Data Analytics
SET10109

Design Principles

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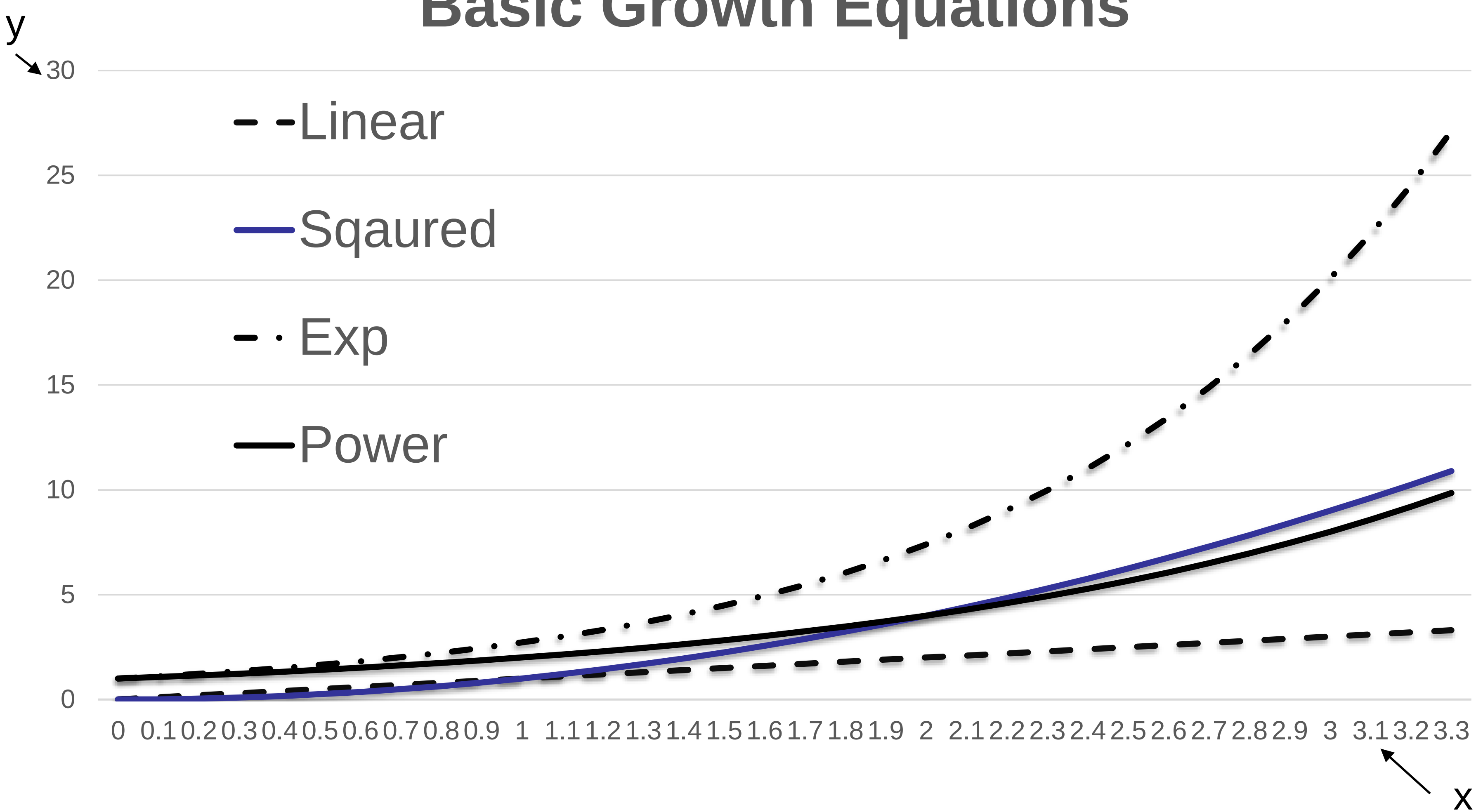
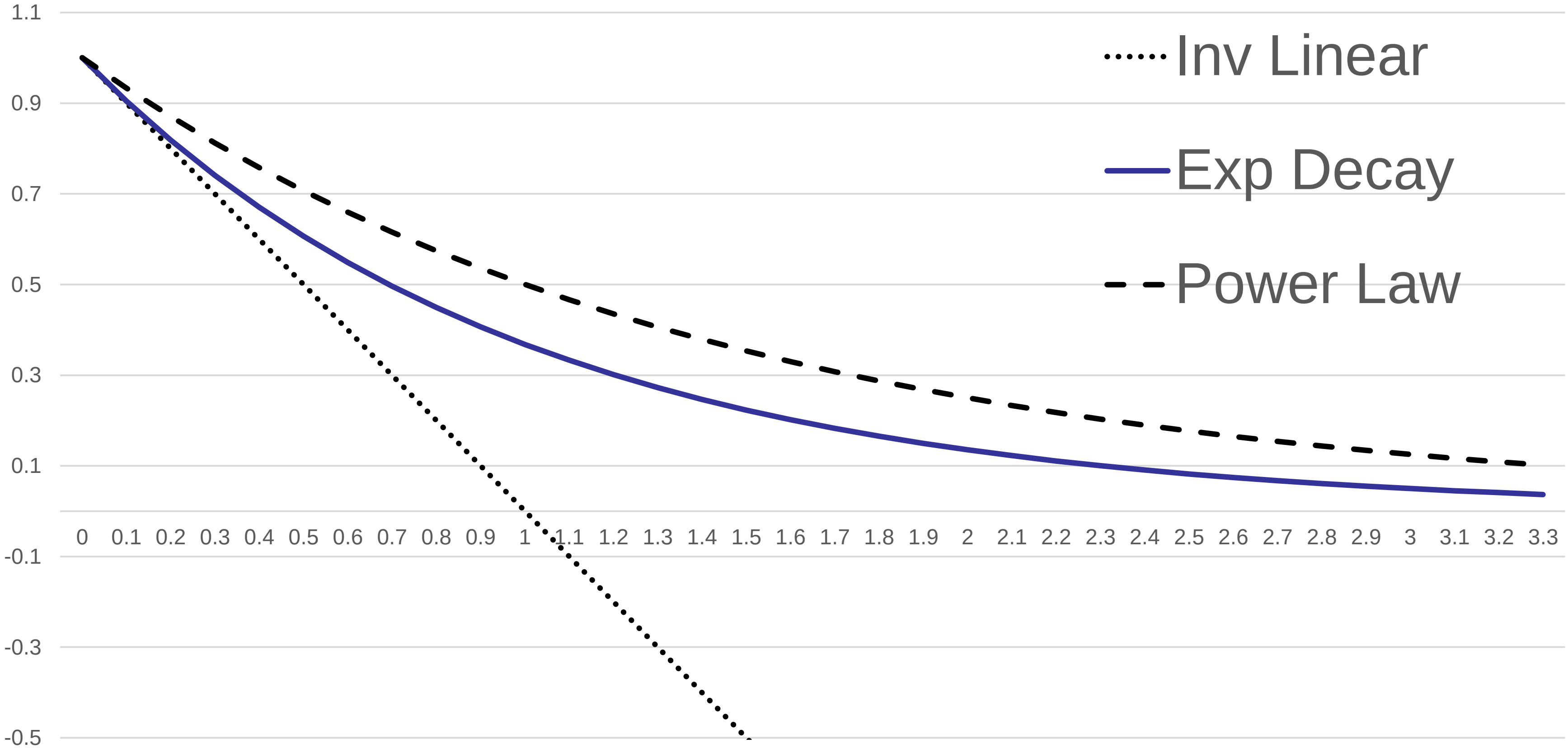
Introduction

