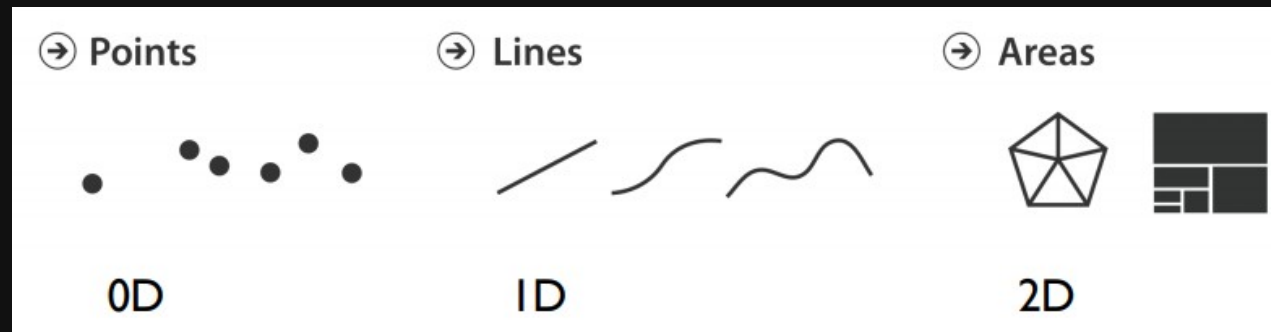


5a: Marks, Channels

Applied Perception

Marks

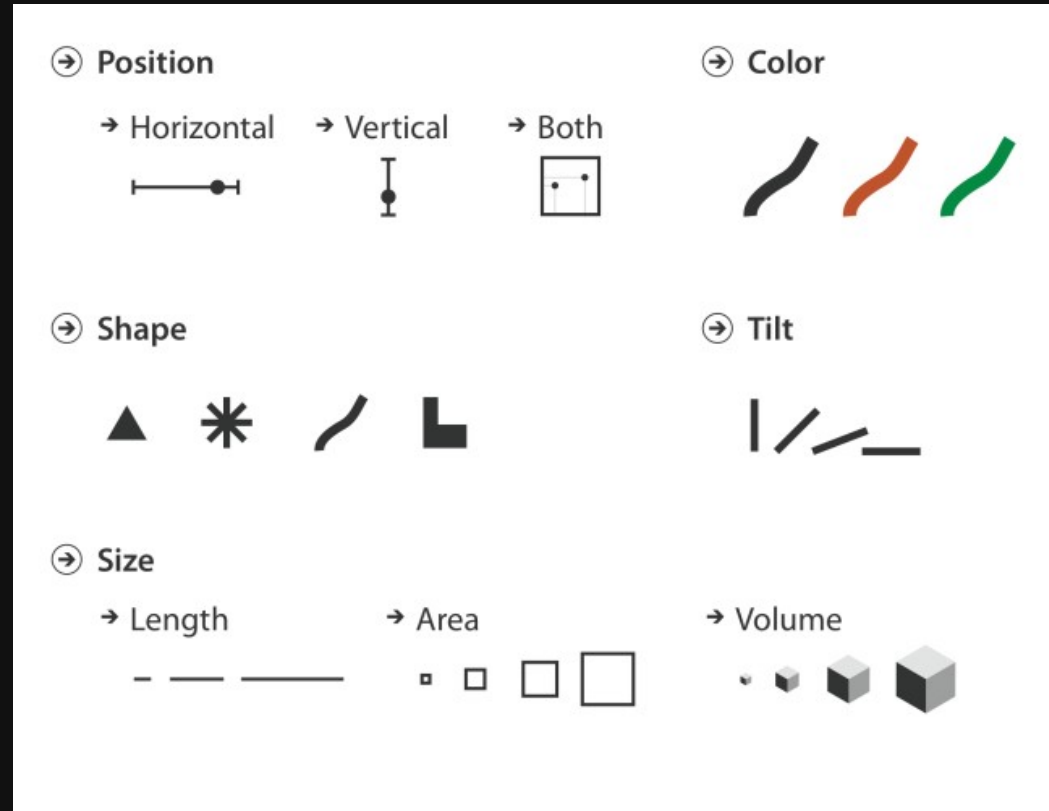
Marks are your basic graphical geometric elements.
E.g. points, bars, circles, lines, etc.



Channels

(aka **Visual variables**)

Channels encode information as attributes / properties of a mark.
E.g. Position, shape, size, color, etc.



Visualization:

Collection of marks (expressed via channels)

A visualization represents data using a collection of graphical **marks** such as bars, lines, and point symbols.

The attributes of a mark — such as its position, shape, size, or color — serve as **channels** in which we can encode underlying data values.

