Information Visualization
Marks & Channels, Rules of Thumb
Design Study Methodology
Ex: Decoding

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Week 3, 21 Sep 2022

https://www.cs.ubc.ca/~tmm/courses/547-22

Plan for today

- 15 min: pitches details & project resources
- 45 min: Marks & Channels
  - mini-lecture
  - examples & discussion
  - further Q&A
- 15 min: Rules of Thumb, Design Study Methodology
  - further Q&A
- (break: 10 min)
- 75 min small groups exercise: Decoding
  - 45 min: breakout groups
  - 30 min: reportbacks

Next week

- to read & discuss (async, before next class)
  - VAD book, Ch 7: Arrange Tables
  - paper: LineUp [technique]
  - paper: Revisiting Bertin Matrices [technique]

- sync class: project pitches!
  - 2 min each
  - if already have full or partial team, can combine your times together
  - up to you: prerecord video OR present live, need slides either way
    - due on Canvas by 1pm (Wed Sep 29)
      - if prerecorded, videos and slides. if live: slides
    - video creation tips/resources https://www.cs.ubc.ca/~tmm/courses/547-22/video.html
  - near-realtime Q&A / discussion through dedicated Piazza thread

Pitches

- everybody must do one (solo or team)
- way to find teammates
  - convince them to work on yours, or you decide to work on theirs
  - even if your team is all set, situational awareness of what others doing
- schedule
  - pitches next week in class (Wed Sep 28)
  - must form teams week after that, by Thu Oct 6, 8pm
  - team pre-proposal meetings week after that, in class & OH slot (Wed Oct 12)
    - if no signoff: followup meetings only possible Thu Oct 13 & Fri Oct 14
  - written proposals due Fri Oct 21
    - no class that week, IEEE VIS conference

Project resources: Datasets

- many choices!
  - Data Is Plural: weekly newsletter of interesting/quirky datasets by Jeremy Singer-Vine
    - browseable weekly lists
    - single master spreadsheet with everything
    - DVS Challenge: London Stage dataset
  - VAST Challenge
    - both data and tasks!
    - multiple mini-challenges per year
  - Kaggle datasets
    - you'll need to think (hard) about tasks
  - many more on Resources page

    http://www.cs.ubc.ca/group/infovis/resources.shtml#data-repos

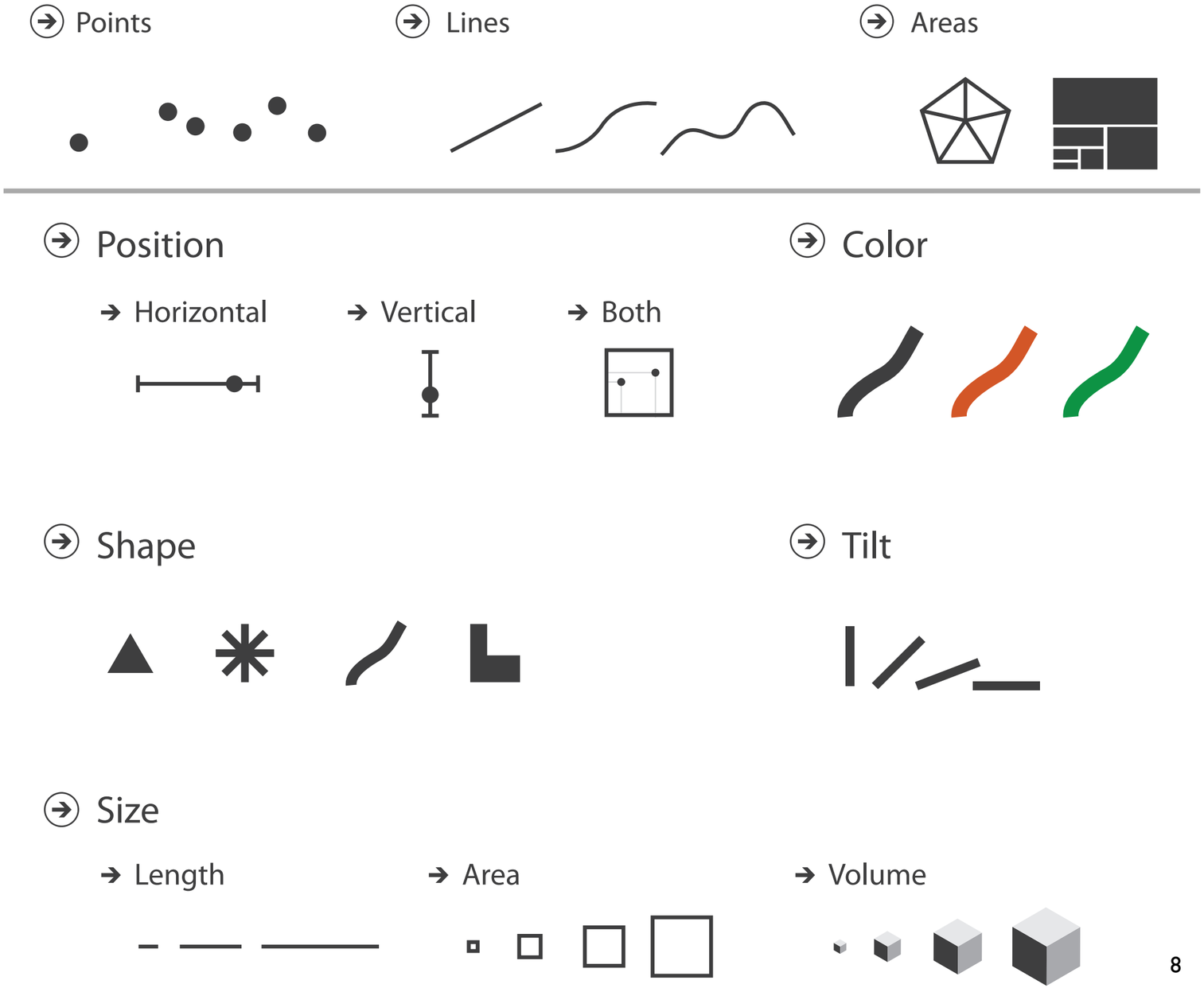
Project resources: Tools

- Tools: you're free to pick platform
  - align with current strengths? learn something new?
  - overview of the "big 4": D3, R/tidyverse, Python, Tableau
    https://www.cs.ubc.ca/~tmm/courses/547-22/tools/
  - consider covering your own strengths & goals in your pitch
- Smaller tools: also free to use
  - you pick project scope:
    - build skills by rolling your own?
    - do something bigger by building on existing toolkits/libraries?
  - many, many smaller building blocks
    - https://www.visualisingdata.com/resources/

Mini-Lecture

Marks and channels

- marks
  - basic geometric elements
- channels
  - control appearance of marks



Channels: Rankings

Magnitude Channels: Ordered Attributes

Position on common scale

Position on unaligned scale

Length (1D size)

Tilt/angle

Area (2D size)

Depth (3D position)

Color luminance

Color saturation

Curvature

Volume (3D size)

Same

Same

Best

Effectiveness

Least

Identity Channels: Categorical Attributes

Spatial region

Color hue

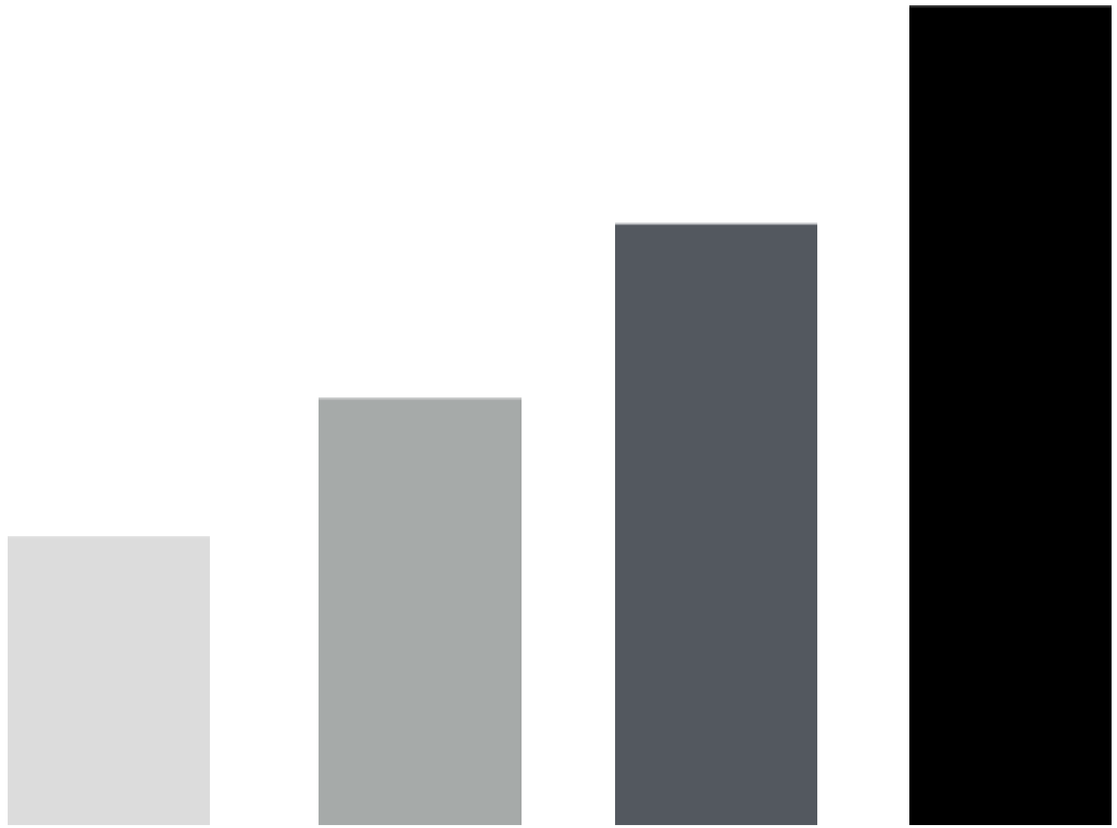
Motion

Shape

- expressiveness
  - match channel and data characteristics
- effectiveness
  - channels differ in accuracy of perception
- distinguishability
  - match available levels in channel w/ data

Redundant encoding

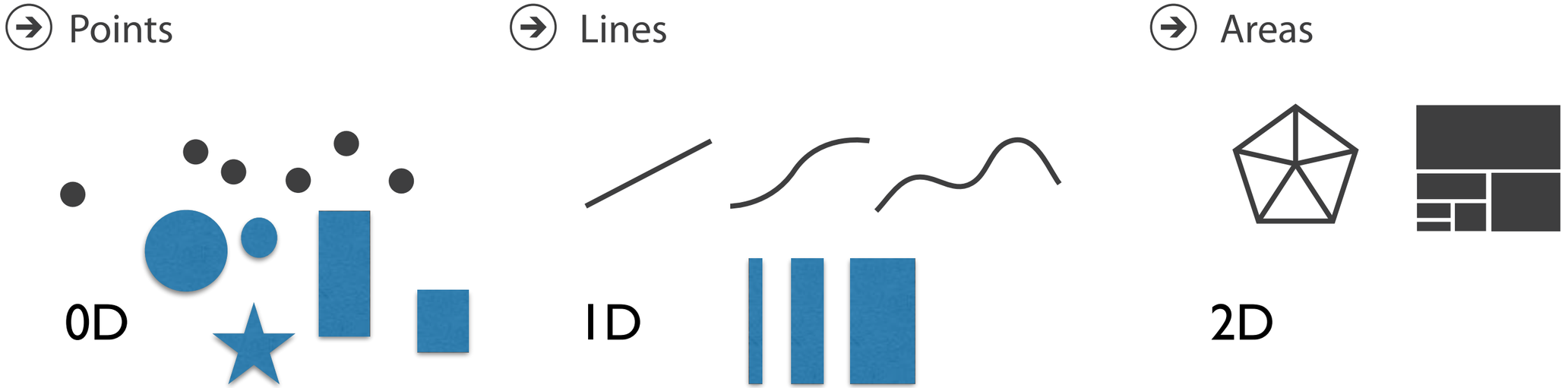
- multiple channels
  - sends stronger message
  - but uses up channels



Length, Position, and Value

Marks: Constrained vs encodable

- math view: geometric primitives have dimensions



- constraint view: mark type constrains what else can be encoded
  - points: 0 constraints on size, can encode more attributes w/ size & shape
  - lines: 1 constraint on size (length), can still size code other way (width)
  - areas: 2 constraints on size (length/width), cannot size code or shape code
    - interlocking: size, shape, position
- quick check: can you size-code another attribute, or is size/shape in use?

Grouping

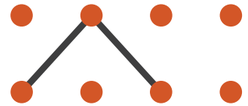
- containment
- connection

- proximity
  - same spatial region
- similarity
  - same values as other categorical channels

Marks as Links

Containment

Connection

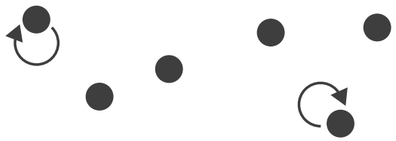


Identity Channels: Categorical Attributes

Spatial region

Color hue

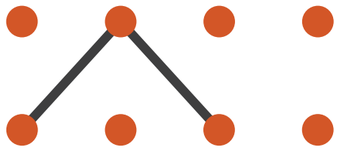
Motion

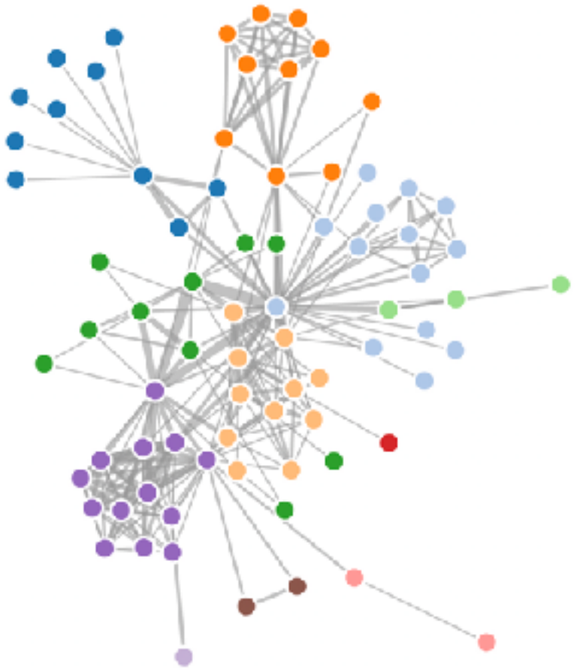


Shape

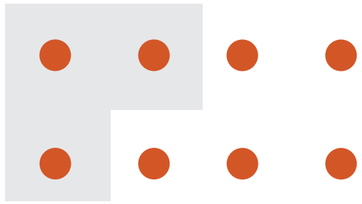
Marks for links

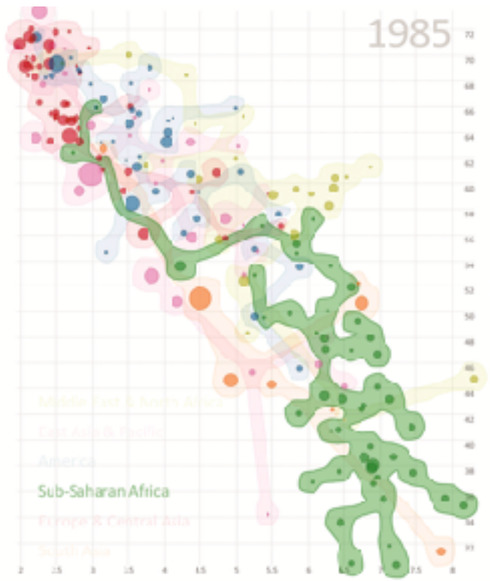
Connection





Containment





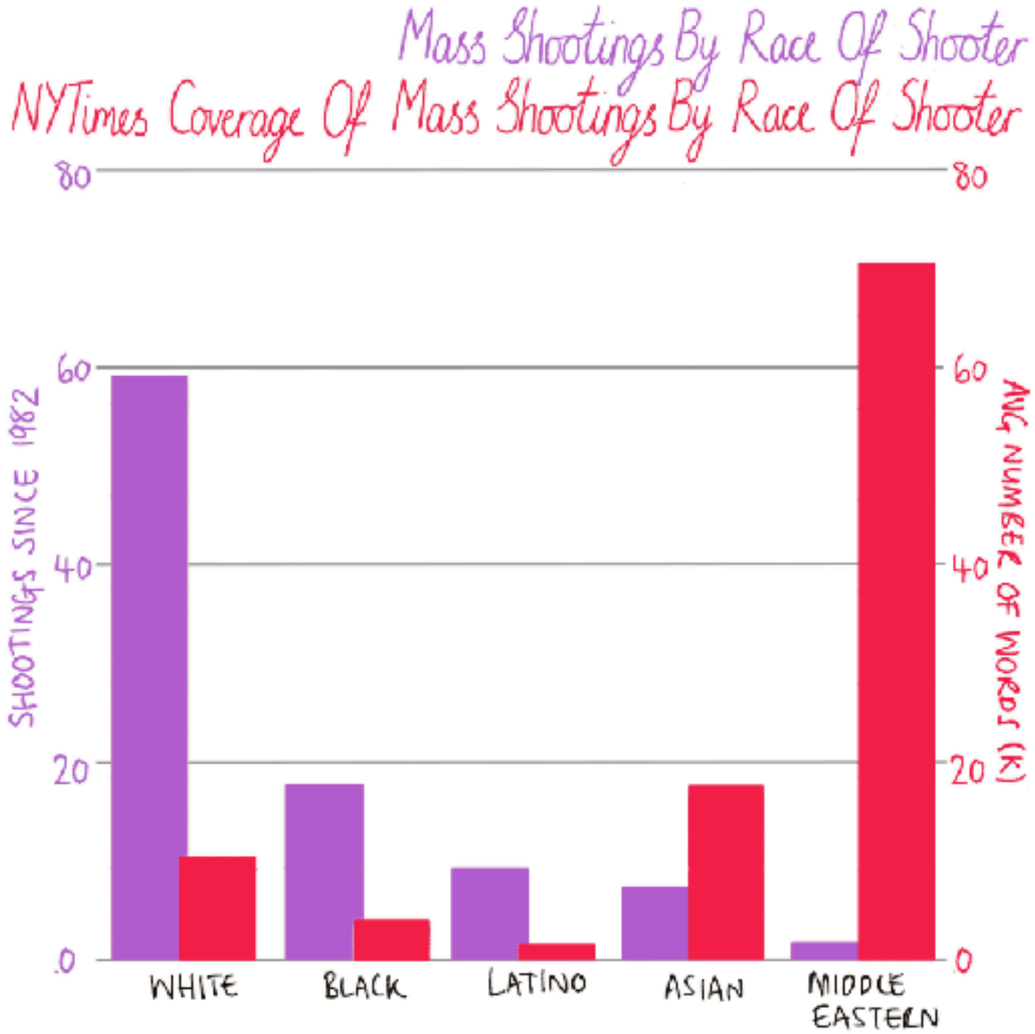
Containment can be nested

[Untangling Euler Diagrams, Riche and Dwyer, 2010]

Examples

Quiz: Name those marks & channels

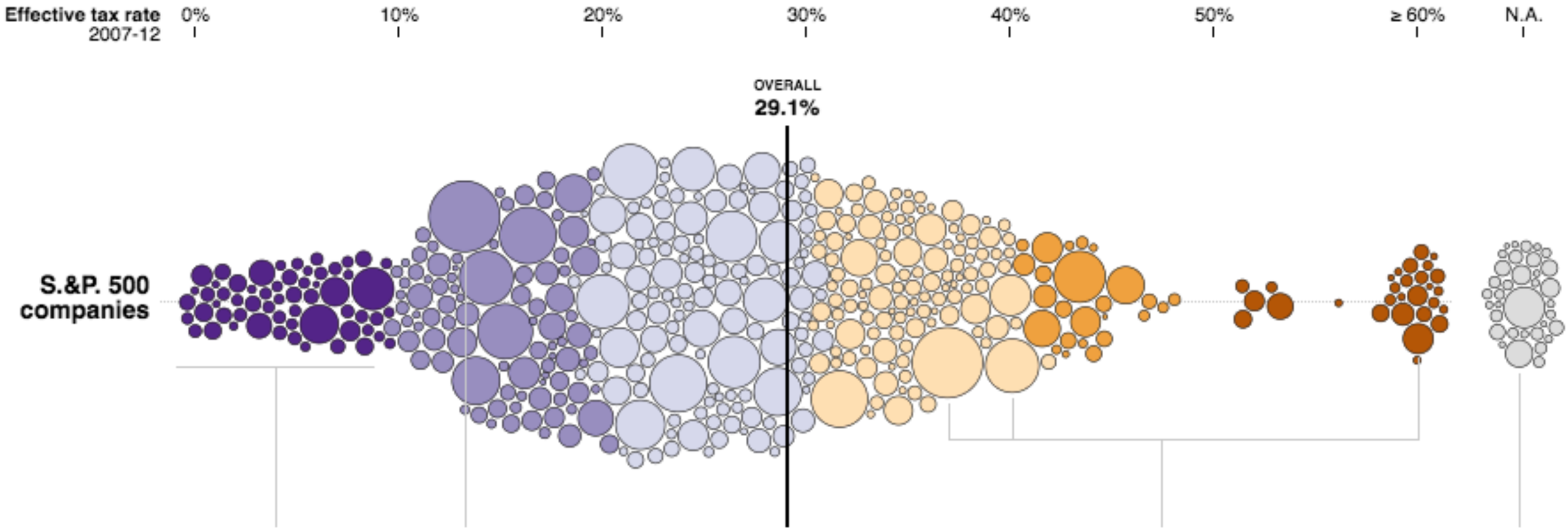
- A: Shooting Media Coverage



https://twitter.com/MonaChalabi/status/1158779046693679106?s=20

Quiz: Name those marks & channels

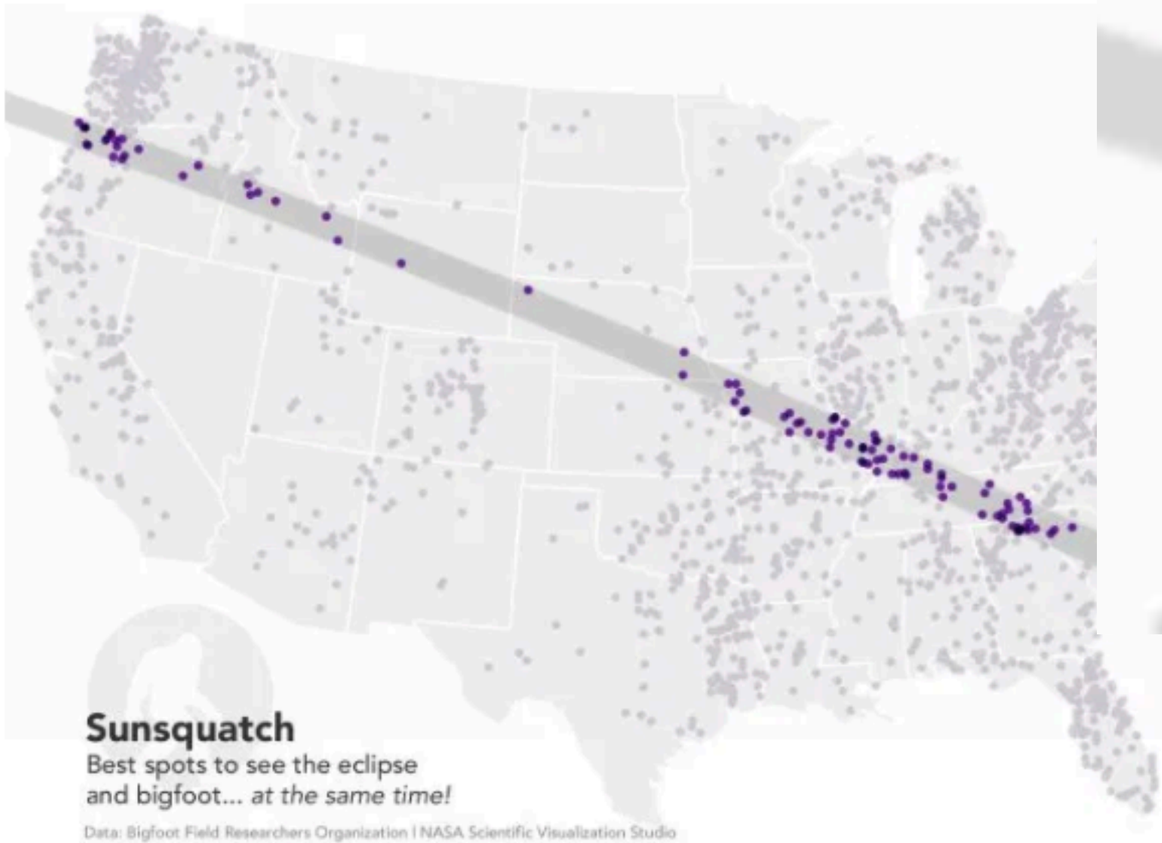
- B: Tax Rates



https://archive.nytimes.com/www.nytimes.com/interactive/2013/05/25/sunday-review/corporate-taxes.html

Quiz: Name those marks & channels

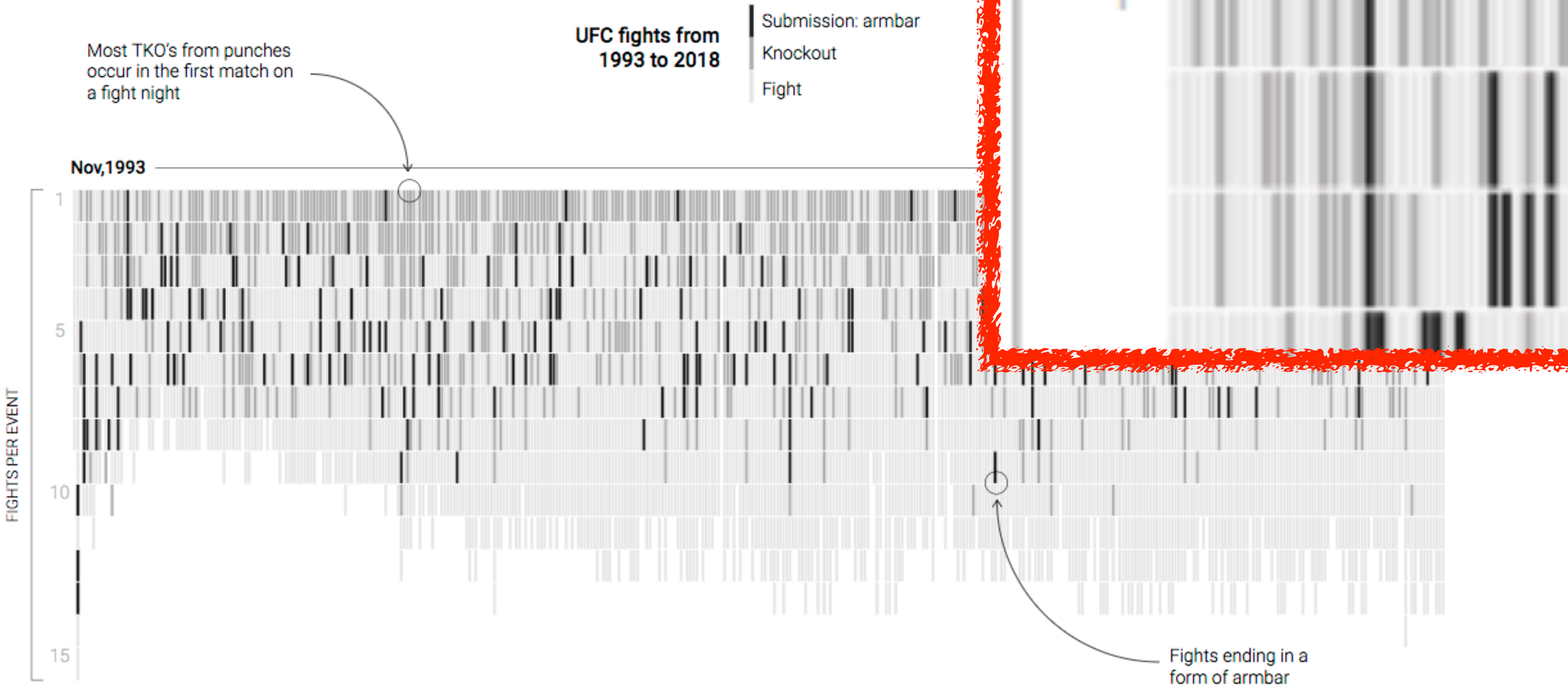
- C: Sunsqatch



https://flowingdata.com/2017/08/20/sunsquatch-the-only-eclipse-map-you-need/

Quiz: Name those marks & channels

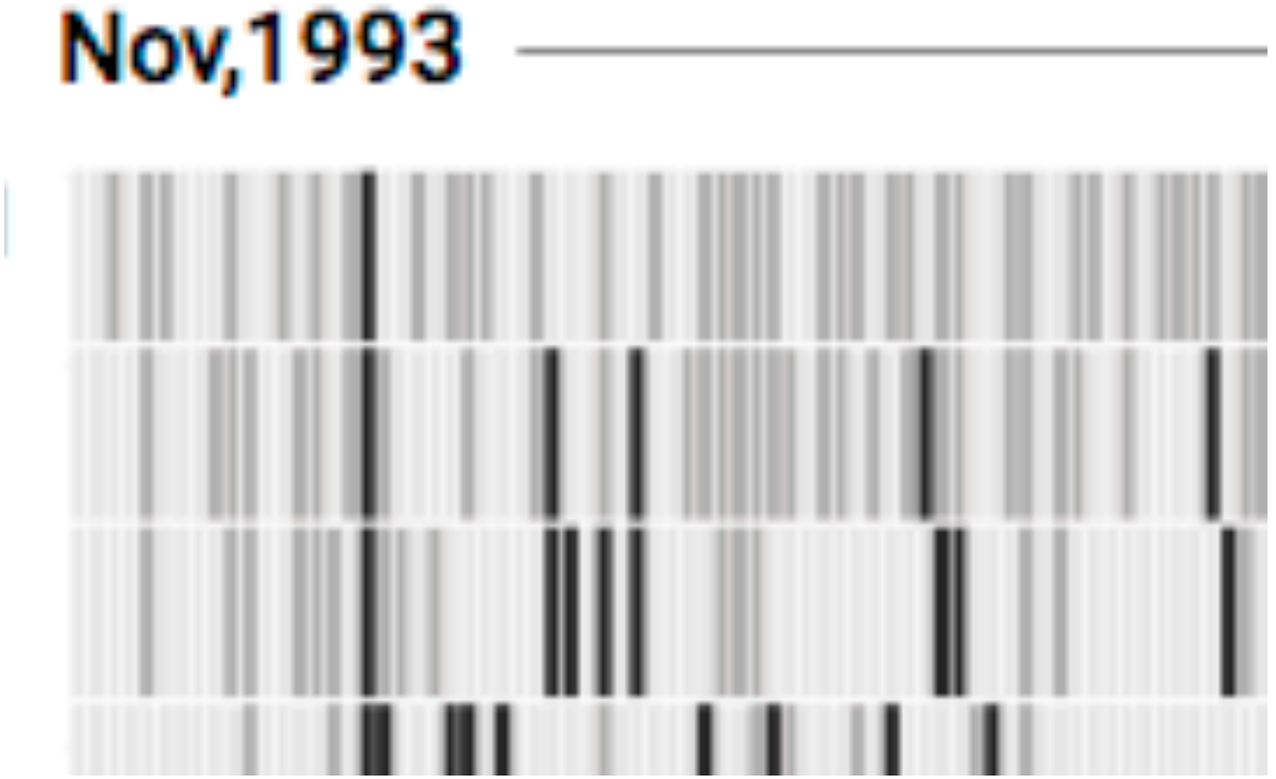
- D: UFC fights



https://multimedia.scmp.com/infographics/sport/article/3010883/bruce-lee-and-mixed-martial-arts