- First some (graphical) Math
- Basic Concepts
- Colour

Basic Growth Equations



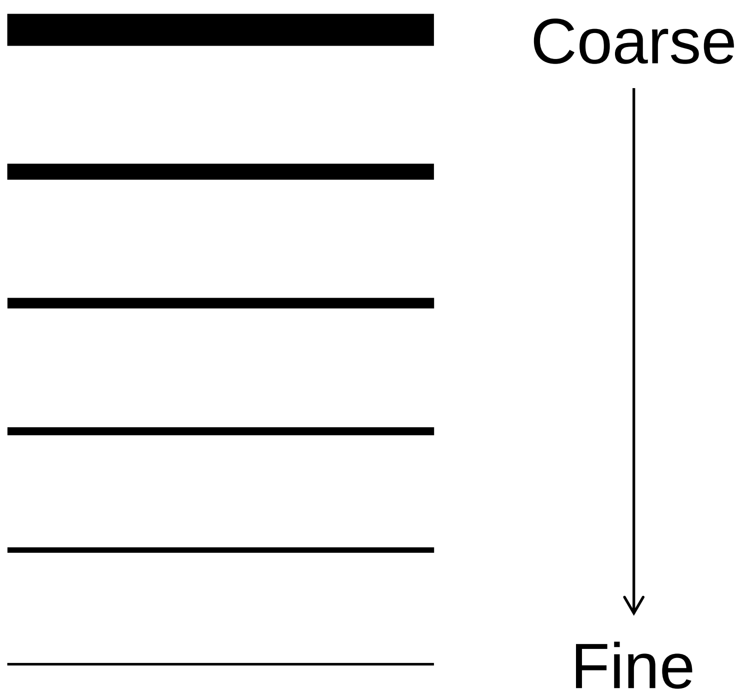
Decay Equations

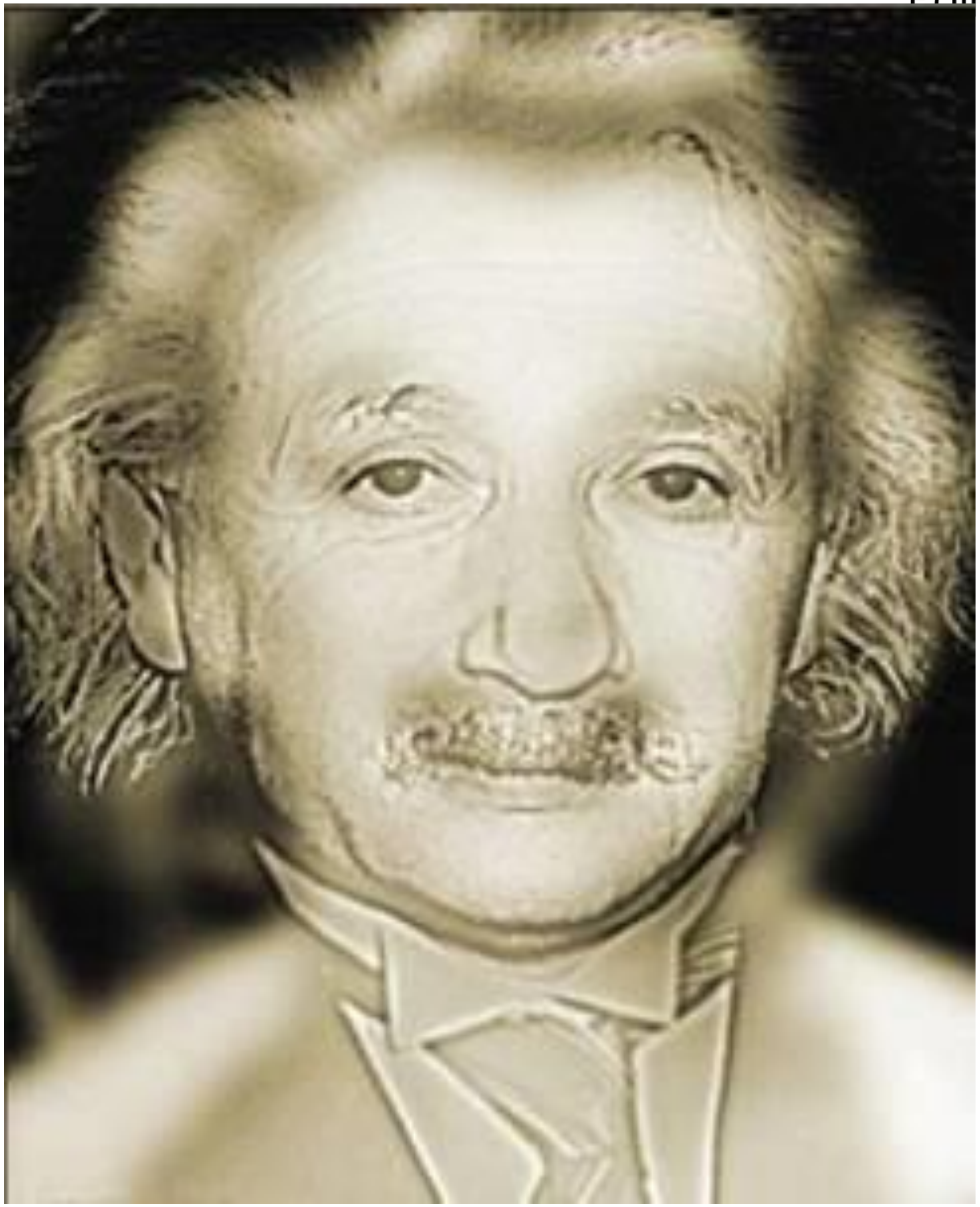


Many names

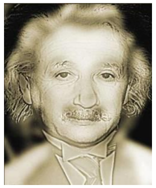
Name	Name	Name	Type	Shown
Linear	Correlated	Linear Regression	Growth	First Slide
Linear	Correlated	Linear Regression	Decay	Second Slide *
Exponential Decay	Exponential distribution	Laplacian distribution	Decay	Second Slide
Power Law	Inverse Power equation		Decay	Second Slide
Increases Exponentially	Exponential equation		Growth	First Slide

Scale

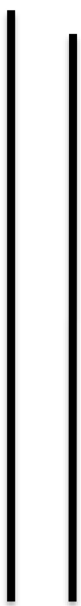




Scale is not resizing.

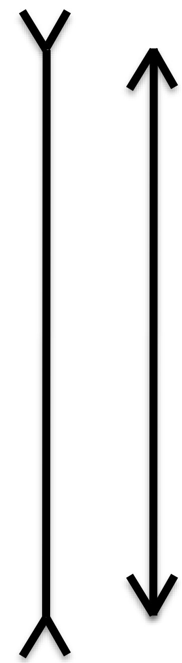


Length



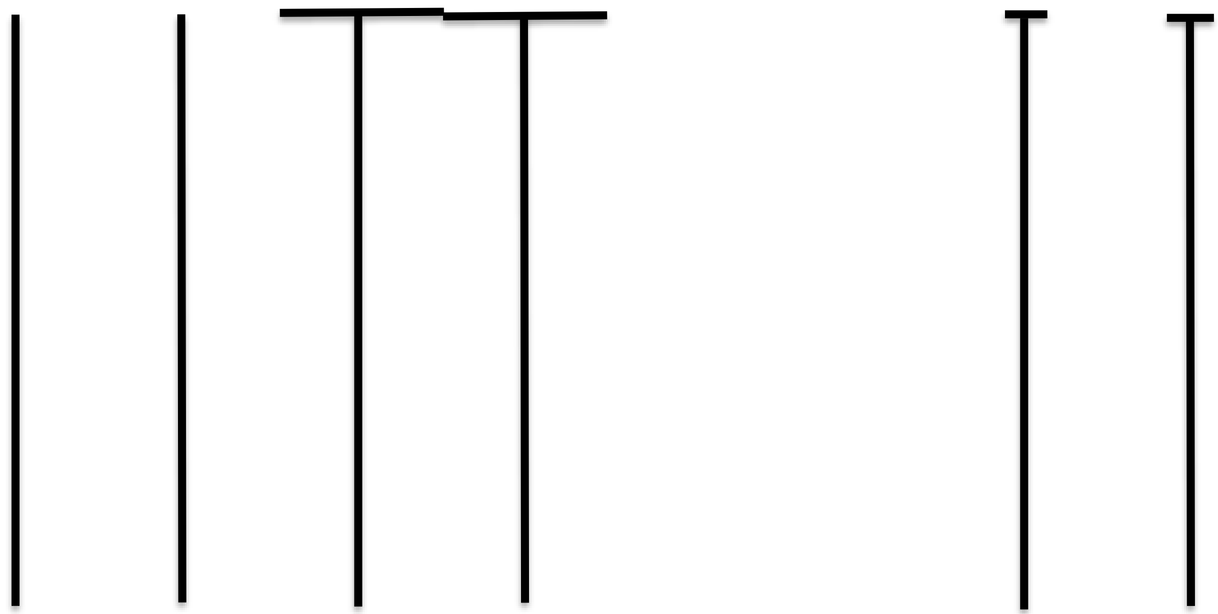
Easy

Hard



Which is Longer?

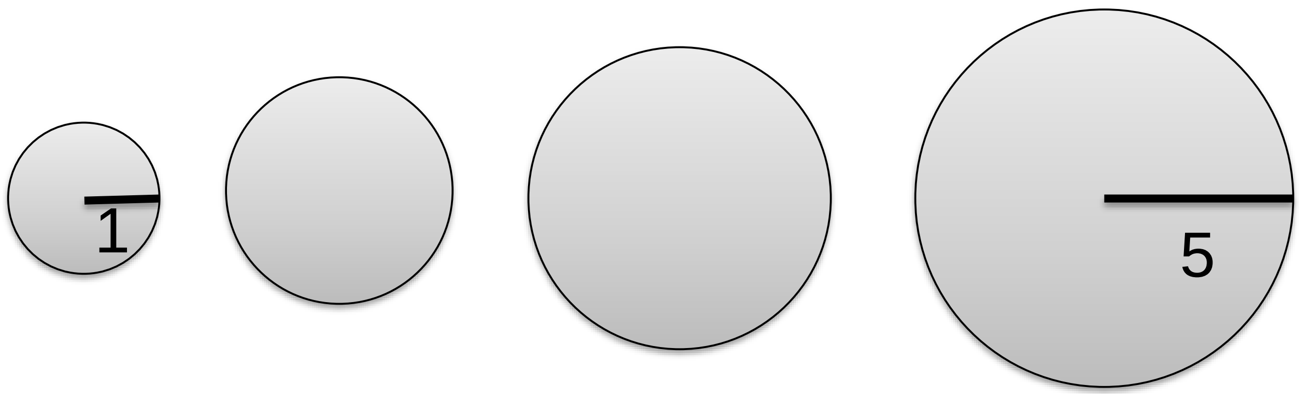
Separation



Hard Easy This is not simply a proximity effect

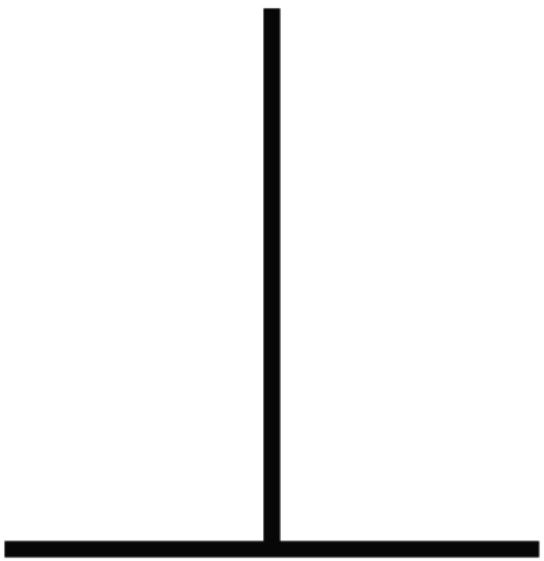
Area

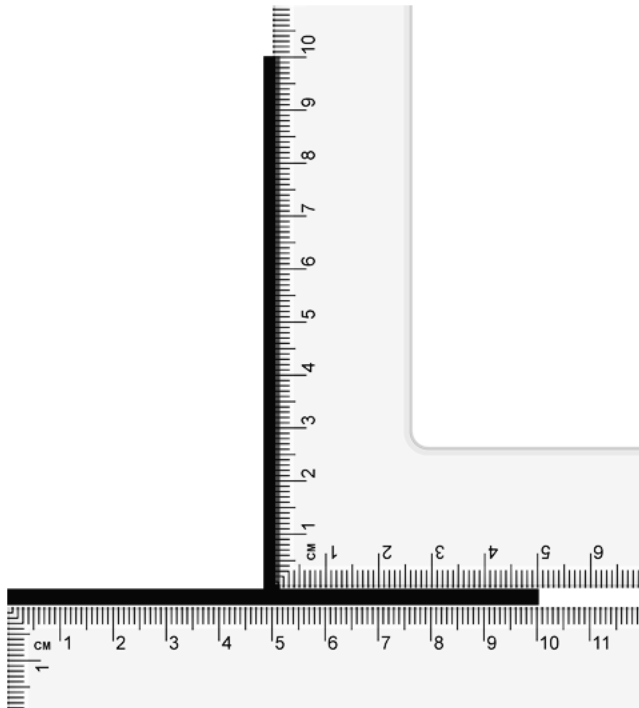
$$A_{real} = \pi r^2$$
$$A_p = r^{2\alpha}$$