Channel: Identity vs Magnitude

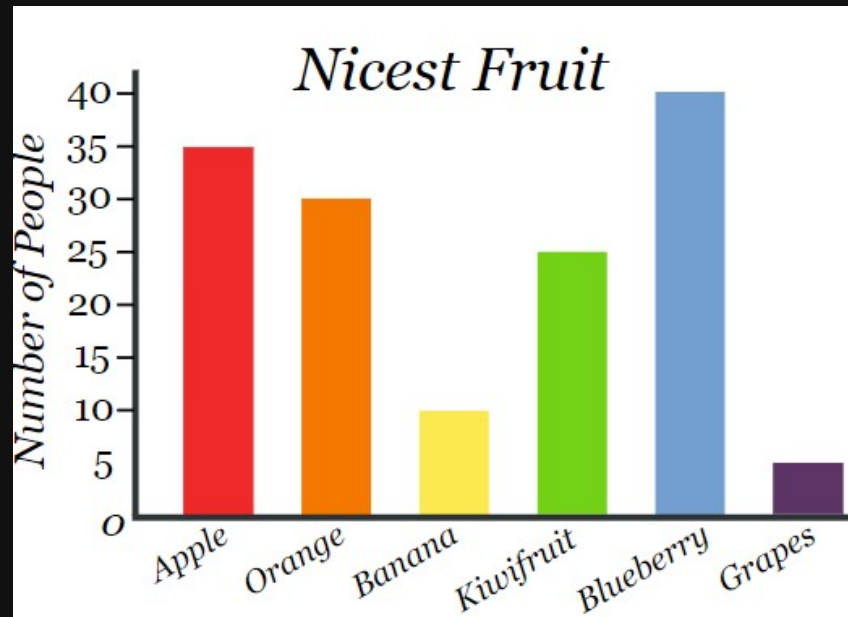
Channels: Expressiveness Types and Effectiveness Ranks

