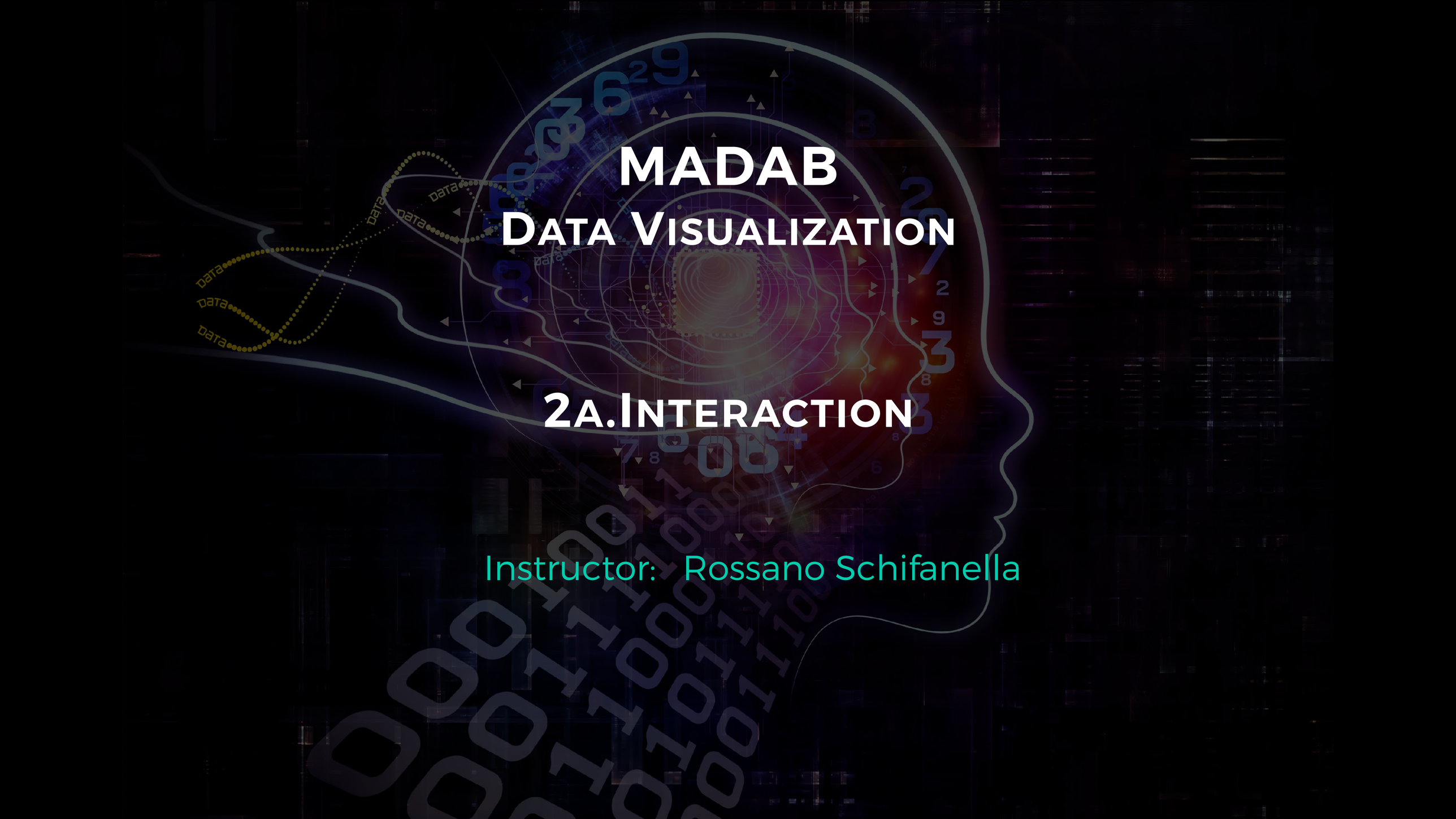


MADAB
Data Visualization

2a.Interaction

Instructor: Rossano Schifanella

Manipulate: Change, Select, Navigate

How to handle complexity: 1 previous strategy + 3 more

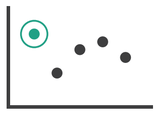
→ *Derive*

- derive new data to show within view
- change view over time
- facet across multiple views
- reduce items/attributes within single view

Manipulate

→ Change

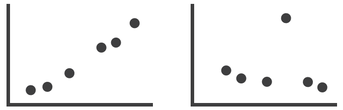
→ Select



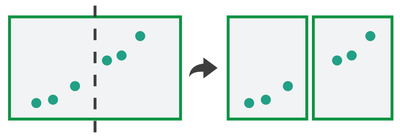
→ Navigate

Facet

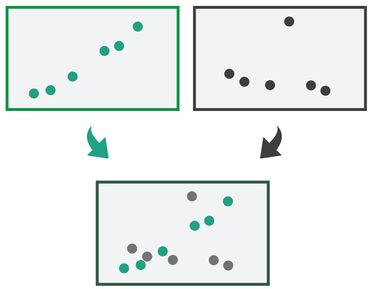
→ Juxtapose



→ Partition



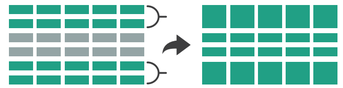
→ Superimpose



Reduce

→ Filter

→ Aggregate

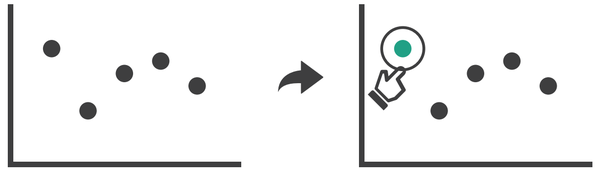


→ Embed

Manipulate

Change over Time

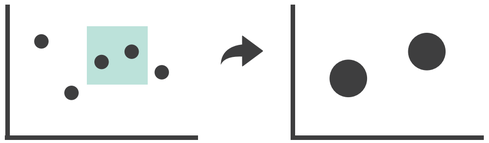
Select



Navigate

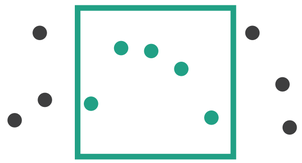
Item Reduction

- *Zoom*
  Geometric or *Semantic*



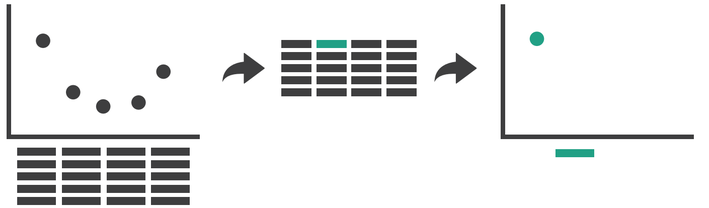
- *Pan/Translate*

- *Constrained*

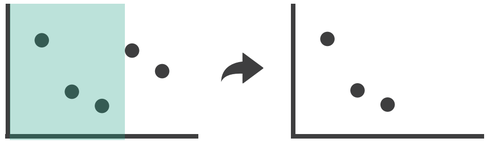


Attribute Reduction

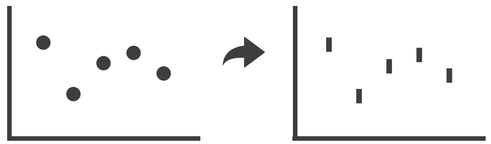
- *Slice*



- *Cut*



- *Project*

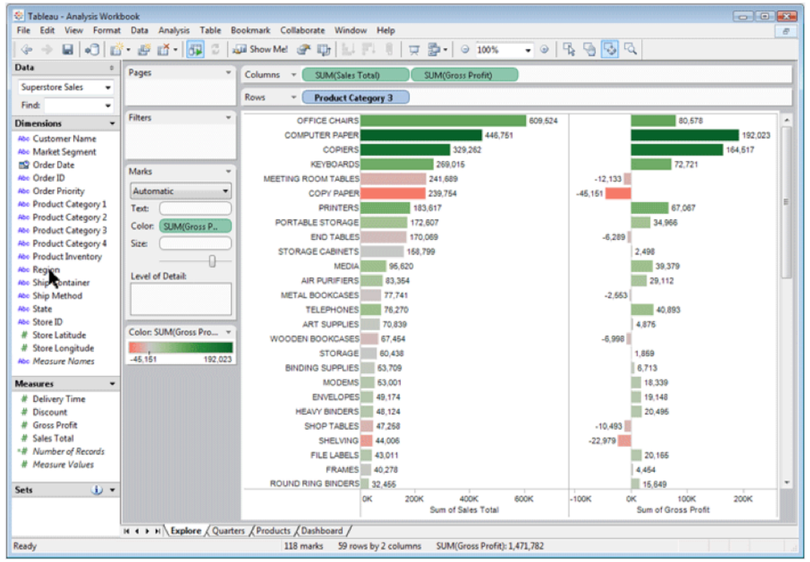


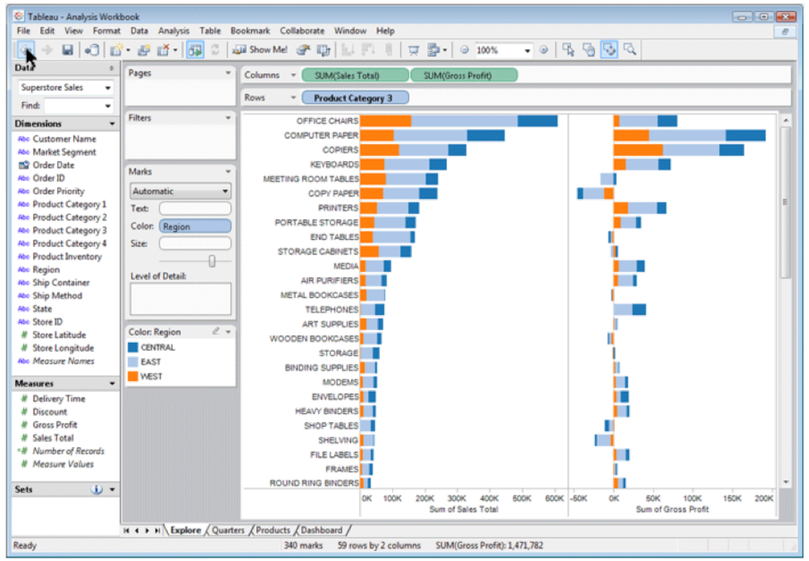
Change over time

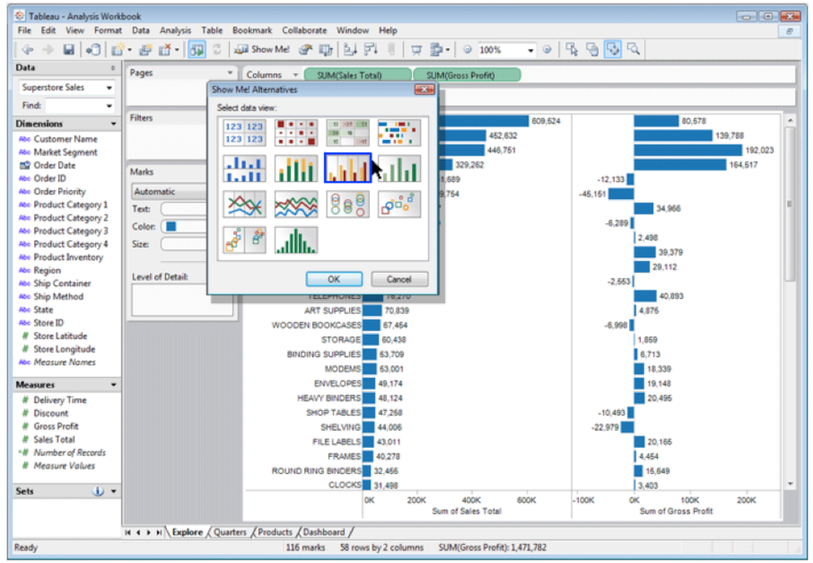
- change any of the other choices
  - encoding itself
  - parameters
  - arrange: rearrange, reorder
  - aggregation level, what is filtered...

