Lectures 7-8:
Networks, Rules of Thumb

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DSCI 531: Data Visualization 1
Lecture 7: 7 December 2016
Lecture 8: 12 December 2016

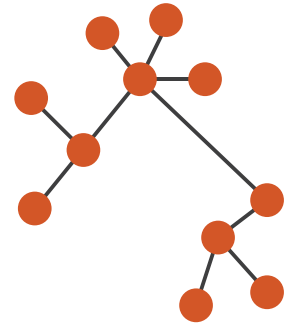**https://github.ubc.ca/ubc-mds-2016/DSCI_531_viz-1_students**

Network Data

Arrange networks and trees
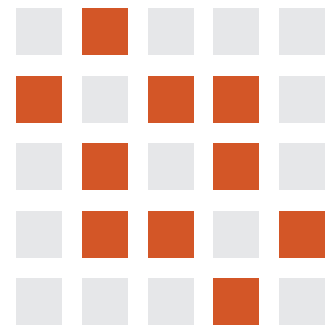
→ **Node–Link Diagrams**
Connection Marks

✔ NETWORKS ✔ TREES

→ **Adjacency Matrix**
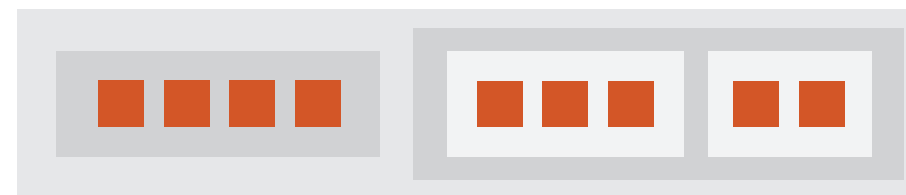Derived Table

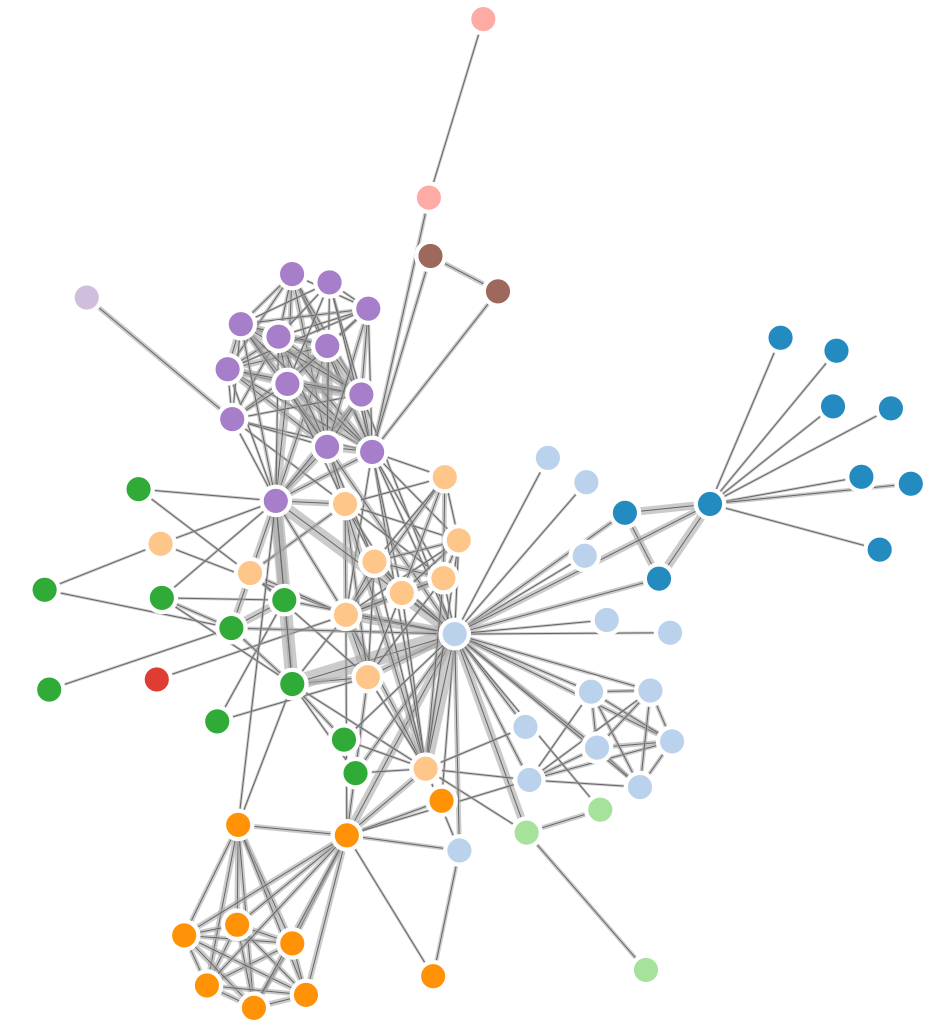✔ NETWORKS ✔ TREES

→ **Enclosure**
Containment Marks

✘ NETWORKS ✔ TREES

Idiom: **force-directed placement**

- visual encoding
  - link connection marks, node point marks

- considerations
  - spatial position: no meaning directly encoded
    - left free to minimize crossings
  - proximity semantics?
    - sometimes meaningful
    - sometimes arbitrary, artifact of layout algorithm
    - tension with length
      - long edges more visually salient than short

- tasks
  - explore topology; locate paths, clusters

- scalability
  - node/edge density E < 4N


```
var width = 960,
    height = 500;

var ...
```
http://mbostock.github.com/d3/ex/force.html
```
var force = d3.layout.force()
```

# Idiom: **sfdp** (multi-level force-directed placement)

- data
  - original: network
  - derived: cluster hierarchy atop it
- considerations
  - better algorithm for same encoding technique
    - same: fundamental use of space
    - hierarchy used for algorithm speed/quality but not shown explicitly
    - (more on algorithm vs encoding in afternoon)
- scalability
  - nodes, edges: 1K-10K
  - hairball problem eventually hits



JGD_Homology@cis-n4c6-b14. 7220 nodes, 13800 edges.
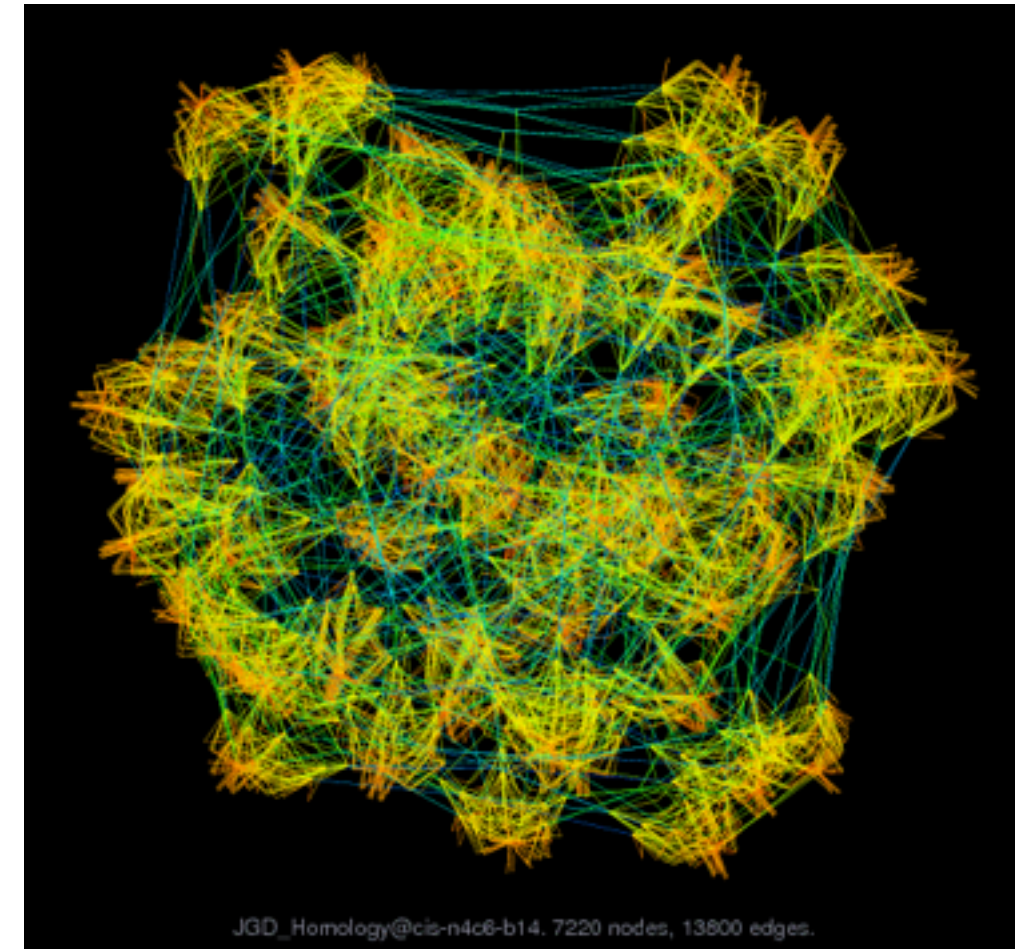
*[Efficient and high quality force-directed graph drawing. Hu. The Mathematica Journal 10:37–71, 2005.]*



*http://www.research.att.com/yifanhu/GALLERY/GRAPHS/index1.html*
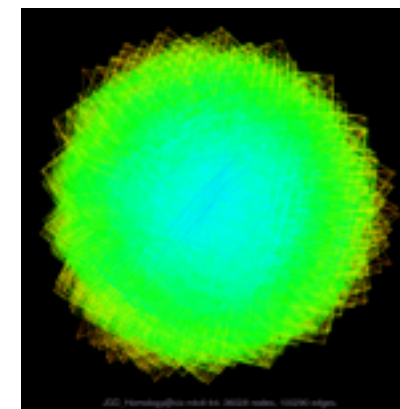
# Idiom: **adjacency matrix view**

- data: network
  - transform into same data/encoding as heatmap
- derived data: table from network
  - 1 quant attrib
    - weighted edge between nodes
  - 2 categ attribs: node list x 2
- visual encoding
  - cell shows presence/absence of edge
- scalability
  - 1K nodes, 1M edges
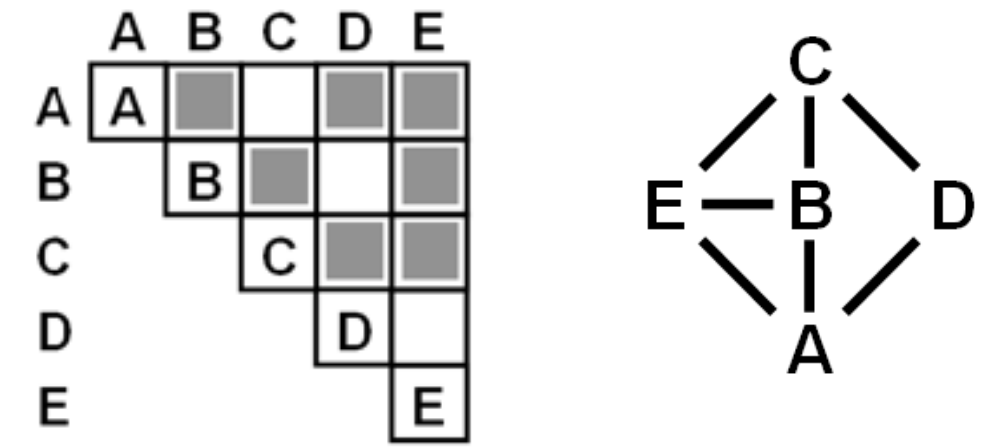


*[NodeTrix: a Hybrid Visualization of Social Networks. Henry, Fekete, and McGuffin. IEEE TVCG (Proc. InfoVis) 13(6): 1302-1309, 2007.]*



*[Points of view: Networks. Gehlenborg and Wong. Nature Methods 9:115.]*

# Connection vs. adjacency comparison

- adjacency matrix strengths
  - predictability, scalability, supports reordering
  - some topology tasks trainable
- node-link diagram strengths
  - topology understanding, path tracing
  - intuitive, no training needed

- empirical study
  - node-link best for small networks
  - matrix best for large networks
    - if tasks don't involve topological structure!