➔ Magnitude Channels: Ordered Attributes



➔ Identity Channels: Categorical Attributes

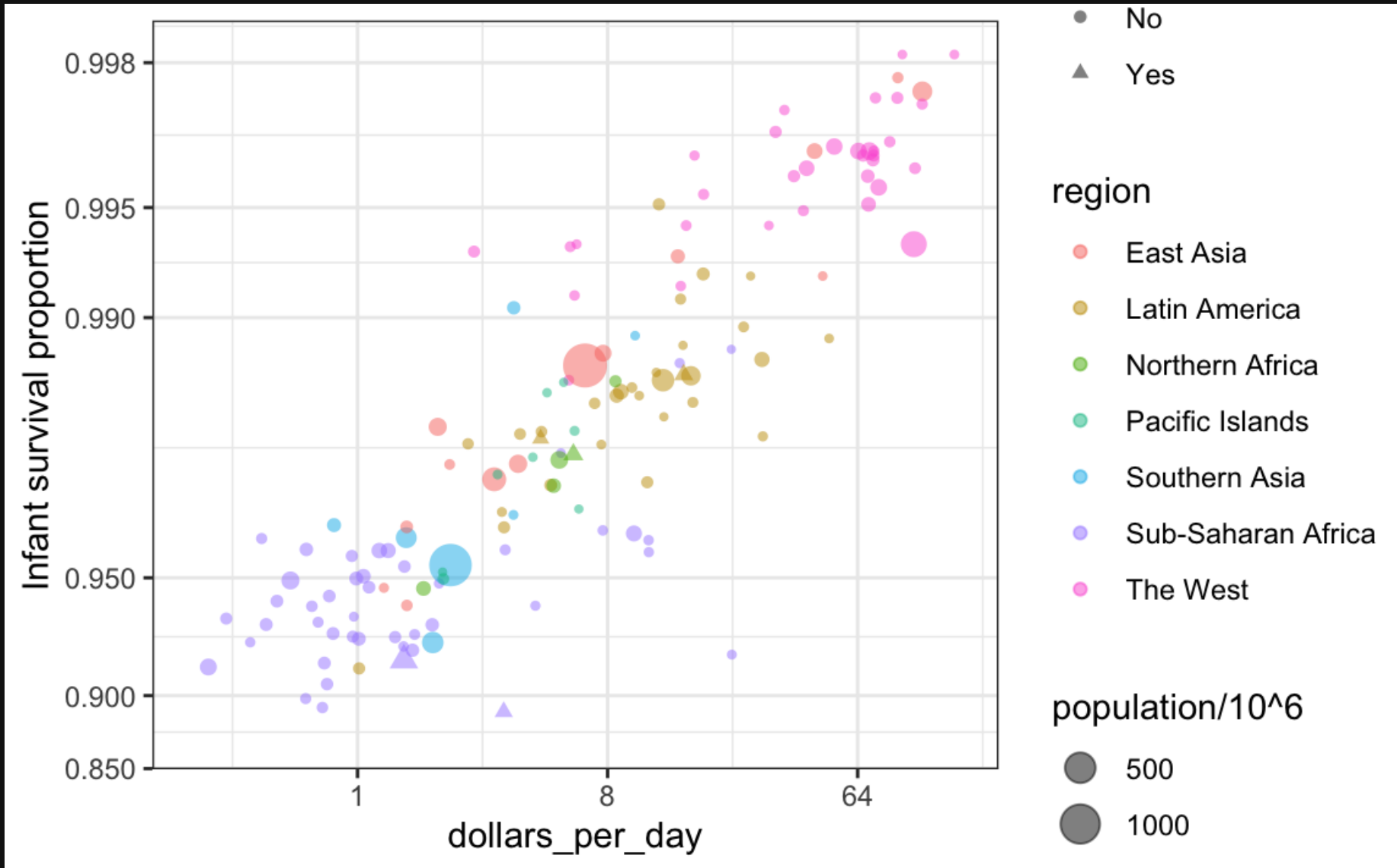




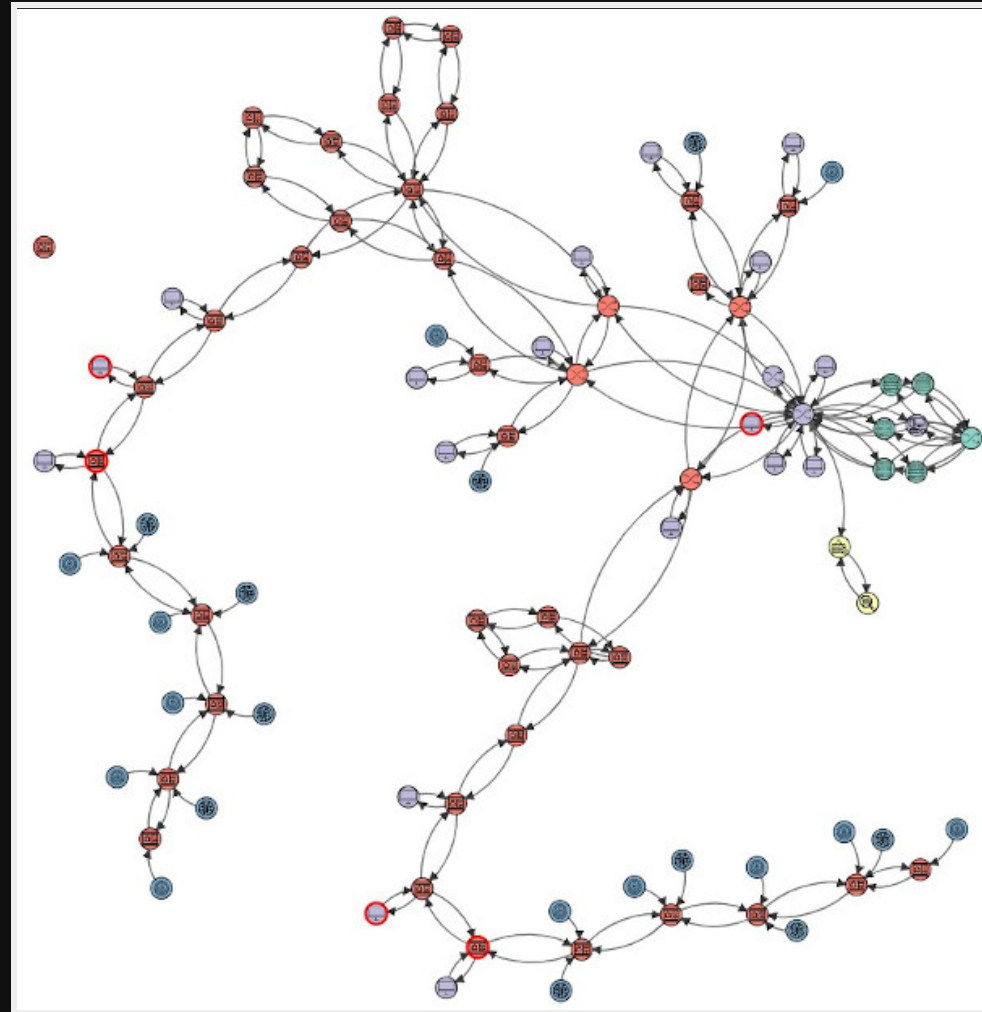
This fruit chart encodes two data attributes as bar marks.

- It encodes number of people - a quantitative data set - as a vertical spatial magnitude channel.
- It encodes type of fruit - a nominal data set - as a horizontal spatial identity channel.
- Type of fruit is also encoded as a redundant color identity channel.

How many channels are there in this chart? What data scales are encoded?



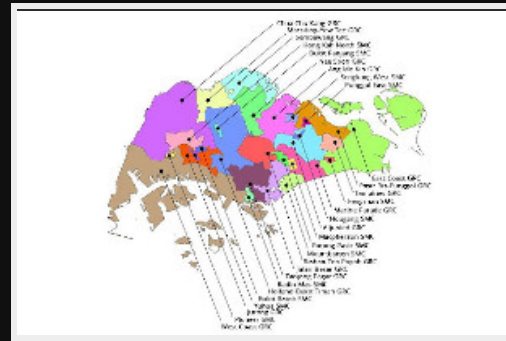
How many channels are there in this chart? What data scales are encoded?



