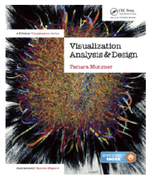
Decoding and Encoding Visualizations: Marks, Channels, and Color



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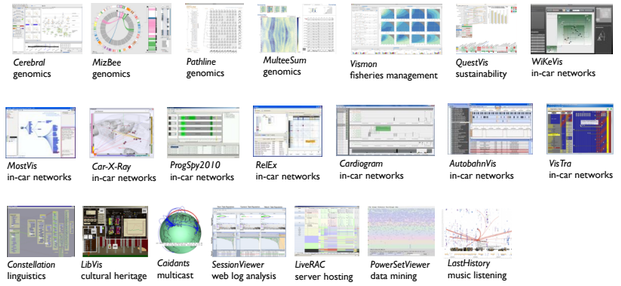
VisualISE
(Visualization for Informal Science Education)
Exploratorium, San Francisco CA, 8 May 2019

www.cs.ubc.ca/~tmm/talks.html#visualise19

@tamaramunzner

How to decode a visualization? How to encode data visually?

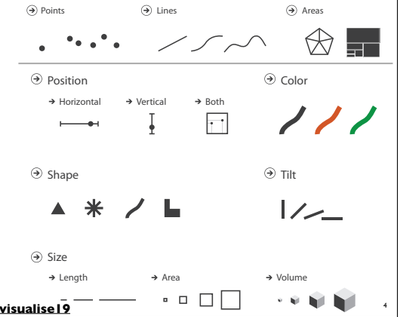


Decoding and encoding visual representations

- systematic way to analyze structure

Decoding and encoding: Marks and channels

- marks
  - geometric primitives
- channels
  - control appearance of marks



Decoding and encoding visual representations

- systematic way to analyze structure
  - as combination of marks and channels

1: vertical position — mark: line

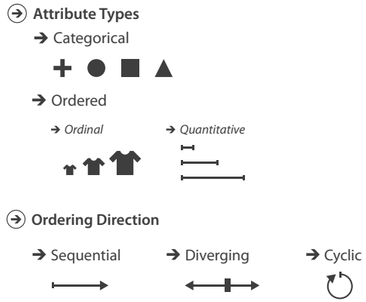
2: vertical position, horizontal position — mark: point

3: vertical position, horizontal position, color hue — mark: point

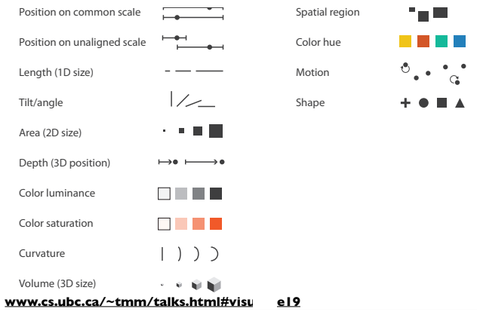
4: vertical position, horizontal position, color hue, size (area) — mark: point

How to choose?

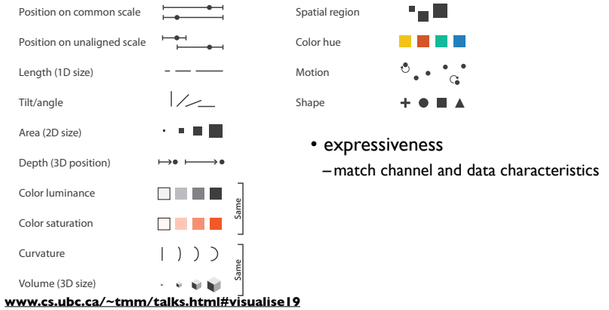
- characteristics of...
  - data
  - task
  - human perceptual system



Channels

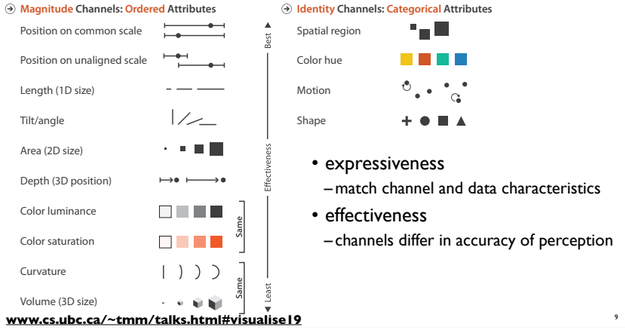


Channels



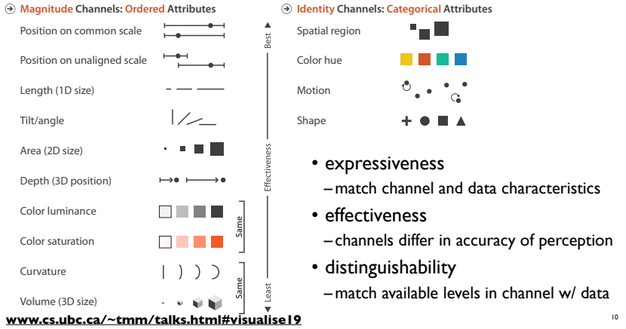
- expressiveness
  - match channel and data characteristics

Channels

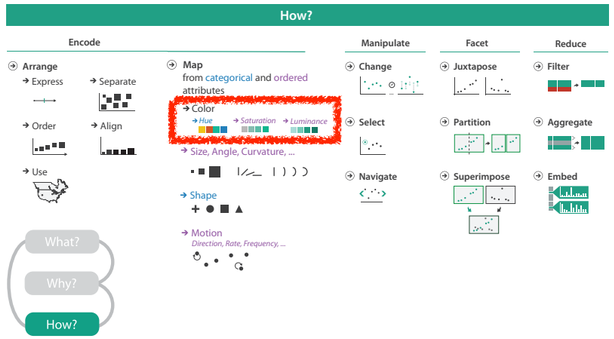


- expressiveness
  - match channel and data characteristics
- effectiveness
  - channels differ in accuracy of perception

