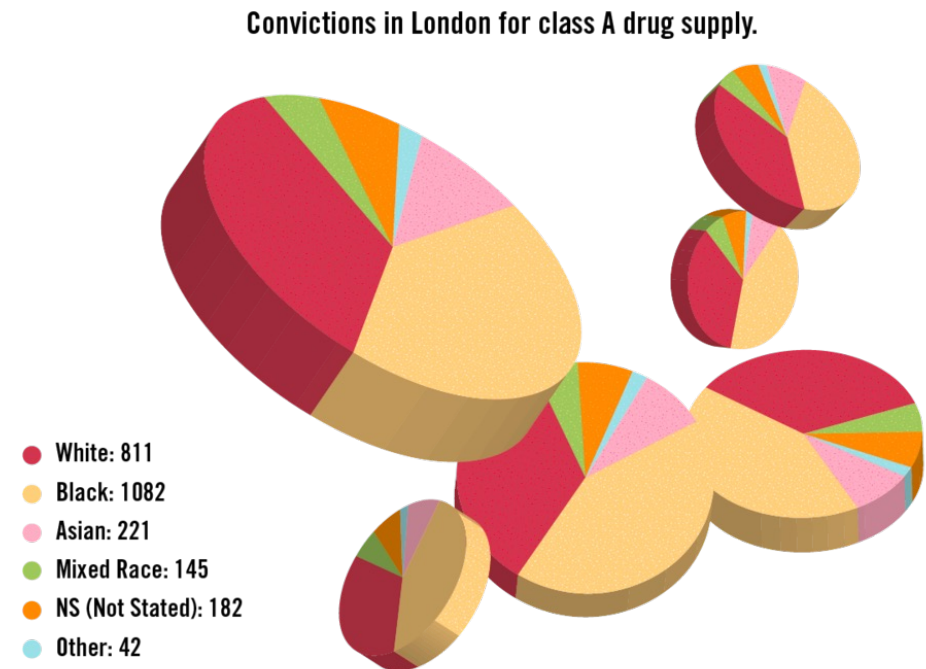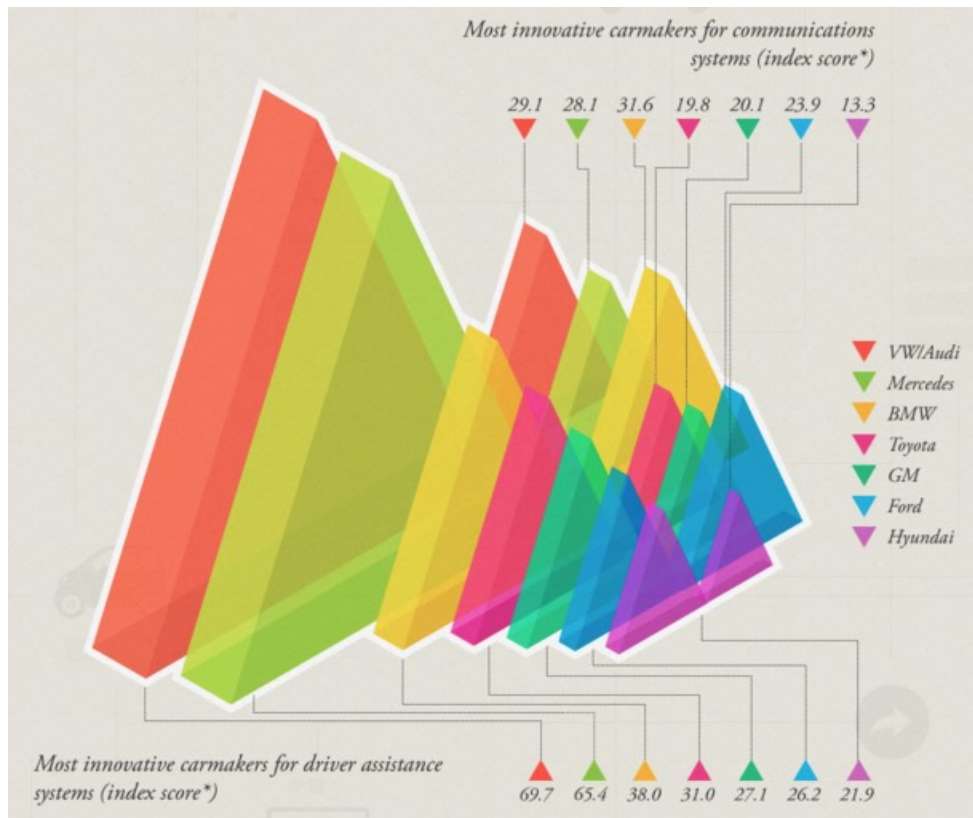# Rules of Thumb

Rules of Thumb

Guidelines and considerations, not absolute rules

- when to use 3D? when to use 2D?

- when to use eyes instead of memory?

- when does immersion help?

- when to use overviews?

- how long is too long?

- which comes first, form or function?

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

Depth vs power of the plane

High-ranked spatial position channel: **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)

Depth vs power of the plane

High-ranked spatial position channel: **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)	

Depth vs power of the plane

High-ranked spatial position channel: **planar** spatial position

– not depth!

Magnitude Channels: Ordered Attributes
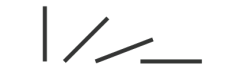
Position on common scale

Position on unaligned scale

Length (1D size)

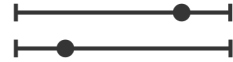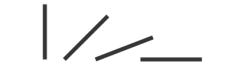Tilt/angle

Area (2D size)

Depth (3D position)

Depth vs power of the plane

High-ranked spatial position channel: **planar** spatial position
- not depth!

Steven's Psychophysical Power Law: $S = I^N$
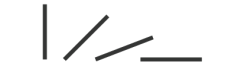
Magnitude Channels: **Ordered** Attributes

