Information Visualization Rules of Thumb

Tamara Munzner

Department of Computer Science
University of British Columbia

Lect 20/21, 19/24 Mar 2020

https://www.cs.ubc.ca/~tmm/courses/436V-20
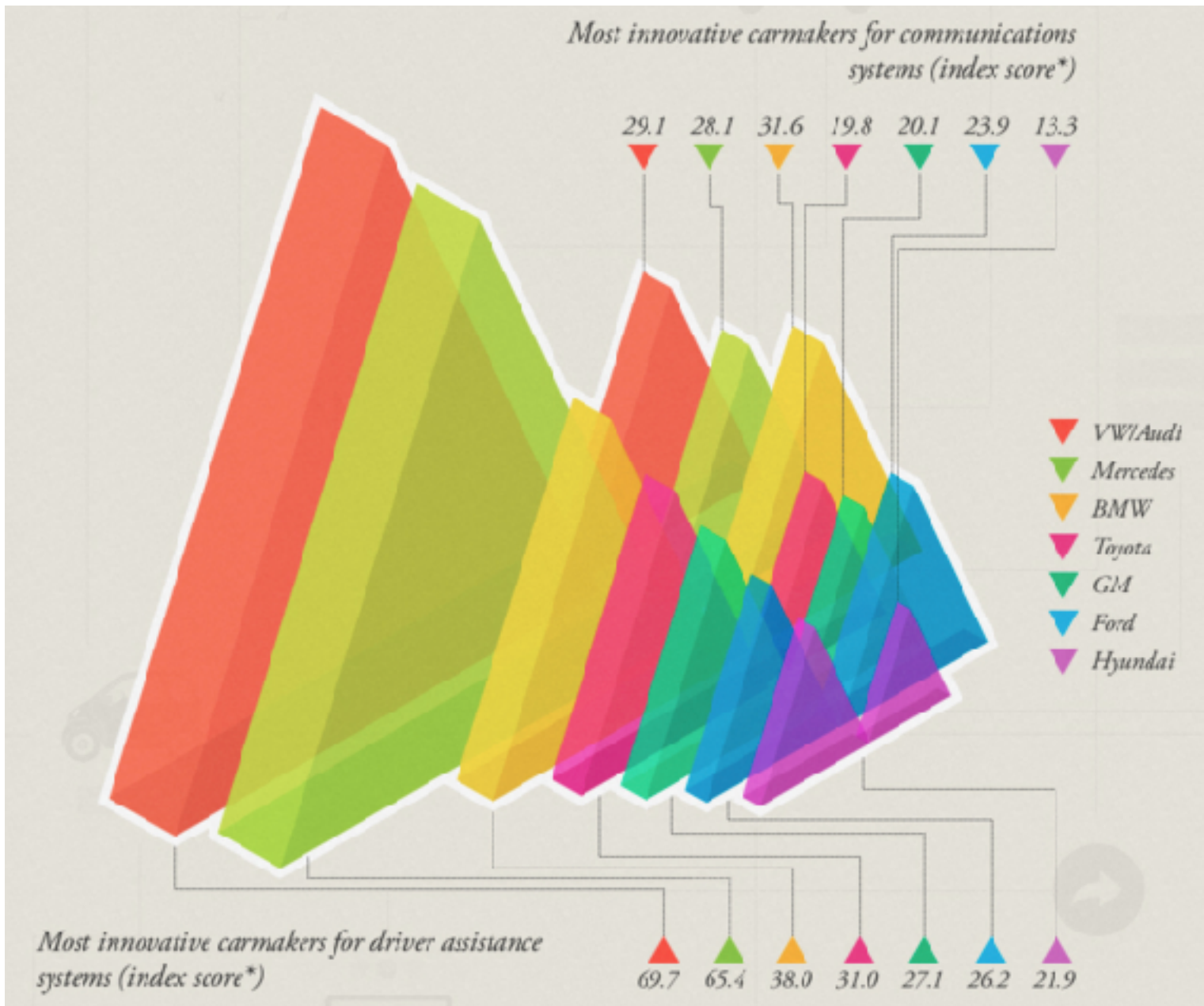
Upcoming

- Milestone 2: still due Wed Mar 25 11:59pm
  - (remember update announced w/ schedule status component)
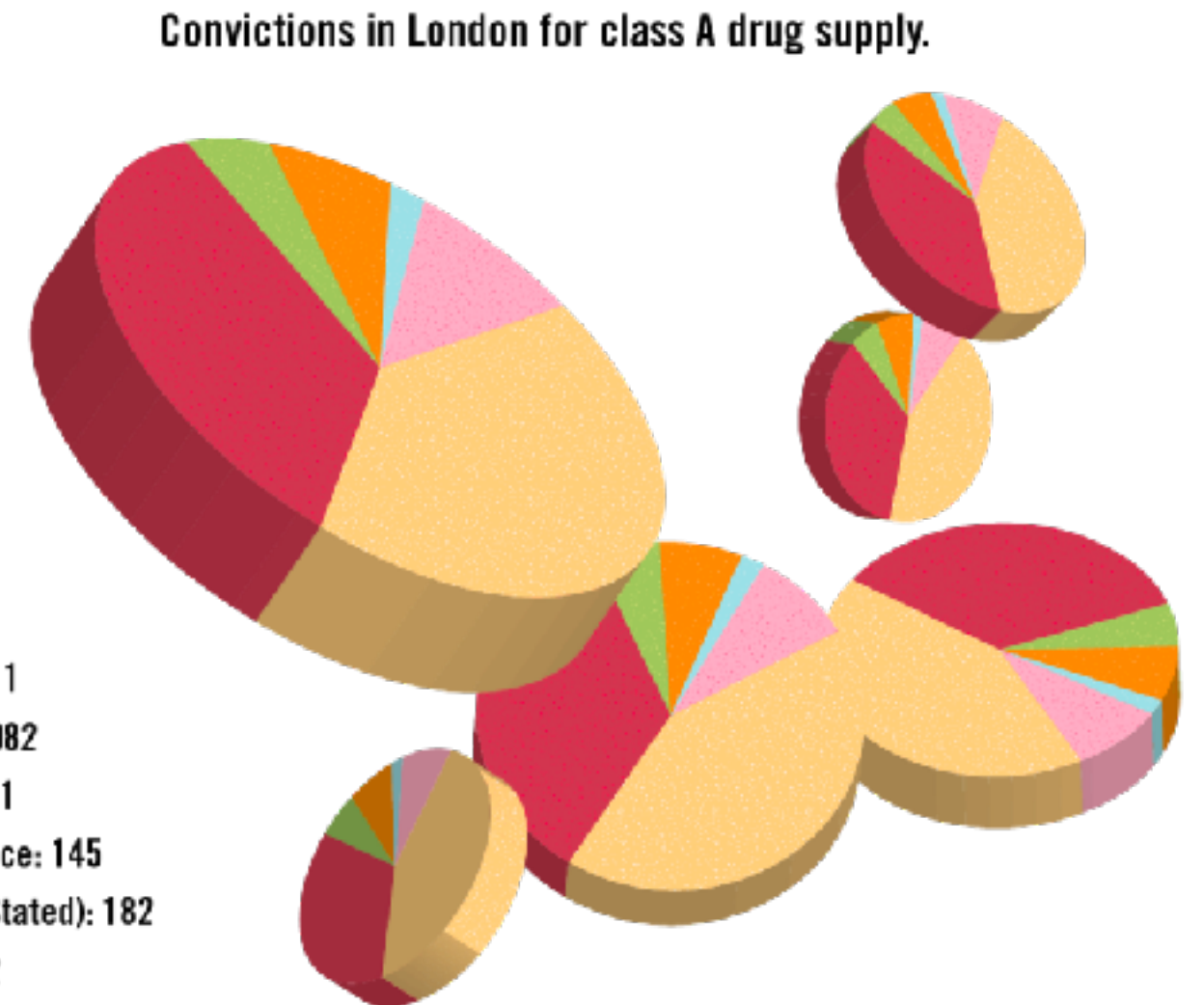
Rules of Thumb

Rules of Thumb Summary

- No unjustified 3D
- No unjustified 2D
- Eyes beat memory
- Resolution over immersion
- Overview first, zoom and filter, details on demand
- Responsiveness is required
- Function first, form next