*[On the readability of graphs using node-link and matrix-based representations: a controlled experiment and statistical analysis. Ghoniem, Fekete, and Castagliola. Information Visualization 4:2 (2005), 114–135.]*



*http://www.michaelmcguffin.com/courses/vis/patternsInAdjacencyMatrix.png*
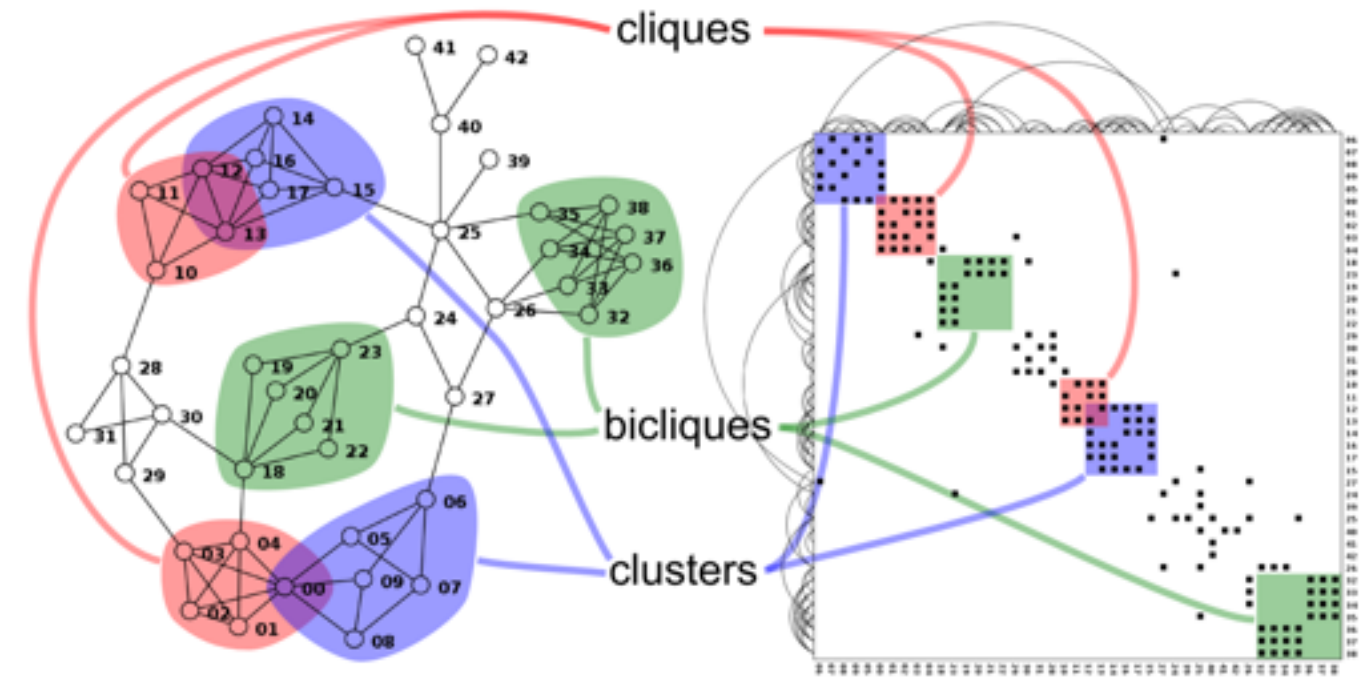
# Idiom: **radial node-link tree**

- data
  - tree
- encoding
  - link connection marks
  - point node marks
  - radial axis orientation
    - angular proximity: siblings
    - distance from center: depth in tree
- tasks
  - understanding topology, following paths
- scalability
  - 1K - 10K nodes



*http://mbostock.github.com/d3/ex/tree.html*
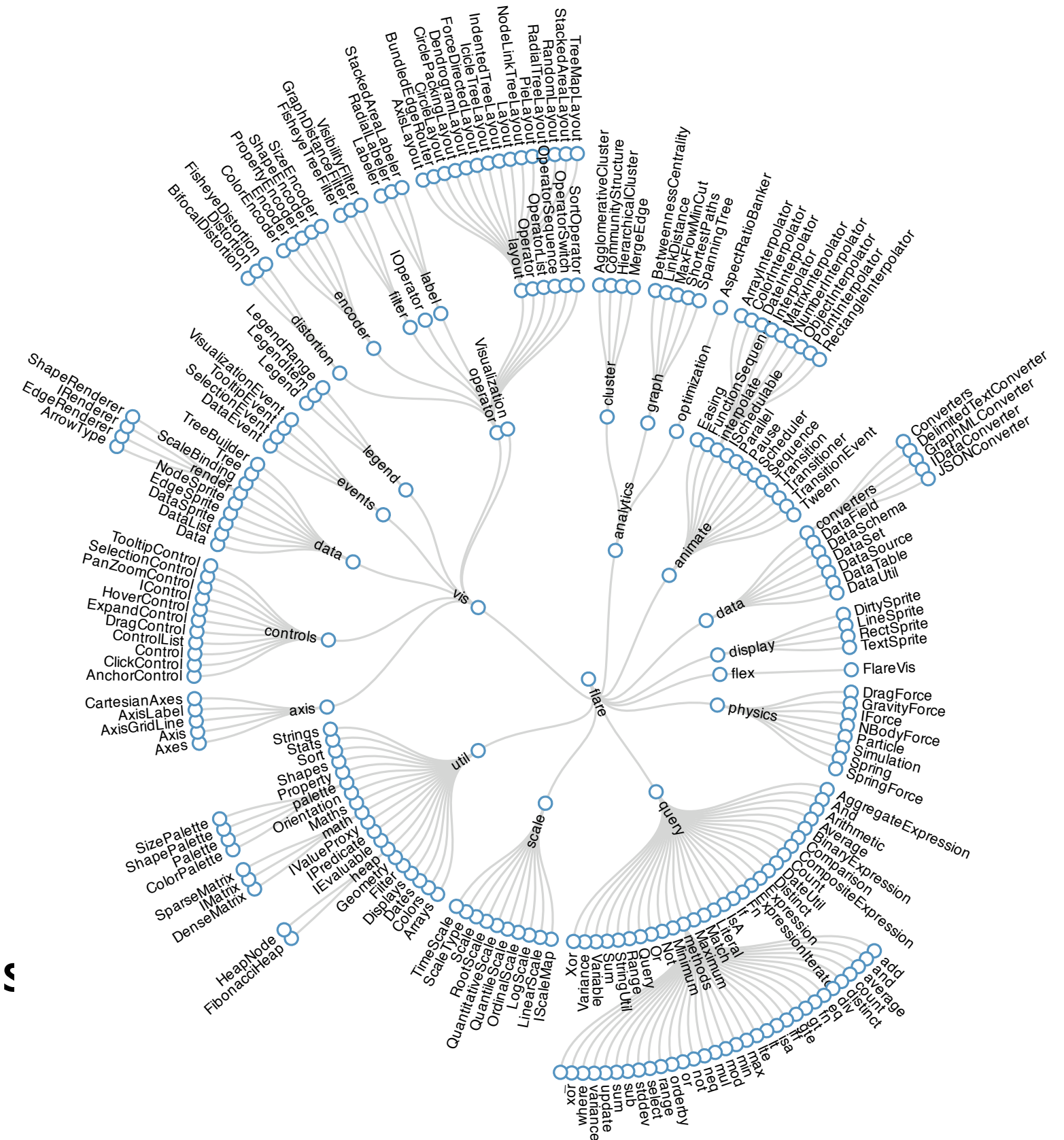
# Idiom: **treemap**

- data
  - tree
  - 1 quant attrib at leaf nodes
- encoding
  - area containment marks for hierarchical structure
  - rectilinear orientation
  - size encodes quant attrib
- tasks
  - query attribute at leaf nodes
- scalability
  - 1M leaf nodes



*http://tulip.labri.fr/Documentation/3_7/userHandbook/html/ch06.html*

# Link marks: Connection and containment

- marks as links (vs. nodes)
  - common case in network drawing
  - 1D case: connection
    - ex: all node-link diagrams
    - emphasizes topology, path tracing
    - networks and trees
  - 2D case: containment
    - ex: all treemap variants
    - emphasizes attribute values at leaves (size coding)
    - only trees