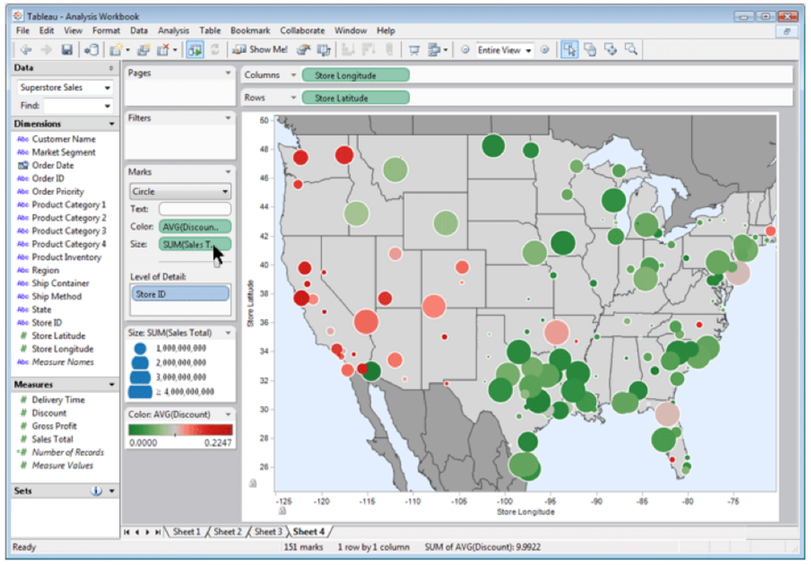
  - interaction entails change

Idiom: **Re-encode** System: **Tableau**







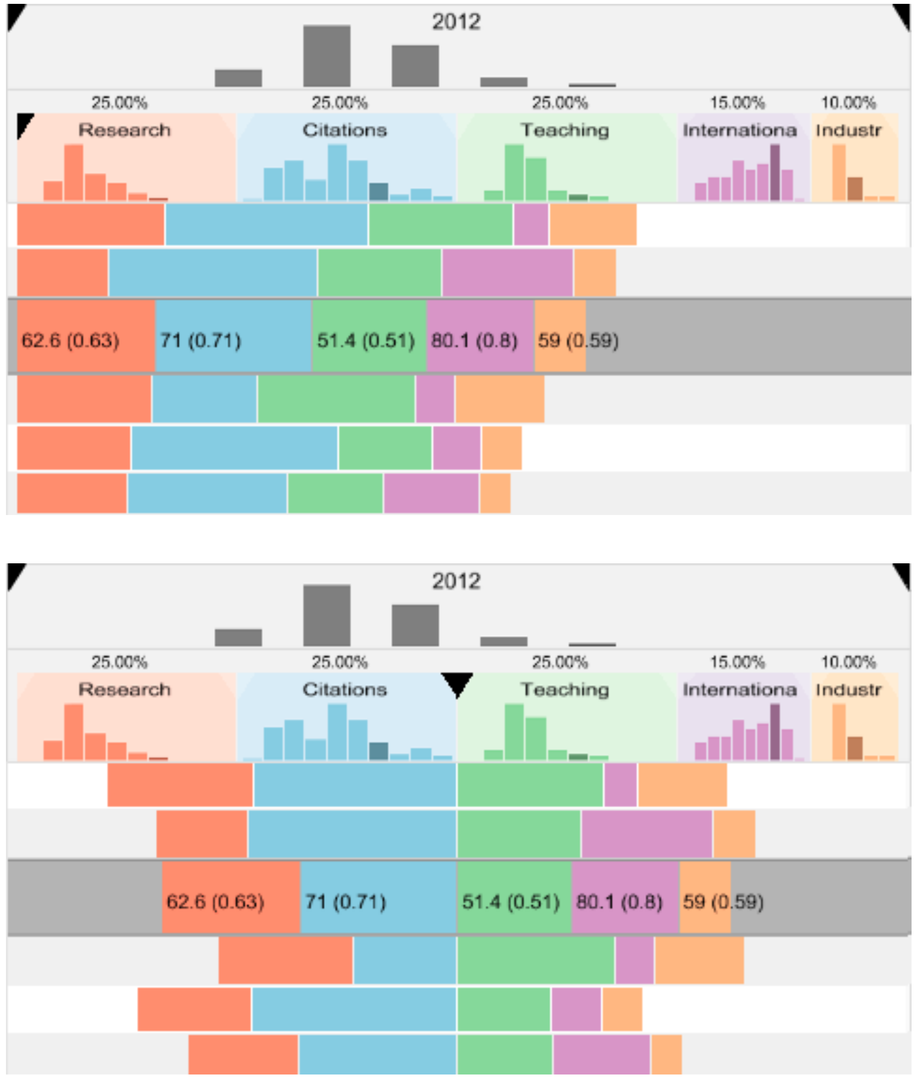


made using Tableau, http://tableausoftware.com

Idiom: **Realign**

System: **LineUp**

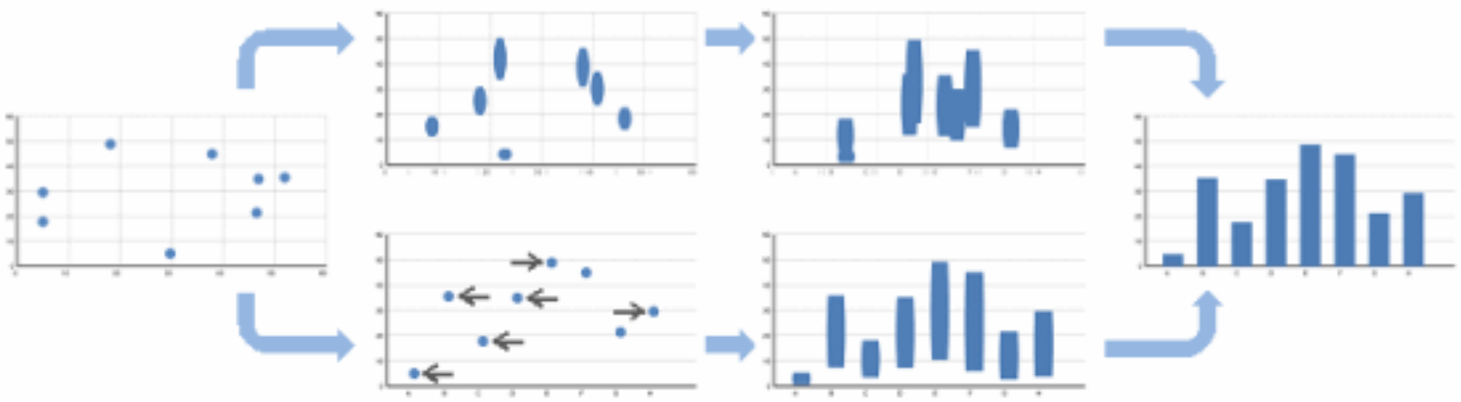
- stacked bars
  - easy to compare
    - first segment
    - total bar
- align to different segment
  - supports flexible comparison



[LineUp:Visual Analysis of Multi-Attribute Rankings.Gratzl, Lex, Gehlenborg, Pfister, and Streit. IEEE Trans.Visualization and Computer Graphics (Proc. InfoVis 2013) 19:12 (2013), 2277–2286.]

Idiom: **Animated transitions**

- smooth interpolation from one state to another
  - alternative to jump cuts, supports item tracking
    - best case for animation
  - staging to reduce cognitive load
- example: animated transitions in statistical data graphics

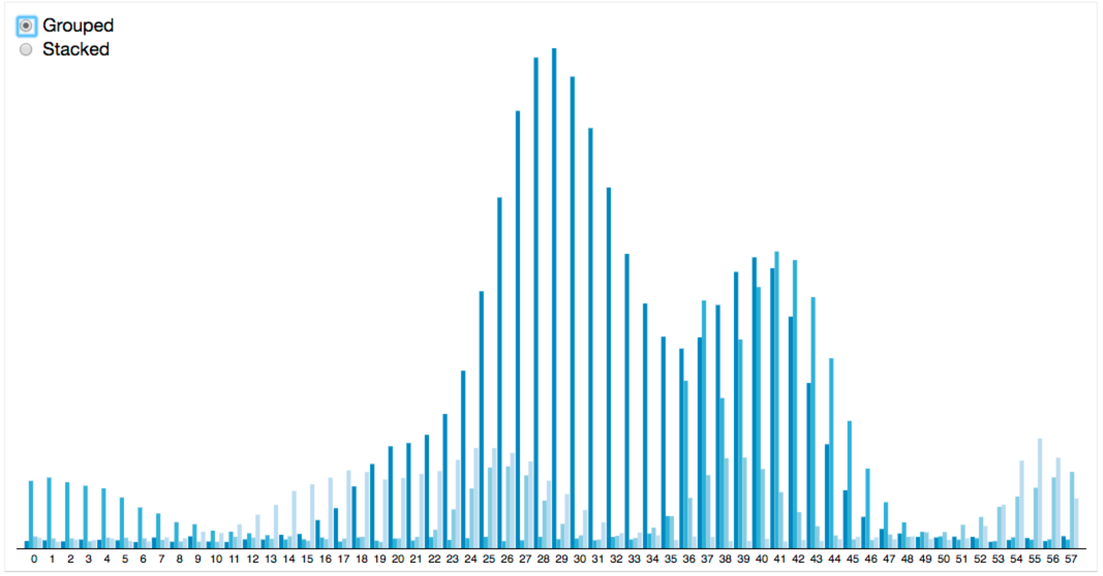


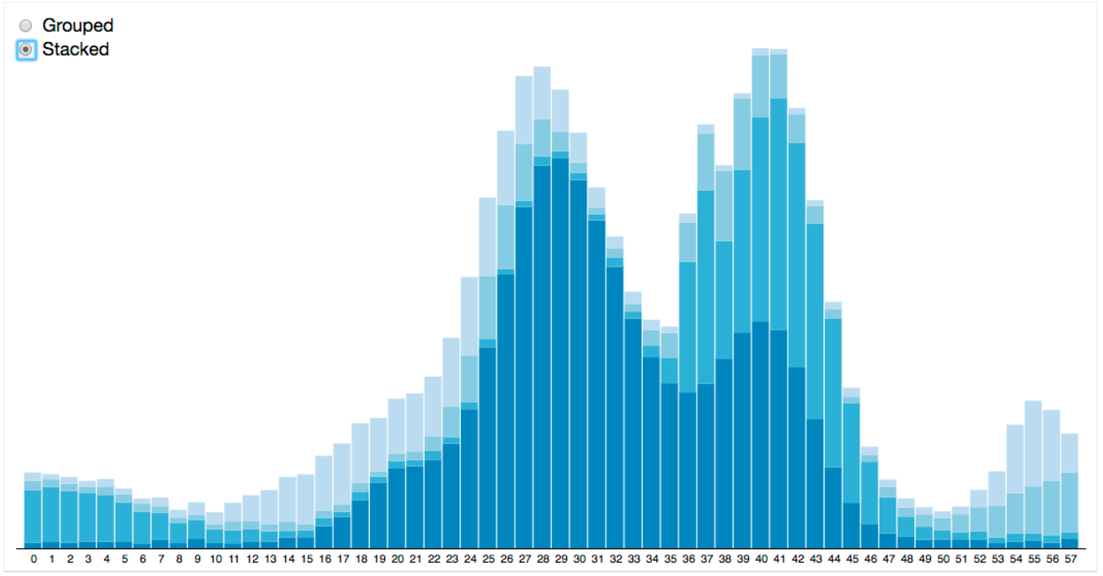
video: vimeo.com/19278444

[Animated Transitions in Statistical Data Graphics. Heer and Robertson. IEEE TVCG (Proc InfoVis 2007) 13(6):1240-1247, 2007]

Idiom: **Animated transitions - visual encoding change**

- smooth transition from one state to another
  - –alternative to jump cuts, supports item tracking
    - –best case for animation
  - –staging to reduce cognitive load

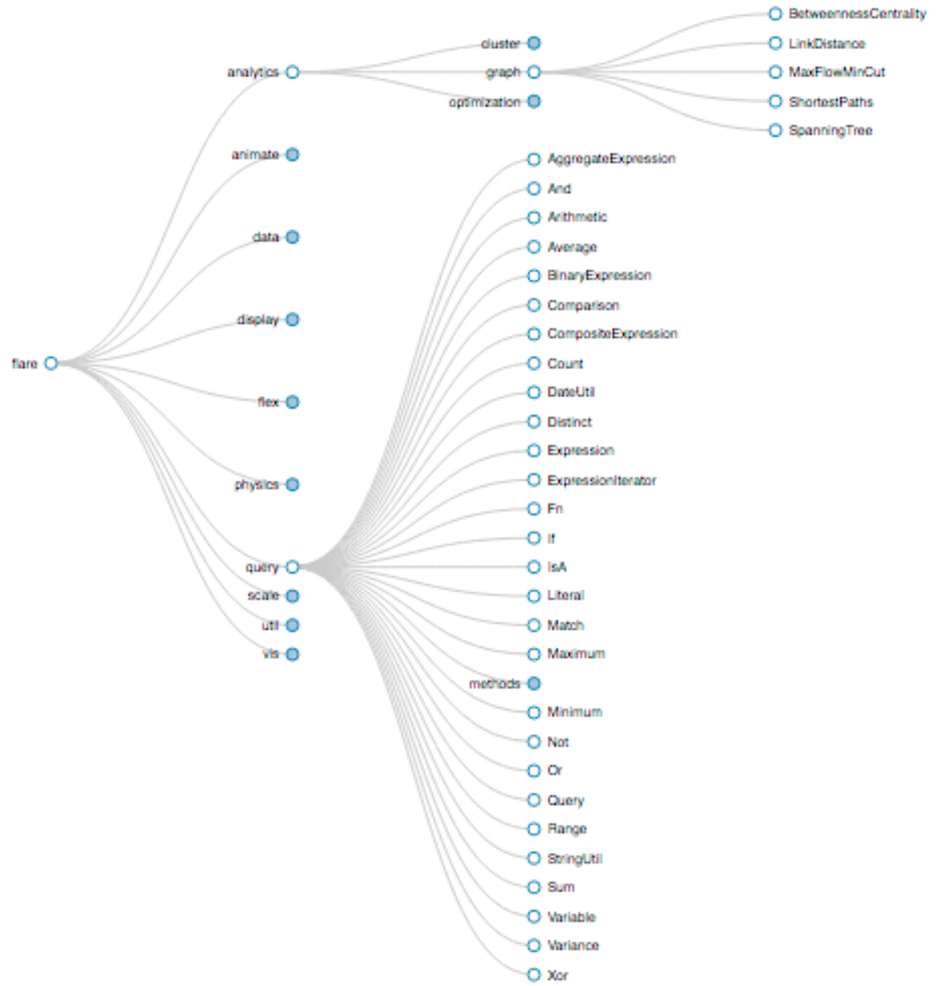




[Stacked to Grouped Bars](http://bl.ocks.org/mbostock/3943967)