Channel: Expressiveness

The **expressiveness** principle dictates that the visual encoding should express all of, and only, the information in the dataset attributes.

Color channel violation of expressiveness principle:



Channel: Effectiveness

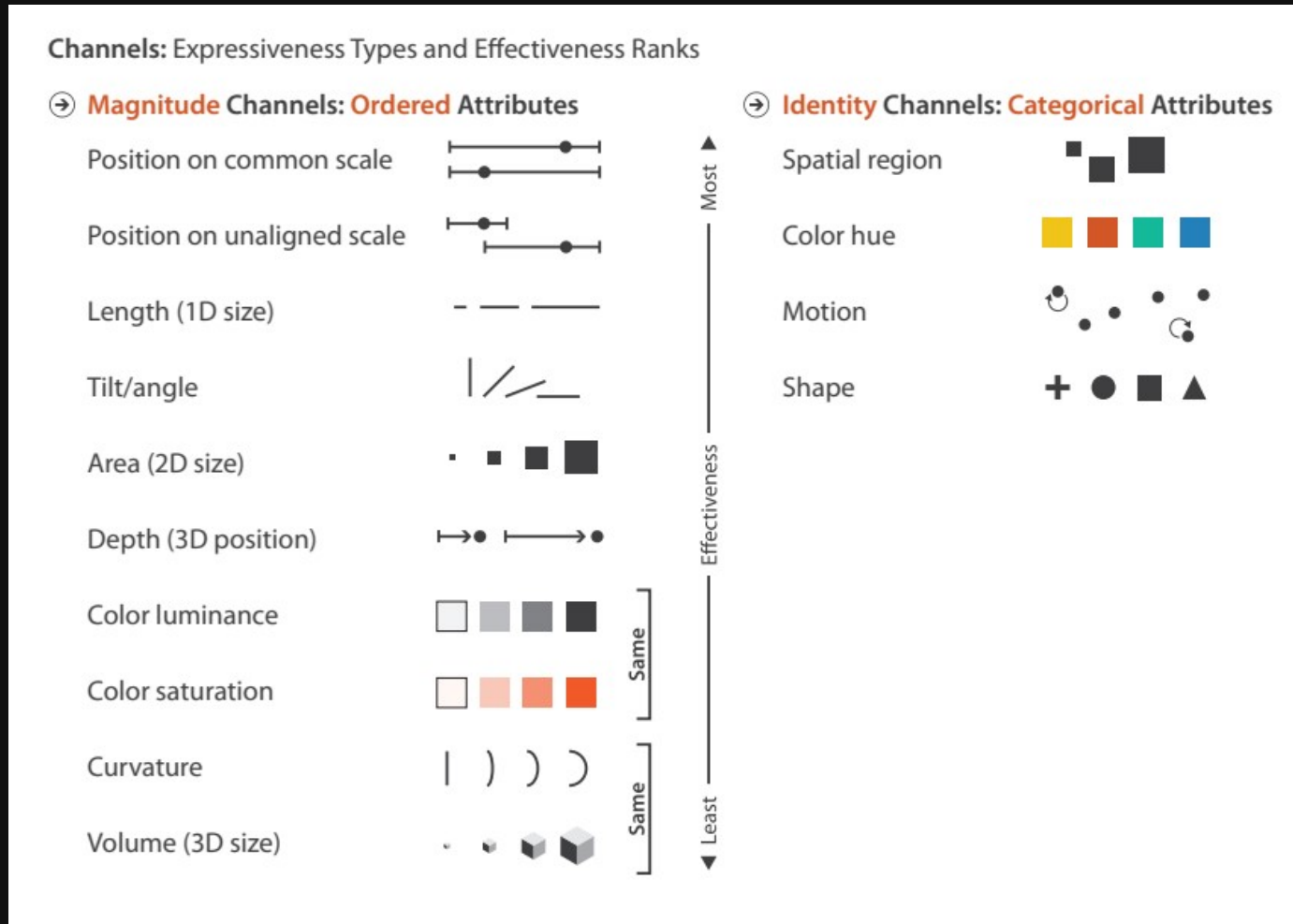
The **effectiveness** principle dictates that the importance of the attribute should match the salience of the channel; that is, its noticeability.

The most important attributes should be encoded with the most effective channels to be noticeable, and so on and so forth.

Channel effectiveness can be described by these principles:

- Accuracy
- Discriminability
- Separability
- Salience (pop-out)
- Grouping

Channel ranking (based on effectiveness)



Human perception

Weber-Fechner Law

The amount of change that is necessary to be noticed is systematically related to the size of the stimulus.