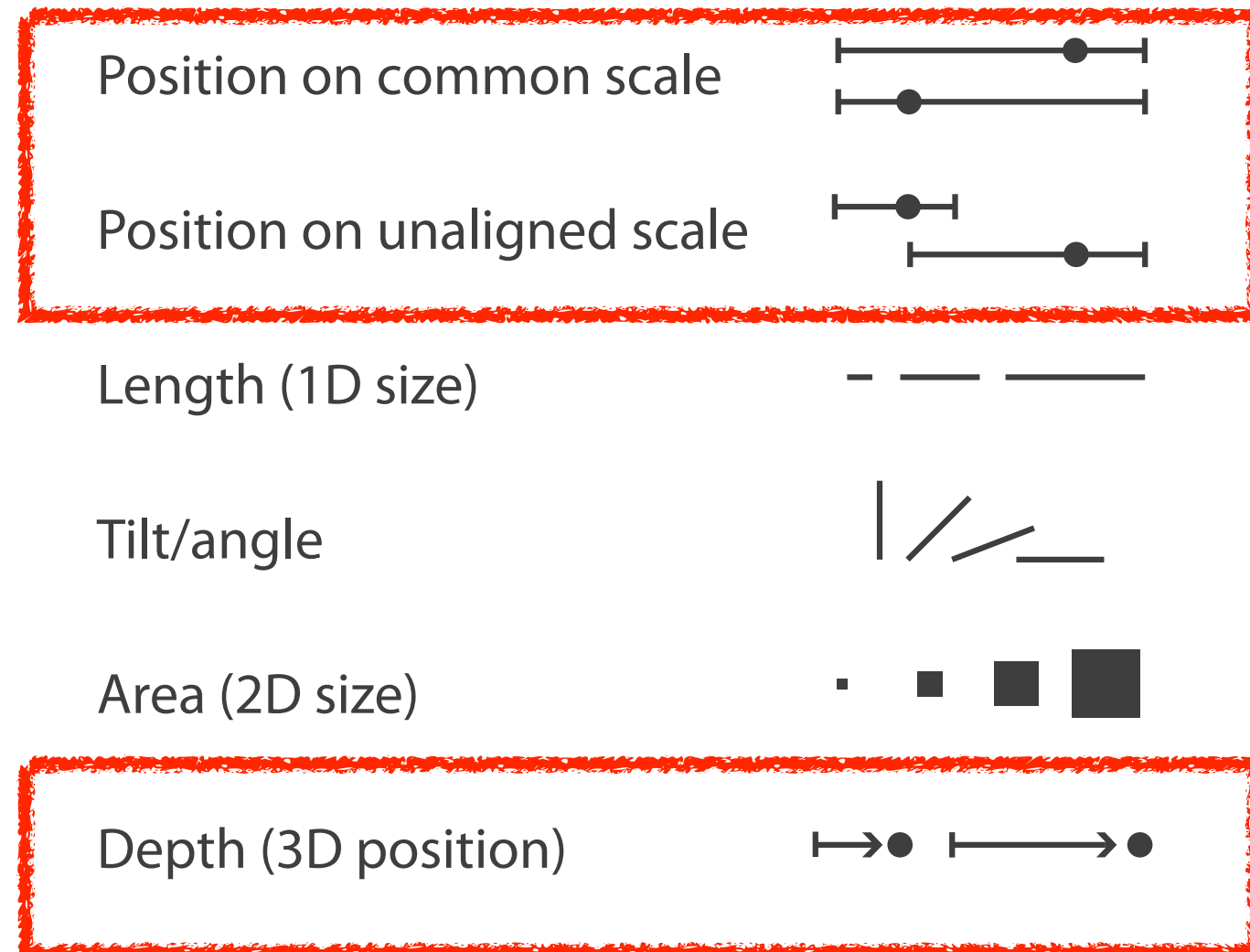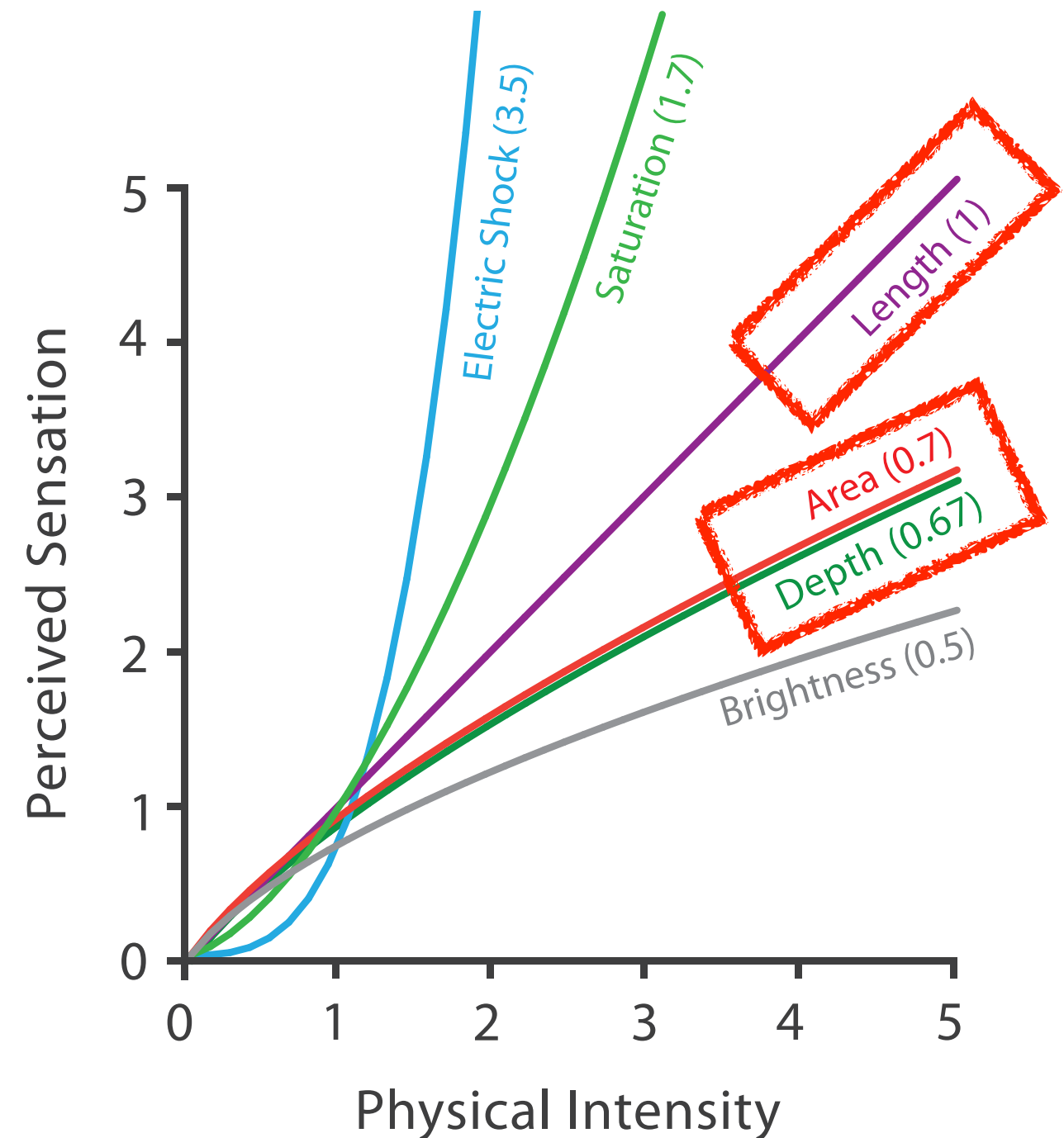# Unjustified 3D all too common, in the news and elsewhere

http://viz.wtf/post/137826497077/eye-popping-3d-triangles

http://viz.wtf/post/139002022202/designer-drugs-ht-ducqn

Depth vs power of the plane

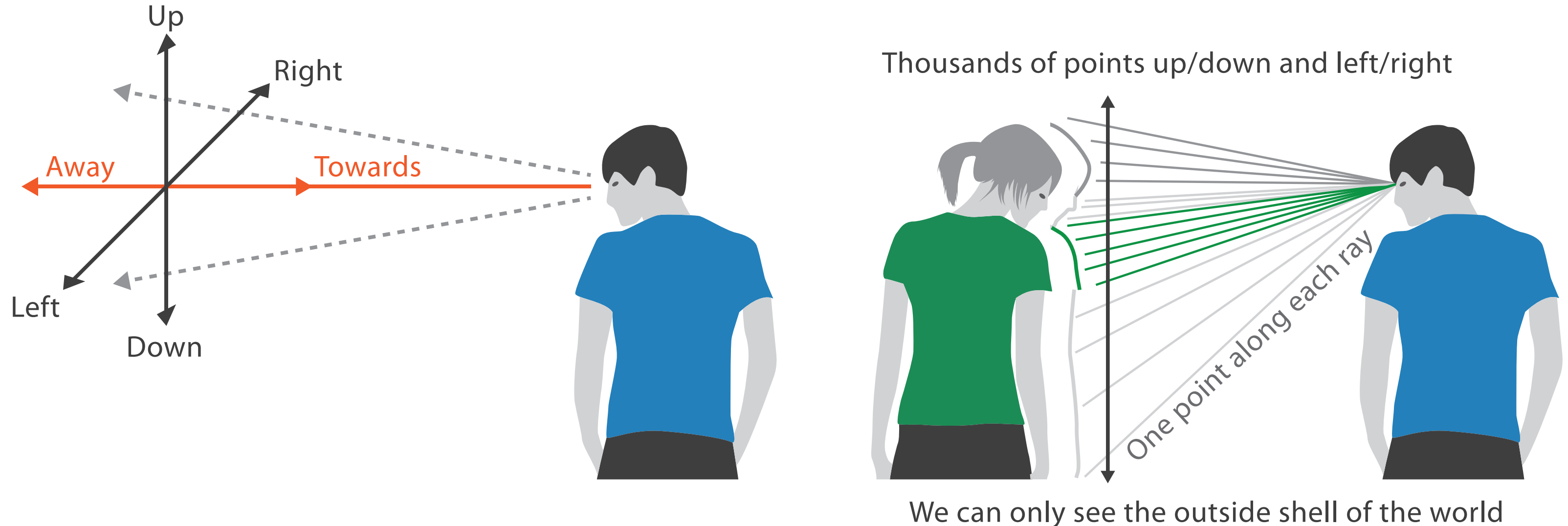- high-ranked spatial position channels: **planar** spatial position
  - not depth!