Idiom: **Animated transition - tree detail**

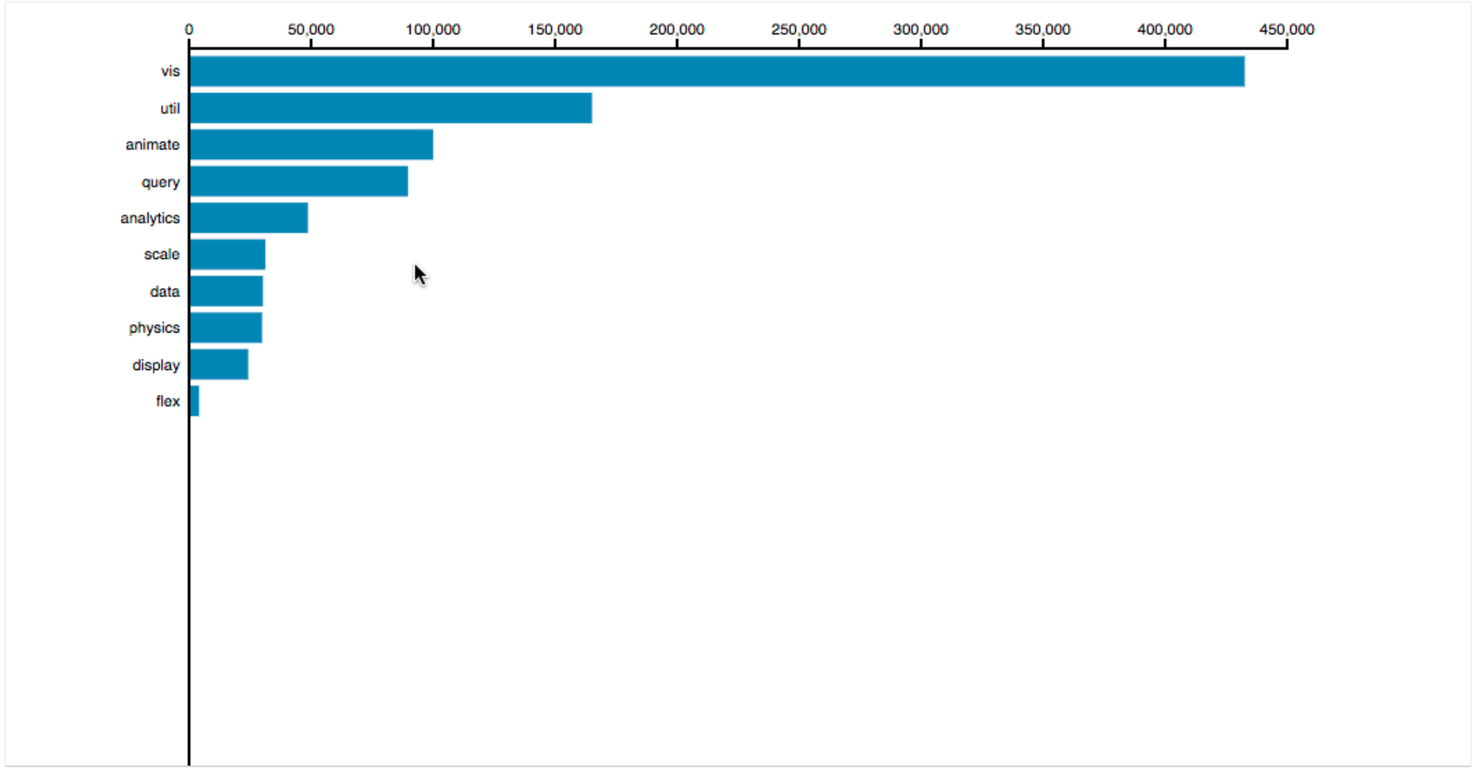
- animated transition
  - network drilldown/rollup



[Collapsible Tree](https://bl.ocks.org/mbostock/4339083)

Idiom: **Animated transition - bar detail**

- example: hierarchical bar chart
  - add detail during transition to new level of detail



[Hierarchical Bar Chart](https://bl.ocks.org/mbostock/1283663)

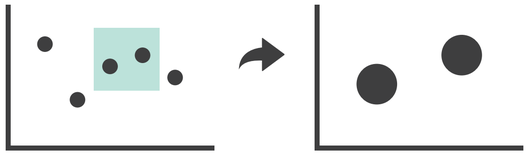
Navigate: Changing item visibility

- change viewpoint
  - changes which items are visible within view
  - camera metaphor
    - zoom
      - geometric zoom: familiar semantics
      - semantic zoom: adapt object representation based on available pixels
        - » dramatic change, or more subtle one
    - pan/translate
    - rotate
      - especially in 3D
  - constrained navigation
    - often with animated transitions
    - often based on selection set

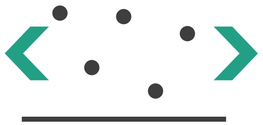
Navigate

→ Item Reduction

→ *Zoom*
Geometric or *Semantic*



→ *Pan/Translate*

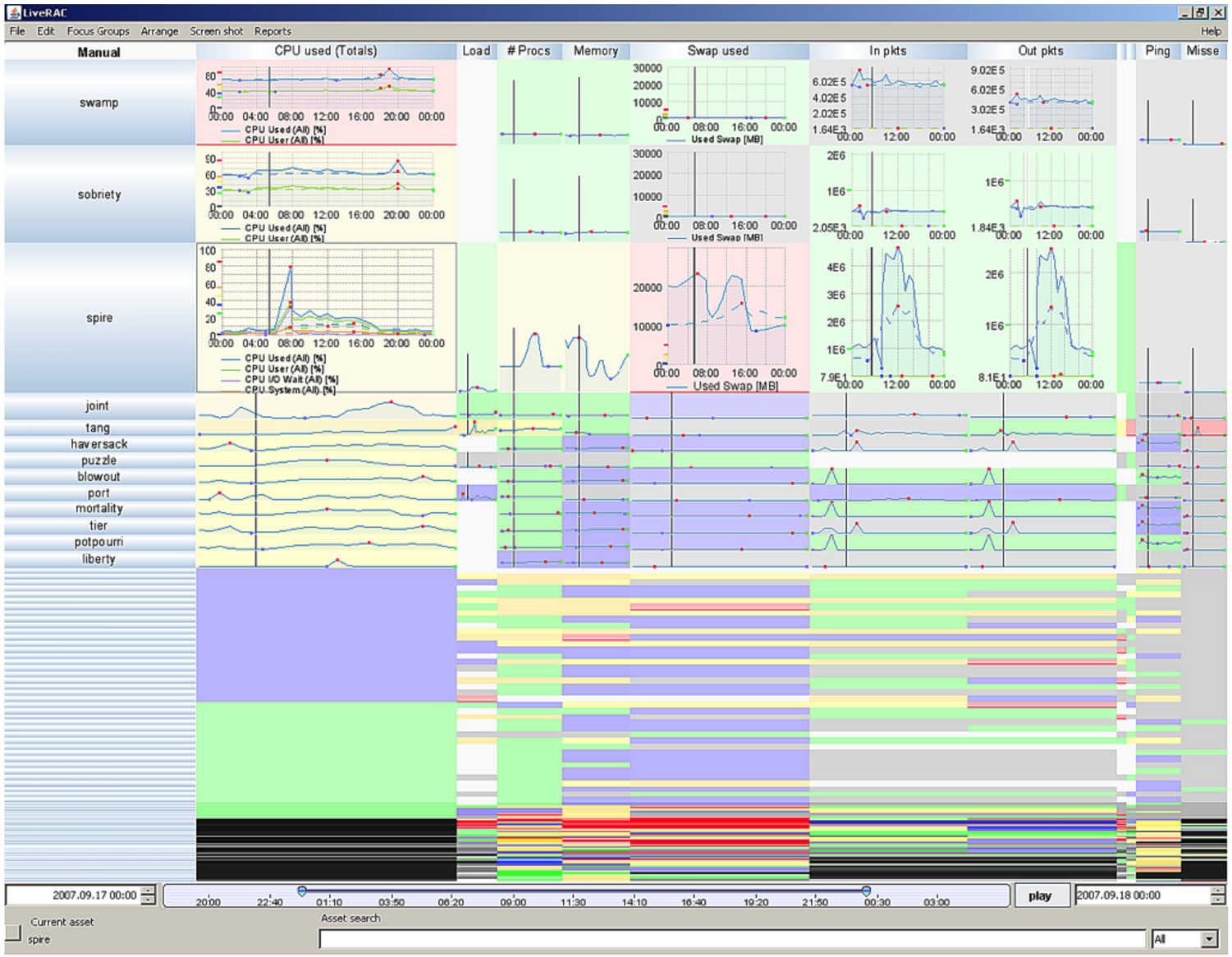


→ *Constrained*

Idiom: **Semantic zooming**

System: **LiveRAC**

- visual encoding change
  - colored box
  - sparkline
  - simple line chart
  - full chart: axes and tickmarks



[LiveRAC - Interactive Visual Exploration of System Management Time-Series Data. McLachlan, Munzner, Koutsofios, and North. Proc. ACM Conf. Human Factors in Computing Systems (CHI), pp. 1483–1492, 2008.]

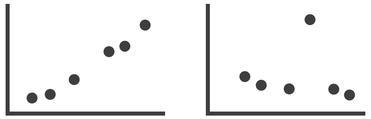
Further reading

- Visualization Analysis and Design. Munzner. AK Peters Visualization Series, CRC Press, 2014.
  - *Chap 11: Manipulate View*
- *Animated Transitions in Statistical Data Graphics*. Heer and Robertson. IEEE Trans. on Visualization and Computer Graphics (Proc. InfoVis07) 13:6 (2007), 1240–1247.
- *Selection: 524,288 Ways to Say "This is Interesting"*. Wills. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 54–61, 1996.
- *Smooth and efficient zooming and panning*. van Wijk and Nuij. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 15–22, 2003.
- *Starting Simple - adding value to static visualisation through simple interaction*. Dix and Ellis. Proc. Advanced Visual Interfaces (AVI), pp. 124–134, 1998.