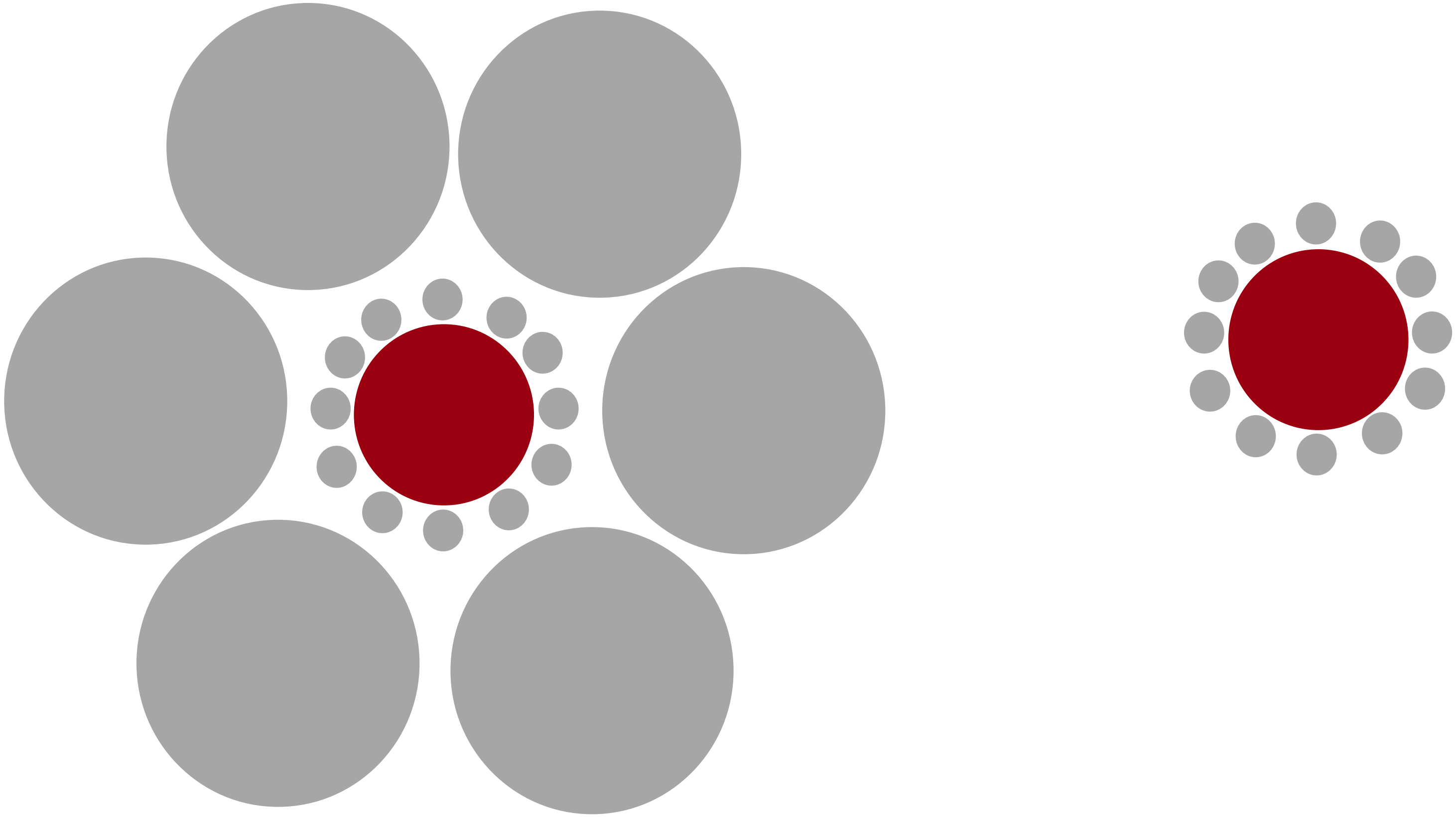
Radius:	1	1.5	2	2.5
Actual Area	3.14	7.1	12.6	19.6
Perceived Area	1	2.9	6.3	11.4

Horizontal-Vertical Illusion



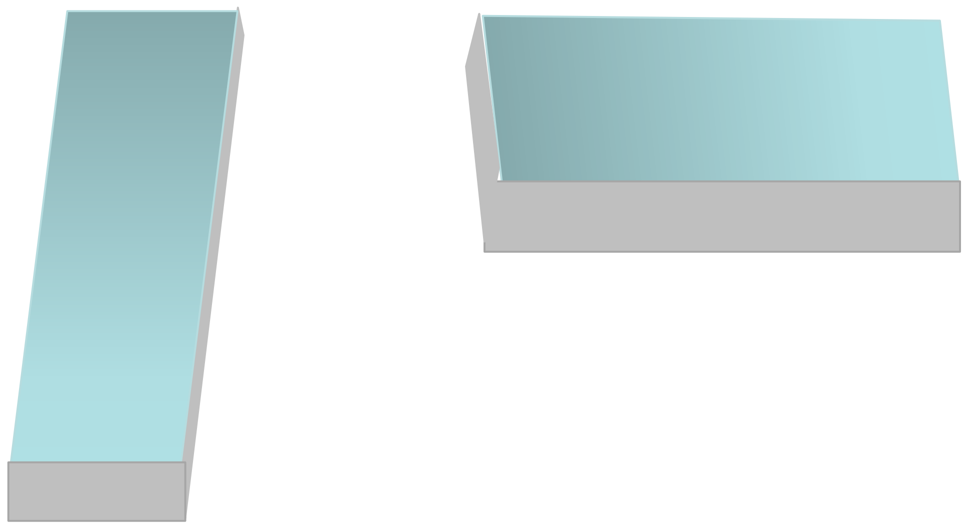


Ambiguous Information: Area (Context)



Ebbinghaus

2.5D Shape

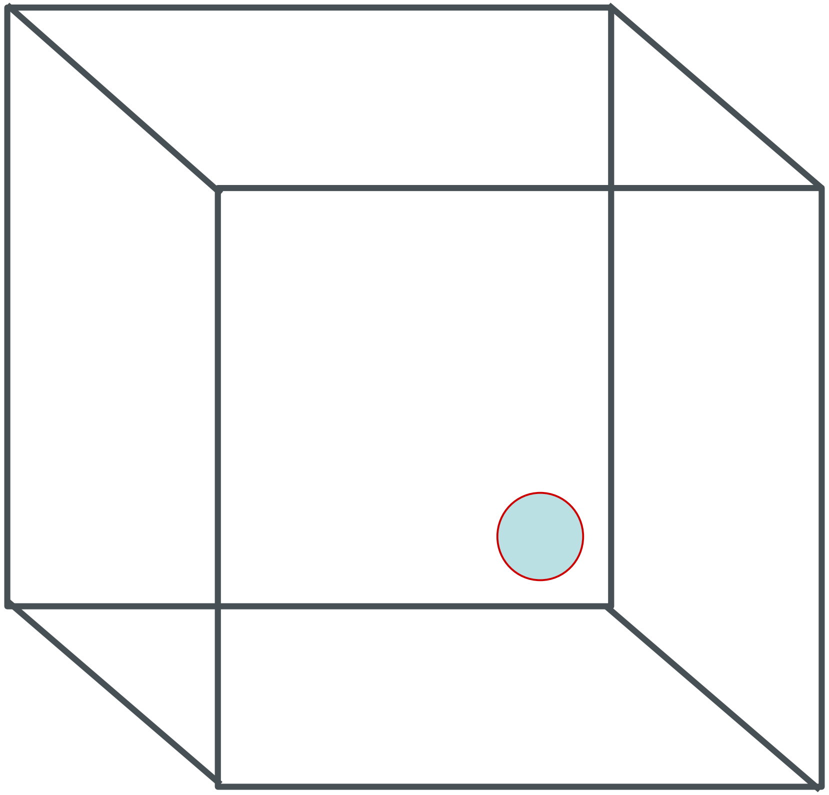


Adapted from Shepard R N, 1990 Mind Sights: Original Visual Illusions, Ambiguities, and other Anomalies (

2.5D Shape

Adapted from Shepard R N, 1990 Mind Sights: Original Visual Illusions, Ambiguities, and other Anomalies (

Ambiguous Information: Position in 2.5D space



Necker Cube

Visual Channels

- Control the appearance of marks

Adapted from Mackinlay J (1986) Automating the design of graphical presentations of relational information.