Analyzing marks

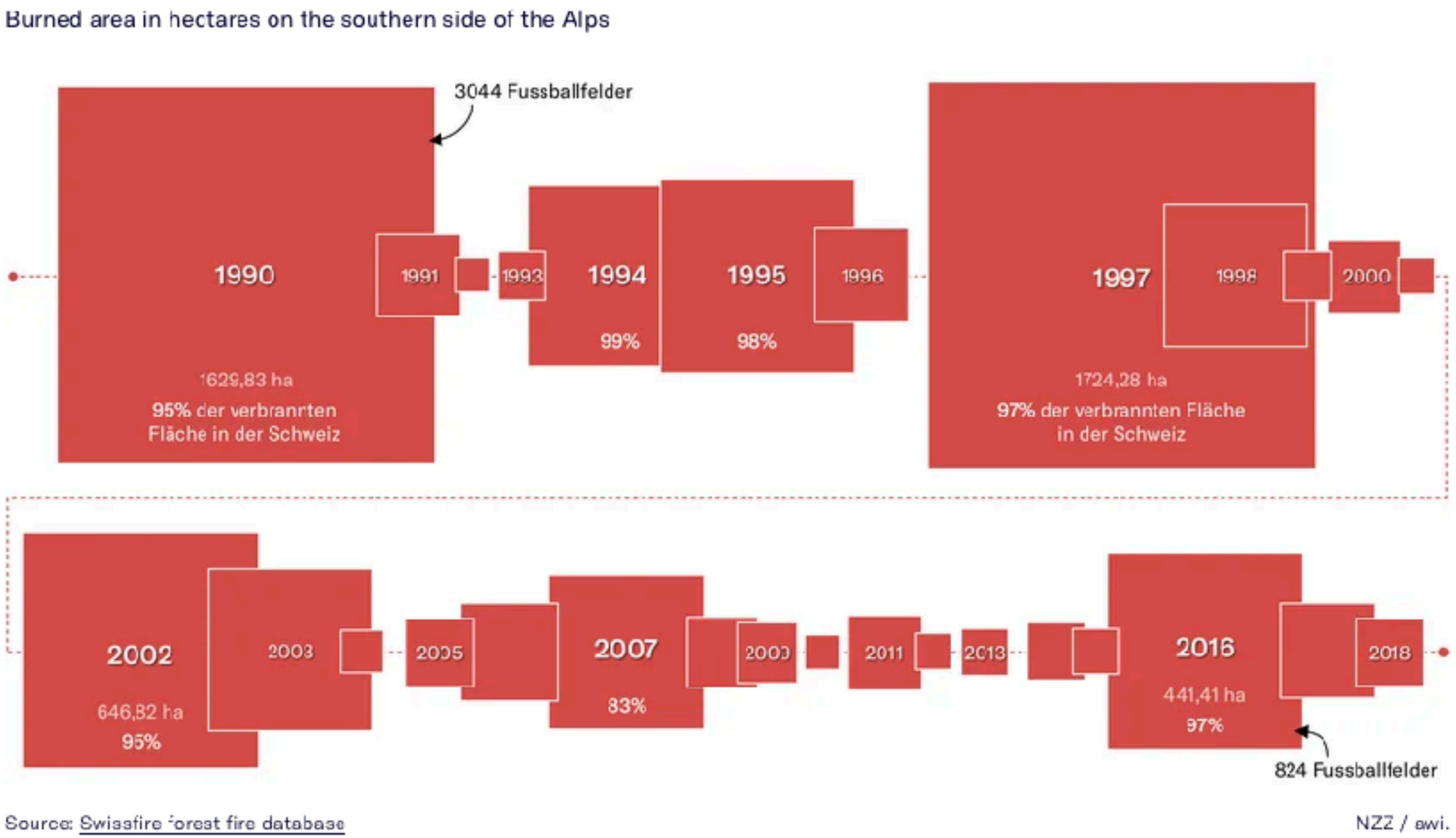
- what type of mark?
  - line?
    - no, not length coded
  - point mark with rectangular shape?
    - yes!
  - area?
    - no, area/shape does not convey meaning



https://multimedia.scmp.com/infographics/sport/article/3010883/bruce-lee-and-mixed-martial-arts/index.html

Quiz: Name those marks & channels

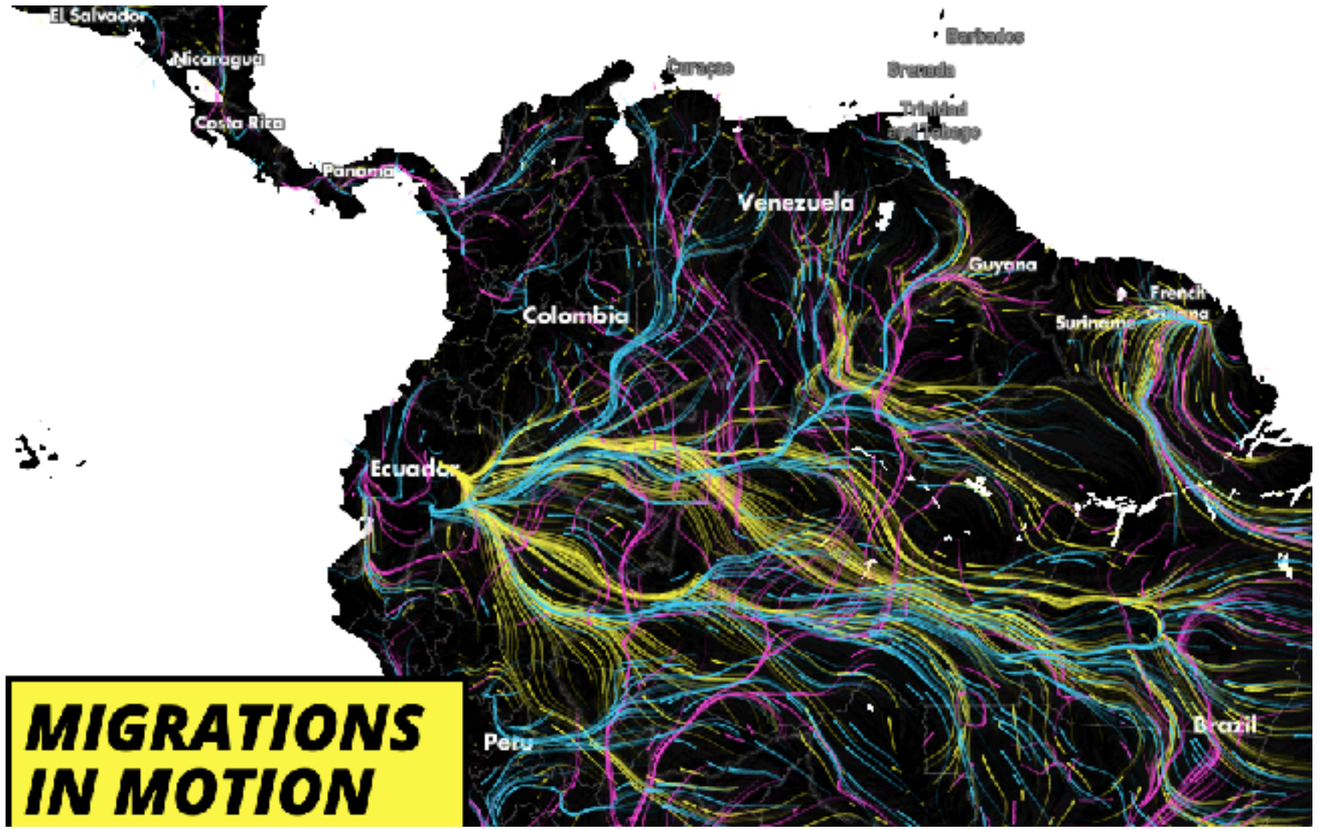
- E: Alpen Forest Fires



https://www.nzz.ch/wissenschaft/waldbraende-erklaert-in-der-schweiz-und-in-europa-ld.1483688

Quiz: Name those channels

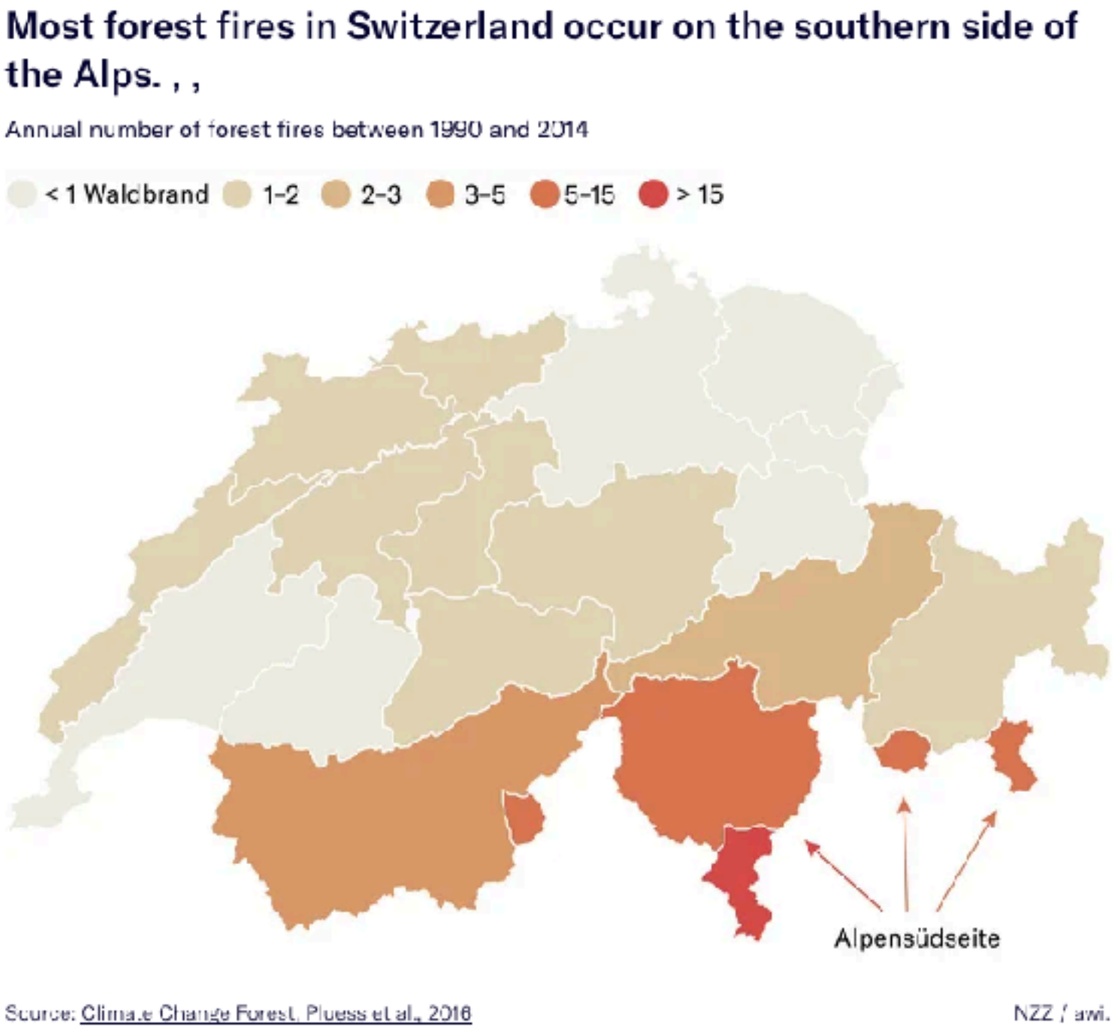
- F: Migrations



https://maps.tnc.org/migrations-in-motion/#5/-7.101/-67.939

Quiz: Name that mark

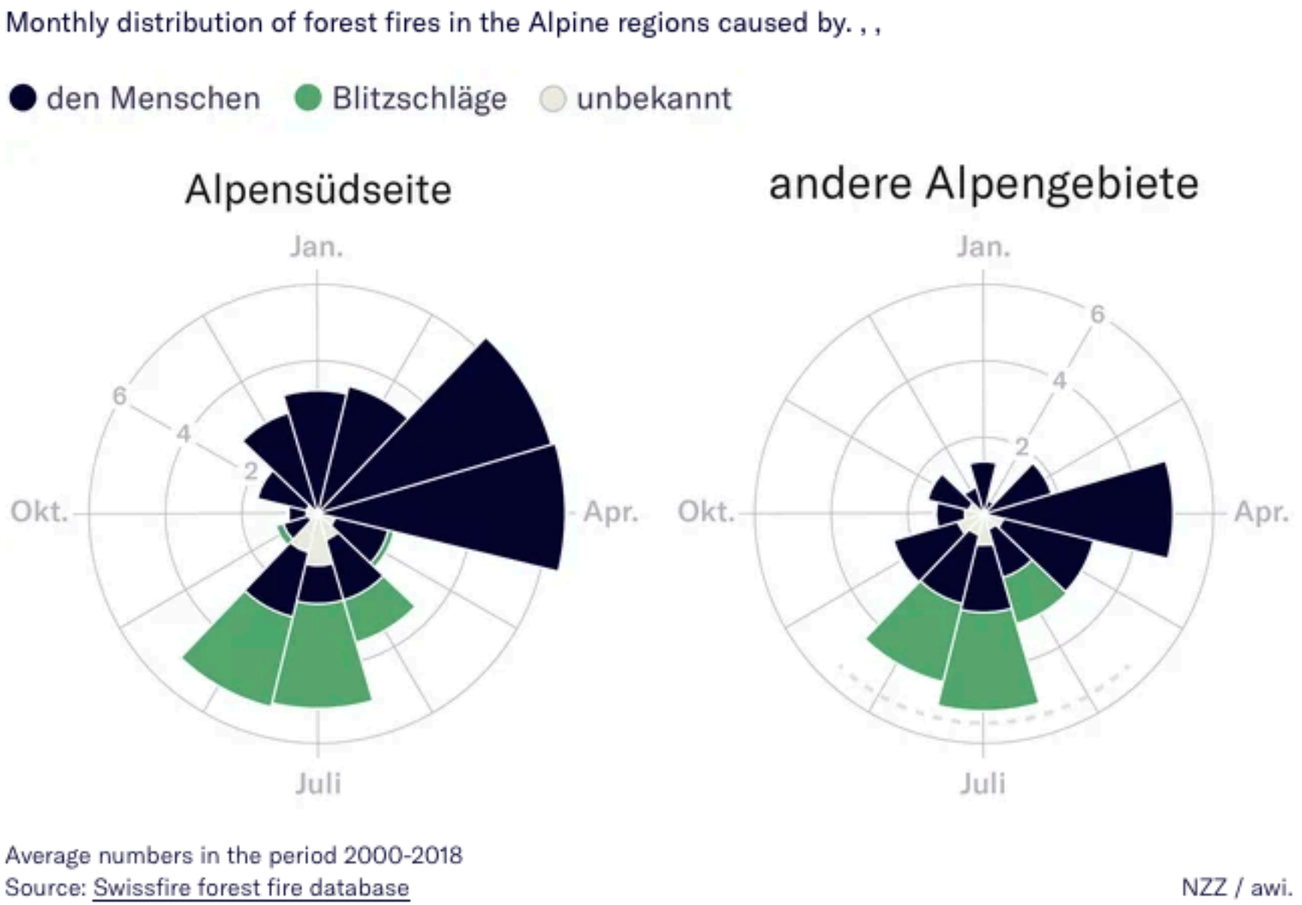
- G: Yet More Alpen Forest Fires



https://www.nzz.ch/wissenschaft/waldbraende-erklaert-in-der-schweiz-und-in-europa-ld.1483688

Quiz: Name those marks & channels

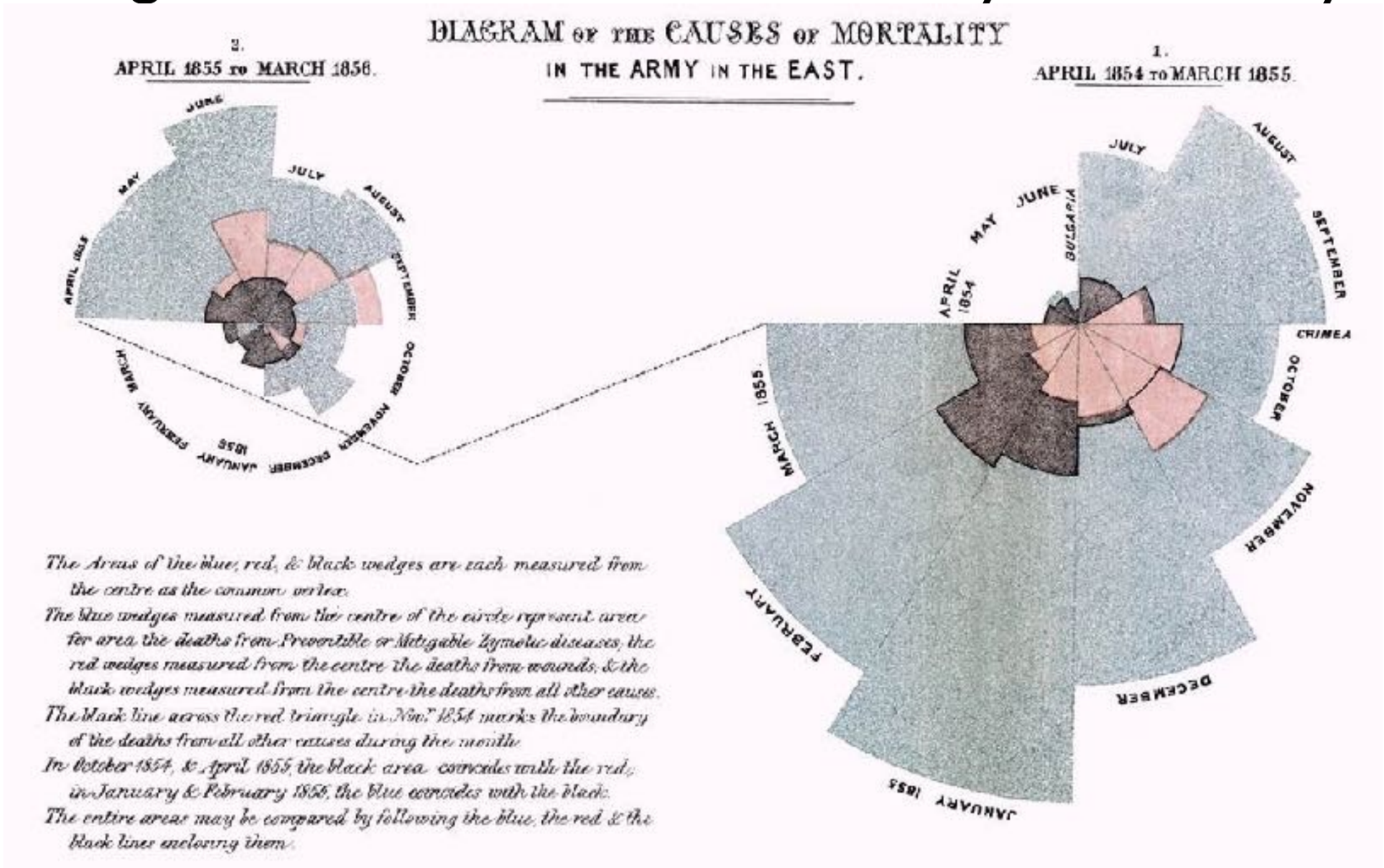
- H: More Alpen Forest Fires



https://www.nzz.ch/wissenschaft/waldbraende-erklaert-in-der-schweiz-und-in-europa-ld.1483688

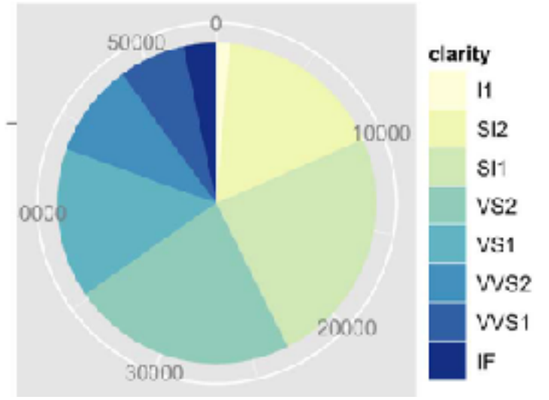
Coxcomb / nightingale rose / polar area chart

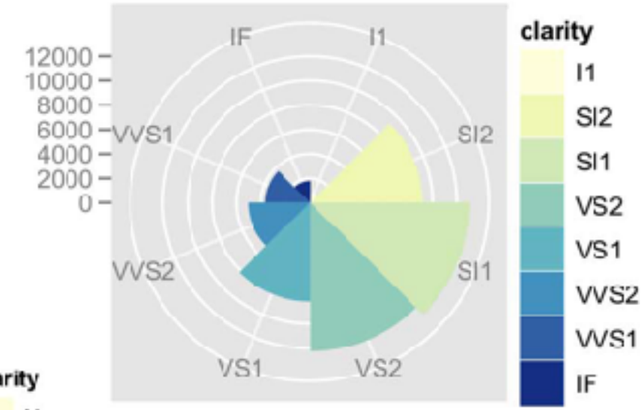
- invented by Florence Nightingale:
  Diagram of the Causes of Mortality in the Army in the East

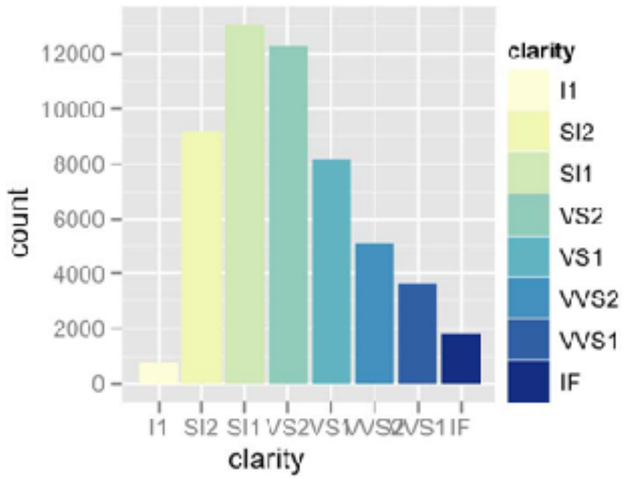


Idioms: **pie chart, coxcomb chart**

- pie chart
  - **interlocking area** marks with angle channel: **2D area varies**
    - separated & ordered radially, uniform height
  - accuracy: area less accurate than rectilinear aligned line length
  - **task: part-to-whole judgements**
- coxcomb chart
  - line marks with length channel: **1D length varies**
    - separated & ordered radially, uniform width
  - direct analog to radial bar charts
- data
  - 1 categ key attrib, 1 quant value attrib







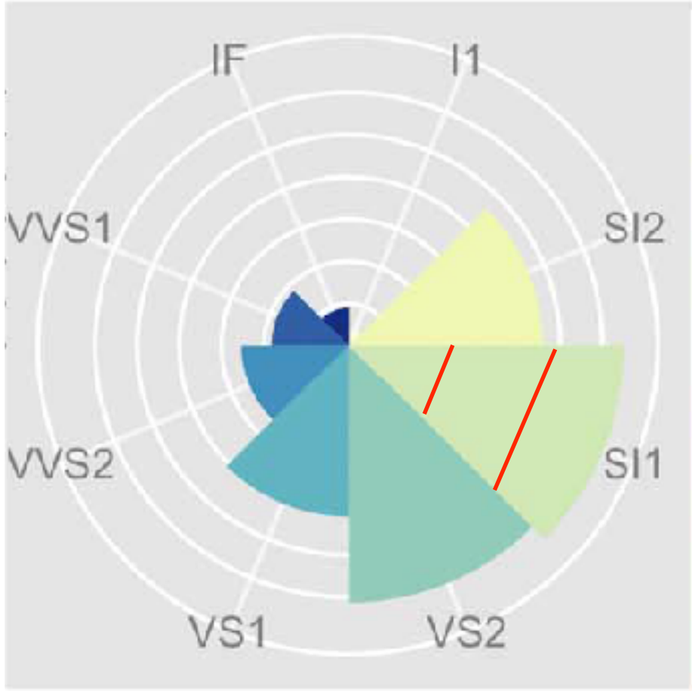
[A layered grammar of graphics. Wickham. Journ. Computational and Graphical Statistics 19:1 (2010), 3–28.]

Coxcomb: perception

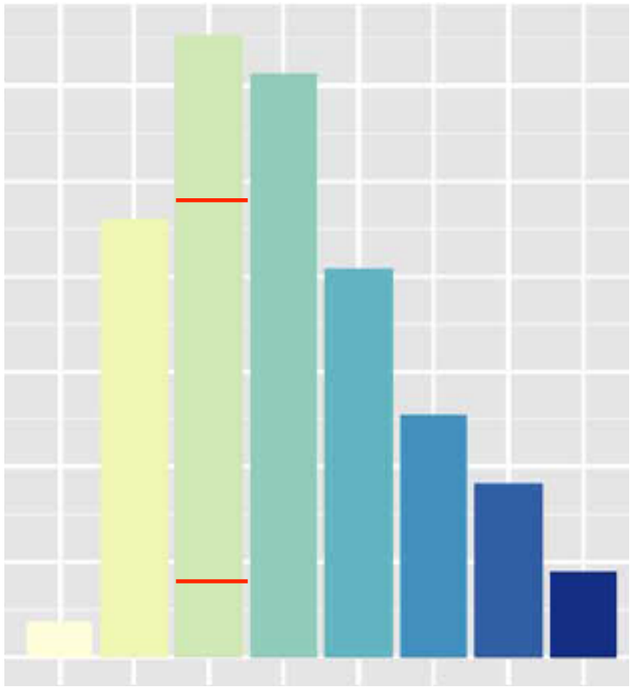
- encode: 1D length
- decode/perceive: 2D area

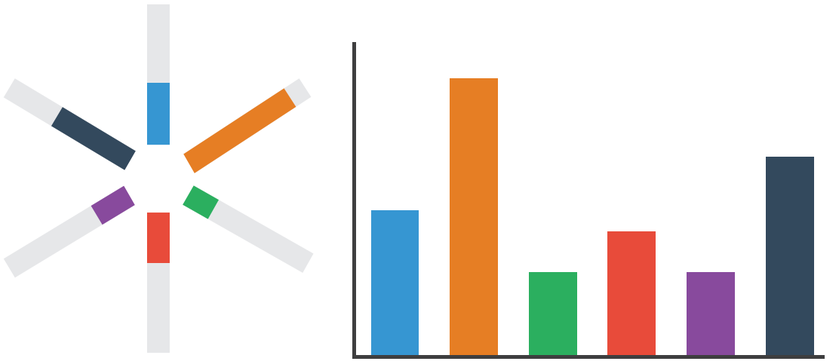
- nonuniform line/sector width as length increases
  - so area variation is nonlinear wrt line mark length!

- bar chart safer: uniform width, so area is linear with line mark length
  - both radial & rectilinear cases



nonuniform width as length increases


uniform width as length increases


radial & rectilinear bars: uniform width as length increases

Q&A: Rules of Thumb, DSM

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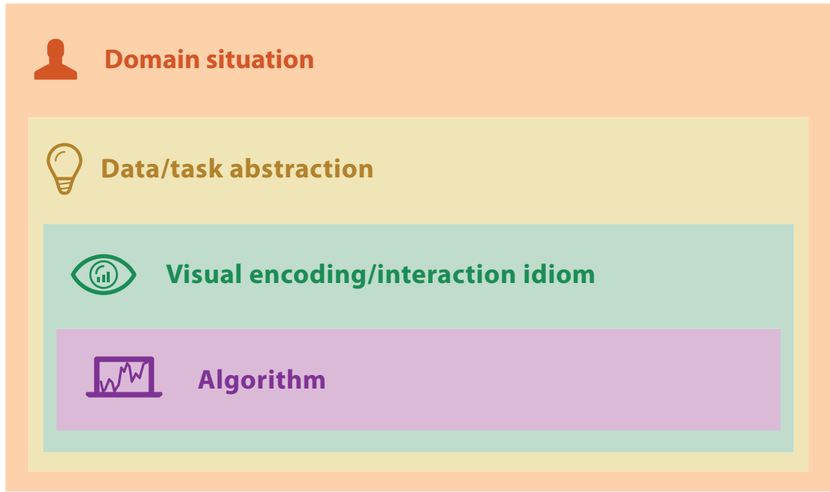
Q&A/Backup Slides

Marks and Channels

Visual encoding

- how to systematically analyze idiom structure?



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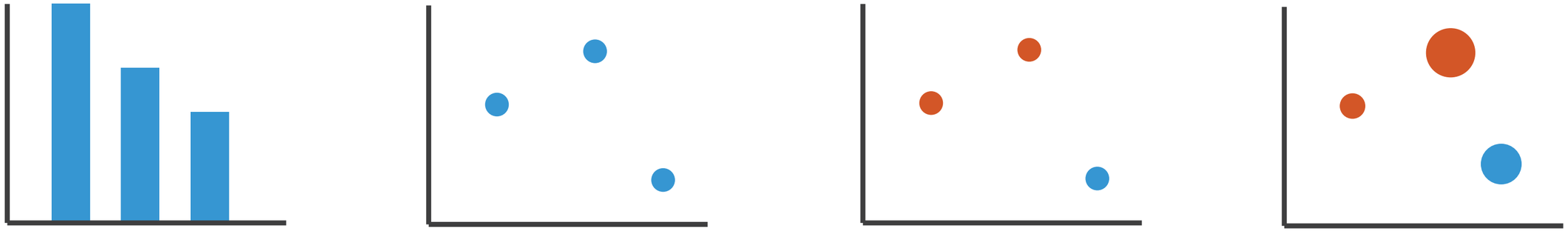

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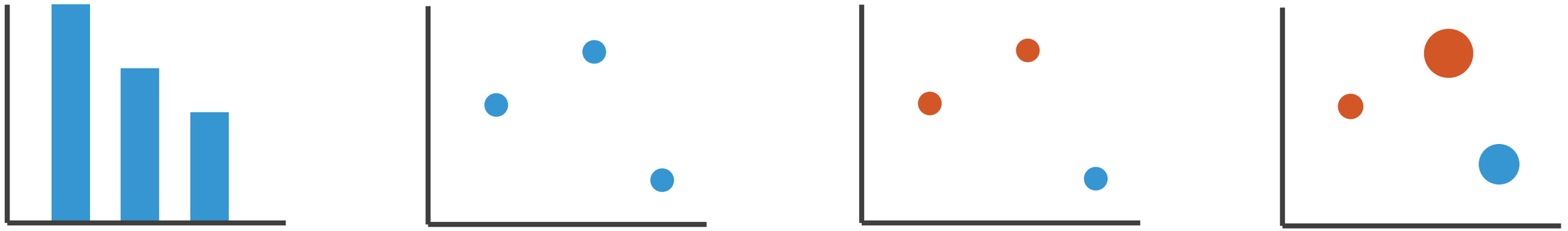


- marks & channels
  - marks: represent items or links
  - channels: change appearance of marks based on attributes

Marks for items

- basic geometric elements

Points

0D

Lines

1D

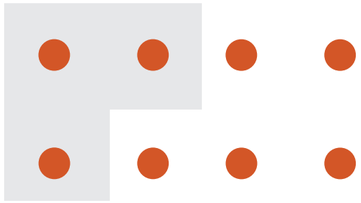
Interlocking Areas

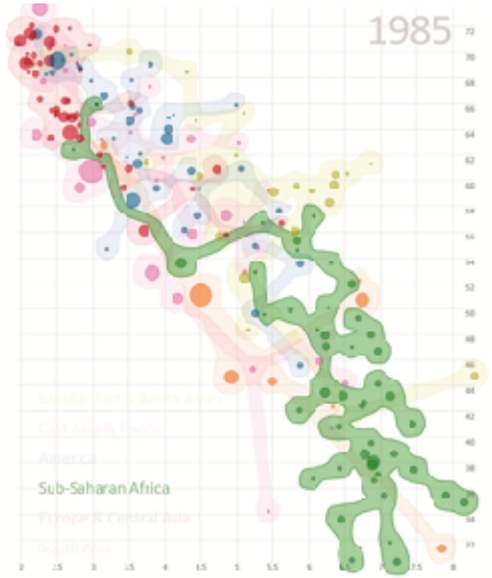
2D

- 3D mark: volume, rarely used

Marks for links

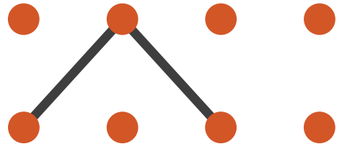
Containment





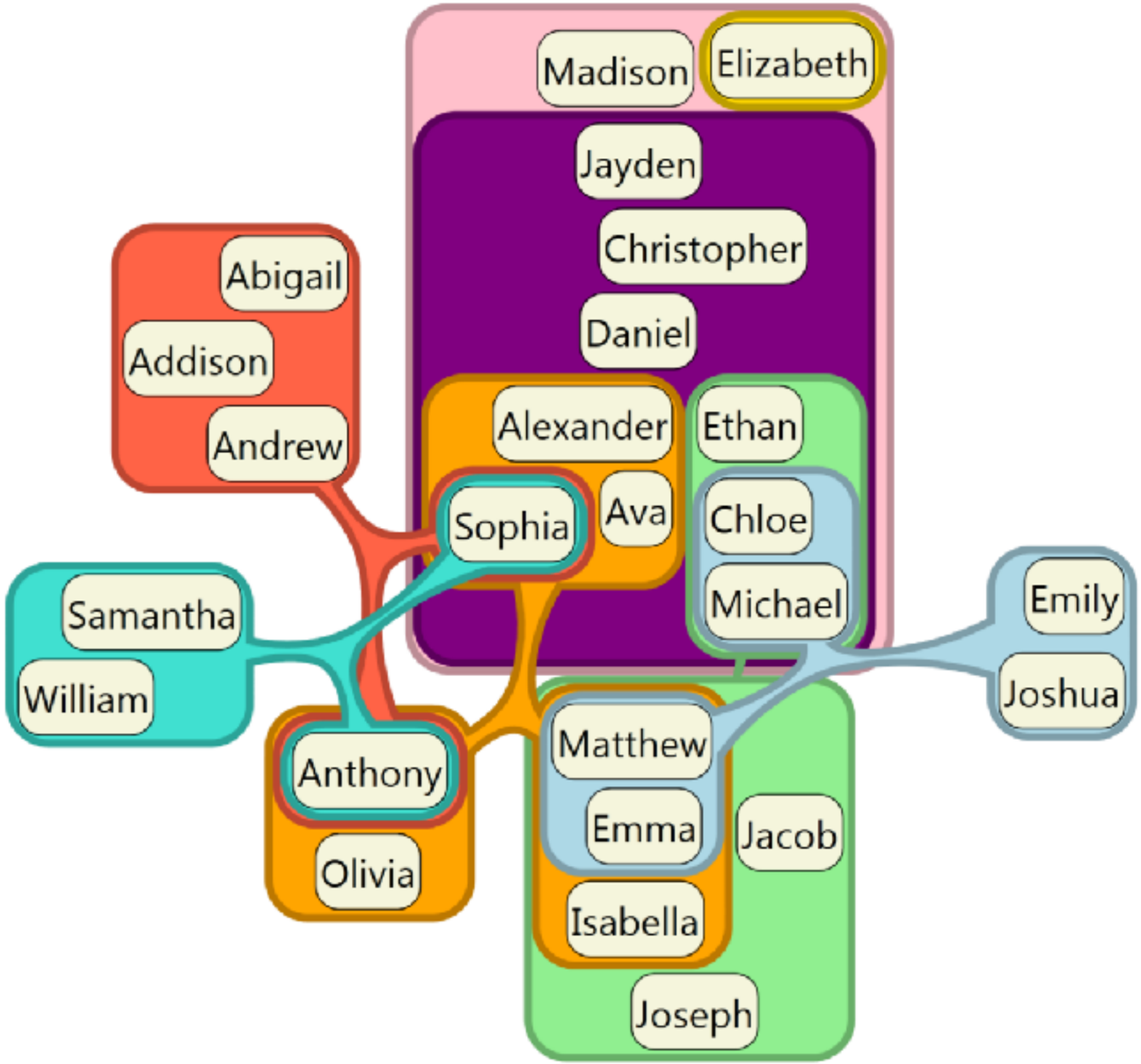
vialab.science.uoit.ca/portfolio/bubblesets

