06: Rules of Thumb

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90529 Data Visualization
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https://2020.aulaweb.unige.it/course/view.php?id=4293

Credits:
material in these slides is partially taken from
- T. Munzner, University of British Columbia
- A. Lex, University of Utah

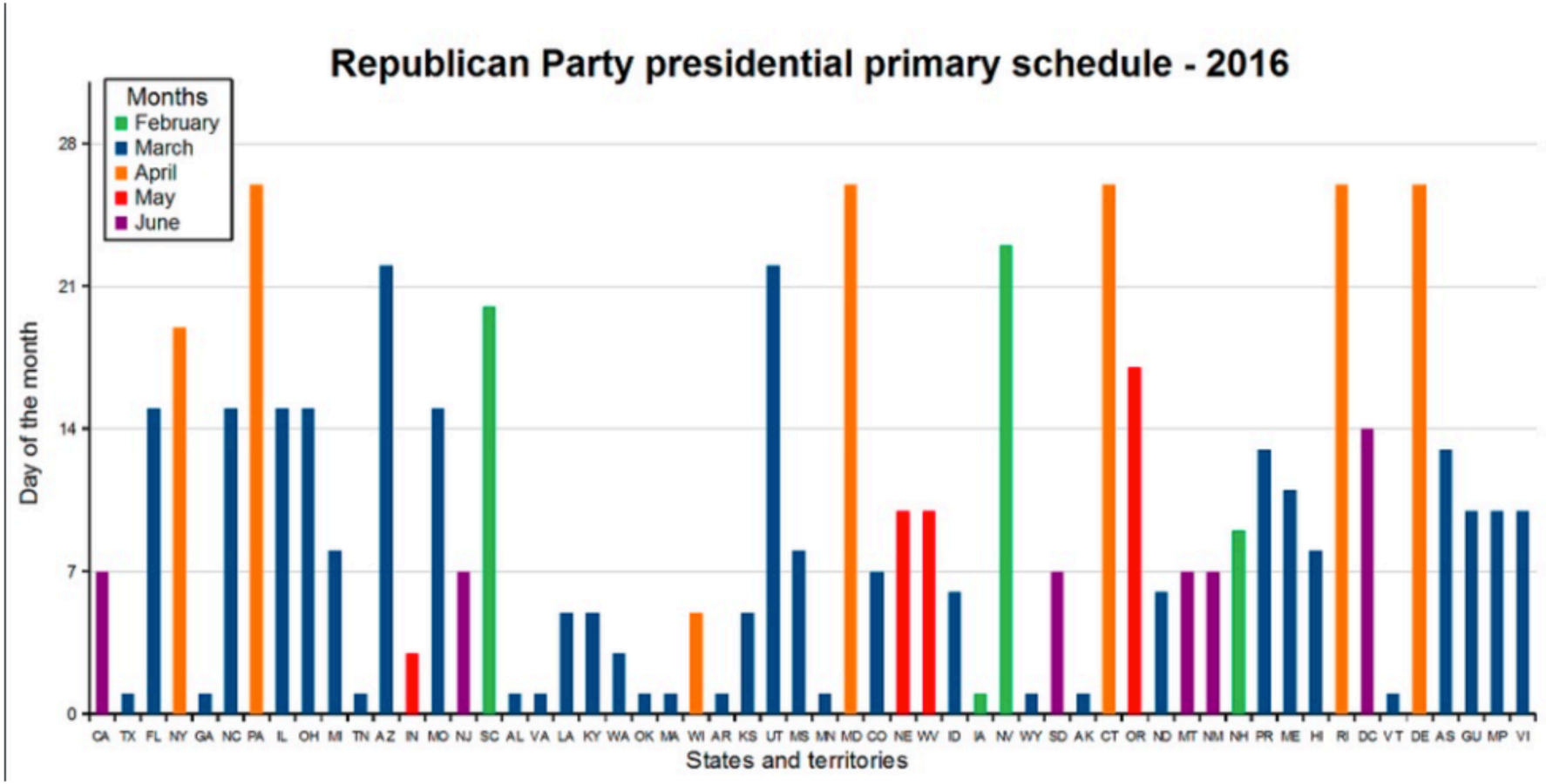
other credits in the slides

Rules of Thumb

- Best channel first!
- Graphical integrity
- No unjustified 3D
- No unjustified 2D
- Eyes beat memory
- Resolution over immersion
- Overview first, zoom and filter, details on demand
- Function first, form next

Best channel first!

- Sort attributes by relevance according to target tasks
- Assign most effective channels to most relevant attributes
- Use additional channels for secondary aspects of your data



Graphical integrity

- Magnitude in data must correspond to magnitude of mark
  - no scale distortions

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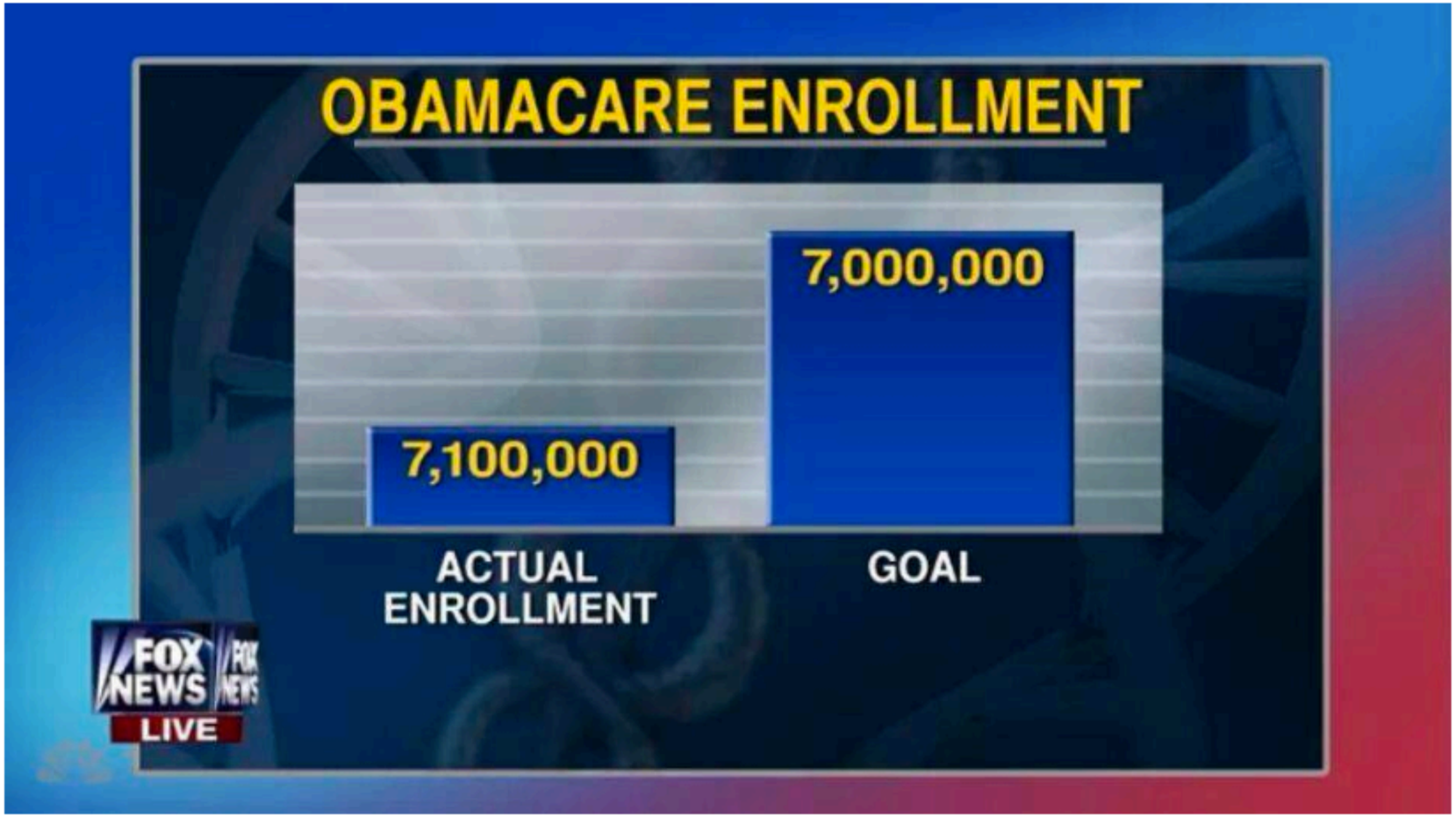