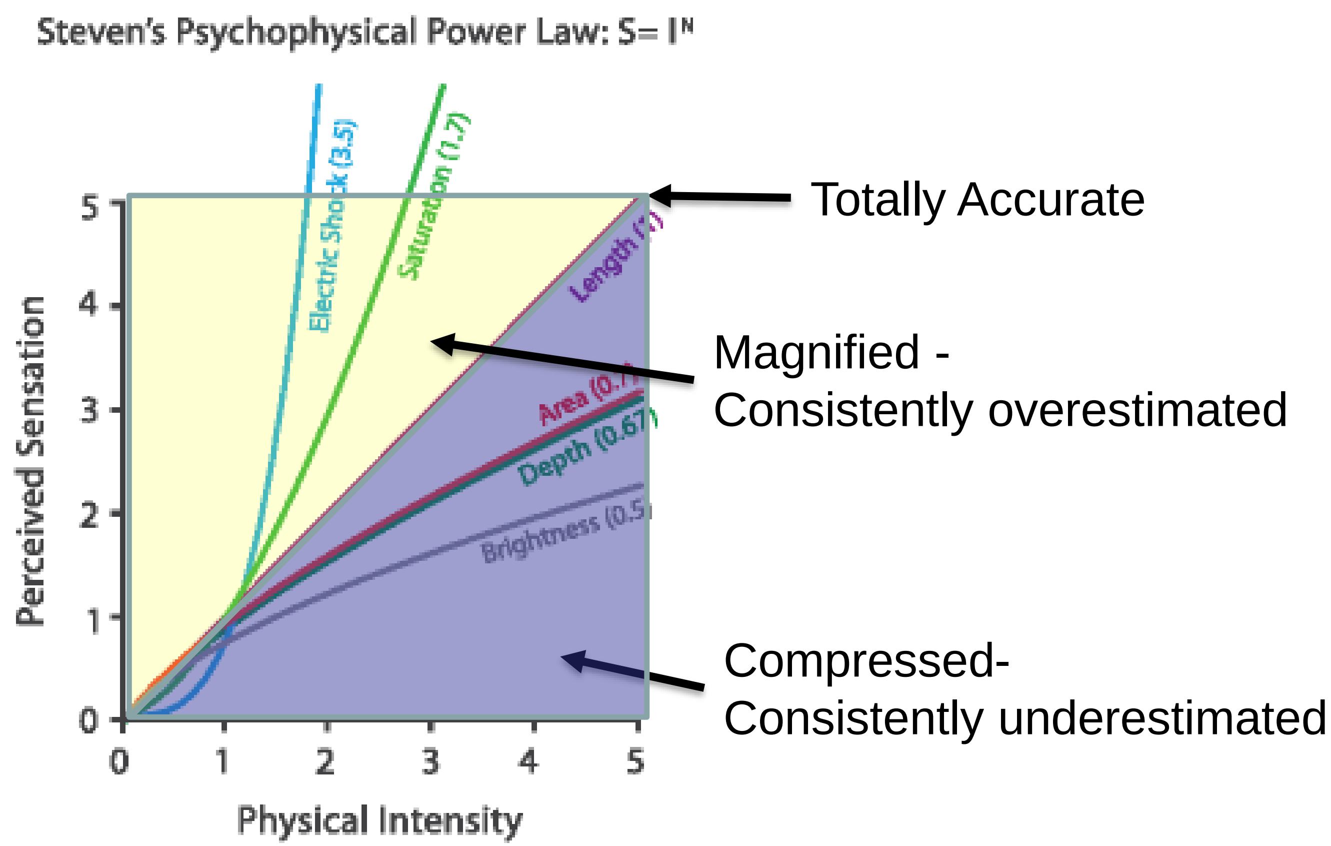
Accuracy

- How accurately does a channel convey information.
- Can mean different things depending on context.

- For Measure/ratio variables:
  - How close to the actual value is the human guestimate.

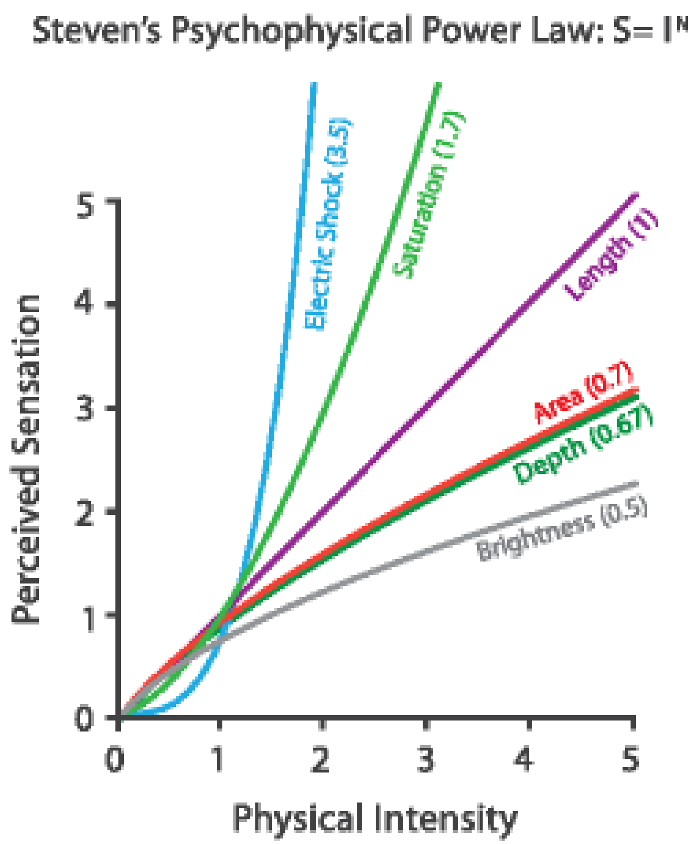
- For categories
  - How well do viewer distinguish between different categories.
  - Red/Green is easier to distinguish than light-green/ligher-green.

Accuracy


Steven's Psychophysical Power Law: S= I^N
Electric Shock (3.5)
Saturation (1.7)
Length (1)
Area (0.7)
Depth (0.67)
Brightness (0.5)
Perceived Sensation
Physical Intensity
0
1
2
3
4
5
Totally Accurate
Magnified -
Consistently overestimated
Compressed-
Consistently underestimated

Steven's Power Law

- **Accuracy**: how close is human perceptual judgement to some objective measurement of the stimulus?



Steven's power law: $S=I^n$

Perception of sensation:

Magnified (n>1):
- Greyscale lightness
- Red-grey saturation

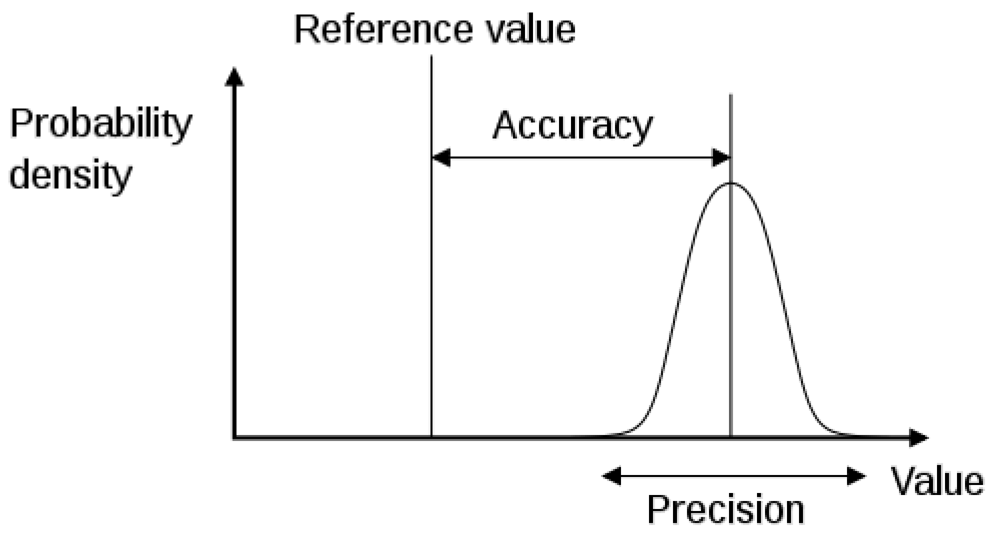
Compressed (n<1):
- Area
- brightness

Accurate (n=1):
- Length

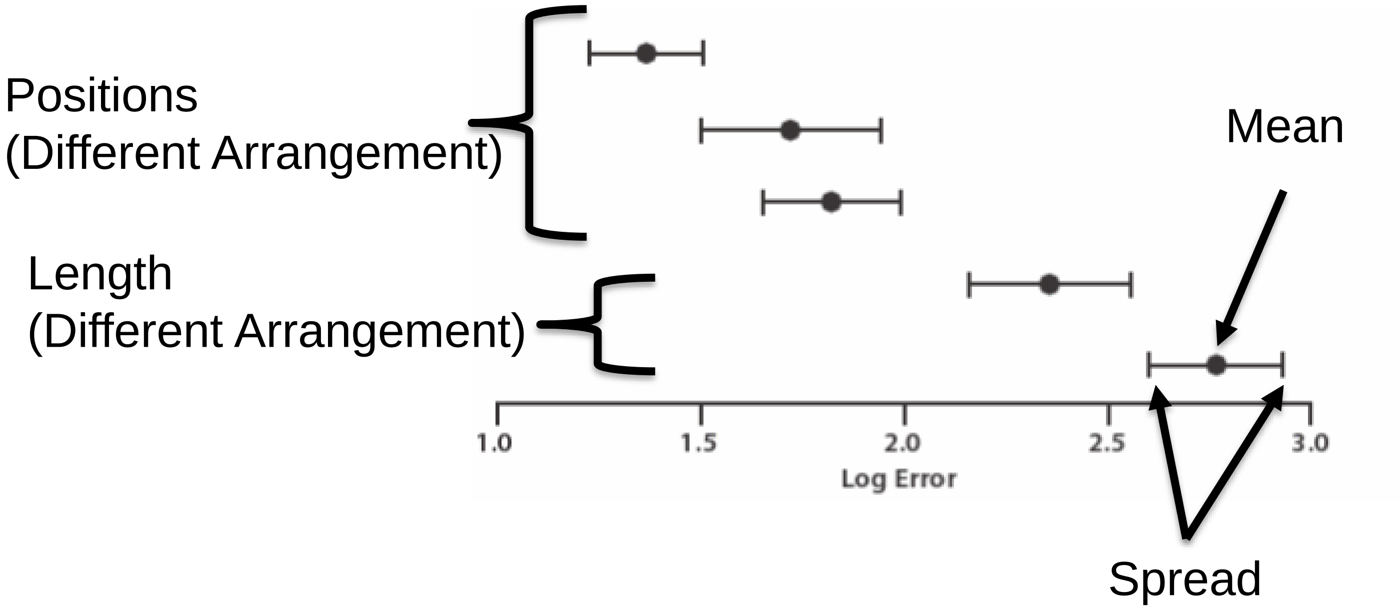
Figure from Munzner (2014) p104; based on original from Stevens, S.S. (1975). Psychophysics: introduction to its perceptual, neural, and social prospects, Transaction Publishers. Page 17.

Precision

- Accuracy measures closeness to the true value.
- Precision measure consistency in response.