Steven's Psychophysical Power Law: $S = I^N$

→ **Magnitude** Channels: **Ordered** Attributes

Position on common scale

Position on unaligned scale

Length (1D size)

Tilt/angle

Area (2D size)

Depth (3D position)

Electric Shock (3.5)

Saturation (1.7)

Length (1)

Area (0.7)

Depth (0.67)

Brightness (0.5)

Perceived Sensation

Physical Intensity

No unjustified 3D: Danger of depth

- we don't really live in 3D: 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

Up

Right

Away   Towards

Left

Down

Thousands of points up/down and left/right

One point along each ray

We can only see the outside shell of the world

Occlusion hides information

- occlusion
- interaction can resolve, but at cost of time and cognitive load
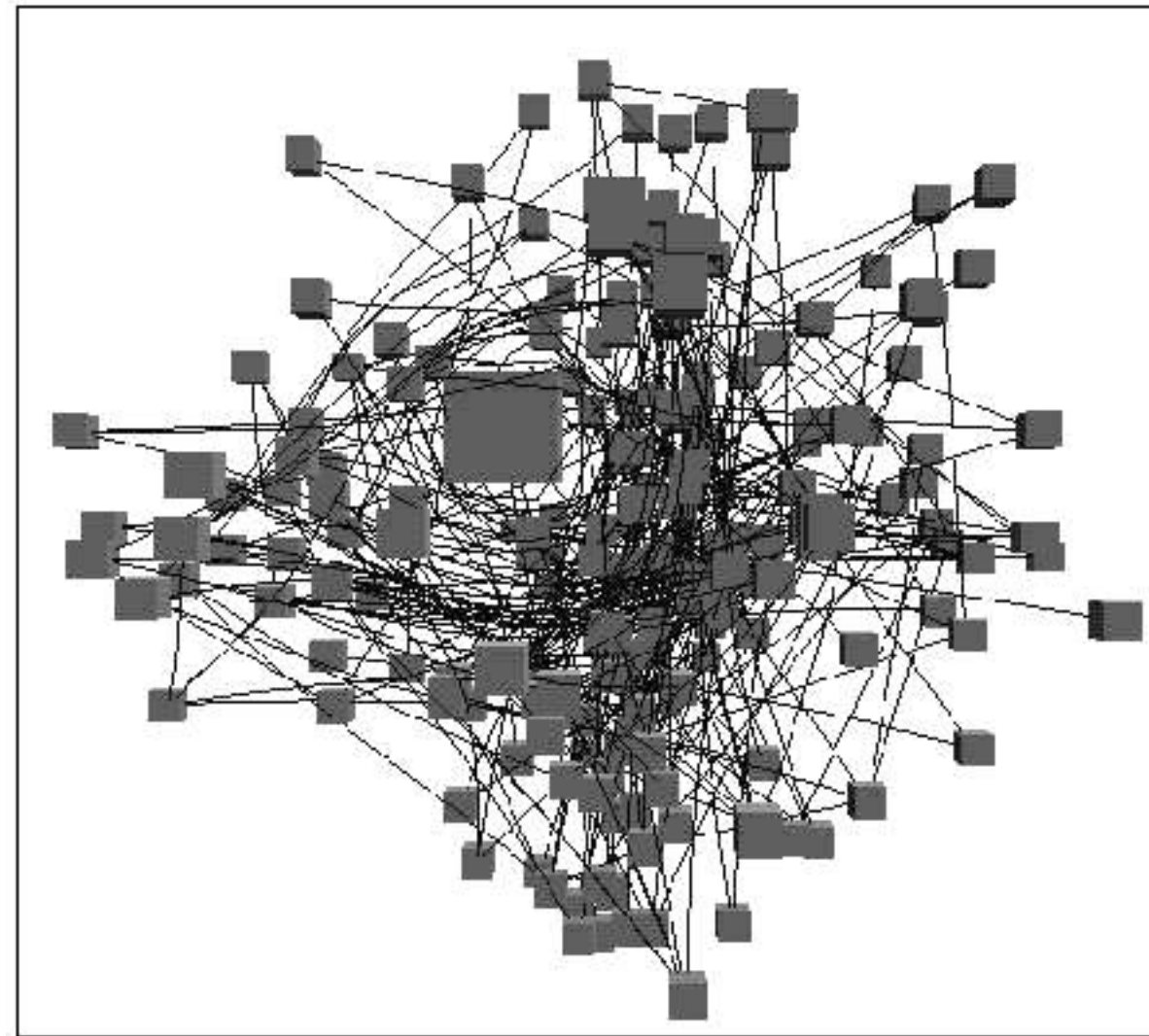
[Distortion Viewing Techniques for 3D Data. Carpendale et al. InfoVis 1996.]

Perspective distortion loses information

- perspective distortion
  - interferes with all size channel encodings
  - power of the plane is lost!

[Visualizing the Results of Multimedia Web Search Engines.
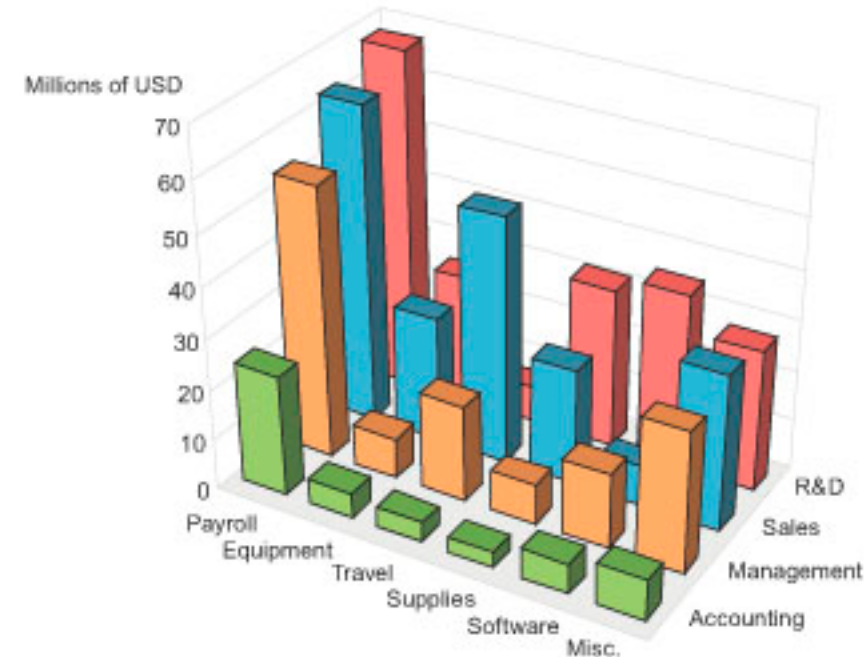*Mukherjea, Hirata, and Hara. InfoVis 96]*

3D vs 2D bar charts

- 3D bars very difficult to justify!
  - perspective distortion
  - occlusion
- faceting into 2D almost always better choice

[http://perceptualedge.com/files/GraphDesignIQ.html]
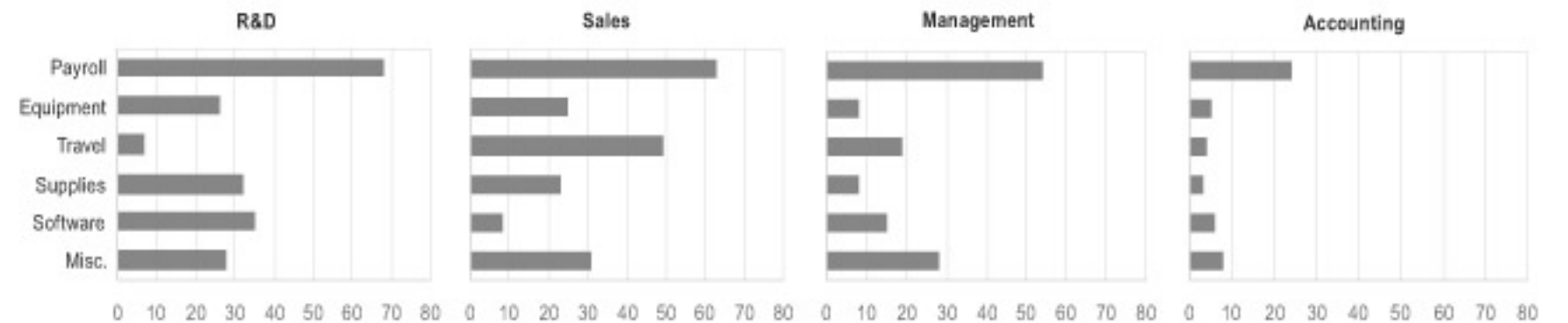
Tilted text isn't legible
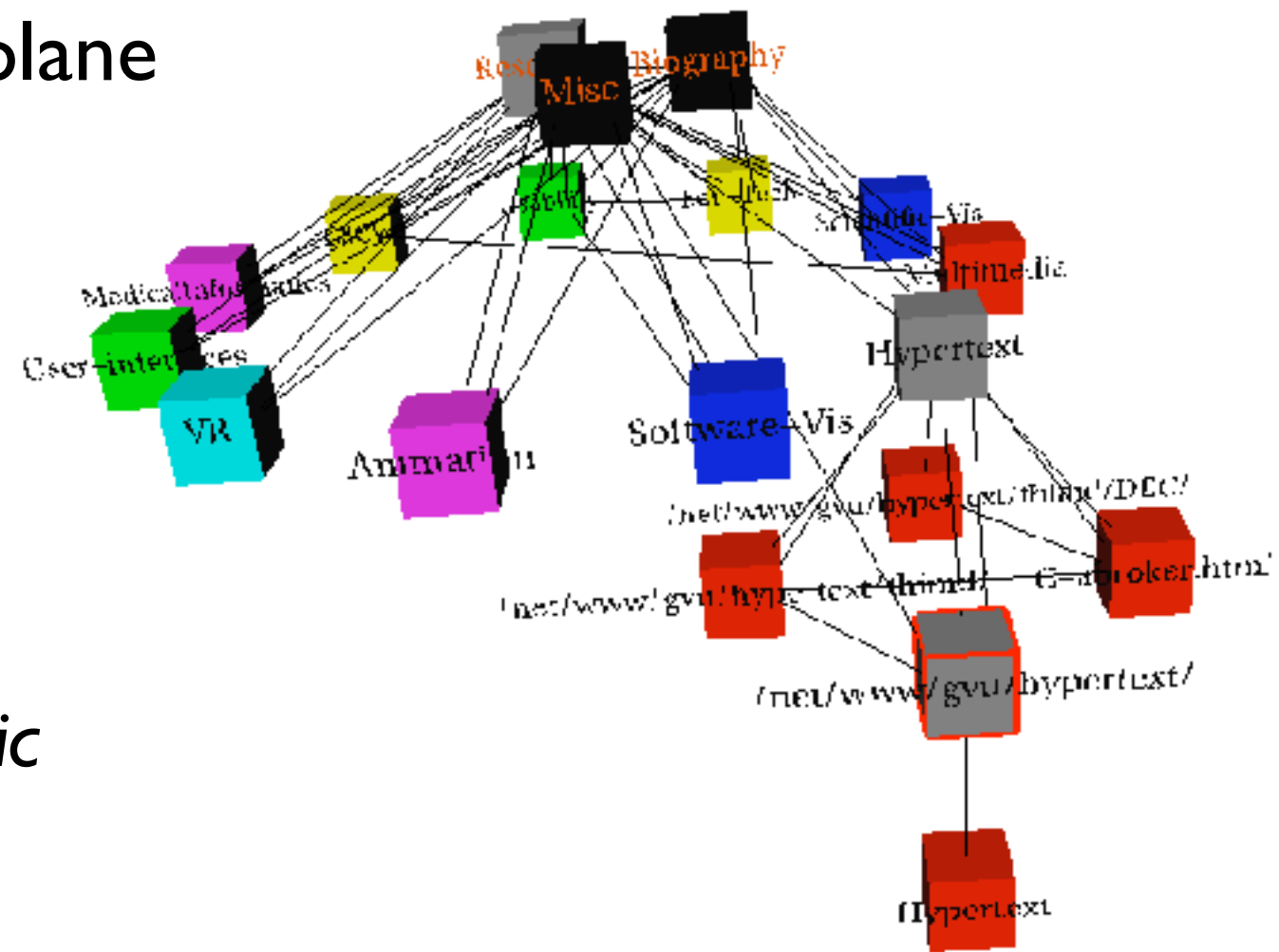
- text legibility
  - far worse when tilted from image plane