Connection



https://observablehq.com/@d3/force-directed-graph

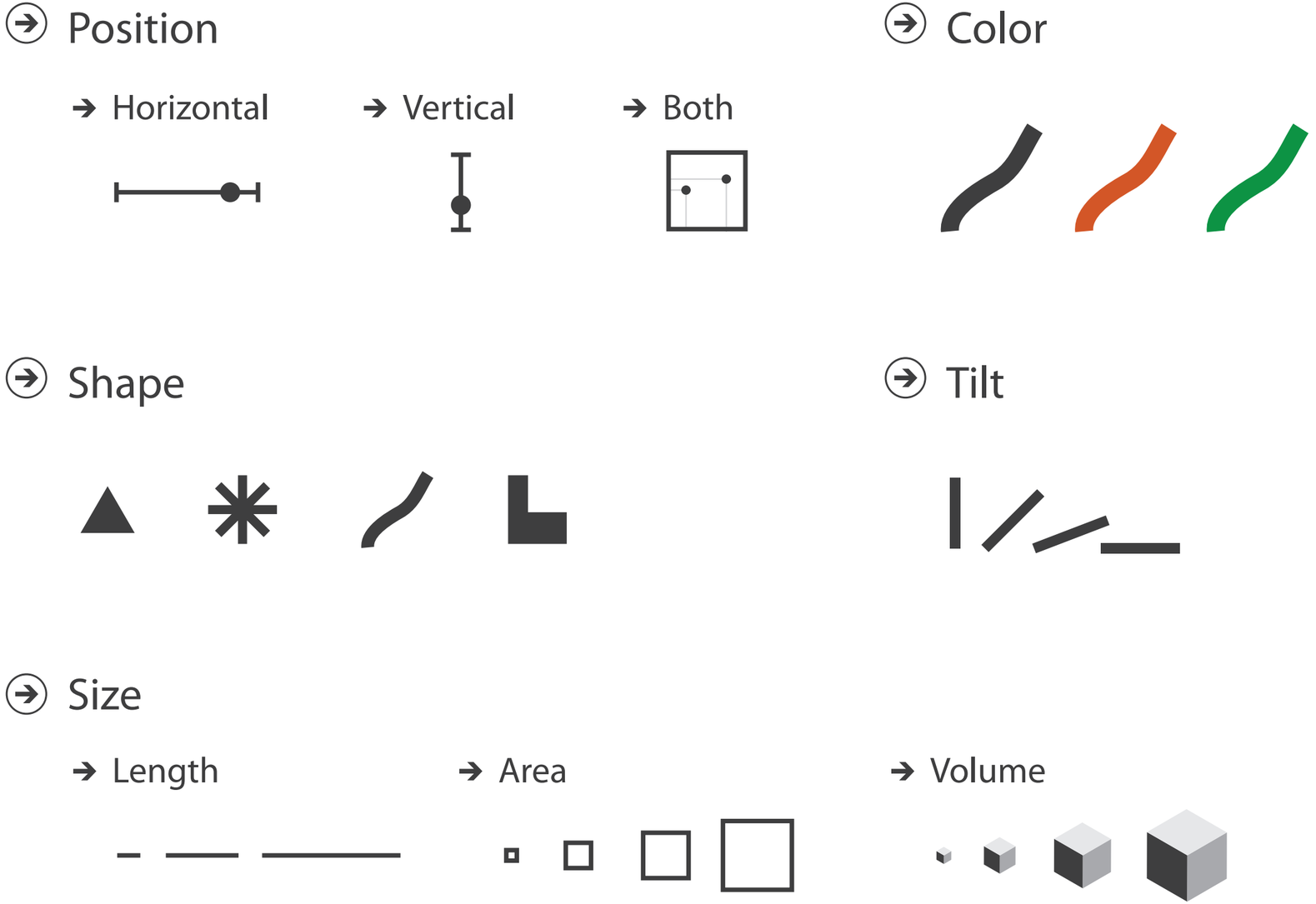
Containment can be nested



[Untangling Euler Diagrams, Riche and Dwyer, 2010]

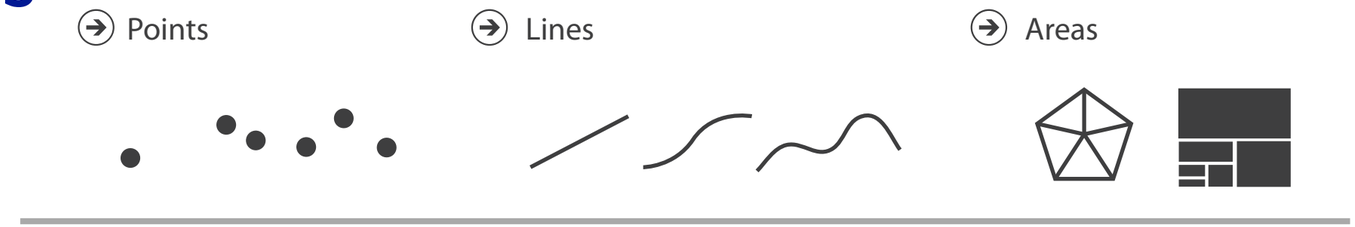
Channels

- control appearance of marks
  - proportional to or based on attributes
- many names
  - **visual channels**
  - visual variables
  - retinal channels
  - visual dimensions
  - ...



Definitions: Marks and channels

- marks
  - geometric primitives



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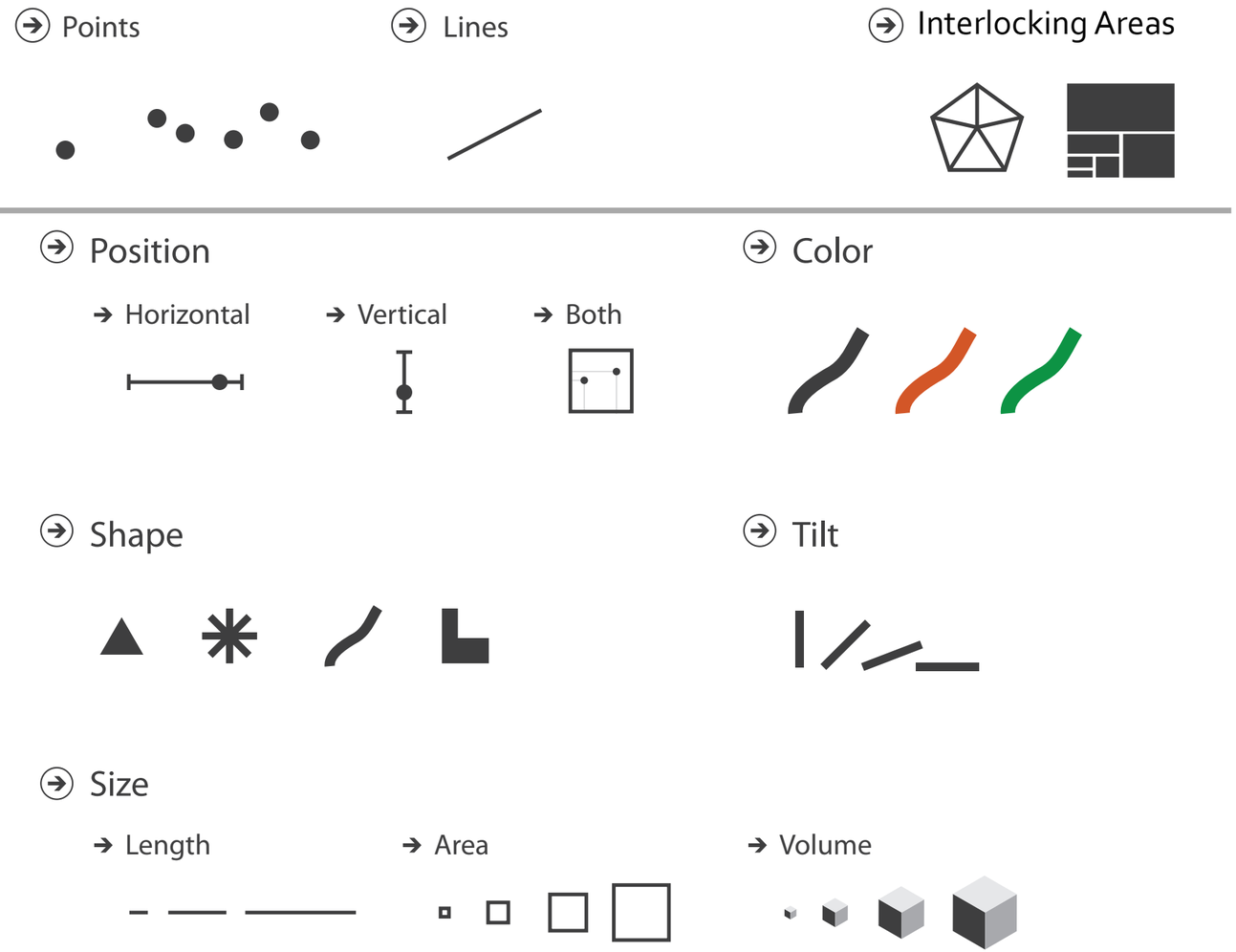
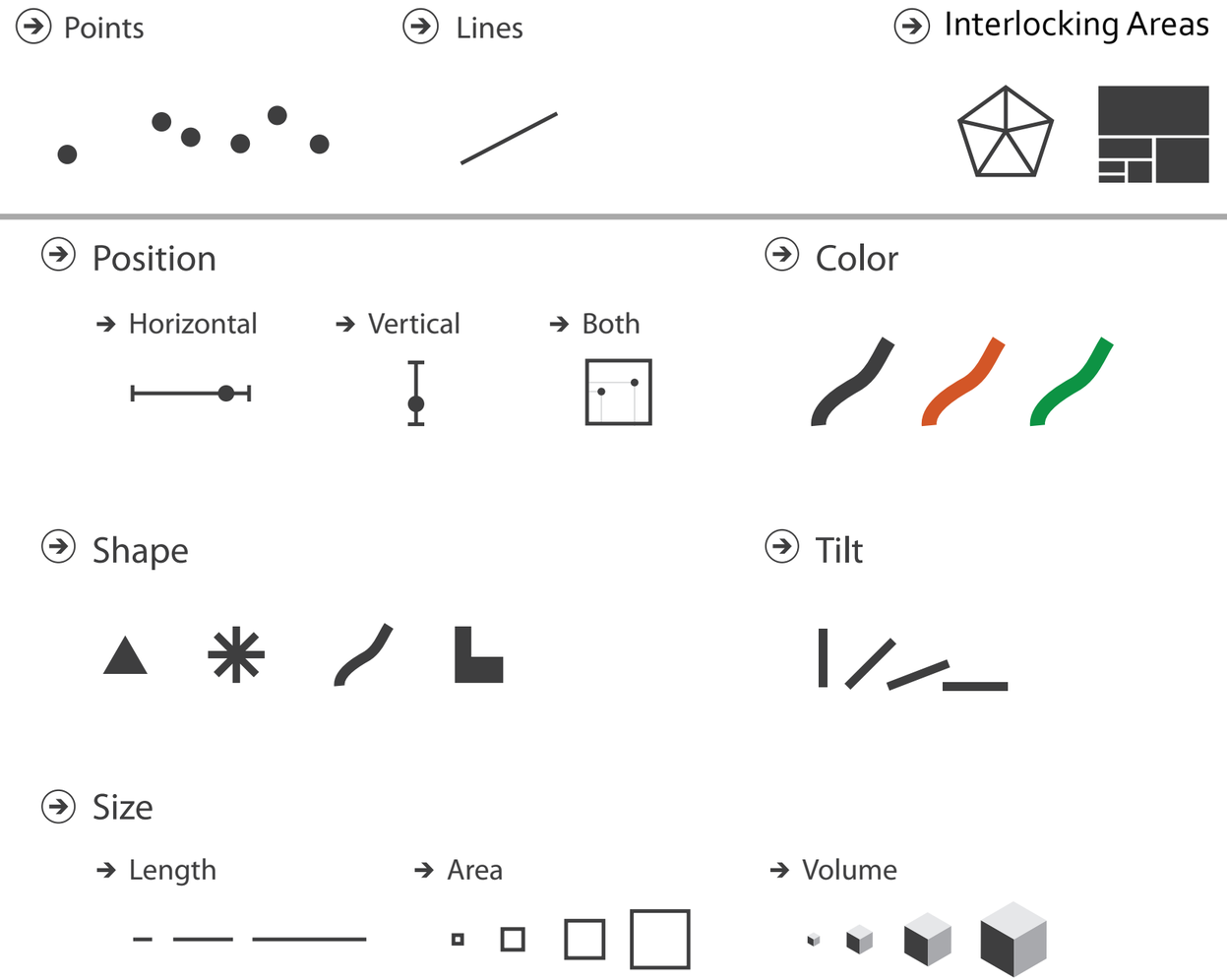


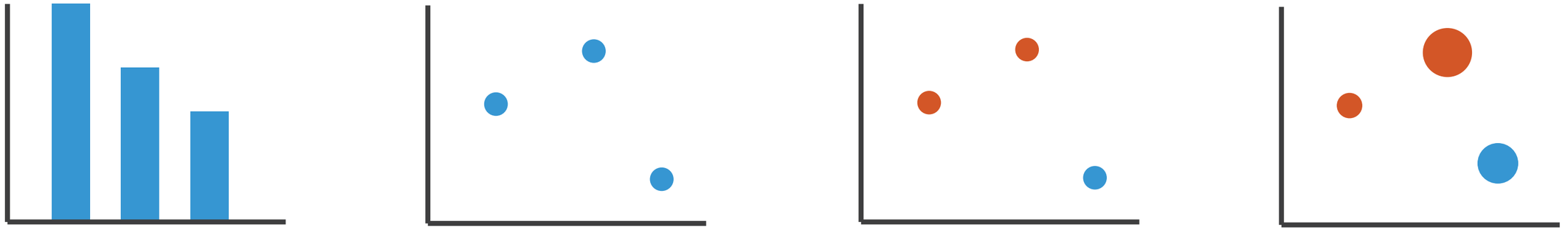
Definitions: Marks and channels

- marks
  - geometric primitives
- channels
  - control appearance of marks
- channel properties differ
    - type & amount of information that can be conveyed to human perceptual system



Visual encoding

- analyze idiom structure as combination of marks and channels



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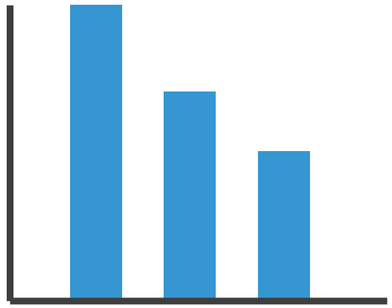
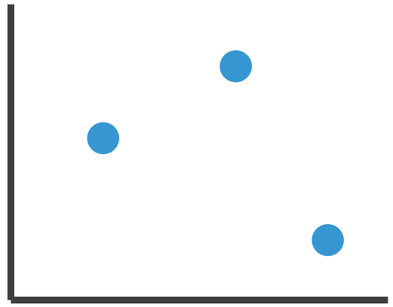
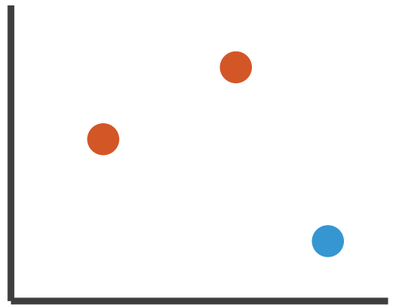
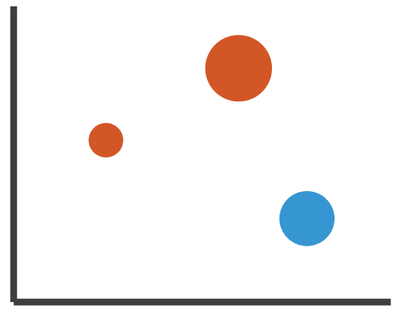






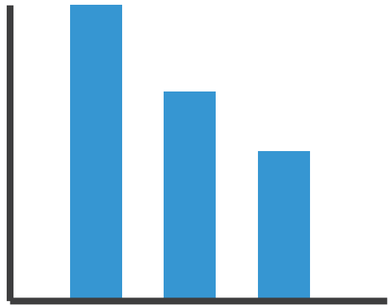


1:
vertical position

mark: line

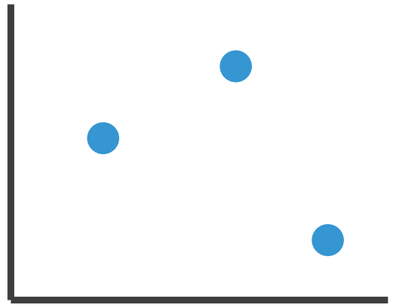
Visual encoding

- analyze idiom structure as combination of marks and channels



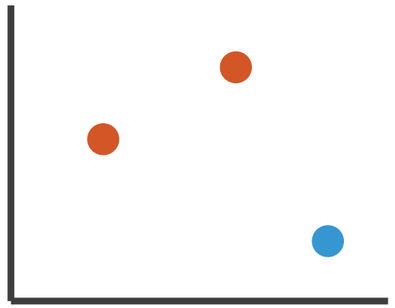
1:
vertical position

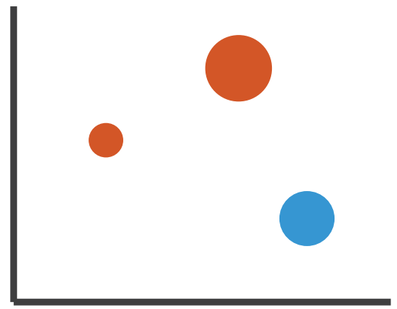
mark: line



2:
vertical position
horizontal position

mark: point





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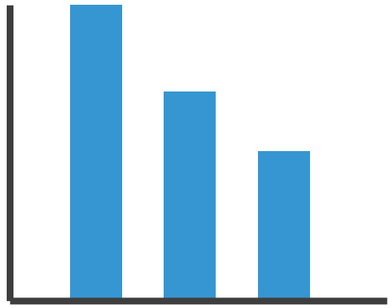

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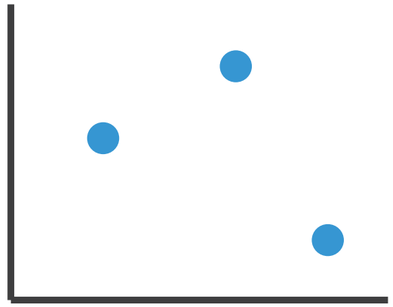
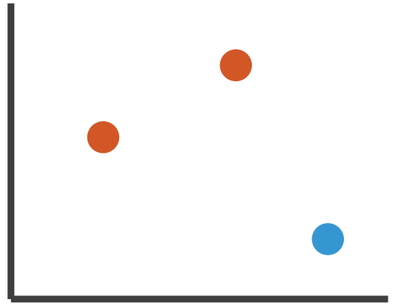


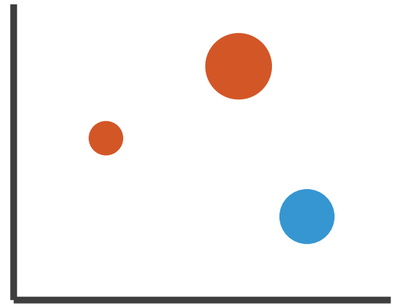
2:
vertical position
horizontal position

mark: point



3:
vertical position
horizontal position
color hue

mark: point



Visual encoding

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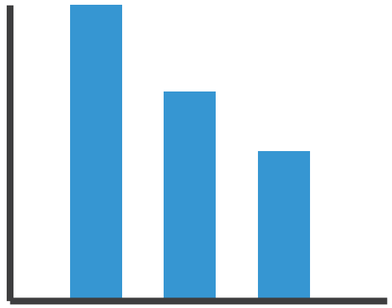
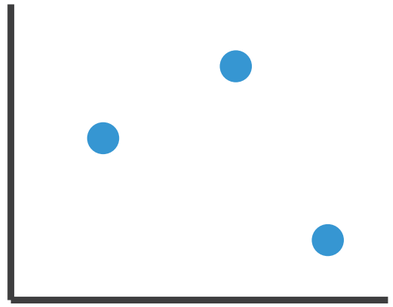


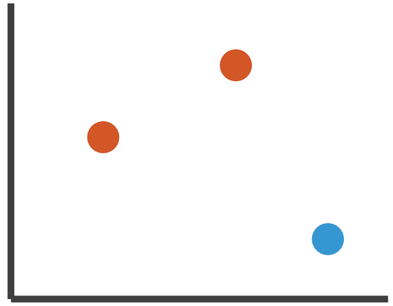
1:
vertical position

mark: line



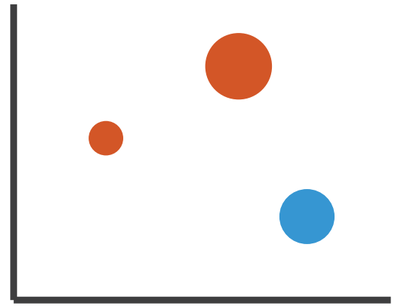
2:
vertical position
horizontal position

mark: point



3:
vertical position
horizontal position
color hue

mark: point

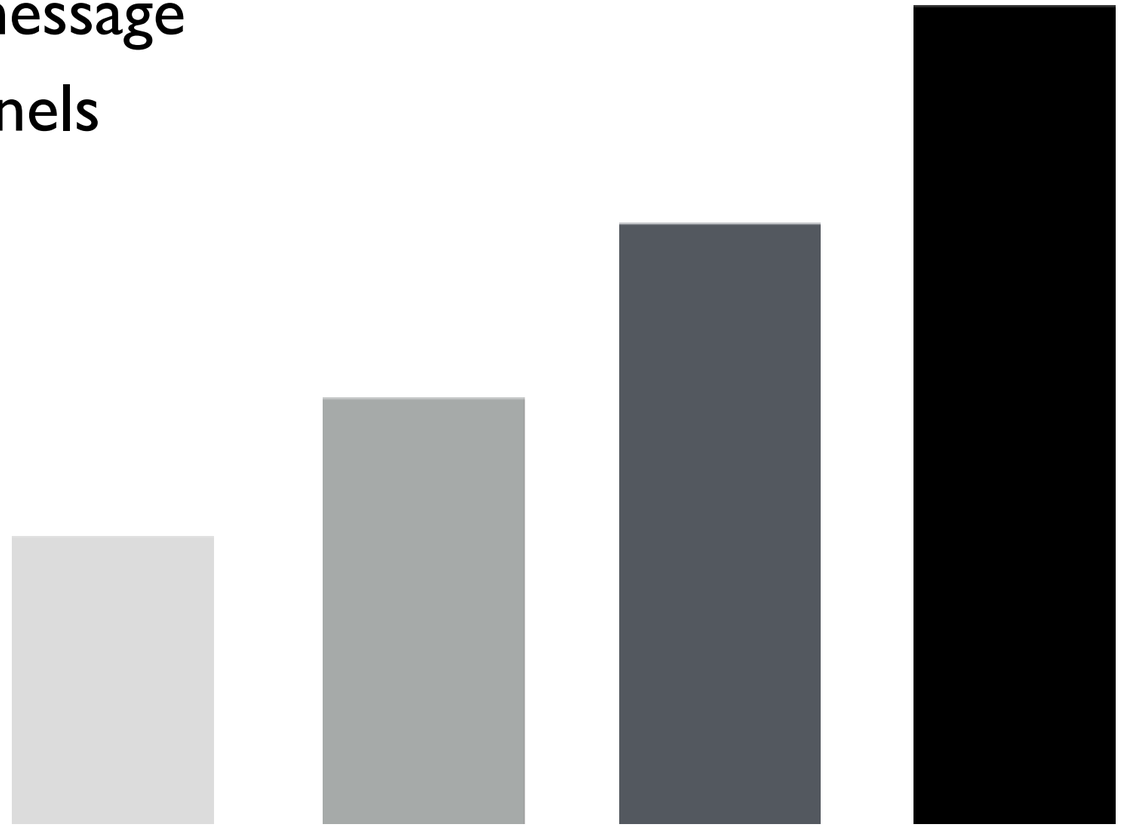


4:
vertical position
horizontal position
color hue
size (area)

mark: point

Redundant encoding

- multiple channels
  - sends stronger message
  - but uses up channels



Length, Position, and Luminance

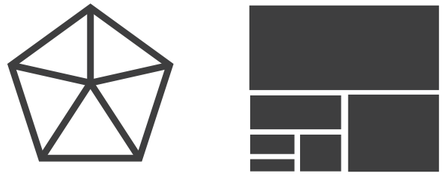
Marks as constraints

- math view: geometric primitives have dimensions

Points 0D

Lines 1D

Interlocking Areas 2D



Marks as constraints

- math view: geometric primitives have dimensions

Points 0D Lines 1D Interlocking Areas 2D

- constraint view: mark type constrains what else can be encoded
  - points: 0 constraints on size, can encode more attributes w/ size & shape
  - lines: 1 constraint on size (length), can still size code other way (width)
  - interlocking areas: 2 constraints on size (length/width), cannot size or shape code
    - interlocking: size, shape, position

Marks as constraints

- math view: geometric primitives have dimensions

Points 0D Lines 1D Interlocking Areas 2D

- constraint view: mark type constrains what else can be encoded
  - points: 0 constraints on size, can encode more attributes w/ size & shape
  - lines: 1 constraint on size (length), can still size code other way (width)
  - interlocking areas: 2 constraints on size (length/width), cannot size or shape code
    - interlocking: size, shape, position
- quick check: can you size-code another attribute
  - or is size/shape in use?

Scope of analysis

- simplifying assumptions: one mark per item, single view

- later on
  - multiple views
  - multiple marks in a region (glyph)
  - some items not represented by marks (aggregation and filtering)

When to use which channel?

expressiveness

match channel type to data type

effectiveness

some channels are better than others

Channels: Rankings

Position on common scale

Position on unaligned scale

Length (1D size)

Tilt/angle

Area (2D size)

Depth (3D position)

Color luminance

Color saturation

Curvature

Volume (3D size)

Same

Same

Spatial region

Color hue

Motion

Shape

Channels: Rankings

Magnitude Channels: Ordered Attributes

Position on common scale

Position on unaligned scale

Length (1D size)

Tilt/angle

Area (2D size)

Depth (3D position)

Color luminance

Color saturation

Curvature

Volume (3D size)

Same

Same

Identity Channels: Categorical Attributes

Spatial region

Color hue

Motion

Shape

- expressiveness
  - match channel and data characteristics

Channels: Rankings

Magnitude Channels: Ordered Attributes

Position on common scale

Position on unaligned scale

Length (1D size)

Tilt/angle

Area (2D size)

Depth (3D position)

Color luminance

Color saturation

Curvature

Volume (3D size)

Same

Same

Identity Channels: Categorical Attributes

Spatial region

Color hue

Motion

Shape

Attribute Types

→ Categorical

→ Ordered

→ *Ordinal*

→ *Quantitative*

- expressiveness
  - match channel and data characteristics
    - magnitude for ordered
      - how much? which rank?
    - identity for categorical
      - what?

Channels: Rankings

Magnitude Channels: Ordered Attributes

Position on common scale

Position on unaligned scale

Length (1D size)

Tilt/angle

Area (2D size)

Depth (3D position)

Color luminance

Color saturation

Curvature

Volume (3D size)

Same

Same

Best

Effectiveness

Least

Identity Channels: Categorical Attributes

Spatial region

Color hue

Motion

Shape

- expressiveness
  - match channel and data characteristics
- effectiveness
  - channels differ in accuracy of perception

Channels: Rankings

Magnitude Channels: Ordered Attributes

Position on common scale

Position on unaligned scale

Length (1D size)

Tilt/angle

Area (2D size)

Depth (3D position)

Color luminance

Color saturation

Curvature

Volume (3D size)

Same

Same

Effectiveness

Best

Least

Identity Channels: Categorical Attributes

Spatial region

Color hue

Motion

Shape

- expressiveness
  - match channel and data characteristics
- effectiveness
  - channels differ in accuracy of perception
  - spatial position ranks high for both

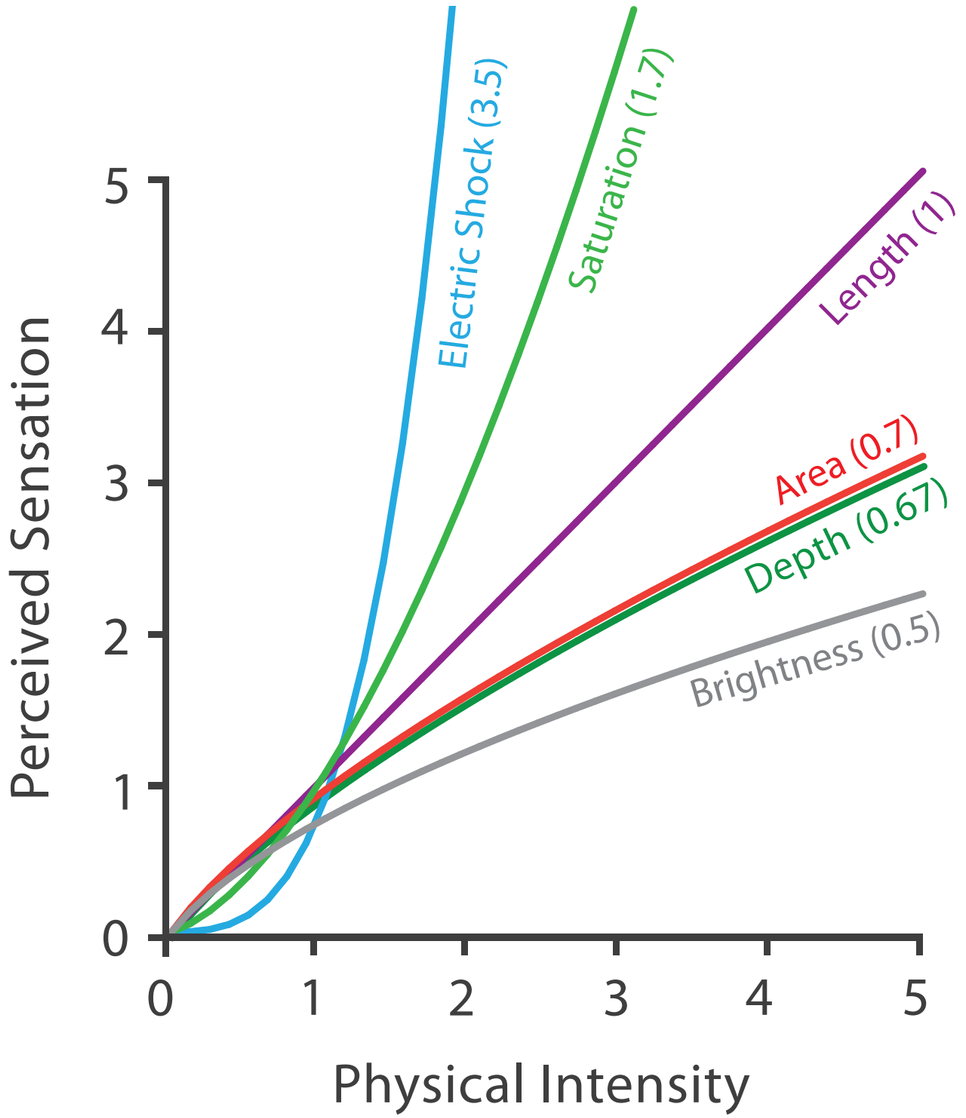
Channel effectiveness

- accuracy: how precisely can we tell the difference between encoded items?
- discriminability: how many unique steps can we perceive?
- separability: is our ability to use this channel affected by another one?
- popout: can things jump out using this channel?