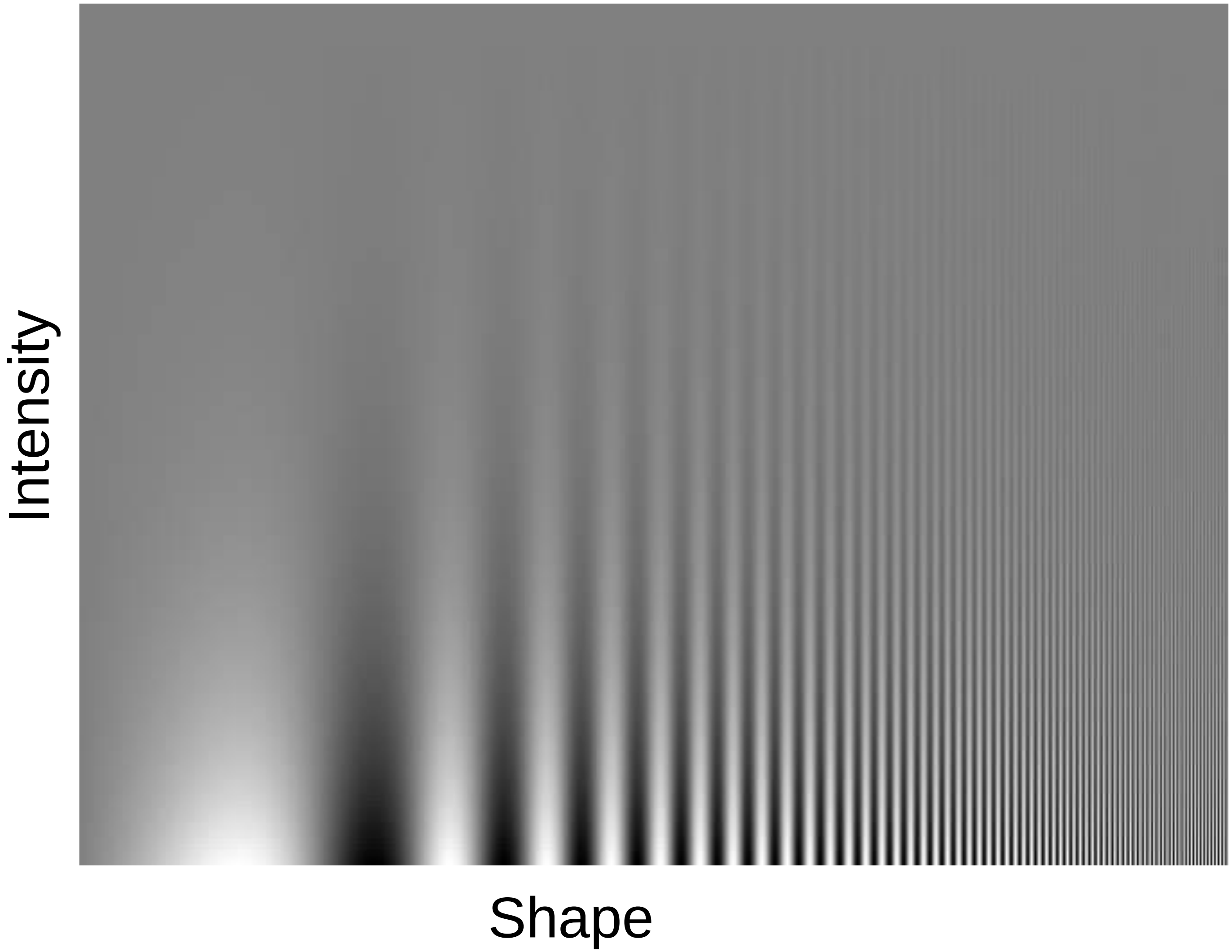


Human Accuracy



Just Noticeable Difference

What is the smallest difference between two stimuli?



http://www.stonesc.com/pubs/Contrast%20Metrics.htm

Just Noticeable Difference

What is the smallest difference between two stimuli?

Determines our ability to understand the data.

We can only detect differences we can see.

Depends on:

Stimuli: Size, Colour, Contrast, Texture etc.

Also depends on:

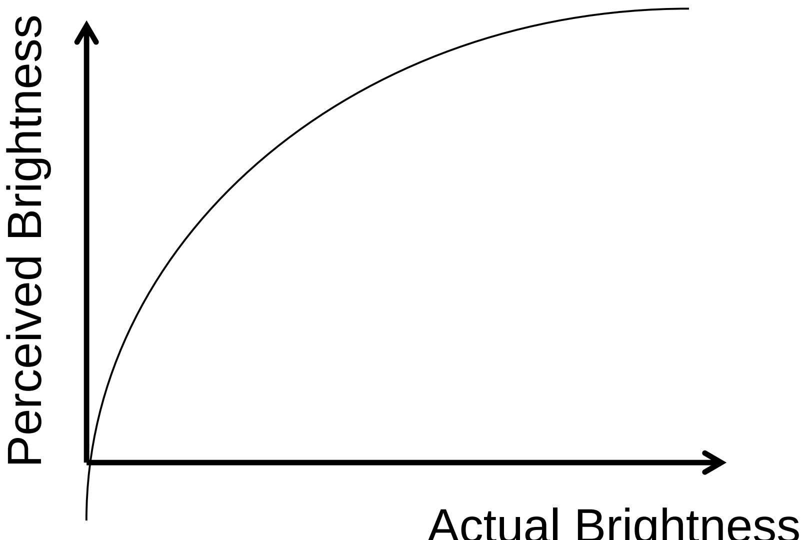
Context: Size, Colour, Contrast, Texture etc. of everything around it.

No two individuals are the same!

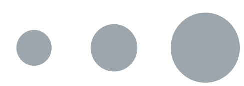
Not all scales are linear

Darkest Lightest

Smallest JND Largest JND



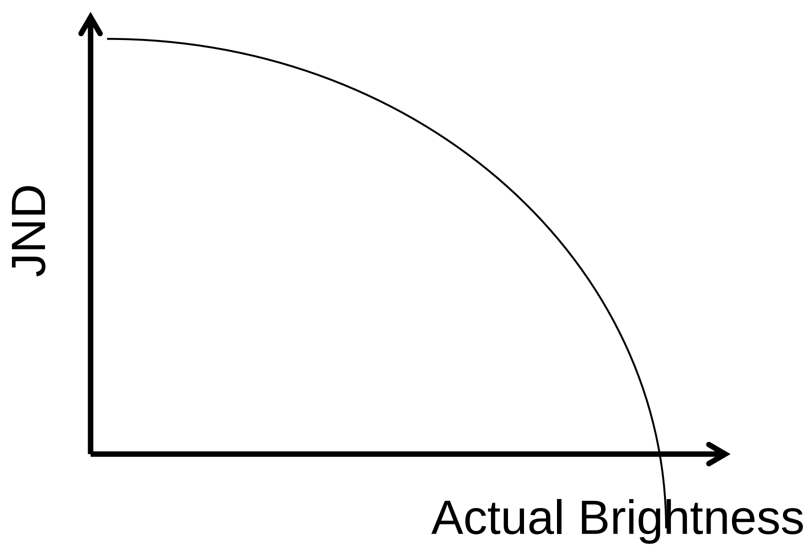
area

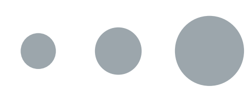


Generally JND is inversed

Darkest Lightest

Smallest JND Largest JND



area 

Section Summary

Different ‘channels’ have different properties.

They vary in their ability to convey information

Individual will vary in how the perceive your image.

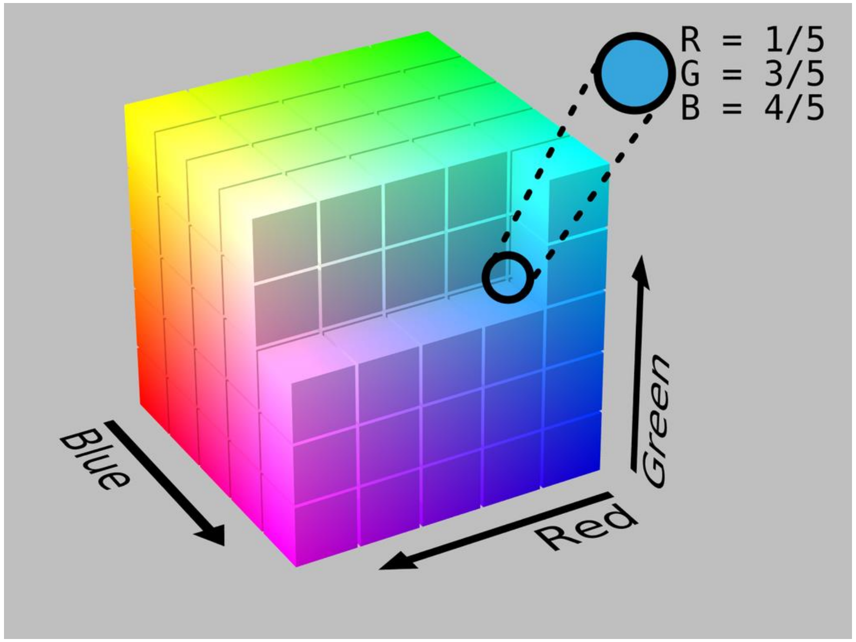
Section Summary

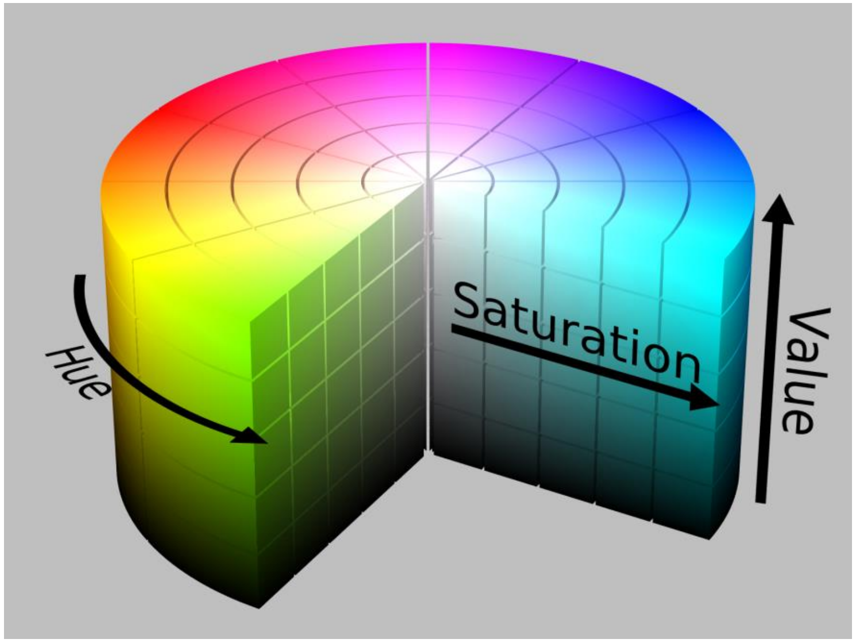
- Viewers exhibit wide range of **accuracy** and **precision**
  - With substantial variations between individuals.
- Values can be consistently overestimated and underestimated.
- Accuracy and precision can both be affected by the size of the measurement.
  - Non-linear relationship between perceived value and actual value.