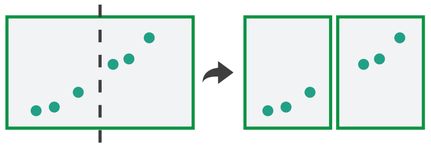
Facet: Juxtapose, Partition, Superimpose

Facet

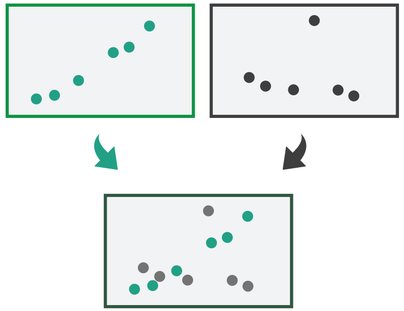
Juxtapose



Partition



Superimpose



Juxtapose and coordinate views

- Share Encoding: Same/Different
  - *Linked Highlighting*

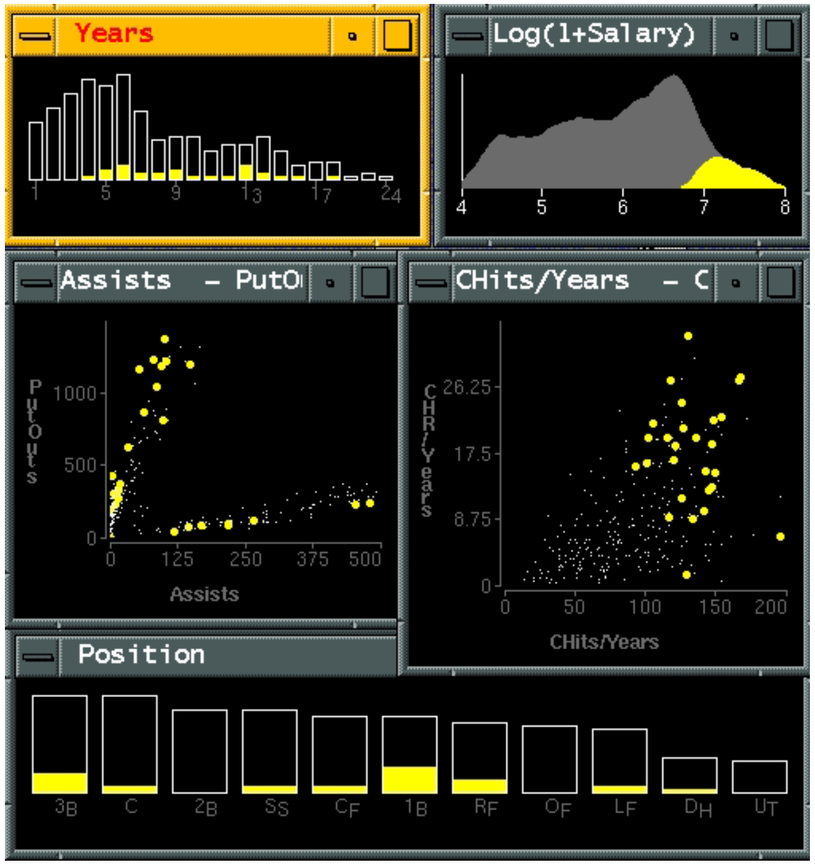
- Share Data: All/Subset/None

- Share Navigation

Idiom: **Linked highlighting**

System: **EDV**

- see how regions contiguous in one view are distributed within another
  - powerful and pervasive interaction idiom
- encoding: different
  - ***multiform***
- data: all shared

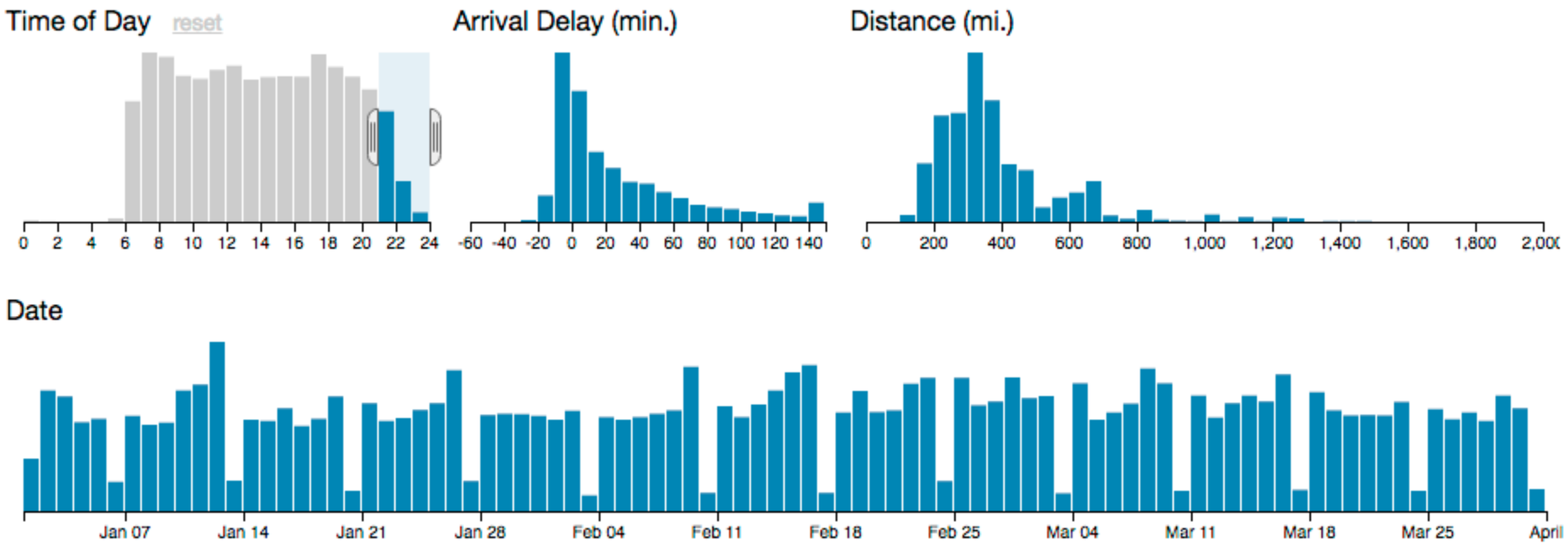


[Visual Exploration of Large Structured Datasets. Wills. Proc. New Techniques and Trends in Statistics (NTTS), pp. 237–246. IOS Press, 1995.]

Idiom: **cross filtering**

System: **Crossfilter**

- item filtering
- coordinated views/controls combined
  - all scented histogram bisliders update when any ranges change



[http://square.github.io/crossfilter/]

Idiom: **bird's-eye maps**

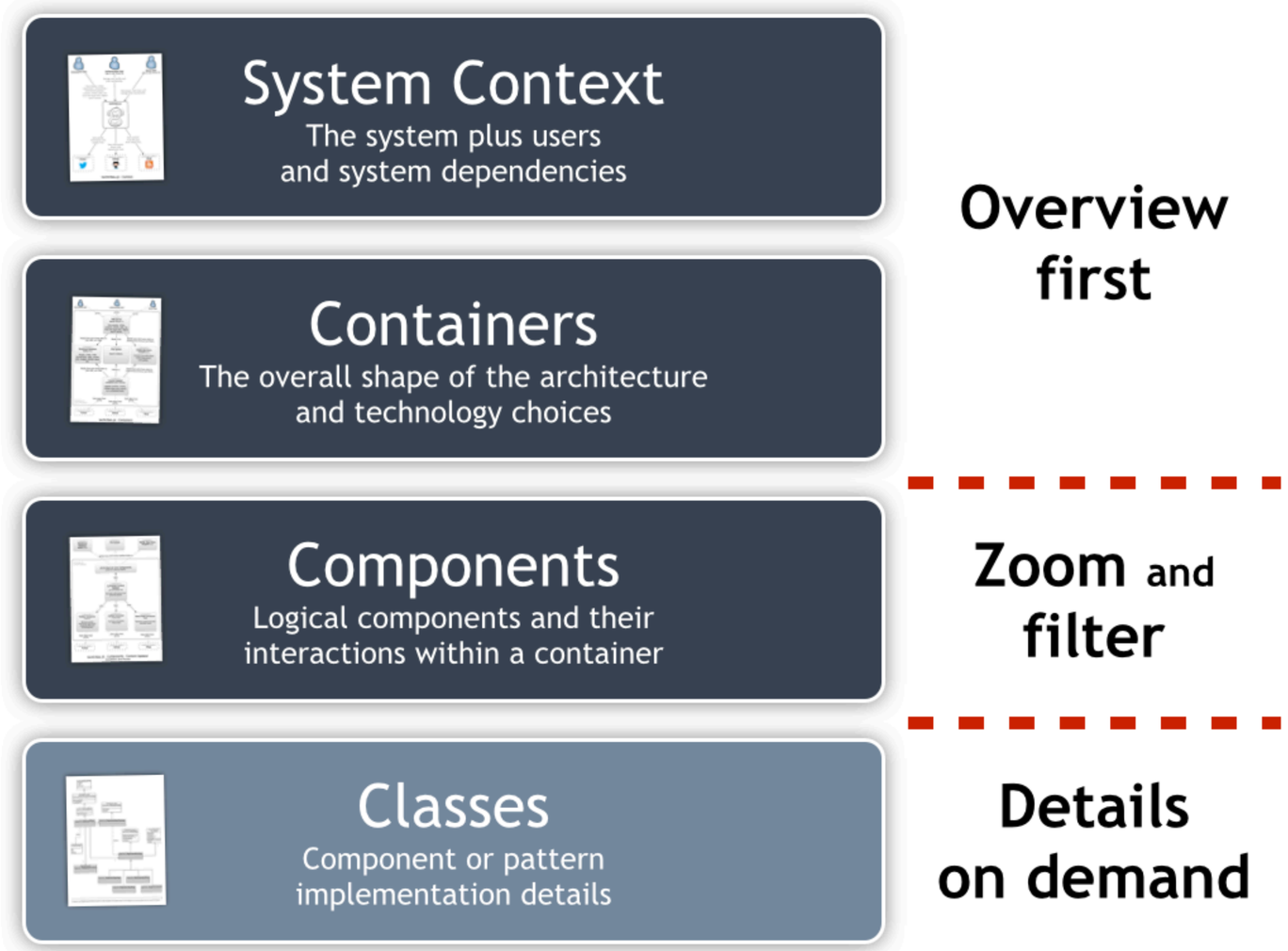
System: **Google Maps**

- encoding: same
- data: subset shared
- navigation: shared
  - bidirectional linking
- differences
  - viewpoint
  - (size)
- ***overview-detail***

[A Review of Overview+Detail, Zooming, and Focus+Context Interfaces. Cockburn, Karlson, and Bederson. ACM Computing Surveys 41:1 (2008), 1–31.]

Shneiderman's mantra

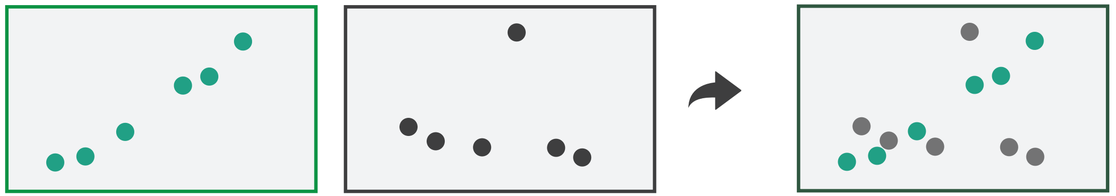
Overview first, zoom and filter, then details-on-demand



Superimpose layers

- ***layer***: set of objects spread out over region
  - each set is visually distinguishable group
  - extent: whole view
- design choices
  - how many layers, how to distinguish?
    - encode with different, nonoverlapping channels
    - two layers achieveable, three with careful design
  - small static set, or dynamic from many possible?

Superimpose Layers



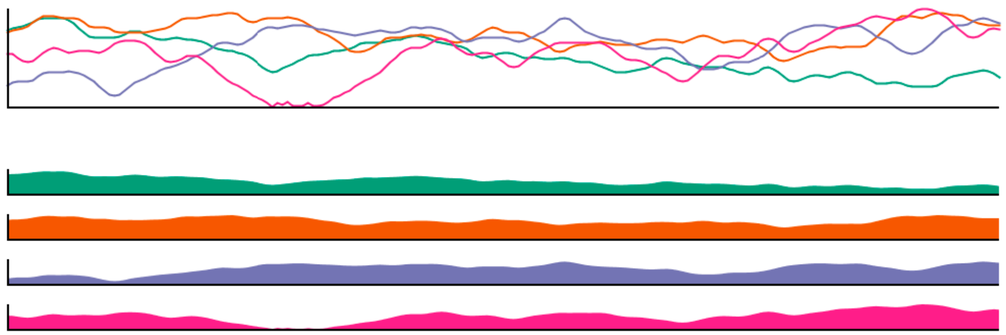
Static visual layering

- foreground layer: roads
  - hue, size distinguishing main from minor
  - high luminance contrast from background
- background layer: regions
  - desaturated colors for water, parks, land areas
- user can selectively focus attention
- "get it right in black and white"
  - check luminance contrast with greyscale view