Containment    Connection
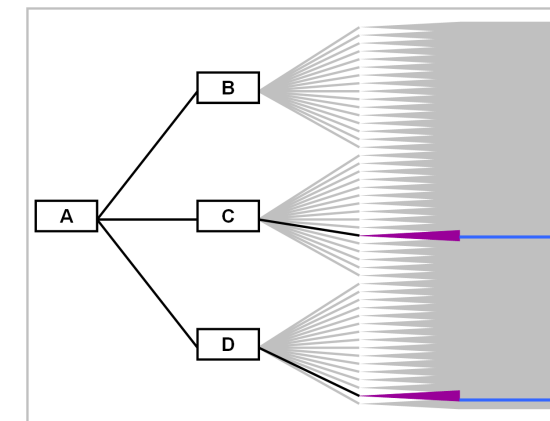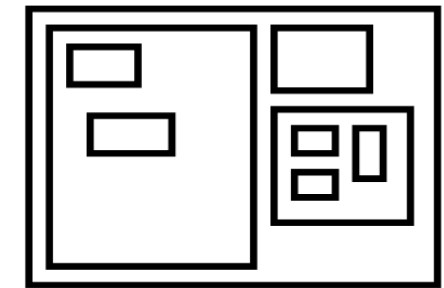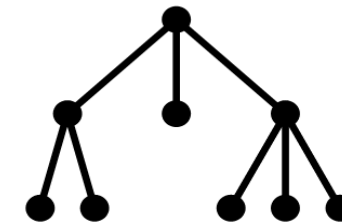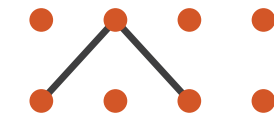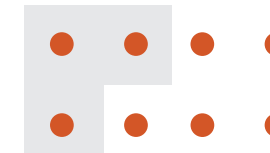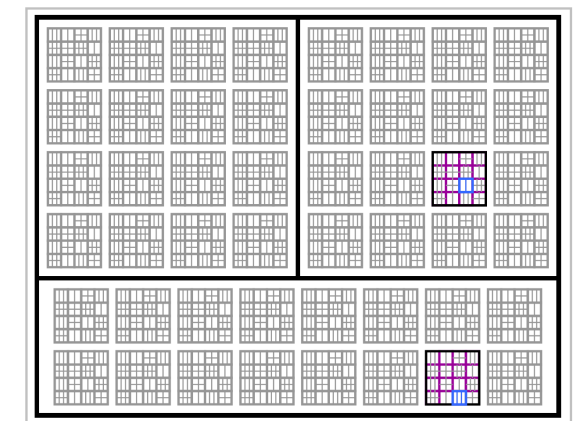
Node–Link Diagram          Treemap

*[Elastic Hierarchies: Combining Treemaps and Node-Link Diagrams. Dong, McGuffin, and Chignell. Proc. InfoVis 2005, p. 57-64.]*

# Tree drawing idioms comparison

- data shown
  - link relationships
  - tree depth
  - sibling order

- design choices
  - connection vs containment link marks
  - rectilinear vs radial layout
  - spatial position channels

- considerations
  - redundant? arbitrary?
  - information density?
    - avoid wasting space
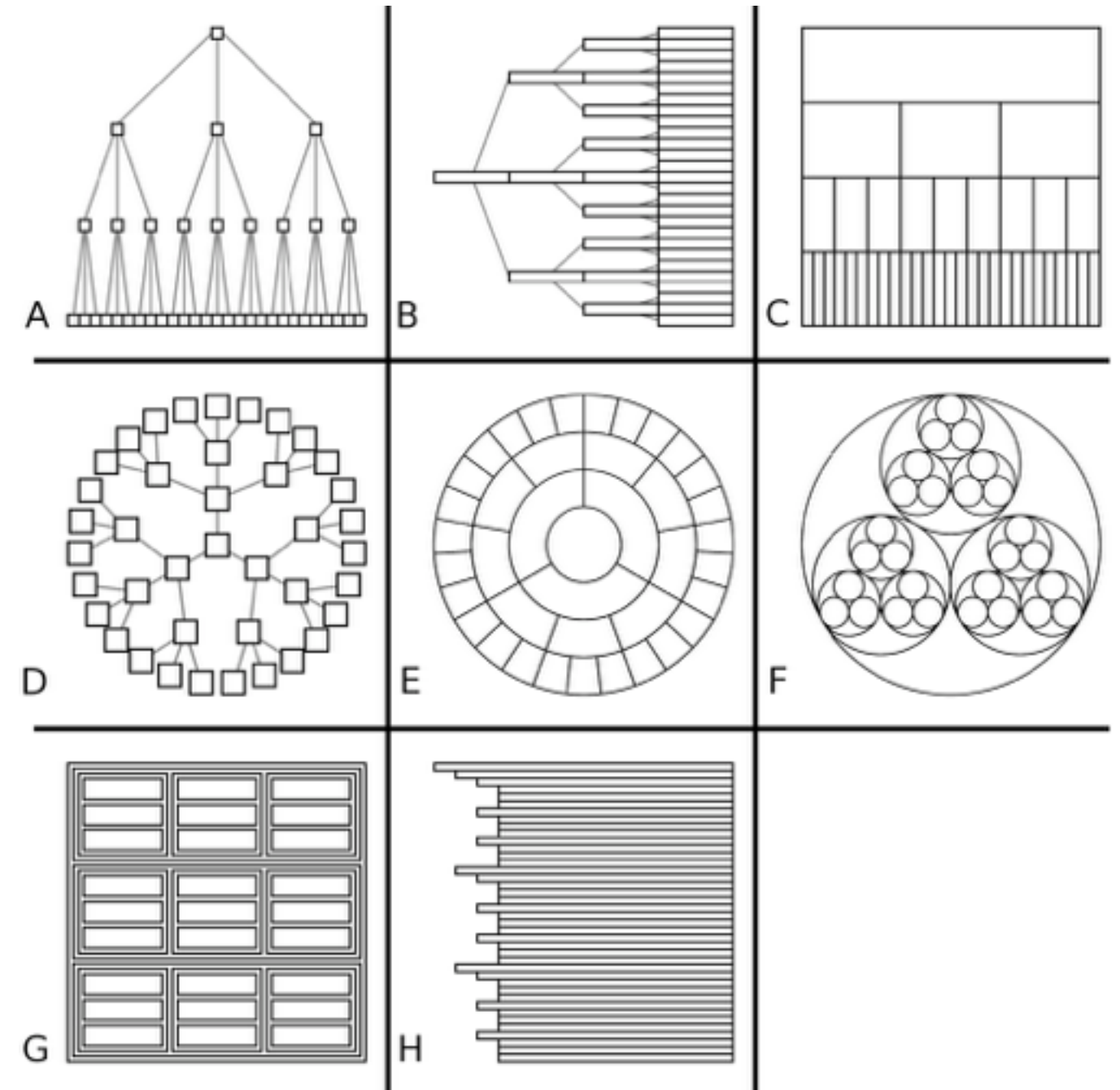


[Quantifying the Space-Efficiency of 2D Graphical Representations of Trees. McGuffin and Robert. Information Visualization 9:2 (2010), 115–140.]

# Rules of Thumb

# Rules of Thumb

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

# No unjustified 3D: Power of the plane

- high-ranked spatial position channels: **planar** spatial position

  – not depth!

  ➔ **Magnitude** Channels: **Ordered** Attributes
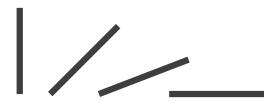
  Position on common scale

  Position on unaligned scale
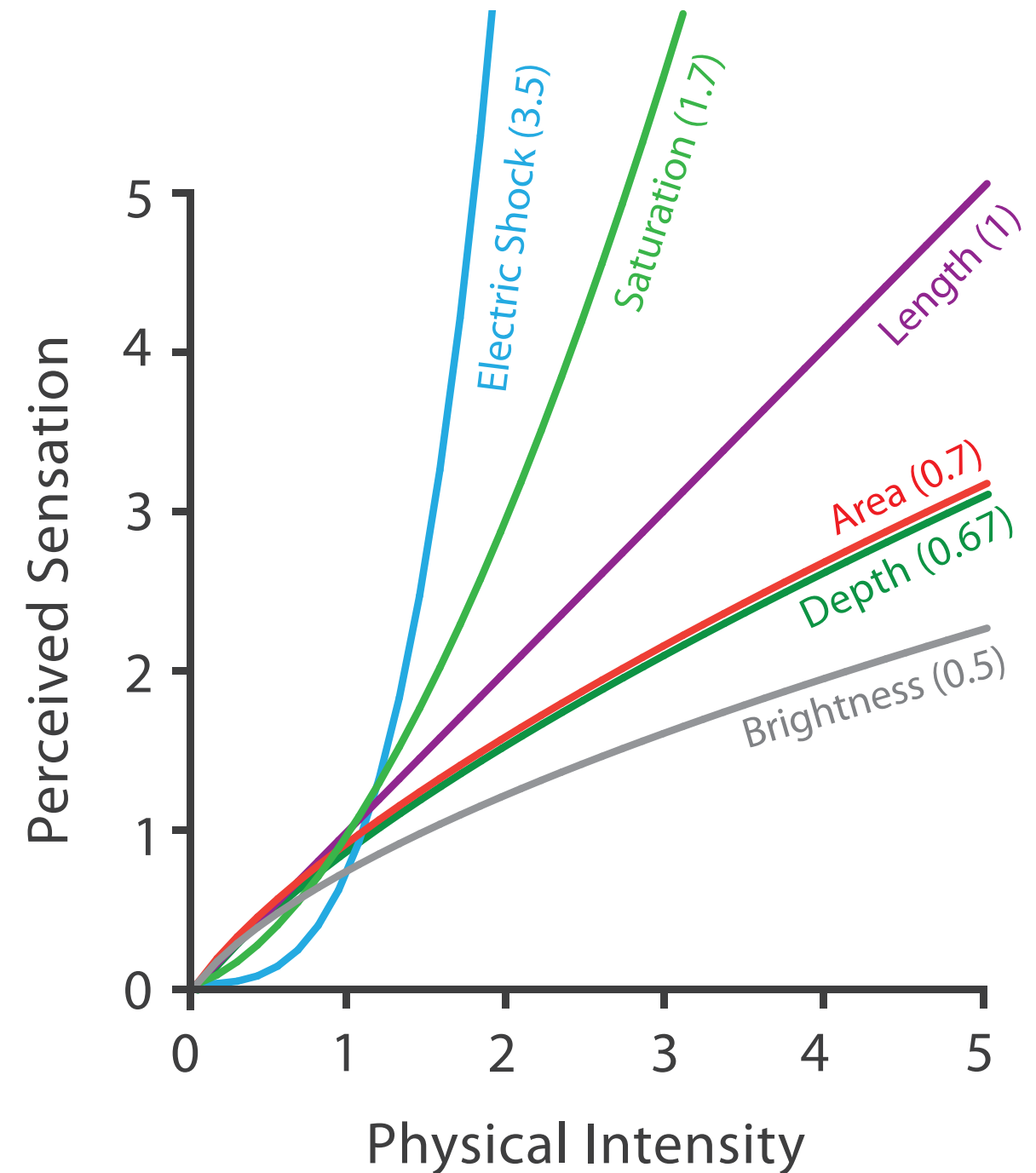
  Length (1D size)