Colour

- “Colour used poorly is worse than no colour at all” - Edward Tufte
  - “Above all, do no harm”
  - colour can cause the wrong information to stand out and
  - make meaningful information difficult to see.

Colour spaces





https://commons.wikimedia.org/wiki/File:RGB_Cube_Show_lowgamma_cutout_b.png

https://commons.wikimedia.org/wiki/File:HSV_color_solid_cylinder_alpha_lowgamma.png

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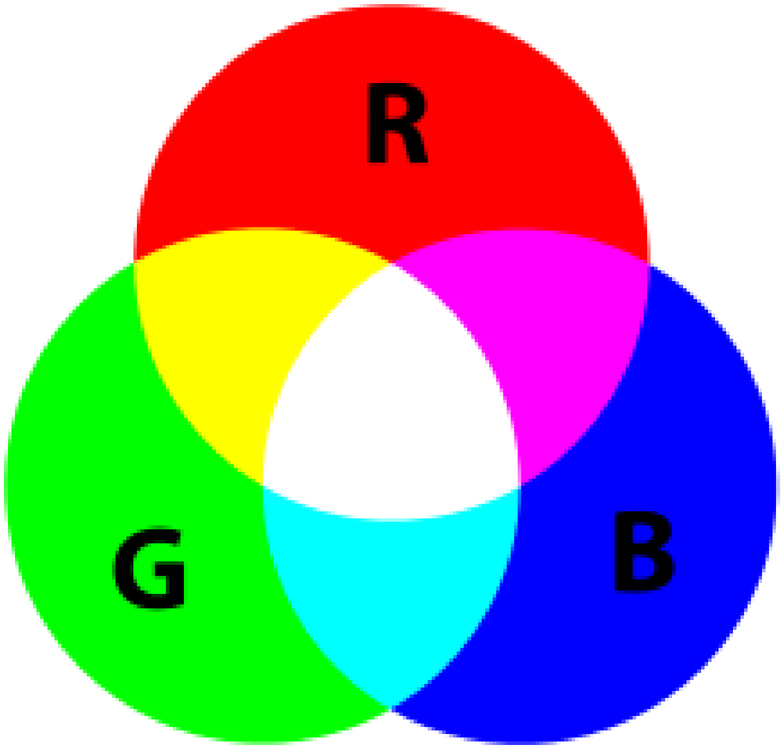
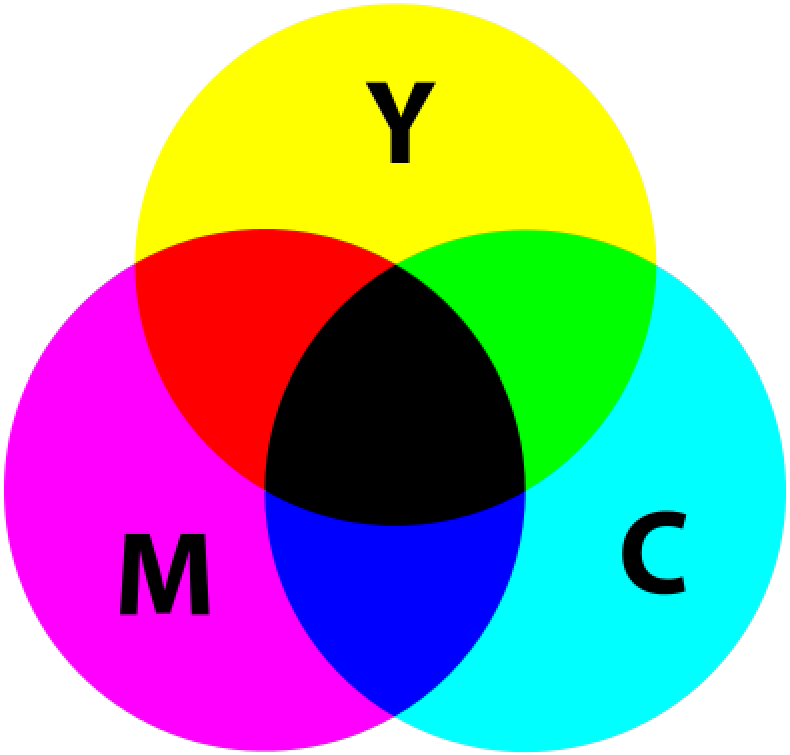
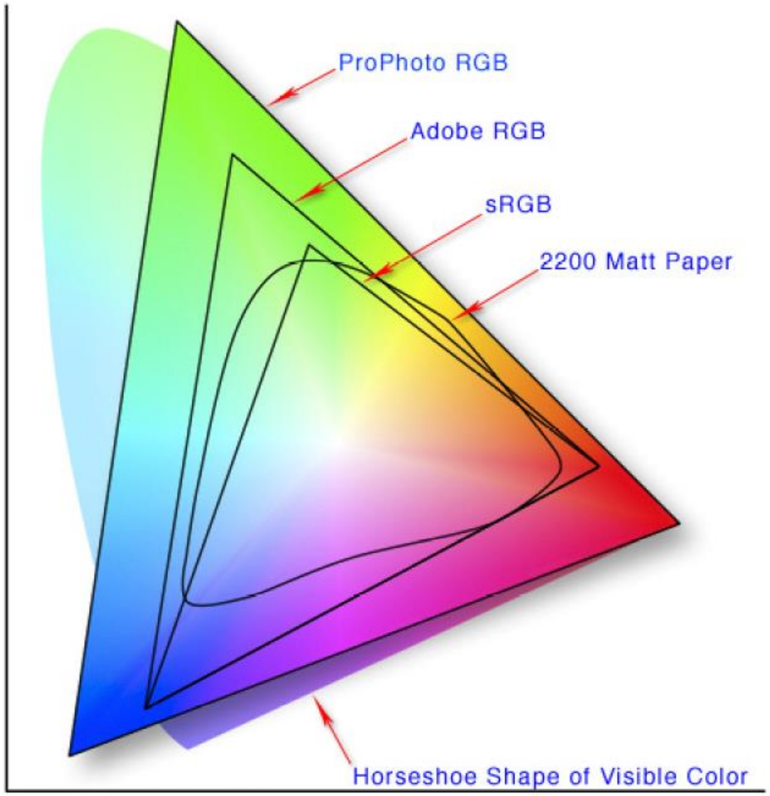
Additive Spaces

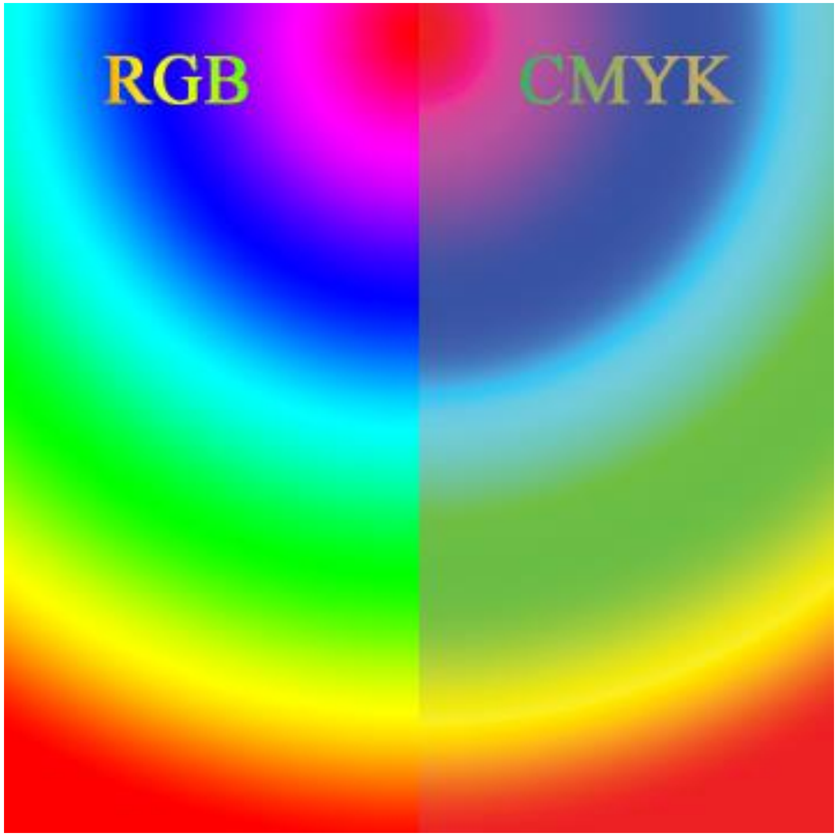


Subtractive Spaces



Colours on the screen are not the same as printed colours





Printers generally have a smaller range of colour than Screens (left)
Printers cannot perfectly reproduce many shades (right)

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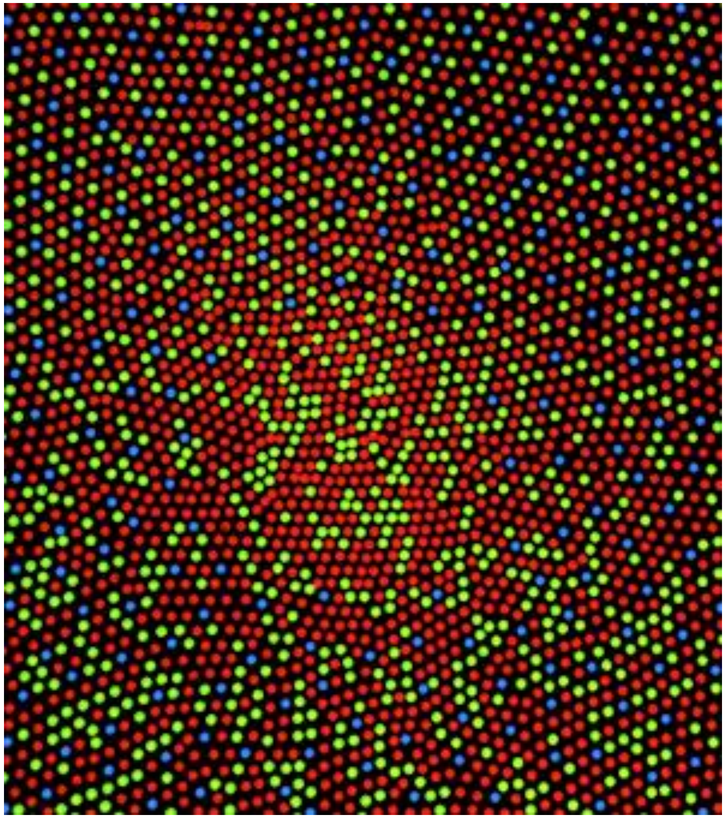
Colour in humans