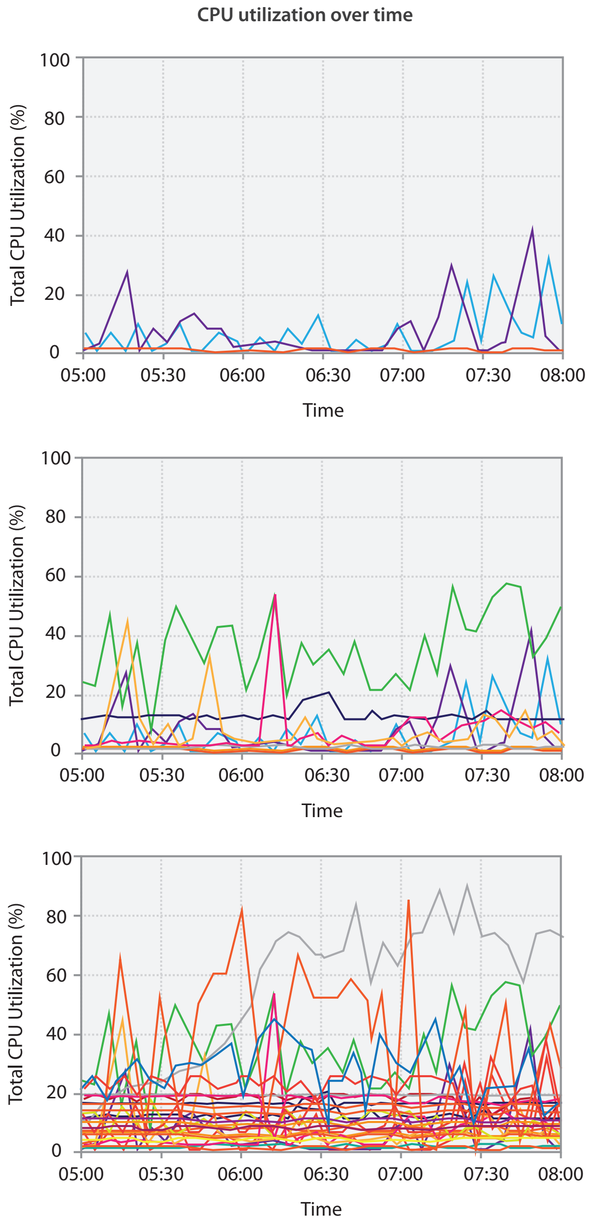
[Get it right in black and white. Stone. 2010. http://www.stonesc.com/wordpress/2010/03/get-it-right-in-black-and-white]

Superimposing limits

- few layers, but many lines
  - up to a few dozen
  - but not hundreds
- superimpose vs juxtapose: empirical study
  - superimposed for local, multiple for global
  - tasks
    - local: maximum, global: slope, discrimination
  - same screen space for all multiples vs single superimposed

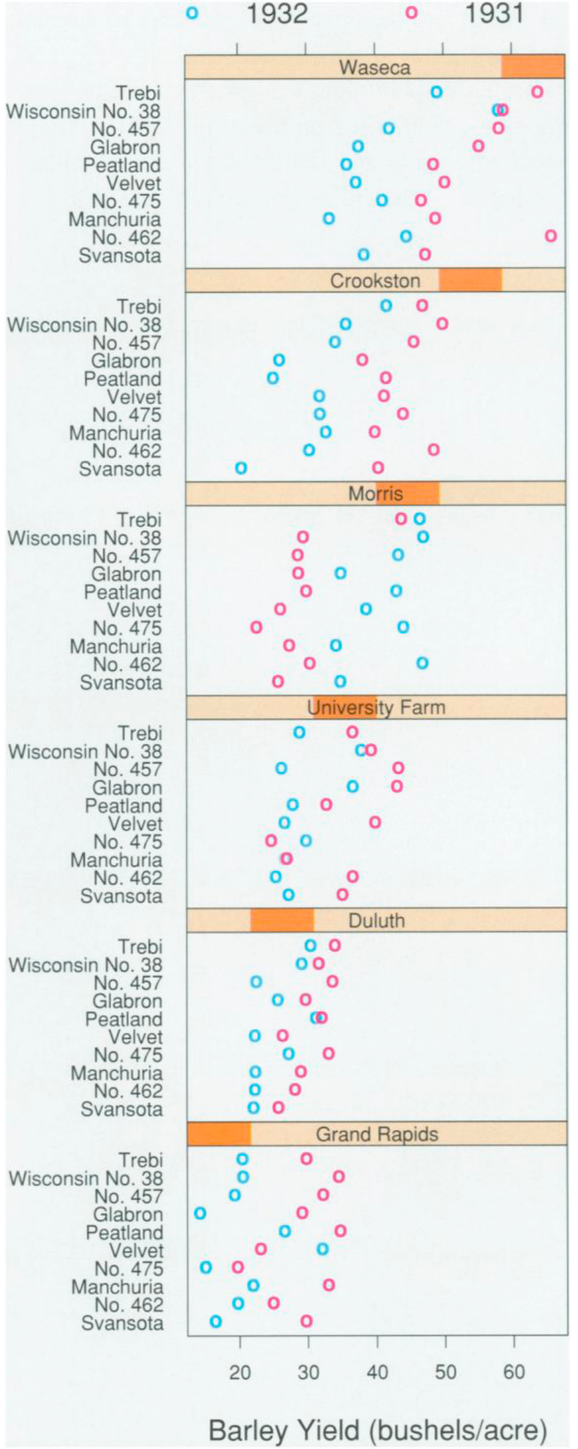


[Graphical Perception of Multiple Time Series. Javed, McDonnel, and Elmqvist. IEEE Transactions on Visualization and Computer Graphics (Proc. IEEE InfoVis 2010) 16:6 (2010), 927–934.]



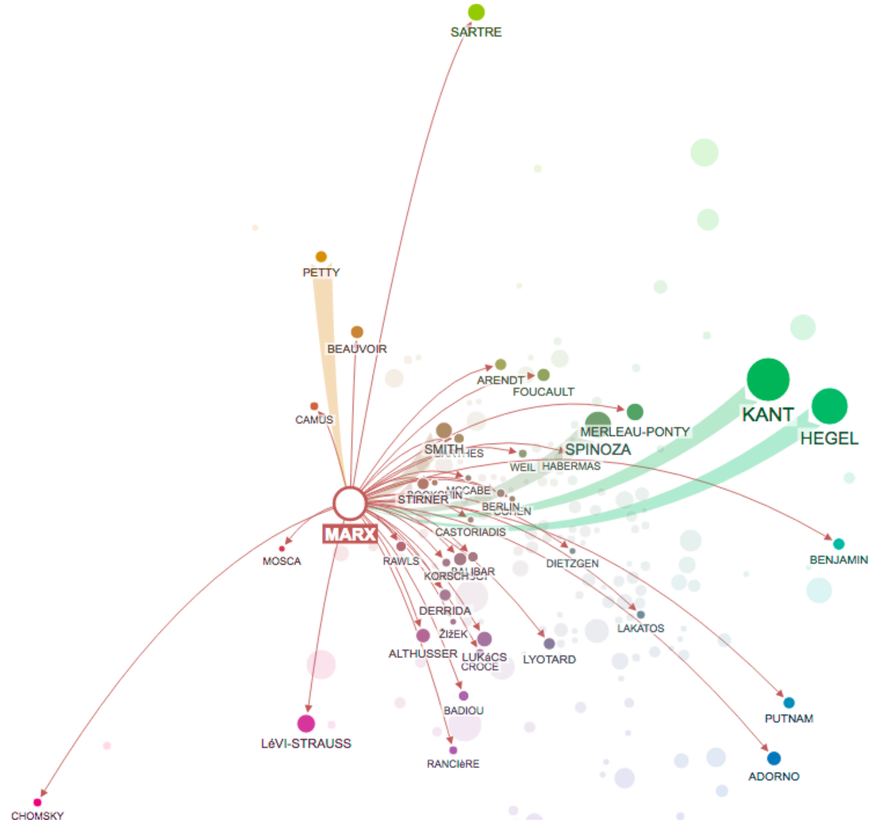
Idiom: **Trellis plots**

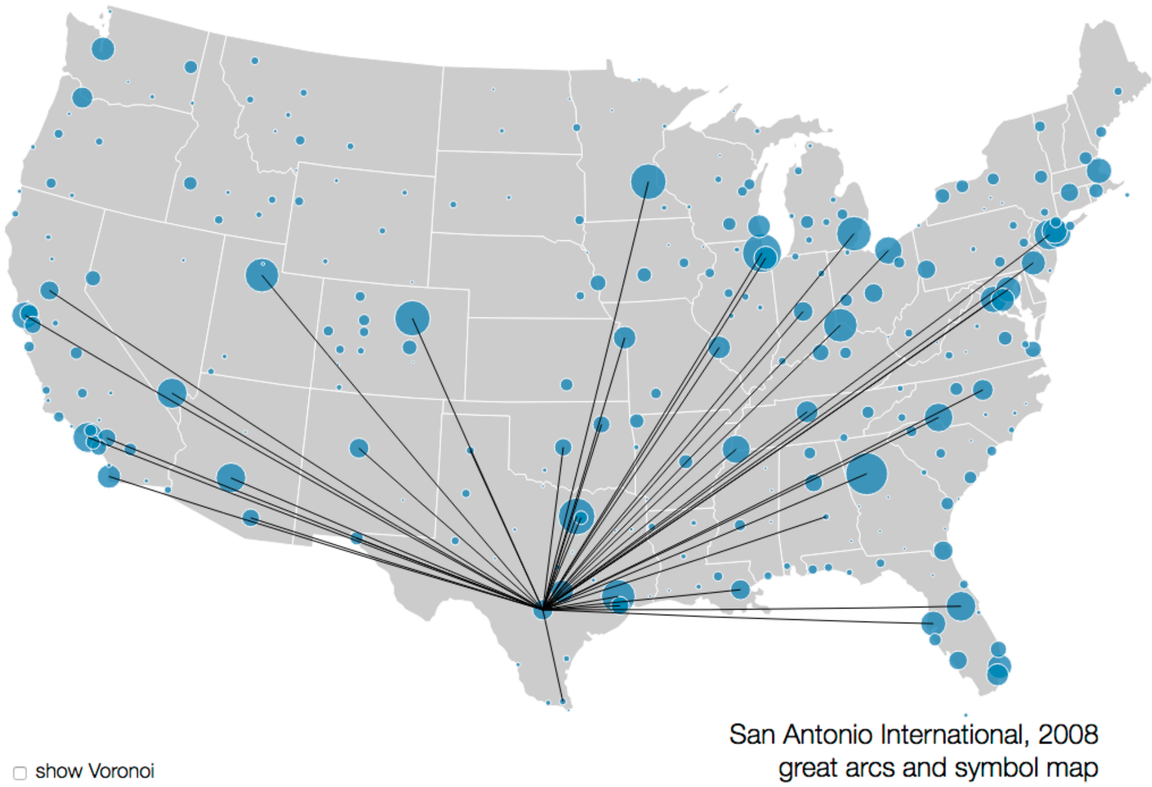
- superimpose within same frame
  - color code by year
- partitioning
  - split by site, rows are wheat varieties
- main-effects ordering
  - derive value of median for group, use to order
  - order rows within view by variety median
  - order views themselves by site median



Dynamic visual layering

- interactive based on selection
- one-hop neighbour highlighting demos: click vs hover (lightweight)





http://mariandoerk.de/edgemaps/demo/

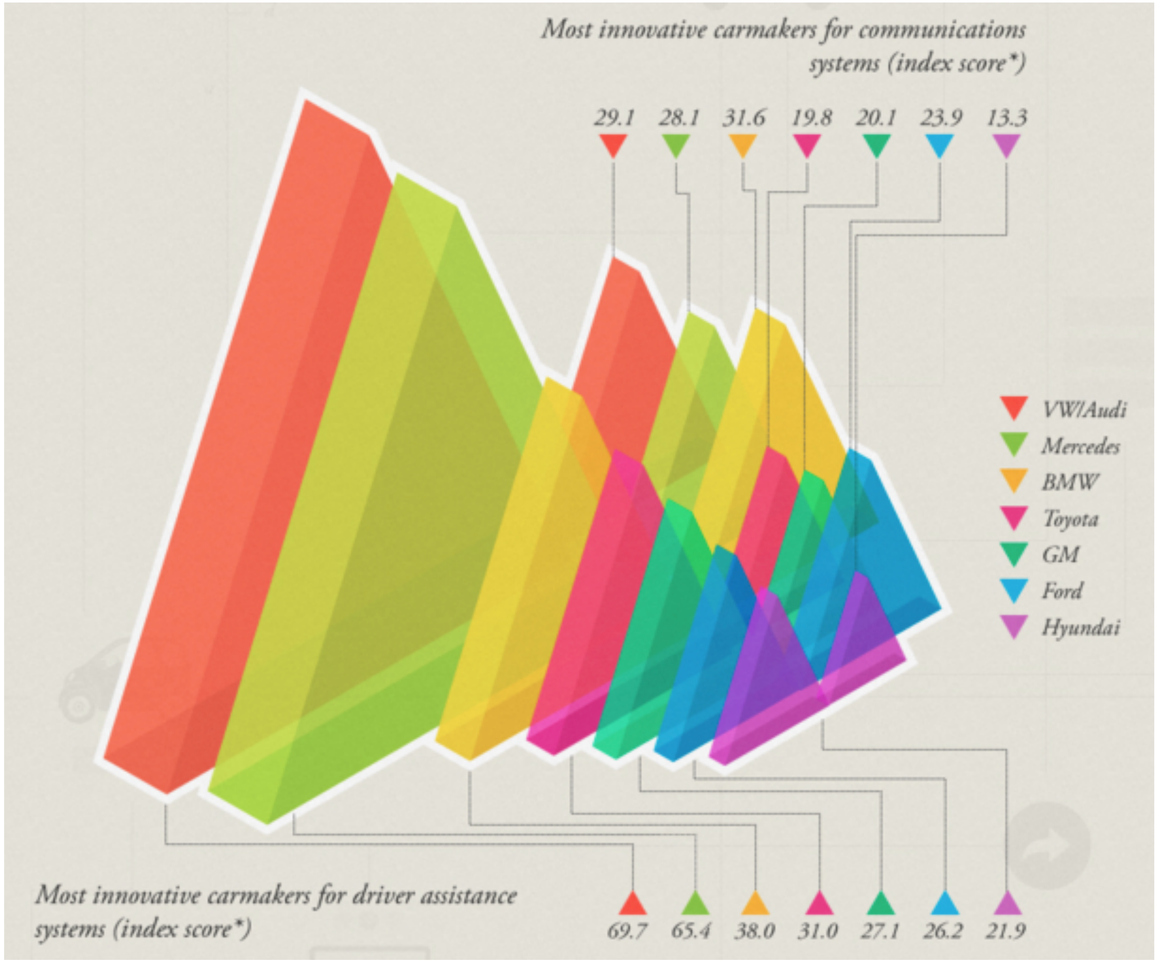
http://mbostock.github.io/d3/talk/20111116/airports.html