Accuracy: Fundamental theory

- length is accurate: linear
- others magnified or compressed
  - –exponent characterizes

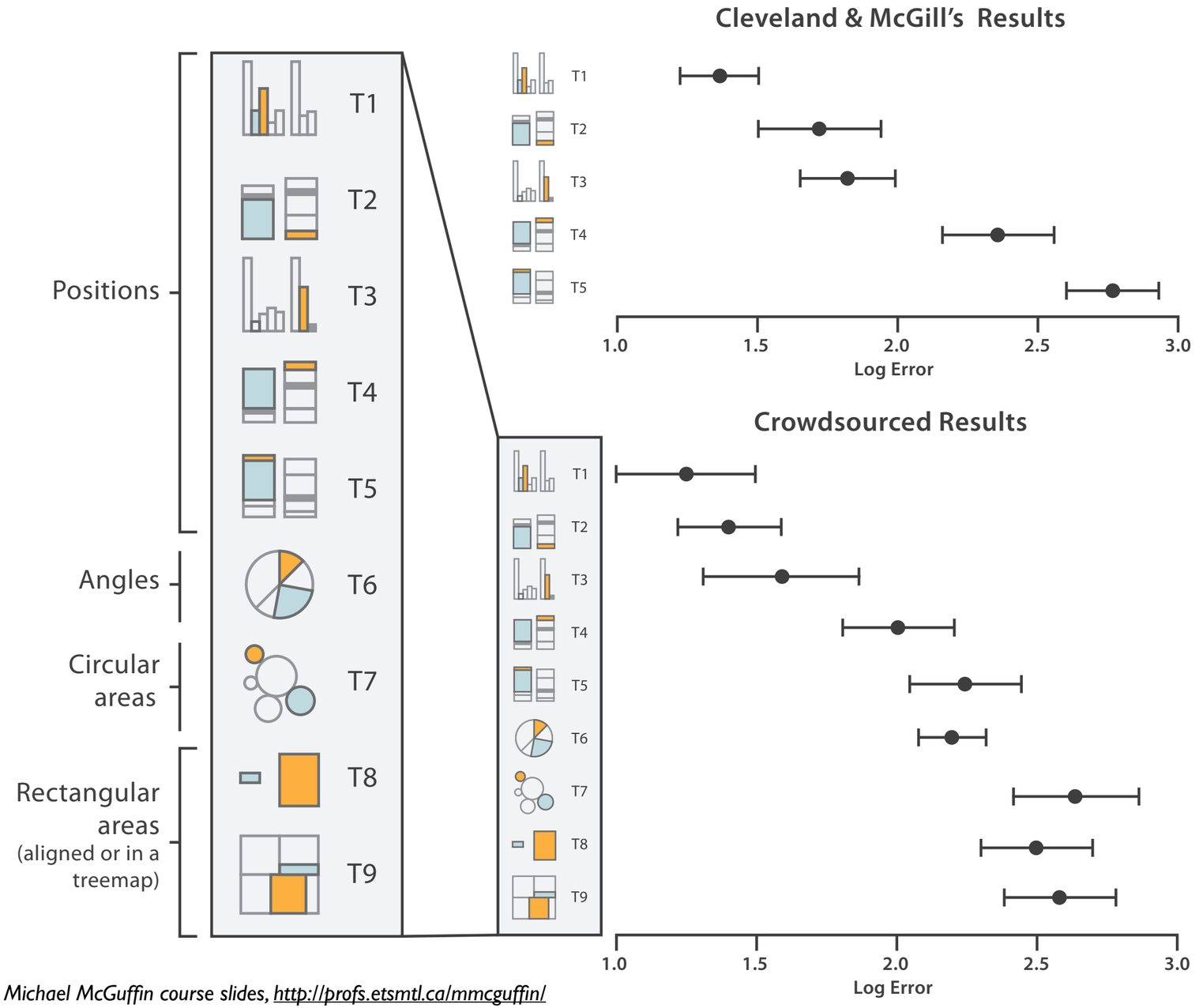
Steven's Psychophysical Power Law: $S = I^N$



S = sensation

I = intensity

Accuracy: Vis experiments

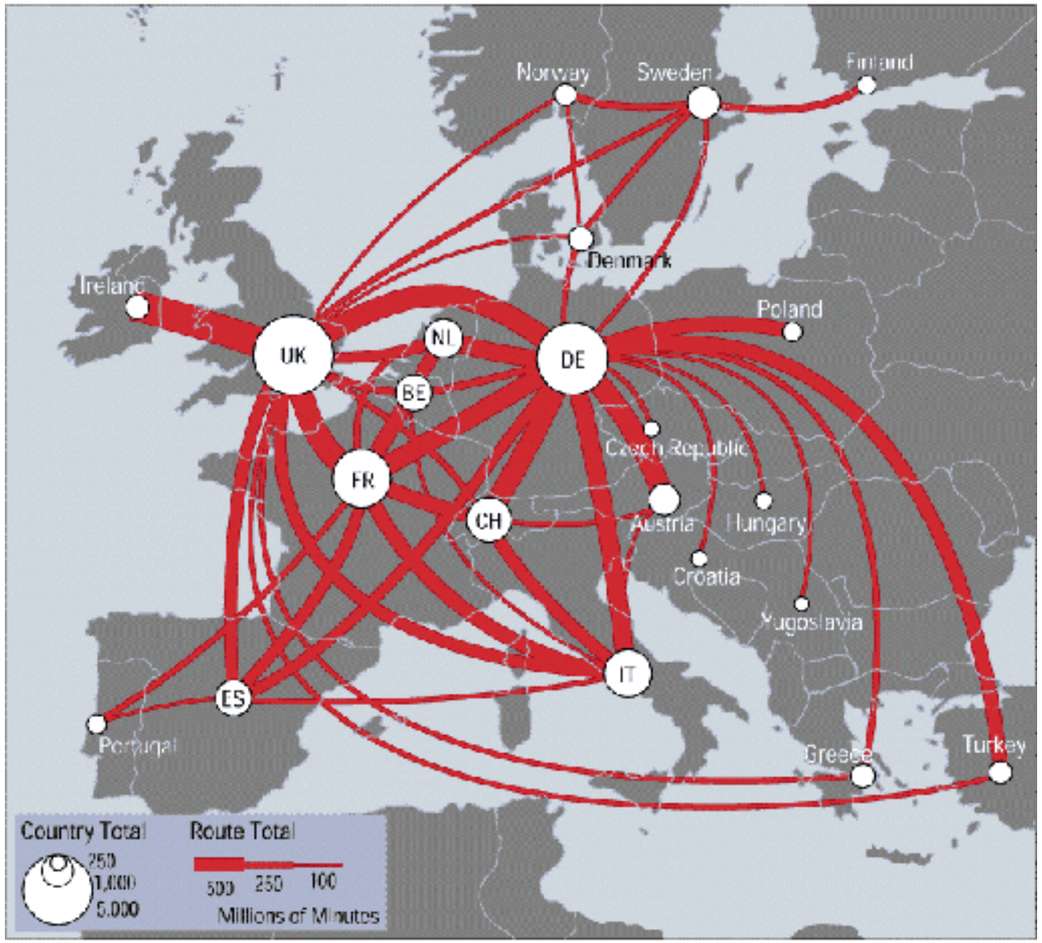


[Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design. Heer and Bostock. Proc ACM Conf. Human Factors in Computing Systems (CHI) 2010, p. 203–212.]

after Michael McGuffin course slides, http://profs.etsmtl.ca/mmcguffin/

Discriminability: How many usable steps?

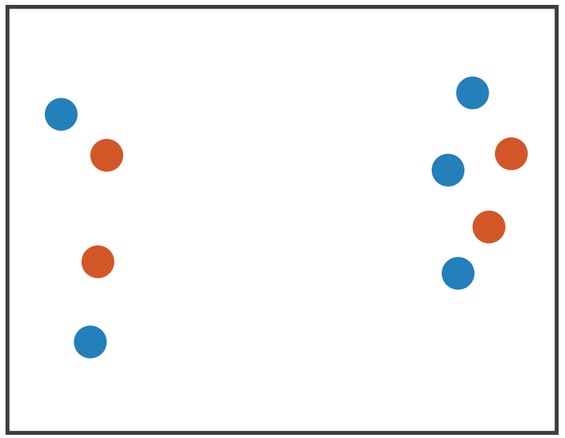
- must be sufficient for number of attribute levels to show
  - linewidth: few bins



[mappa.mundi.net/maps/maps 014/telegeography.html]

Separability vs. Integrality

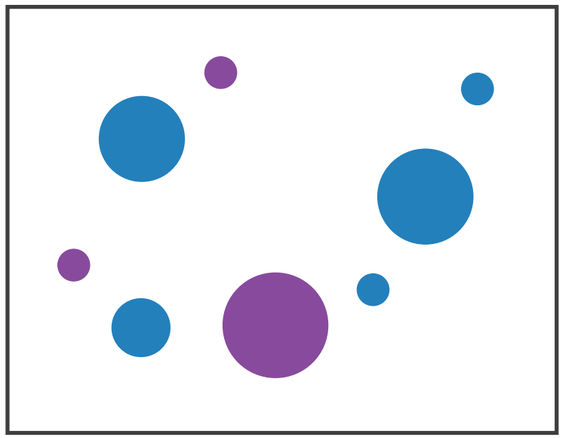
Position
+ Hue (Color)



Fully separable

2 groups each

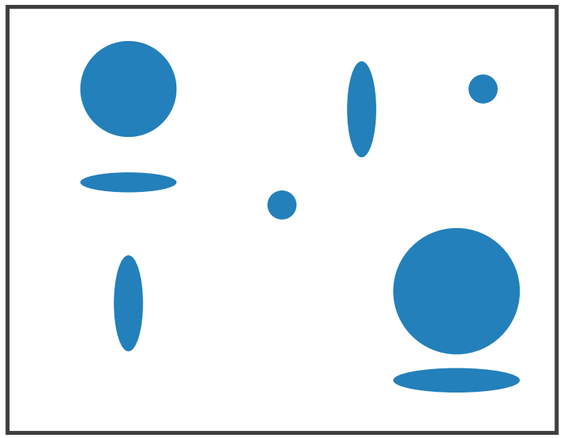
Size
+ Hue (Color)



Some interference

2 groups each

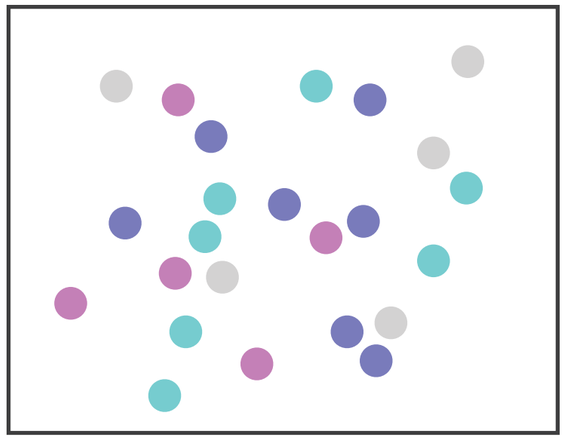
Width
+ Height



Some/significant interference

3 groups total: integral area

Red
+ Green



Major interference

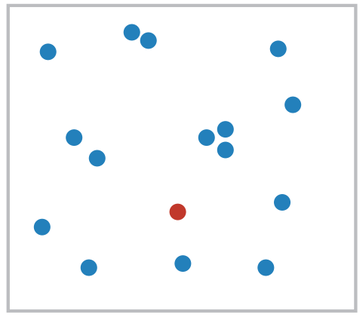
4 groups total: integral hue

Popout

- find the red dot
  - how long does it take?

Popout

- find the red dot
  - how long does it take?



Popout

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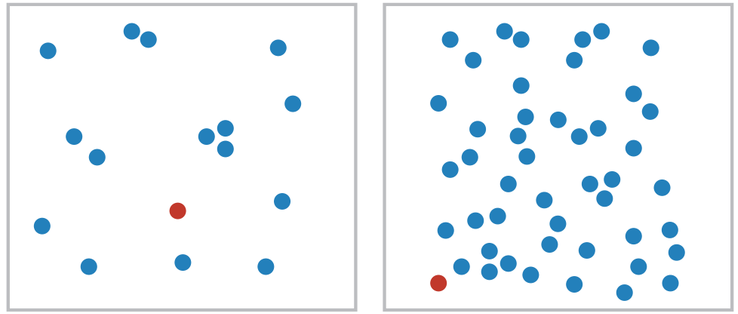

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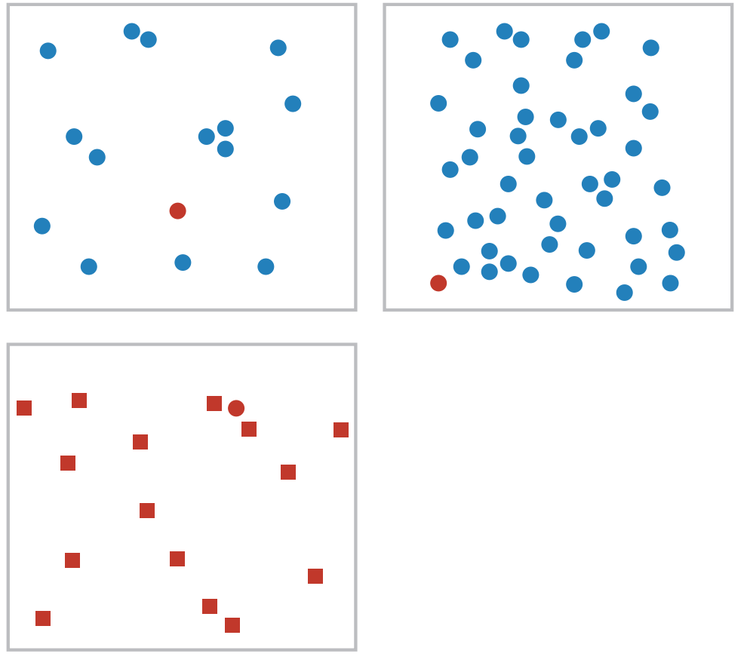

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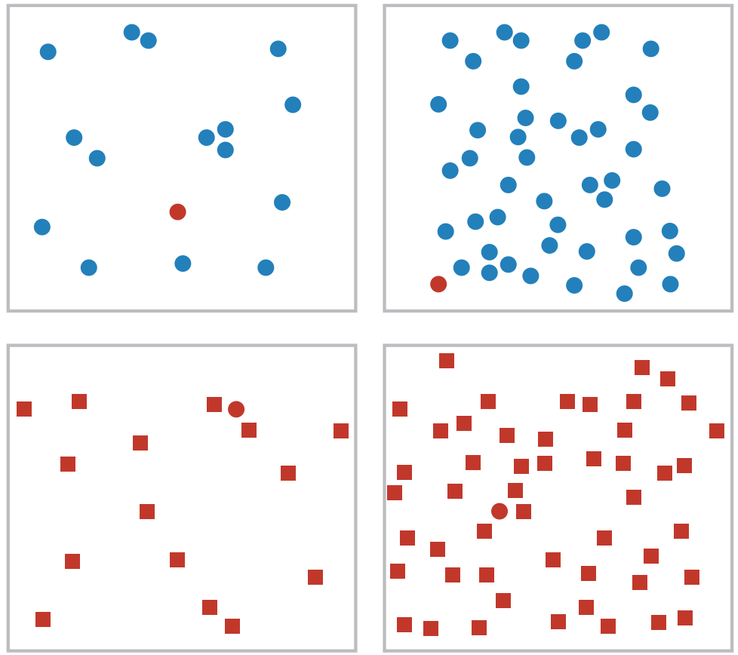

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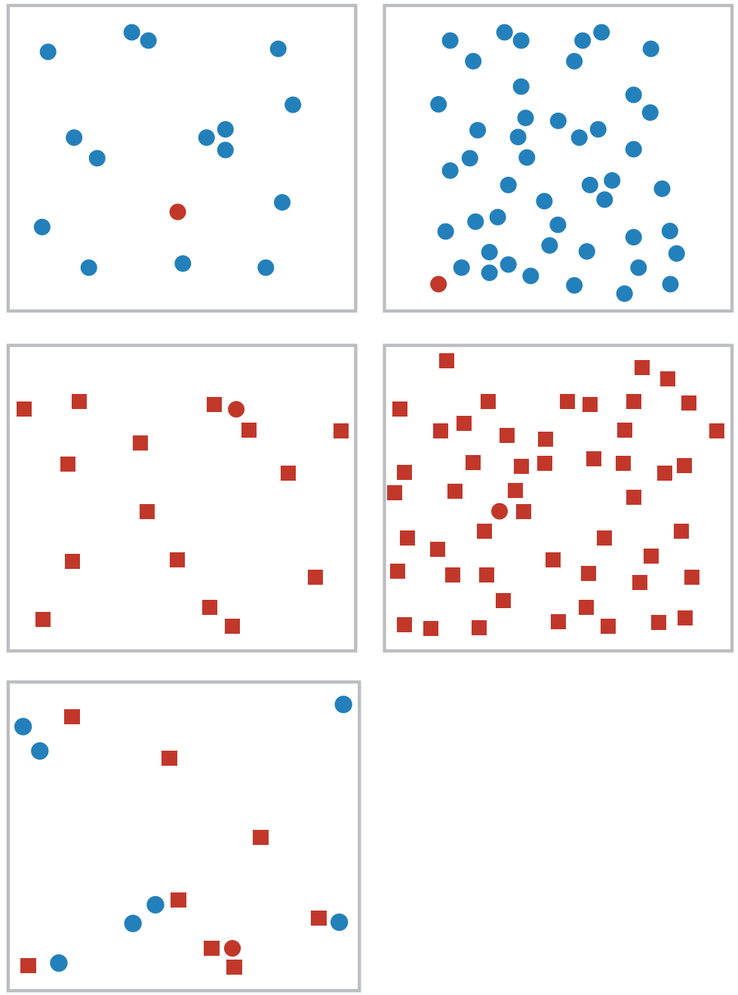

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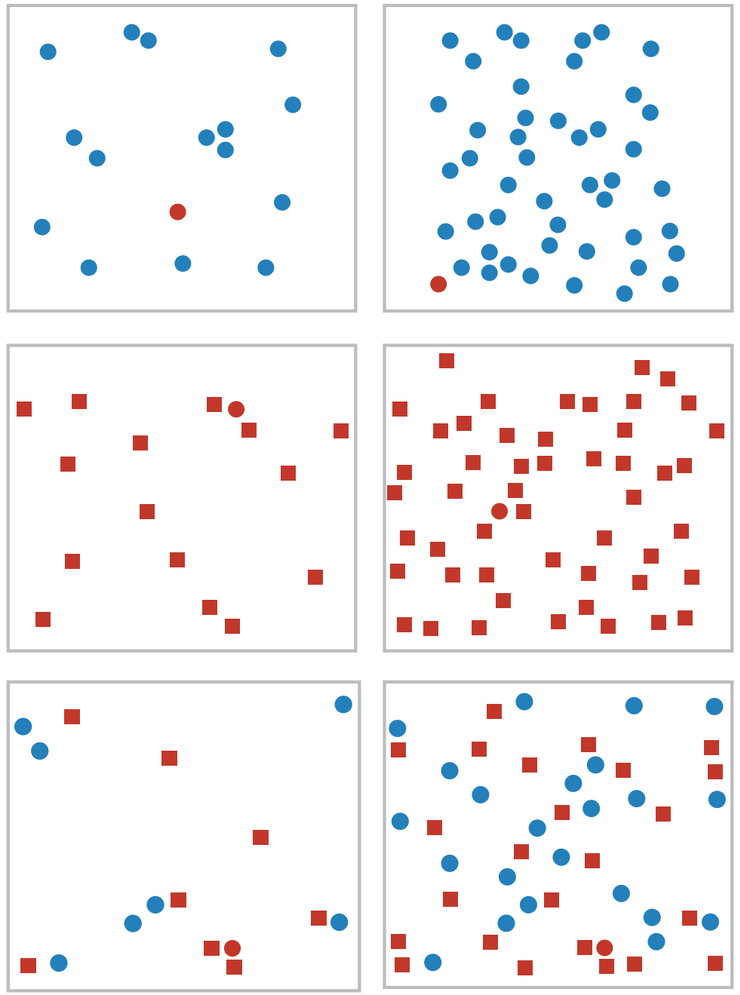
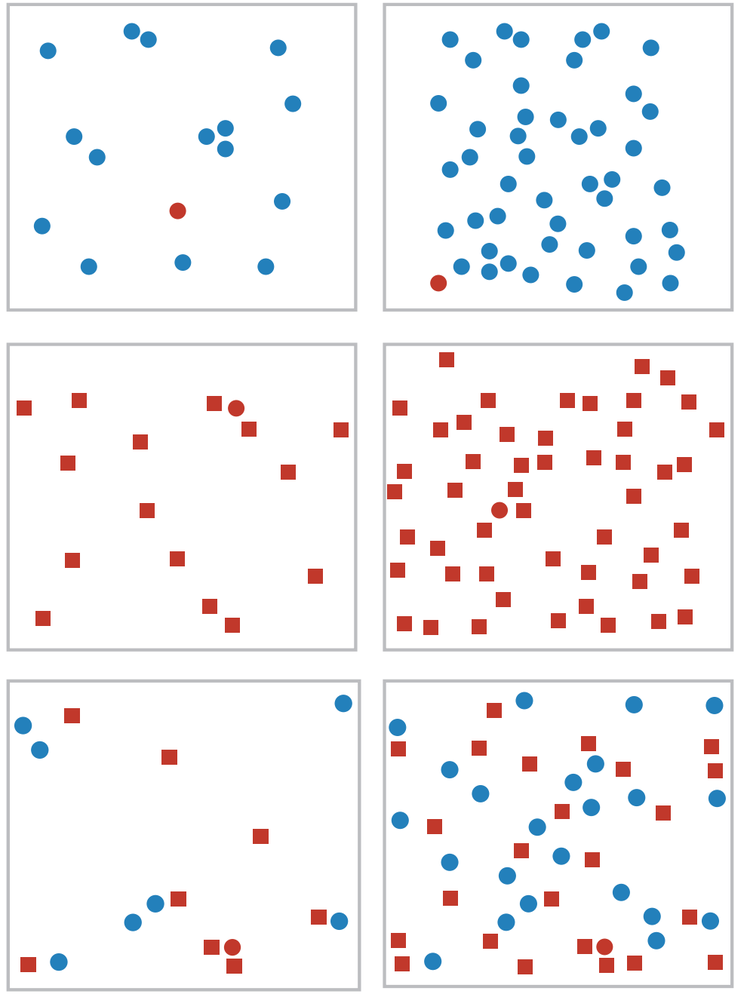
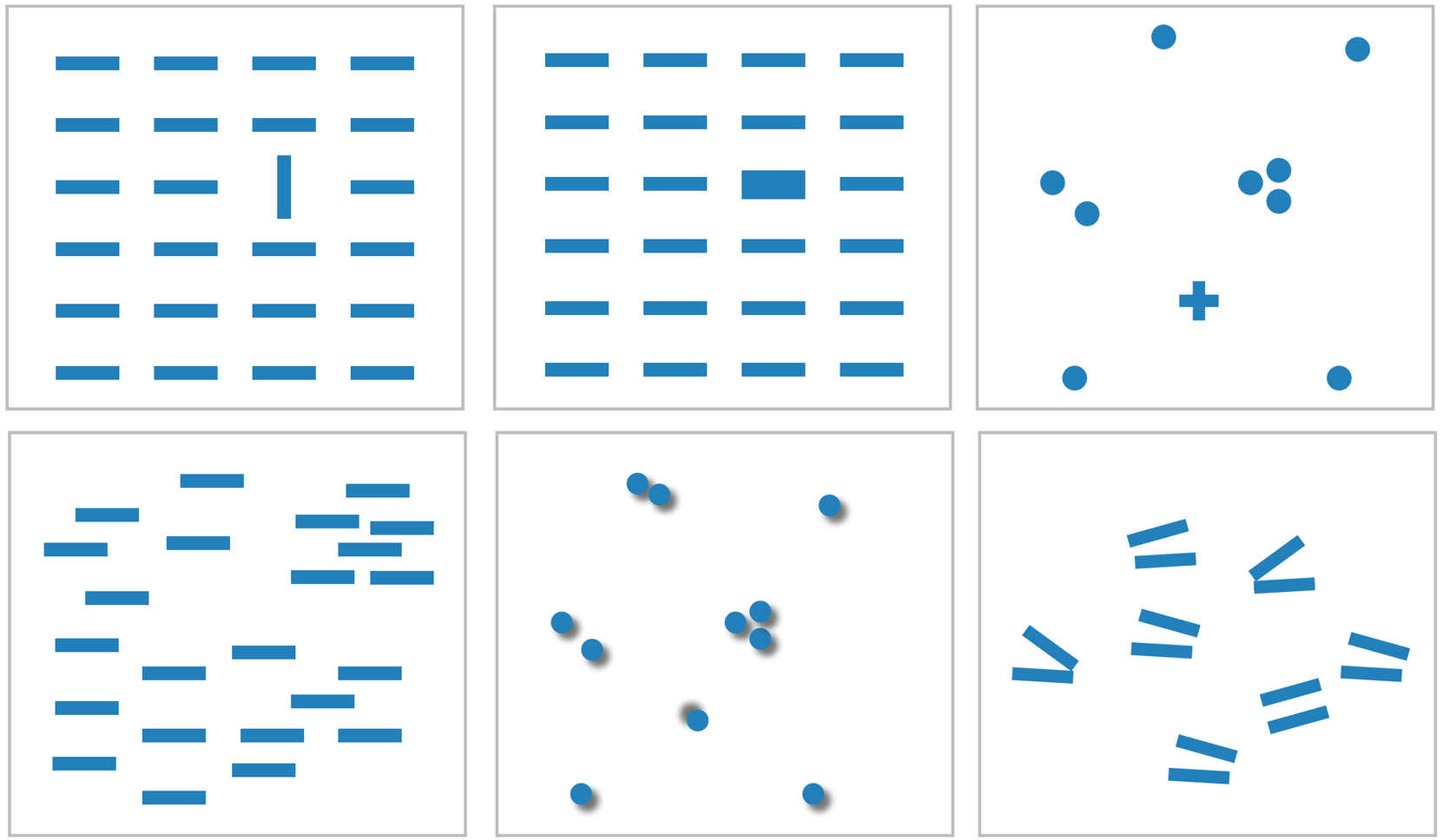


Popout

- find the red dot
  - how long does it take?
- parallel processing on many individual channels
  - speed independent of distractor count
  - speed depends on channel and amount of difference from distractors
- serial search for (almost all) combinations
  - speed depends on number of distractors

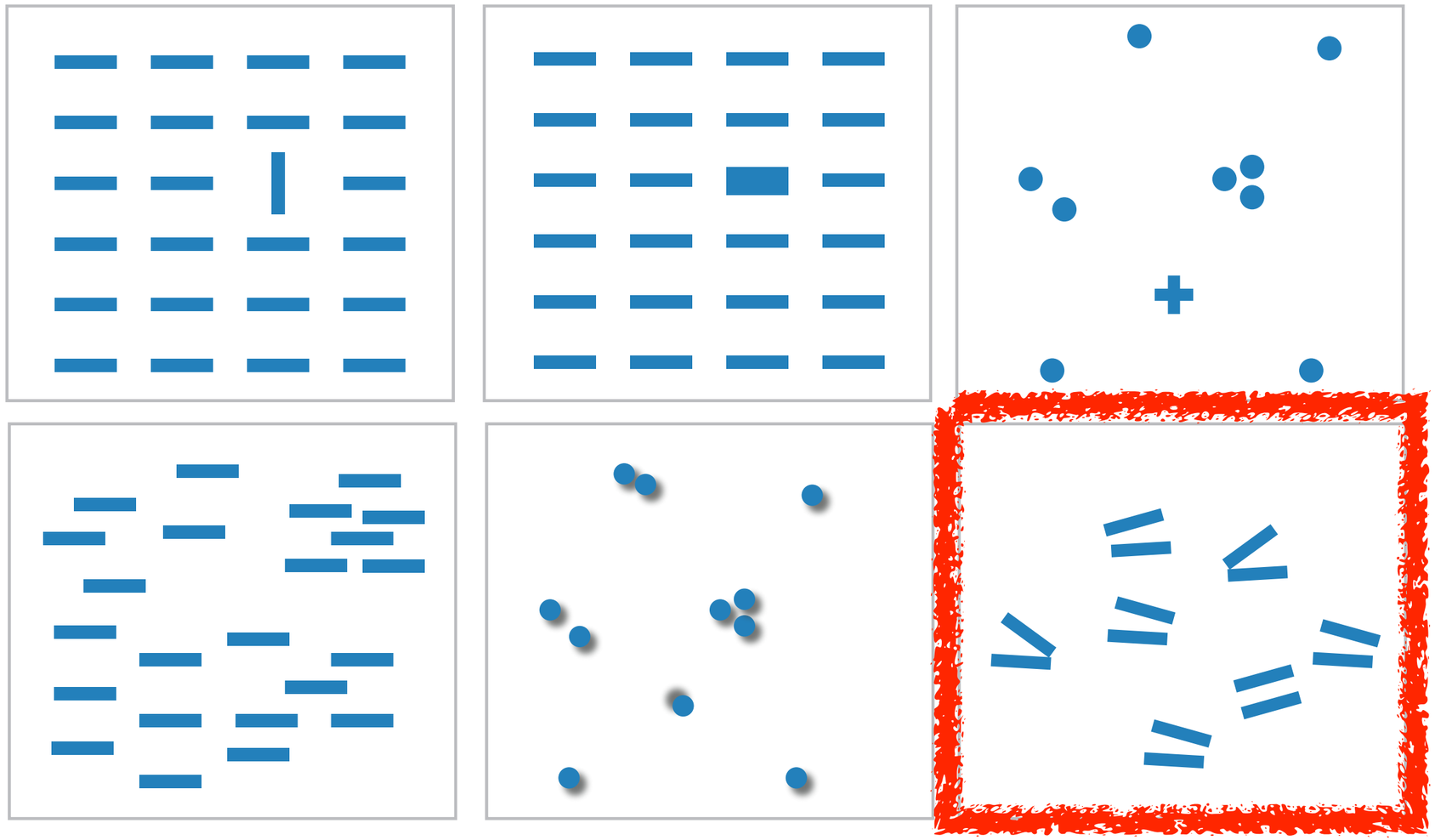


Popout



- many channels
  - tilt, size, shape, proximity, shadow direction, ...