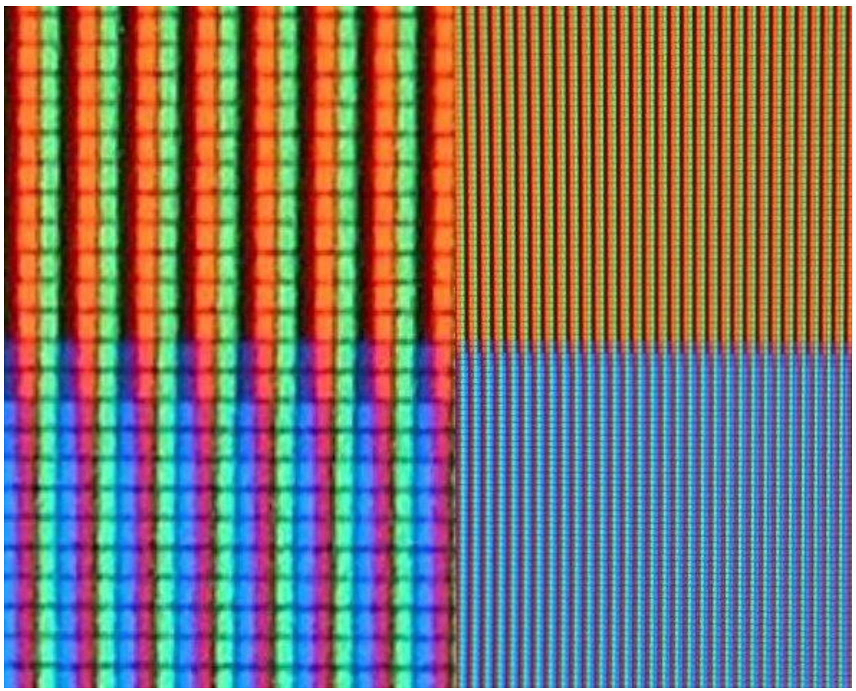
Cells in the retina are sensitive to light at different wavelengths.

The wavelengths are roughly

Red, Green & Blue

Colour perception is made by combining these colours.

How colour is displayed



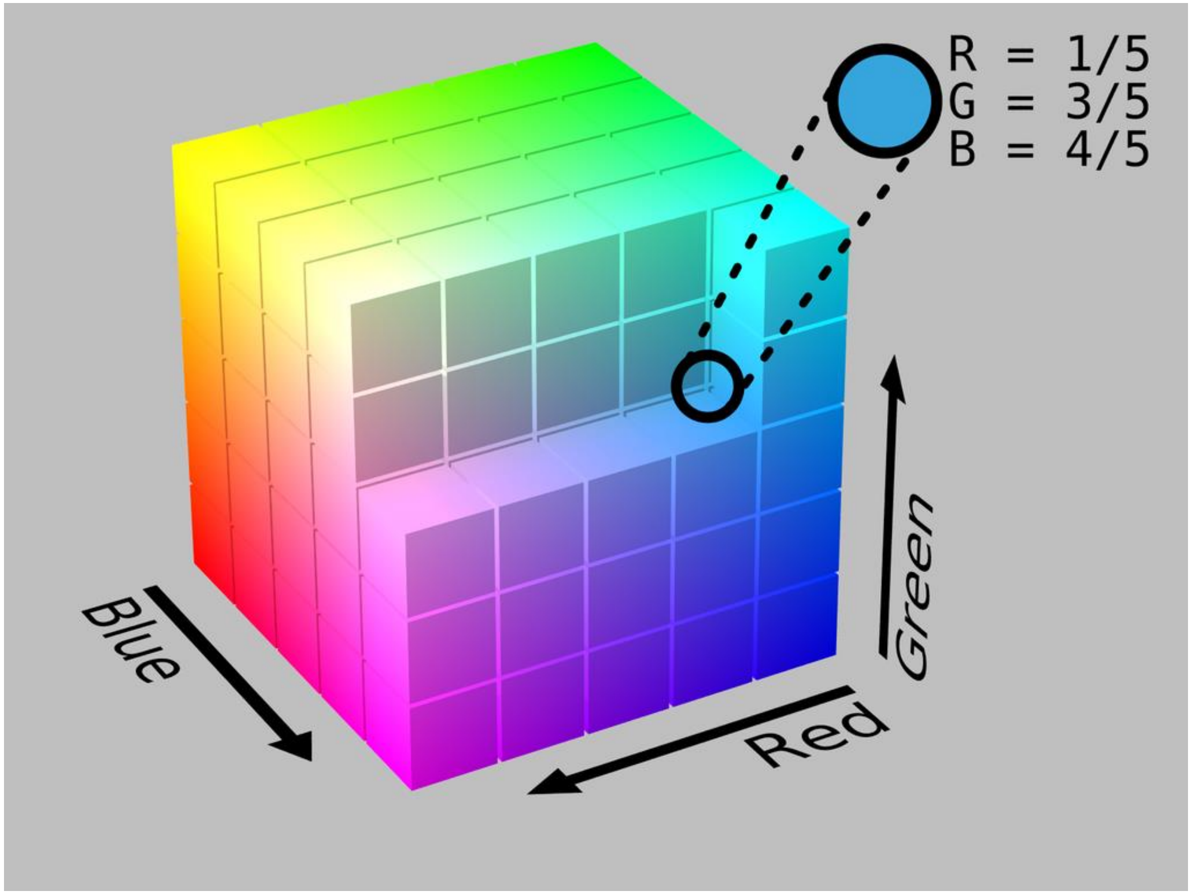
Computer displays (LCD, CRT) operate by lighting up tiny little pixels with one of three colours;

Red Green Blue

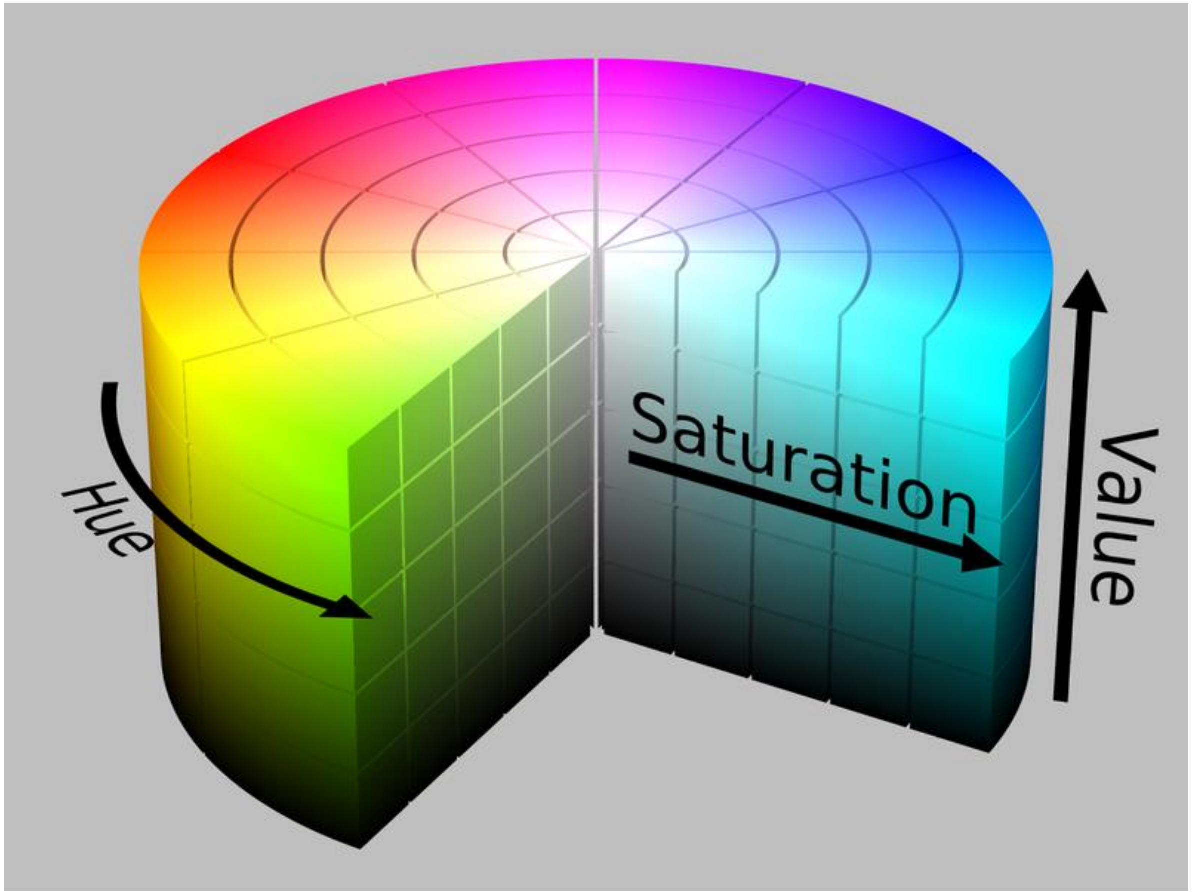
Colours are additive sums

Red, Green and Blue colour are **not** in exactly the same position and **not** in equal numbers.

RGB Colour space



HSV Colour Space



Brewer Palettes

- Brewer palettes (colorbrewer.org) provide a range of palettes based on HSV model which make life easier for us….

