

Visualization Analysis & Design

Rules of Thumb (Ch 6)

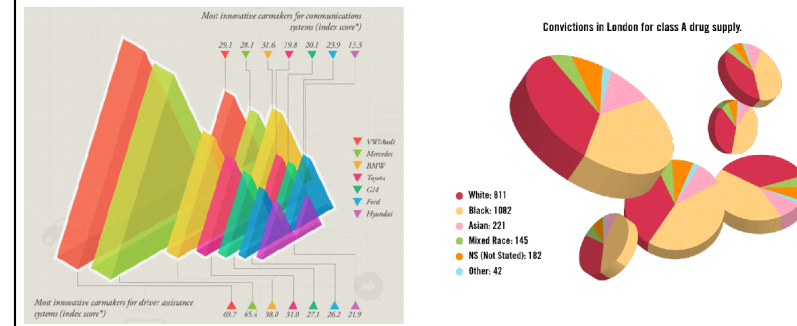
Tamara Munzner
 Department of Computer Science
 University of British Columbia
 @tamaramunzner



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?

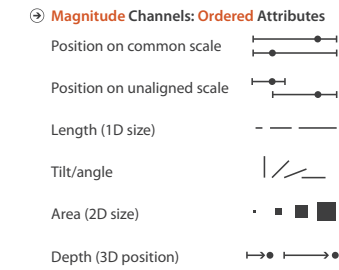
Unjustified 3D all too common, in the news and elsewhere



<http://viz.wtf/post/137826497077/eye-popping-3d-triangles>
<http://viz.wtf/post/139002022202/designer-drugs-ht-ducqn>

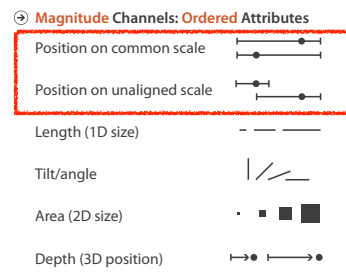
Depth vs power of the plane

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



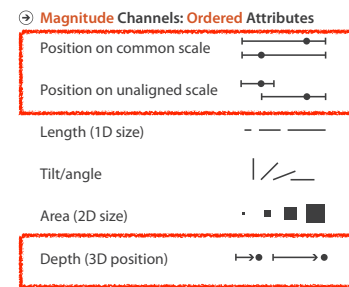
Depth vs power of the plane

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



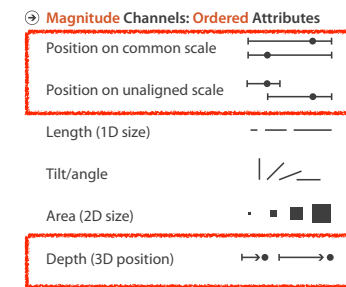
Depth vs power of the plane

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

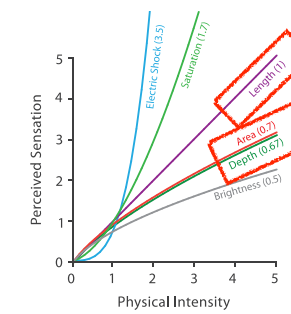


Depth vs power of the plane

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

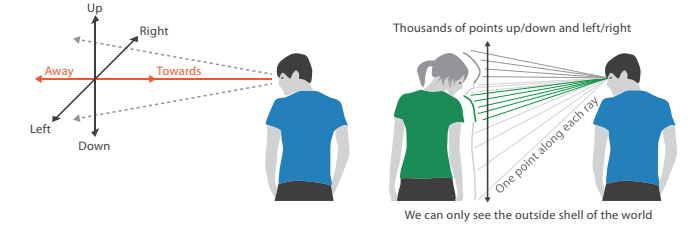


Steven's Psychophysical Power Law: $S = I^p$



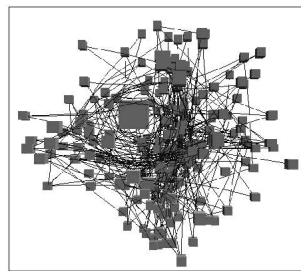
No unjustified 3D: Danger of depth

- 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



Occlusion hides information

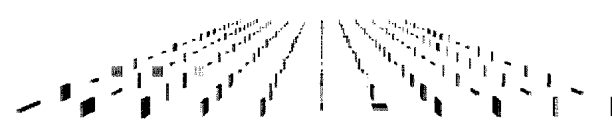
- occlusion
- interaction can resolve, but at cost of time and cognitive load



[Distortion Viewing Techniques for 3D Data. Carpendale et al. InfoVis 1996.]

Perspective distortion loses information

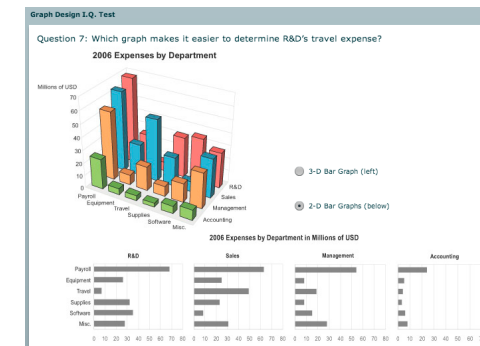
- perspective distortion
 - interferes with all size channel encodings
 - power of the plane is lost!