Popout



- many channels
  - tilt, size, shape, proximity, shadow direction, ...
- but not all!
  - parallel line pairs do not pop out from tilted pairs

Factors affecting accuracy

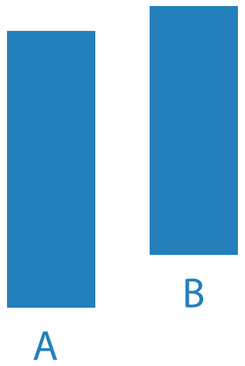
- alignment
- distractors
- distance
- common scale

Relative vs. absolute judgements

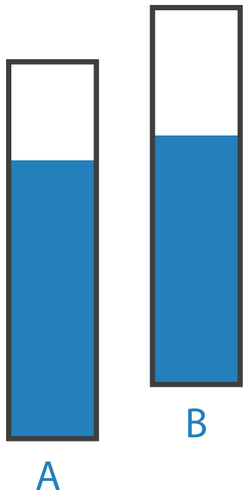
- perceptual system mostly operates with relative judgements, not absolute

Relative vs. absolute judgements

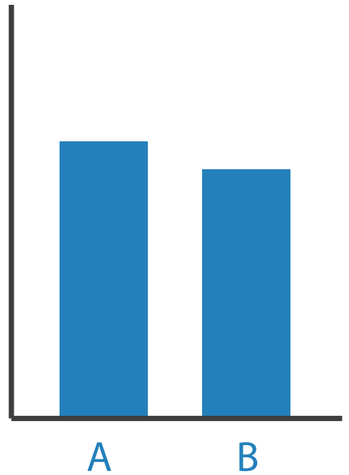
- perceptual system mostly operates with relative judgements, not absolute
  - that's why accuracy increases with common frame/scale and alignment



length



position along unaligned common scale

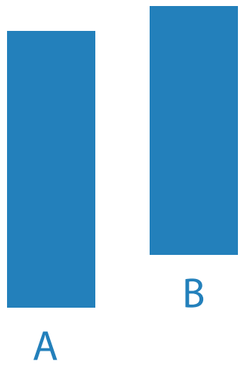


position along aligned scale

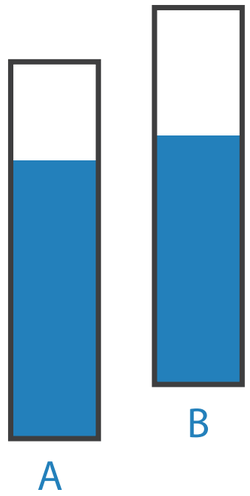
after [Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods. Cleveland and McGill. Journ. American Statistical Association 79:387 (1984), 531–554.]

Relative vs. absolute judgements

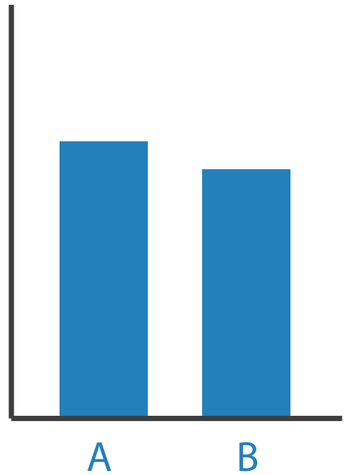
- perceptual system mostly operates with relative judgements, not absolute
  - that's why accuracy increases with common frame/scale and alignment
  - Weber's Law: ratio of increment to background is constant



length



position along unaligned common scale



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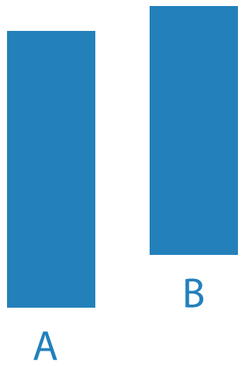
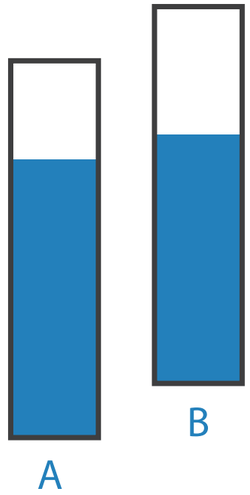
Relative vs. absolute judgements

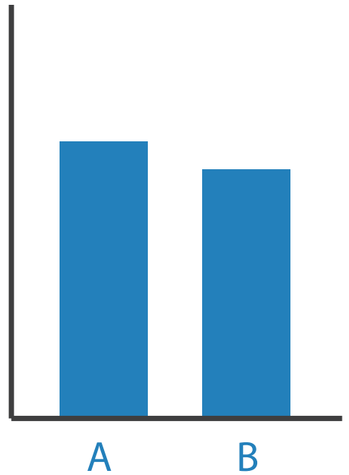
- perceptual system mostly operates with relative judgements, not absolute
  - that's why accuracy increases with common frame/scale and alignment
  - Weber's Law: ratio of increment to background is constant
    - filled rectangles differ in length by 1:9, difficult judgement
    - white rectangles differ in length by 1:2, easy judgement



length



position along unaligned common scale



position along aligned scale

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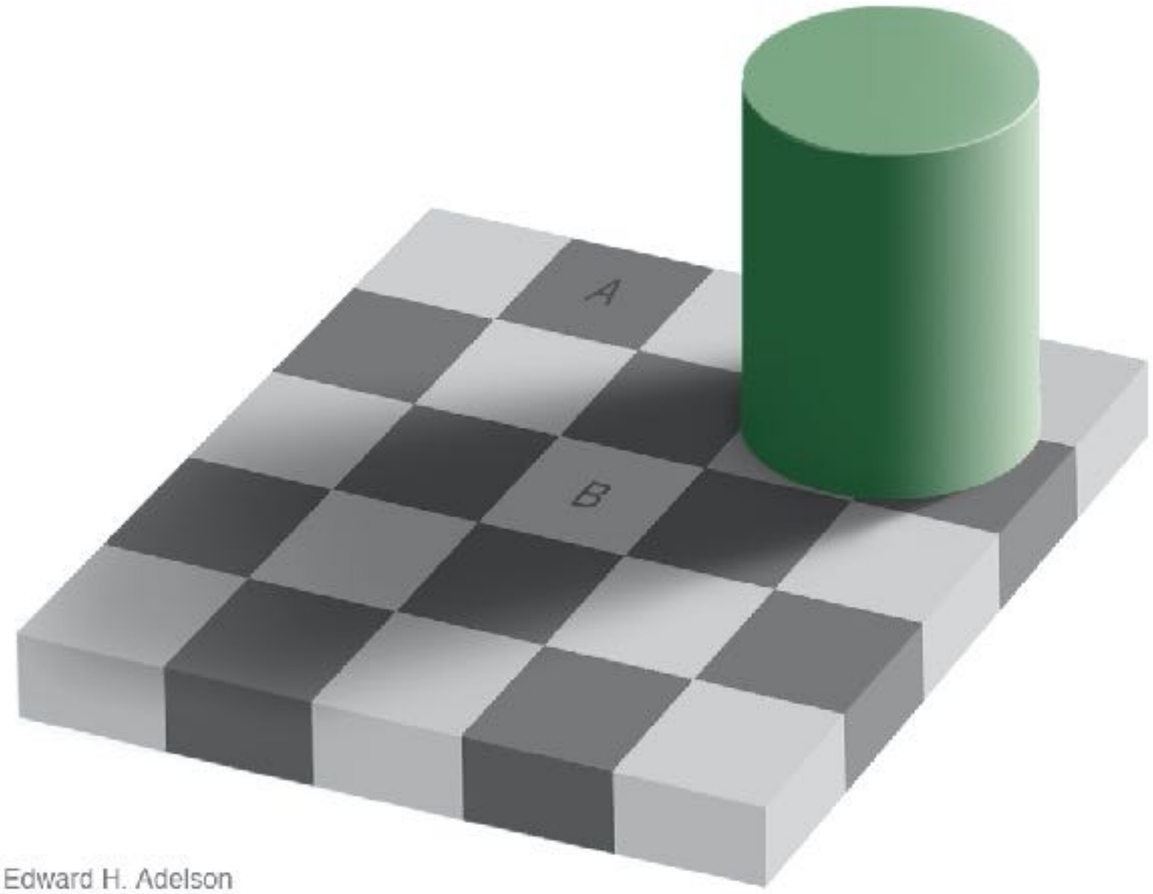
Relative luminance judgements

- perception of luminance is contextual based on contrast with surroundings



Edward H. Adelson

http://persci.mit.edu/gallery/checkershadow

Relative luminance judgements

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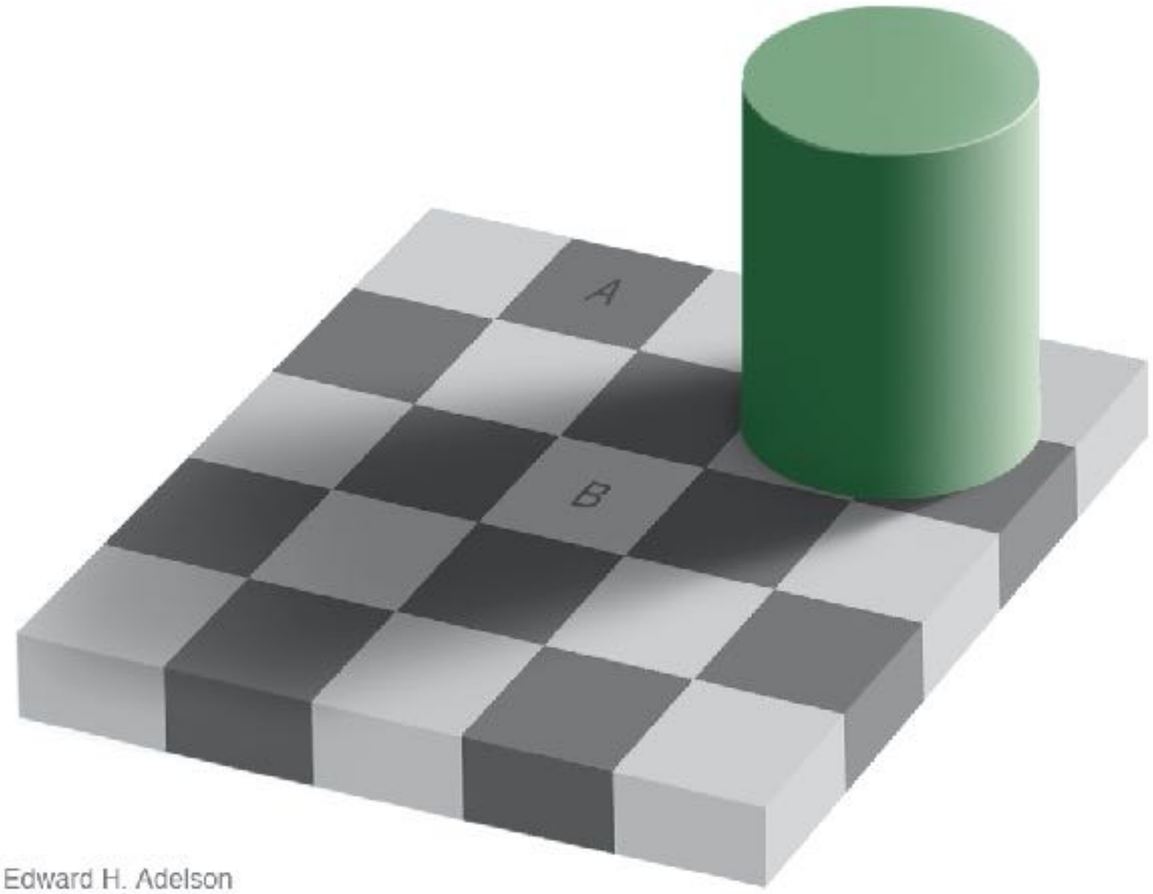
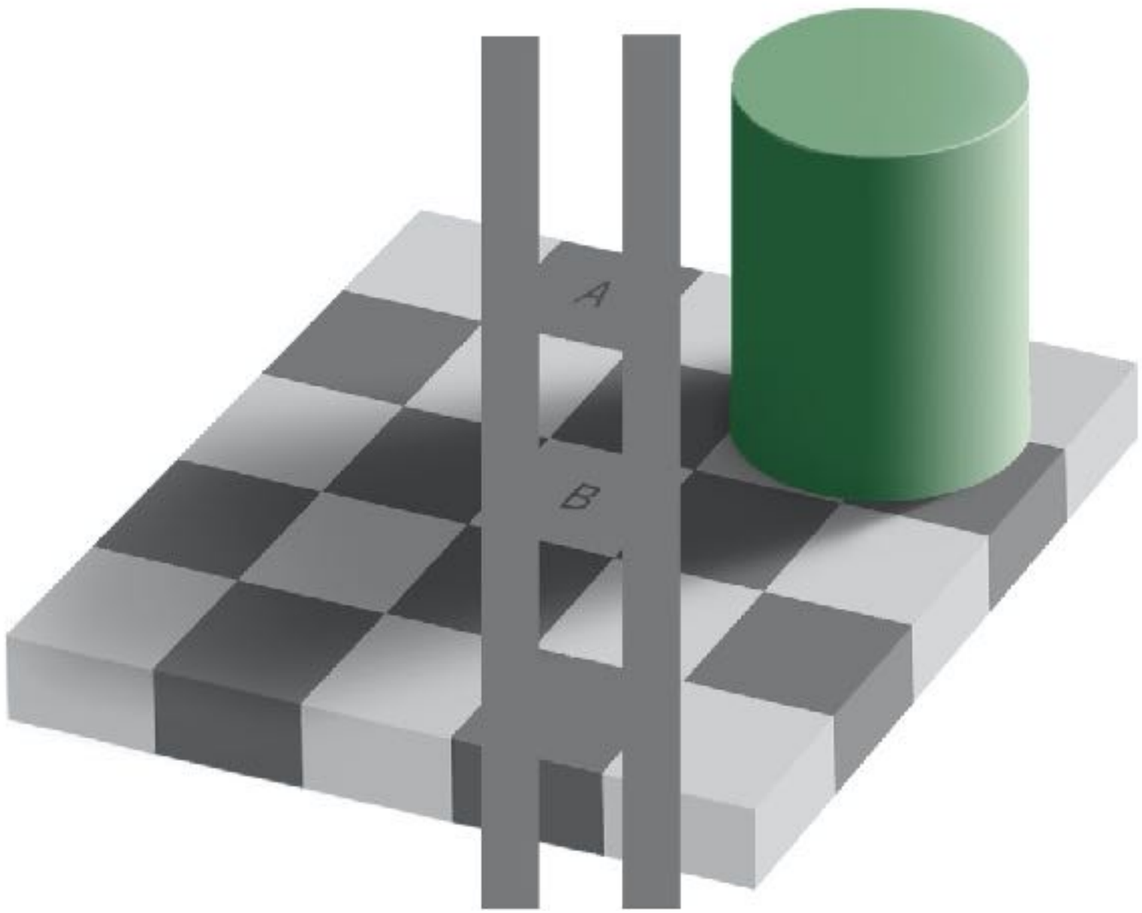


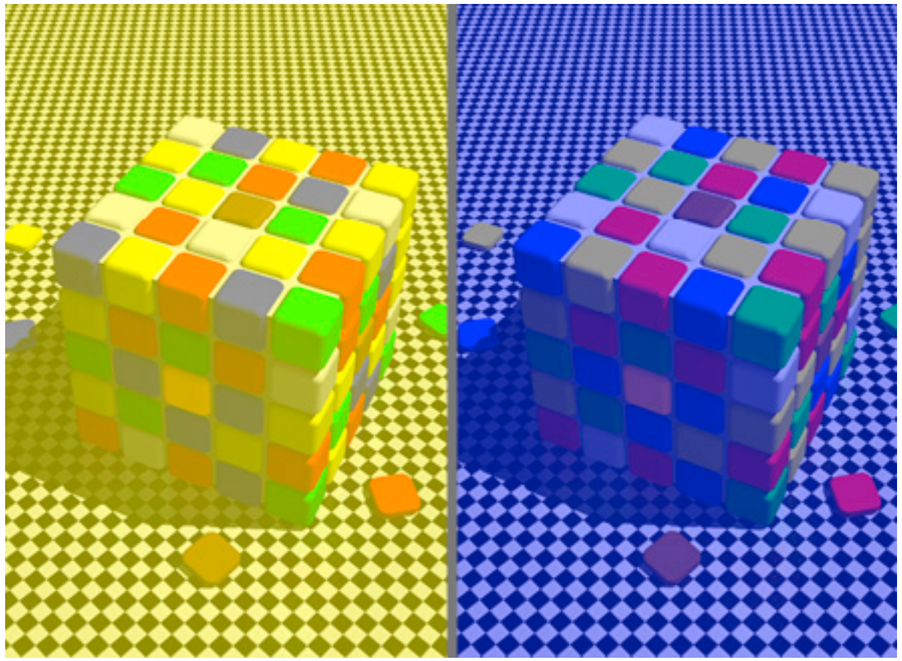
Edward H. Adelson



http://persci.mit.edu/gallery/checkershadow

Relative color judgements

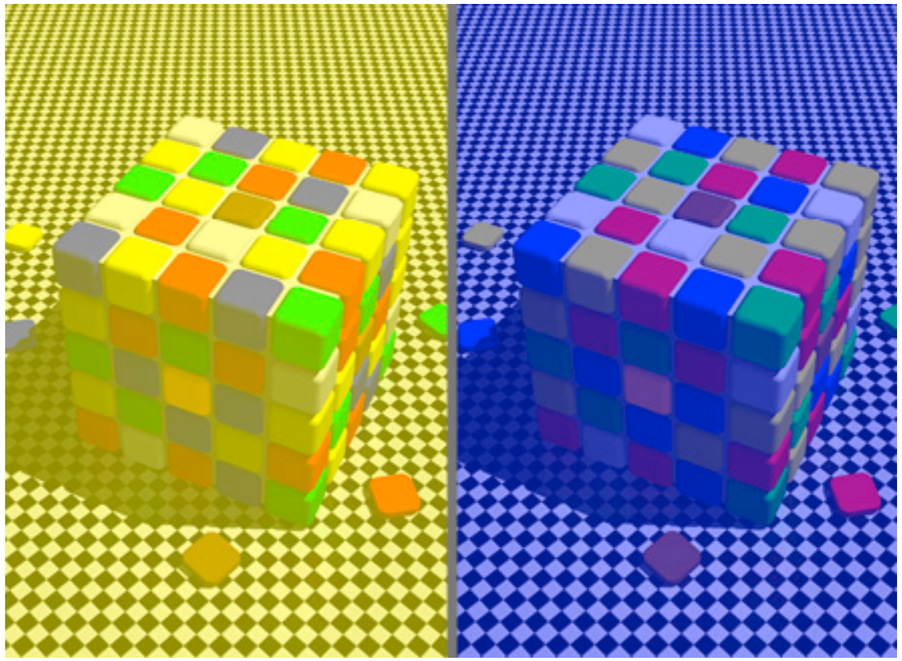
- color constancy across broad range of illumination conditions

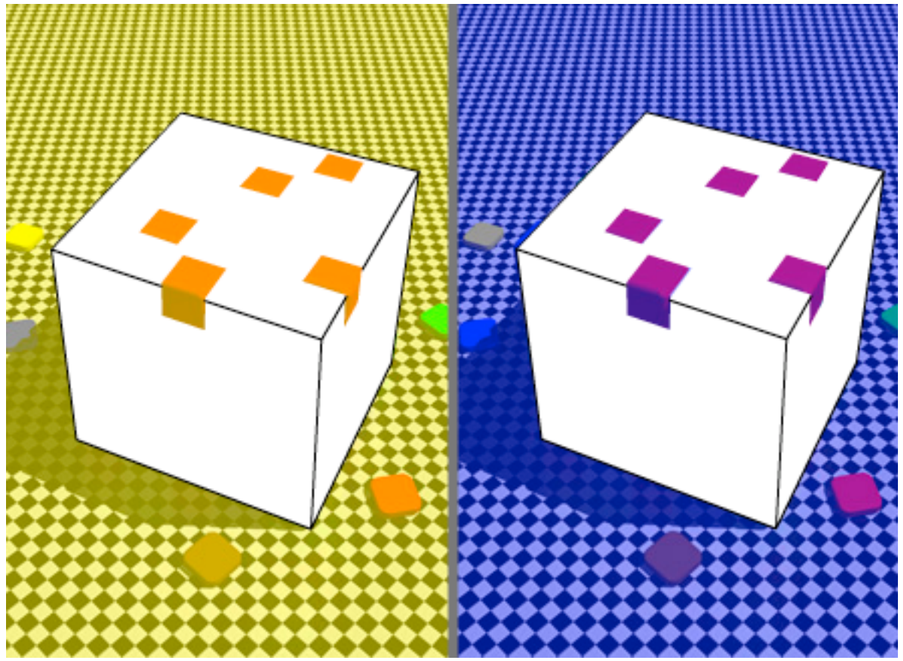


http://www.purveslab.net/seeforyourself/

Relative color judgements

- color constancy across broad range of illumination conditions





http://www.purveslab.net/seeforyourself/

Grouping

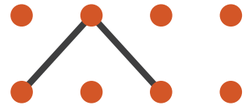
- containment
- connection

- proximity
  - same spatial region
- similarity
  - same values as other categorical channels

Marks as Links

Containment

Connection

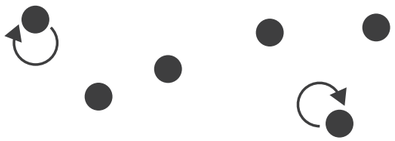


Identity Channels: Categorical Attributes

Spatial region

Color hue

Motion



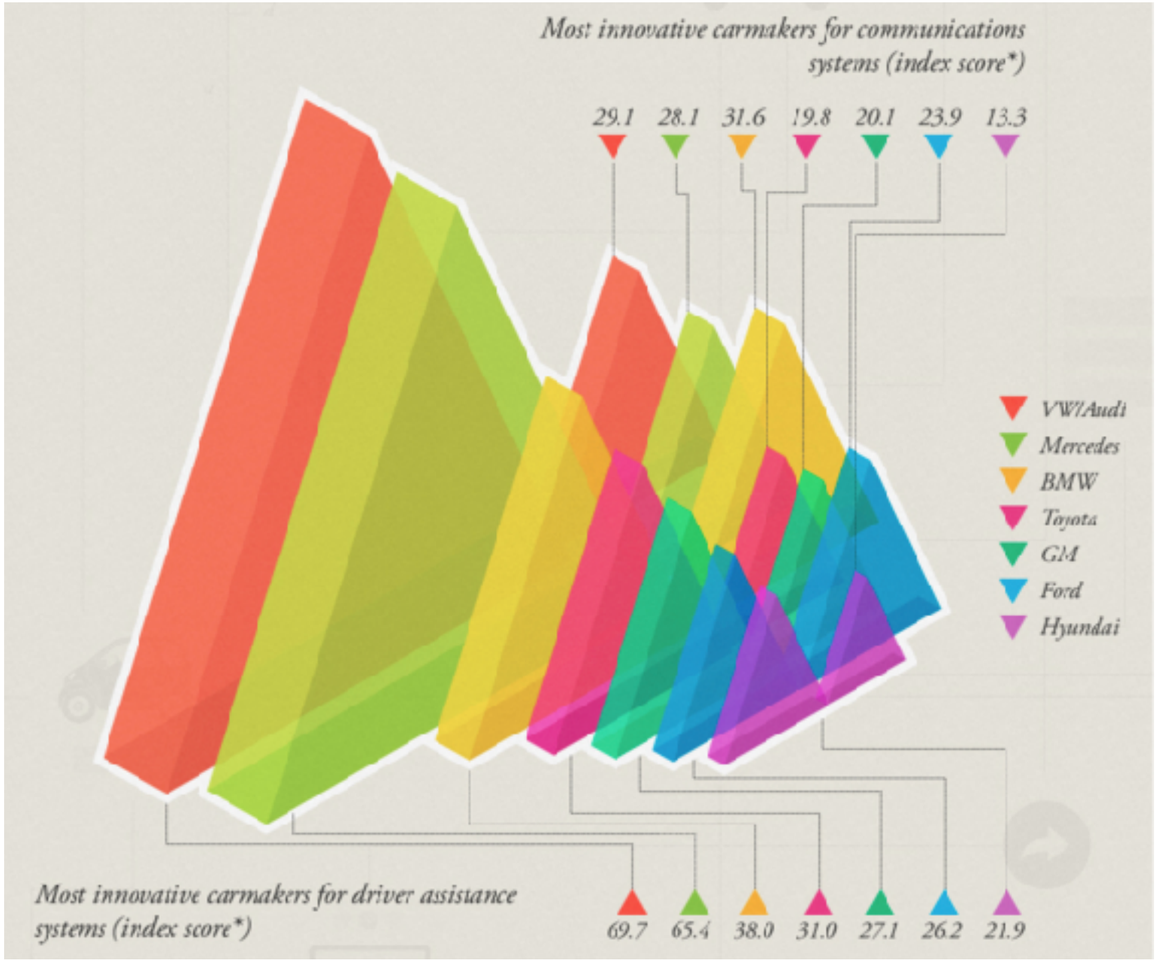
Shape

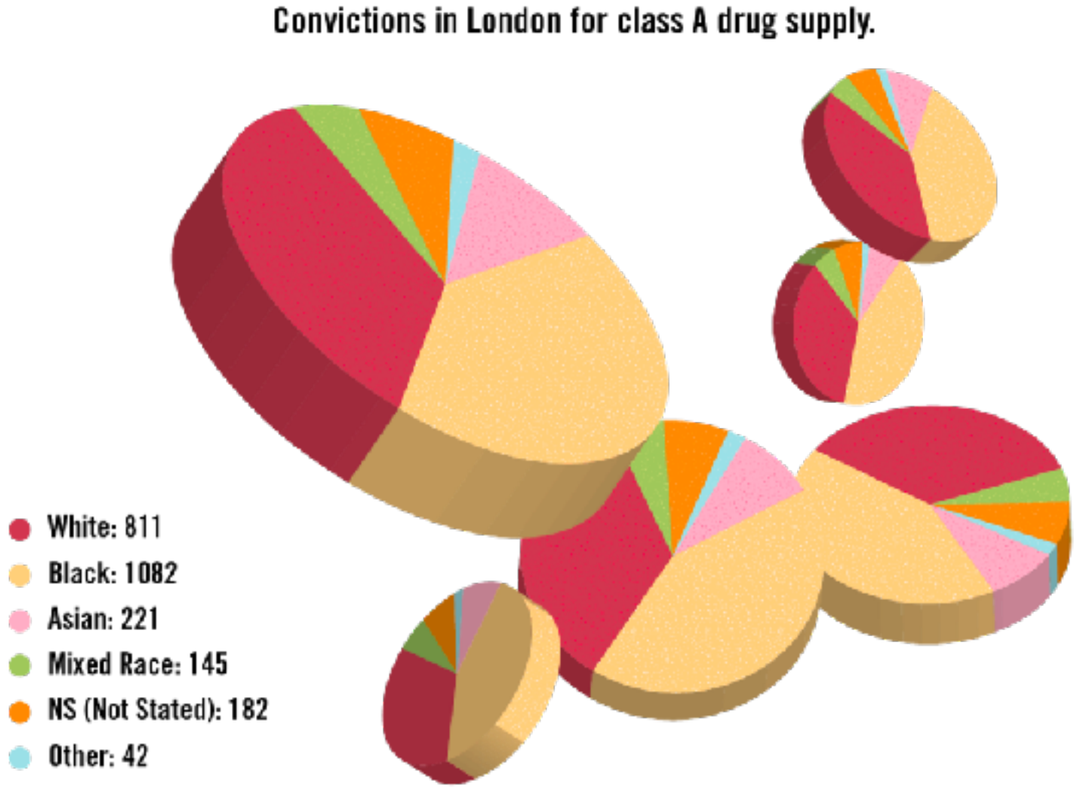
Rules of Thumb

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



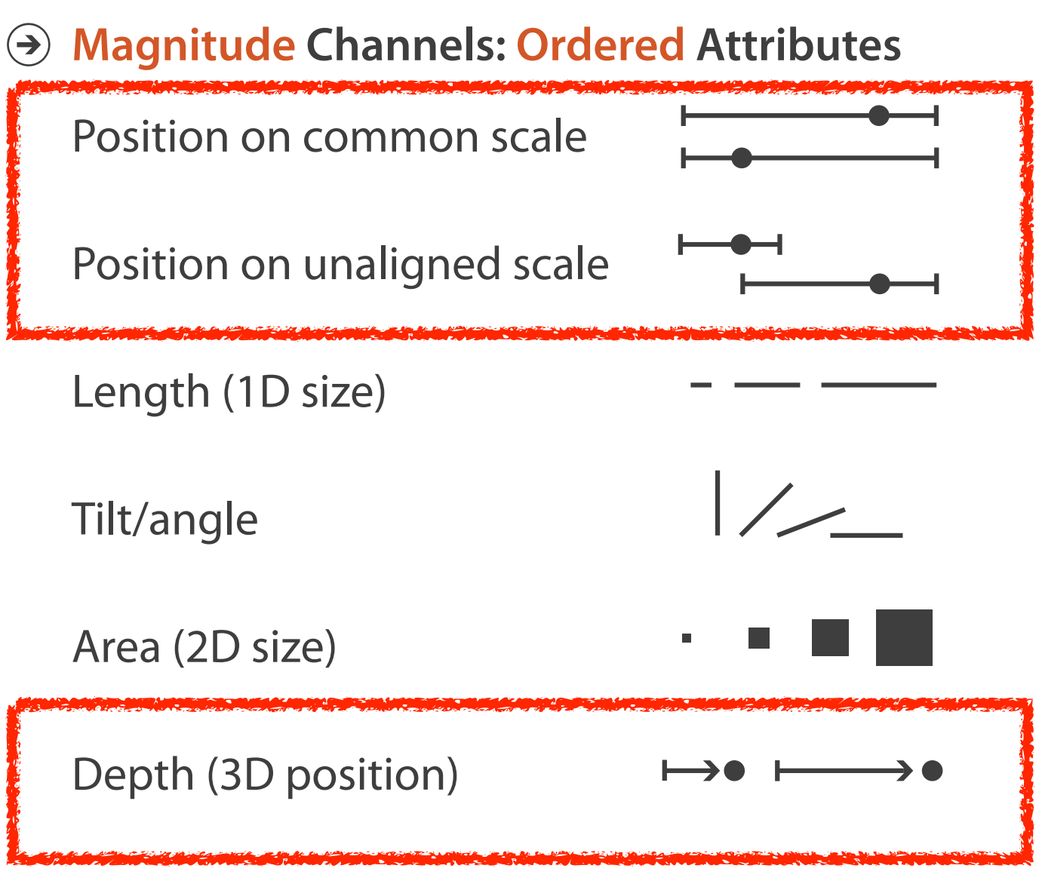


http://viz.wtf/post/137826497077/eye-popping-3d-triangles

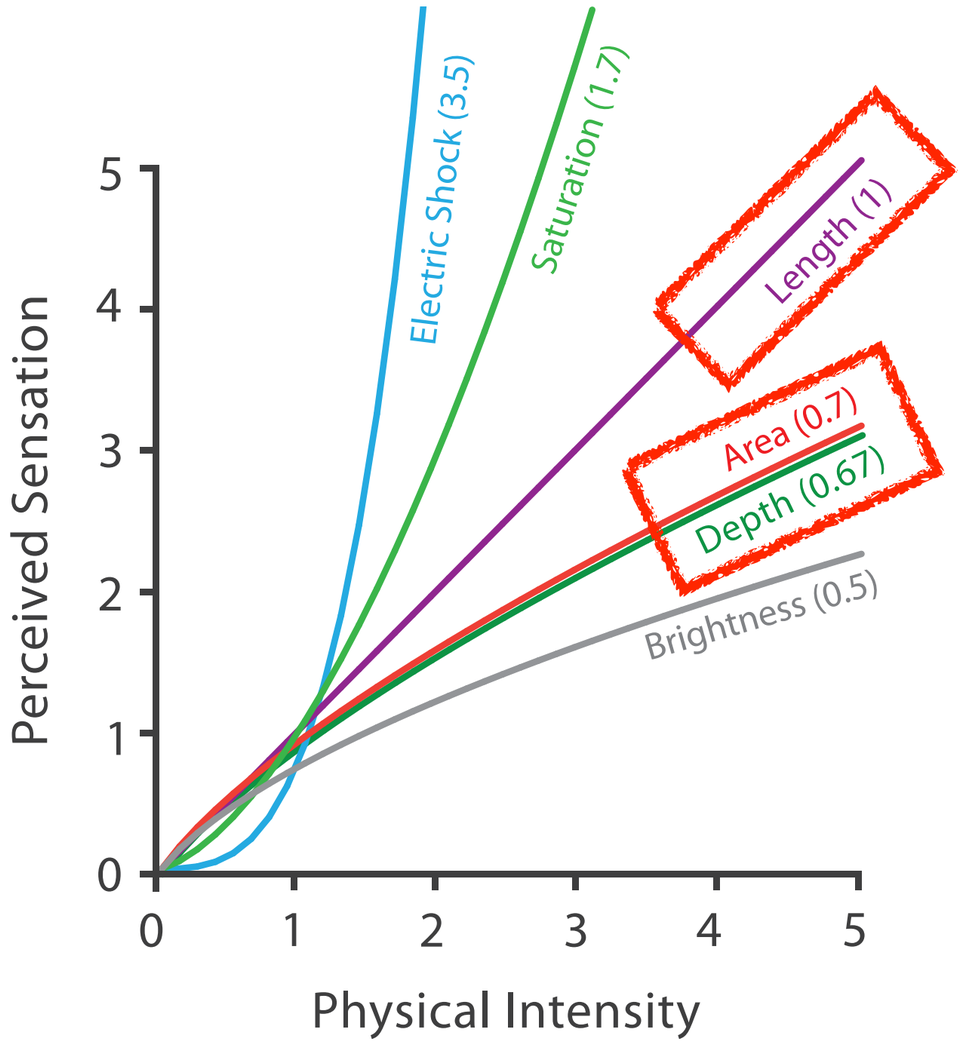
http://viz.wtf/post/139002022202/designer-drugs-ht-ducqn

