# Visual Analytics
# Vision and Perception

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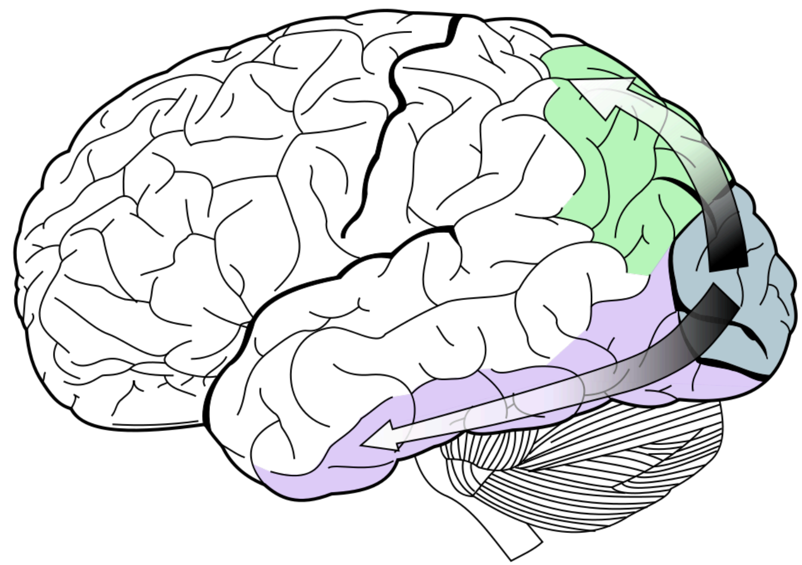
# Perception

- Perception: the way in which something is regarded, understood, or interpreted (Oxford Dictionary)
- Electrical signals from vision system are interpreted and organized by the brain
- Two-stream hypothesis:
  - Ventral Stream
  - Dorsal Stream

The dorsal stream (green) and ventral stream (purple) are shown. They originate from a common source in the visual cortex



# Perception and Congnition

**Stage 1**

- Rapid parallel processing to extract basic features

**Stage 2**

- Slow serial processing to extract patterns and structures

**Stage 3**

- Sequential scan to perform task-oriented interpretation of visual information

Ware Colin. Information Visualization, third edition. 2004

# Perception and Cognition

12589651687651321689432‌13
54634796543213203549684‌13
20687984171845295292871‌49
21749531781952939265468‌31
35465165098985546849829‌84

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12589651687651321689432‌13
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2068798417184[illegible]9287149
2174953178195[illegible]939[illegible]6546831
3546516509898[illegible]4982984

How many “3”?