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

3D vs 2D bar charts

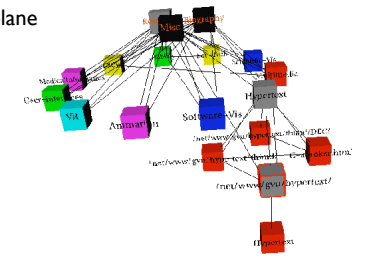
- 3D bars:
 - very difficult to justify!
 - perspective distortion
 - occlusion
- faceting into 2D almost always better choice



[http://perceptualedge.com/files/GraphDesignQ.html]

Tilted text isn't legible

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

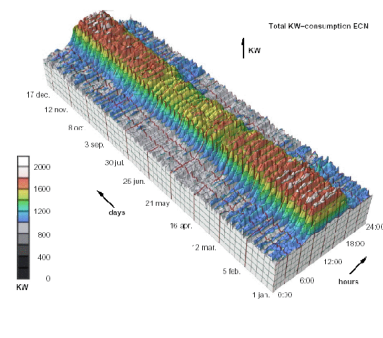


Exploring and Reducing the Effects of Orientation on Text Readability in Volumetric Displays. Grossman et al. CHI 2007

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

No unjustified 3D example: Time-series data

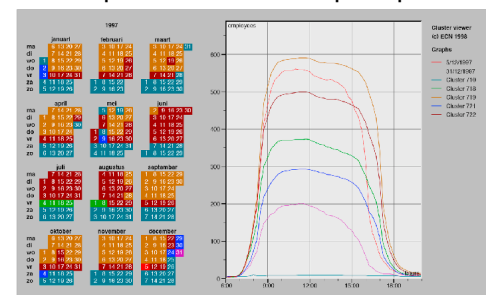
- extruded curves: detailed comparisons impossible



[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

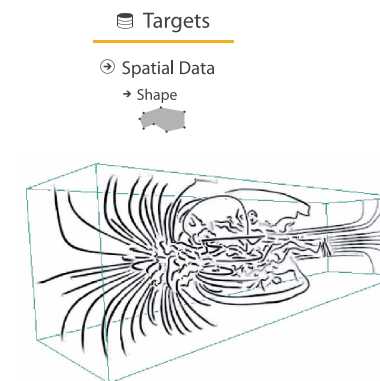
- derived data: cluster hierarchy
- juxtapose multiple views: calendar, superimposed 2D curves



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

Justified 3D: shape perception

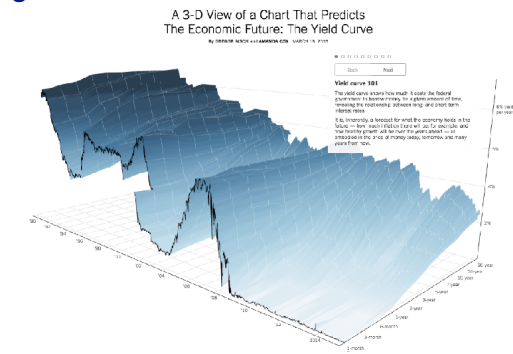
- benefits outweigh costs when task is shape perception for 3D spatial data
 - interactive navigation supports synthesis across many viewpoints



[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

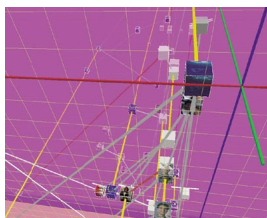
- constrained navigation steps through carefully designed viewpoints



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

No unjustified 3D

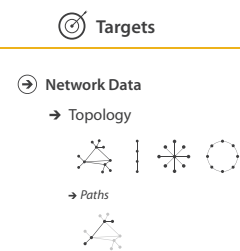
- 3D legitimate for true 3D spatial data
- 3D needs very careful justification for abstract data
 - enthusiasm in 1990s, but now skepticism
 - be especially careful with 3D for point clouds or networks



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

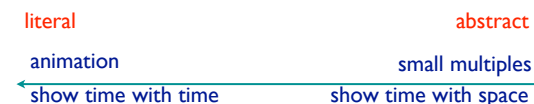
No unjustified 2D

- 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



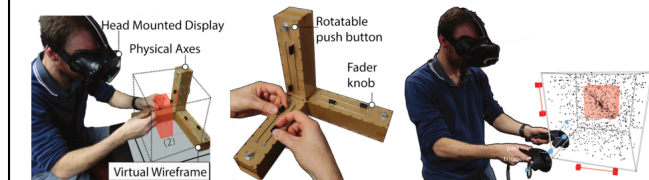
Eyes beat memory

- 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



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
- first wave: virtual reality for abstract data difficult to justify
- second wave: AR/MR (augmented/mixed reality) has more promise



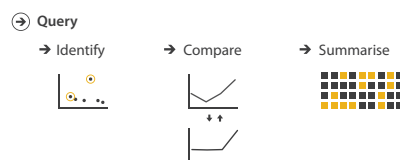
[A Design Space for Spatio-Data Coordination: Tangible Interaction Devices for Immersive Information Visualisation. Cordeil, Bach, Li, Elliott, and Dwyer. Proc. PacificVis 2017 Notes.]

Overview first, zoom and filter, details on demand

- influential 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



Rule of thumb: Responsiveness is required

- visual feedback: three rough categories

Rule of thumb: Responsiveness is required

- visual feedback: three rough categories
 - 0.1 seconds: perceptual processing
 - subsecond response for mouseover highlighting - ballistic motion

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

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)

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

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)

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)

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)

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

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

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 good graphic designer to work with
 - aesthetics do matter! another level of function
 - visual hierarchy, alignment, flow
 - Gestalt principles in action

Form: Basic graphic design ideas

Form: Basic graphic design ideas

Form: Basic graphic design ideas

- proximity
 - do group related items together
 - avoid equal whitespace between unrelated

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

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

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

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, 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, then very different
 - avoid not quite the same

• *The Non-Designer's Design Book, 4th ed. Robin Williams, Peachpit Press, 2015.*

- fast read, very practical to work through whole thing

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