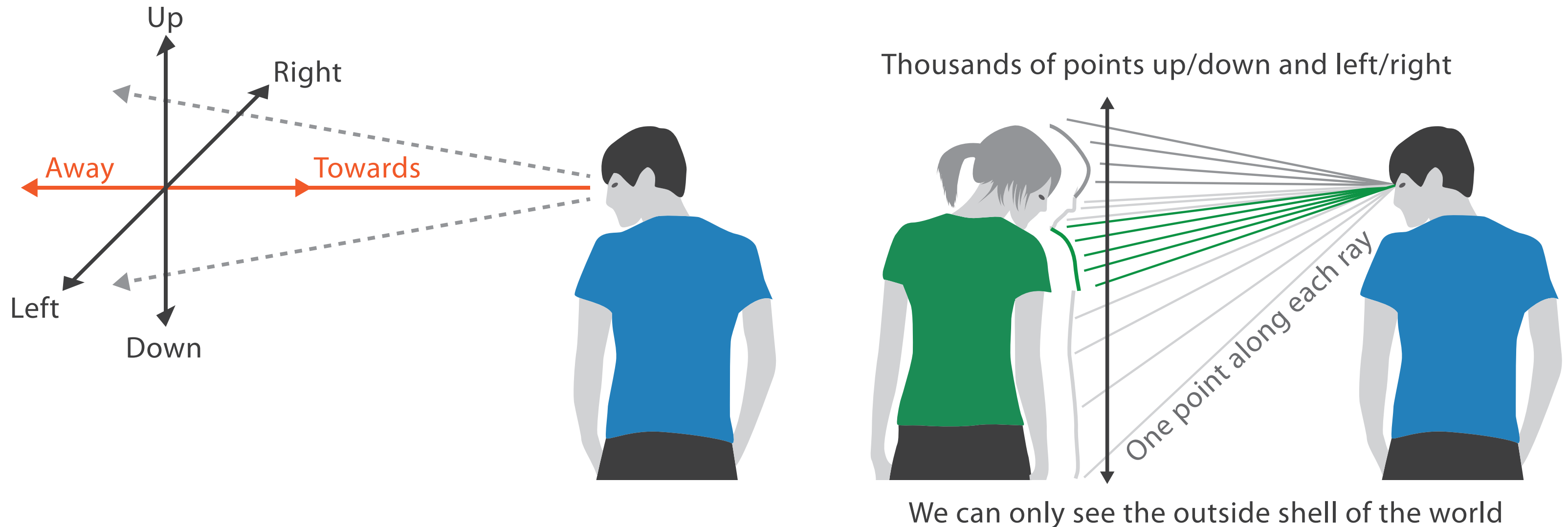  Tilt/angle

  Area (2D size)

  Depth (3D position)



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

Electric Shock (3.5)

Saturation (1.7)

Length (1)

Area (0.7)

Depth (0.67)

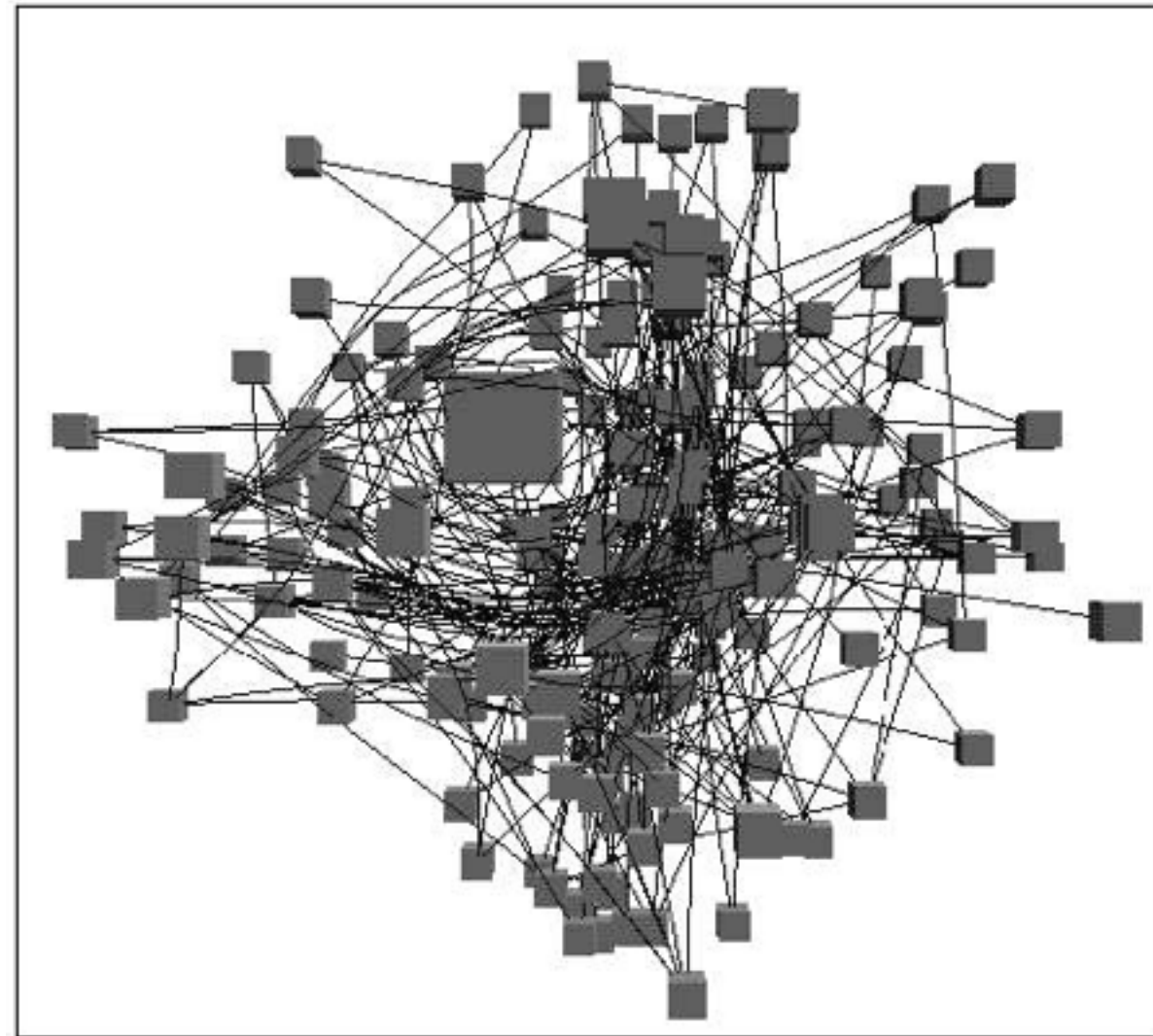Brightness (0.5)

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
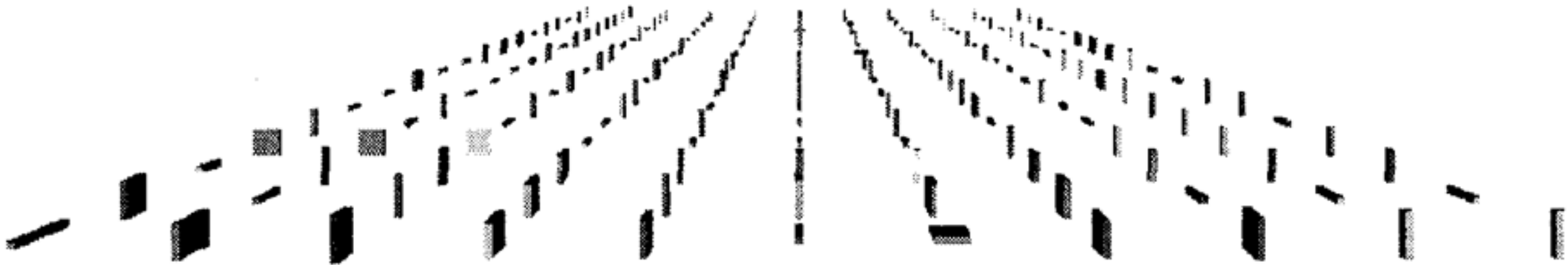
# Occlusion hides information

- occlusion

- interaction complexity



*[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]*
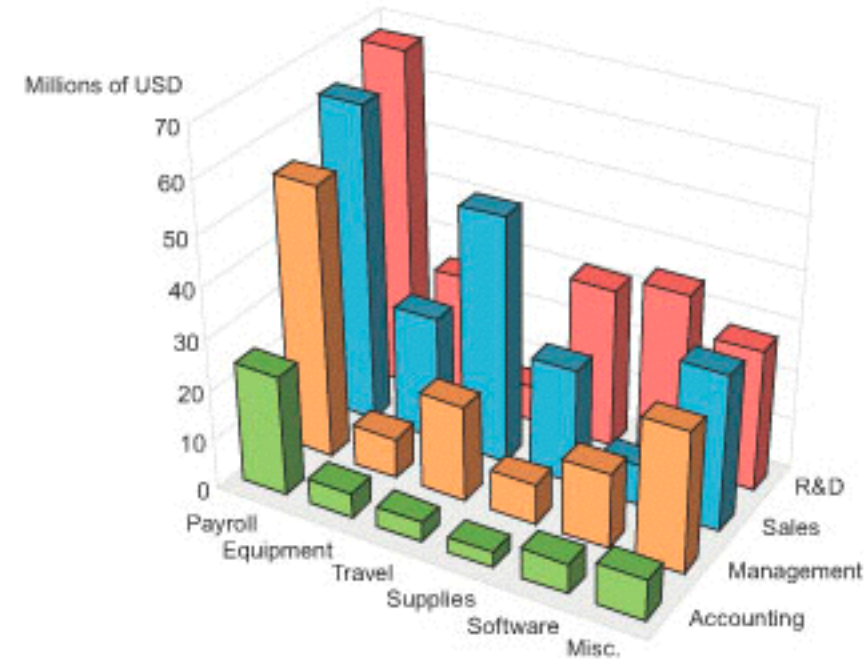
# 3D vs 2D bar charts

- 3D bars never a good idea!