Depth vs power of the plane

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

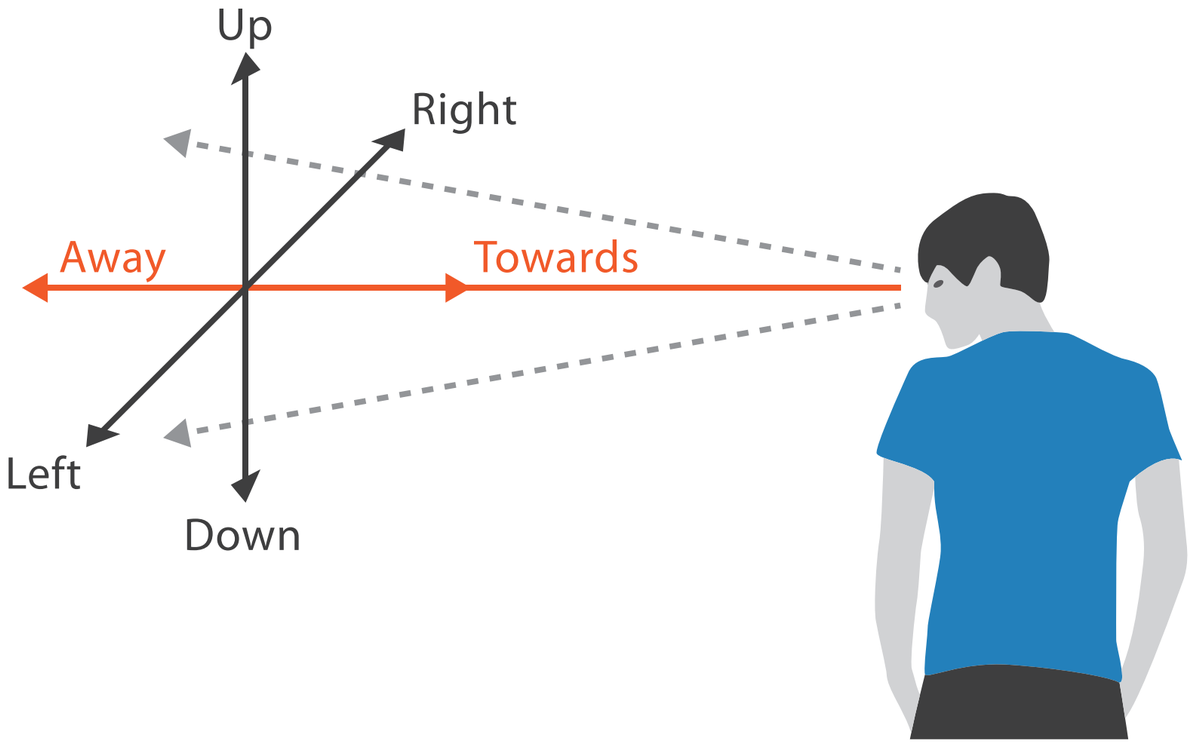


Steven's Psychophysical Power Law: $S = I^N$

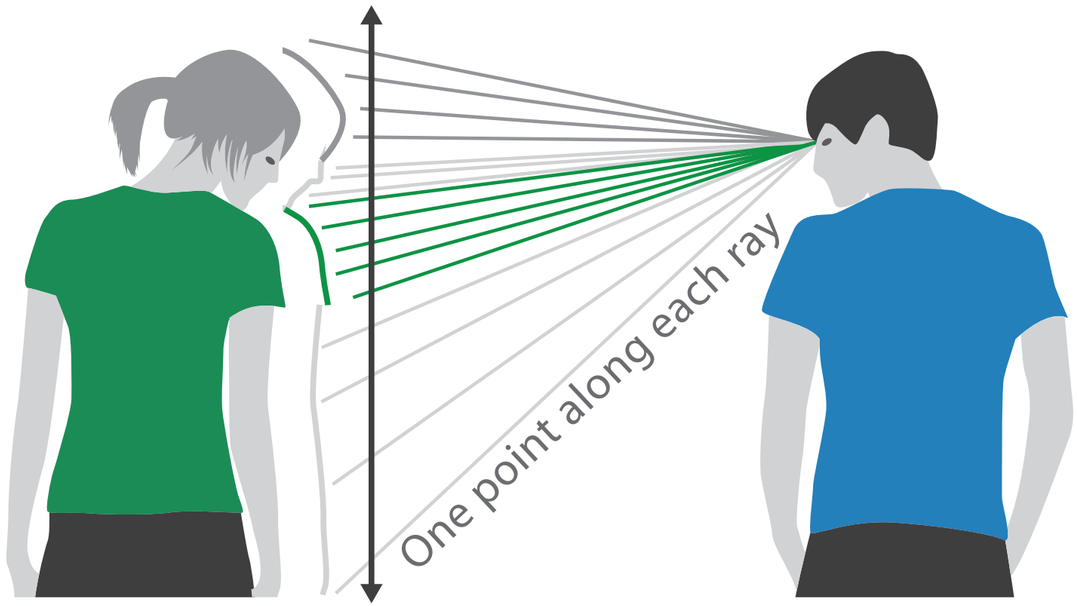


No unjustified 3D: Danger of depth

- 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



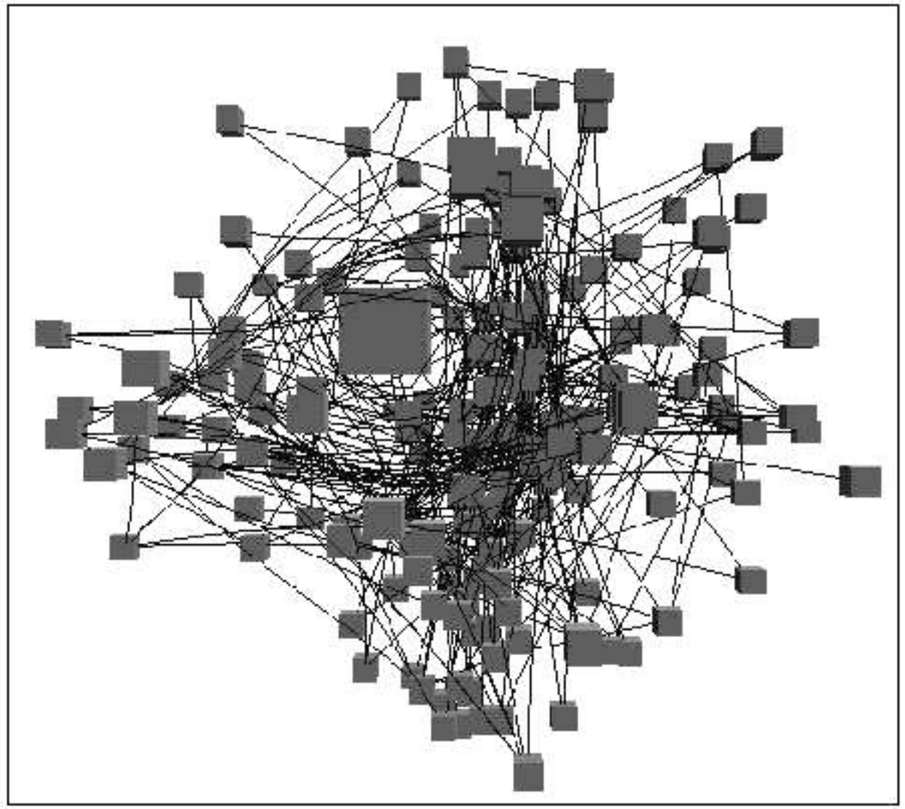
Thousands of points up/down and left/right



We can only see the outside shell of the world

Occlusion hides information

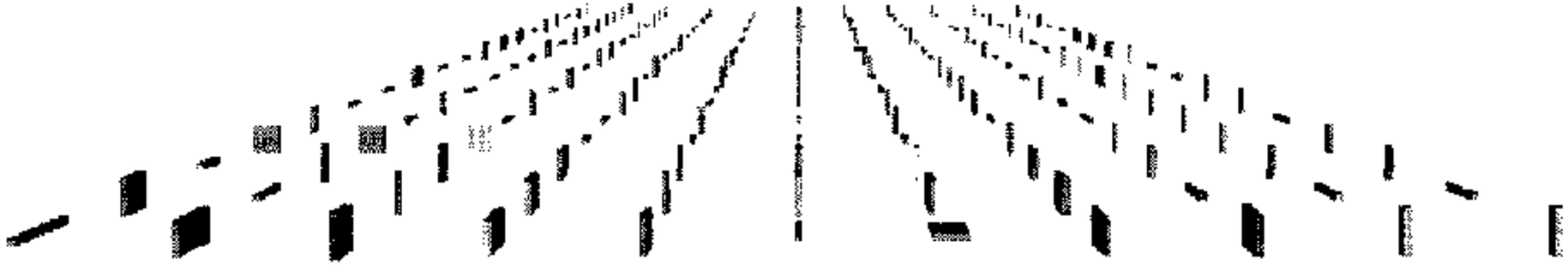
- occlusion
- interaction can resolve, but at cost of time and cognitive load



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

Perspective distortion loses information

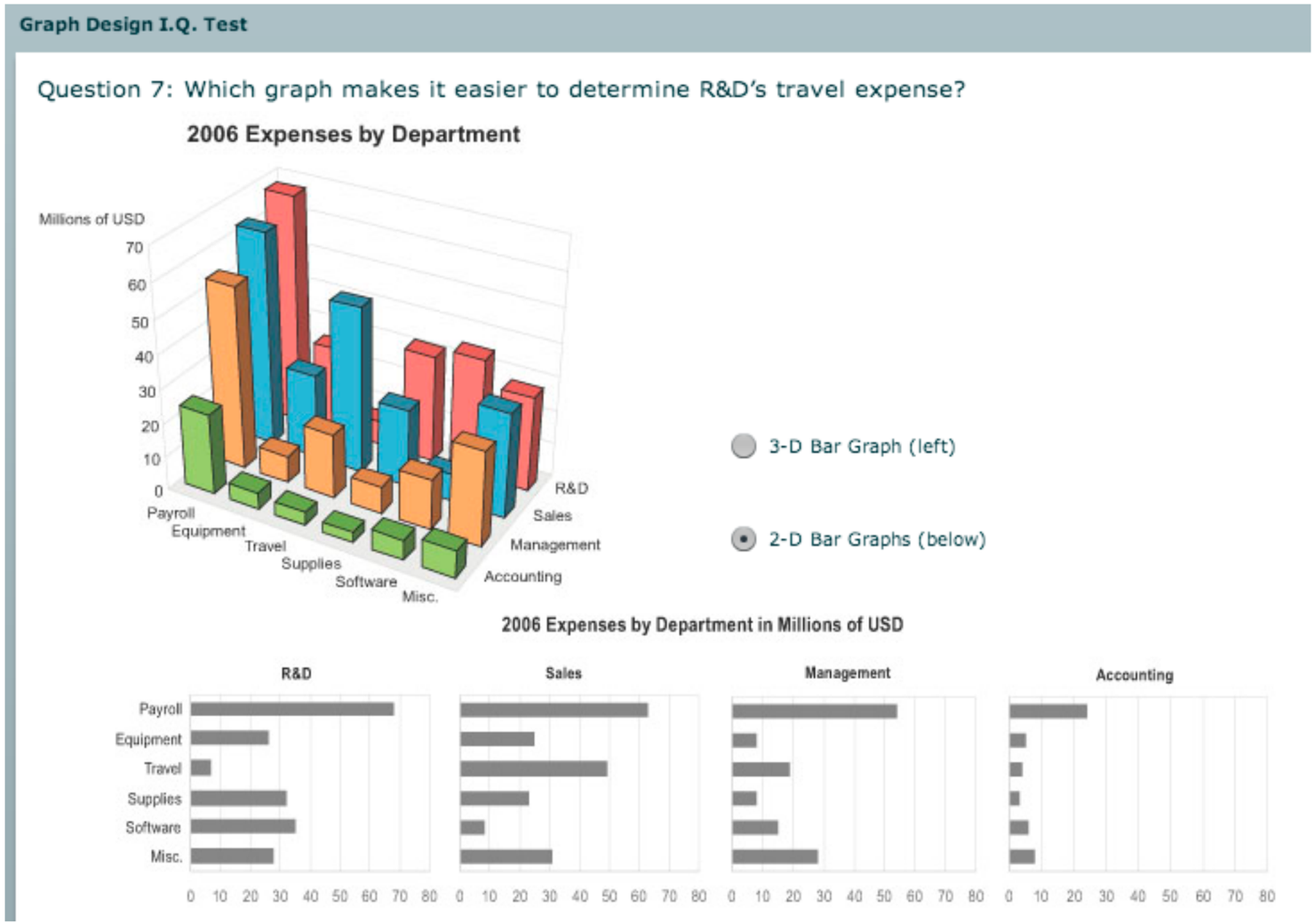
- perspective distortion
  - interferes with all size channel encodings
  - power of the plane is lost!



[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



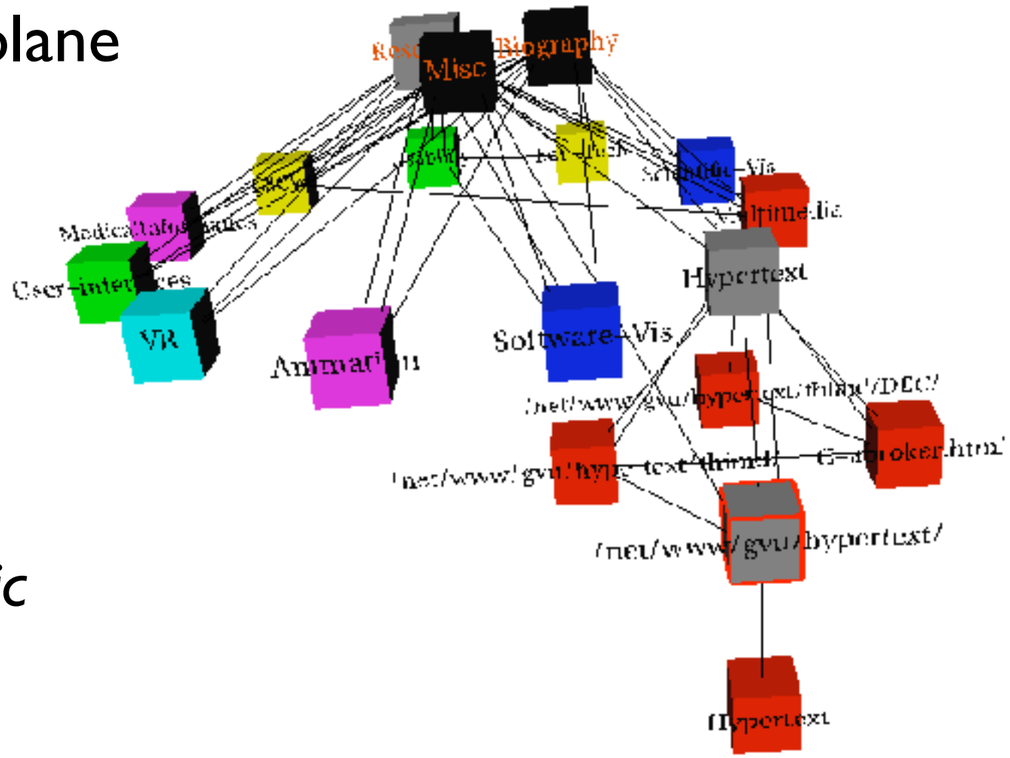
[http://perceptualedge.com/files/GraphDesignIQ.html]

Tilted text isn't legible

- text legibility
  - far worse when tilted from image plane

- further reading

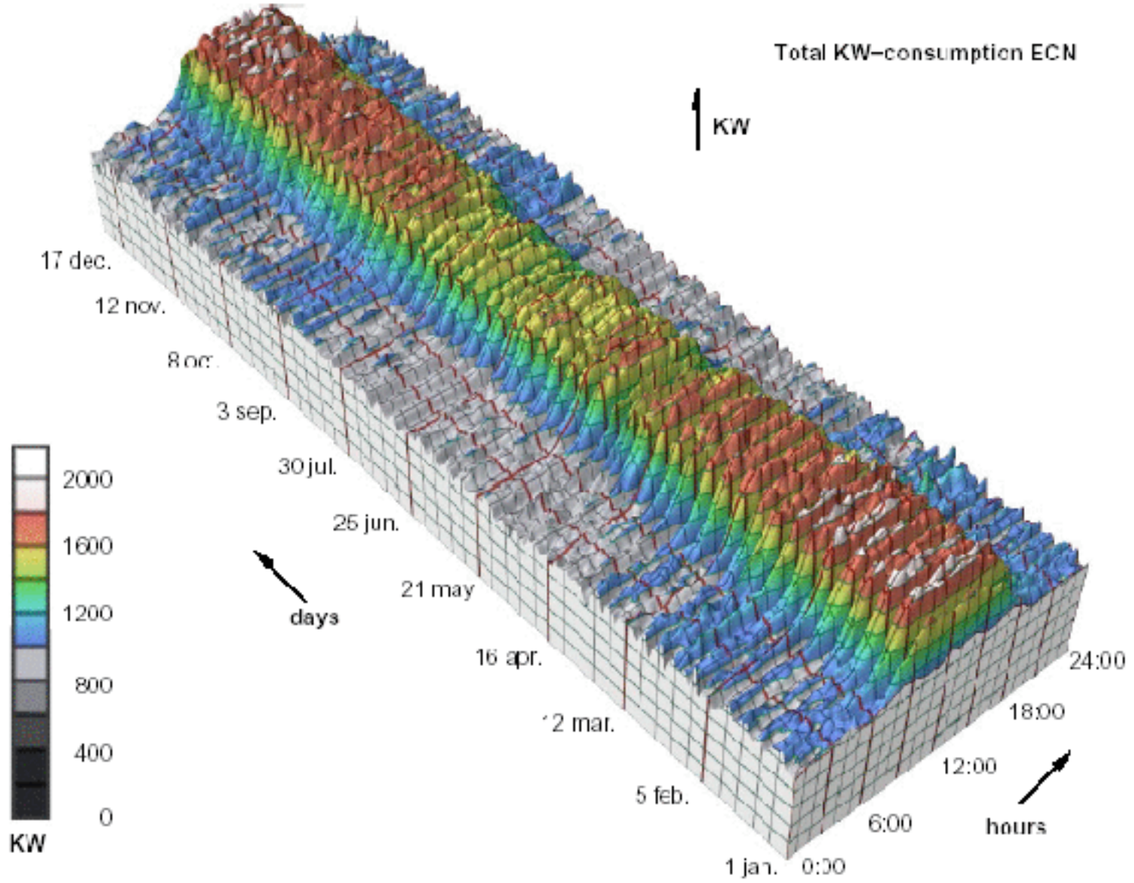
  [Exploring and Reducing the Effects of Orientation on Text Readability in Volumetric Displays.
  Grossman et al. CHI 2007]



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

No unjustified 3D example: Time-series data

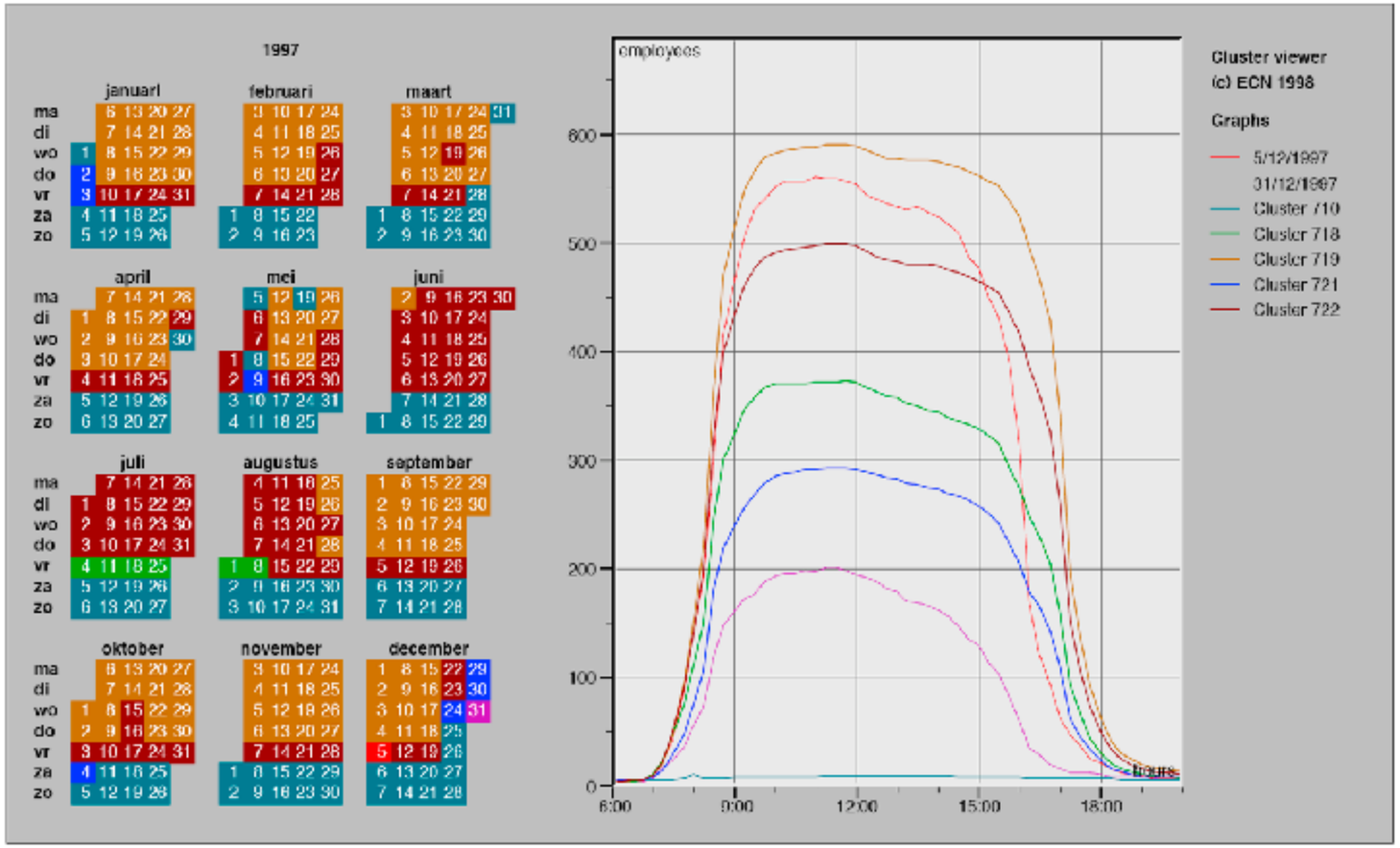
- extruded curves: detailed comparisons impossible



[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

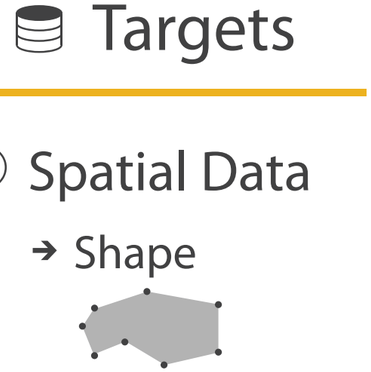
- derived data: cluster hierarchy
- juxtapose multiple views: calendar, superimposed 2D curves

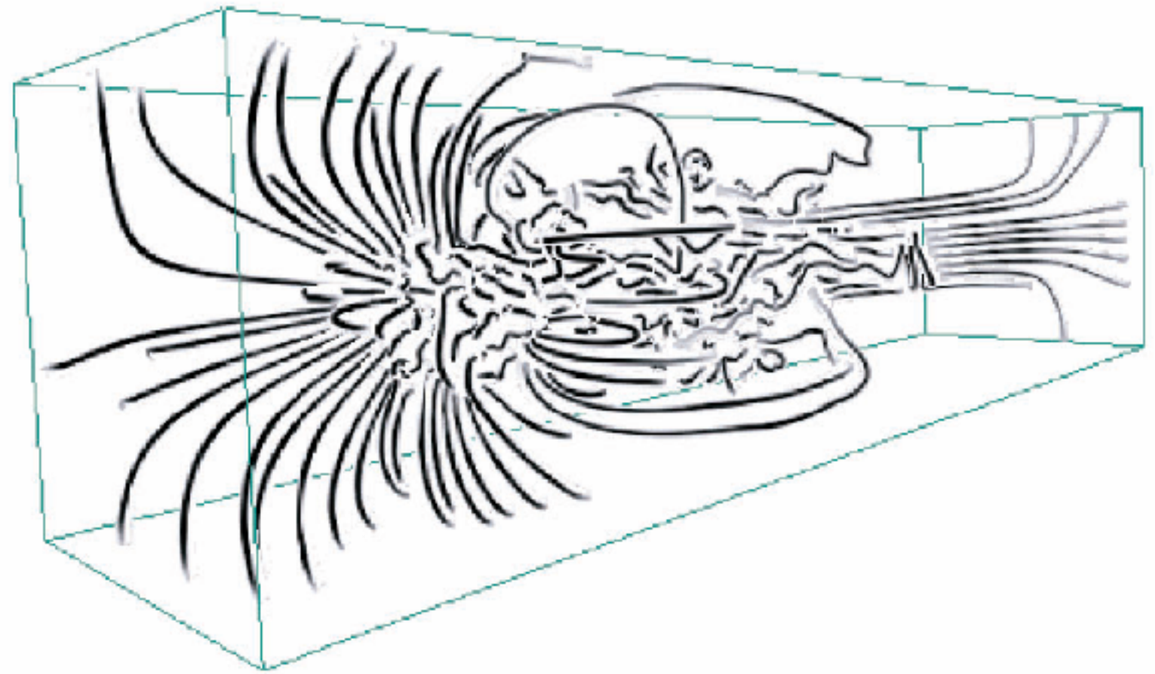


[Cluster and Calendar based Visualization of Time Series Data. van Wijk and van Selow, Proc. InfoVis 99.]

Justified 3D: shape perception

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

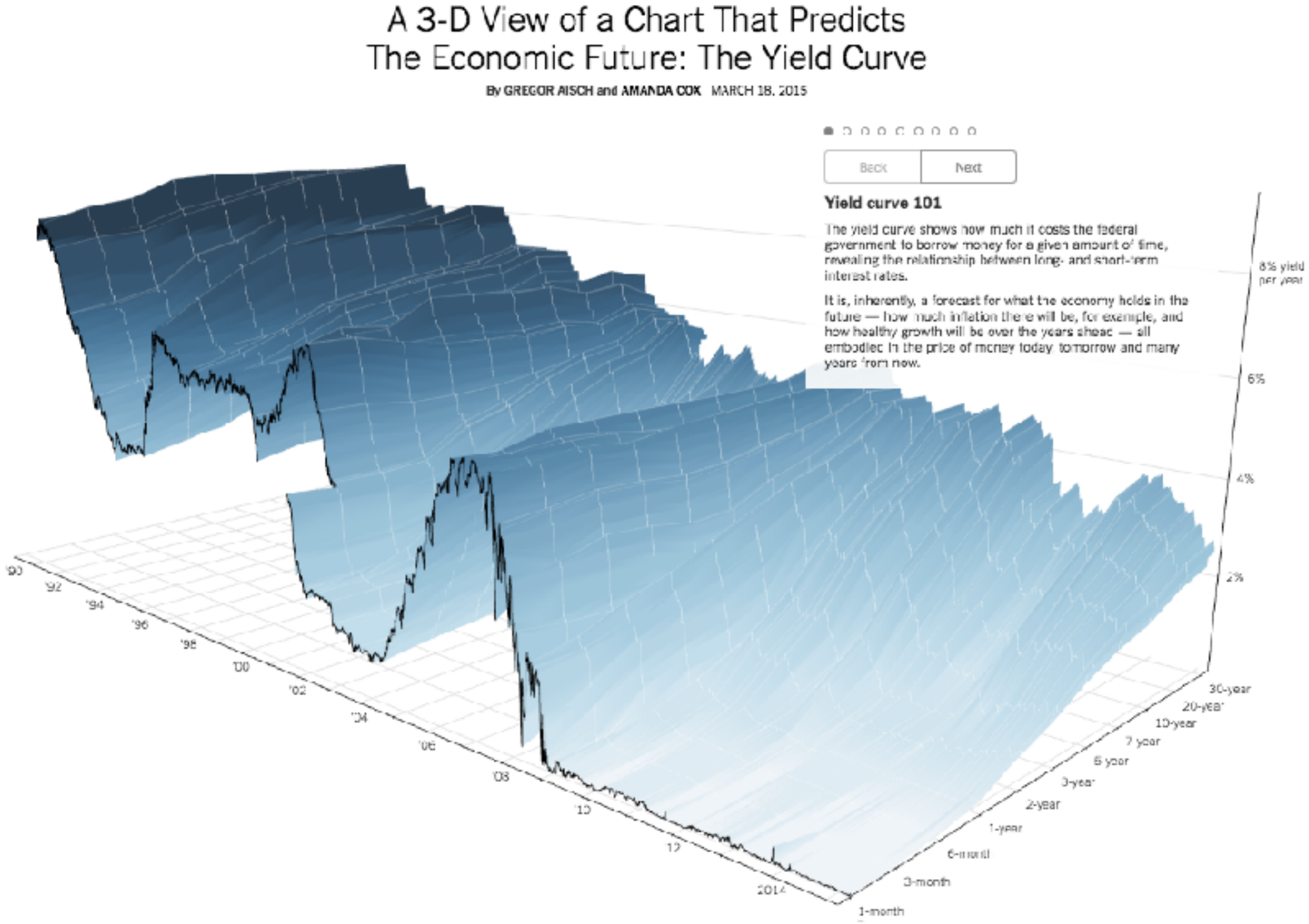




[Image-Based Streamline Generation and Rendering. Li and Shen. IEEE Trans. Visualization and Computer Graphics (TVCG) 13:3 (2007), 630–640.]