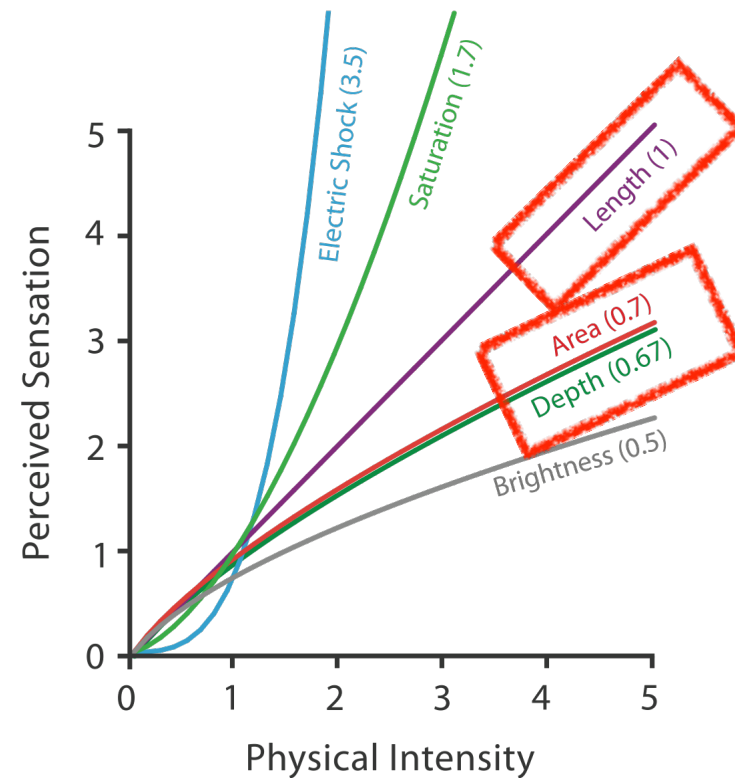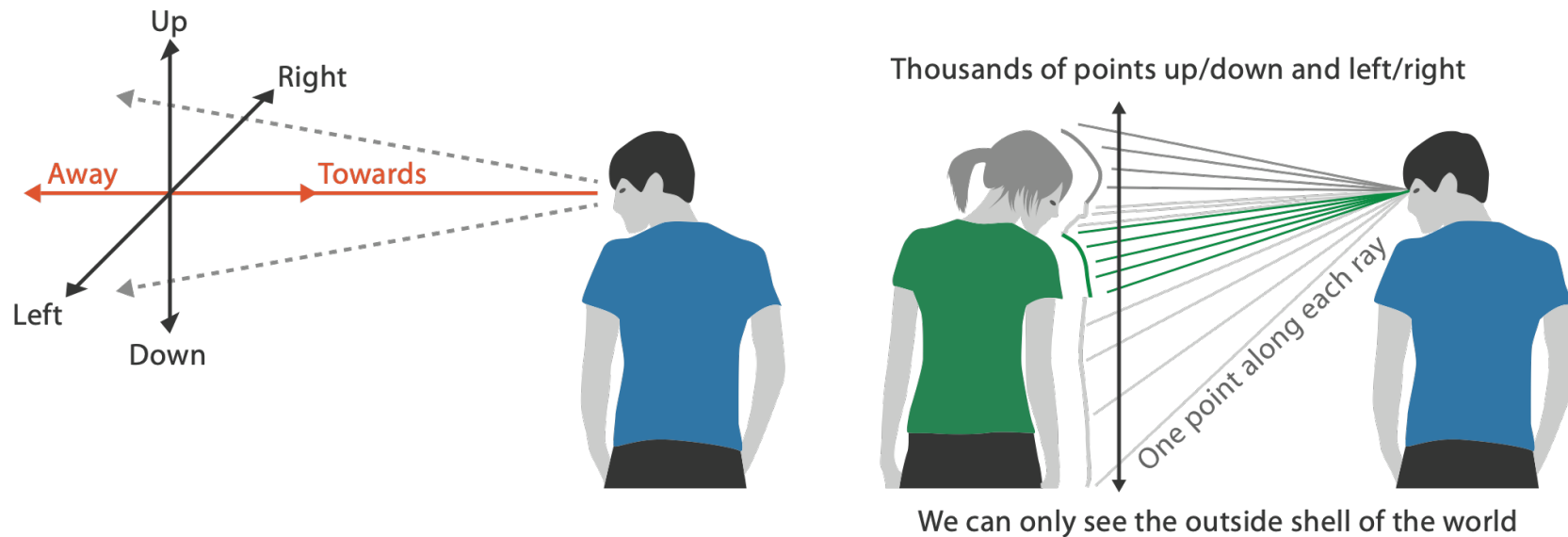|	
Position on common scale	
Position on unaligned scale	
Length (1D size)	
Tilt/angle	
Area (2D size)	
Depth (3D position)	

# No unjustified 3D: Danger of depth

We don't really 'live' in 3D: we **'see'** in 2.05D

- We acquire more info on image plane quickly, from eye movements
- We acquire more info for depth slowly, 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: the blocking of the view of objects by others, in front

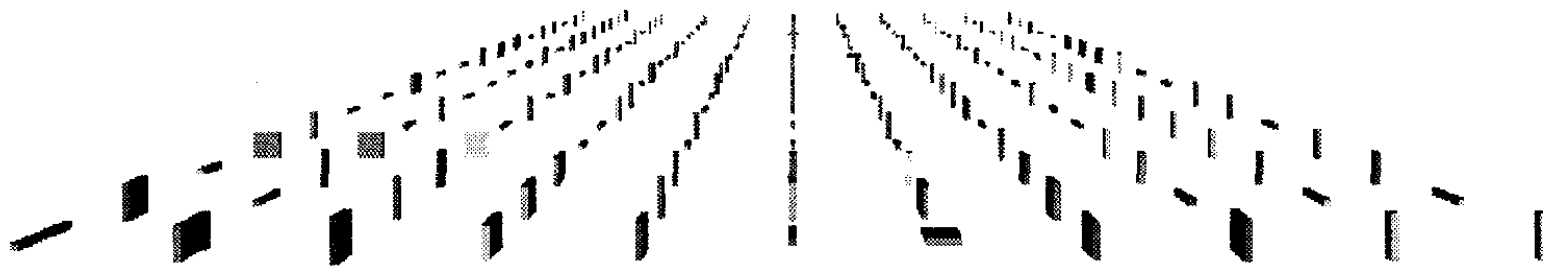Interaction can resolve this, but with a cost: time and cognitive load
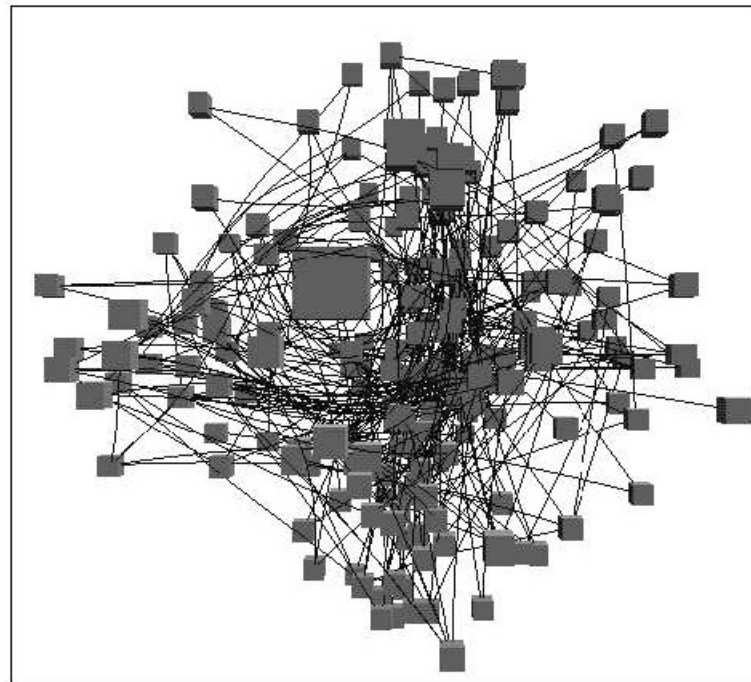
[Distortion Viewing Techniques for 3D Data. Carpendale et al. InfoVis1996.]