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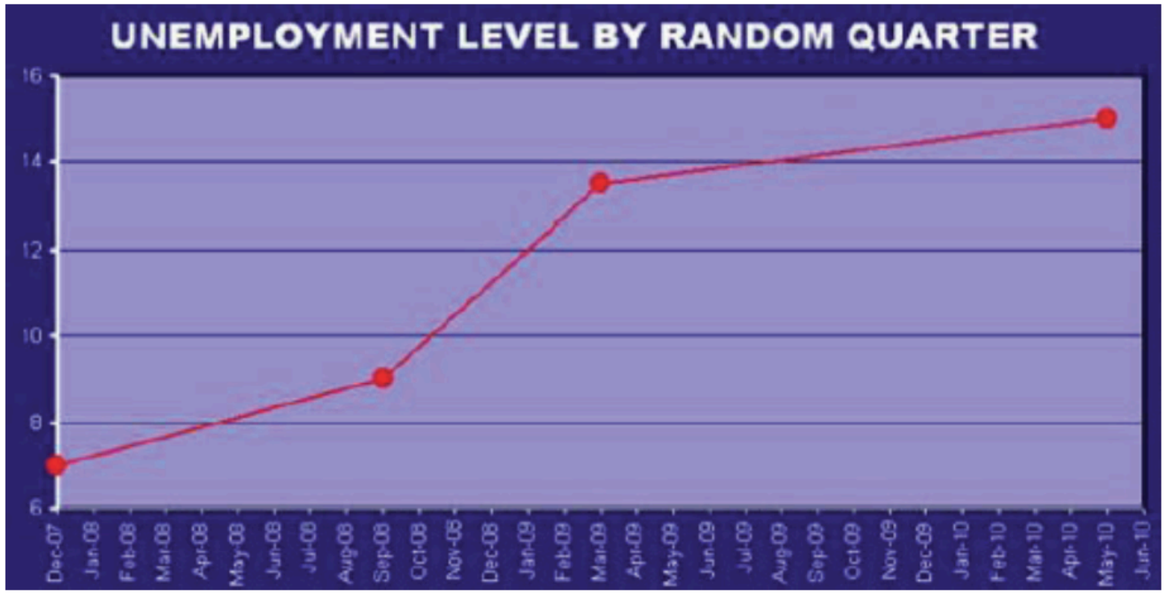
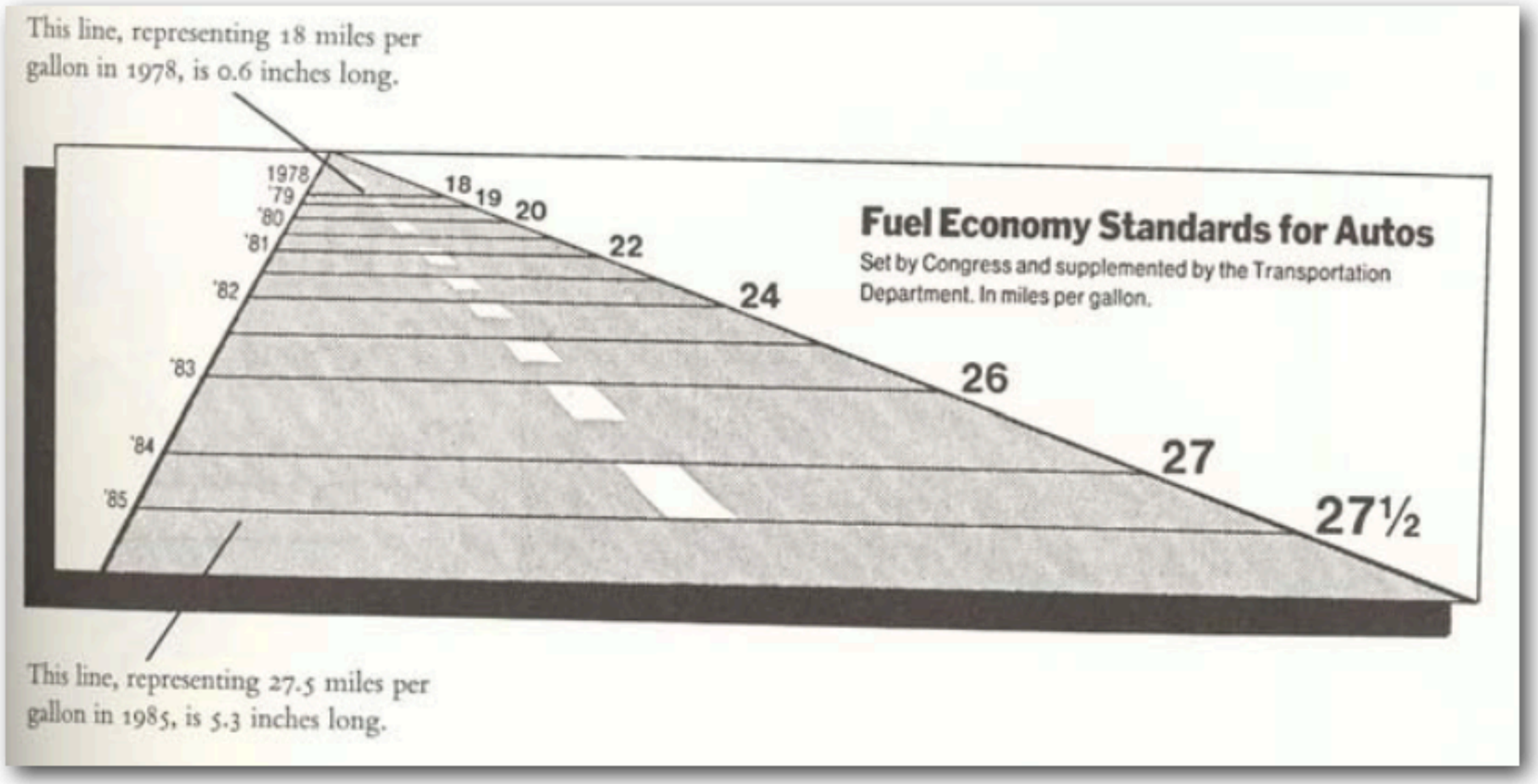
vs



Graphical integrity

- Magnitude in data must correspond to magnitude of mark
  - no scale distortions: the **Lie factor**

$$\frac{\text{size of effect shown in graphics}}{\text{size of effect in data}}$$



Tufte, VDQI

Graphical integrity

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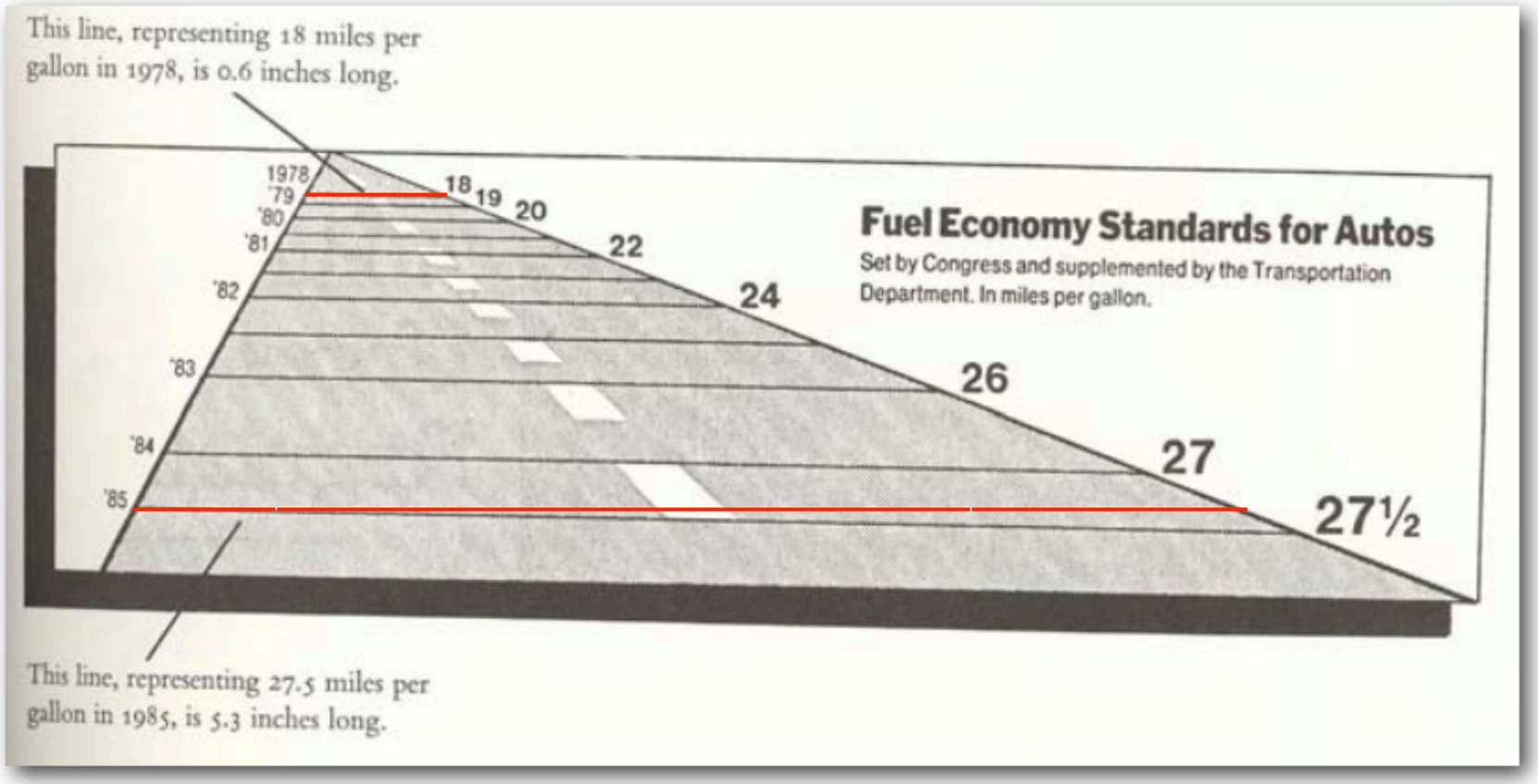
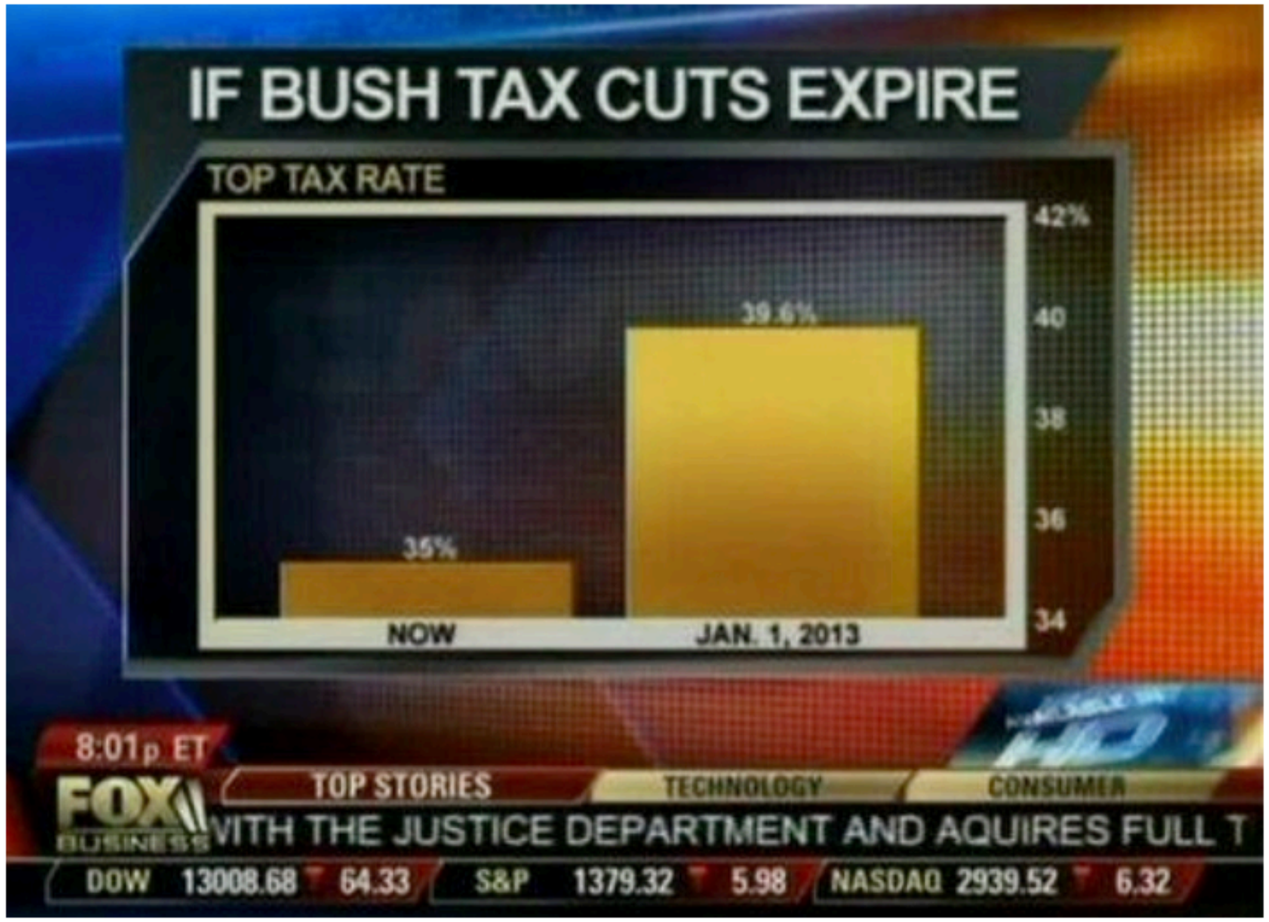
$$\frac{5.3}{0.6} \Big/ \frac{27.5}{18} = 5.78$$