Justified 3D: Economic growth curve

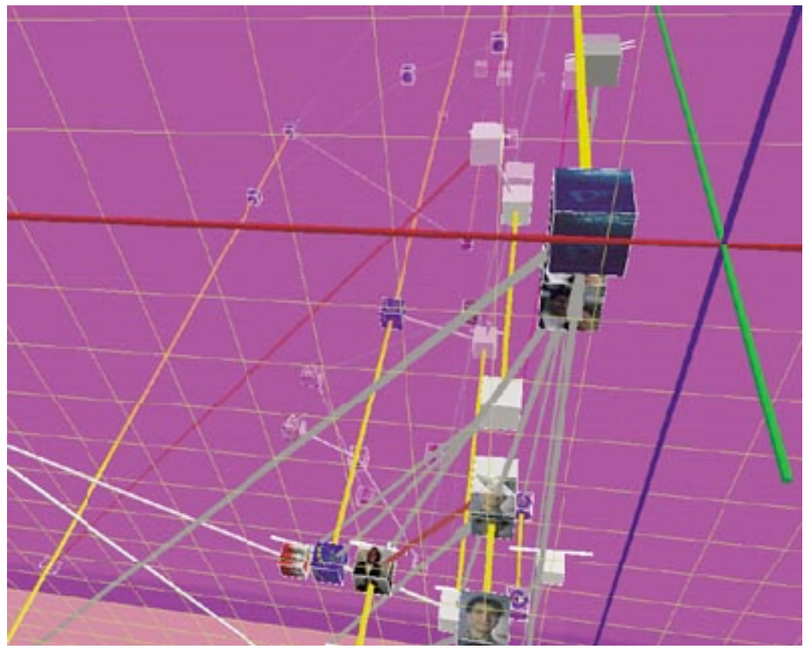
- constrained navigation steps through carefully designed viewpoints



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

No unjustified 3D

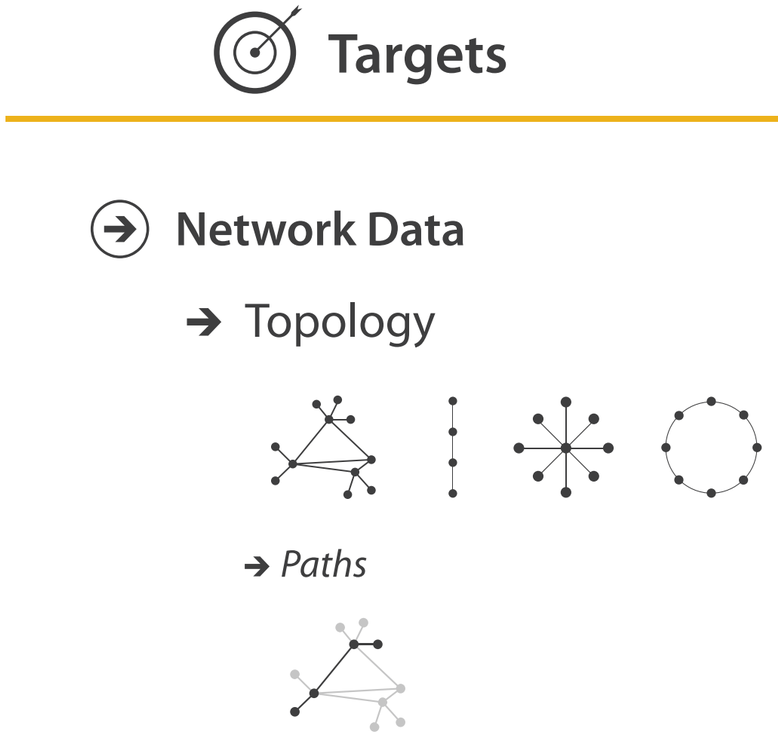
- 3D legitimate for true 3D spatial data
- 3D needs very careful justification for abstract data
  - enthusiasm in 1990s, but now skepticism
  - be especially careful with 3D for point clouds or networks



[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

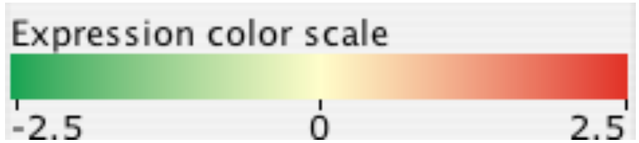


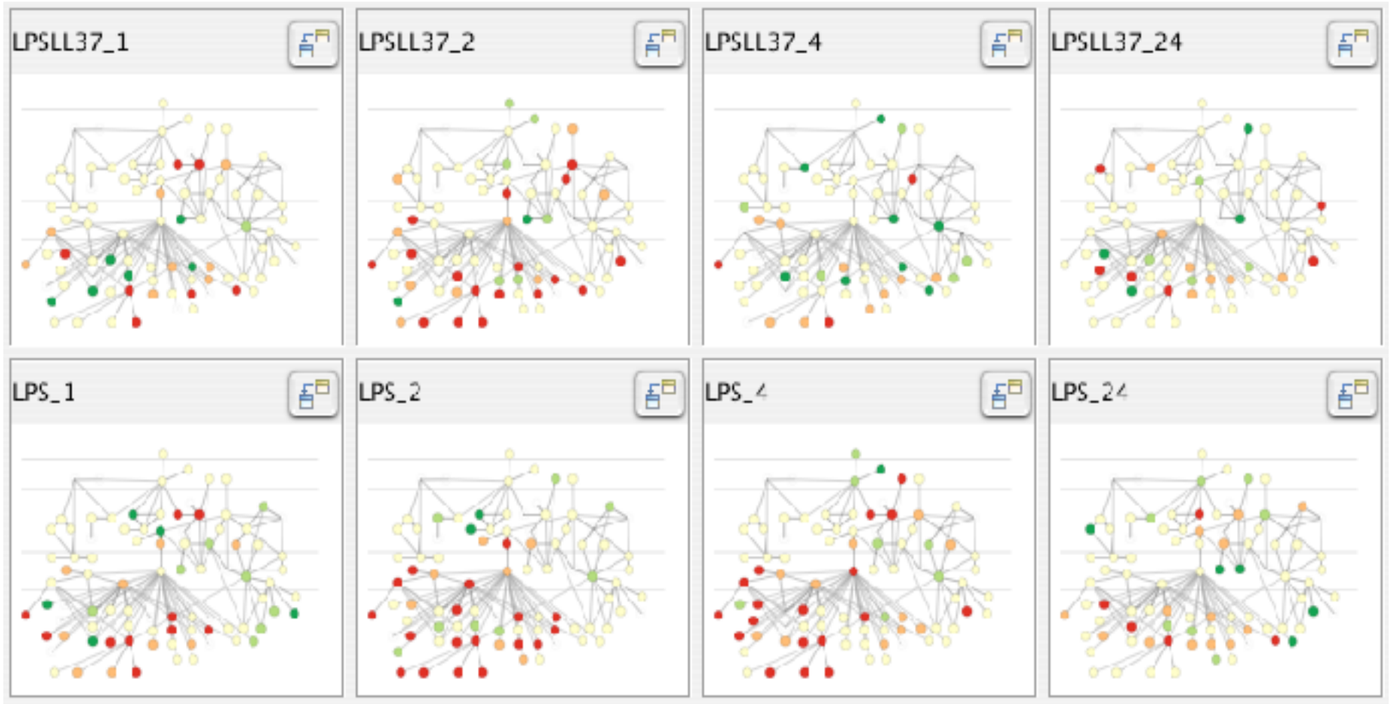
Eyes beat memory

- 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

Eyes beat memory example: Cerebral

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



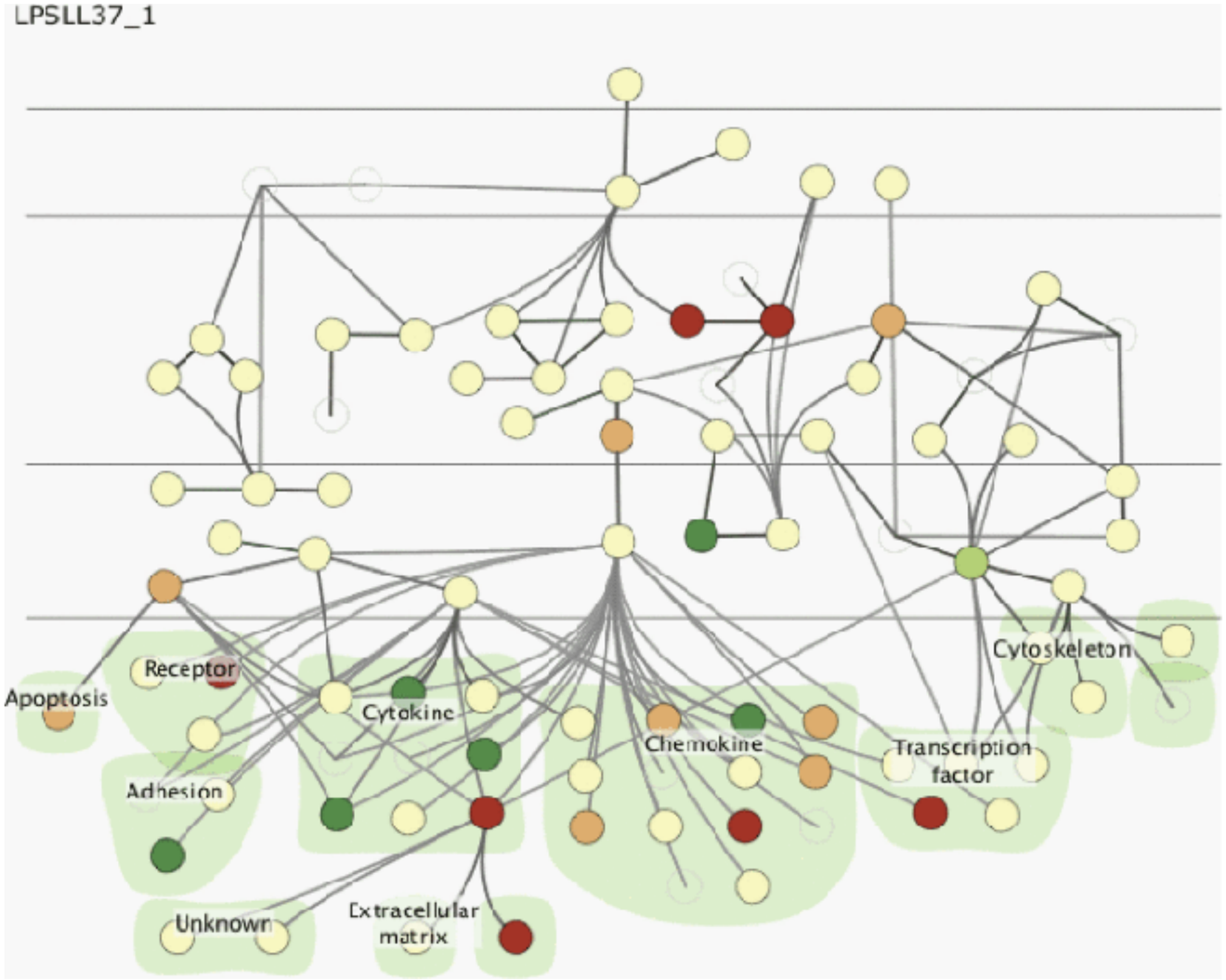


[Cerebral: Visualizing Multiple Experimental Conditions on a Graph with Biological Context. Barsky, Munzner, Gardy, and Kincaid. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2008) 14:6 (2008), 1253–1260.]

Why not animation?

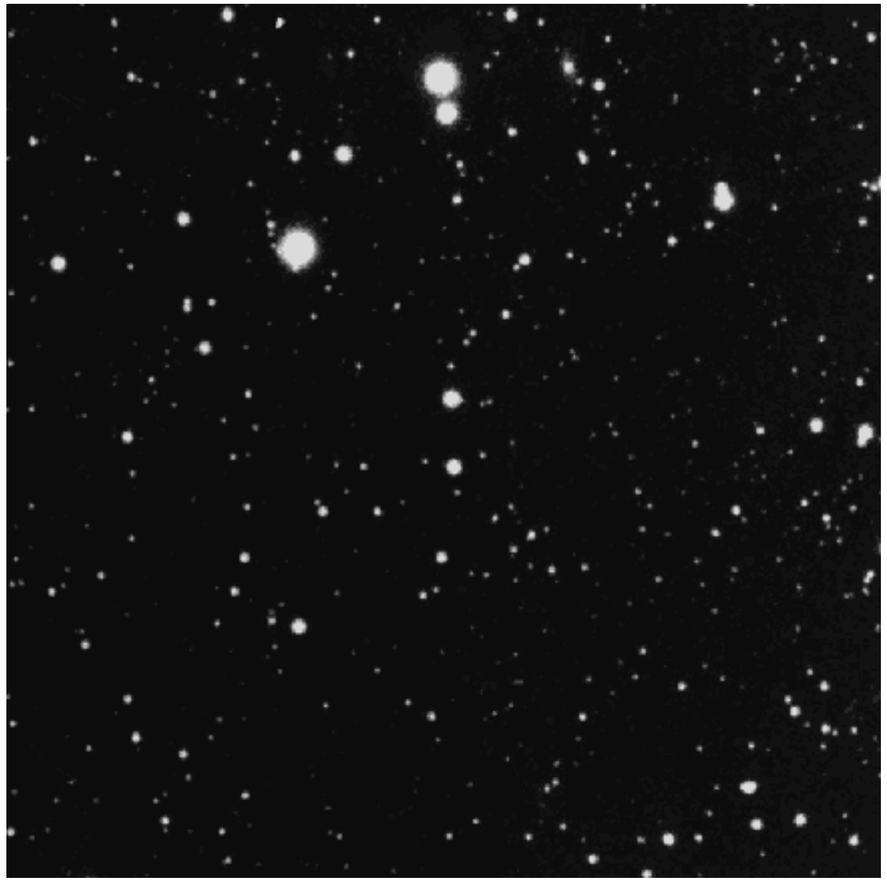
- disparate frames and regions: comparison difficult
  - vs contiguous frames
  - vs small region
  - vs coherent motion of group

- safe special case
  - animated transitions



Animation: Blink comparator

- just two contiguous frames is a special case: animation beats side by side
  - blink comparator used to discover Pluto

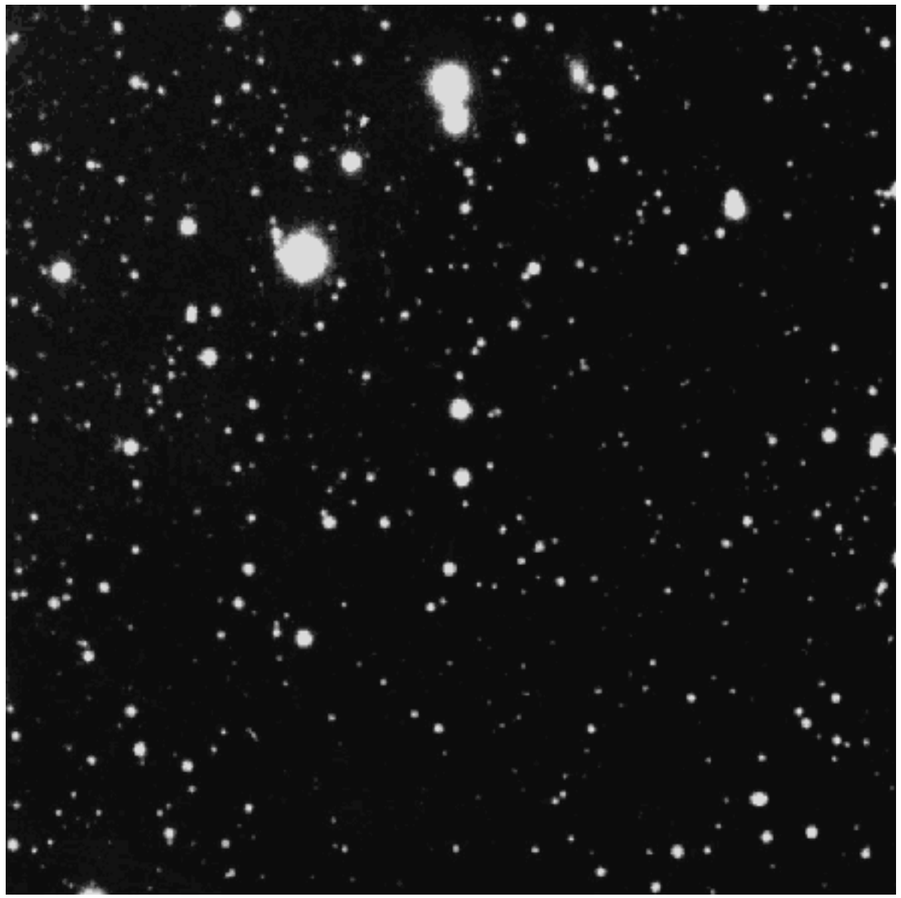


side by side

https://www.sightsize.com/the-blink-comparator/

Animation: Blink comparator

- just two contiguous frames is a special case: animation is great!
  - blink comparator used to discover Pluto



animated

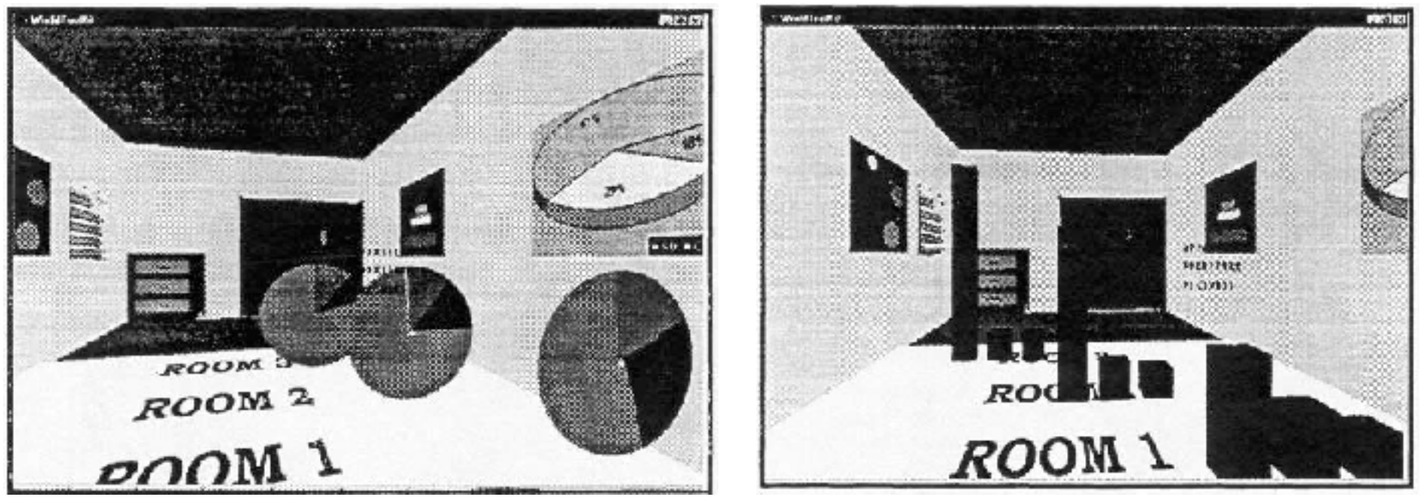
https://www.sightsize.com/the-blink-comparator/

Change blindness

- if attention is directed elsewhere, even drastic changes not noticeable
  - remember 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



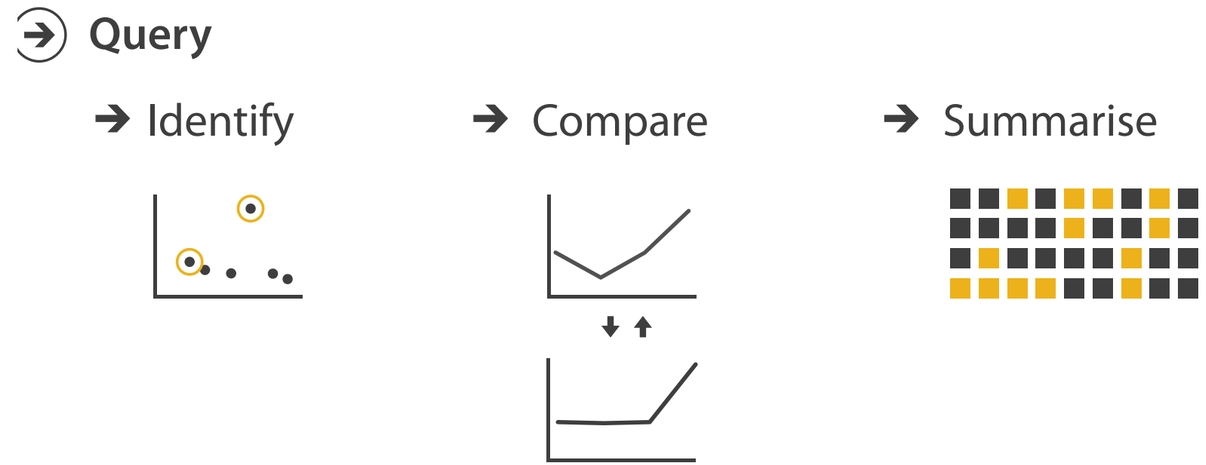
[Development of an information visualization tool using virtual reality. Kirner and Martins. Proc. Symp. Applied Computing 2000]

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



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)

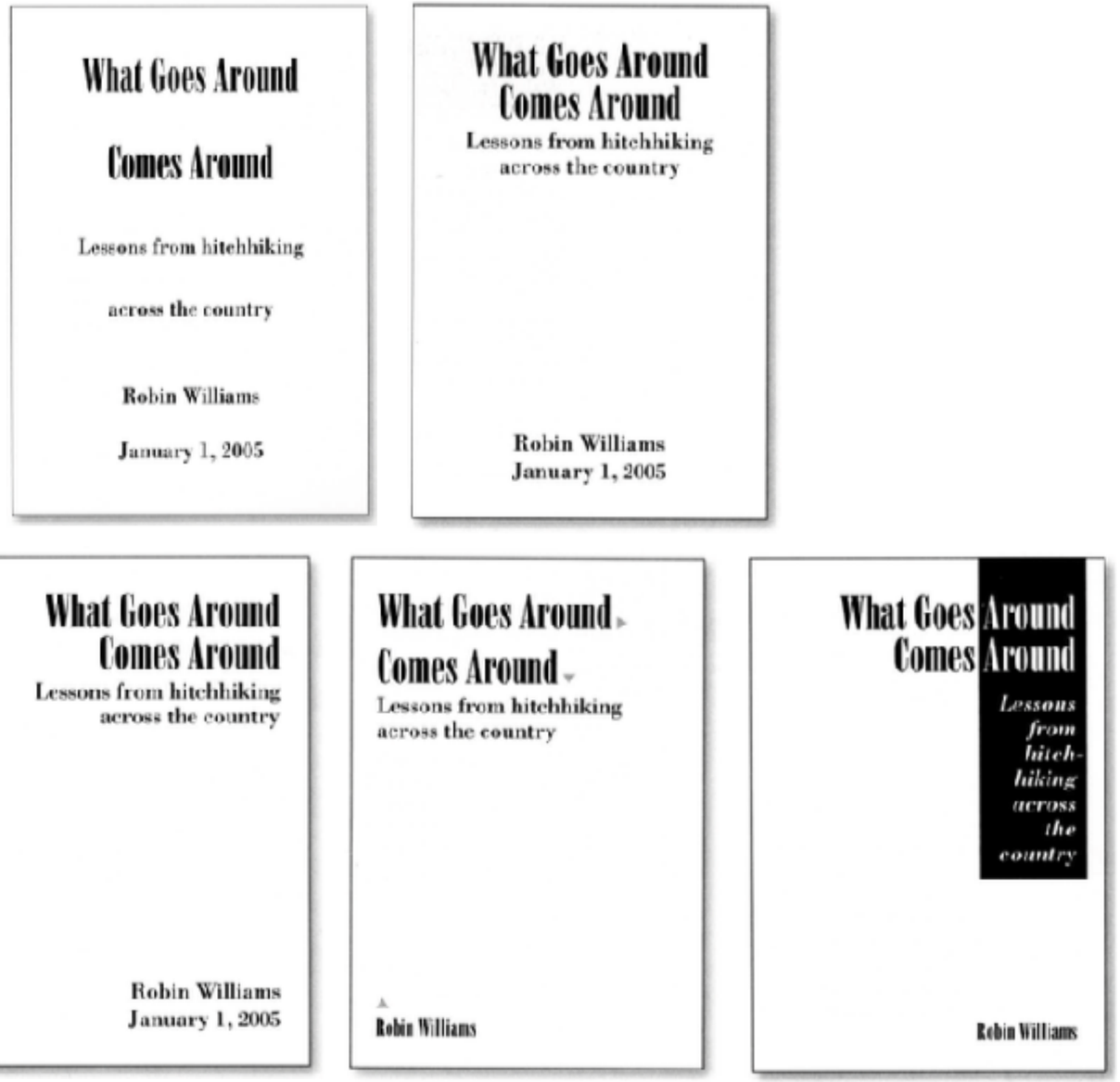
Function first, form next

- 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 ideas

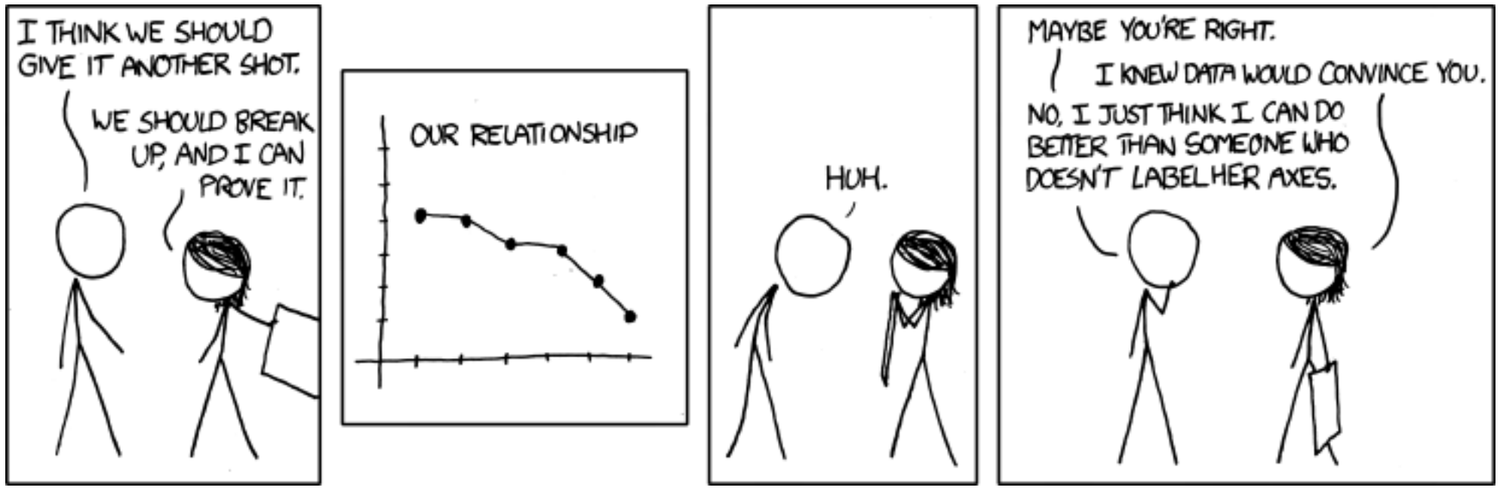
- proximity
  - do group related items together
  - avoid equal whitespace between unrelated
- alignment
  - do find/make strong line, stick to it
  - avoid automatic centering
- repetition
  - do unify by pushing existing consistencies
- contrast
  - if not identical, then very different
  - avoid not quite the same



- 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

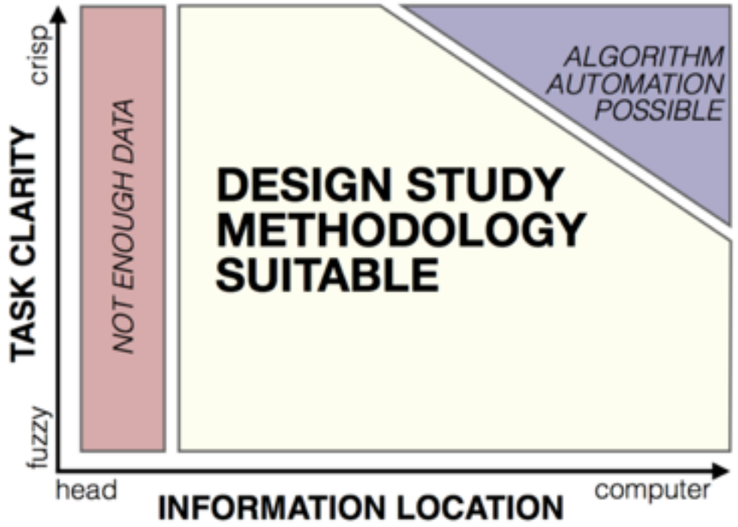


[https://xkcd.com/833/]

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

Design Study Methodology



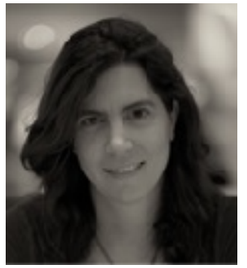
Michael Sedlmair

Miriah Meyer

Design Study Methodology

Reflections from the Trenches and from the Stacks

Tamara Munzner
@tamaramunzner

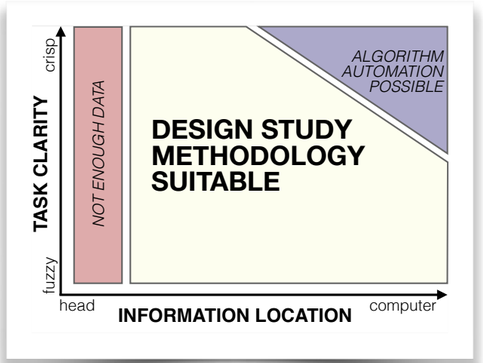


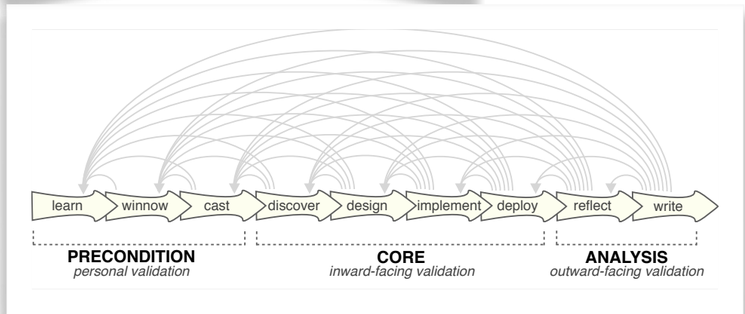
http://www.cs.ubc.ca/labs/imager/tr/2012/dsm/

Design Study Methodology: Reflections from the Trenches and from the Stacks.
Sedlmair, Meyer, Munzner. IEEE Trans. Visualization and Computer Graphics 18(12): 2431-2440, 2012 (Proc. InfoVis 2012).