Perspective distortion loses information

Object size and angle appears to vary as they are further away

- Interferes with all size encodings
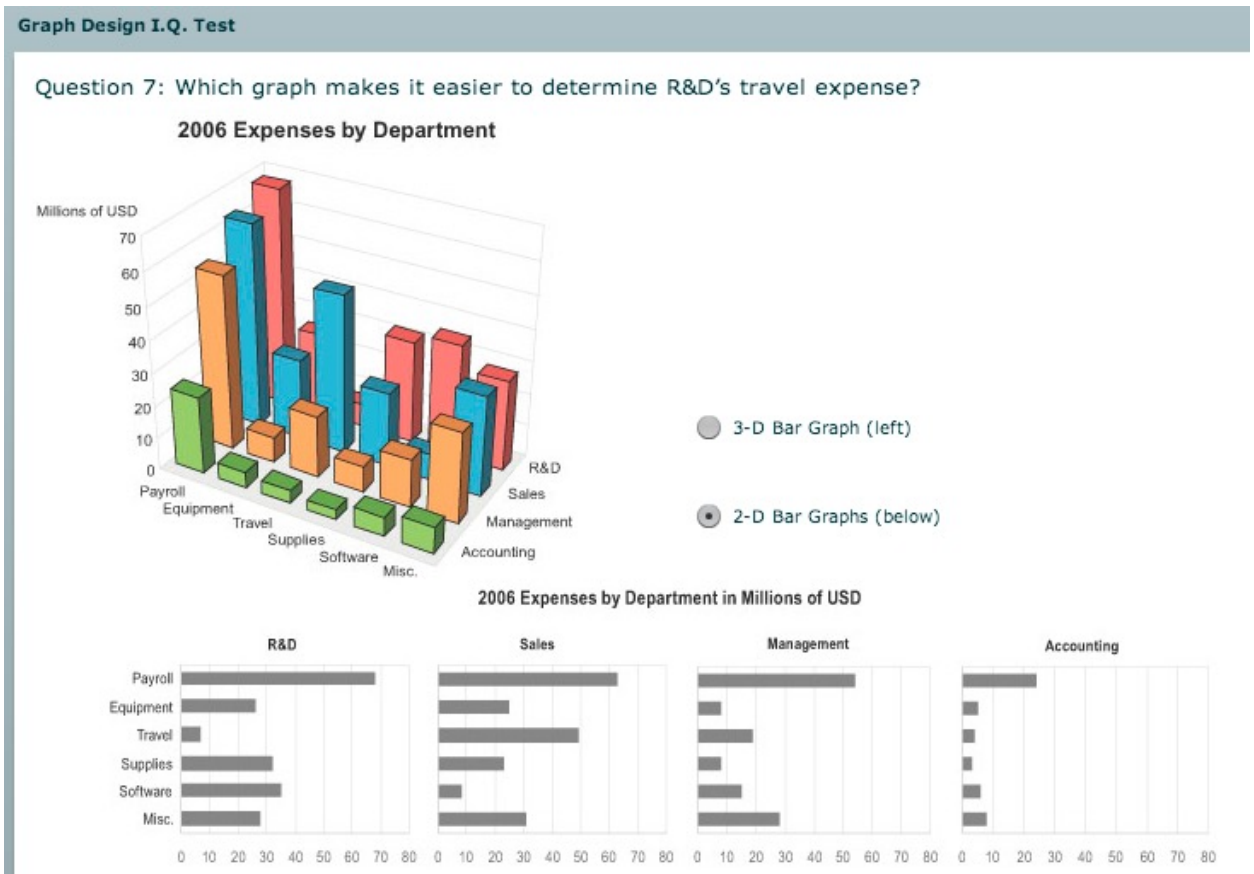- The 'power of the plane' is lost!

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

3D vs 2D bar charts

3D bars: just bad design
- Occlusion
- Perspective distortion

Breaking out a dimension, into multiple 2D views, is almost always a better choice

[http://perceptualedge.com/files/GraphDesignIQ.html]
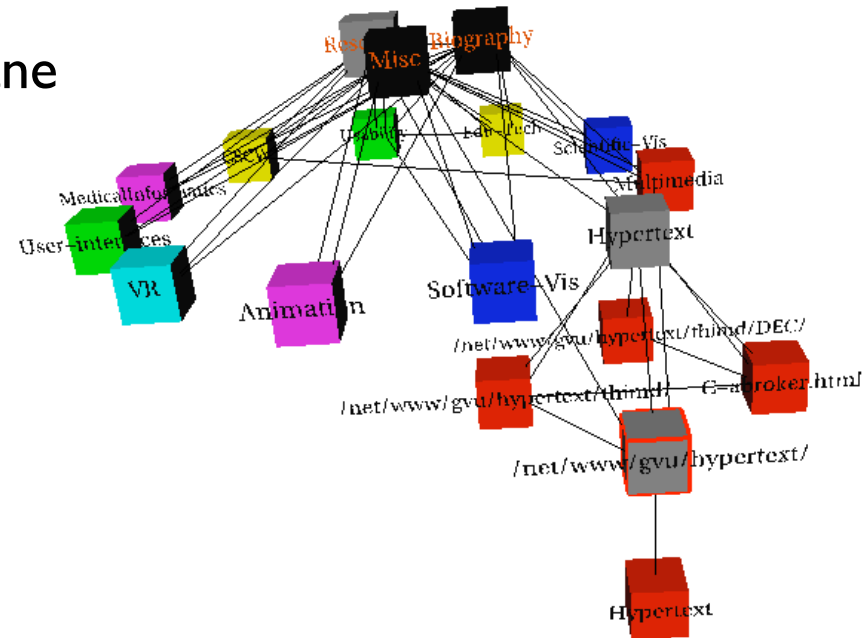
Tilted text isn't legible

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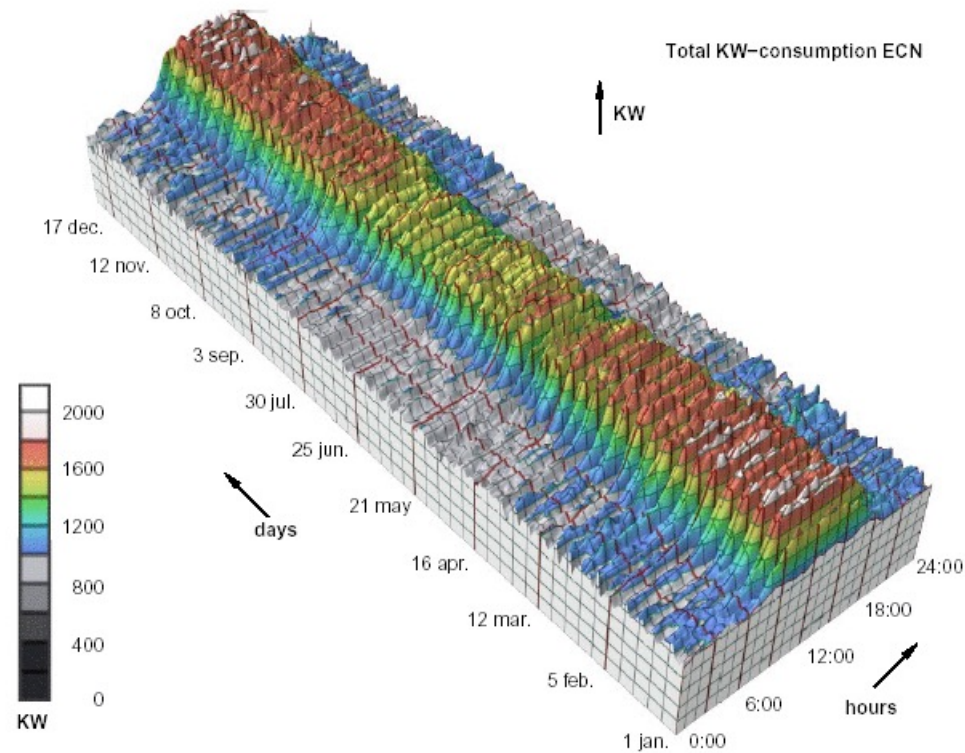
[Cluster and Calendar based Visualization of Time Series Data. van Wijk and van Selow, Proc. InfoVis 99.]