- further reading

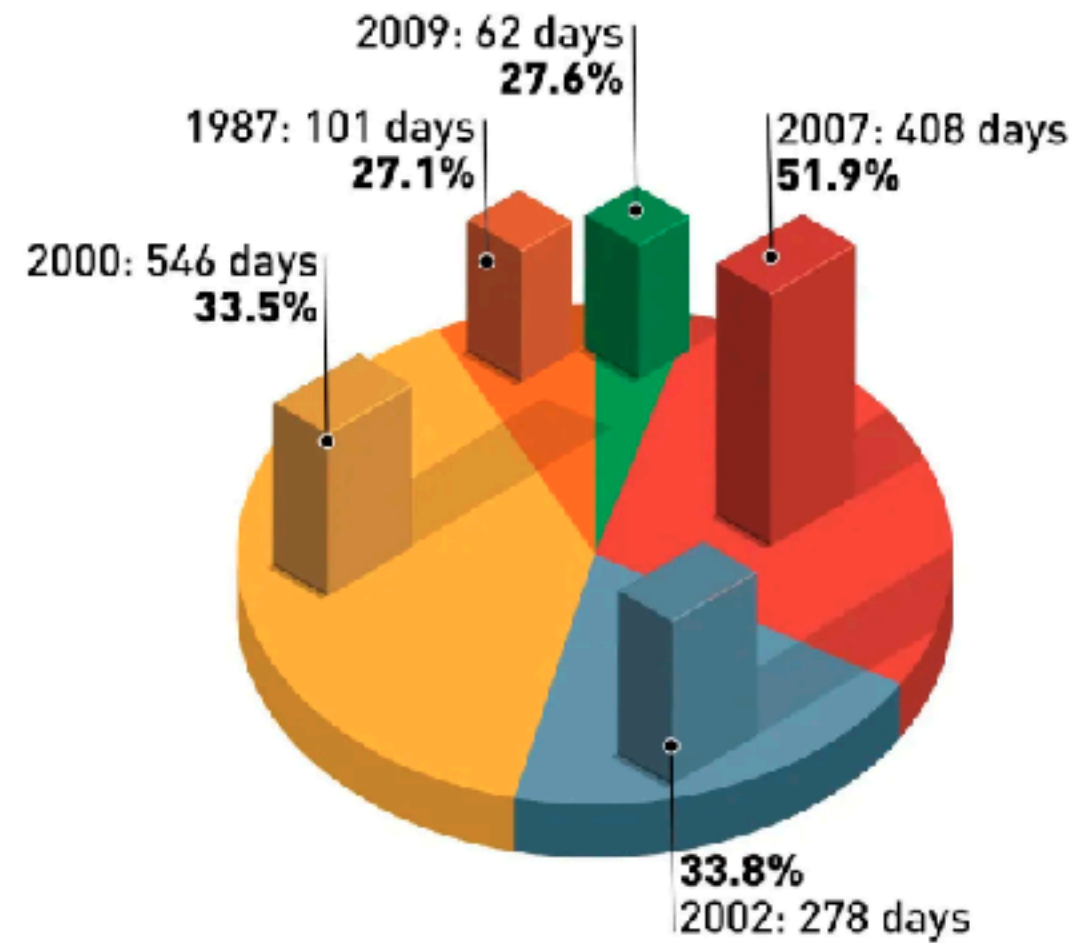 *[Exploring and Reducing the Effects of Orientation on Text Readability in Volumetric Displays.*
  Grossman et al. CHI 2007]

[Visualizing the World-Wide Web with the Navigational View Builder. Mukherjea and Foley. Computer Networks and ISDN Systems, 1995.]

Socrative quiz: 3D pie charts++

Bear markets, how long do they last?

2009: 62 days
27.6%

1987: 101 days
27.1%

2007: 408 days
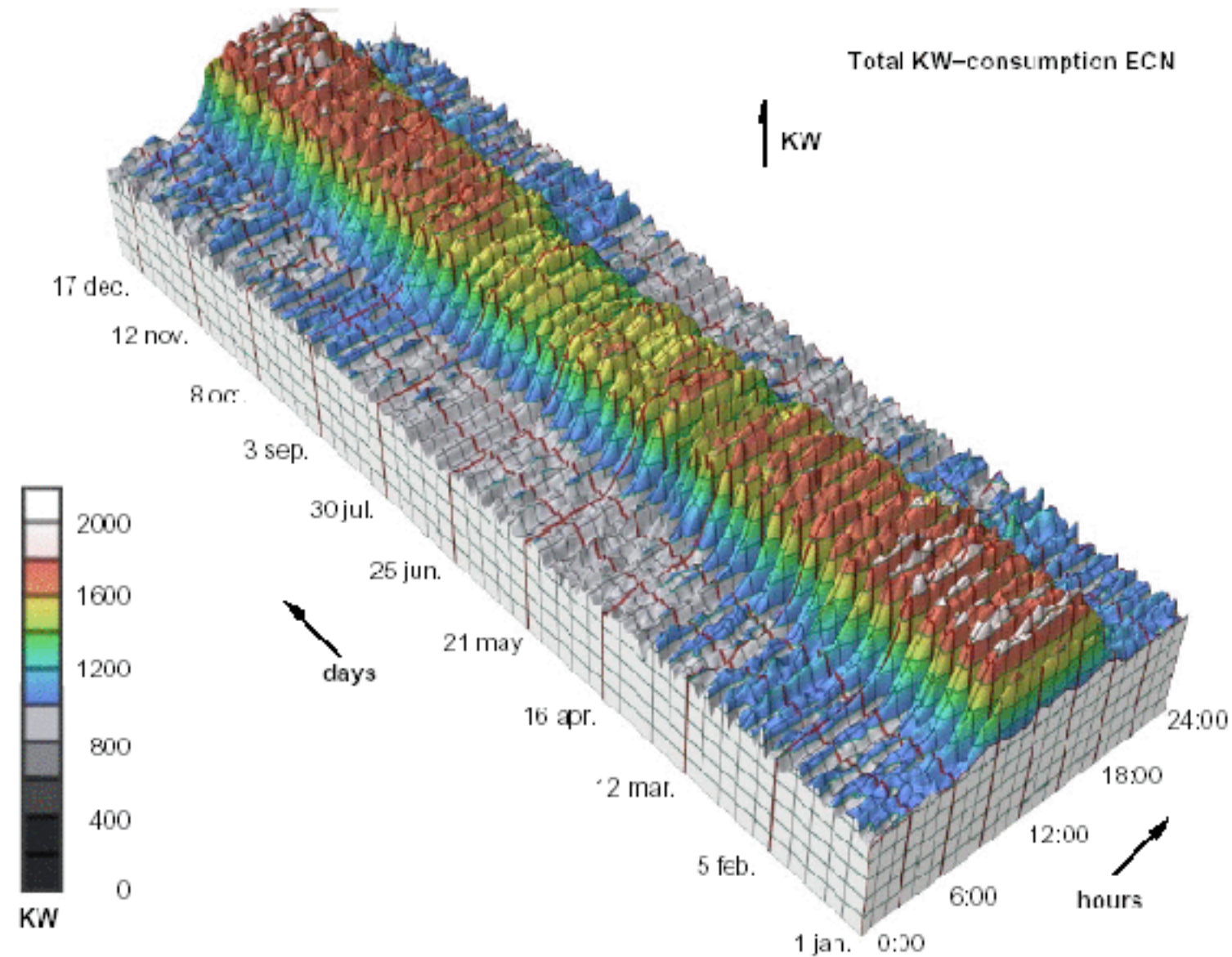**51.9%**

2000: 546 days
33.5%

33.8%
2002: 278 days

CBC NEWS

This shows the lengths and depths of the last five bear markets on the S&P 500 that we've seen, prior to this one. (Scott Galley/CBC)