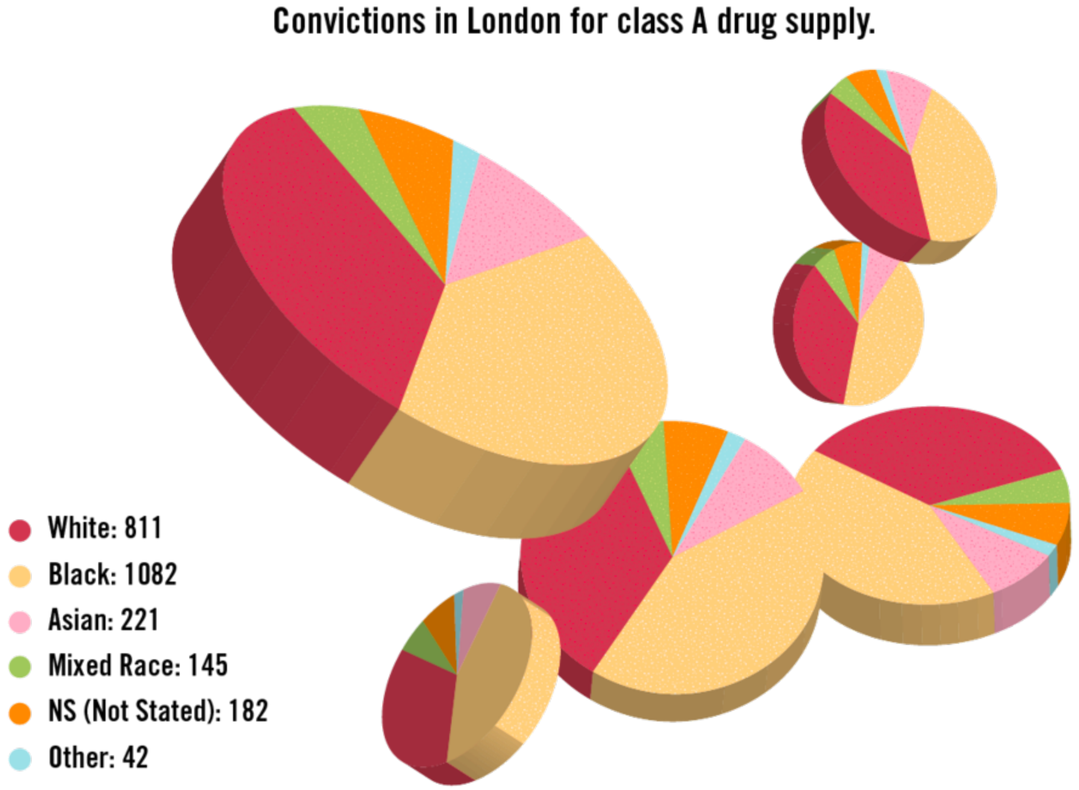
Further reading

- Visualization Analysis and Design. Munzner. AK Peters Visualization Series, CRC Press, 2014.
  - *Chap 12: Facet Into Multiple Views*
- *A Review of Overview+Detail, Zooming, and Focus+Context Interfaces*. Cockburn, Karlson, and Bederson. ACM Computing Surveys 41:1 (2008), 1–31.
- *A Guide to Visual Multi-Level Interface Design From Synthesis of Empirical Study Evidence*. Lam and Munzner. Synthesis Lectures on Visualization Series, Morgan Claypool, 2010.
- *Zooming versus multiple window interfaces: Cognitive costs of visual comparisons*. Plumlee and Ware. ACM Trans. on Computer-Human Interaction (ToCHI) 13:2 (2006), 179–209.
- *Exploring the Design Space of Composite Visualization*. Javed and Elmqvist. Proc. Pacific Visualization Symp. (PacificVis), pp. 1–9, 2012.
- *Visual Comparison for Information Visualization*. Gleicher, Albers, Walker, Jusufi, Hansen, and Roberts. Information Visualization 10:4 (2011), 289–309.
- *Guidelines for Using Multiple Views in Information Visualizations*. Baldonado, Woodruff, and Kuchinsky. In Proc. ACM Advanced Visual Interfaces (AVI), pp. 110–119, 2000.
- *Cross-Filtered Views for Multidimensional Visual Analysis*. Weaver. IEEE Trans. Visualization and Computer Graphics 16:2 (Proc. InfoVis 2010), 192–204, 2010.
- *Linked Data Views*. Wills. In Handbook of Data Visualization, Computational Statistics, edited by Unwin, Chen, and Härdle, pp. 216–241. Springer-Verlag, 2008.
- *Glyph-based Visualization: Foundations, Design Guidelines, Techniques and Applications*. Borgo, Kehrer, Chung, Maguire, Laramee, Hauser, Ward, and Chen. In Eurographics State of the Art Reports, pp. 39–63, 2013.

Rules of Thumb

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!

Magnitude Channels: Ordered Attributes

Position on common scale

Position on unaligned scale

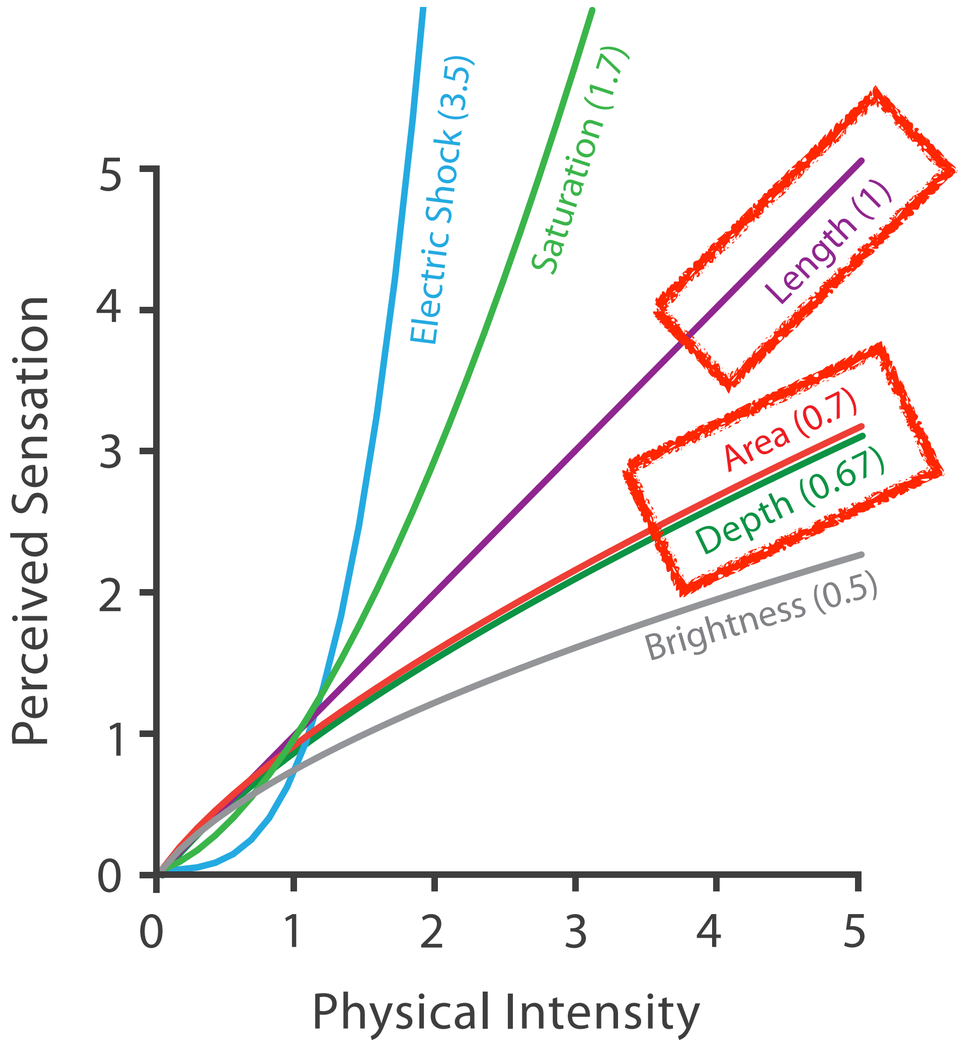
Length (1D size)

Tilt/angle

Area (2D size)

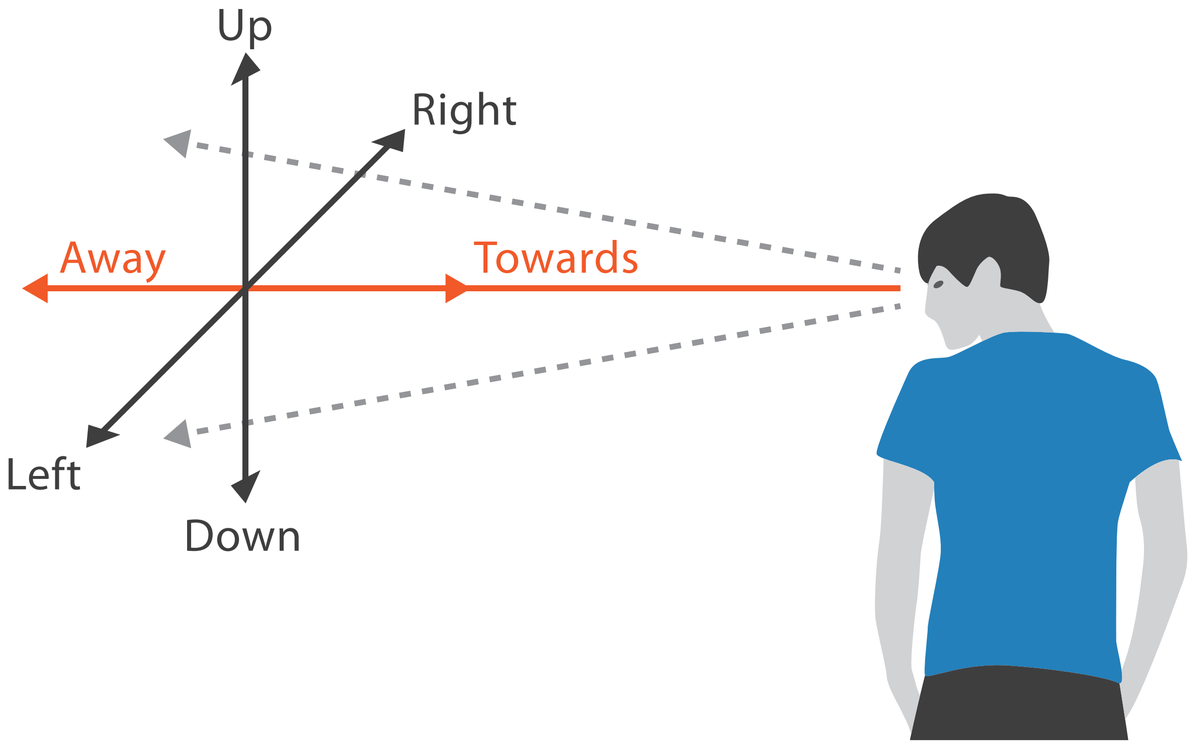
Depth (3D position)