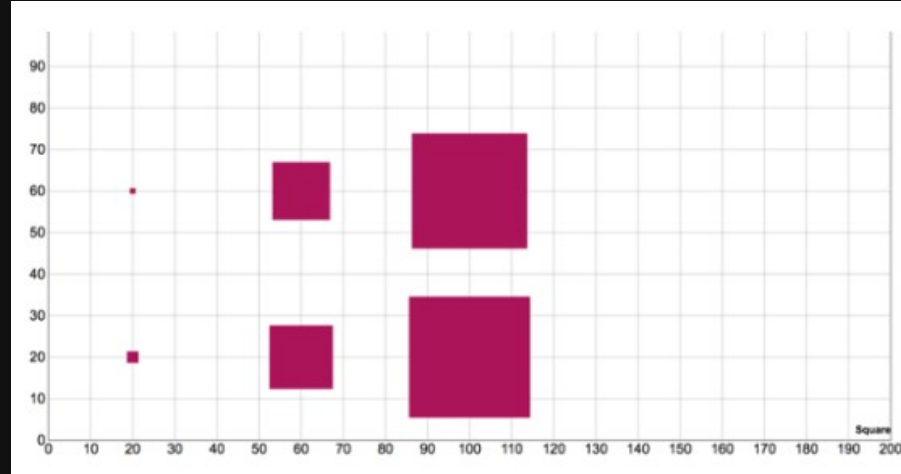
The stronger the initial stimulus, the greater a change must be for it to be noticed.

Mathematically:

$$K = \frac{\Delta i}{I}$$

- K = A constant (varies across senses)
- Δi = The minimal change in the intensity required to produce j.n.d.
- I = the intensity of the stimulus where the change occurs