https://twitter.com/amcrisan/status/1238215422530342912?s=20
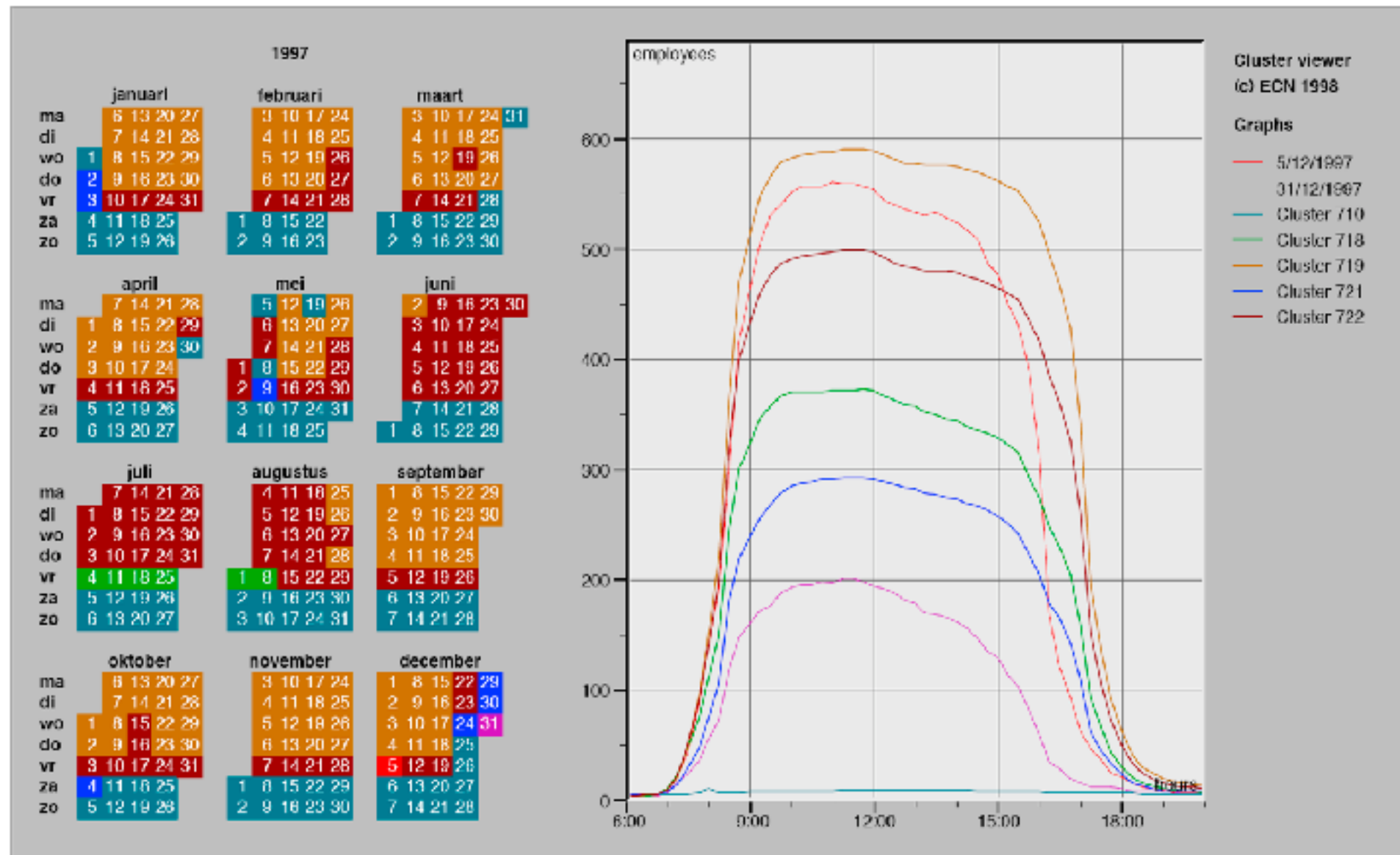
No unjustified 3D example: Time-series data

- 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.]
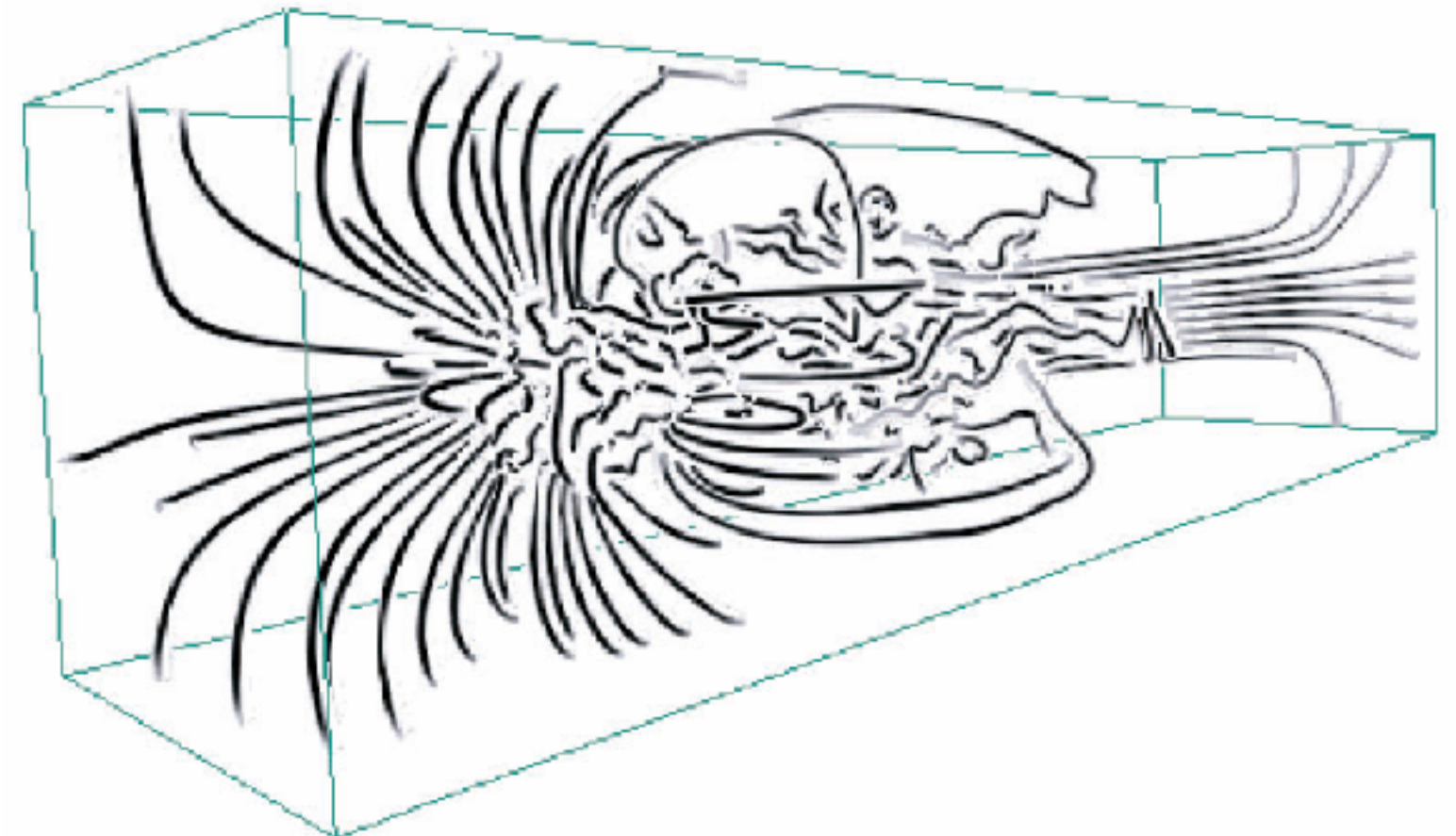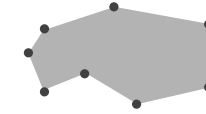
Justified 3D: shape perception