'No unjustified 3D' example: Transform for new data abstraction

Derived data from time series: a cluster hierarchy, shown as colours here
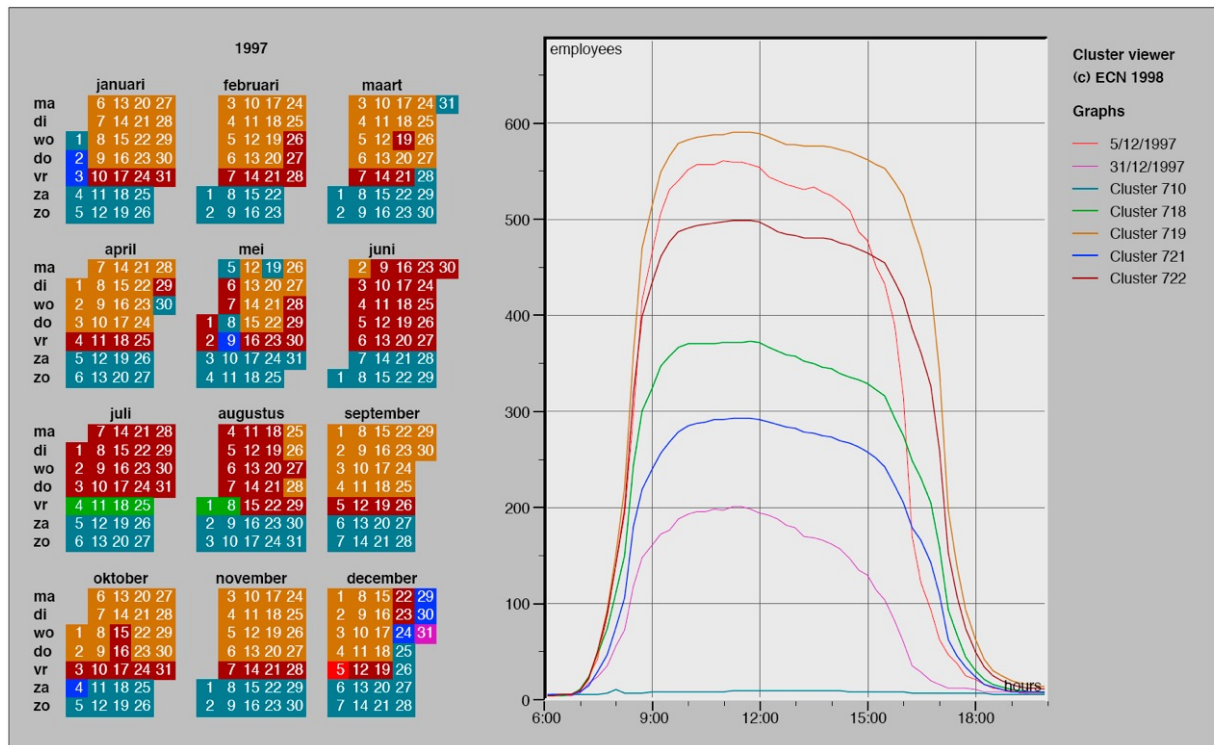- Link multiple views: calendar and graph of superimposed 2D curves

[Cluster and Calendar based Visualization of Time Series Data. van Wijk and van Selow, Proc. InfoVis 99.]
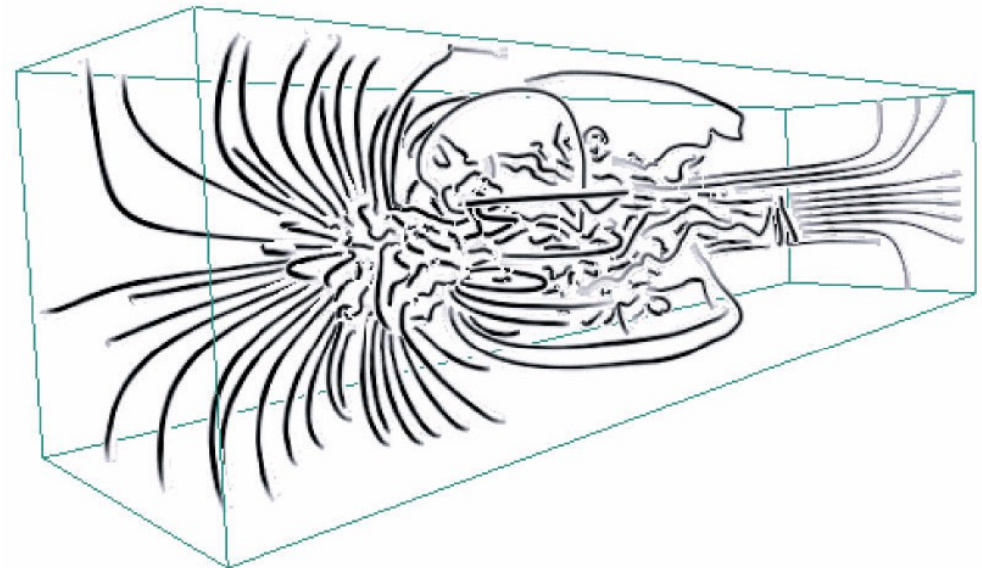
Justified 3D: shape perception