Weber-Fechner Law

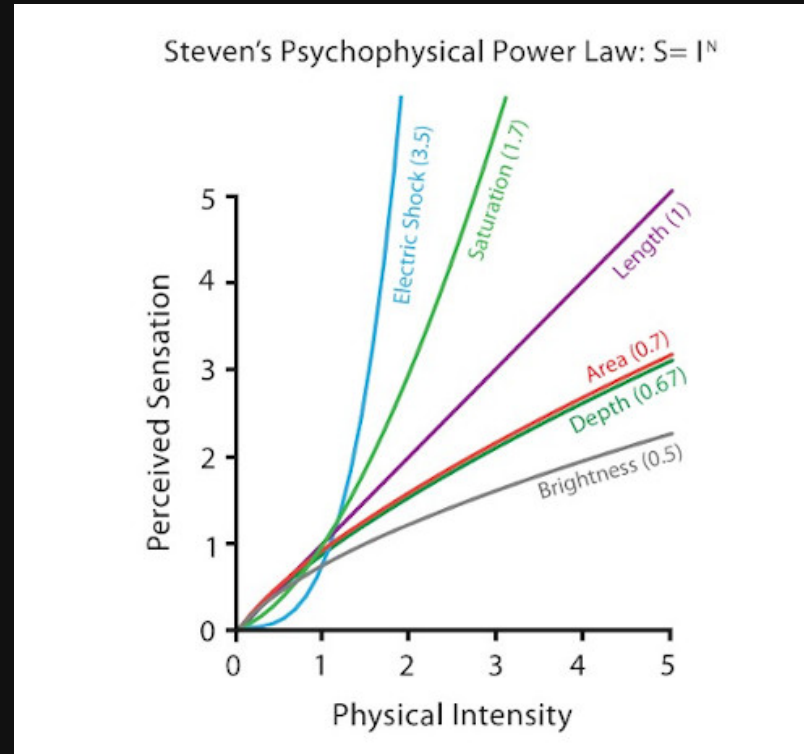


Numberphile's video on Weber's Law

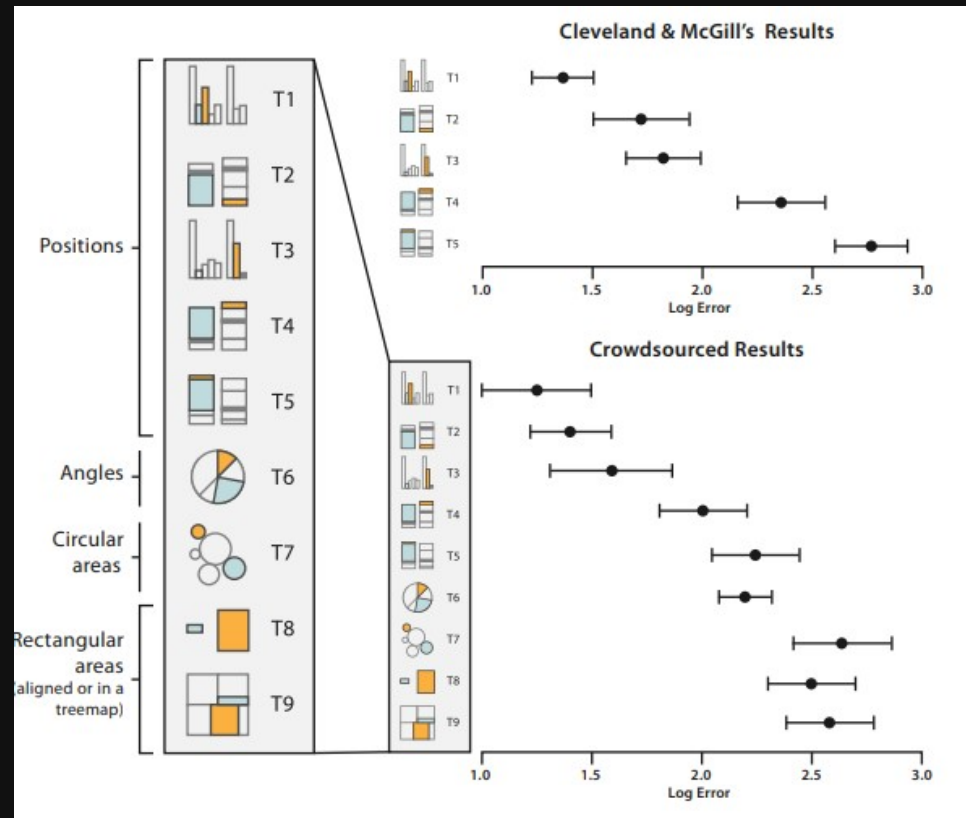
Implication: The human perceptual system is fundamentally based on relative judgements, not absolute ones.

Steven's Power Law

Psychophysics: the subfield of psychology devoted to the systematic measurement of general human perception.



Graphical Perception: Cleveland and McGill



Reading: Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods

Reading: Ranking Visualizations of Correlation Using Weber's Law

Channel effectiveness: Accuracy

Pick higher ranking channels (with reason).

E.g. Position > length, Angles > area

Channel effectiveness: Accuracy

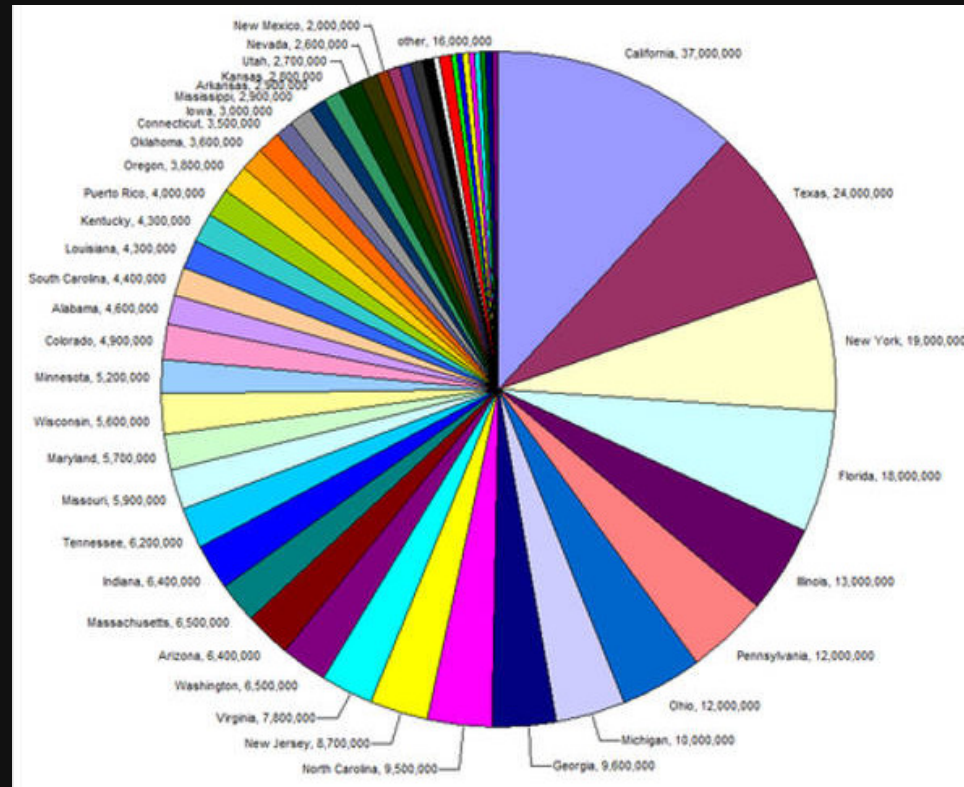
Example: Analyze profit over time for 3 categories