Avoid the use of hue to encode quantitative variables

Quantitative encoding e.g. heat maps

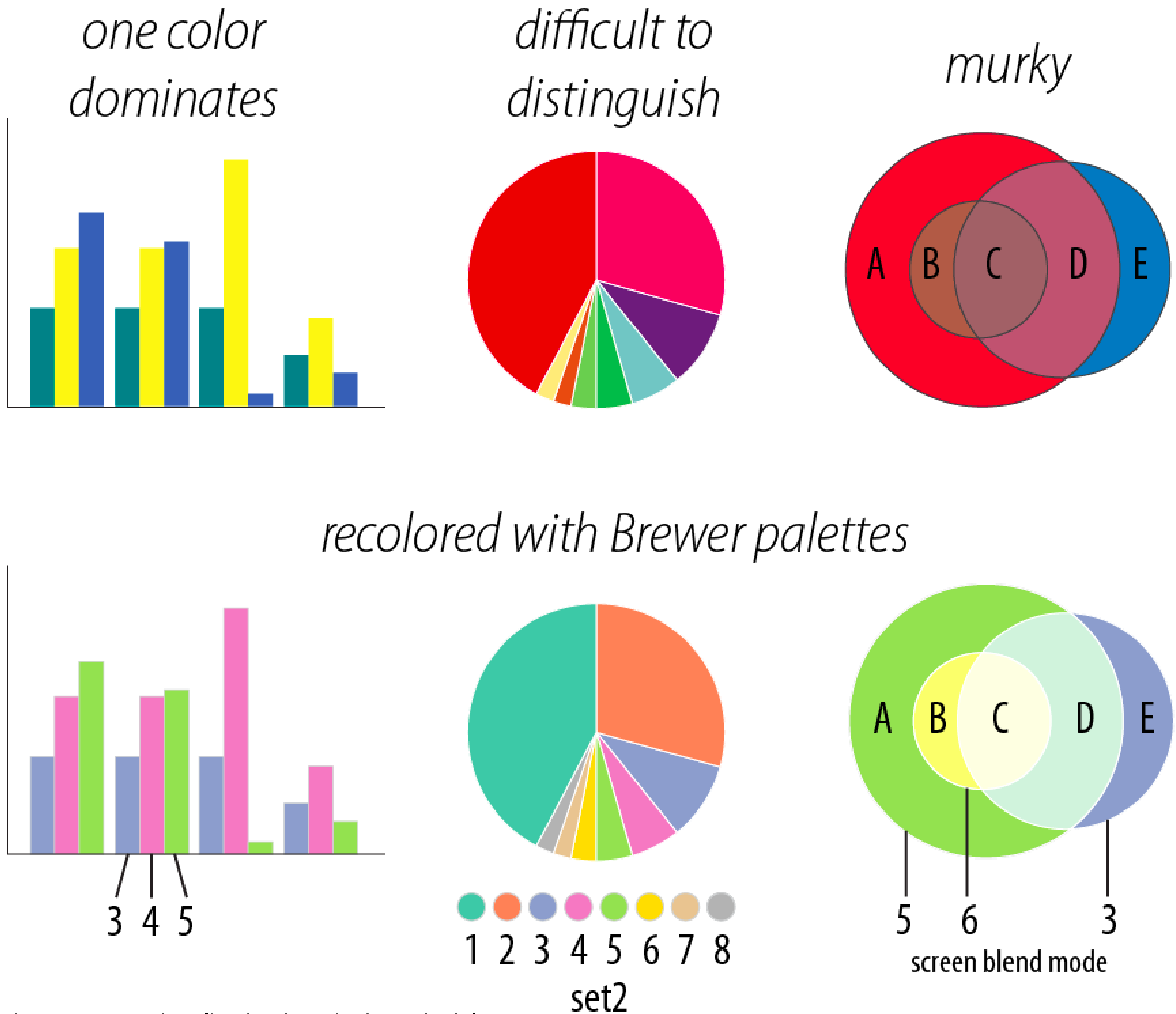
Two-sided quantitative encodings

Fig. Courtesy of M. Krzwinski,

Examples

Poor use of colour

Brewer colours



M. Krzwinski, behind every great visualization is a design principle, 2012

Conversion to Grey scale

- Ensure chosen colour set works well in grey scale
  - Sequential palette works well here

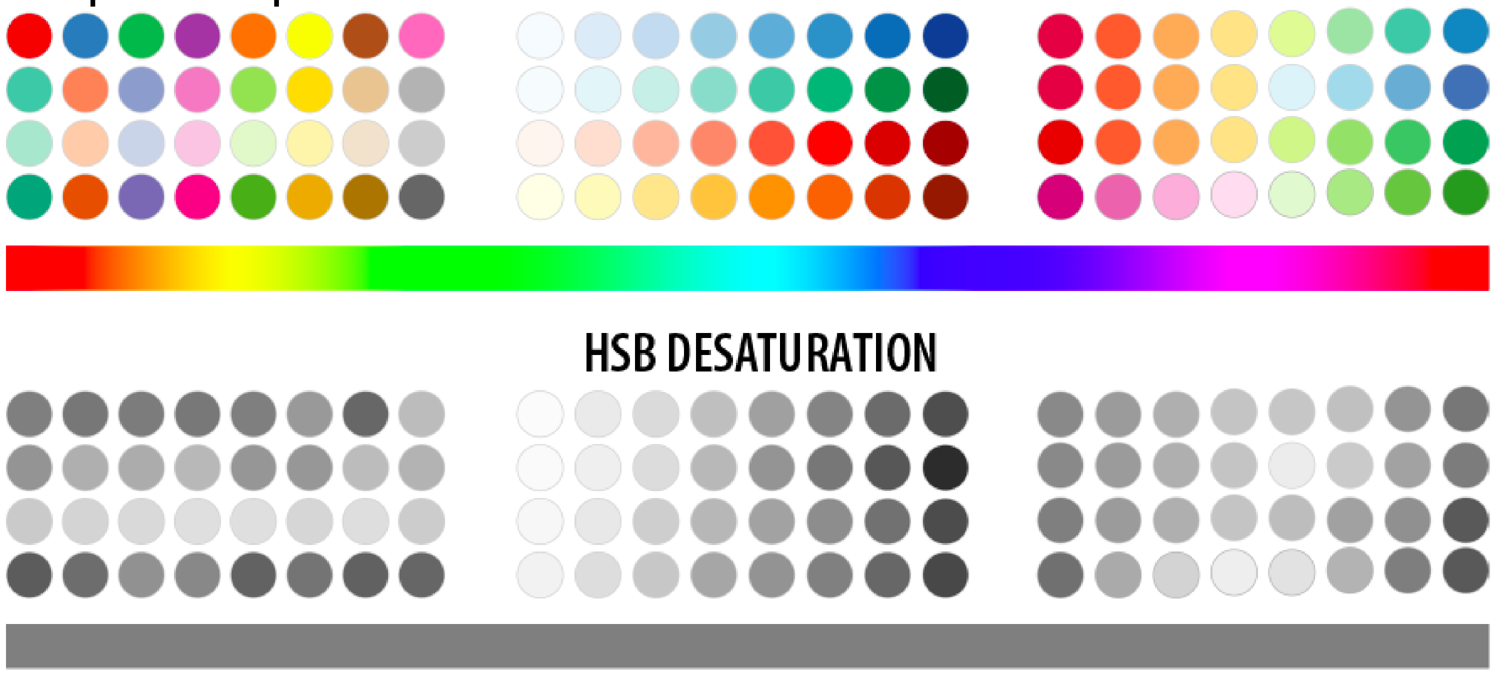
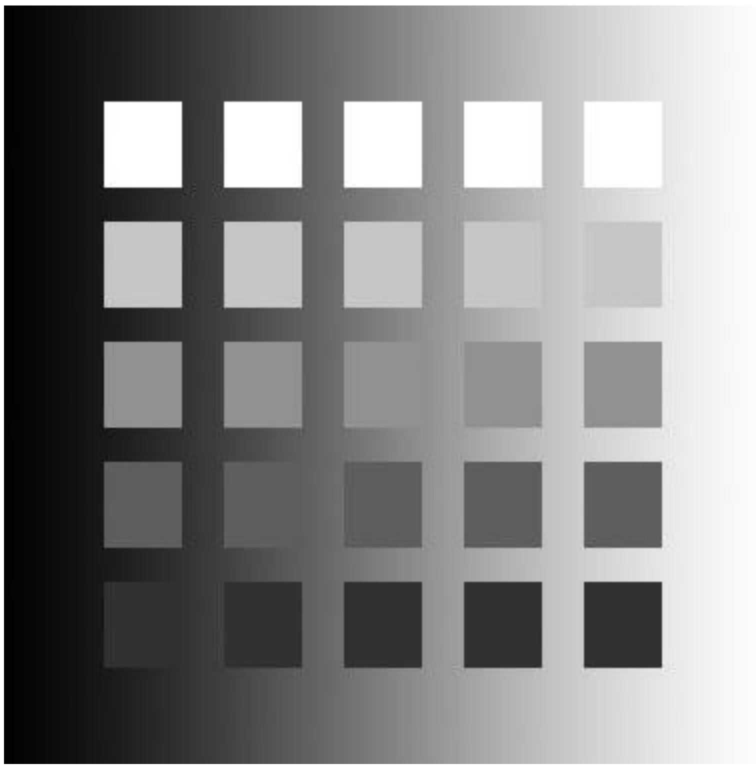


Fig. Courtesy of M Krzywinski



The Bartleson-Breneman Effect

Perceived luminance depends on the background.

Larger contrasts induce brighter seeming stimuli

Steven Few's Graph Design IQ Test

- http://www.perceptualedge.com/files/GraphDesignIQ.html

Study guide for this lecture

Required Reading:

Munzner, T. (2014). *Visualization Analysis and Design*.

Chapter 5 - Marks and Channels

Chapter 10 - Map Colour and Other Channels.

Reflective Questions:

- Discuss the properties of data that need to be considered when designing a visualisation, and give examples of how they might influence your design choices.
- Discuss the different properties of an image that are available to us when designing a visual representation and the factors that need to be taken into consideration when making our design choices.
- Illustrating with examples, explain the rules which help us select the best visual encodings for our data.

References

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Further reading

- behind every great visualization is a design principle: MARTIN KRZYWINSKI -2012 http://mkweb.bcgsc.ca/vizbi/2012/