# Visual Perception

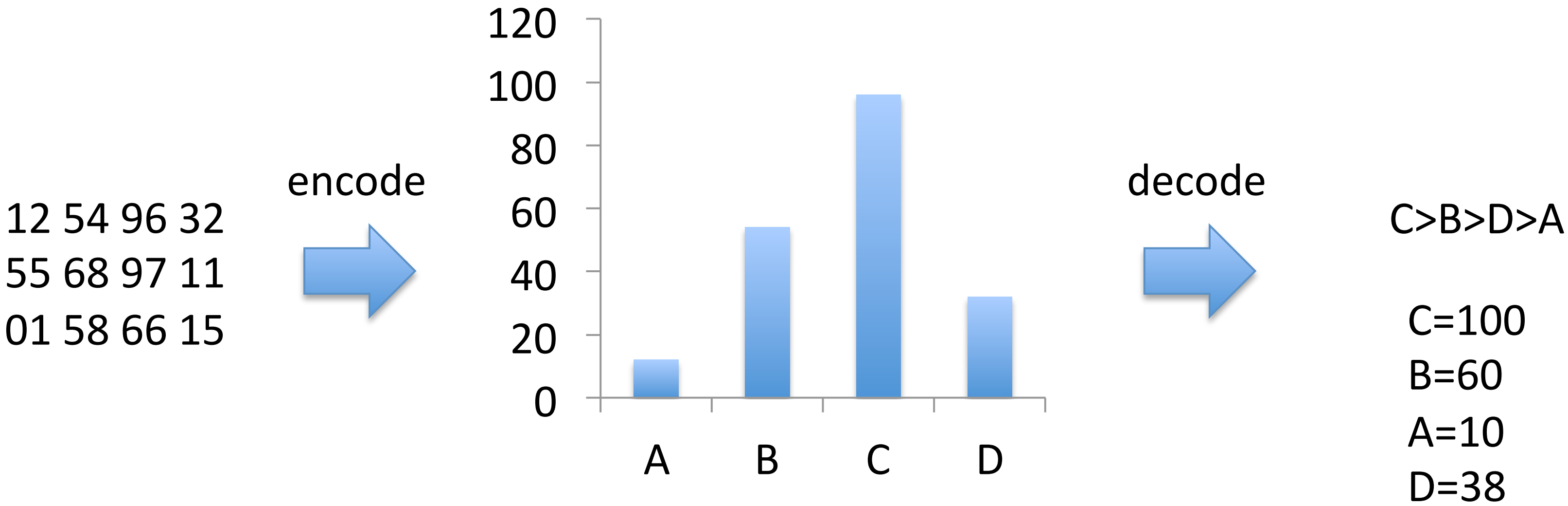
- Early visual processing takes places without our conscious intervention: pre-attentive vision
- Graphs that convey information at this level allow the observer to be more efficient in decoding

# Visual Cognition

- At second stage, the observer is required to consciously analyze the image/scene
- At this level, the observer can perform higher level reasoning
  - This object is larger than the other one
  - This street slope is lower than the previous

# Visual Encoding/Decoding

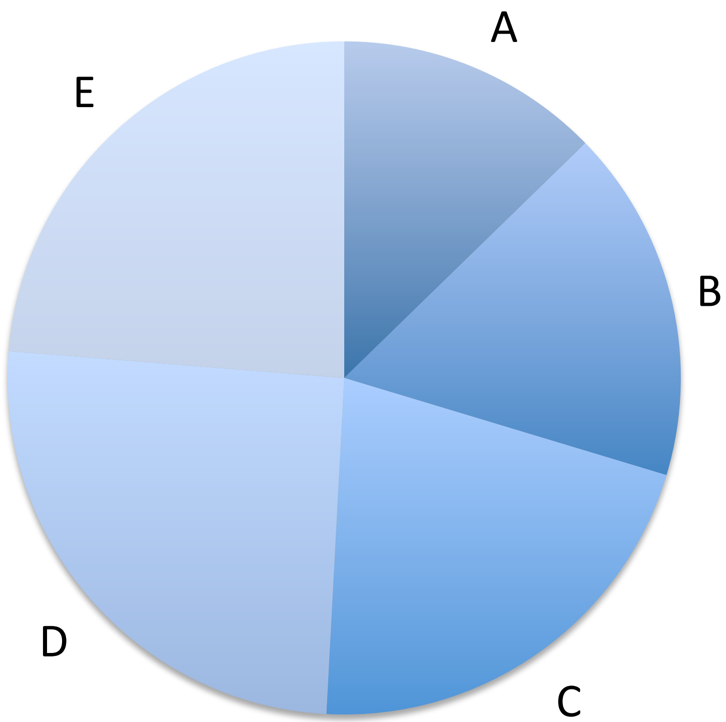
- A graph encode a set of information as a set of graphical attributes
- The observer have to decode the graphical attributes to extract the original information