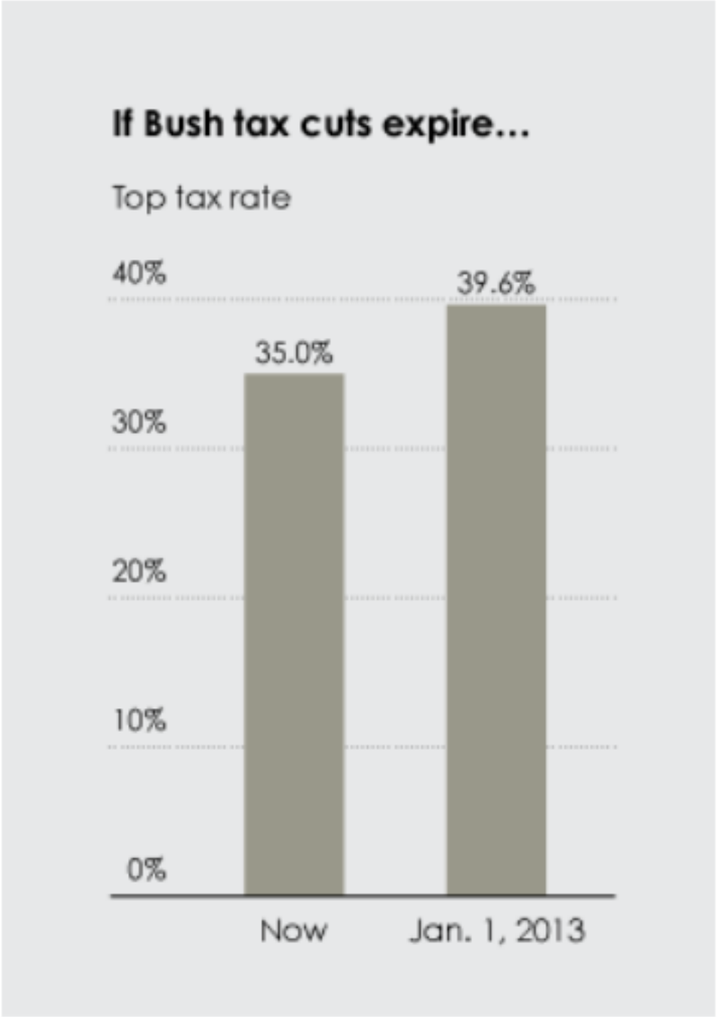
Tufte, VDQI

Graphical integrity

- Magnitude in data must correspond to magnitude of mark
  - no scale distortions
  - start scales at zero (when applicable)



vs



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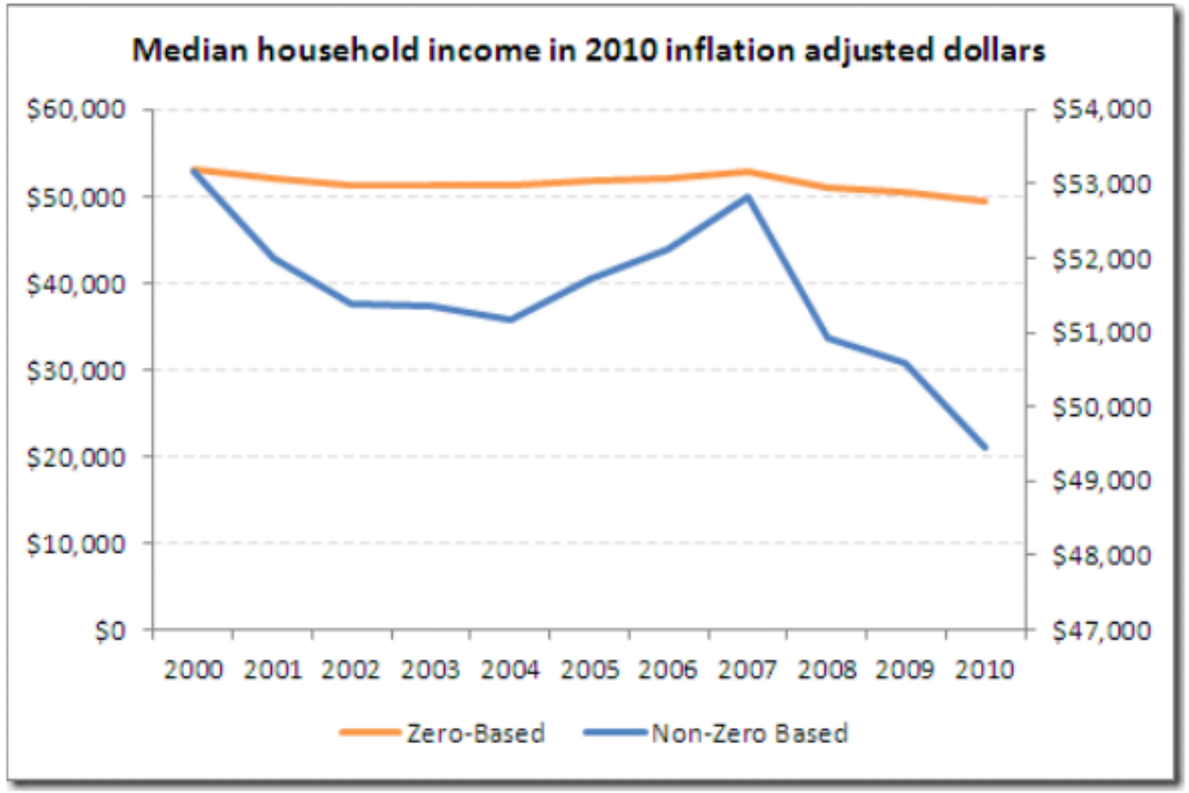
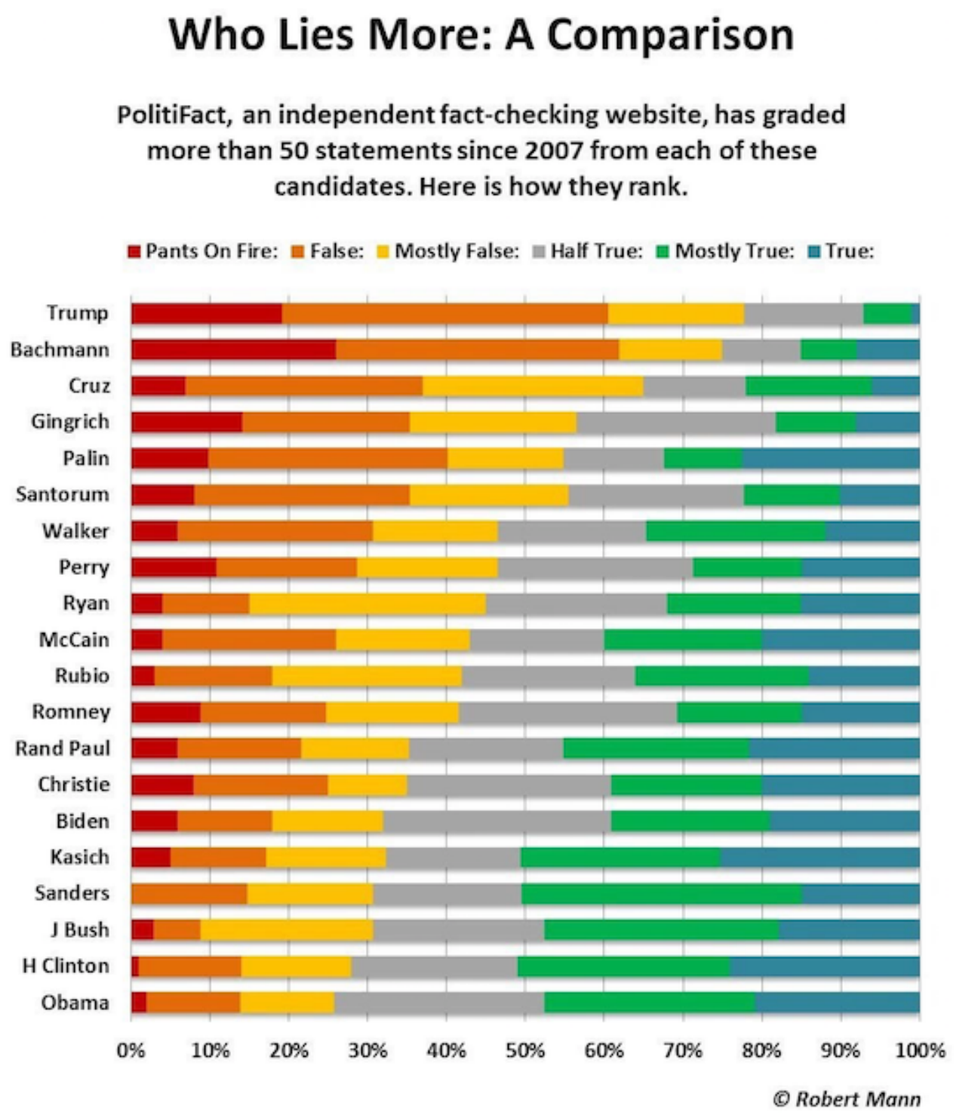
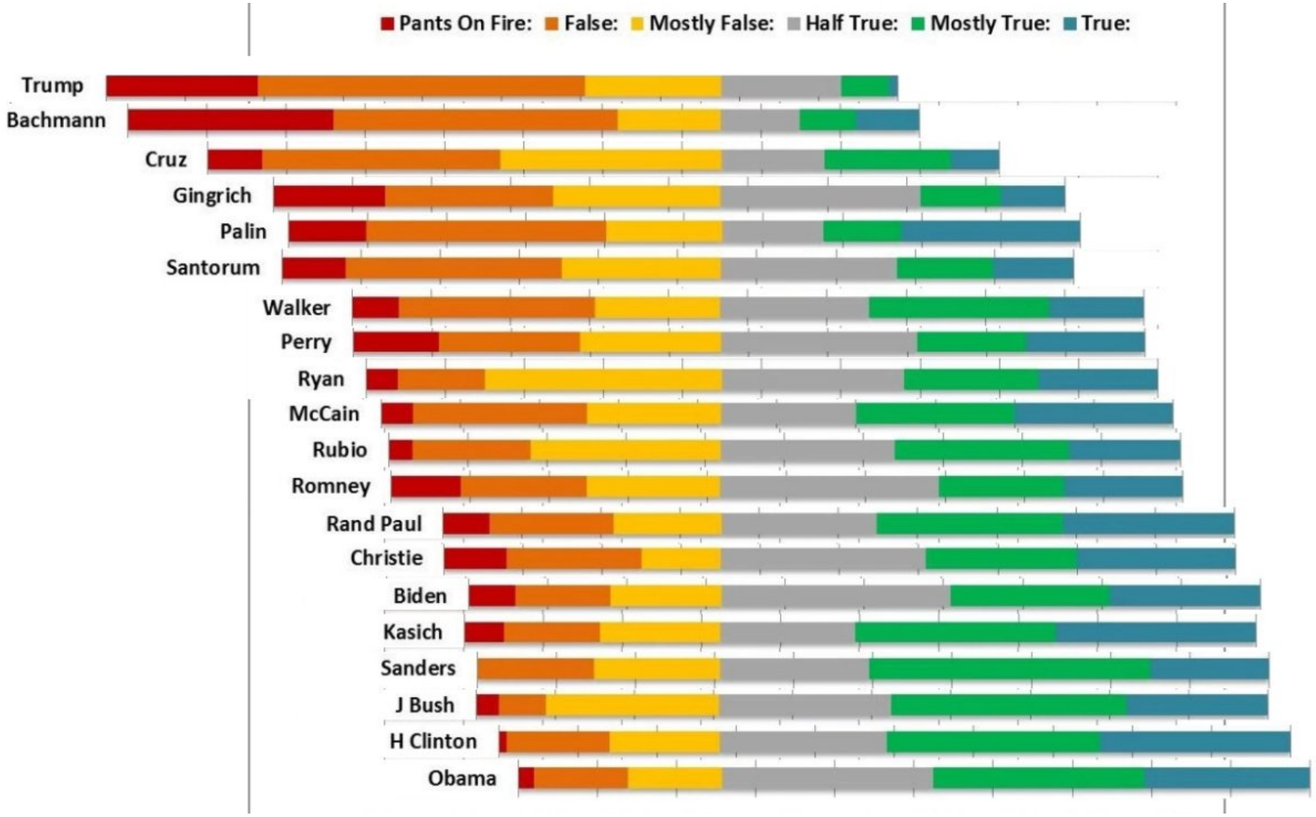


