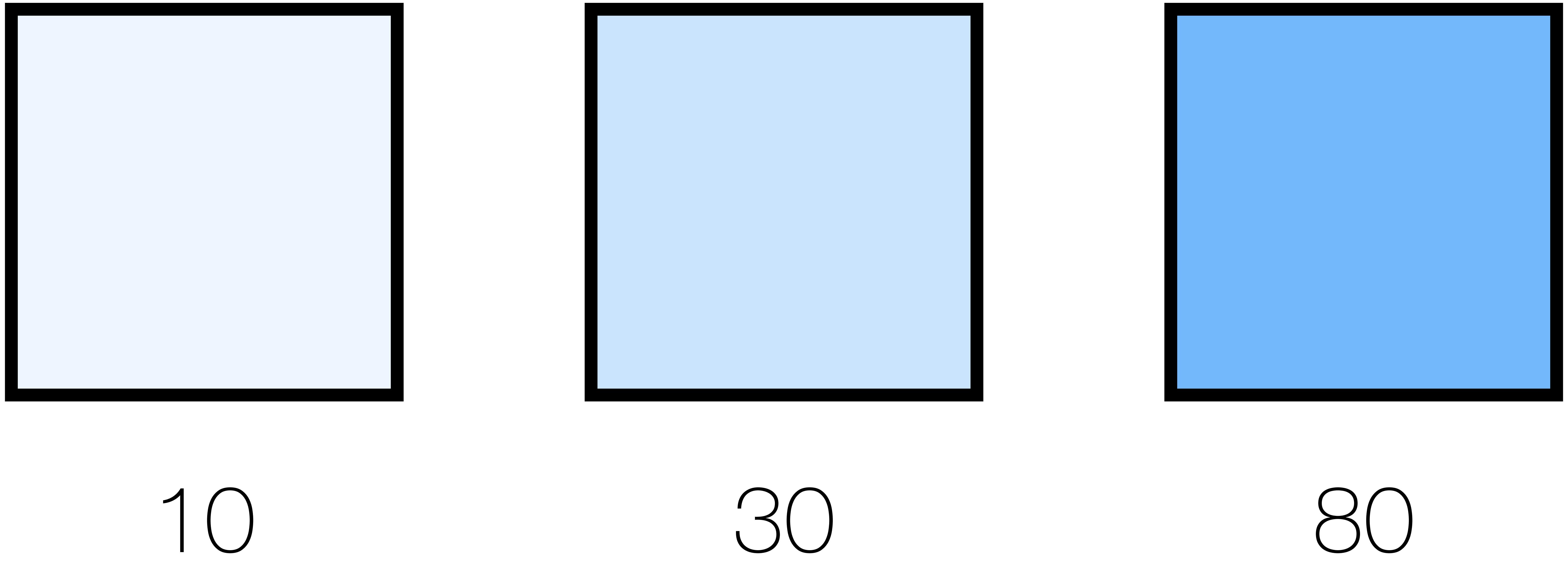


1. Three numerical values
2. Three categorical values
3. Three numerical values & three categorical values

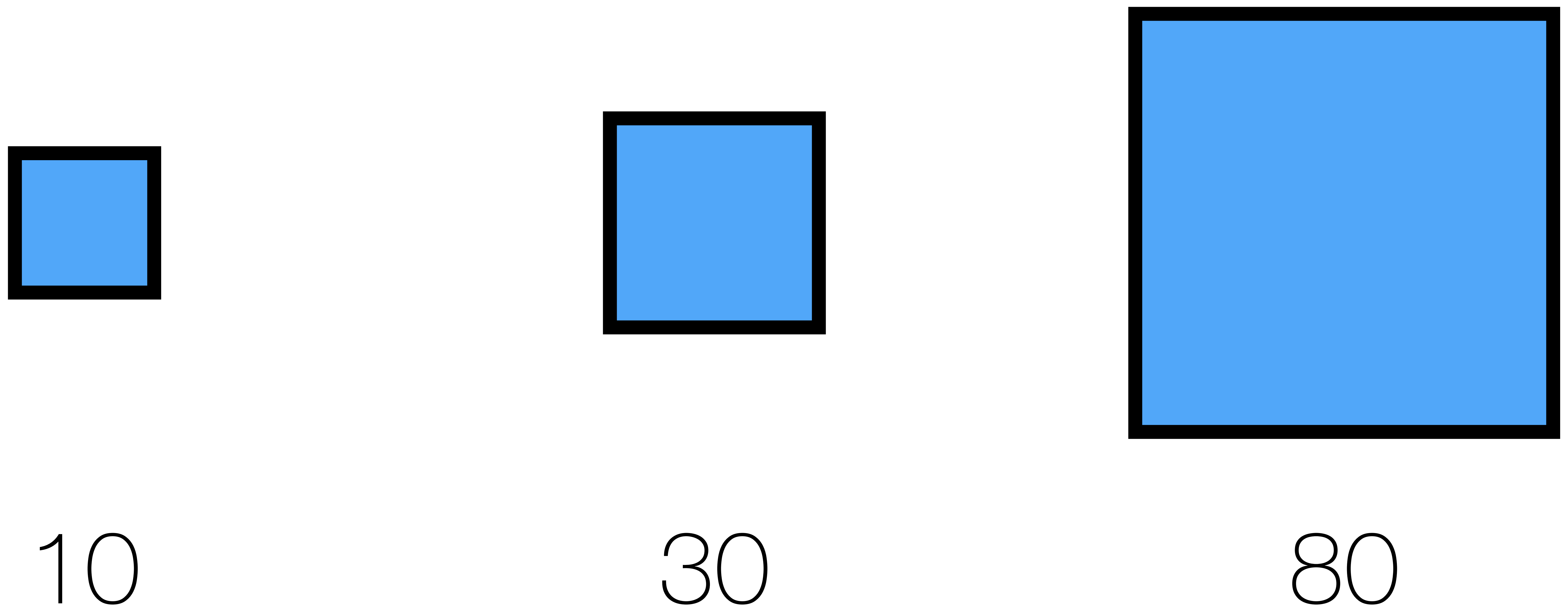
1. **Three numerical values**
2. Three categorical values
3. Three numerical values & three categorical values