# Cleveland & McGill: graphical encodings

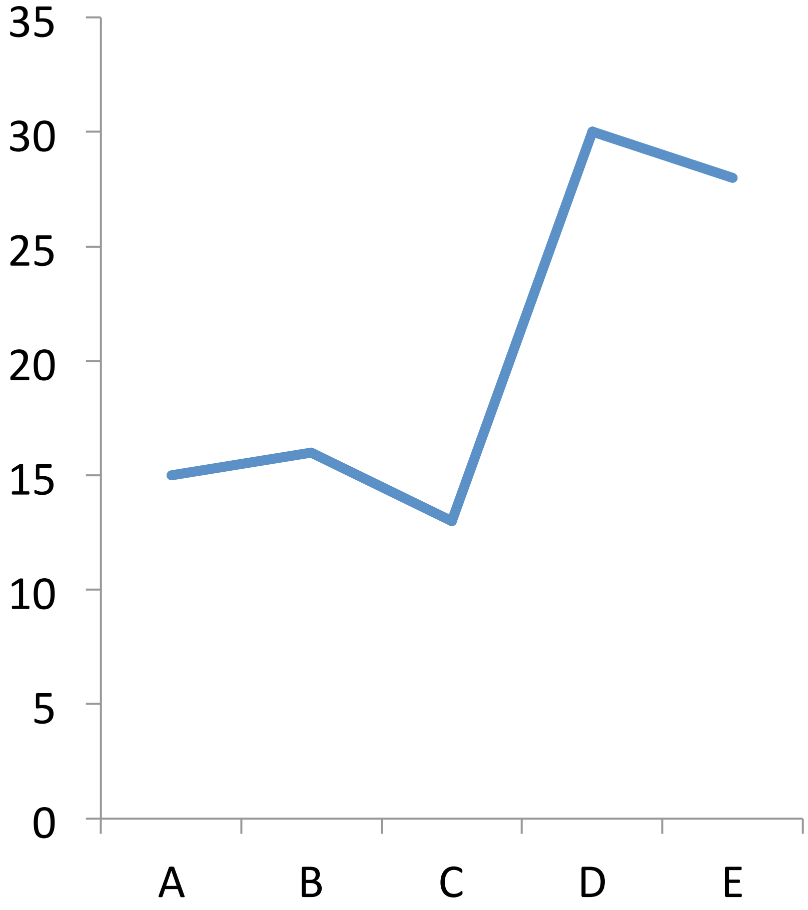
- Angle
- Area
- Color Hue
- Color Saturation
- Density
- Length
- Position on a common scale
- Position on non aligned scale
- Slope
- Volume

# Angle decoding



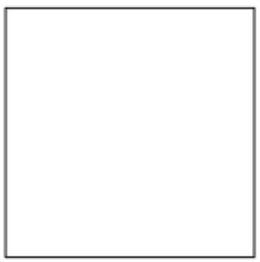

- It is difficult to compare angles
  - Underestimation of acute angles
  - Overestimation of obtuse angles
  - Easier if bisectors are aligned

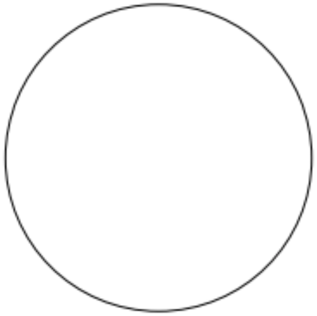
# Slopes Decoding




- Same difficulties as angles
- Easier task since one branch is aligned with x-axis