Graphical integrity

- Alignment matters





No unjustified 3D: Power of the plane

- high-ranked spatial position channels: **planar** spatial position
  - not depth!

➔ **Magnitude Channels: Ordered Attributes**

Position on common scale

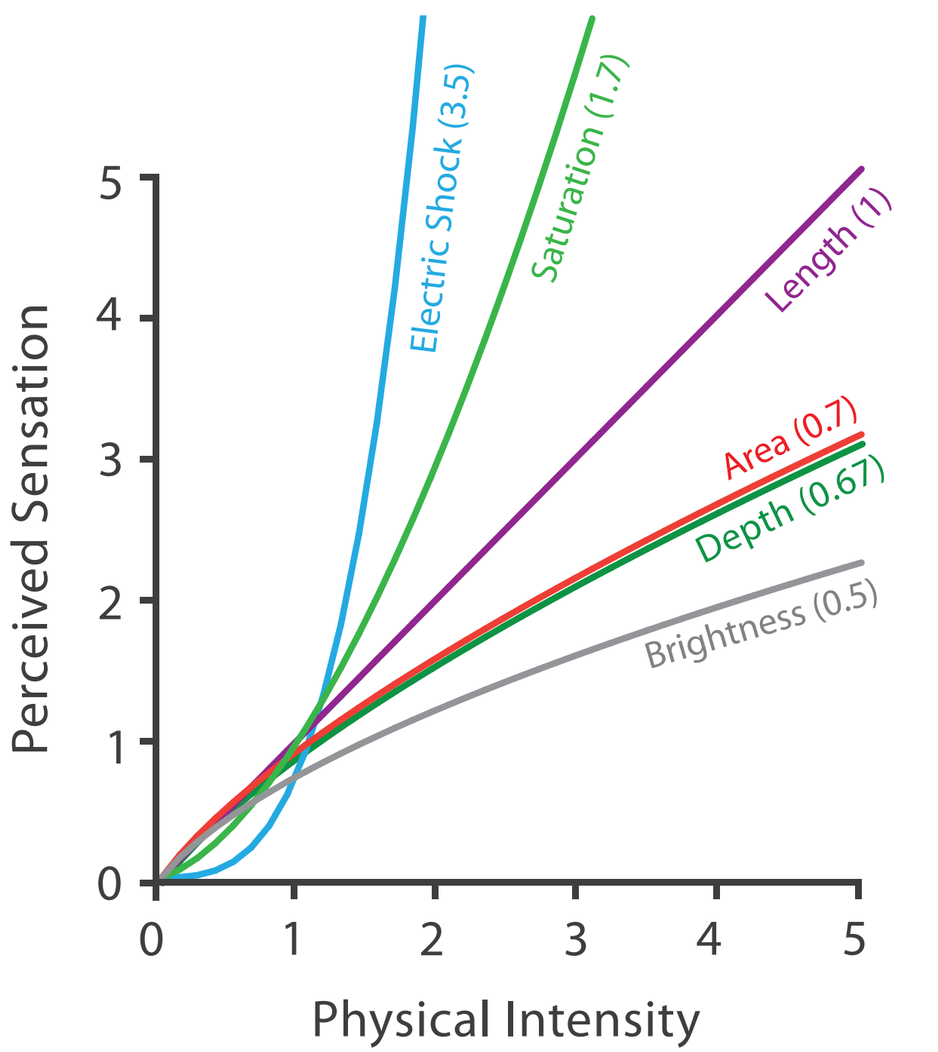
Position on unaligned scale

Length (1D size)

Tilt/angle

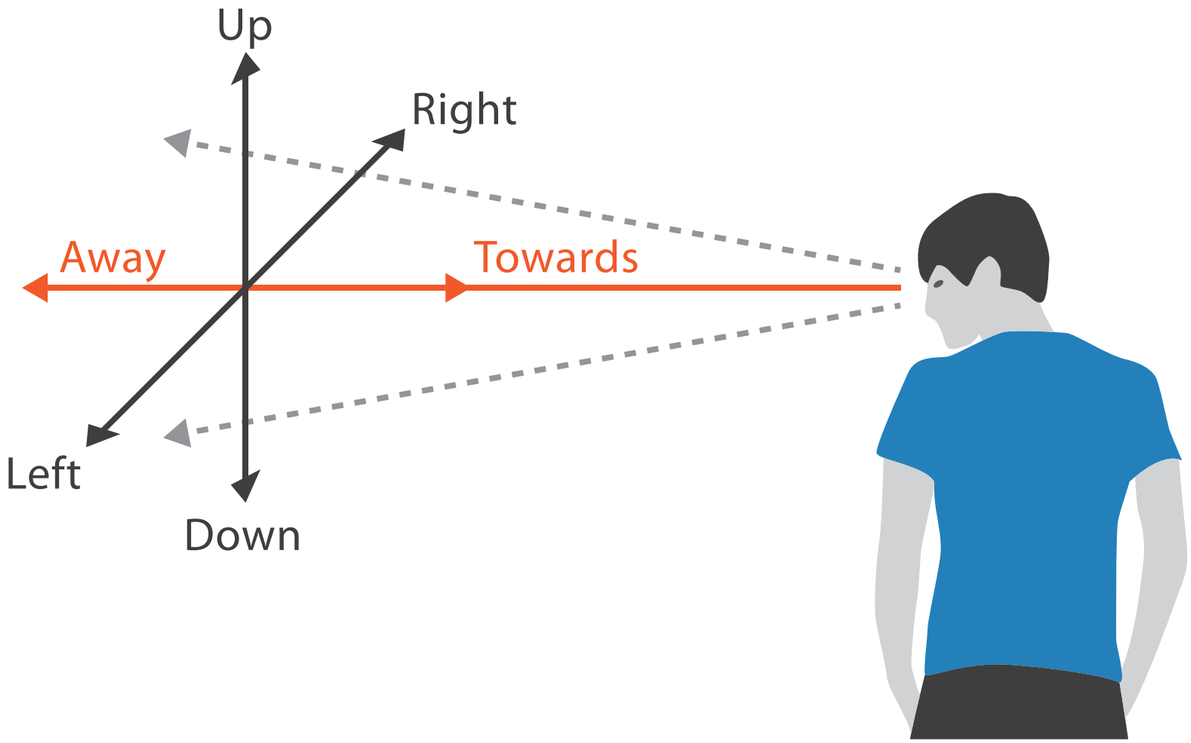
Area (2D size)

Depth (3D position)