10
30
80

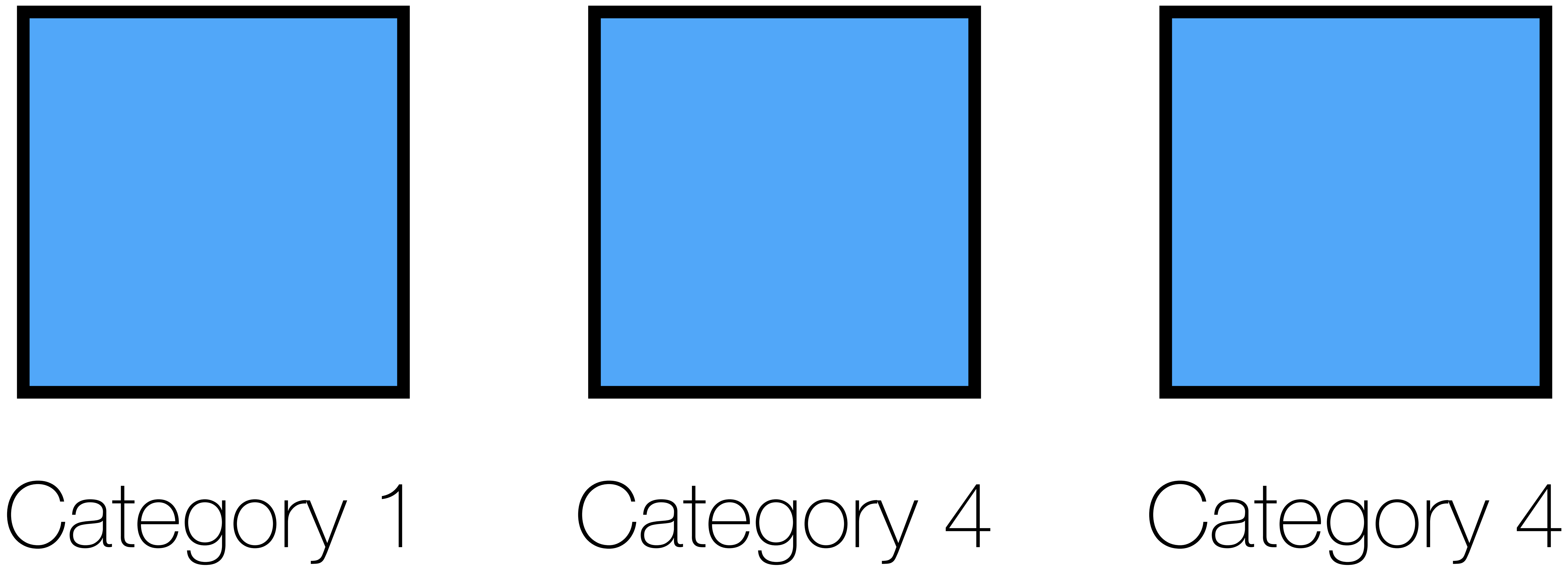
Retinal variable: **Value**



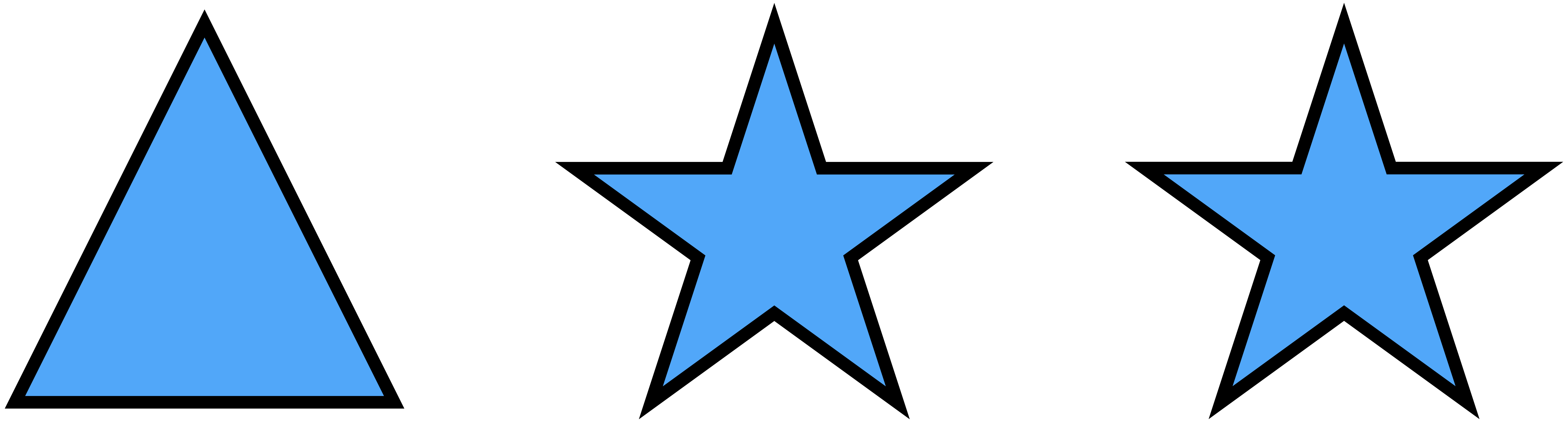
Retinal variable: **Size**



1. Three numerical values
2. **Three categorical values**
3. Three numerical values & three categorical values

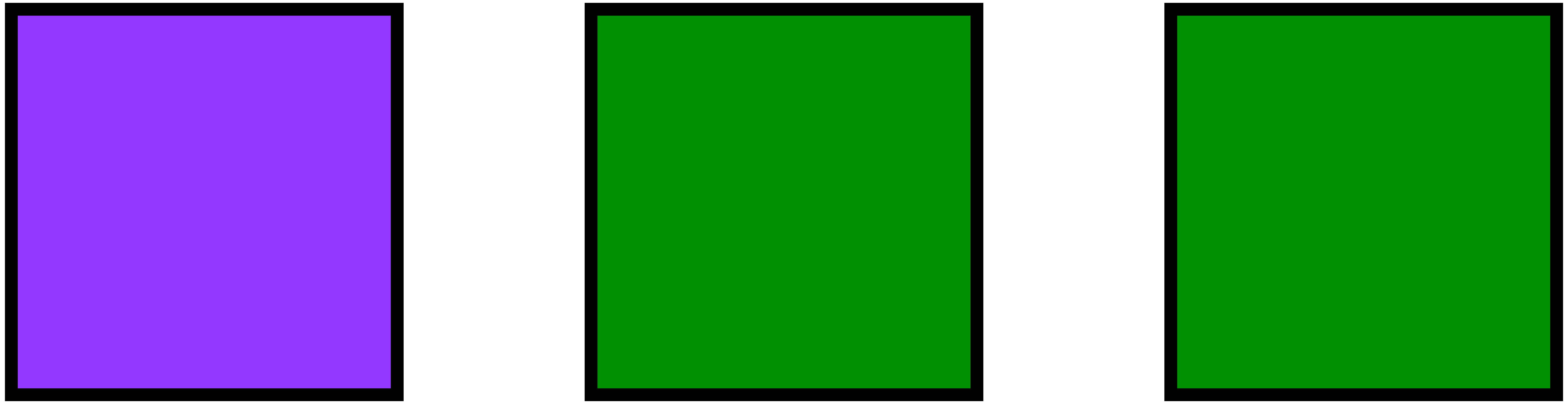

Category 1