18
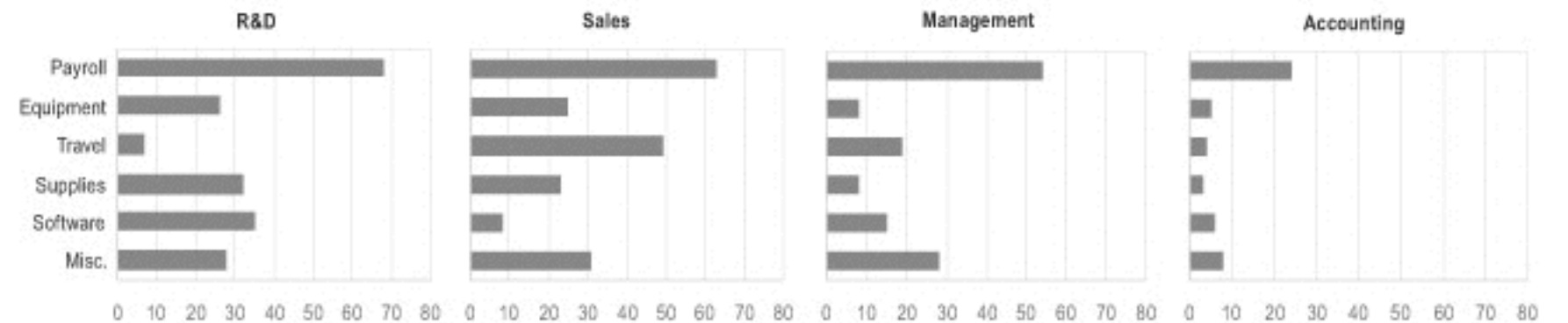
# Tilted text isn't legible

- text legibility
  - far worse when tilted from image plane
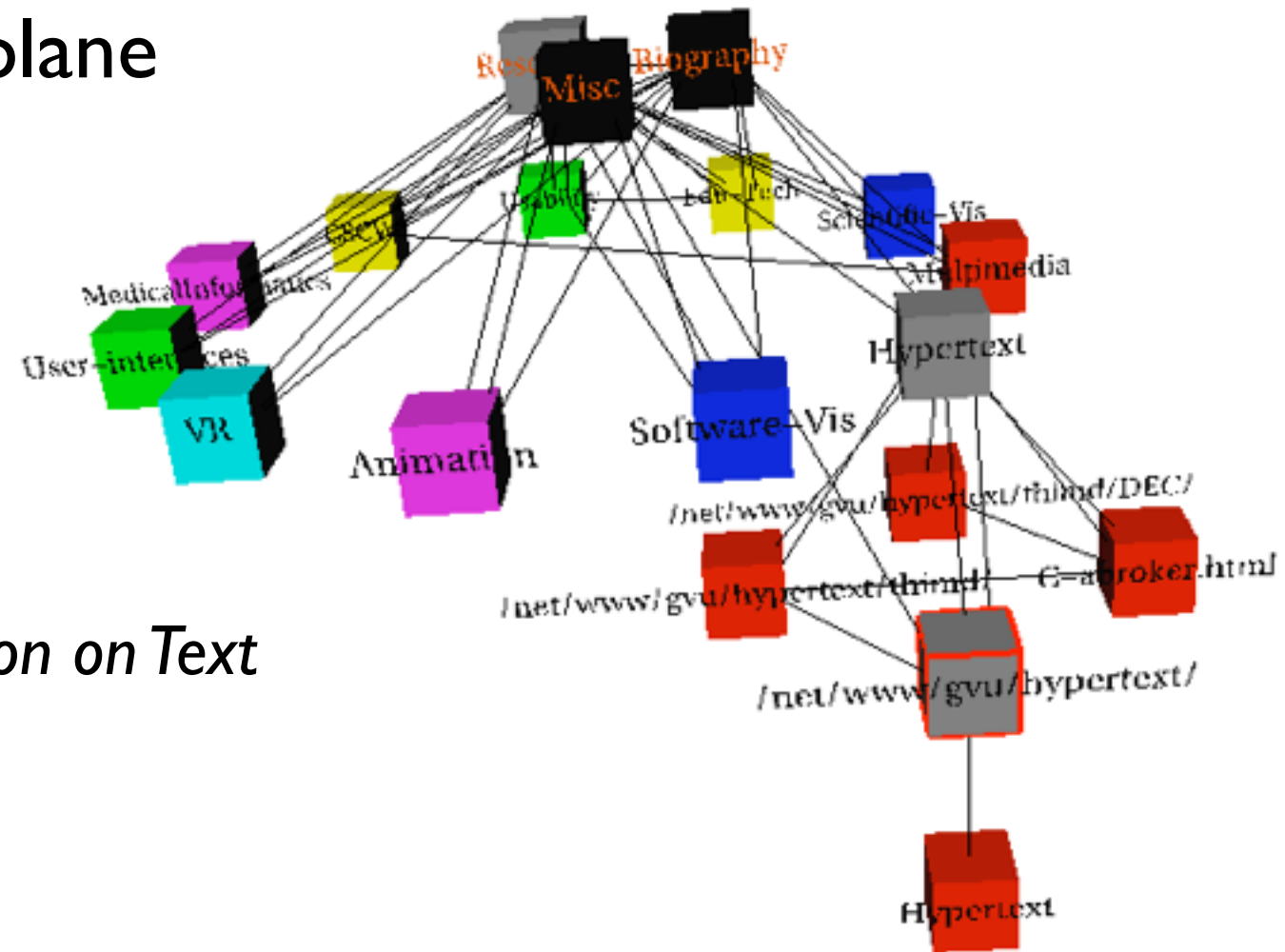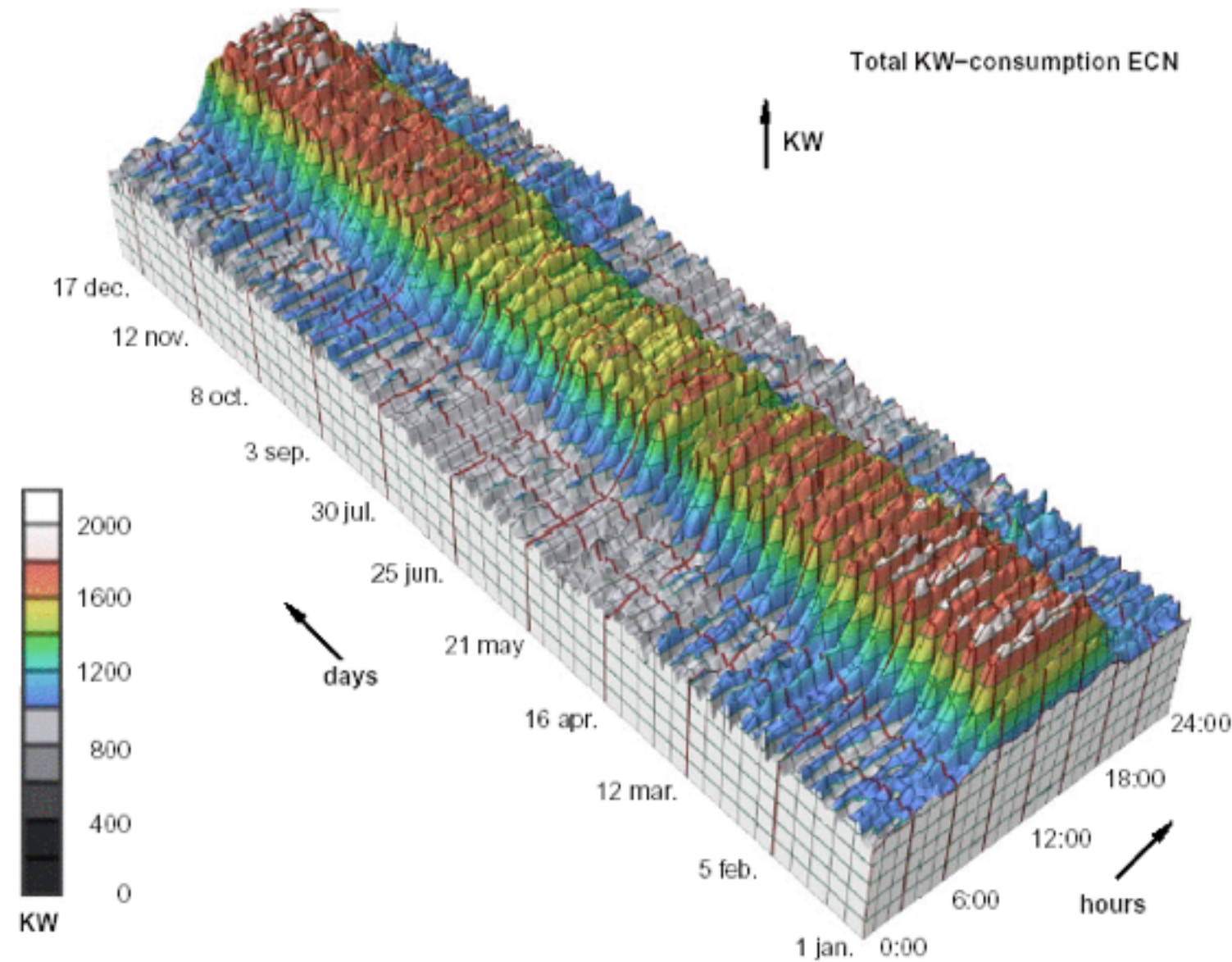
- further reading