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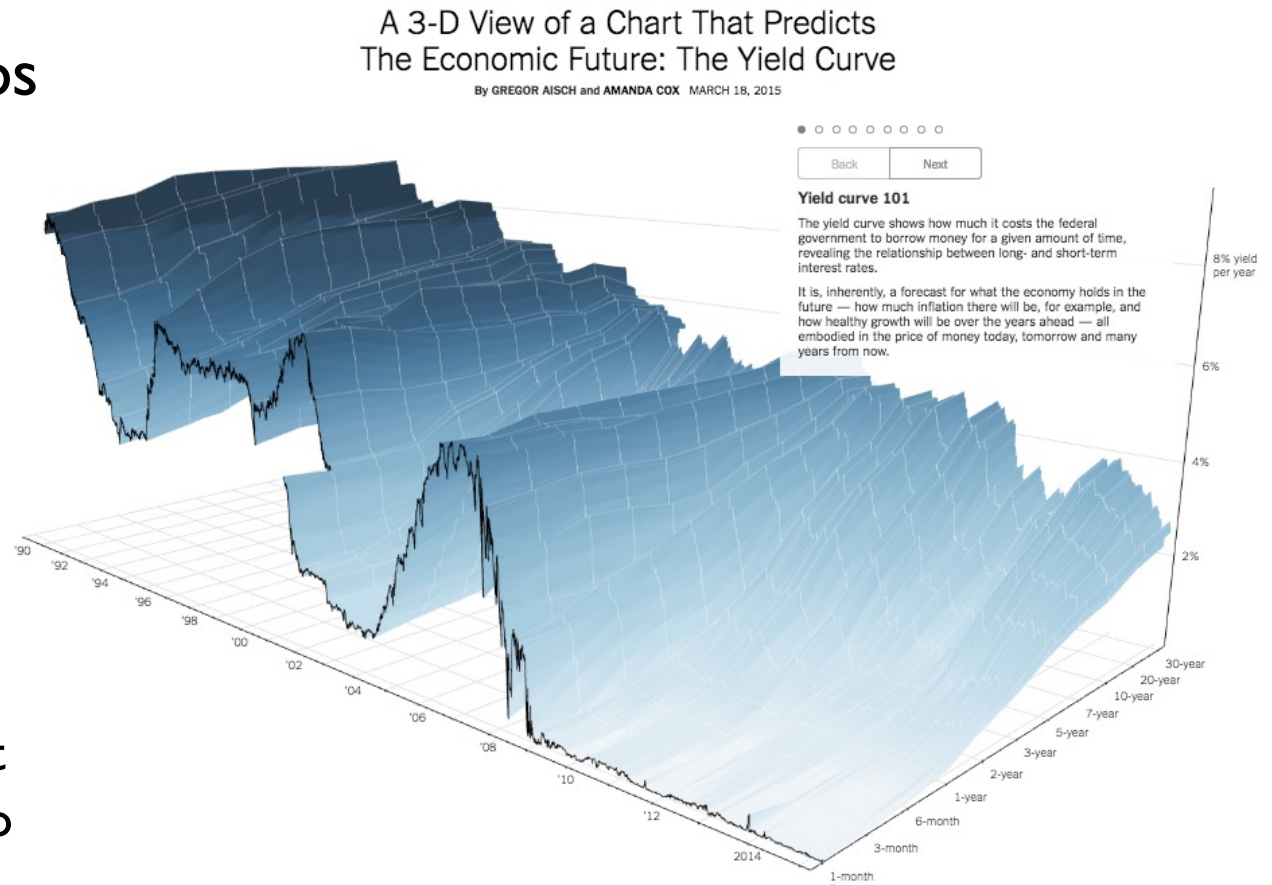
Targets

→ 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

Constrained navigation steps the user through carefully designed viewpoints

- Viewpoints are prepared by the designer, to show key data features well

- This is a linear sequence of chosen scenes, not an open exploration

- Annotations and supporting text make these features clearer, also


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

By GREGOR AISCH and AMANDA COX   MARCH 18, 2015

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

No unjustified 3D

3D viewing is 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. People get lost!
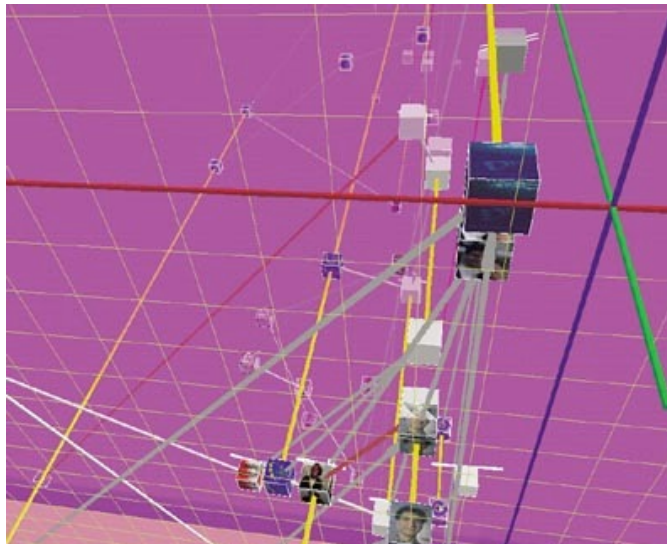
[WEBPATH-a three dimensional Web history. Frecon and Smith. Proc. InfoVis 1999]

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
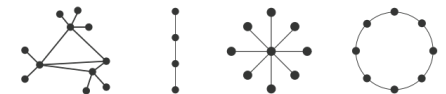
Benefits outweigh costs when topological structure/context is important for task

- – However, be especially careful for search results, document collections, ontologies

Targets

➔ **Network Data**

➔ Topology

➔ *Paths*

Eyes beat memory

Principle: external cognition vs. internal memory
- It is easy to compare side-by-side views, by moving eyes between them quickly
- harder to compare a new item, to memory of what you saw before in the same view

Implications for animation
- great for choreographed storytelling (see also the 'economic growth curve' example)
- 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
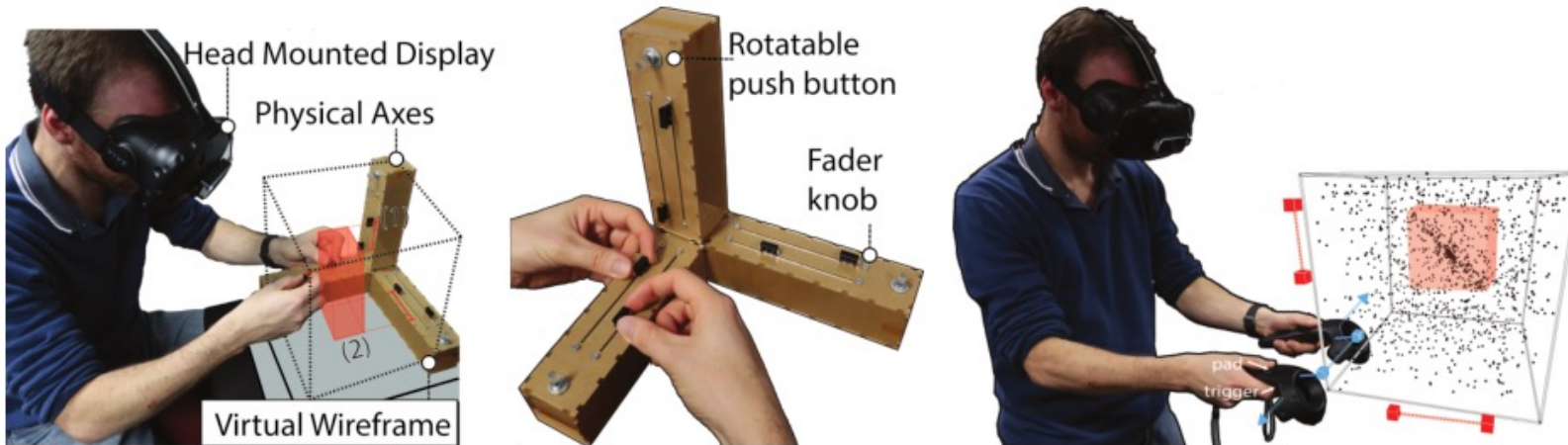
Resolution beats immersion