Category 4
Category 4

Retinal variable: **Shape**



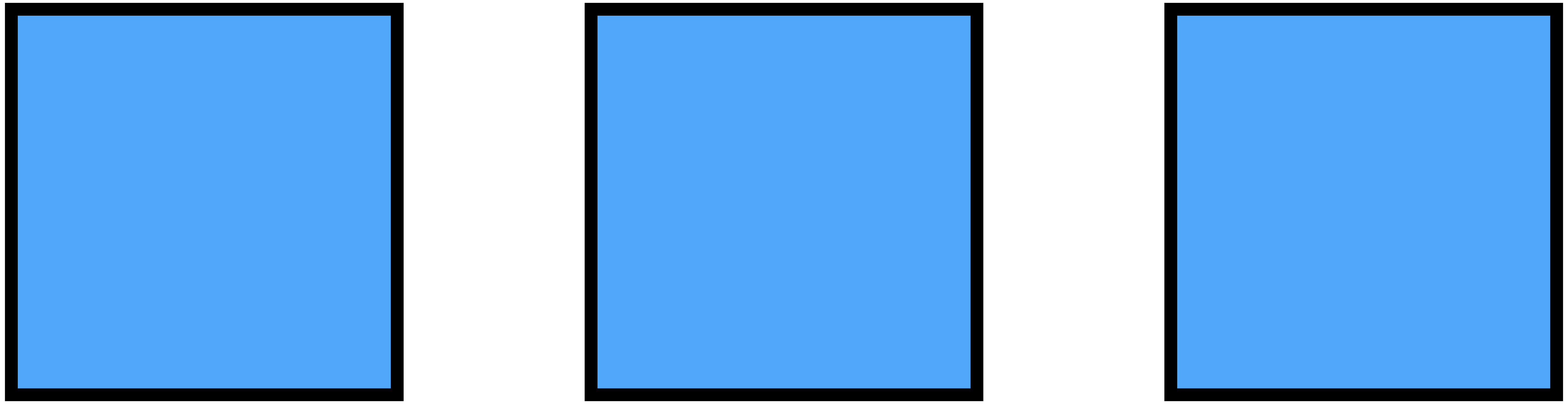
Category 1 Category 4 Category 4

Retinal variable: **Color**



Category 1 Category 4 Category 4

1. Three numerical values
2. Three categorical values
3. **Three numerical values & three categorical values**