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

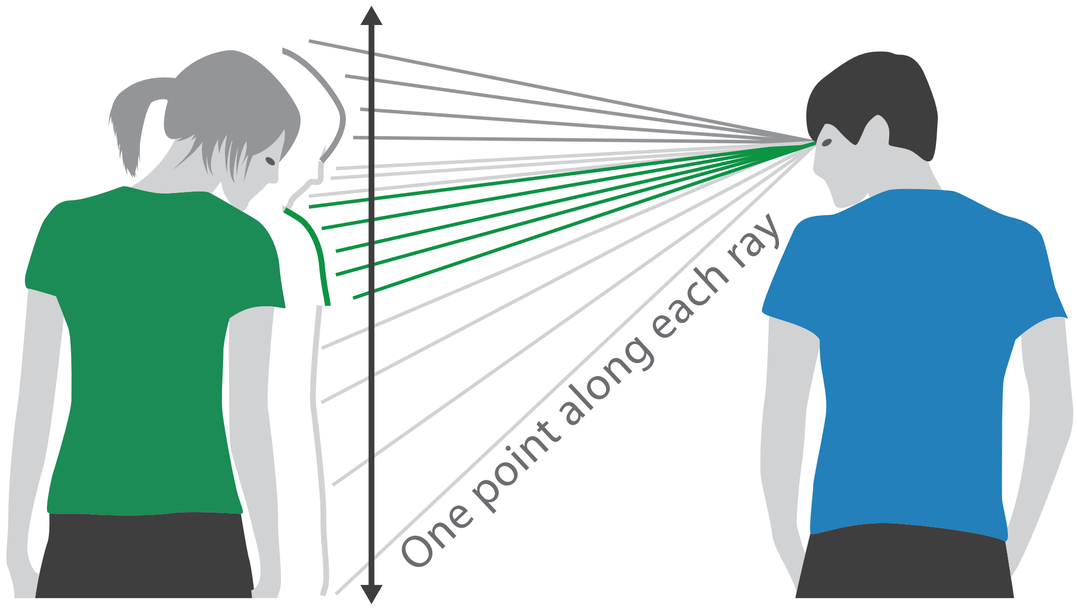


No unjustified 3D: Danger of depth

- 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



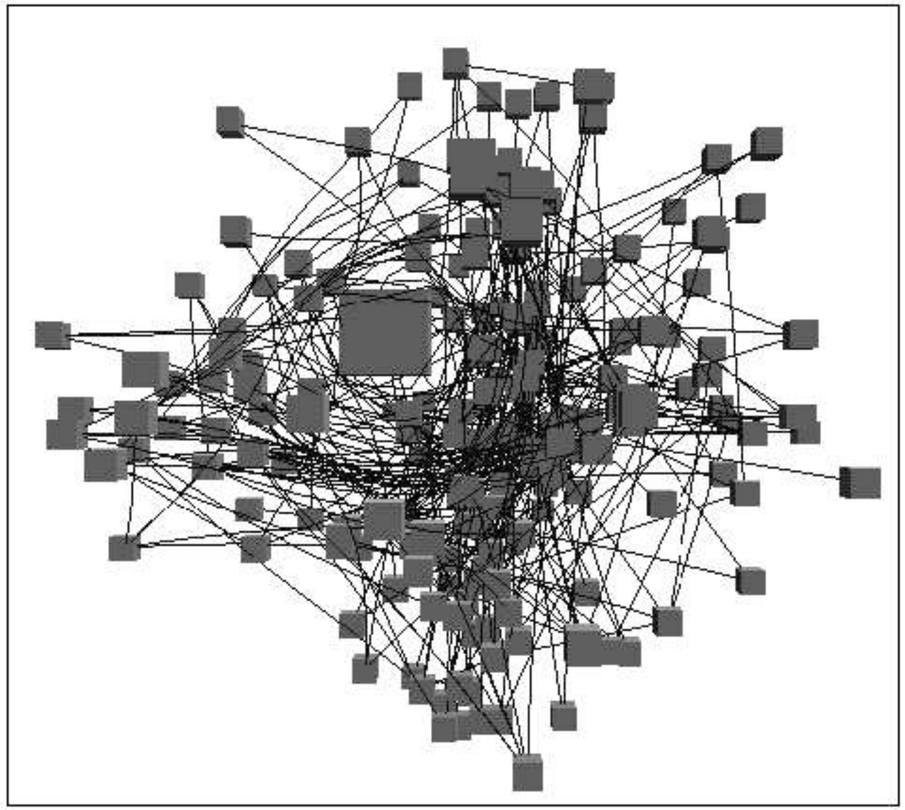
Thousands of points up/down and left/right



We can only see the outside shell of the world

Occlusion hides information

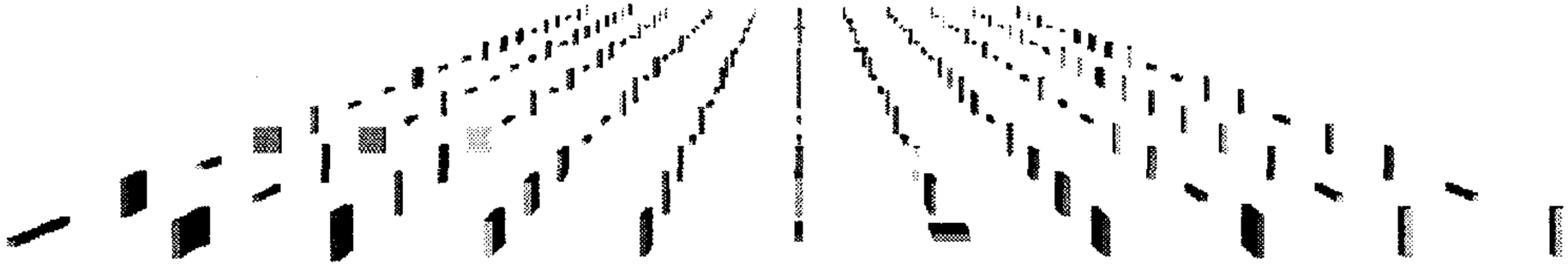
- occlusion
- interaction can resolve, but at cost of time and cognitive load



[Distortion Viewing Techniques for 3D Data. Carpendale et al. InfoVis1996.]

Perspective distortion loses information

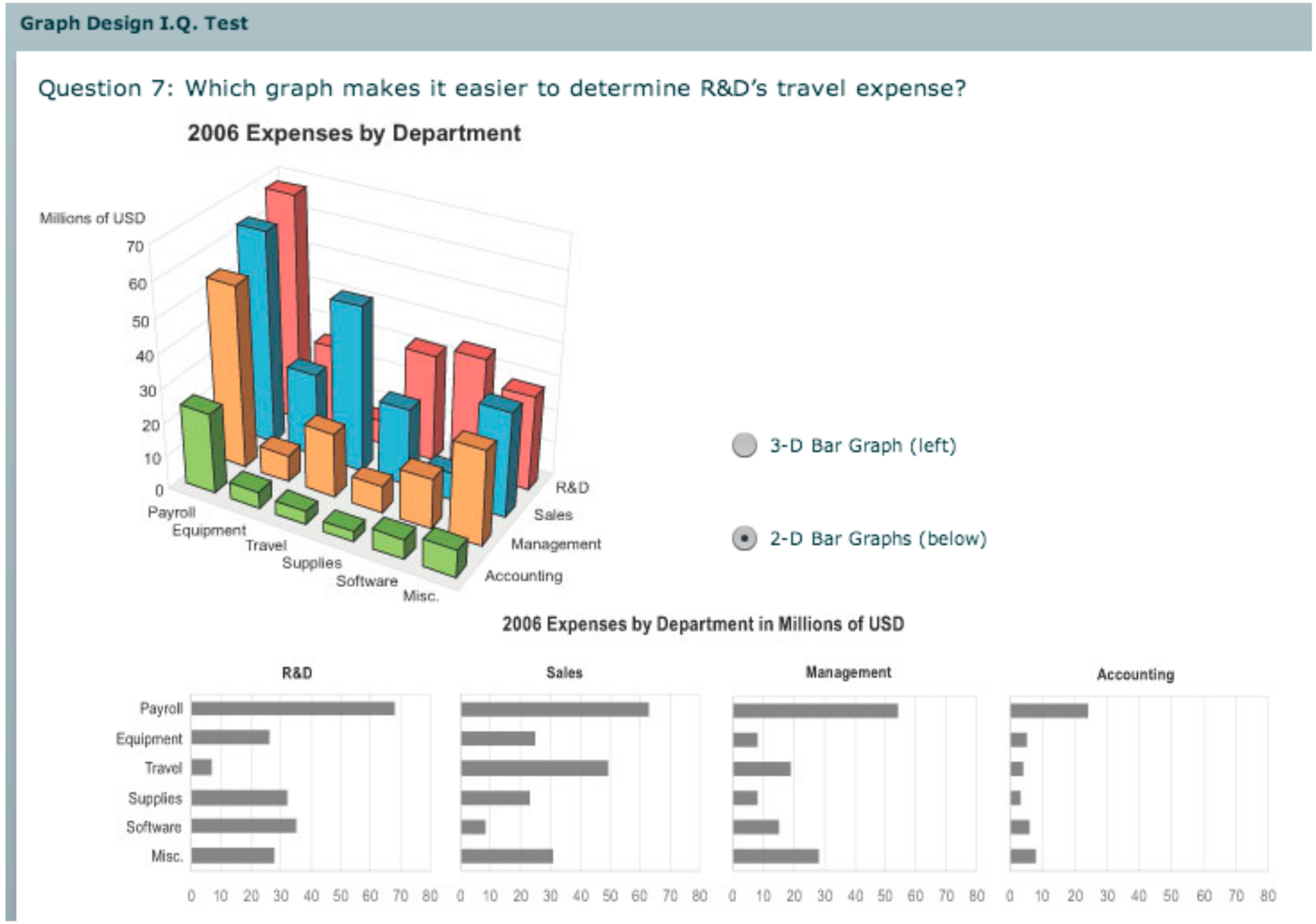
- perspective distortion
  - interferes with all size channel encodings
  - power of the plane is lost!



[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



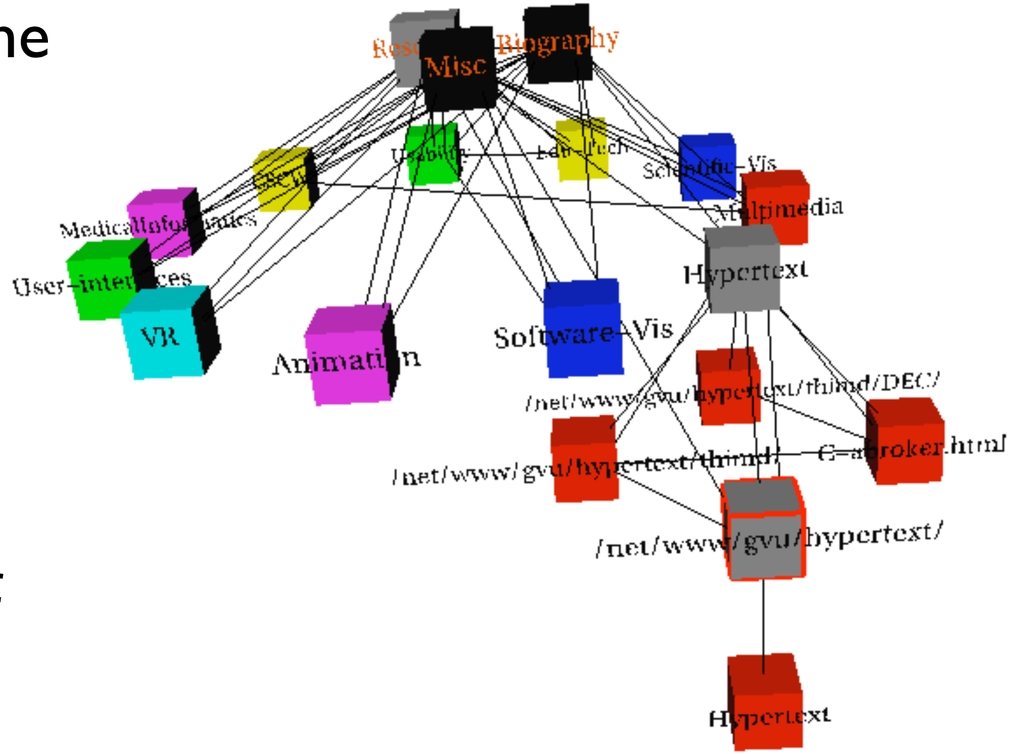
[http://perceptualedge.com/files/GraphDesignIQ.html]