- benefits outweigh costs when task is shape perception for 3D spatial data

  - interactive navigation supports synthesis across many viewpoints
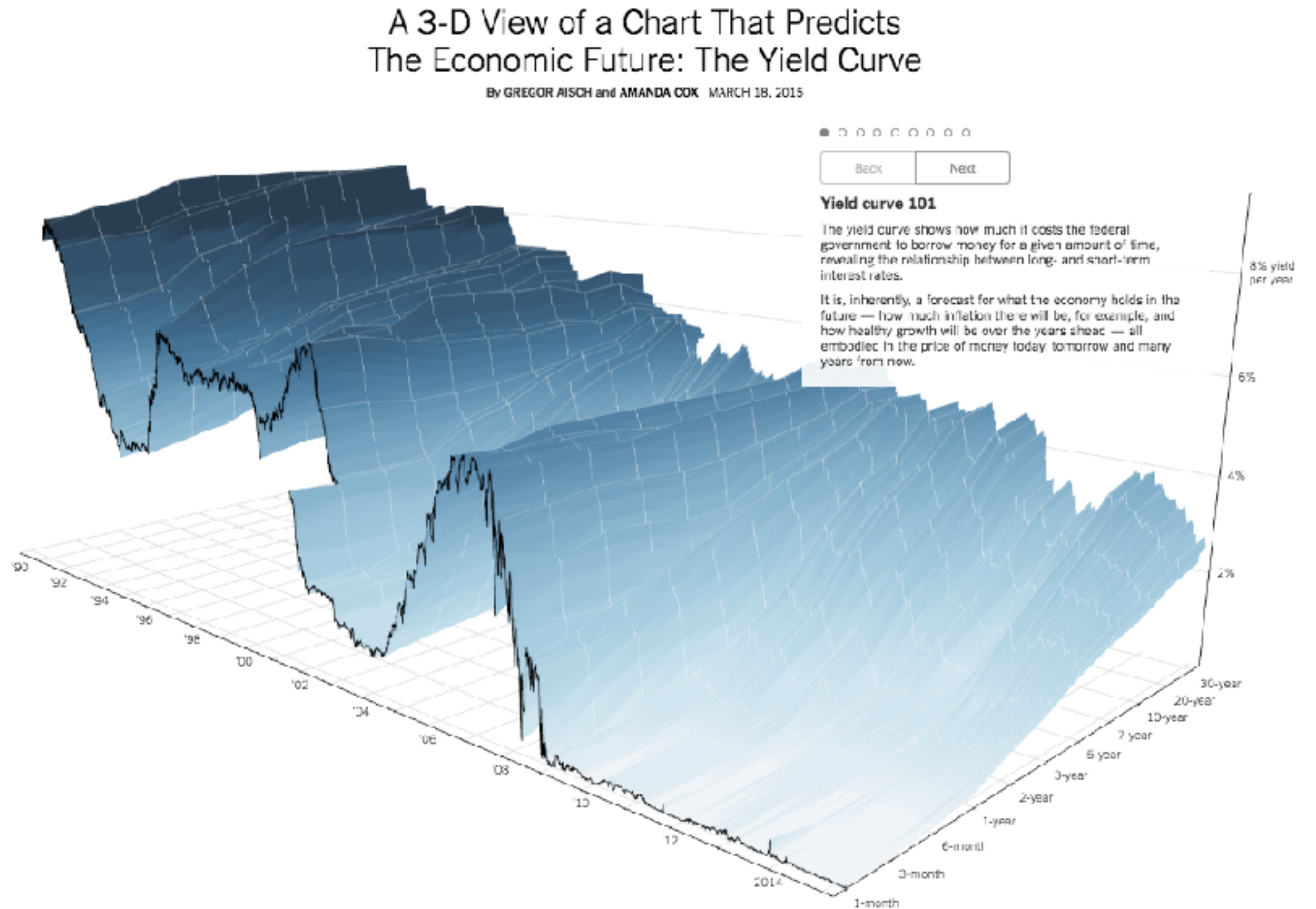
🛢 Targets

→ Spatial Data

↦ Shape

Justified 3D: Economic growth curve

- constrained navigation steps through carefully designed viewpoints

A 3-D View of a Chart That Predicts The Economic Future: The Yield Curve

By GREGOR AISCH and AMANDA COX   MARCH 18, 2015

Yield curve 101

The yield curve shows how much it costs the federal government to borrow money for a given amount of time, revealing the relationship between long- and short-term interest rates.

It is, inherently, a forecast for what the economy holds in the future — how much inflation there will be, for example, and how healthy growth will be over the years ahead — all embodied in the price of money today, tomorrow and many years from now.

http://www.nytimes.com/interactive/2015/03/19/upshot/3d-yield-curve-economic-growth.html

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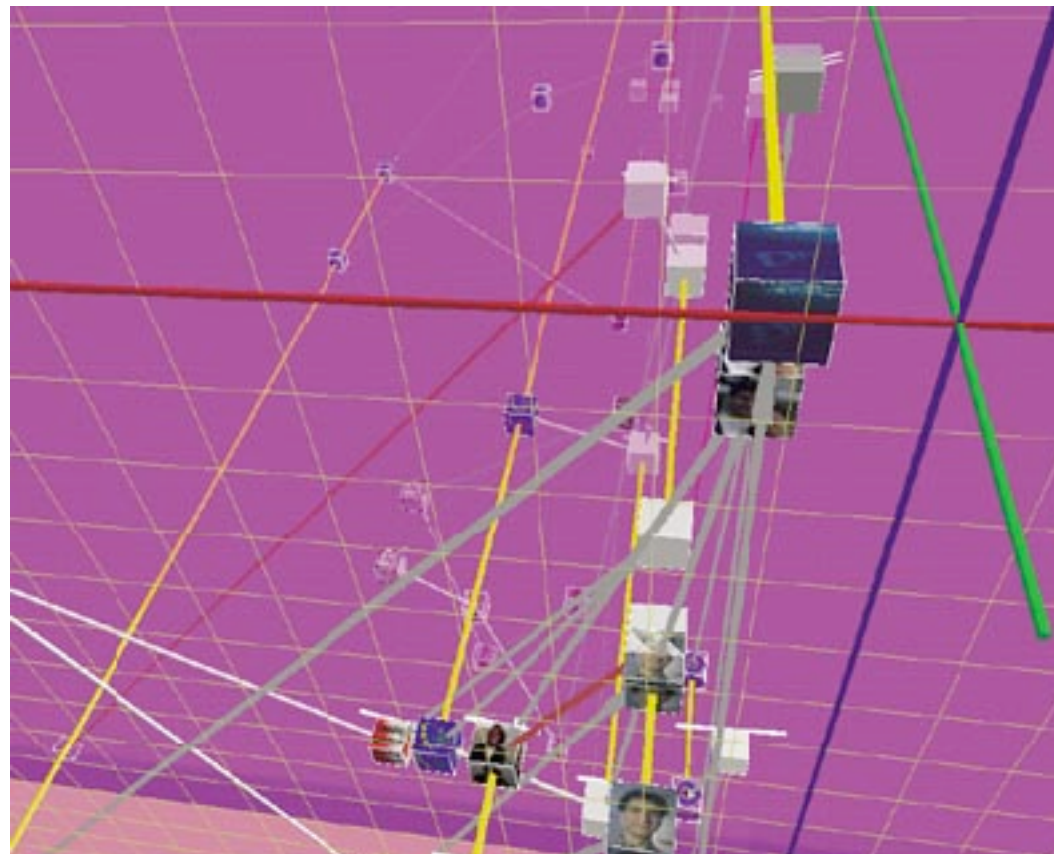
[WEBPATH-a three dimensional Web history. Frecon and Smith. Proc. InfoVis 1999]

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
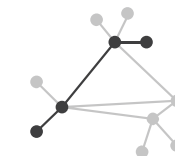
Targets

➔ **Network Data**
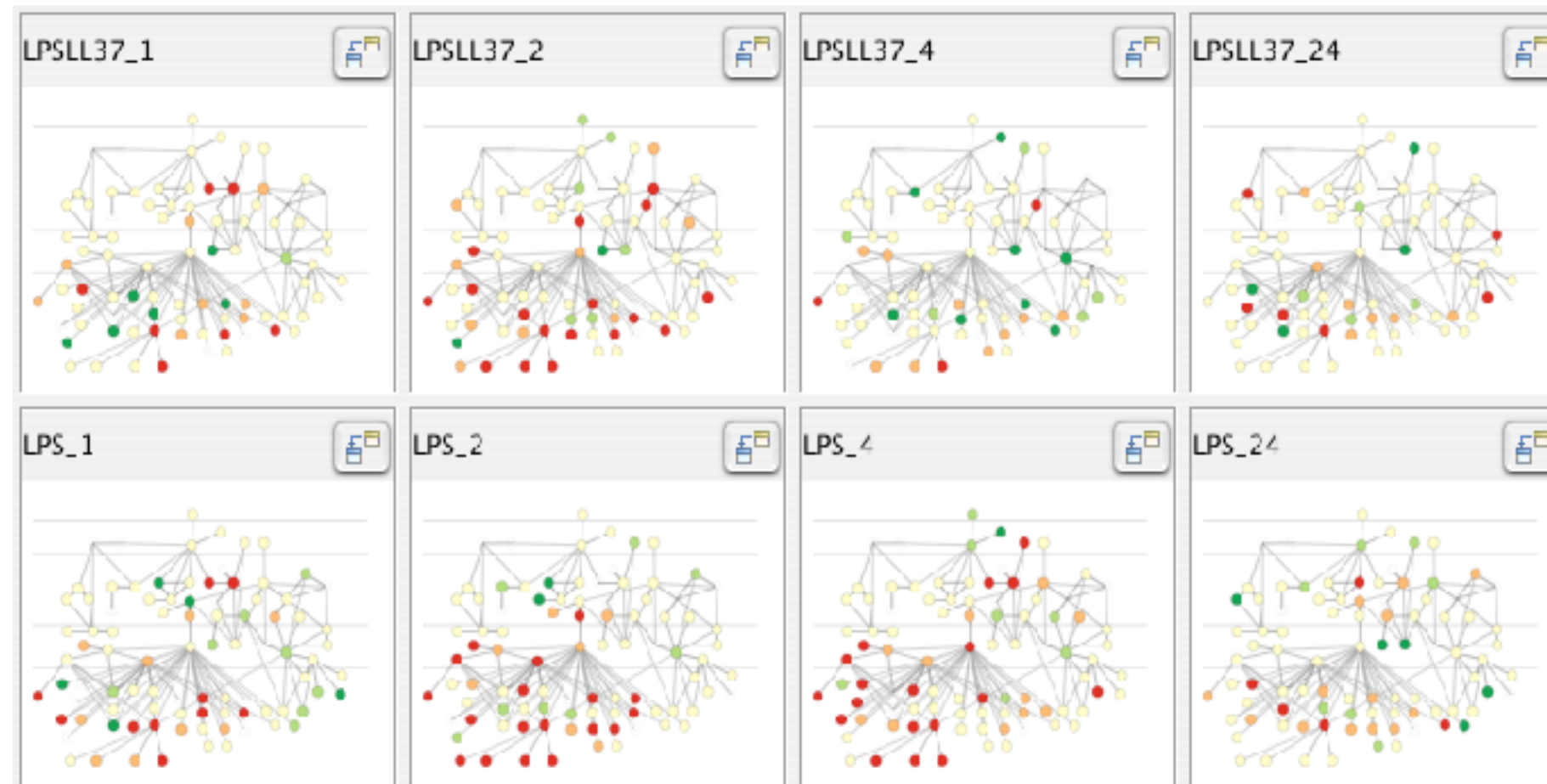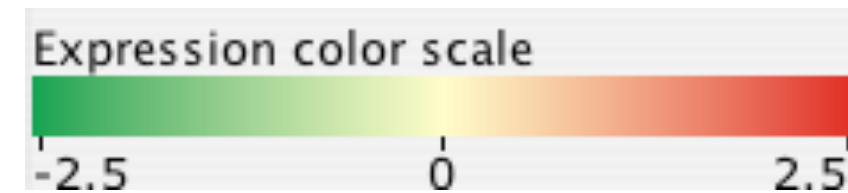
  ➔ Topology
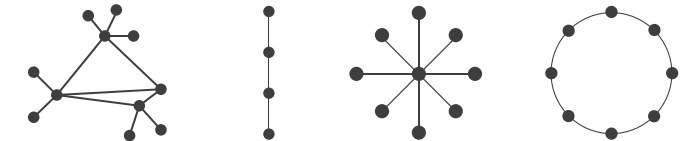
    ➔ *Paths*