*[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.]*

# No unjustified 3D example: Time-series data

- extruded curves: detailed comparisons impossible



Total KW-consumption ECN

*[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.]*
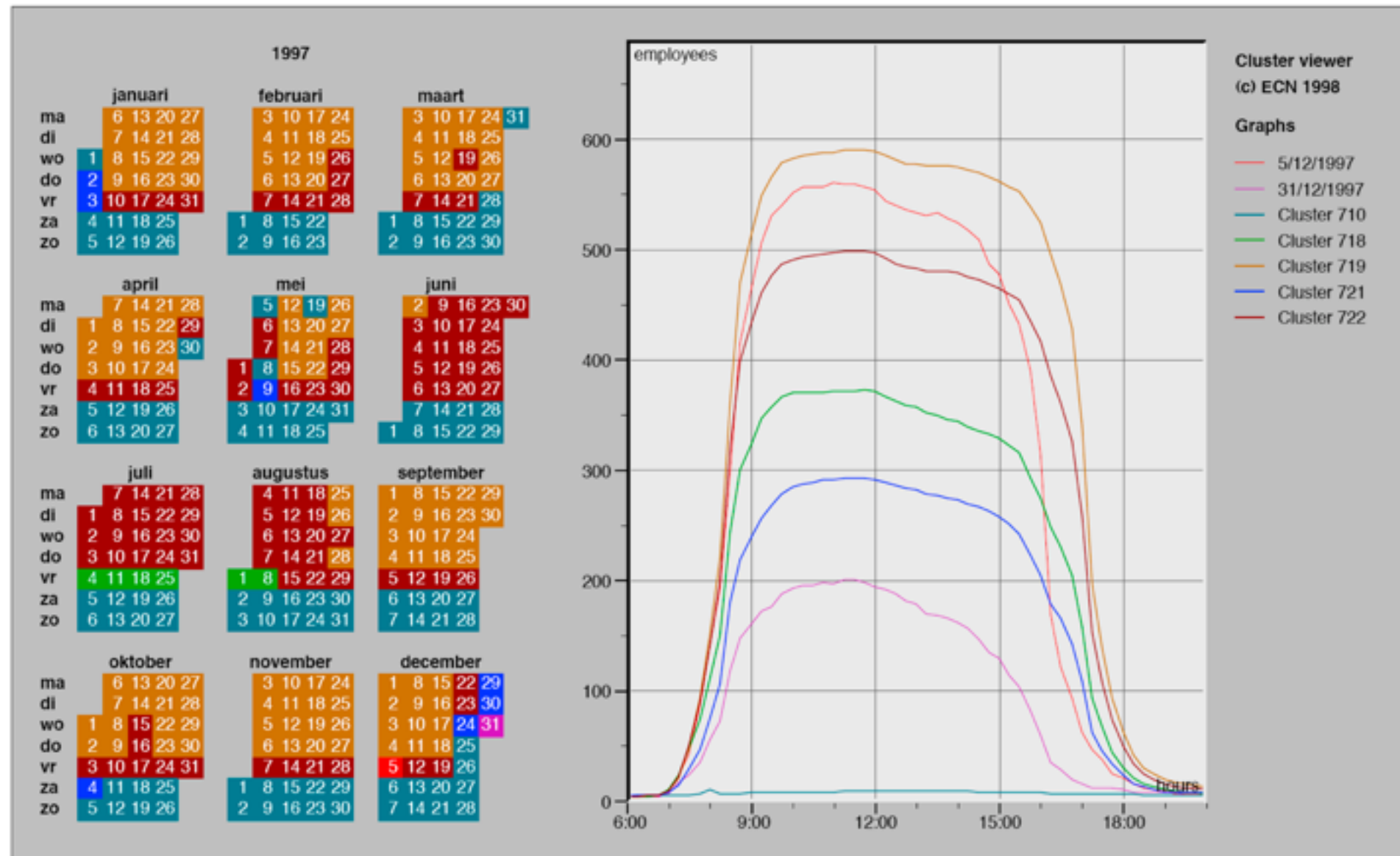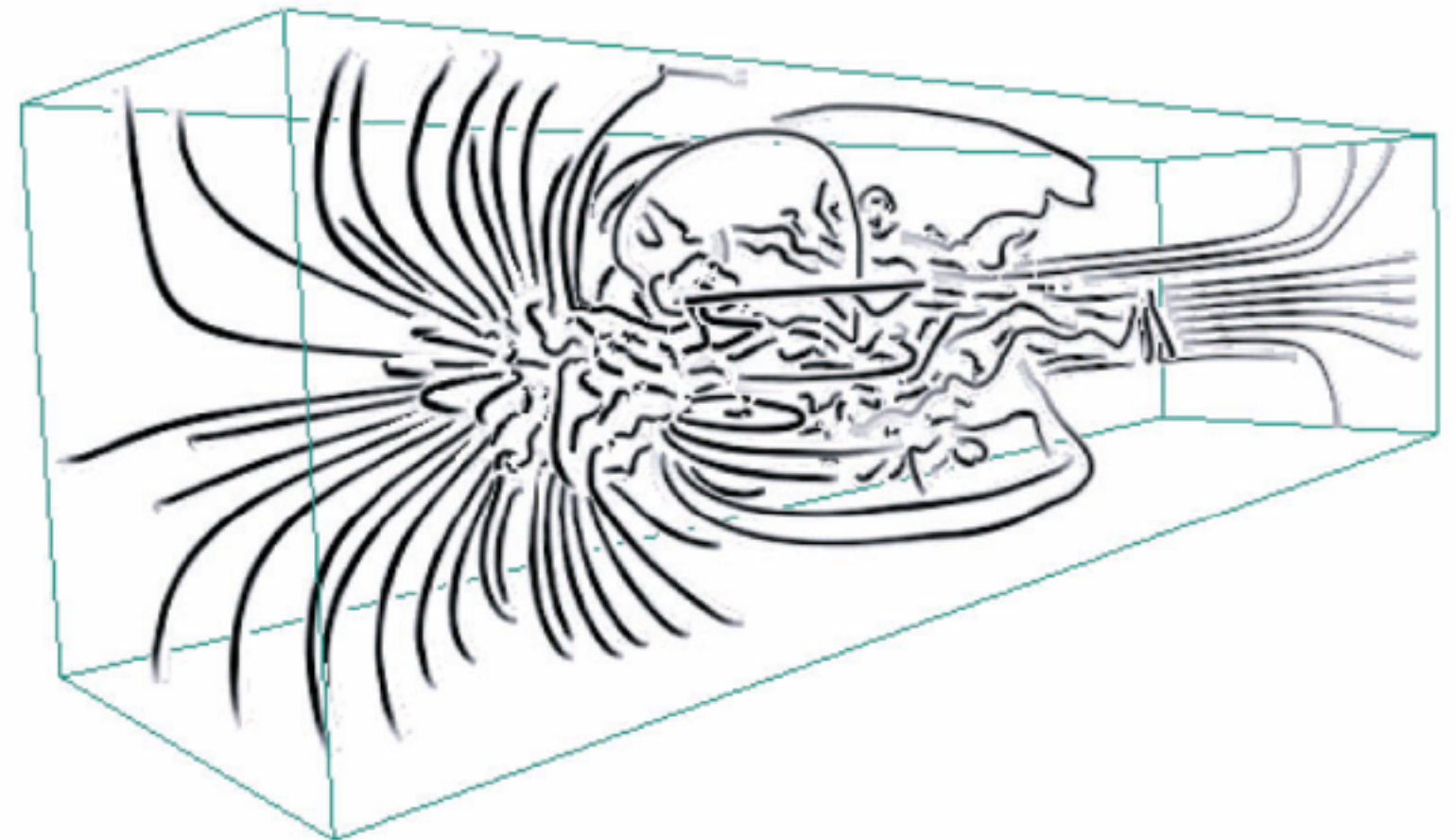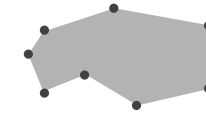
# Justified 3D: shape perception

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

  - interactive navigation supports synthesis across many viewpoints
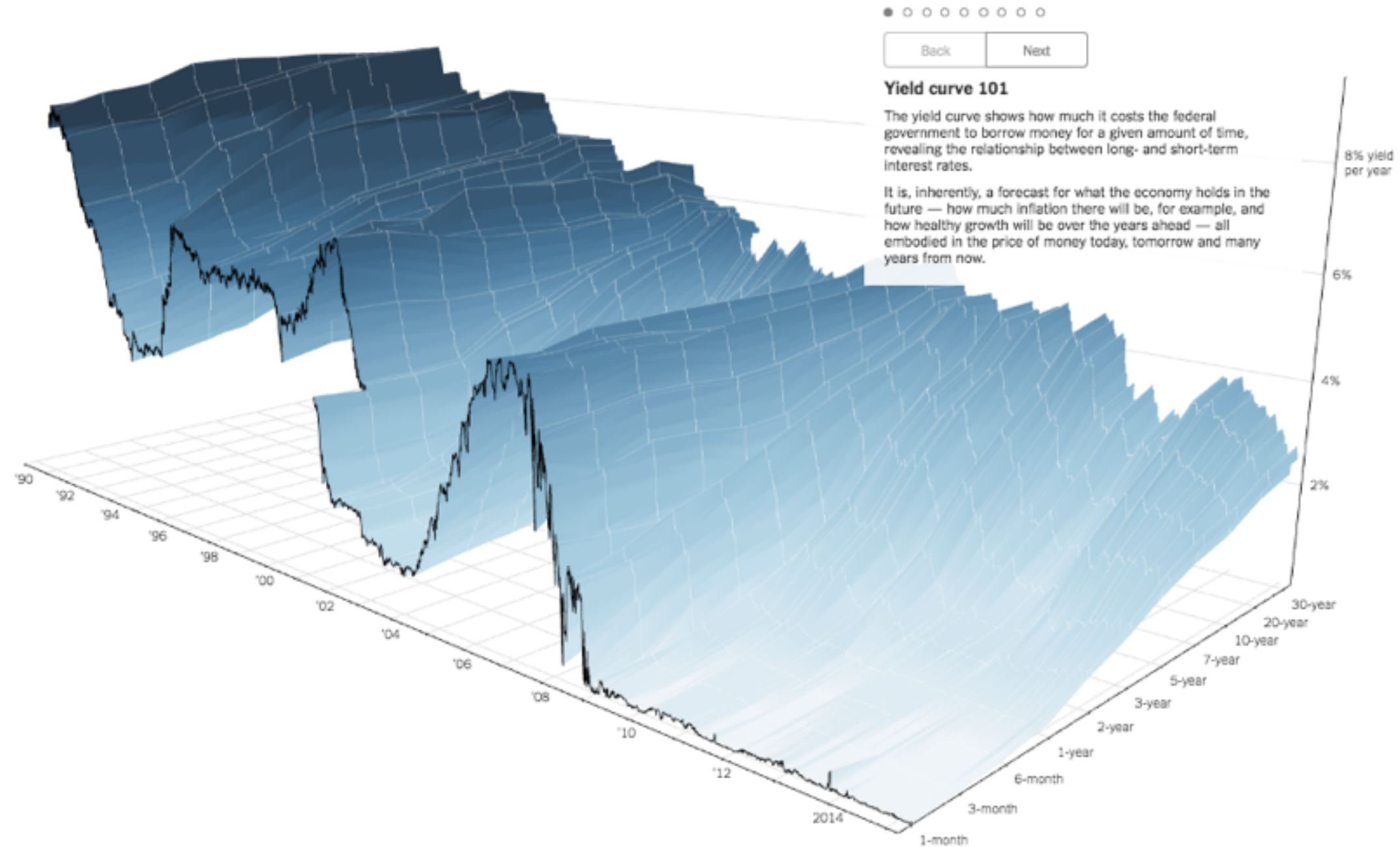
🛢 Targets

➔ Spatial Data

➔ Shape

[Image-Based Streamline Generation and Rendering. Li and Shen. IEEE Trans. Visualization and Computer Graphics (TVCG) 13:3 (2007), 630–640.]

# Justified 3D: Economic growth curve



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

By GREGOR AISCH and AMANDA COX   MARCH 18, 2015

Back    Next

**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*

# No unjustified 3D

- 3D legitimate for true 3D spatial data
- 3D needs very careful justification <span style="color:red">for abstract data</span>
  - enthusiasm in 1990s, but now skepticism
  - be especially careful with 3D for point clouds or networks
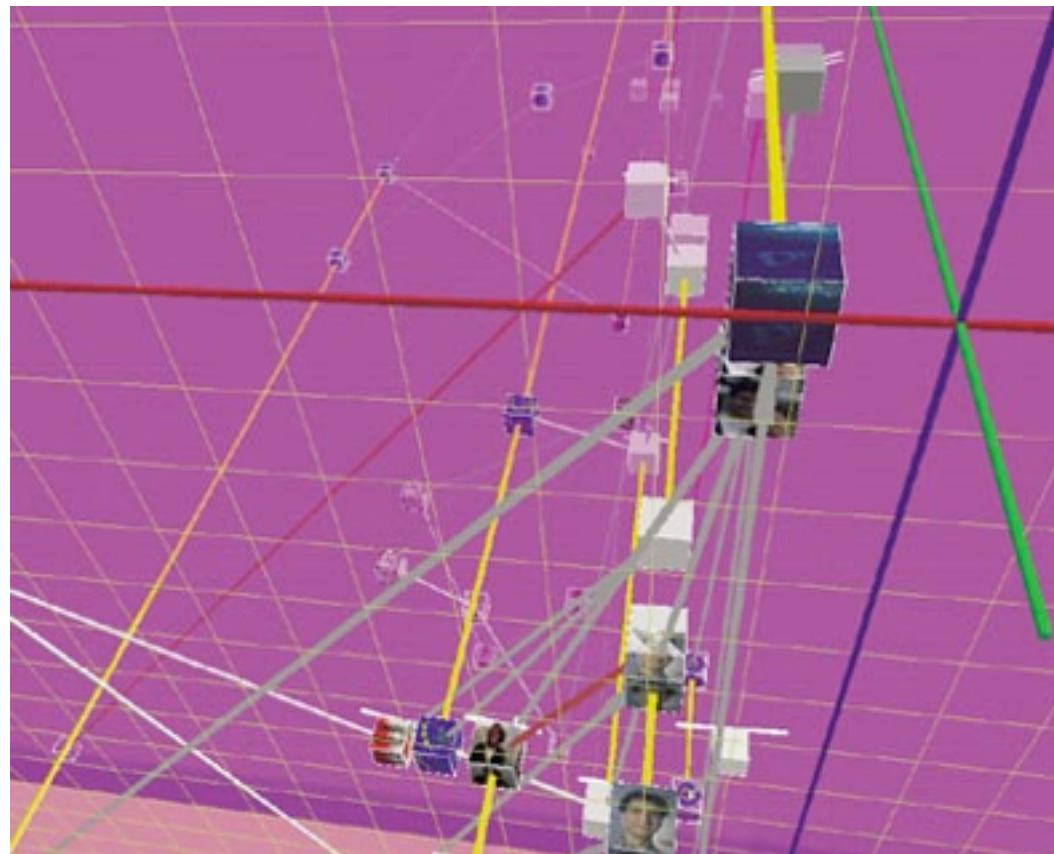