Tilted text isn't legible

- text legibility
  - far worse when tilted from image plane

- further reading

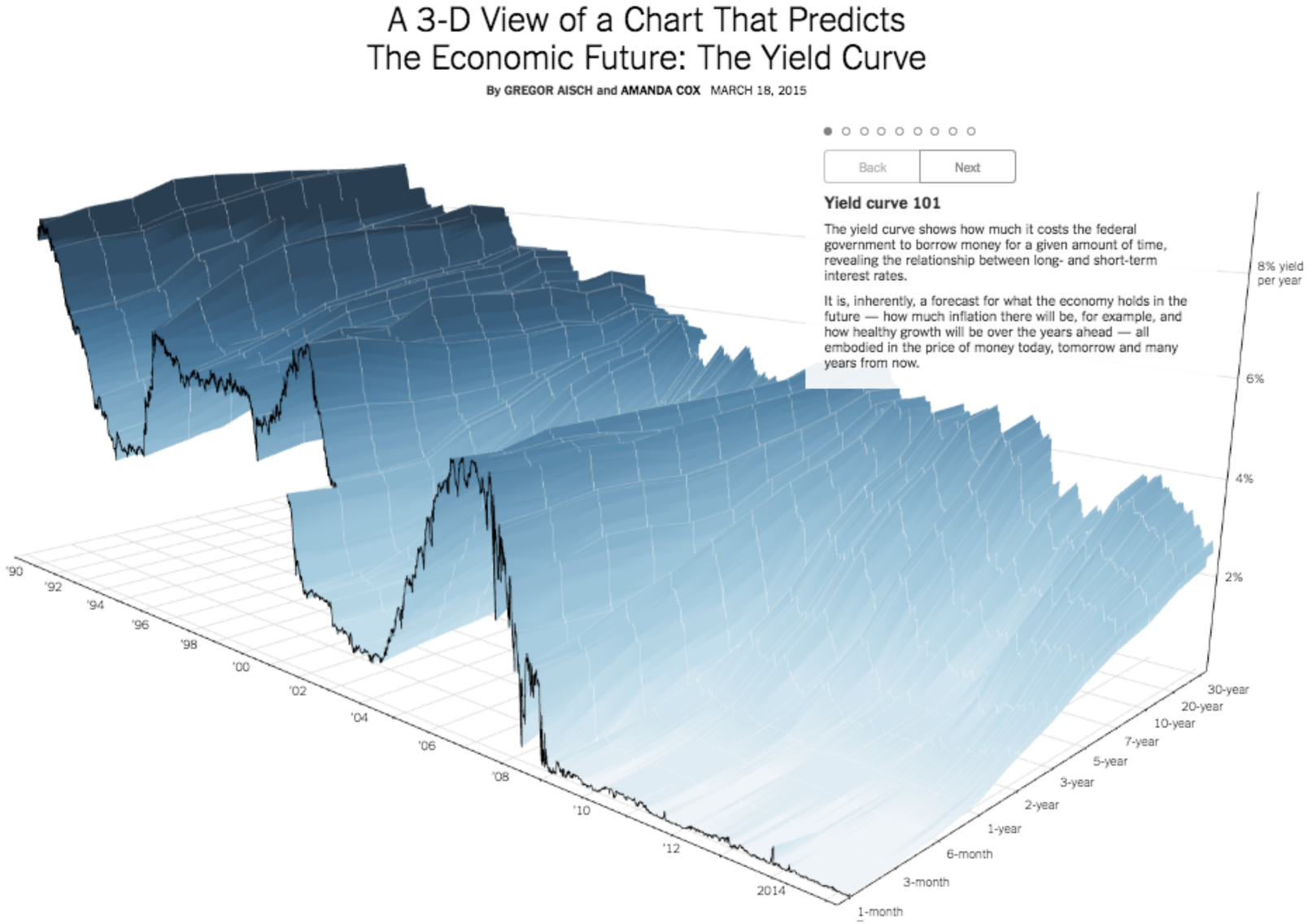
  [Exploring and Reducing the Effects of Orientation on Text Readability in Volumetric Displays.
  Grossman et al. CHI 2007]



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

Justified 3D: Economic growth curve

- constrained navigation steps through carefully designed viewpoints



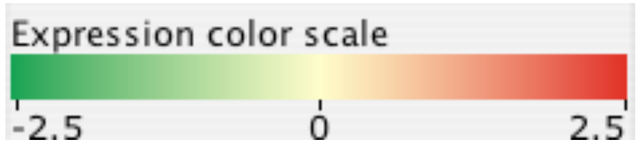
http://www.nytimes.com/interactive/2015/03/19/upshot/3d-yield-curve-economic-growth.html

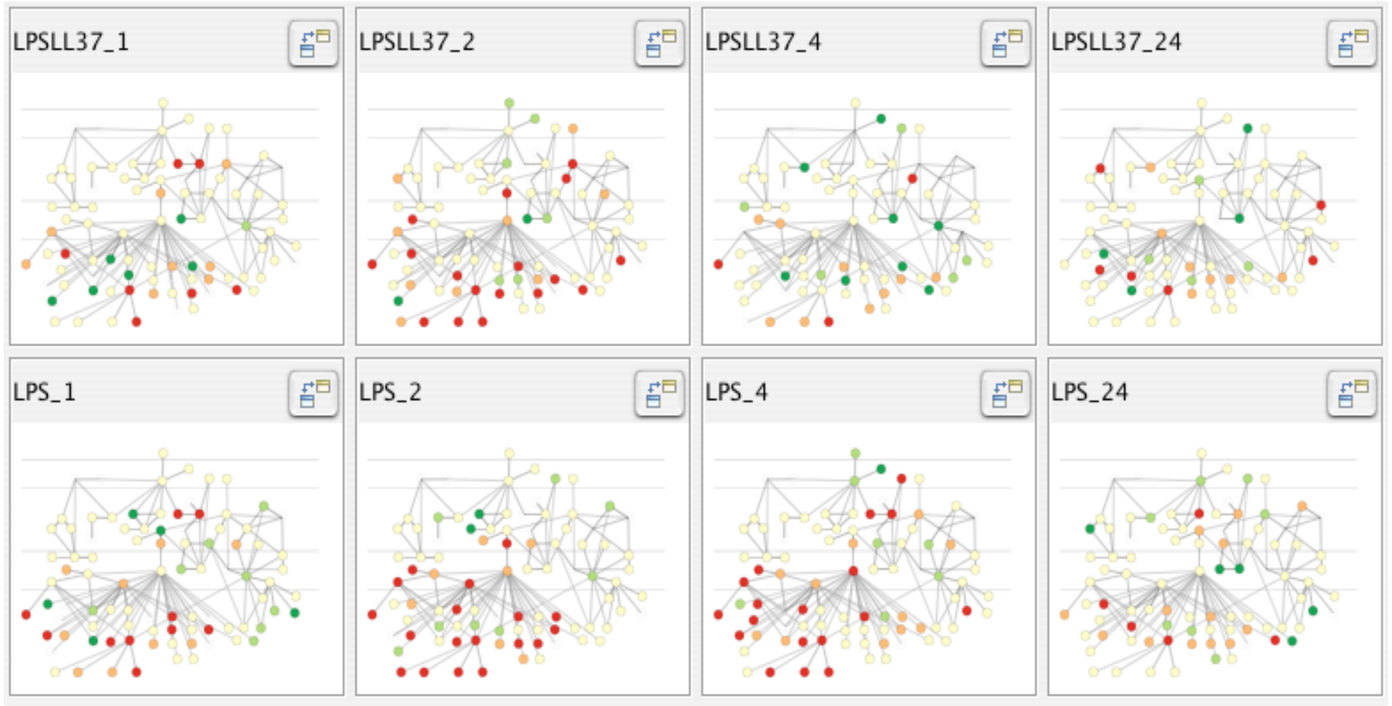
Eyes beat memory

- 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

Eyes beat memory example: Cerebral

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



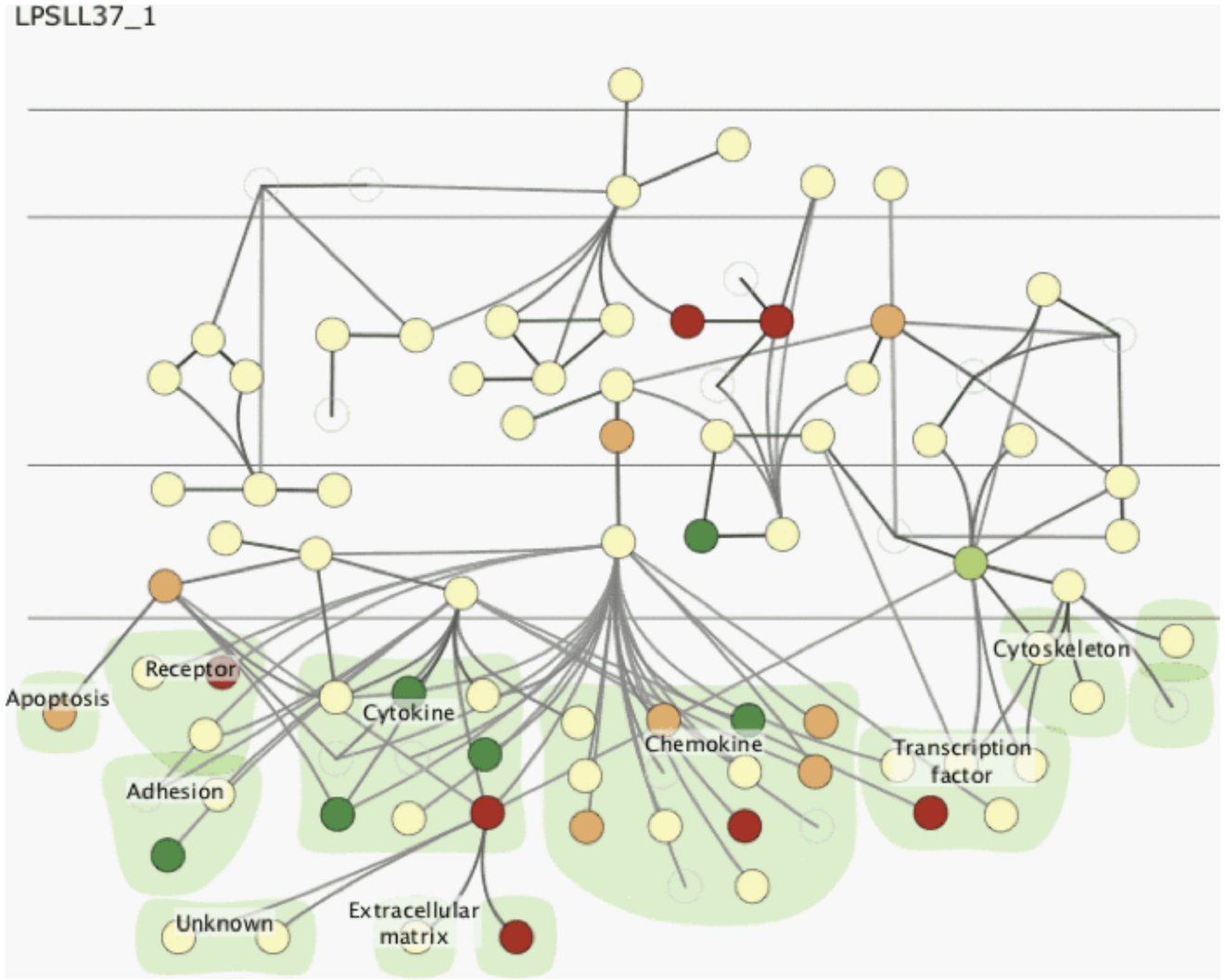


[Cerebral: Visualizing Multiple Experimental Conditions on a Graph with Biological Context. Barsky, Munzner, Gardy, and Kincaid. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2008) 14:6 (2008), 1253–1260.]

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

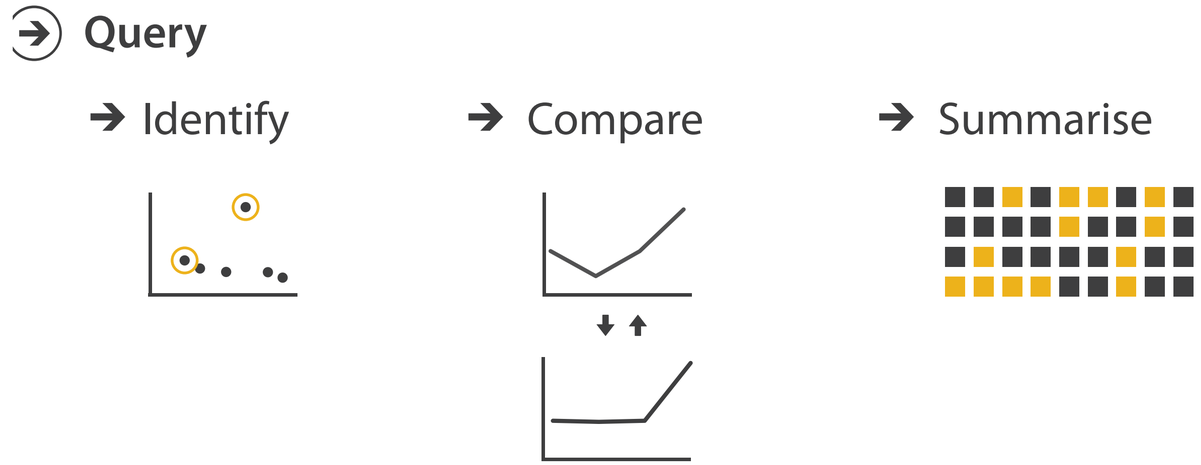


Overview first, zoom and filter, details on demand

- 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
  - 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

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

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

Questions?

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