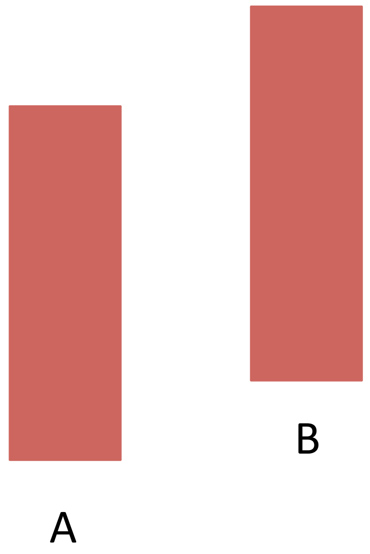
# Area Decoding





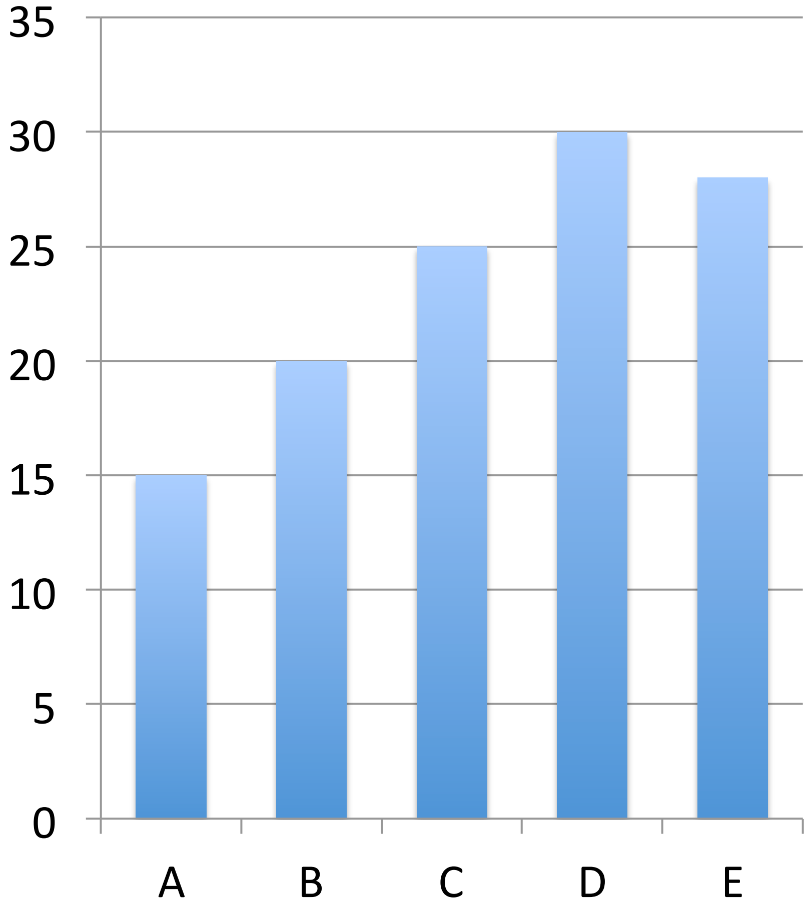

- Area is not well decoded
  - Different regular shapes
  - Irregular shapes
  - Context influences (thin area within compact thick area)

# Length Decoding



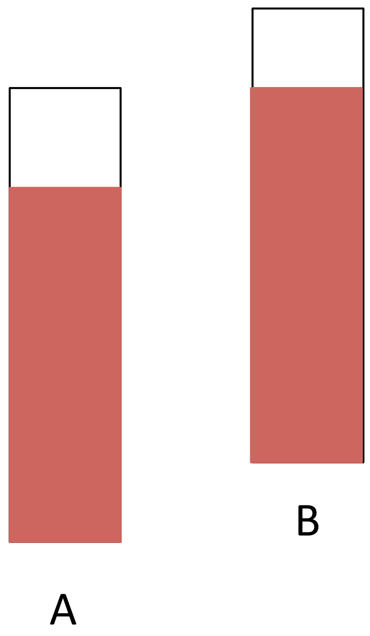

- Straight forward to endoce numerical values
- Difficulties with relative lengths