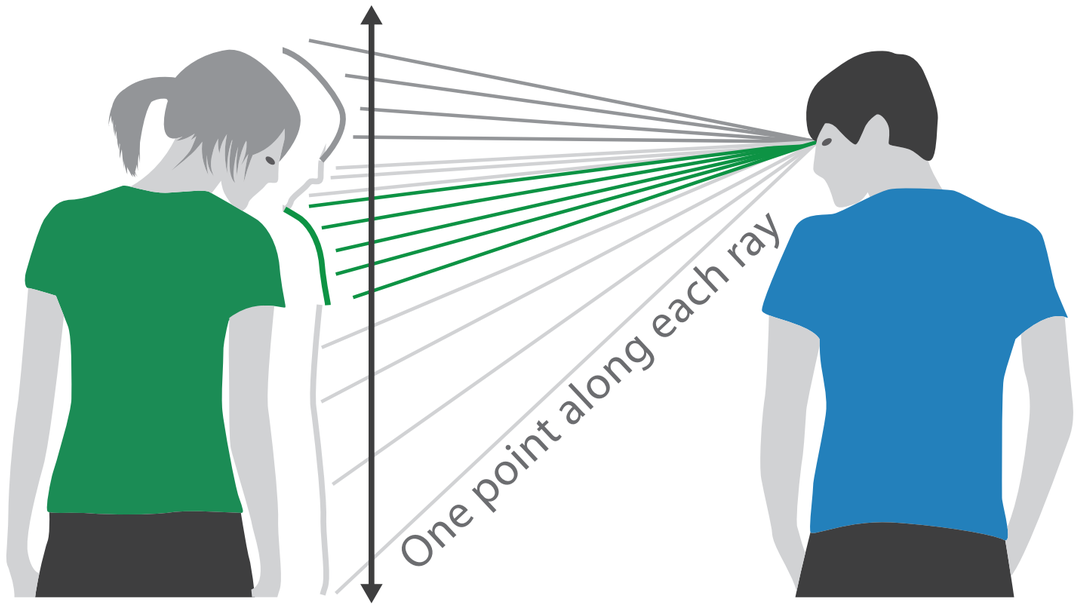


No unjustified 3D: Danger of depth

- we see in 2.05D
  - acquire more info on image plane quickly from eye movements
  - acquire more info for depth slower, from head/body motion



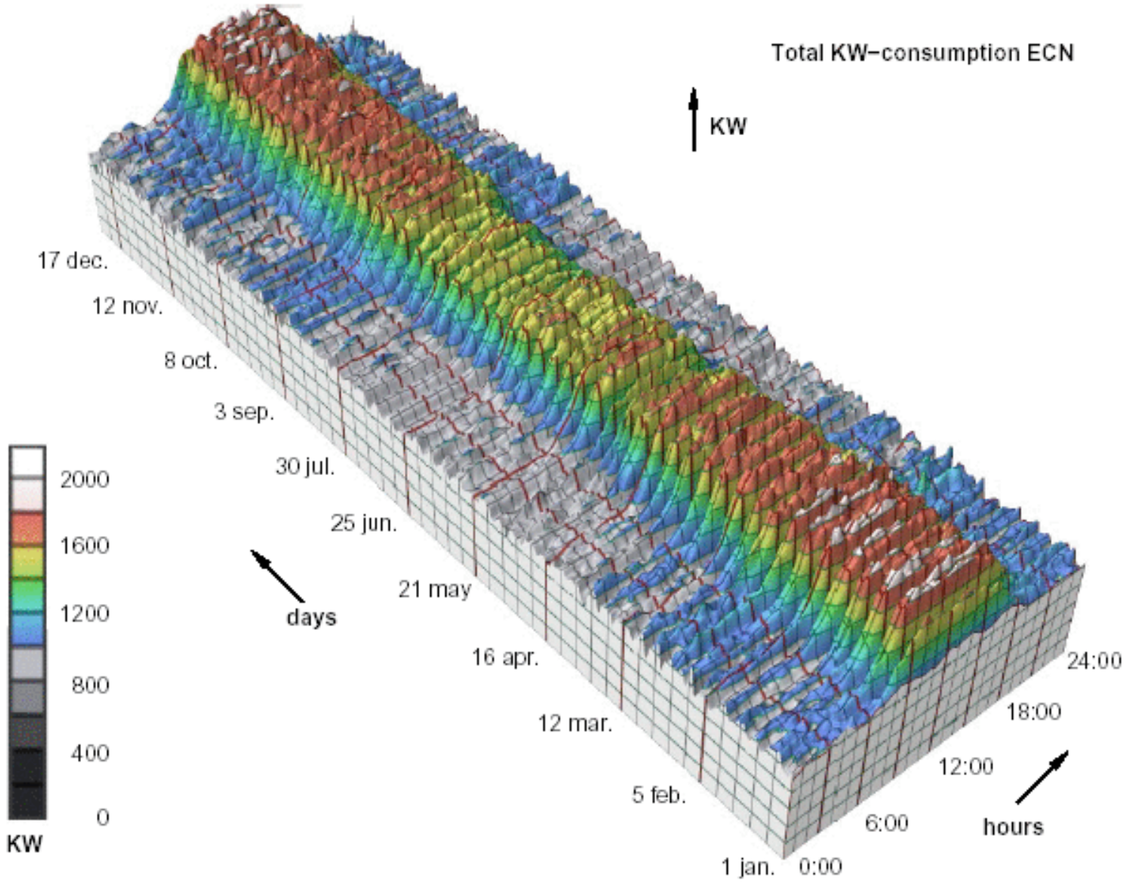
Thousands of points up/down and left/right



We can only see the outside shell of the world

No unjustified 3D example: Time-series data

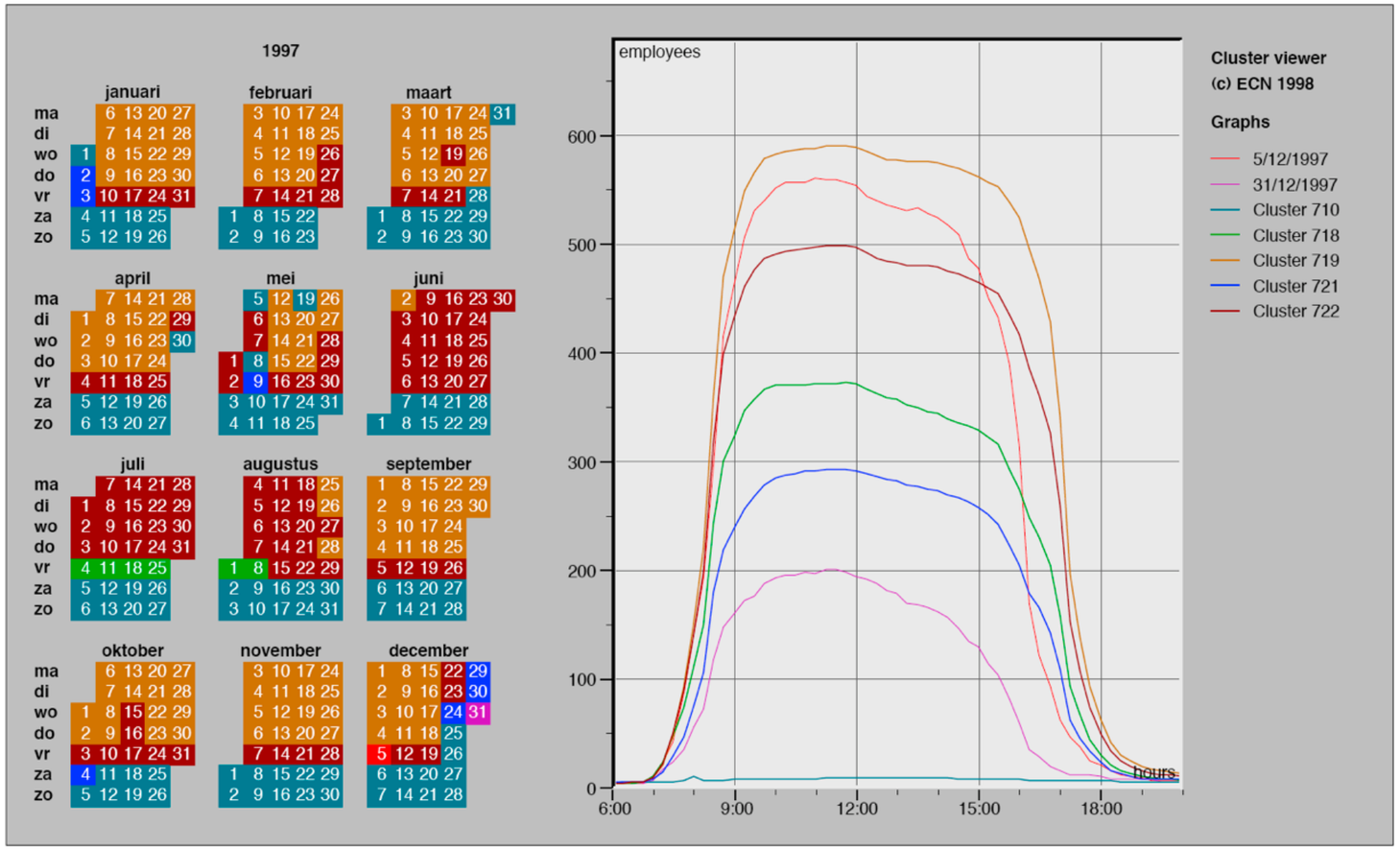
- extruded curves: detailed comparisons impossible



[Cluster and Calendar based Visualization of Time Series Data. van Wijk and van Selow, Proc. InfoVis 99.]

No unjustified 3D example: Transform for new data abstraction

- derived data: cluster hierarchy
- juxtapose multiple views: calendar, superimposed 2D curves



[Cluster and Calendar based Visualization of Time Series Data. van Wijk and van Selow, Proc. InfoVis 99.]