Channel effectiveness: Discriminability

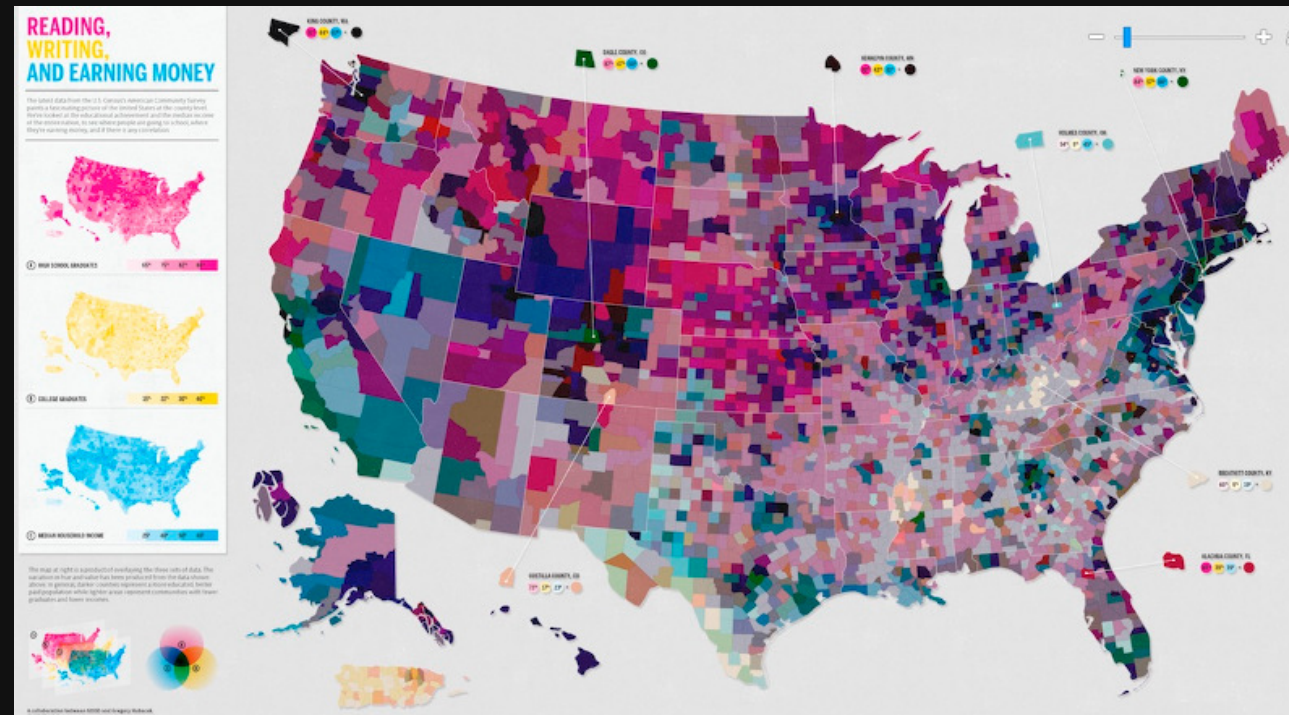
Must be able to discriminate between a reasonable number of bins
(typically max 5 to 7)



So how to deal with lots of data? You use techniques like grouping, filtering or faceting (we'll cover in later lectures)


Channel effectiveness: Separability

This ranges from the **seperable** (e.g. channels: position and hue) to the **integral** (e.g. channels: red and green color scales)



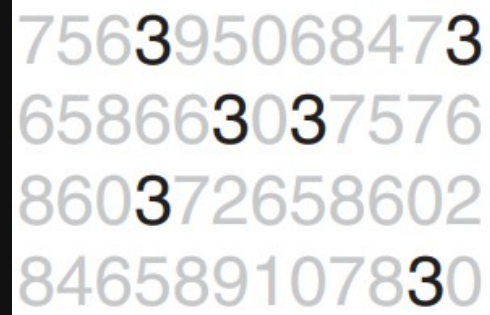
Channel effectiveness: Salience (popout)

Many visual channels provide visual **popout**, where a distinct item stands out from many others immediately.



7	5	6	3	9	5	0	6	8	4	7	3
6	5	8	6	6	3	0	3	7	5	7	6
8	6	0	3	7	2	6	5	8	6	0	2
8	4	6	5	8	9	1	0	7	8	3	0

Count the number of threes



7	5	6	3	9	5	0	6	8	4	7	3
6	5	8	6	6	3	0	3	7	5	7	6
8	6	0	3	7	2	6	5	8	6	0	2
8	4	6	5	8	9	1	0	7	8	3	0

Far easier, right? Using the color channel to popout elements.