# Position on a common scale




- Widely used in statistical charts

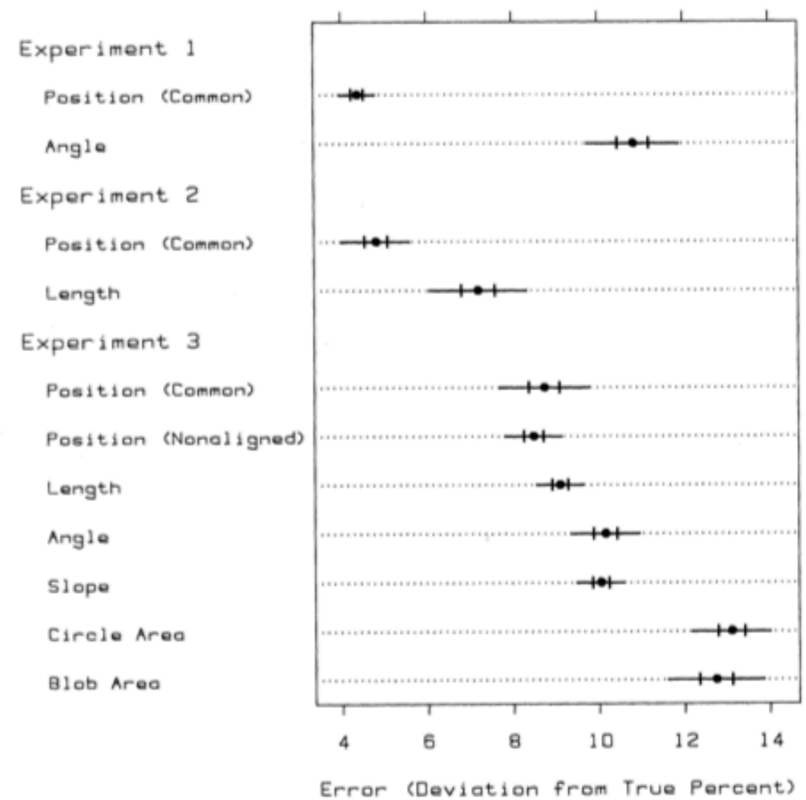
# Position on non-aligned scale




- Not as bas as common scale
- Still acceptable

# Designing Effective Visualizations

- If possible, use graphical encoding that are easily decoded
- Graphical Attributes ordered(Cleveland & McGill):
  - Position along a common scale
  - Position on non aligned scales
  - Length
  - Angle and Slope
  - Area
  - Volume, density, color saturation
  - Color Hue



# PERCEPTION LAWS

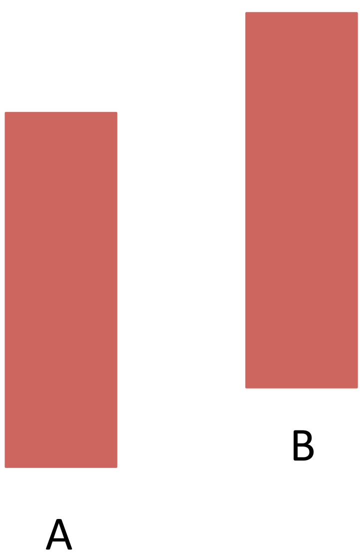
# Weber's Law

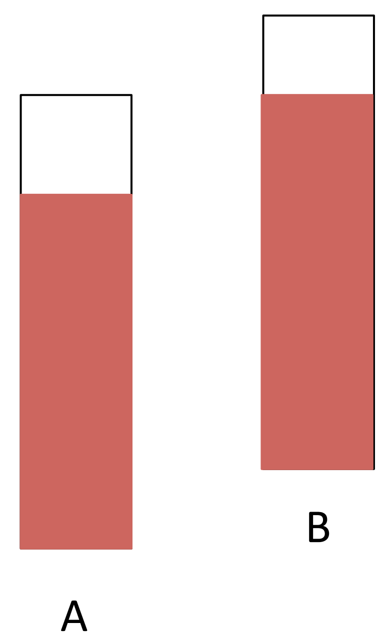
- Just-noticeable difference between two stimuli is proportional to their magnitudes
- Case study on length
  - Given two lines with lengths *x* and *x+w*
  - If *w* is small, it is difficult to notice difference between the two lines
  - If *w* is larger, it is easier to catch the difference
- How large should w be?
  - The probability of detecting the change is proportional to the reltaive value *w/x*