Immersion typically not helpful for abstract data
- do not need sense of presence or stereoscopic 3D
- desktop also better for integration with other parts of one's work/activity
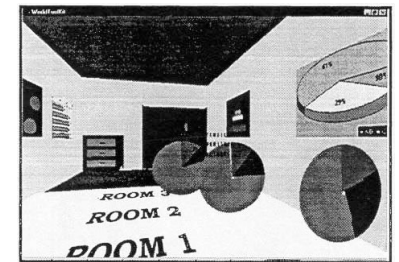
Resolution much more important: pixels are the scarcest resource

First wave (1980/1990): virtual reality for abstract data is just bad

Second wave (now): AR/MR (augmented/mixed reality) seems bad too

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

[A Design Space for Spatio-Data Coordination: Tangible Interaction Devices for Immersive Information Visualisation. Cordeil, Bach, Li, Elliott, and Dwyer. Proc. PacificVis 2017 Notes.]

Overview first, zoom and filter, details on demand

Influential slogan, about a pattern of tasks to design for

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

Overview ≅ identify pattern/structure

- give a view of most/all of the data
- find interesting large-scale aggregates

Zoom and filter ≅ compare

- Use closer views, selection, filtering to understand these aggregate features better

Details ≅ summarise

- Look at individual data items within these features, to get most valuable result(s)

Responsiveness is required

Visual feedback: three rough categories

- ~0.1 seconds: perceptual processing
  - Interaction makes it feel like the action and the response are basically the same thing
  - Subsecond response for mouseover highlighting, cursor movement responding to mouse/trackpad

- ~1 second: immediate response
  - fast but discrete response, so it feels like the action triggers a simple/lightweight operation
  - e.g. window pop-up after mouse click or button press, selection highlighting when you drag out a rectangle over a scatterplot

- ~10 seconds: brief task
  - Delayed or gradual response after dialog box → mental model of heavyweight operation
  - e.g. file loading and visualisation redraw, after a 'New File' command

Responsiveness is required

Considerations when scaling to large data sets
- 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
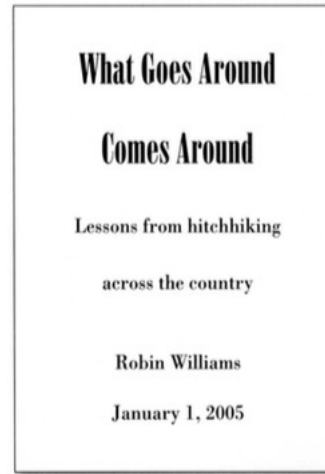
Dangerous to start with aesthetics

- Usually impossible to add function retroactively

Start with focus on functionality

- Possible to improve aesthetics later on, as refinement
- If no expertise in-house, find a graphic designer to work with
- Aesthetics do matter! another level of function
  - Culture, norms and expectations, in visual hierarchy, alignment, flow
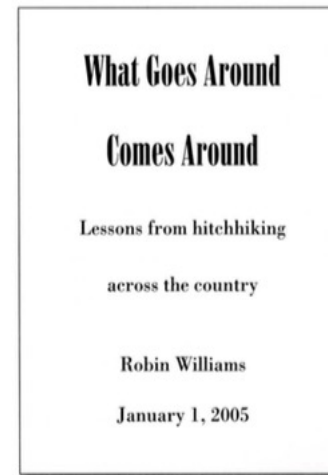 - Also psychology, e.g. Gestalt principles in action

Form: basic graphic design ideas

Form: basic graphic design ideas

What Goes Around

Comes Around

Lessons from hitchhiking

across the country

Robin Williams

January 1, 2005

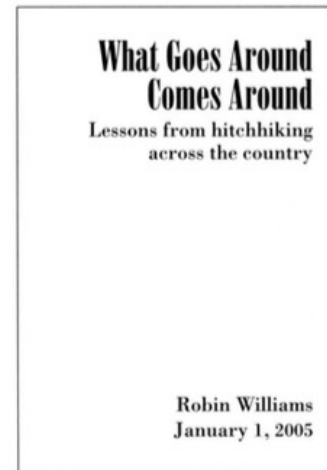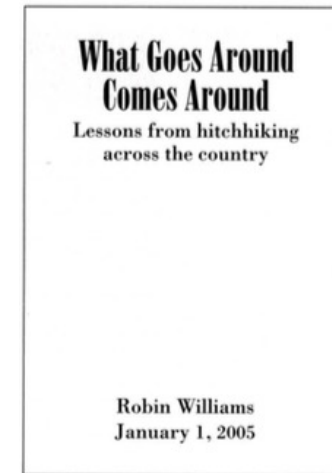# Form: basic graphic design ideas

- proximity
  - group related items together
  - avoid equal whitespace if items unrelated

What Goes Around

Comes Around

Lessons from hitchhiking

across the country

Robin Williams
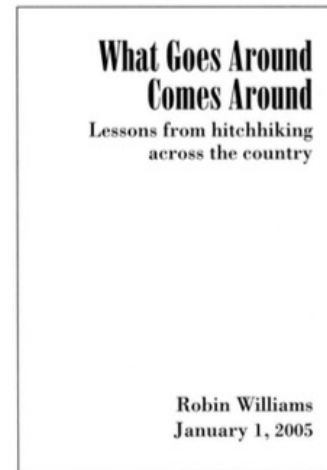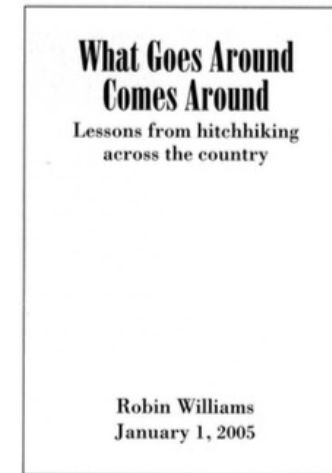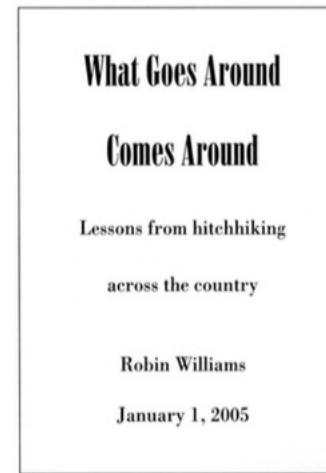
January 1, 2005

Form: basic graphic design ideas

- proximity
  - group related items together
  - avoid equal whitespace if items unrelated
- alignment
  - do find/make strong line, stick to it
  - avoid automatic centering