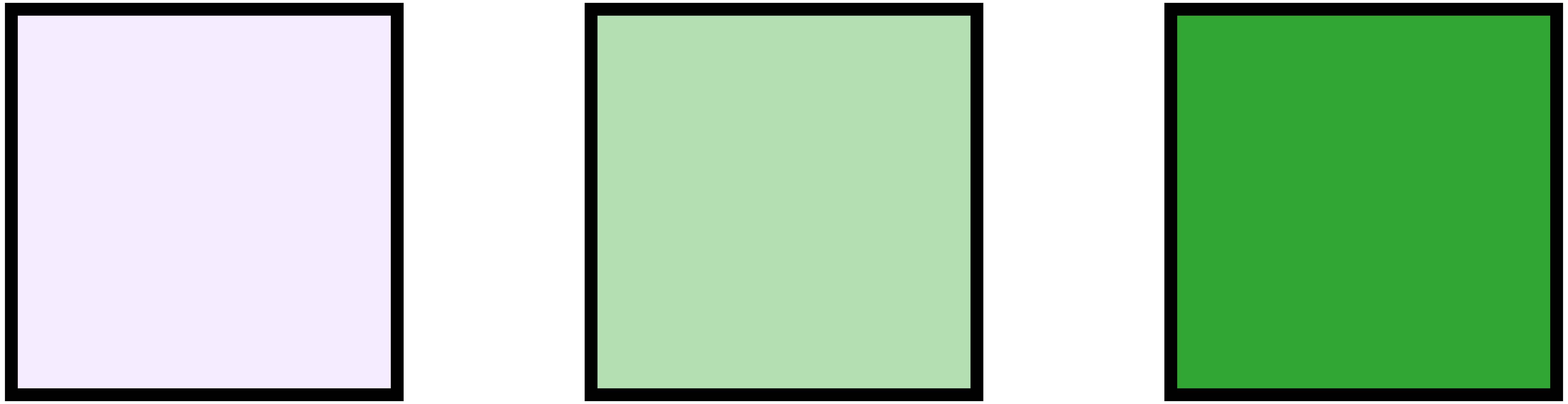
10 Category 1

30 Category 4

80 Category 4

Retinal variables: **Shape** and **Value**

Retinal variables: **Color** and **Value**



10
Category 1

30
Category 4

80
Category 4

Use your intuition. Some combinations of variables are more readable than others.

Questions?