# Weber's Law

- Given values (90, 92)
- Detect with probability of 2/90

- Given values(90,92)
- Detect with probability of 2/10



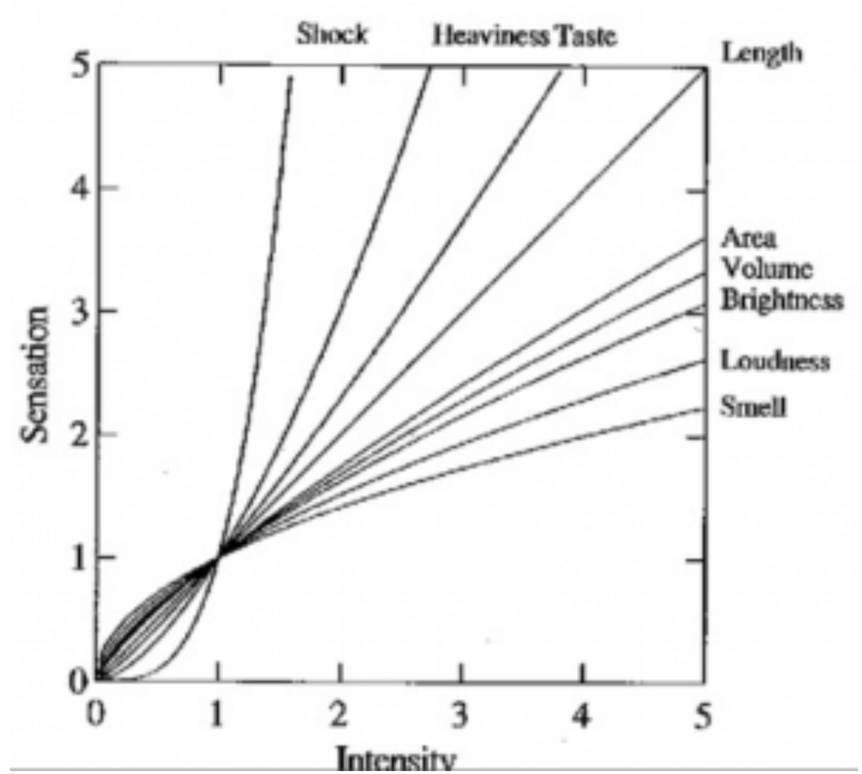



# Stevens' Law

- Model the relation between a stimulus and its perceived intensity
- Given a stimulus $x$ encoded with a visual attribute
- An observer decode a perceived value $p(x)$
- Stevens' law states that
  - $p(x) = kx^{\beta}$
  - where $k$ is constant and
  - $\beta$ is a constant that depends on the nature of stimulus

# Stevens' law

- Better effectiveness when $p(x) = kx^{\beta}$ is linear
- Linearity depends only on β
- Different visual encodings yields typical ranges for β
  - Lengths: 0.9 – 1.1
  - Area: 0.6 – 0.9
  - Volume: 0.5 – 0.8



# Weber and Stevens' Laws

- Given two values $x_1$ and $x_2$
- Let the perceived values be $p(x_1)$ and $p(x_2)$

$$\frac{p(x_1)}{p(x_2)} = \left(\frac{x_1}{x_2}\right)^{\beta}$$

# Weber and Stevens' Laws: areas

- For areas β=0.7
- Let $x_1$=2 and $x_2$=1
- The perceived difference will be

$$\frac{p(2)}{p(1)} = \left(\frac{2}{1}\right)^{0.7} = 1,6245$$

- For areas β=0.7
- Let $x_1$=0,5 and $x_2$=1
- The perceived difference will be

$$\frac{p(\frac{1}{2})}{p(1)} = \left(\frac{1/2}{1}\right)^{0.7} = 0,6155$$

# Weber and Stevens' Laws: areas vs lengths

- For areas β=0.7
- Let $x_2=x_1+w$
- The perceived difference will be

$$\left(\frac{x+w}{x}\right)^{0.7} \approx 1+\frac{0.7w}{x}$$

- For lengths β=1
- Let $x_2=x_1+w$
- The perceived difference will be

$$\left(\frac{x+w}{x}\right)^{1} = 1+\frac{w}{x}$$