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

literal   abstract

animation   small multiples

show time with time   show time with space

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

- safe special case
  - animated transitions
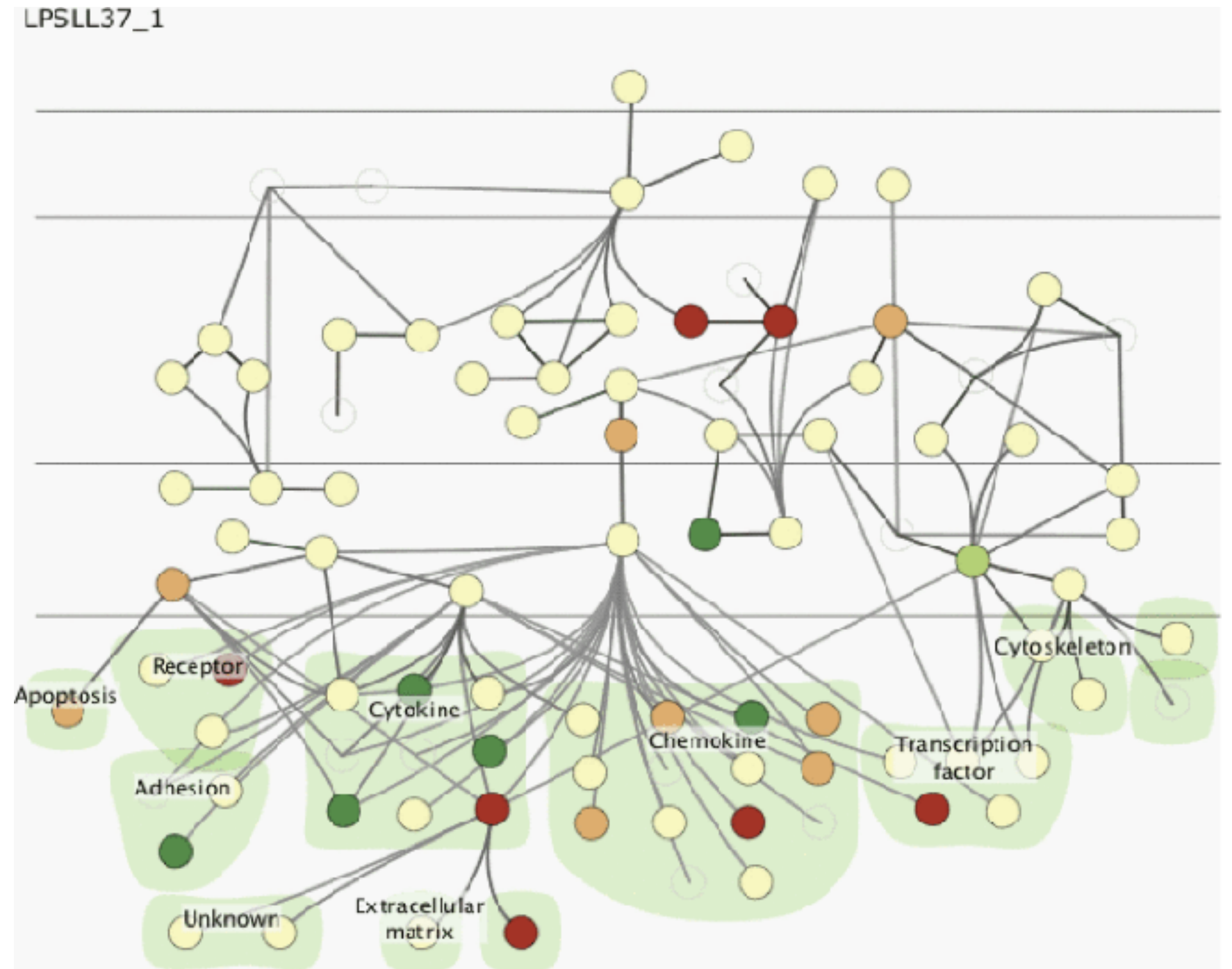
Change blindness

- if attention is directed elsewhere, even drastic changes not noticeable
  - door experiment
- change blindness demos
  - mask in between images
    https://youtu.be/bh_9XFzbWV8

Resolution beats immersion

- immersion typically not helpful for abstract data
  - do not need sense of presence or stereoscopic 3D
  - desktop also better for workflow integration
- resolution much more important: pixels are the scarcest resource
- virtual reality for abstract data difficult to justify thus far
  - but stay tuned with second wave, AR (augmented reality) has more promise
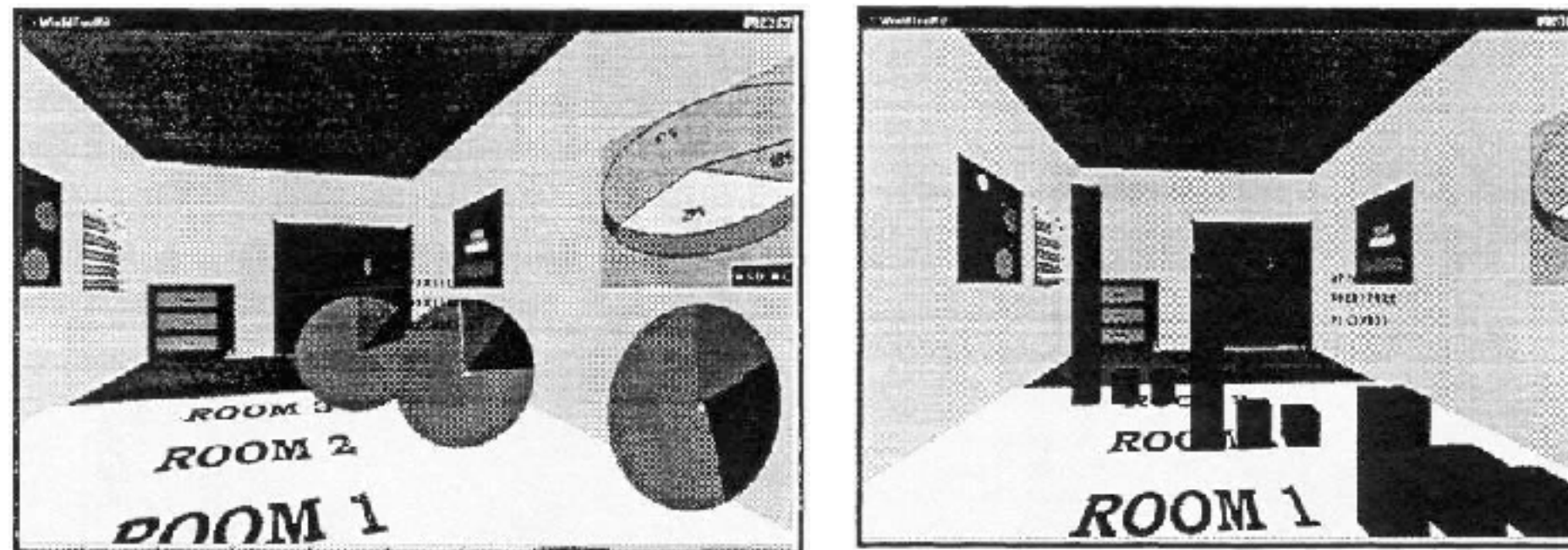
[Development of an information visualization tool using virtual reality. Kirner and Martins. Proc. Symp. Applied Computing 2000]

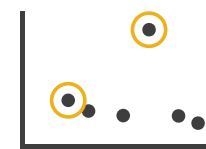# Overview first, zoom and filter, details on demand

- influential mantra from Shneiderman

[The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations. Shneiderman. Proc. IEEE Visual Languages, pp. 336–343, 1996.]
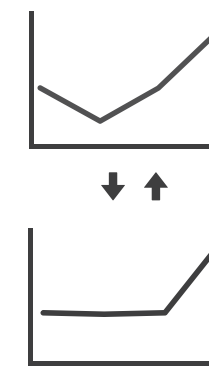
- **overview = summary**
  - microcosm of full vis design problem

➔ **Query**

➔ Identify

➔ Compare

➔ Summarise

# Rule of thumb: **Responsiveness is required**

- *visual feedback: three rough categories*
  - *0.1 seconds: perceptual processing*
    - subsecond response for mouseover highlighting - ballistic motion
  - *1 second: immediate response*
    - fast response after mouseclick, button press - Fitts' Law limits on motor control
  - *10 seconds: brief tasks*
    - bounded response after dialog box - mental model of heavyweight operation (file load)
- scalability considerations
  - highlight selection without complete redraw of view (graphics frontbuffer)
  - show hourglass for multi-second operations (check for cancel/undo)
  - show progress bar for long operations (process in background thread)
  - rendering speed when item count is large (guaranteed frame rate)