*[WEBPATH-a three dimensional Web history. Frecon and Smith. Proc. InfoVis 1999]*

# 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
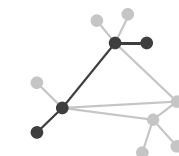  - be especially careful for search results, document collections, ontologies

**Targets**

➔ **Network Data**

  ➔ Topology
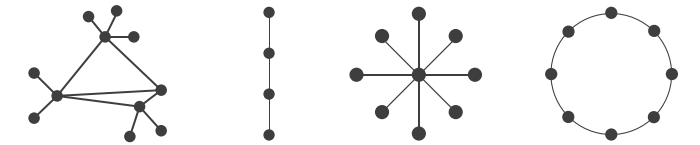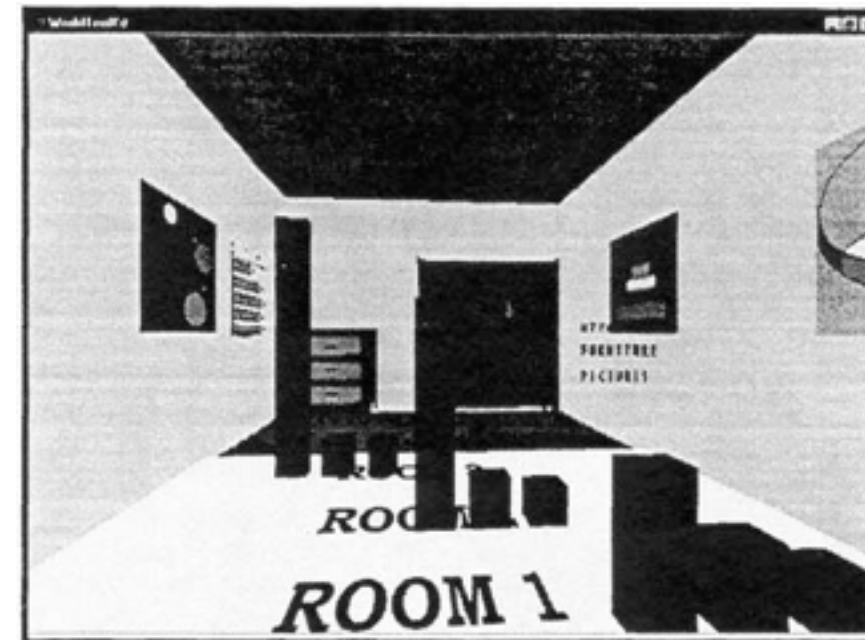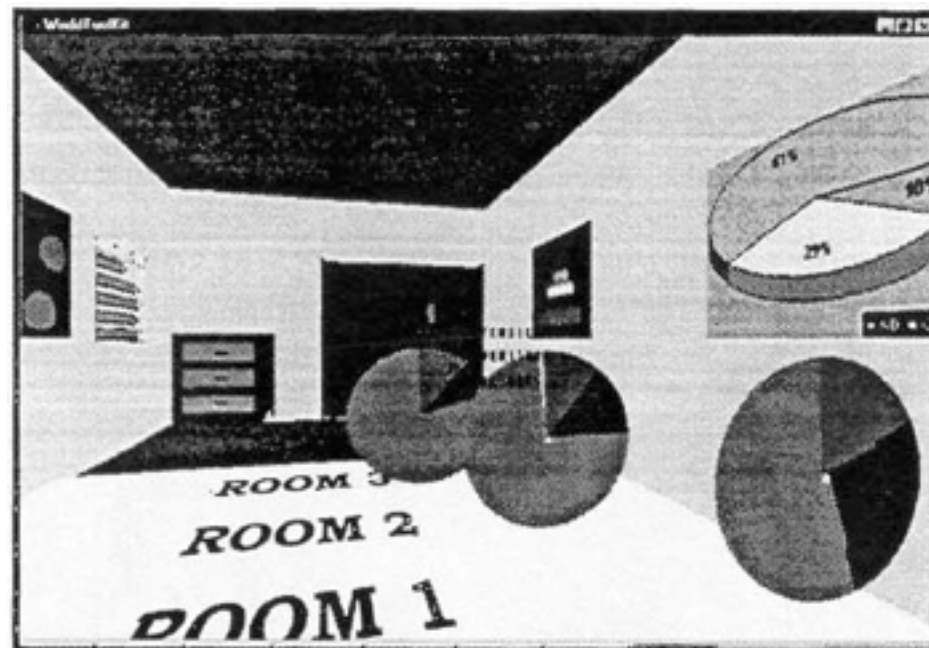
    ➔ *Paths*

# Resolution beats immersion

- immersion typically not helpful <span style="color:red">for abstract data</span>
  - 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]*

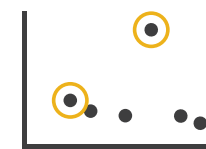# Overview first, zoom and filter, details on demand

- 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.]*
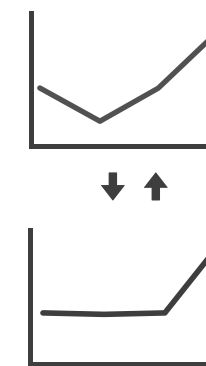
- **overview = summary**
  - −microcosm of full vis design problem

# Responsiveness is required

- three major categories
  - 0.1 seconds: perceptual processing
  - 1 second: immediate response
  - 10 seconds: brief tasks

- importance of visual feedback

# 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

# 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
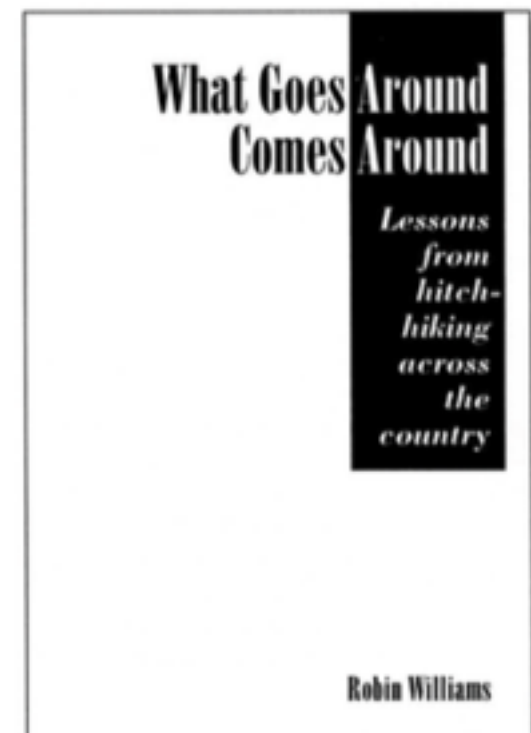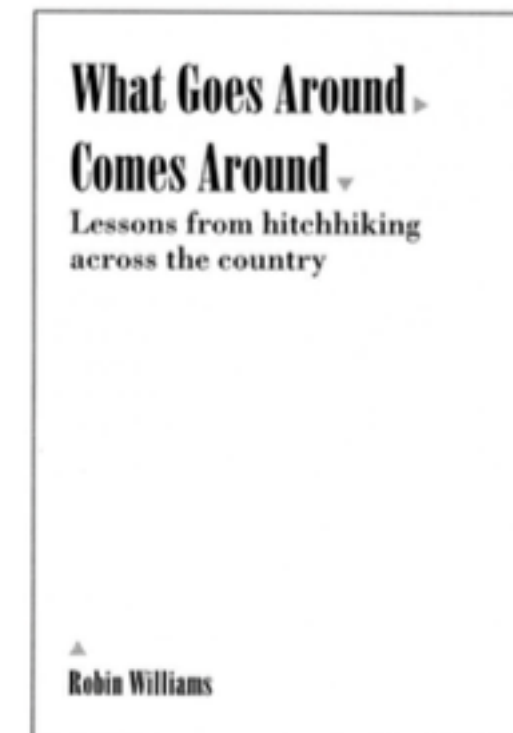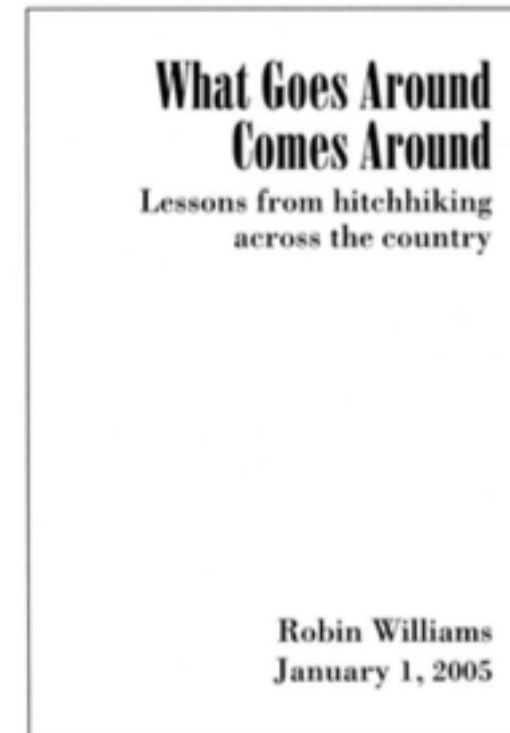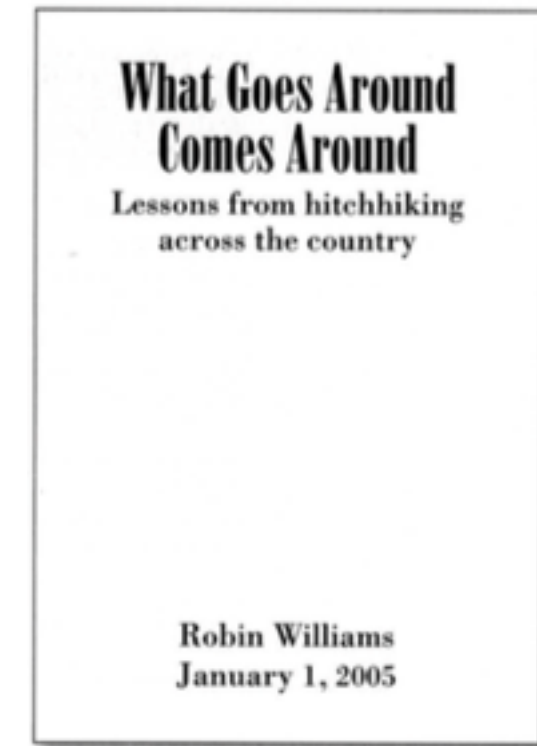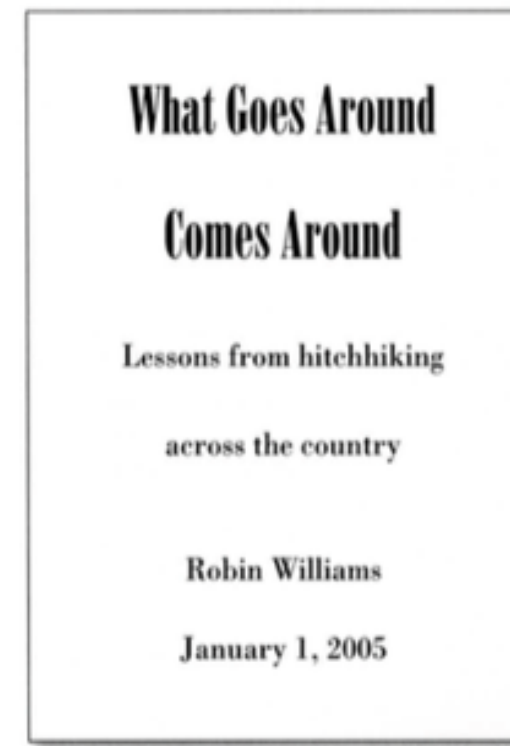
- buy now and read cover to cover - very practical, worth your time, fast read!
  *The Non-Designer's Design Book, 4th ed. Robin Williams, Peachpit Press, 2015.*