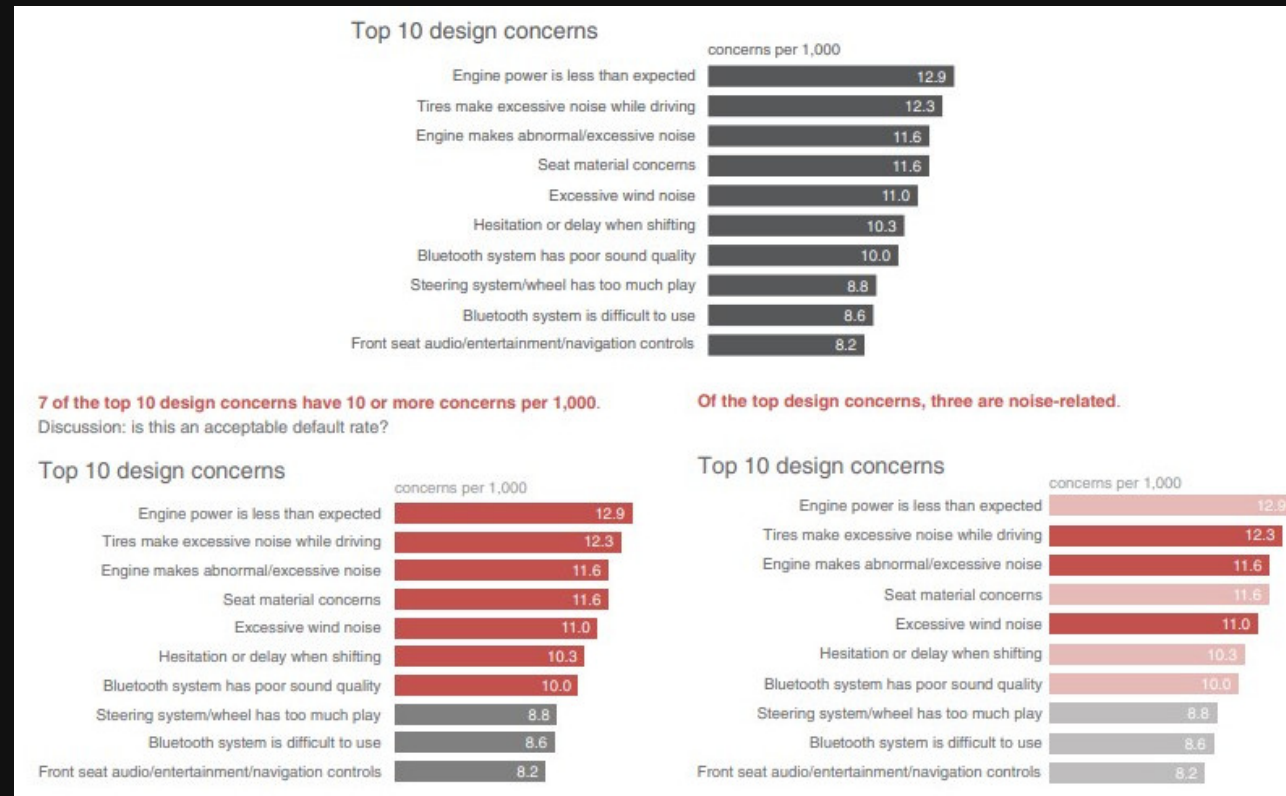
Perception in visualization, Healey

Concepts: Pre-attention in vision, change blindness

Change blindness demo

Many pairs of channels do not support popout, and 3 or more channels definitely do not. As a general rule, use popout for one channel only.

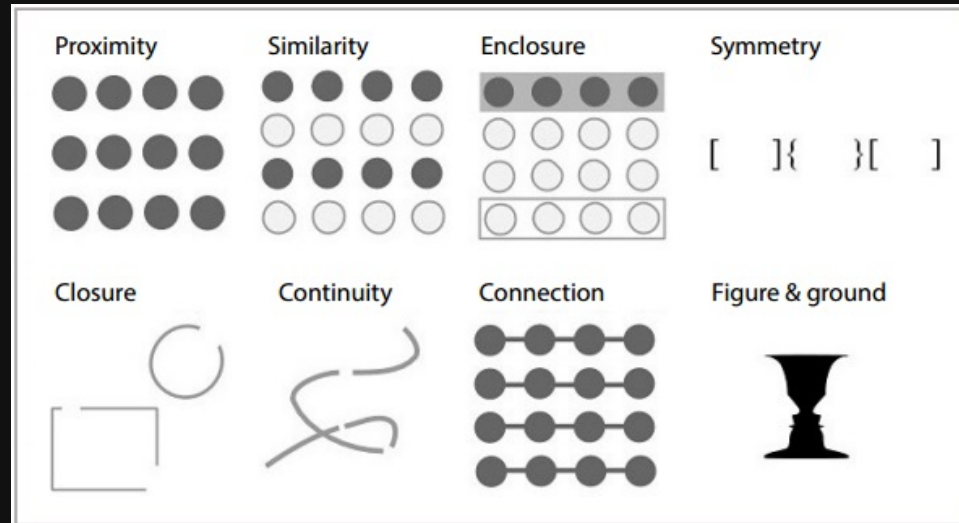
Channel effectiveness: Salience (popout)



Storytelling with Data: A Data Visualization Guide for Business Professionals, chapter 4, Nussbaumer

Channel effectiveness: Grouping

Gestalt principles of grouping



Reading: [Gestalt principles and income inequality](#), Silas Bergen

Questions?



Chi-Loong | V/R