Function first, form next

- start with focus on functionality
  - possible to improve aesthetics later on, as refinement
  - if no expertise in-house, find good graphic designer to work with
  - aesthetics do matter: another level of function
    - visual hierarchy, alignment, flow
    - Gestalt principles in action
      - *(not covered in this class)*

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

Form: Basic graphic design principles

- proximity
  - do group related items together
  - avoid equal whitespace between unrelated
- alignment
  - do find/make strong line, stick to it
  - avoid automatic centering
- repetition
  - do unify by pushing existing consistencies
- contrast
  - if not identical, then very different
  - avoid similar
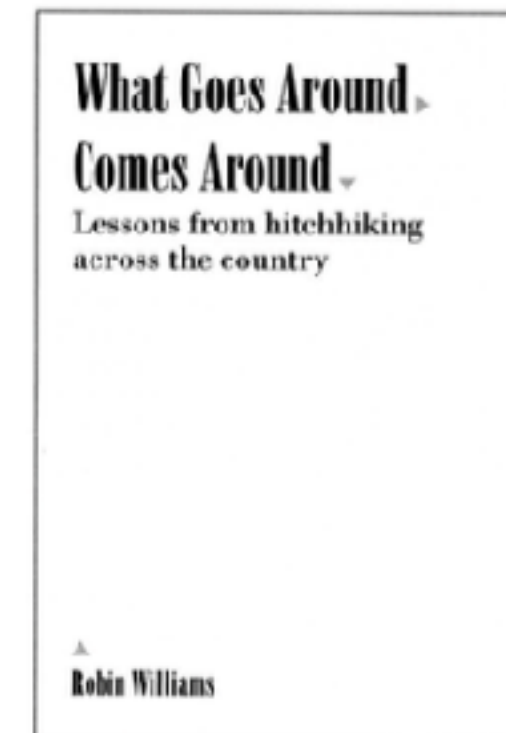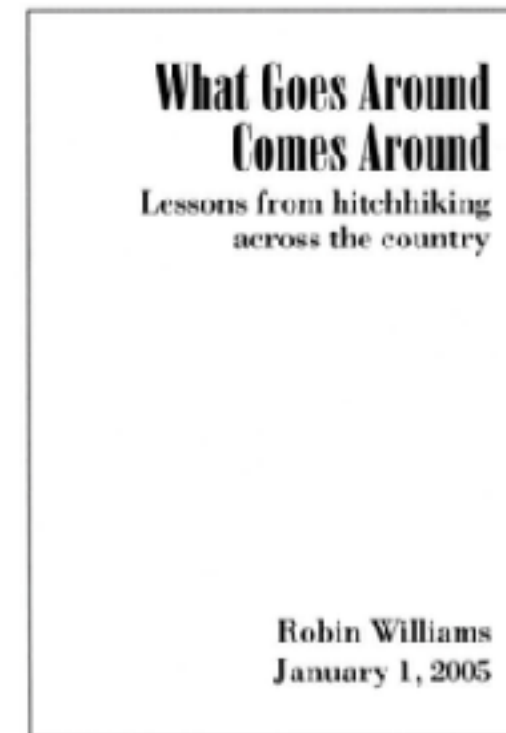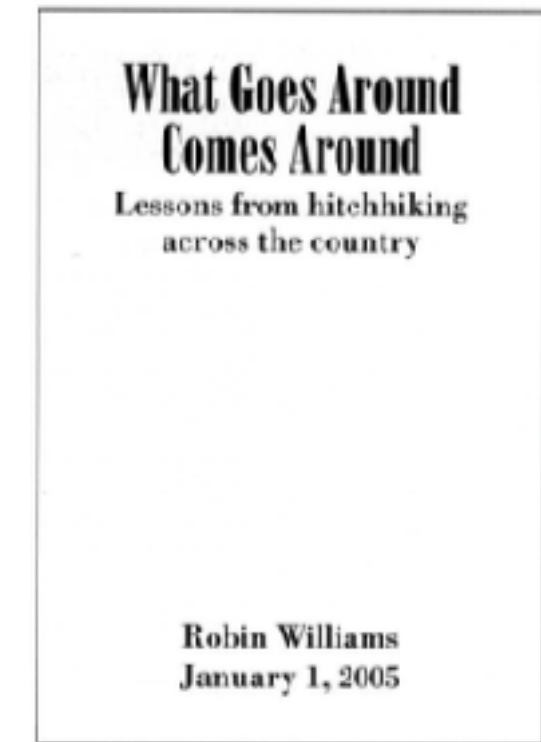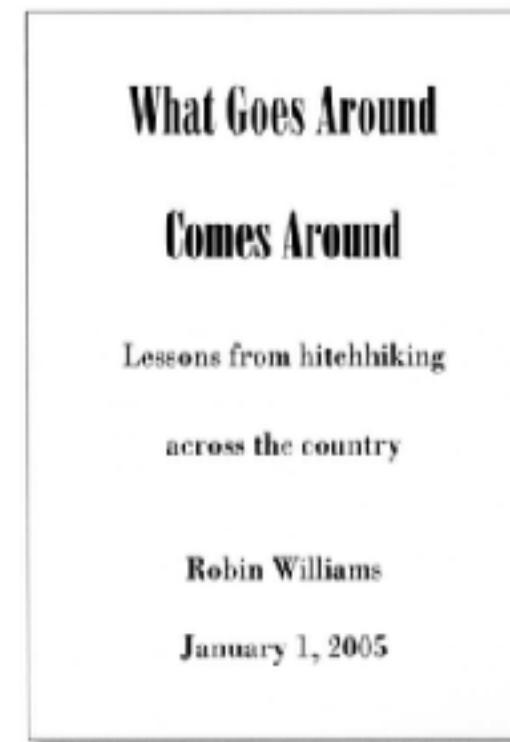
- buy now and read cover to cover - very practical, worth your time, fast read!
  The Non-Designer's Design Book, 4th ed. Robin Williams, Peachpit Press, 2015.

Best practices: Labelling

- make visualizations as self-documenting as possible
  - meaningful & useful title, labels, legends
    - axes and panes/subwindows should have labels
      - and axes should have good mix/max boundary tick marks
    - everything that's plotted should have a legend
      - and own header/labels if not redundant with main title
    - use reasonable numerical format
      - avoid scientific notation in most cases
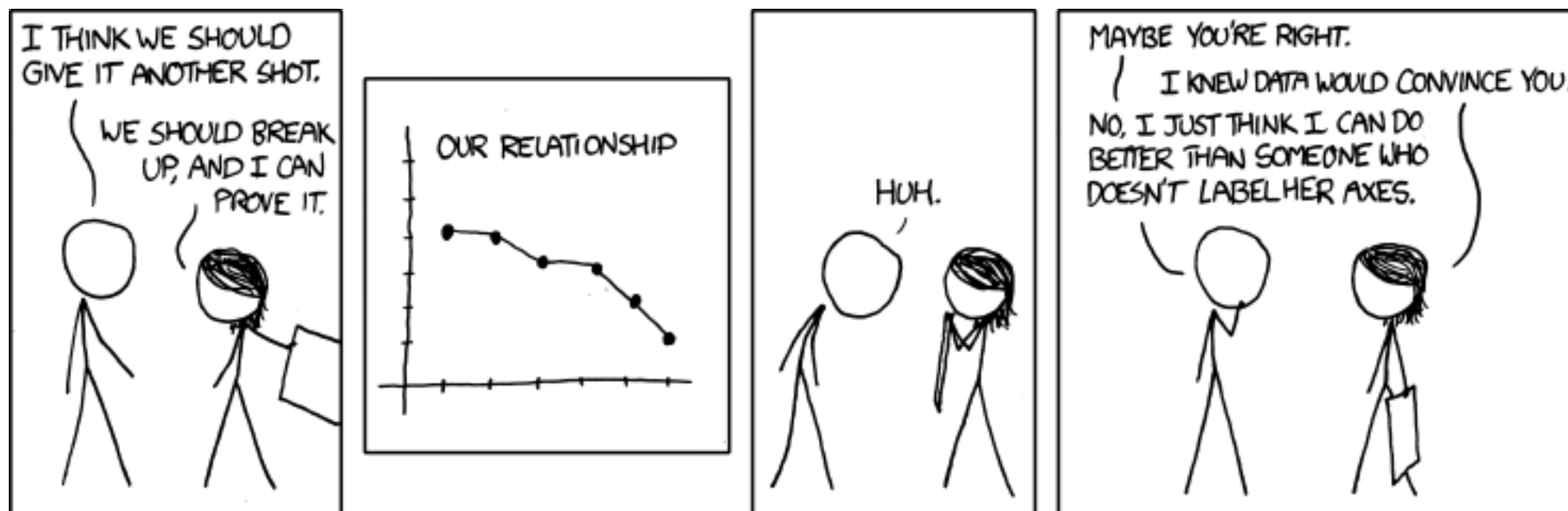
Rules of Thumb Summary

- No unjustified 3D
  - Power of the plane
  - Disparity of depth
  - Occlusion hides information
  - Perspective distortion dangers
  - Tilted text isn't legible
- No unjustified 2D
- Eyes beat memory
- Resolution over immersion
- Overview first, zoom and filter, details on demand
- Responsiveness is required
- Function first, form next

Further reading

- Visualization Analysis and Design. Tamara Munzner. CRC Press, 2014.
  - *Chap 6: Rules of Thumb*

- Designing with the Mind in Mind: Simple Guide to Understanding User Interface Design Rules. Jeff Johnson. Morgan Kaufmann, 2010.
  - *Chap 12: We Have Time Requirements*

- The Non-Designer's Design Book. 3rd edition. Robin Williams. Peachpit Press, 2008.

Credits

- Visualization Analysis and Design (Ch 6)