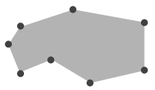
Justified 3D: shape perception

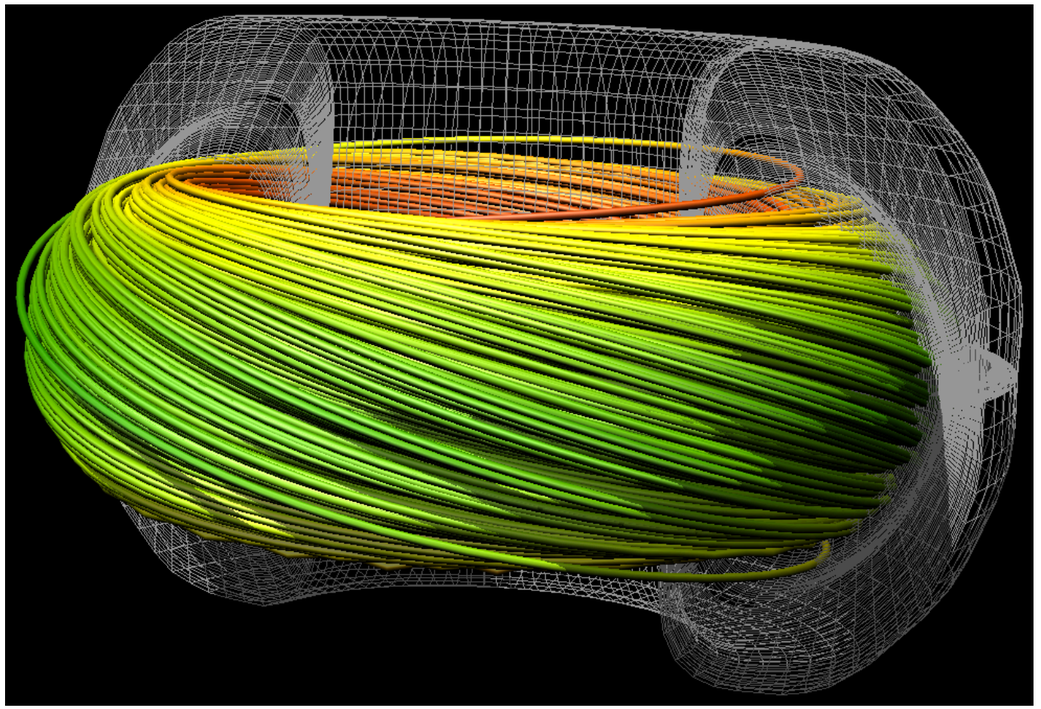
- benefits outweigh costs when task is shape perception for 3D spatial data
  - interactive navigation supports synthesis across many viewpoints

Targets

Spatial Data

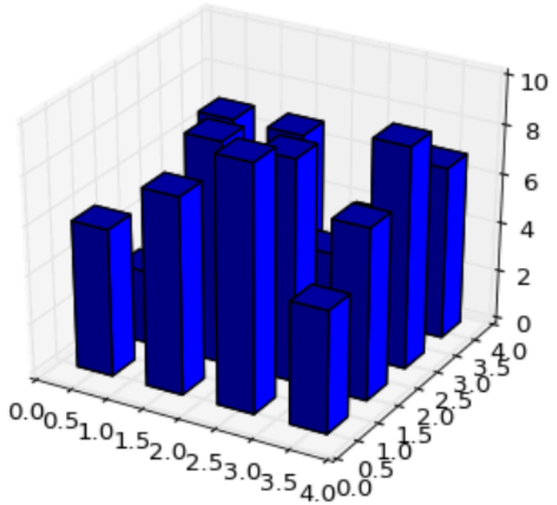
→ Shape

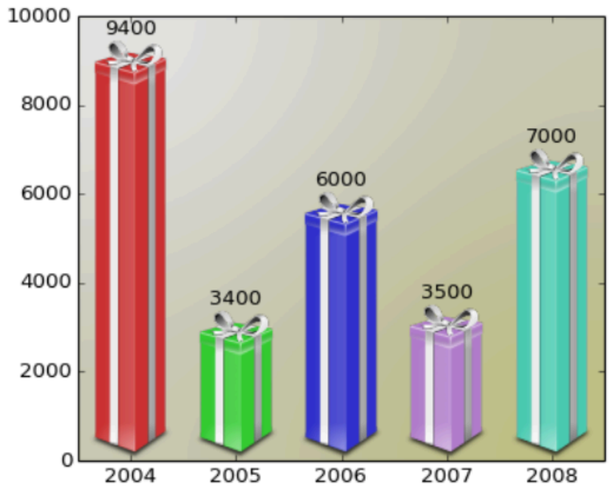




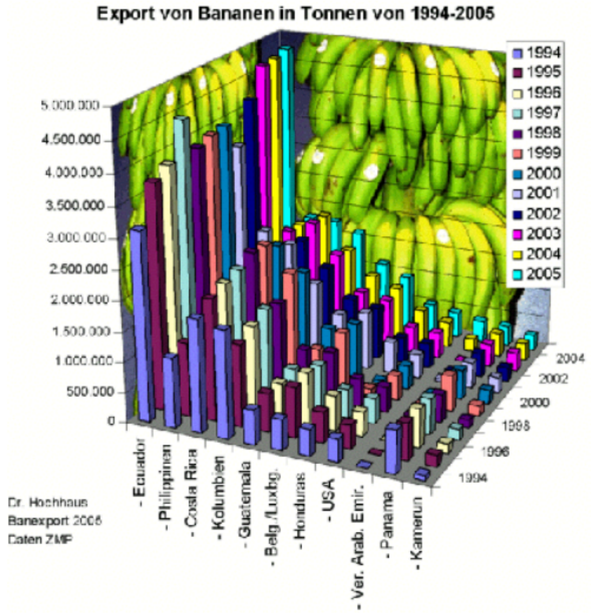
Laurence Berkeley National Laboratory - Visualization group

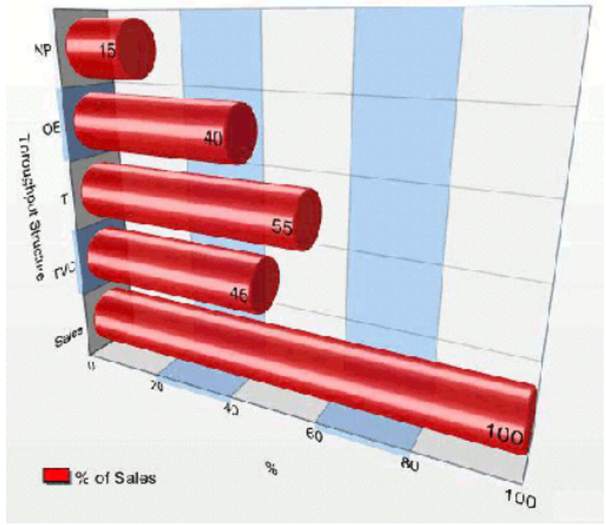
No unjustified 3D





matplotlib gallery

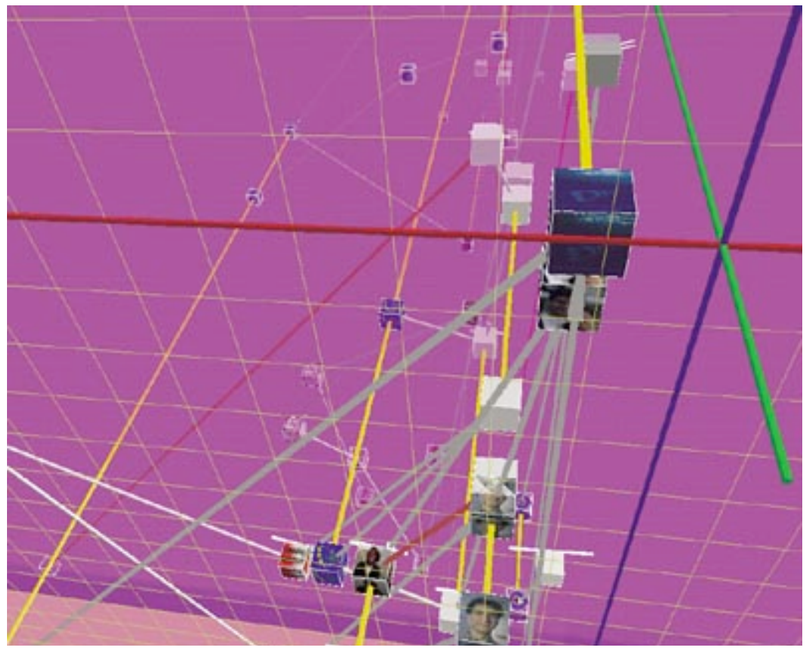




Excel Charts Blog

No unjustified 3D

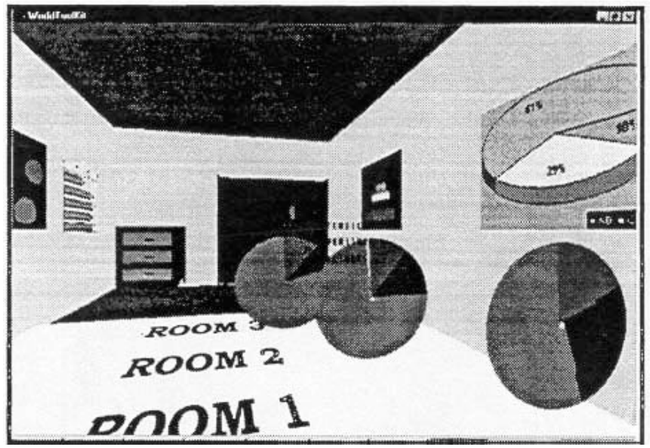
- 3D legitimate for true 3D spatial data
- 3D needs very careful justification for abstract data
  - enthusiasm in 1990s, but now skepticism
  - be especially careful with 3D for point clouds or networks

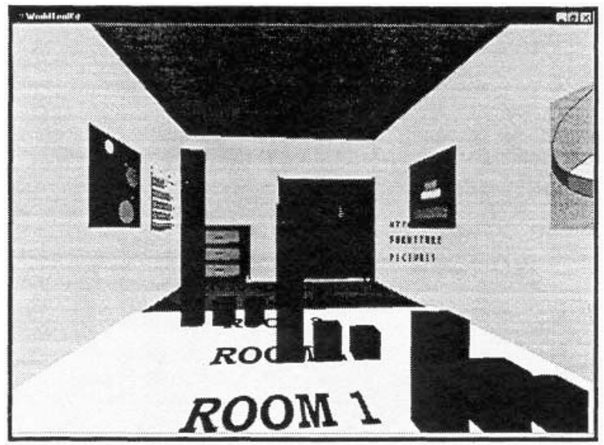


[WEBPATH-a three dimensional Web history. Frecon and Smith. Proc. InfoVis 1999]

Resolution beats immersion

- immersion typically not helpful for abstract data
  - do not need sense of presence or stereoscopic 3D
- resolution much more important
  - pixels are the scarcest resource
  - desktop also better for workflow integration
- virtual reality for abstract data very difficult to justify





[Development of an information visualization tool using virtual reality. Kirner and Martins. Proc. Symp. Applied Computing 2000]

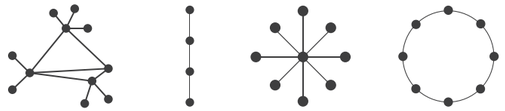
No unjustified 2D

- consider whether network data requires 2D spatial layout
  - especially if reading text is central to task!
  - arranging as network means lower information density and harder label lookup compared to text lists
- benefits outweigh costs when topological structure/context important for task
  - be especially careful for search results, document collections, ontologies