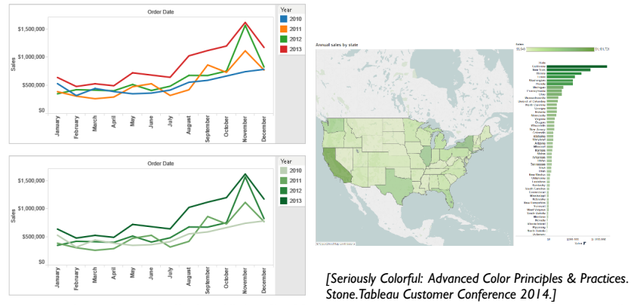
Channels



- expressiveness
  - match channel and data characteristics
- effectiveness
  - channels differ in accuracy of perception
- distinguishability
  - match available levels in channel w/ data



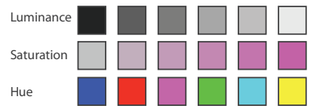
Categorical vs ordered color



[Seriously Colorful: Advanced Color Principles & Practices. Stone.Tableau Customer Conference 2014.]

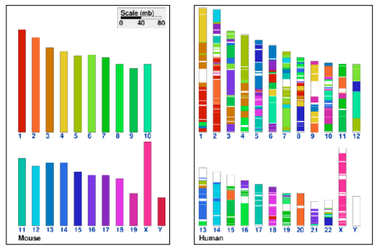
Decomposing color

- first rule of color: do not talk about color!
  - color is confusing if treated as monolithic
- decompose into three channels
  - ordered can show magnitude
    - luminance: how bright
    - saturation: how colorful
  - categorical can show identity
    - hue: what color
  - caveat: not well supported by current tools
- channels have different properties
  - what they convey directly to perceptual system
  - how much they can convey: how many discriminable bins can we use?



Categorical color: limited number of discriminable bins

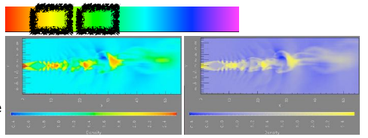
- human perception built on relative comparisons
  - great if color contiguous
  - surprisingly bad for absolute comparisons
- noncontiguous small regions of color
  - fewer bins than you want
  - rule of thumb: 6-12 bins, including background and highlights
- alternatives? other talks!



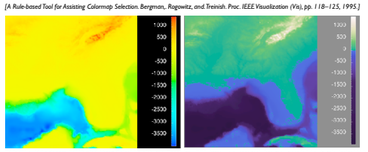
[Cinteny: flexible analysis and visualization of synteny and genome rearrangements in multiple organisms. Sinha and Meller. BMC Bioinformatics, 8:82, 2007.]

Ordered color: Rainbow is poor default

- problems
  - perceptually unordered
  - perceptually nonlinear
- benefits
  - small-scale structure: see & name
- alternatives
  - large-scale structure: fewer hues
  - known structure: segmented
  - have it both ways, small+large:
    - multiple hues
    - monotonically increasing luminance



[A Rule-based Tool for Assisting Colormap Selection: Bergman, Rogowitz, and Treinish. Proc. IEEE Visualization (Vis), pp. 118–125, 1995.]

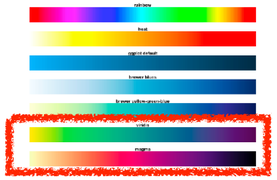


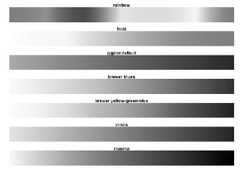
[Why Should Engineers Be Worried About Color? Treinish and Rogowitz 1998. http://www.research.ibm.com/people/l/lloydt/color/color.HTM]

Viridis / Magma

- colorful, perceptually uniform, colorblind-safe, monotonically increasing luminance

https://cran.r-project.org/web/packages/viridis/vignettes/intro-to-viridis.html





Further reading

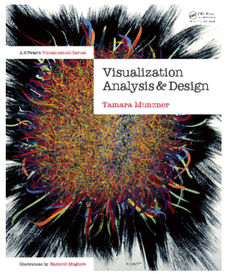
- Visualization Analysis and Design. Munzner. AK Peters Visualization Series, CRC Press, 2014
  - *Chap 10: Map Color and Other Channels*
- ColorBrewer, Brewer.
  - http://www.colorbrewer2.org
- *Color In Information Display*. Stone. IEEE Vis Course Notes, 2006.
  - http://www.stonesc.com/Vis06
- A Field Guide to Digital Color. Stone. AK Peters, 2003.
- *Rainbow Color Map (Still) Considered Harmful.* Borland and Taylor. IEEE Computer Graphics and Applications 27:2 (2007), 14–17.
- Visual Thinking for Design. Ware. Morgan Kaufmann, 2008.
- Information Visualization: Perception for Design, 3rd edition. Ware. Morgan Kaufmann /Academic Press, 2004.
- https://cran.r-project.org/web/packages/viridis/vignettes/intro-to-viridis.html

More Information

- papers, videos, software, talks, courses
  http://www.cs.ubc.ca/group/infovis
  http://www.cs.ubc.ca/~tmm

- book page (including tutorial lecture slides)
  http://www.cs.ubc.ca/~tmm/vadbook
  - 20% promo code for book+ebook combo: HVN17
  - http://www.crcpress.com/product/isbn/9781466508910
  - illustrations: Eamonn Maguire

- this talk



Visualization Analysis and Design.
Munzner. A K Peters Visualization Series, CRC Press, Visualization Series, 2014.