What Goes Around

Comes Around

Lessons from hitchhiking

across the country

Robin Williams

January 1, 2005

What Goes Around
Comes Around
Lessons from hitchhiking
across the country

Robin Williams
January 1, 2005
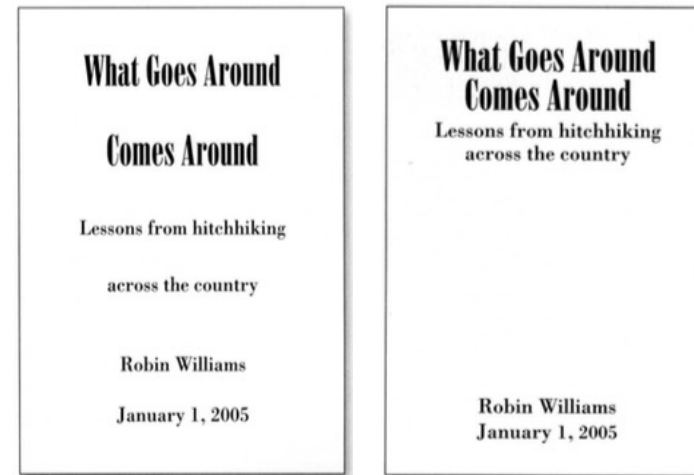
Form: basic graphic design ideas

- proximity
  - group related items together
  - avoid equal whitespace if items unrelated
- alignment
  - do find/make strong line, stick to it
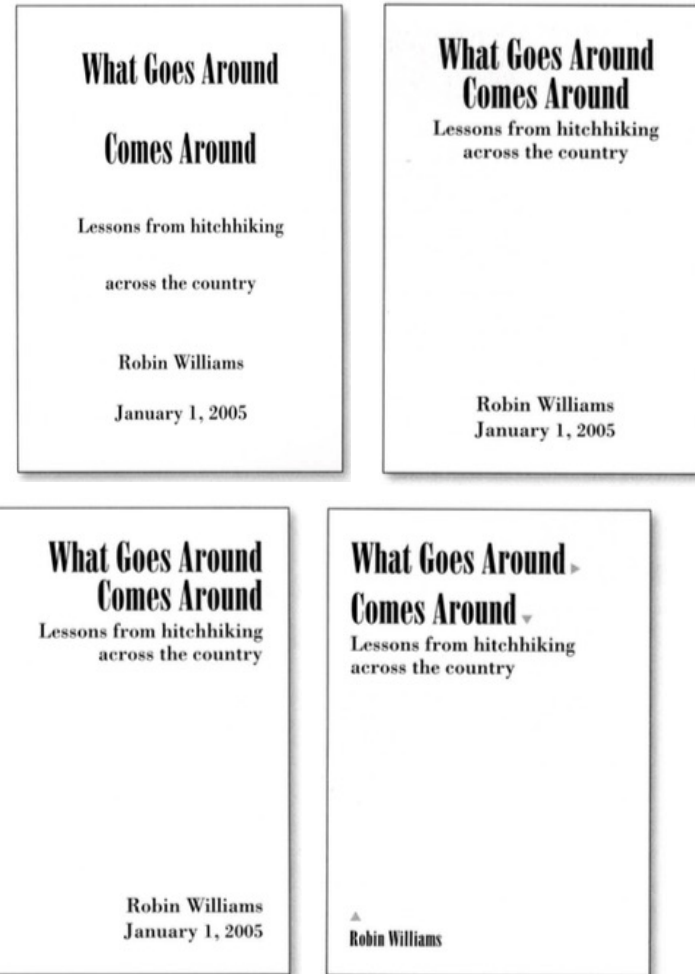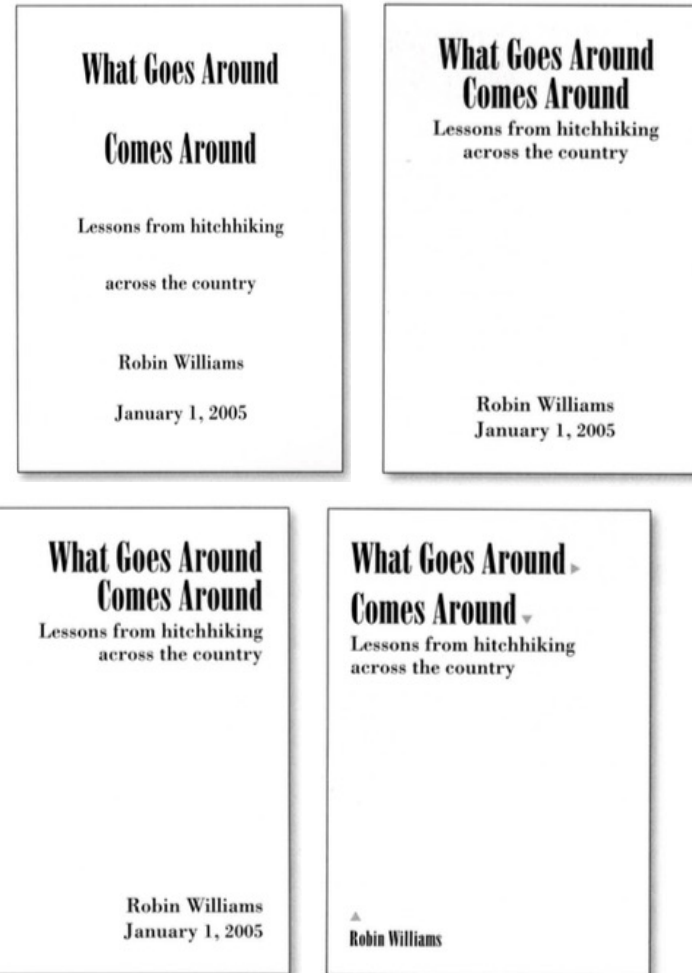 - avoid automatic centering

Form: basic graphic design ideas

- proximity
  - do group related items together
  - avoid equal whitespace between unrelated
- alignment
  - do find/make strong line, stick to it
  - avoid automatic centering
- repetition
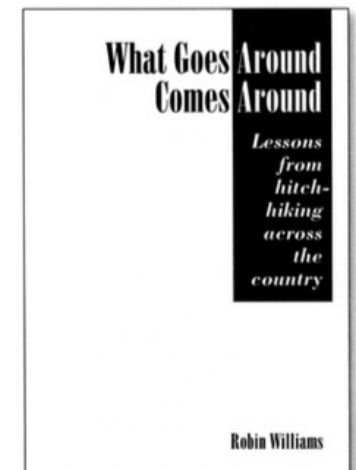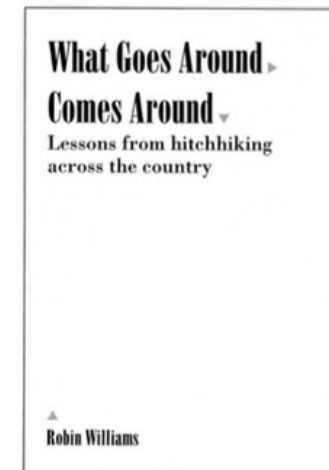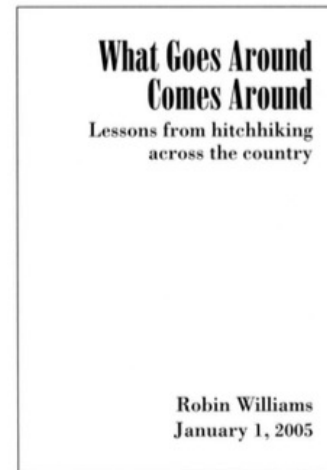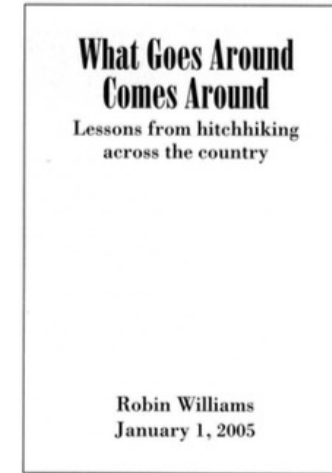 - do unify by pushing existing consistencies