Targets

Network Data

→ Topology



→ *Paths*

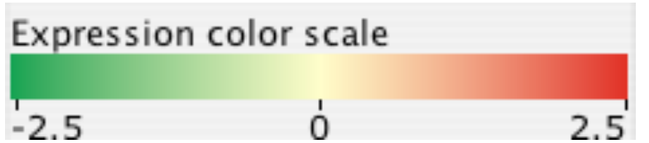
Eyes beat memory

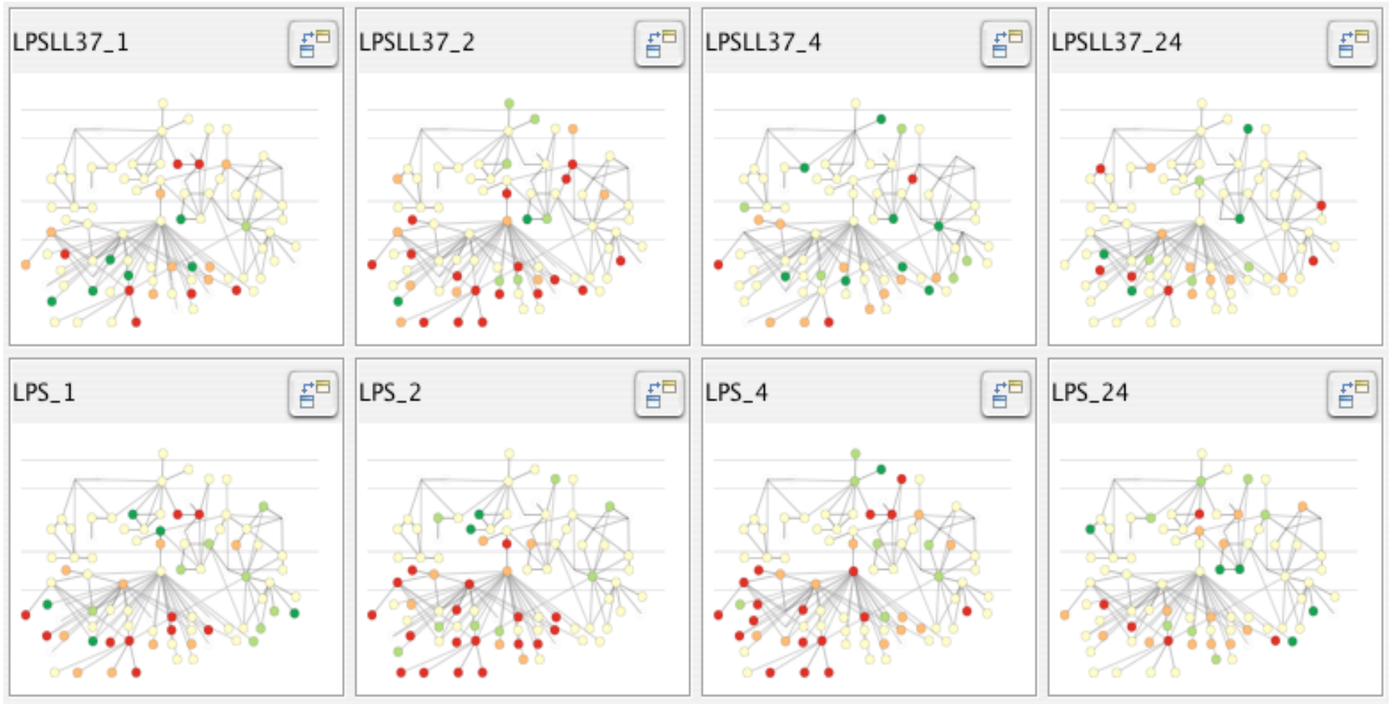
- principle: external cognition vs. internal memory
  - easy to compare by moving eyes between side-by-side views
  - harder to compare visible item to memory of what you saw
- implications for animation
  - great for choreographed storytelling
  - great for transitions between two states
  - poor for many states with changes everywhere
    - consider small multiples instead

Change blindness
(Lecture 1)

Eyes beat memory example: Cerebral

- small multiples: one graph instance per experimental condition
  - same spatial layout
  - color differently, by condition

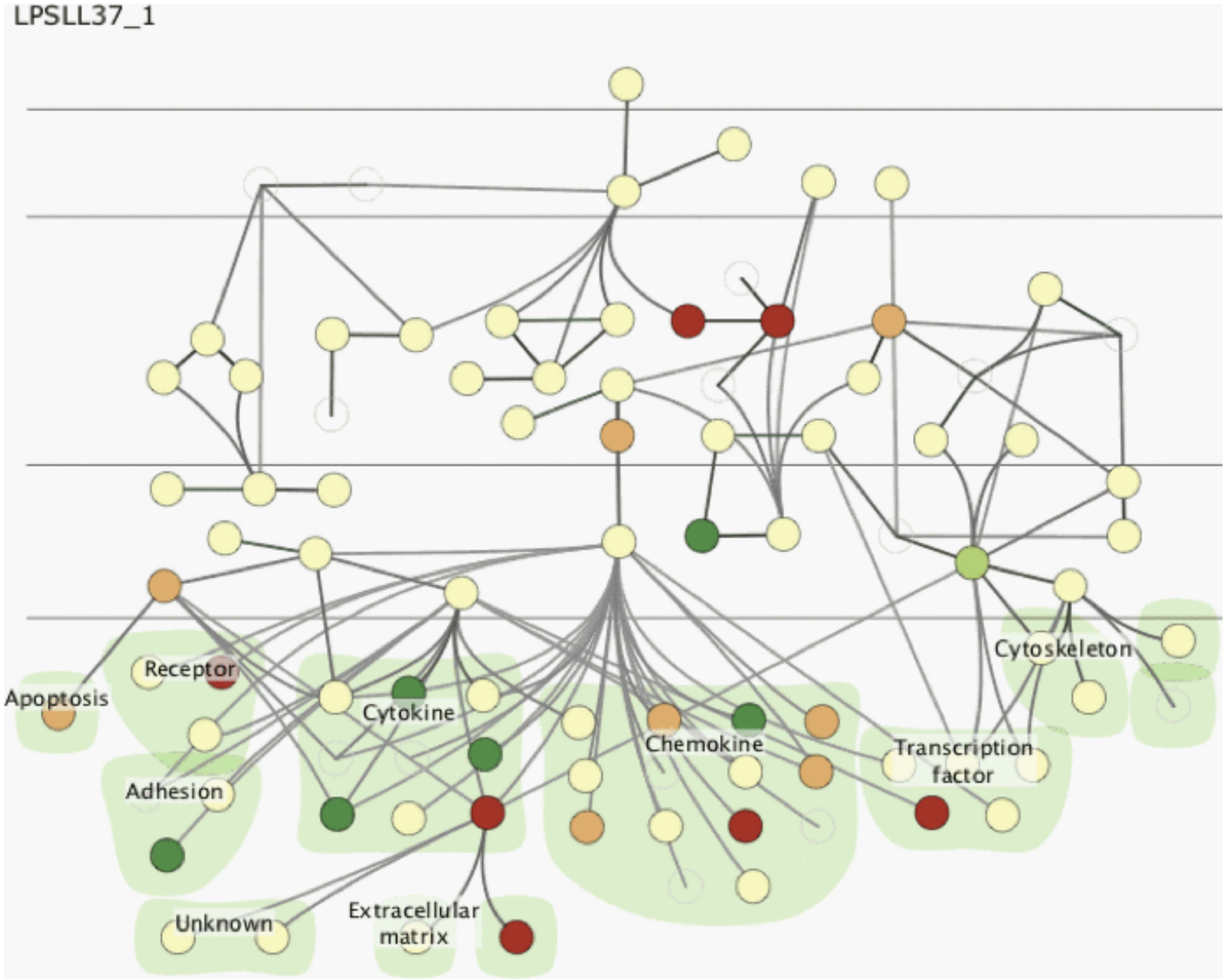




[Cerebral: Visualizing Multiple Experimental Conditions on a Graph with Biological Context. Barsky, Munzner, Gardy, and Kincaid. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2008) 14:6 (2008), 1253–1260.]

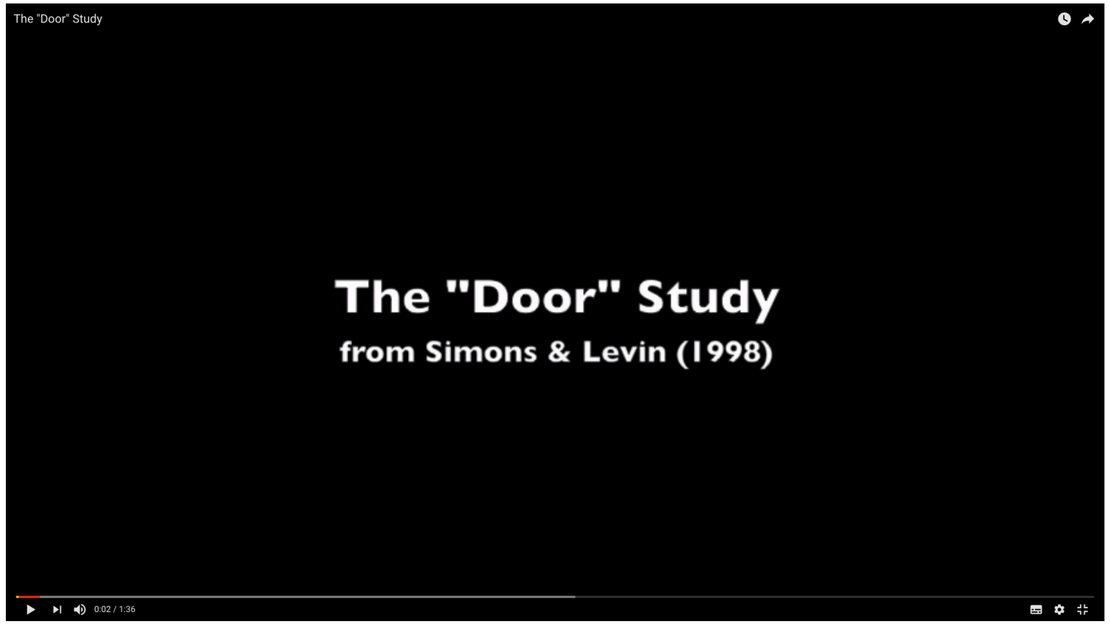
Why not animation?