# 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, navigation, complex shape deformations
  - great for transitions between two states: blink comparator
  - poor for many states with changes everywhere (common case when data-driven)
    - 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
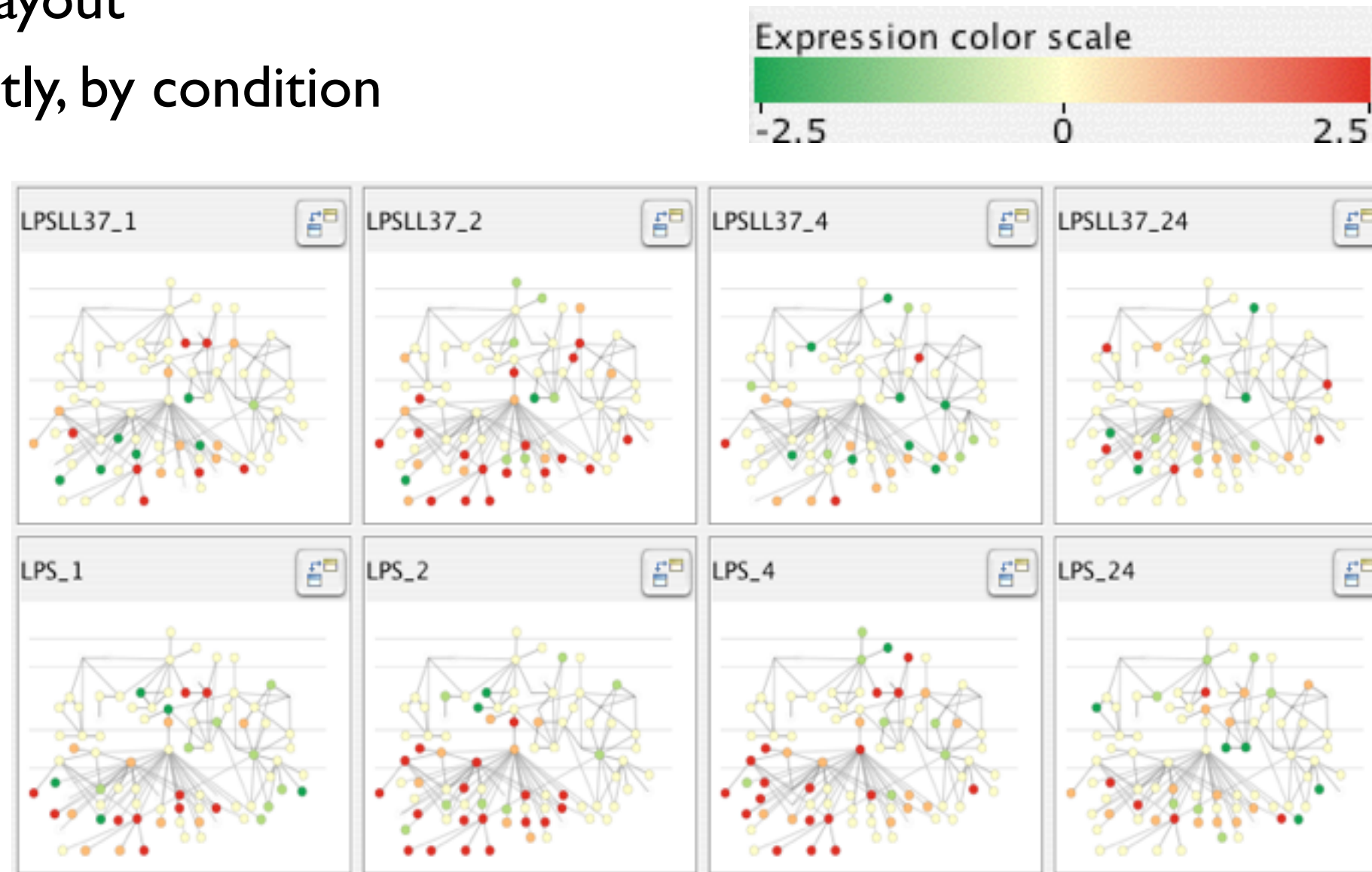


*[Cerebral: Visualizing Multiple Experimental Conditions on a Graph with Biological Context. Barsky, Munzner, Gardy, and Kincaid. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2008) 14:6 (2008), 1253–1260.]*

# 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



LPSLL37_1
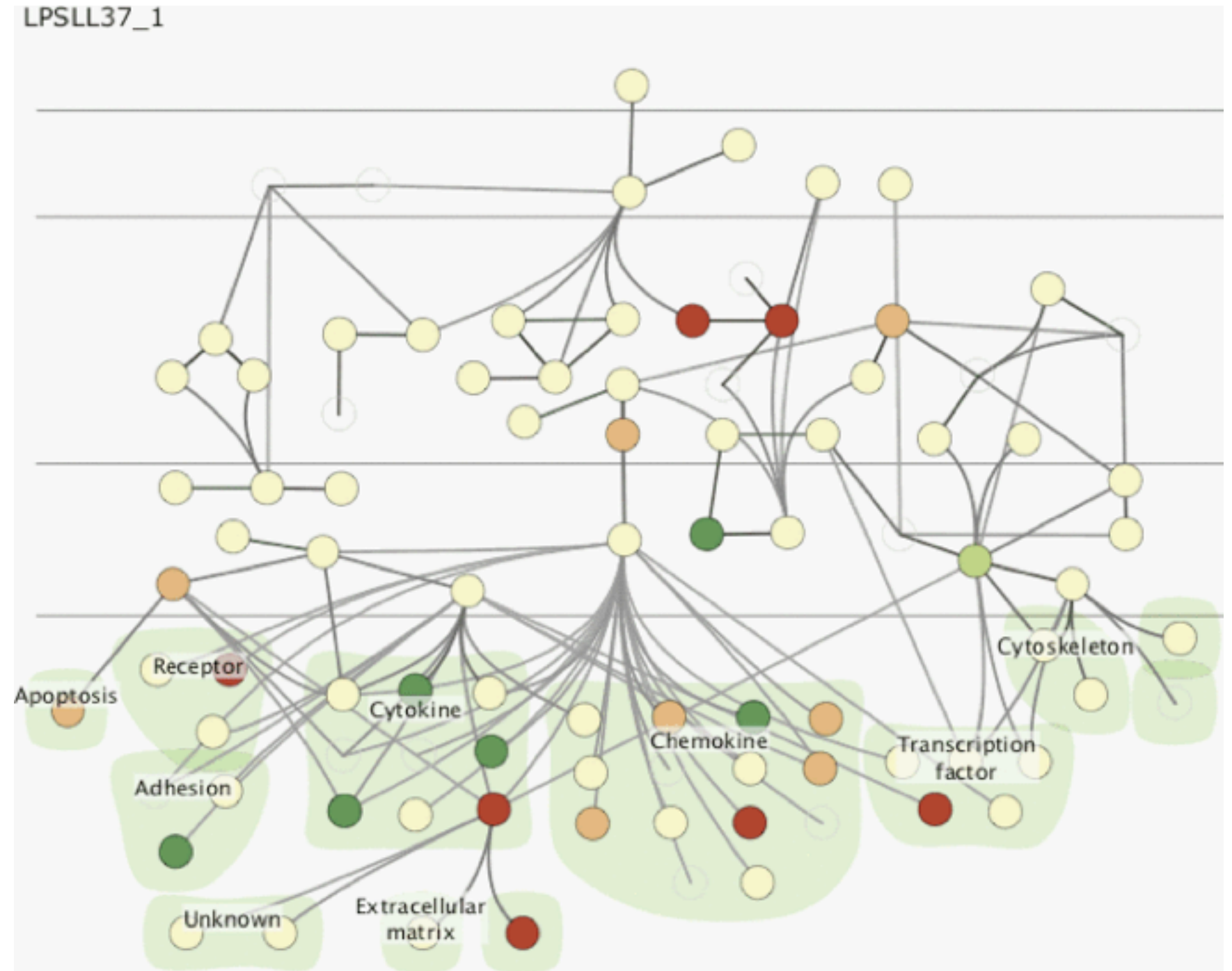
# Change blindness

- if attention is directed elsewhere, even drastic changes not noticeable
  - door experiment
- change blindness demos
  - mask in between images