521
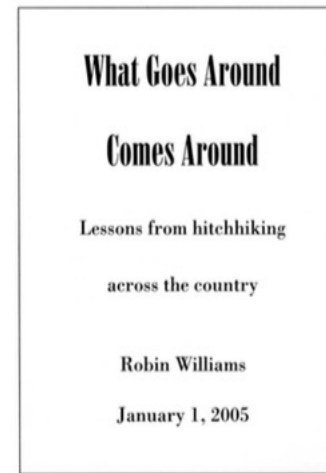
Form: basic graphic design ideas

- proximity
  - do group related items together
  - avoid equal whitespace between unrelated
- alignment
  - do find/make strong line, stick to it
  - avoid automatic centering
- repetition
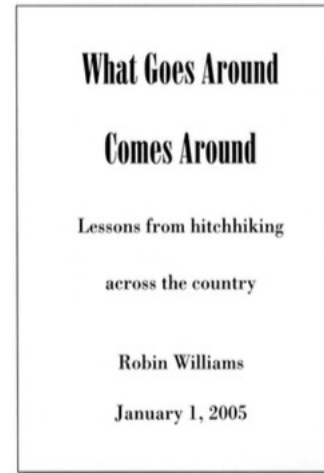 - do unify by pushing existing consistencies

Form: basic graphic design ideas

- 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
 - Be careful of 'not quite the same' features

Form: basic graphic design ideas

- 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 not quite the same

Form: basic graphic design ideas

- 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, make them very different
  - avoid 'not quite the same' appearance

- *The Non-Designer's Design Book, 4th ed. Robin Williams, Peachpit Press, 2015.*
  - fast read, very practical to work through whole book
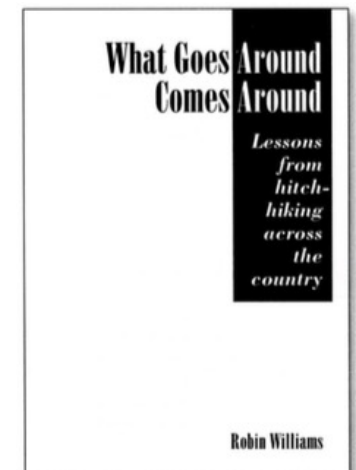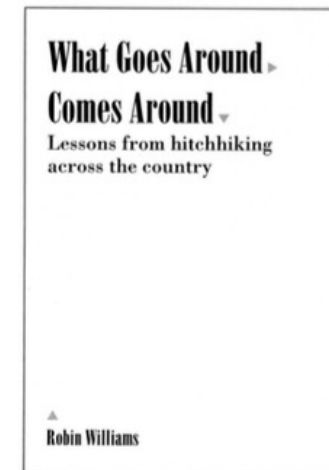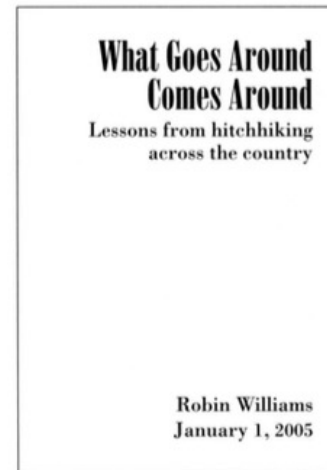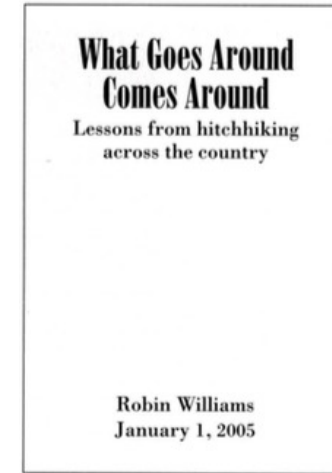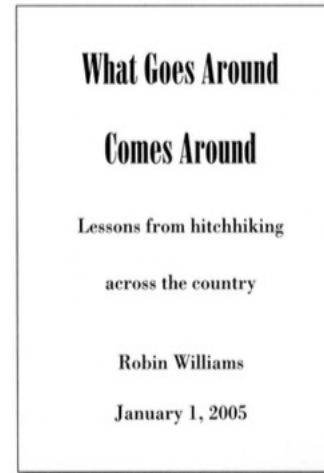
Best practices: Labelling

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

[https://xkcd.com/833/]
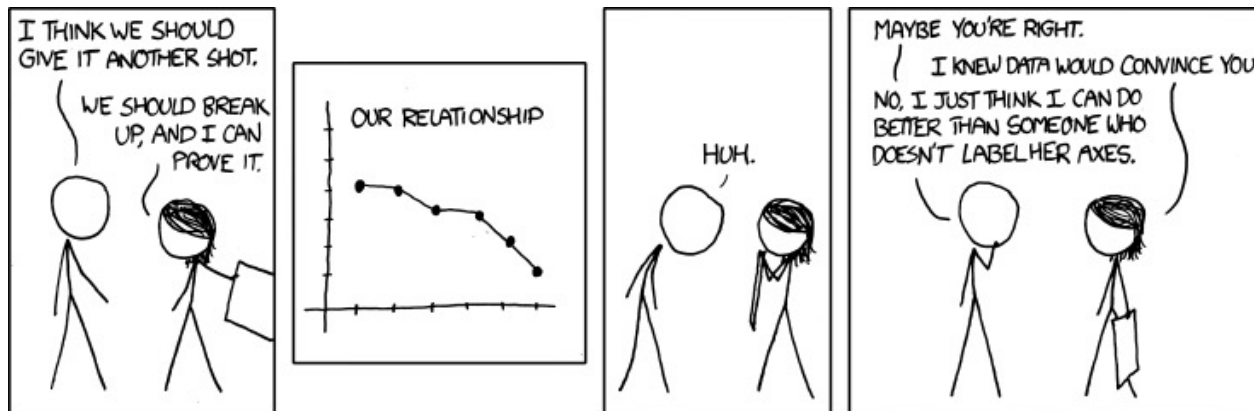
Rules of Thumb Summary

- 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

Rules of Thumb