Lecture 2 Conceiving Your Vis Design

Perception:
- Identification and interpretation of sensory information
- First processing (edges, planes) in visual cortex
- From the physical stimulus to recognising information
- Reflexes, not conscious
- e.g. hearing someone speak

Cognition:
- processing of information, applying knowledge, conclusion, drawing, problem solving, leaning, relations between objects, ong-term memory
- e.g. understanding the language and the words

Ames Room
- Demonstrate that we have no general purpose, vision.
- What we see depends on our goals and expectations

Change blidness:
* a change in a scene might be invisible to many people because of a great blank slate in between that is shown
* It might be a visualisation of streaming data that changes, then you are also blinking. And a bit in between those blinks, you are running into the change blindness problem
* Details of an image cannot be remembered across separate scenes - except in areas with forces attention
* Interruption amplifies this effect
  * e.g. a blink, eye saccade, or blank screen)
* No failure of vision system, failure based on inappropriate attentional guidance
* Relevant for visualisation when using animation to encode time-dependent data
* The more changing elements you add to a scene, the more severe the effect gets

Inattention Blindness:
* If you have a scene, then you can fail to notice parts of the scene that are in plain sight
* Person fails to notice stimulus in plain sight
* Stimulus usually unexpected but fully visible
* Depends on attention and expectations

Pre-attentive Features:
* Perceptional effect
* Flickr/motion is distracting because it grabs attention —> rarely used in visualisation.
* Combination of difference in hue and different in shape does not work
* Properties detected by the low-level visual system
  * Very rapid, very accurate, processed in parallel
  * Happens before focused attention
  * Attention is very important for cognition
* Low-level vision is driven by object features(colour, shape, borders) rather than a conscious effort where to look
* To find meaning in what we see we must selectively pay attention to what is important
* Attention is driven by **preexisting knowledge**, **expectations**, and **goals stored in long-term** memory

Dimension of Color
* Hue: what actually refer to as the colour, Luke yellow, red, blue and soon
  * No clear order
* Saturation: purity of a colour
  * Perceived as ordered
* Brightness, luminance, value: lightness or darkness of a color
  * Perceived as ordered
  * In theory, you could use those different dimensions independent of each other. But it is not recommended, because humans are not able to separate those three channels
* Order blacks by colour is subjective, but order by brightness is more objective.

Three important colour cases
* Qualitative scale (for categorical data)
  * Do not use more than 7-10 colours
* Sequential scale (for ordered data)
  * Use one hue and vary the separation or vary the brightness
* Diverging scale (for ordered data)
  * Having a neutral point(usually white or yellow) in the centre like a zero
  * Shape can encode much more categories than colour

Rainbow Colormap
* Problematic:
  * It is impossible for us to interpret that without the legend
  * Have this permanent look-up task to see what colours are matched to which they ranges
  * It is impossible for us to intuitively perceive this
  * Therefore, using colour to order is problematic
  * Using brightness is easy
  * Rainbow colour scale is perceptually non-linear
  * Segmentation effect: because of this non-linearity, we might see areas that are not there

The Alphabet of Visualisation: Visual Marks and Channels

Marks:
* Points
* Lines
* Areas

Channels(aka visual variables):
* change appearance of marks based on attribute
* Way to control appearance of marks proportional to or based on attributes
* Magnitude Channels/Ordered Attributes: ordinal & quantitative attributes
  * Position on common scale
  * Position on unaligned scale
  * Length (1D size)
  * Tilt/angle
  * Area (2D size)
  * Depth (3D position)
  * Color luminance
  * Color saturation Curvature
  * Volume (3D size)
* Identity Channels: categorical attributes

  * Spatial region
  * Color hue
  * Motion
  * Shape

Characteristics of Channels
* Selective
  * Is a mark distinct from other marks?
  * Can we make out the difference between two marks?
* Associative
  * Does it support grouping?
* Quantitative
  * Can we quantify the difference between two marks?
* Order
  * Can we see a change in order?
* Length
  * How many unique marks can we see?

Position
* Strongest channel!
* Problems:
  * Not available for maps
  * Visual clutter (too many elements in close proximity)
* Characteristics
  * Selective: yes
  * Associative: yes
  * Quantitative: yes
  * Order: yes
  * Length: fairly big
* 3D could be problematic for abstract data because you run into various problems

Length (1D) & Area (2D)
* Good for 1D, OK for 2D, Bad for 3D
* Easy to see which one is bigger
* Aligned bars use position redundantly
* Characteristics
  * Selective: yes
  * Associative: yes
  * Quantitative: yes
  * Order: yes
  * Length: high

Brightness & Saturation
* OK for quantitative data when pos, length & area are used
* Not very many shades recognisable
* Characteristics
  * Selective: yes
  * Associative: yes
  * Quantitative: somewhat (with problems)
  * Order: yes

    * Length: limited

Color
* Good for categorical data
* Limited number of categories/length (~7-10!) Does not work well for quantitative data!
* Lots of pitfalls! Be careful!
* Rules of thumb:
    * Minimize color use for encoding data
    * Use for highlighting
* Characteristics
    * Selective: yes
    * Associative: yes
    * Quantitative: no
    * Order: no
    * Length: limited

Shape
* Great to recognize many classes
* Limited grouping, no ordering
* Characteristics
    * Selective: yes
    * Associative: limited
    * Quantitative: no
    * Order: no
    * Length: vast

Redundant Encoding / double encoding:
* use the same channel for the same or you use multiple channels for the same attribute
* You can always do to stress that something is really important by justing assigning two channels to

Separability of Attributes
* Position + colour: still fully separately
* Size + colour: already some interference
* Width + height: some/significant interference
* Red green: major interference

Gestalt Laws
* Understand pattern perception
* Perceptual hysteresis
    * Once you've seen it, you can't un-see it!
    * If you've seen it before, your brain will immediately recognise it and group this
* The whole is greater than the same of the parts
* Grouping principle: connection is a very strong grouping principle, can overrule others.
    * Proximity: if two points are close to each other, they will be perceived as group
    * Color
    * Size
    * Shape

Tufte's Design Principles
* Clear, detailed, and thorough labeling and appropriate scales
* Size of the graphic effect should be directly proportional to the numerical quantities
  * "lie factor"
* Maximize data-ink ratio
* Avoid chart junk

Scale Distortions change the whole story
* What are your bounds – upper and lower?
* What scale works?
  * Linear? Log? Clipping? Breaks?
  * Zero-based or not
  * Large or small scale in x and y
  * Absolute or relative numbers
* How can you make things comparable?

"Lie factor:

$$\text{Lie Factor} = \frac{\text{Size of effect shown in graphic}}{\text{Size of effect in data}}$$

* Smartphone marketshare of Apple
  * Rotated the pie chart in a way that Apple is in the front
  * Slightly tilted to make it appear bigger
  * The number of pixels that are purple are much lower than the number of pixels that are green because of the three-dimensional tilt

Maximize Data-ink ratio:

$$\text{Data-Ink Ratio} = \frac{\text{Data ink}}{\text{Total ink used in graphic}}$$

* Don't use ink for the shadow
* Don't use ink the 3D effects

Avoid chart junk:
* Extraneous visual elements that distract from the messages

Rules of Thumb:
* No Unjustified 3D
  * Exception: 3D Phenomena
  * Perspective distortion: things that are further will appear smaller