- disparate frames and regions: comparison difficult
  - vs contiguous frames
  - vs small region
  - vs coherent motion of group
- change blindness
  - even major changes difficult to notice if mental buffer wiped
- safe special case
  - animated transitions

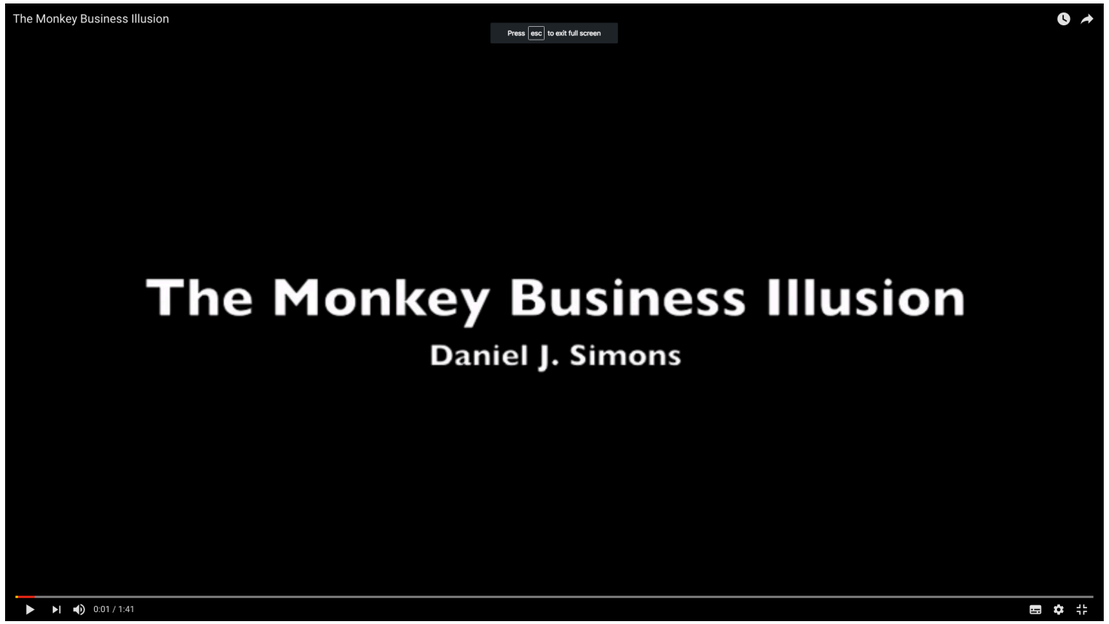


Change and attention blindness

- We don’t have memory of what we *saw*
- We only remember things we were *looking at*
- We don’t even see things we are not interested in



https://www.youtube.com/watch?v=FWSxSQsspiQ



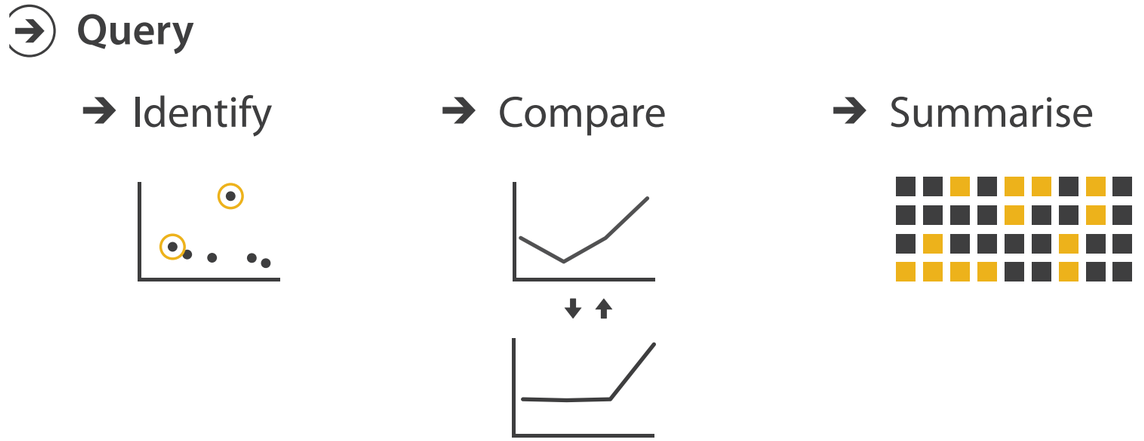
https://www.youtube.com/watch?v=IGQmdoK_ZfY

Overview first, zoom and filter, details on demand

- influential mantra from Ben Shneiderman

[The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations. Shneiderman. Proc. IEEE Visual Languages, pp. 336–343, 1996.]

- overview = summary
  - microcosm of full Vis design problem



- nuances
  - beyond just two levels: multi-scale structure
  - difficult when scale huge: give up on overview and browse local neighborhoods?

[Search, Show Context, Expand on Demand: Supporting Large Graph Exploration with Degree-of-Interest. van Ham and Perer. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 953–960.]

Responsiveness

- *Latency*: time interval between user action and system responsiveness
- Interactive Vis apps require short latency times
- System responsiveness in Vis app: *visual feedback*
- Interaction design goal: good match of latency for
  - low-level interaction mechanism
  - visual feedback
  - system update
  - cognitive load

Time Constant	Value (in seconds)
perceptual processing	0.1
immediate response	1
brief tasks	10

Responsiveness - Examples

- Low-level interaction:
  - Click on item
  - Mouseover hover with dwell time
  - Mouseover hover without dwell time
- Visual feedback:
  - Fixed detail pane
  - Popup window
  - Visual highlight change (selected entity in other views, neighbors, members of the same group…)

Responsiveness - Examples

- System update:
  - Dataset size may heavily impact on load & update times
    - datasets that don't fit primary memory
    - distributed datasets (across the network)
  - Refresh of graphics critical if there are too many primitives (unlikely in 2D)
- Cognitive load:
  - User must have sufficient time to appreciate changes
  - Messages, popups, and highlights must linger long enough to be understood
  - Animations must be slow enough the perceive their effects

Get it right in black and white

- Color coding should be used only when it is necessary or has justified advantages
- Encode most important attributes with position, length
- Favor luminance over saturation and hue
  - but hue may be better support for pre-attentive tasks
- Check robustness to color blindness

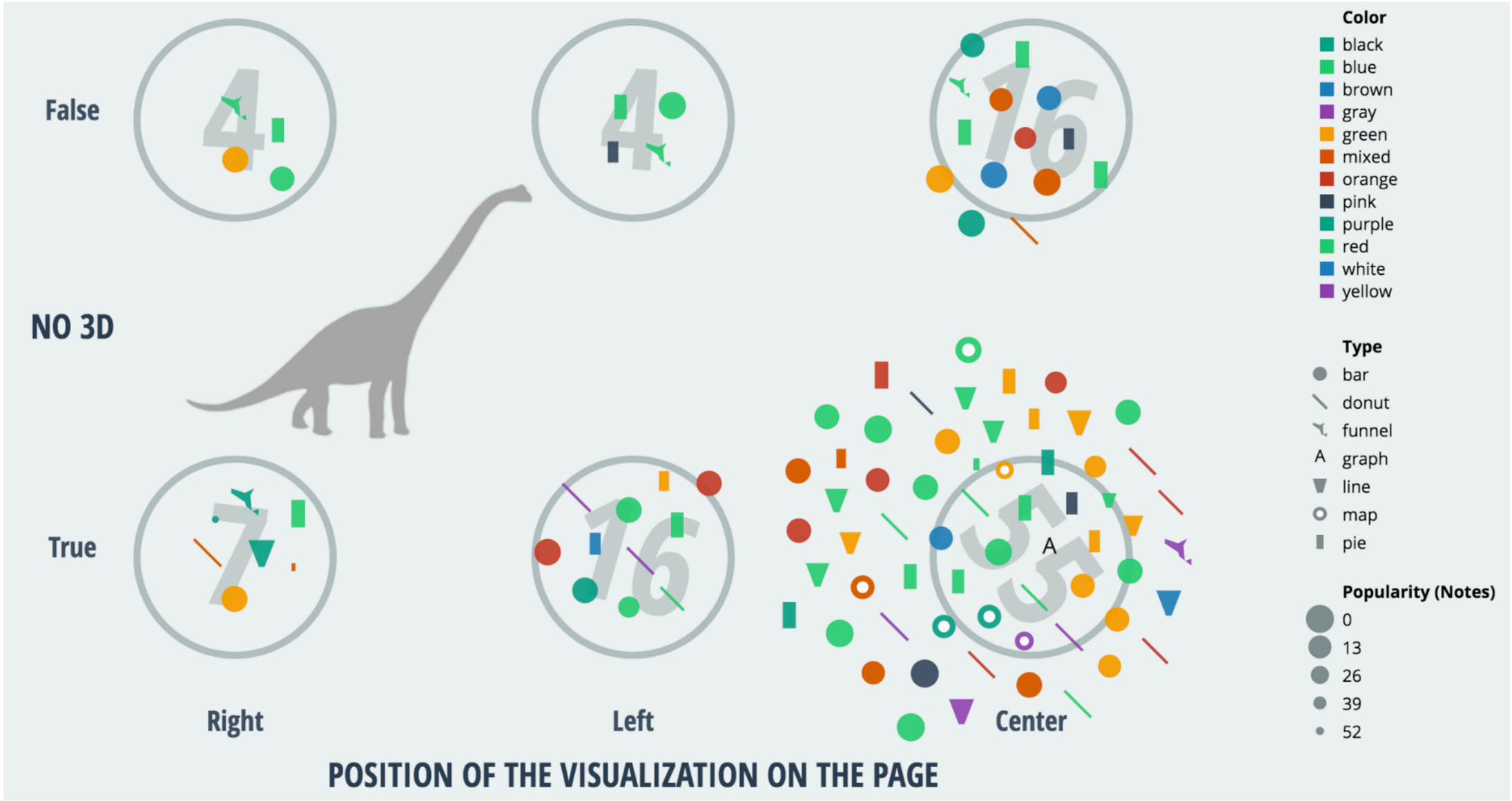
Function first, form next

- start with focus on functionality
  - straightforward to improve aesthetics later on, as refinement
  - if no expertise in-house, find good graphic designer to work with

- dangerous to start with aesthetics
  - usually impossible to add function retroactively

Bad examples

https://medium.freecodecamp.com/how-i-carefully-crafted-a-terrible-visualization-2c8e06d50ebb#.at9unqify



Plenty of examples on http://viz.wtf/

Next Time

- to read:
  - VAD Chap 7: Arrange Tables