Methodology for problem-driven work

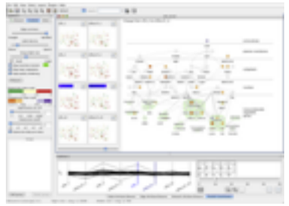
- definitions
- 9-stage framework
- 32 pitfalls & how to avoid them
- comparison to related methodologies



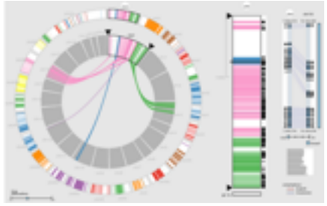


PF-1	premature advance: jumping forward over stages	general
PF-2	premature start: insufficient knowledge of vis literature	learn
PF-3	premature commitment: collaboration with wrong people	winnow
PF-4	no real data available (yet)	winnow
PF-5	insufficient time available from potential collaborators	winnow
PF-6	no need for visualization: problem can be automated	winnow
PF-7	researcher expertise does not match domain problem	winnow
PF-8	no need for research: engineering vs. research project	winnow
PF-9	no need for change: existing tools are good enough	winnow

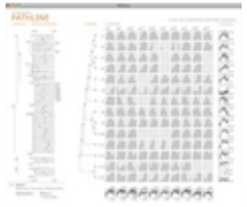
Lessons learned from the trenches: 21 between us



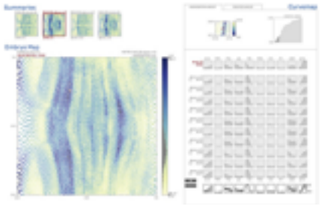
Cerebral
genomics



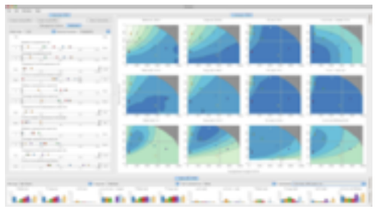
MizBee
genomics



Pathline
genomics



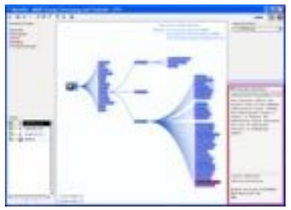
MulteeSum
genomics



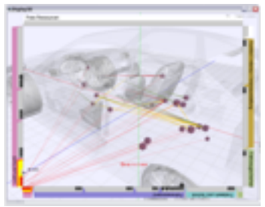
Vismon
fisheries management

QuestVis
sustainability

WiKeVis
in-car networks



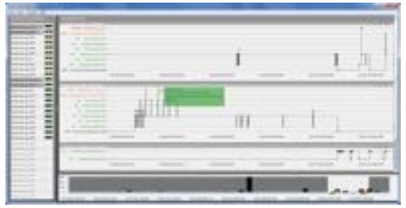
MostVis
in-car networks



Car-X-Ray
in-car networks

ProgSpy2010
in-car networks

RelEx
in-car networks

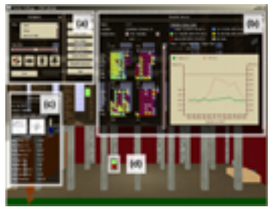


Cardiogram
in-car networks

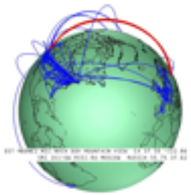
AutobahnVis
in-car networks

VisTra
in-car networks

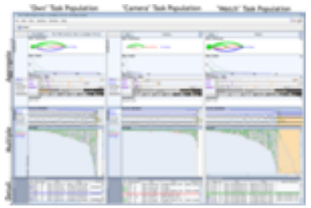
Constellation
linguistics



LibVis
cultural heritage

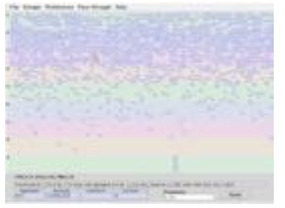


Caidants
multicast

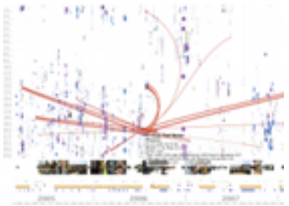


SessionViewer
web log analysis

LiveRAC
server hosting

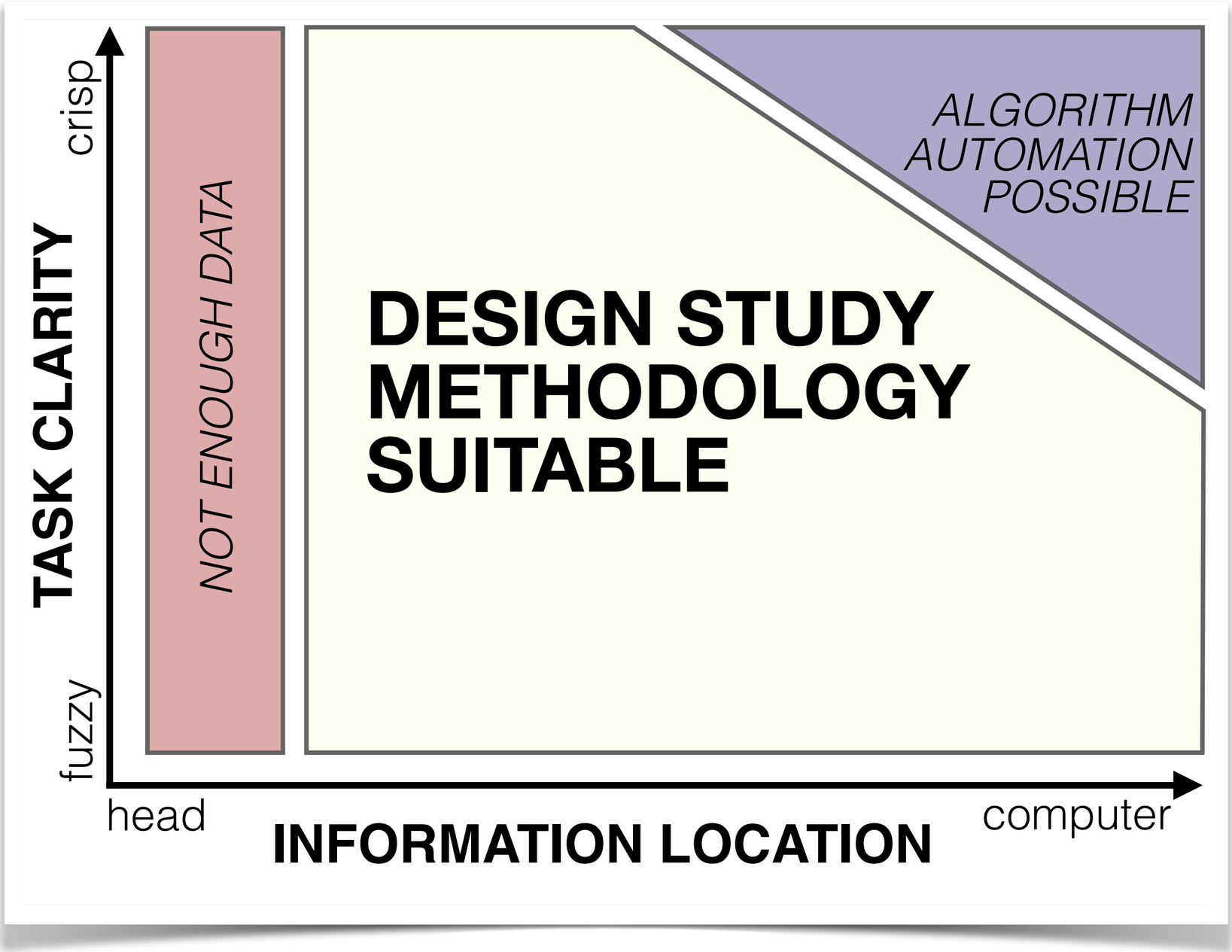


PowerSetViewer
data mining

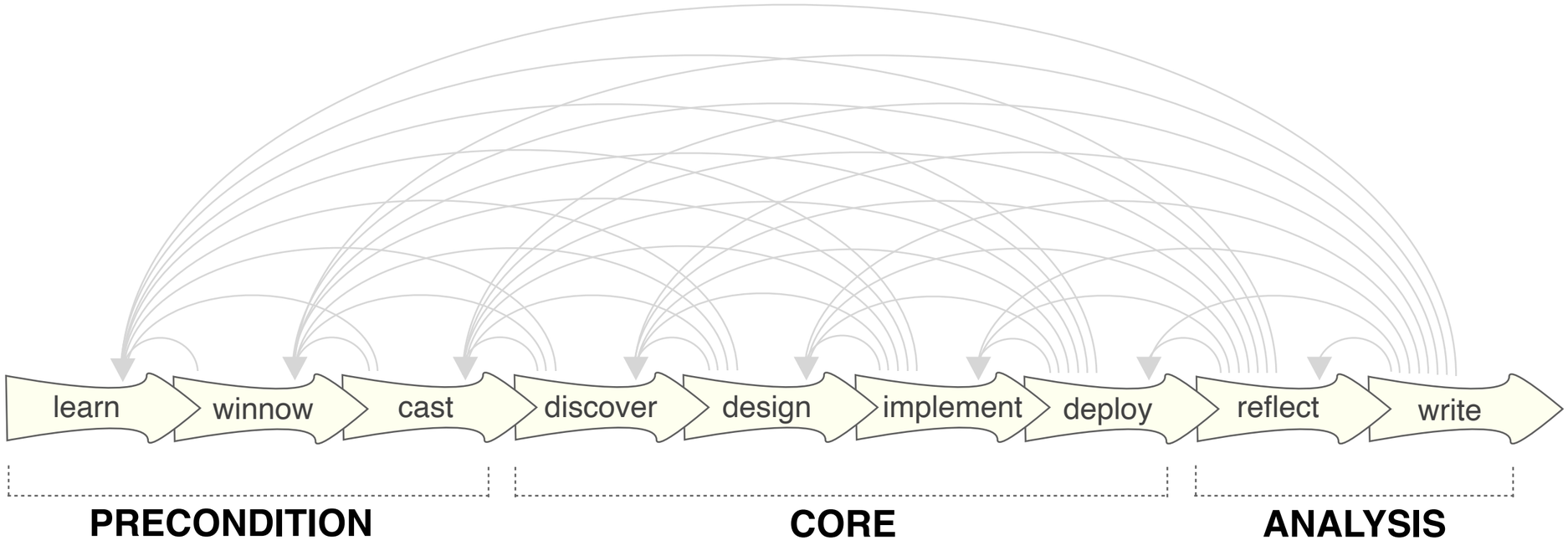


LastHistory
music listening

Design study methodology: definitions

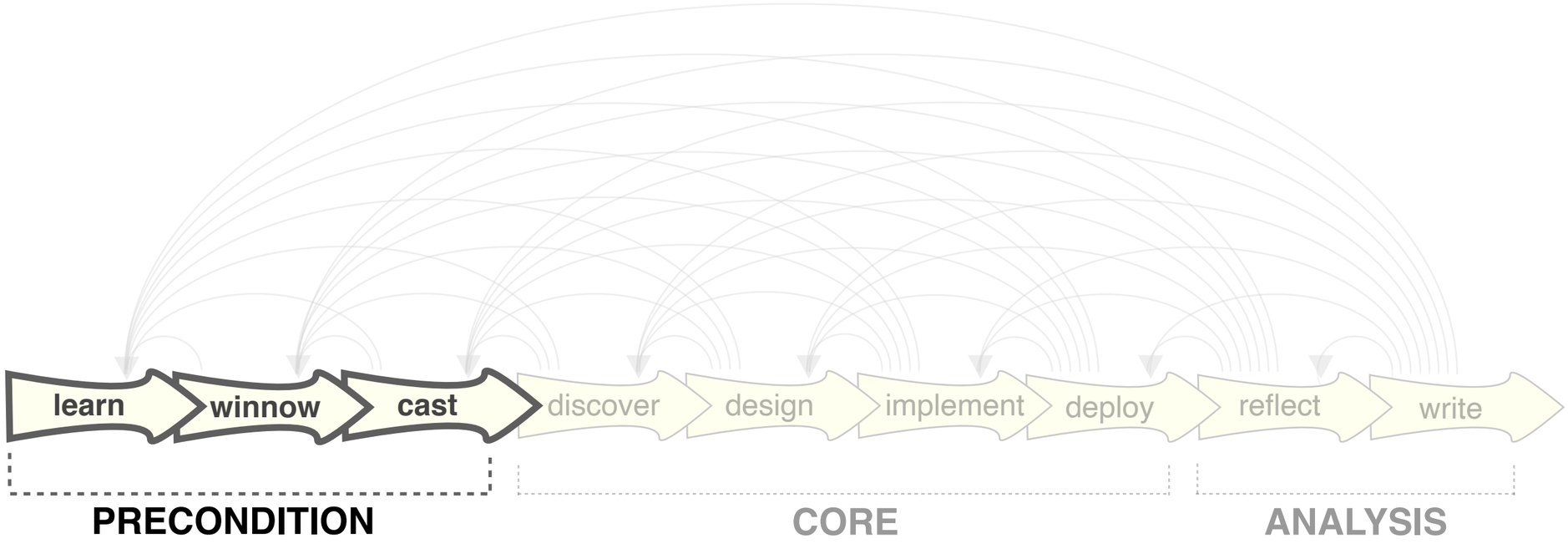


9 stage framework



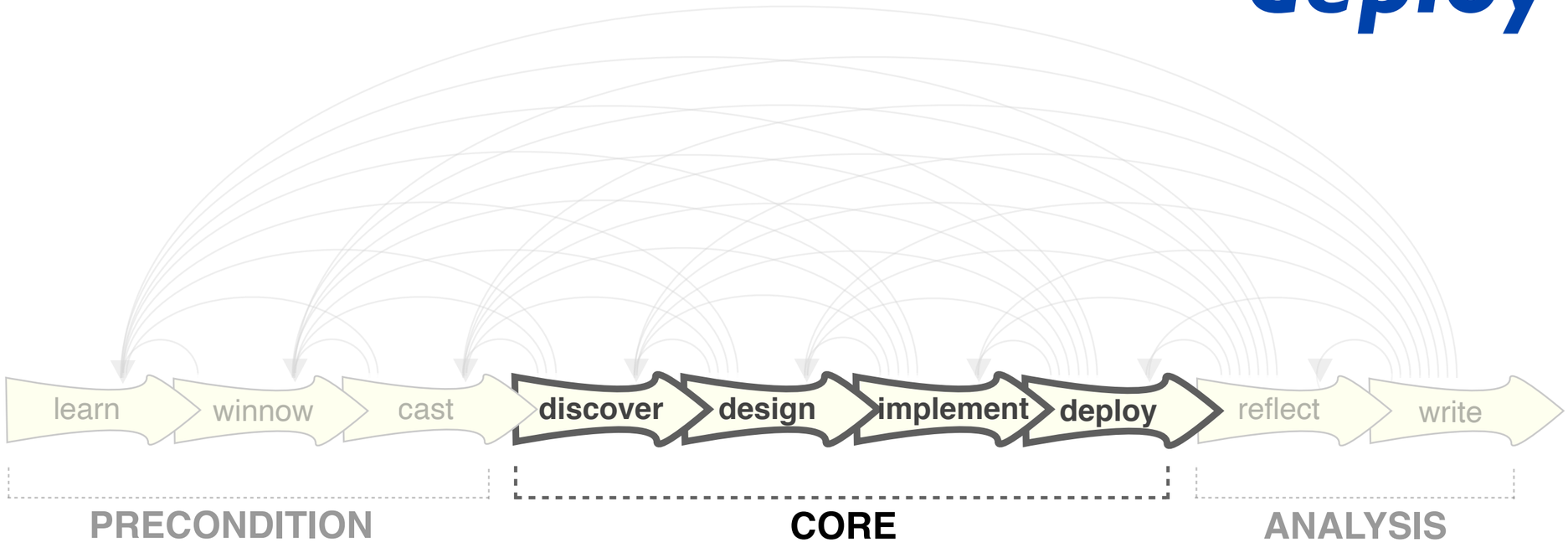
9-stage framework

learn
winnow
cast



9-stage framework

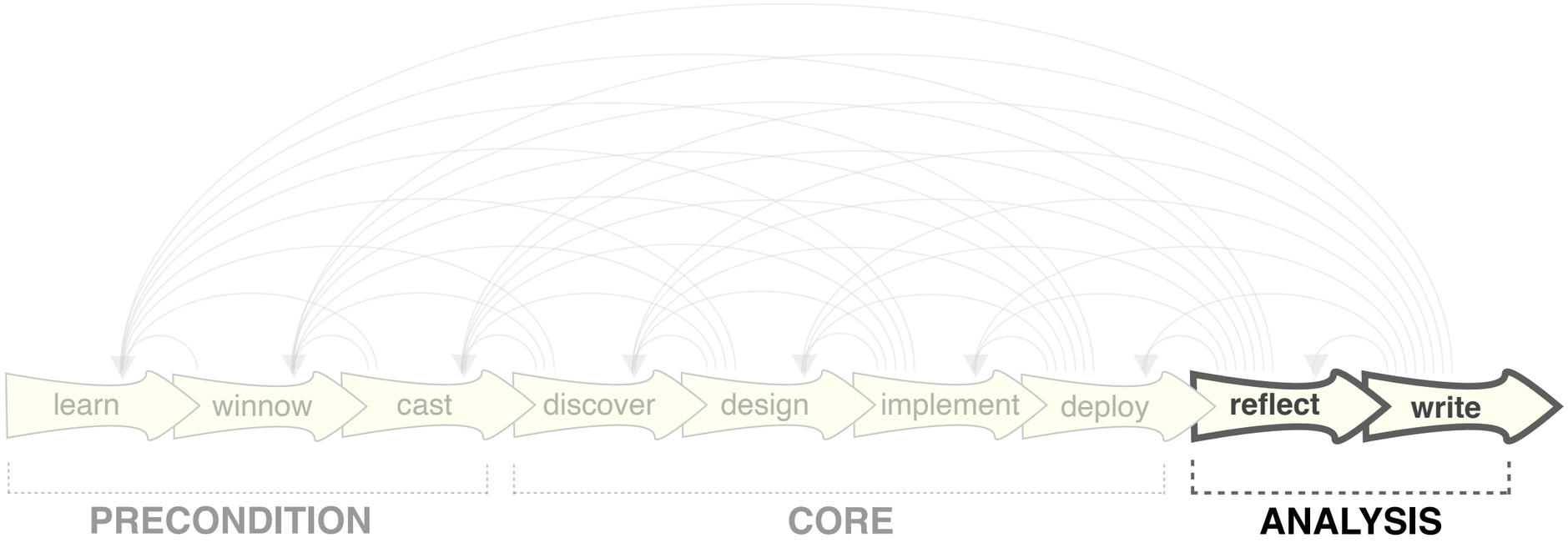
discover
design
implement
deploy



9-stage framework

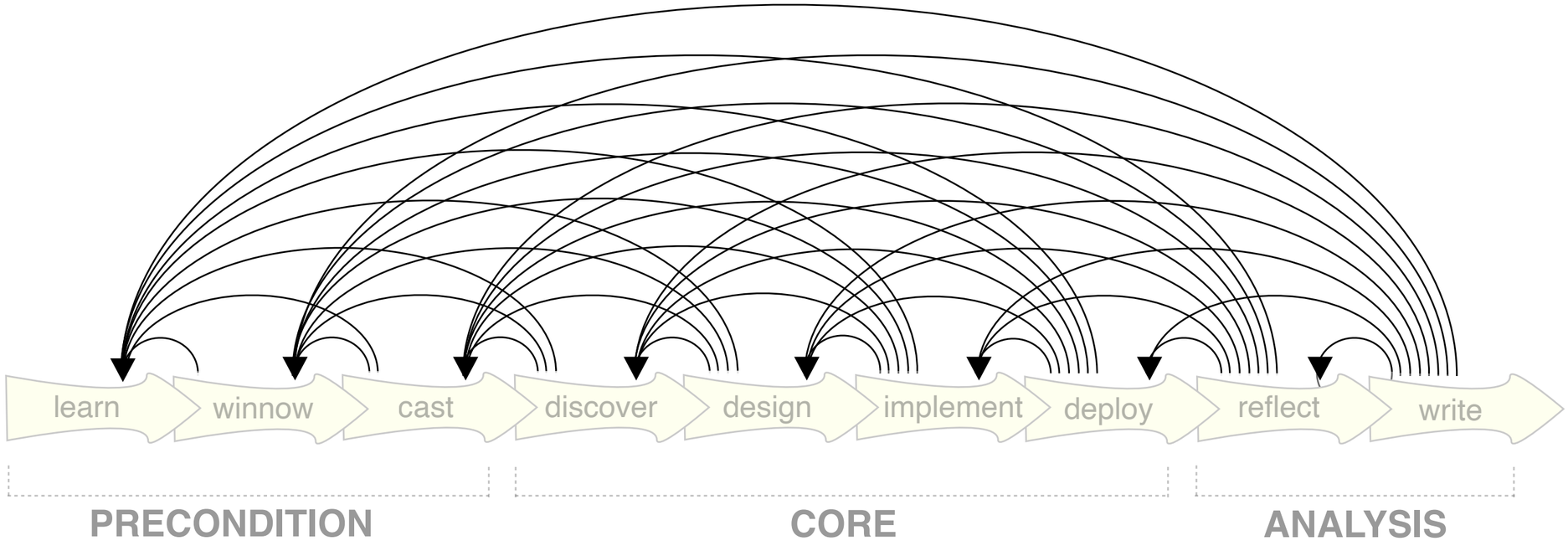
- guidelines: confirm, refine, reject, propose

reflect
write



9-stage framework

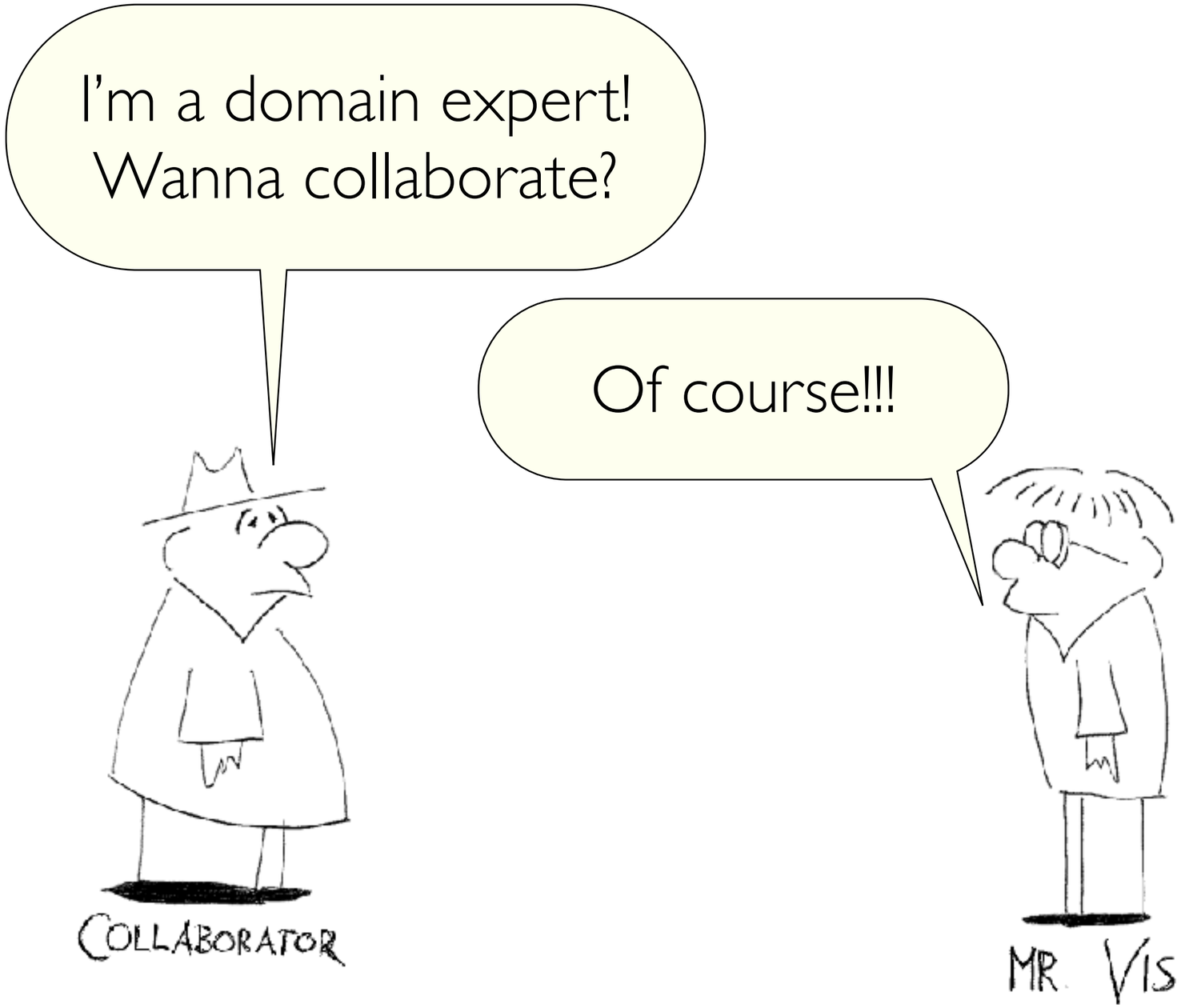
iterative



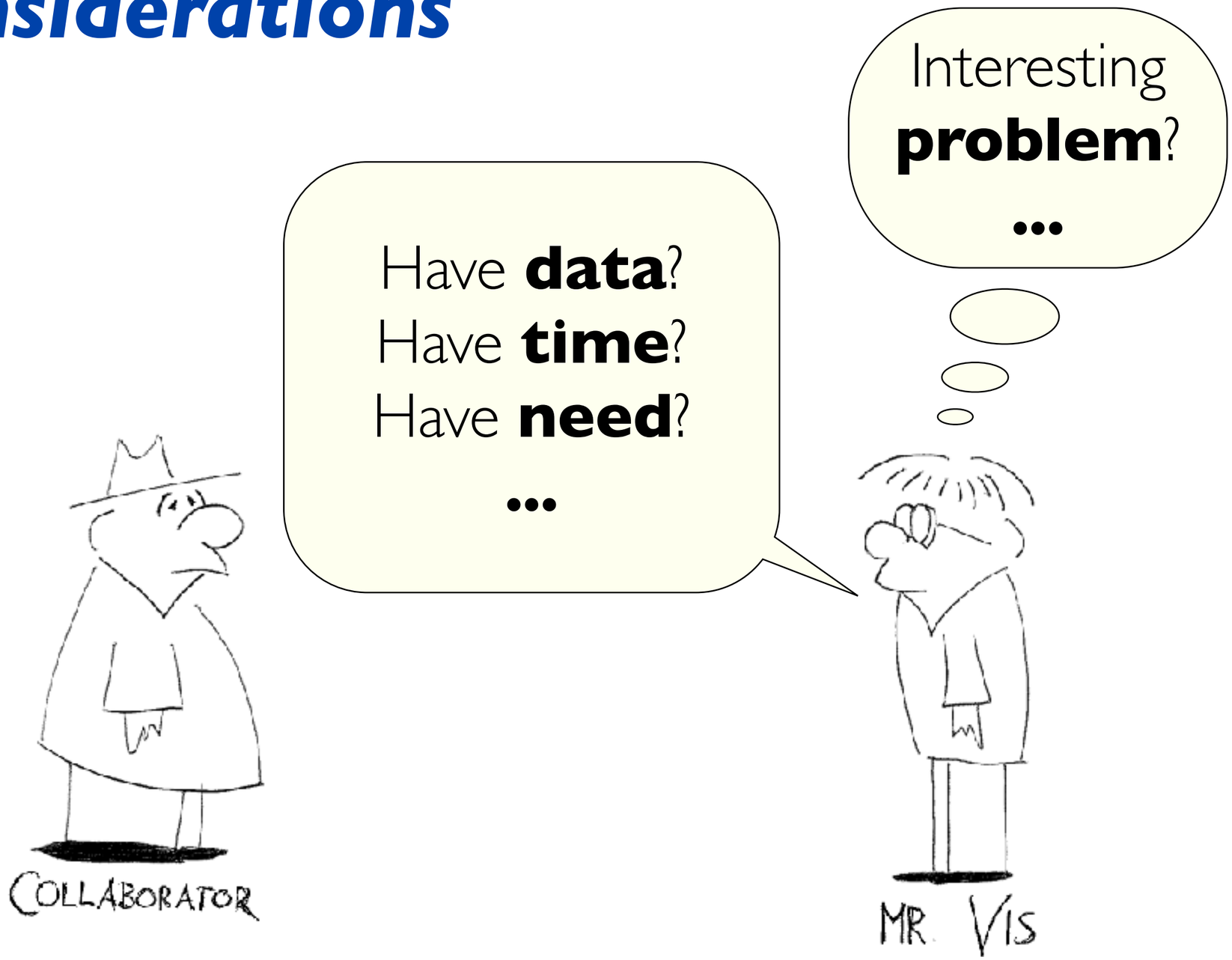
Design study methodology: 32 pitfalls

- and how to avoid them

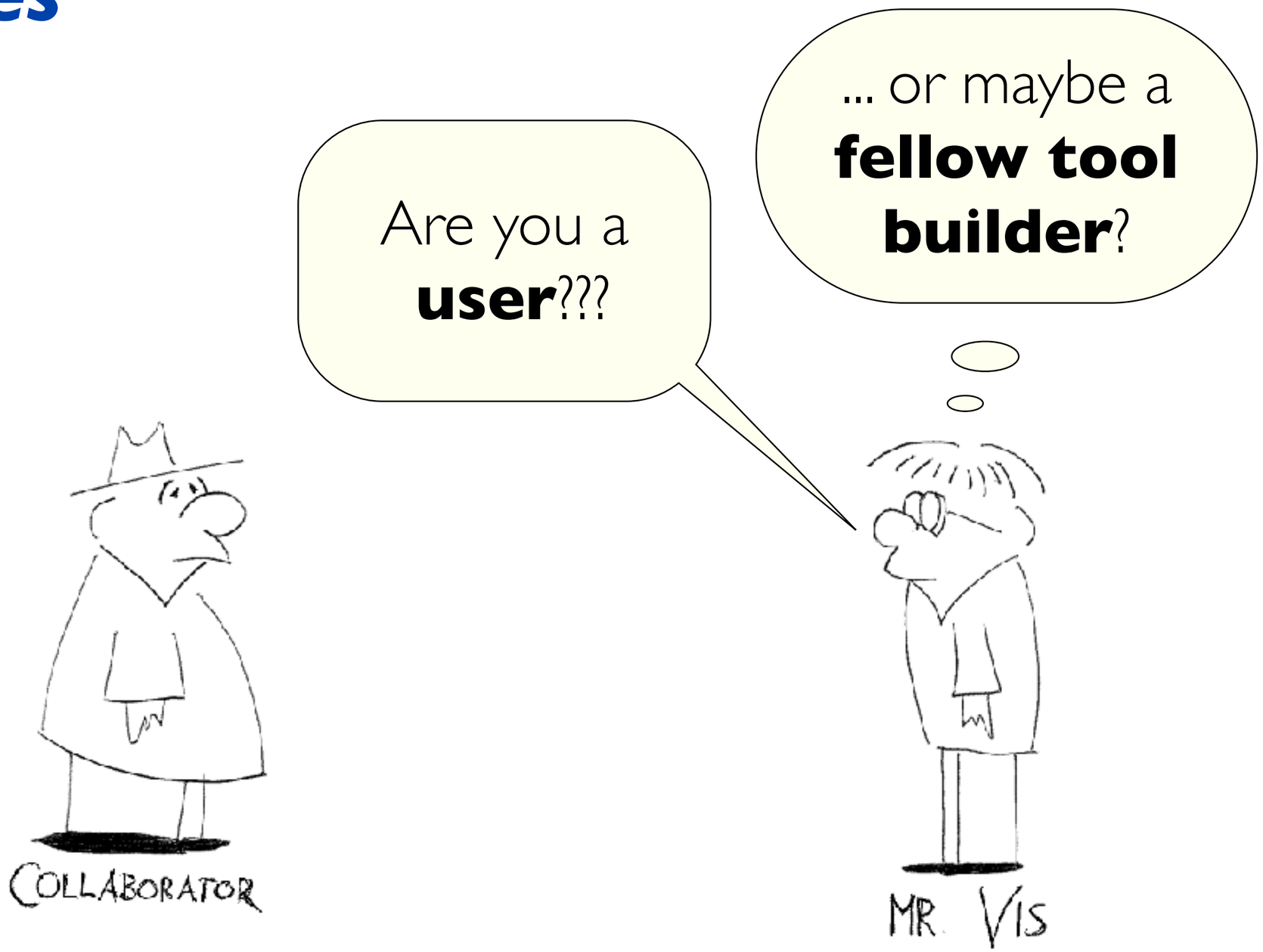
PF-1	premature advance: jumping forward over stages	general
PF-2	premature start: insufficient knowledge of vis literature	learn
PF-3	premature commitment: collaboration with wrong people	winnow
PF-4	no real data available (yet)	winnow
PF-5	insufficient time available from potential collaborators	winnow
PF-6	no need for visualization: problem can be automated	winnow
PF-7	researcher expertise does not match domain problem	winnow
PF-8	no need for research: engineering vs. research project	winnow
PF-9	no need for change: existing tools are good enough	winnow


I'm a domain expert!
Wanna collaborate?
Of course!!!
COLLABORATOR
MR. VIS

considerations

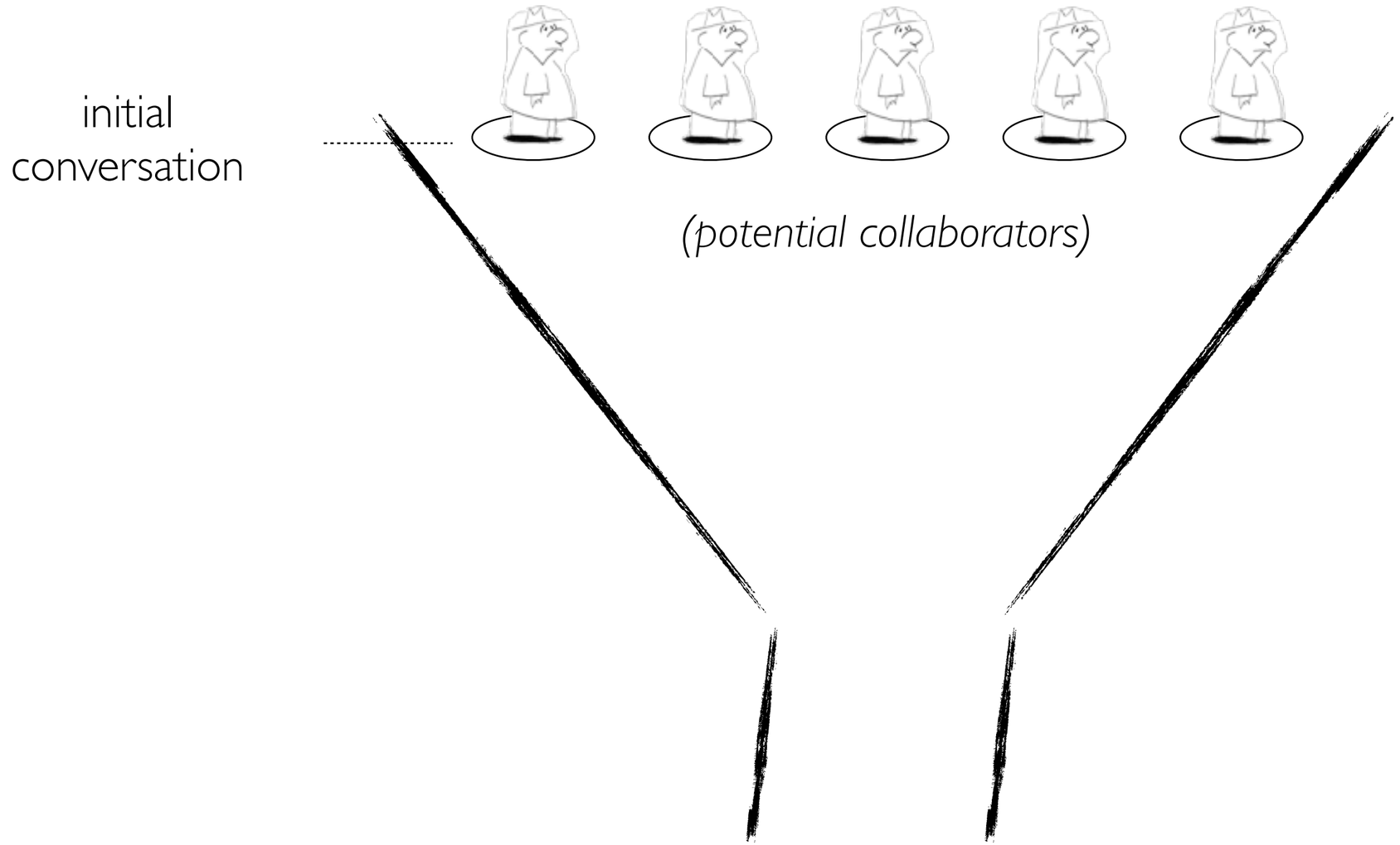


roles

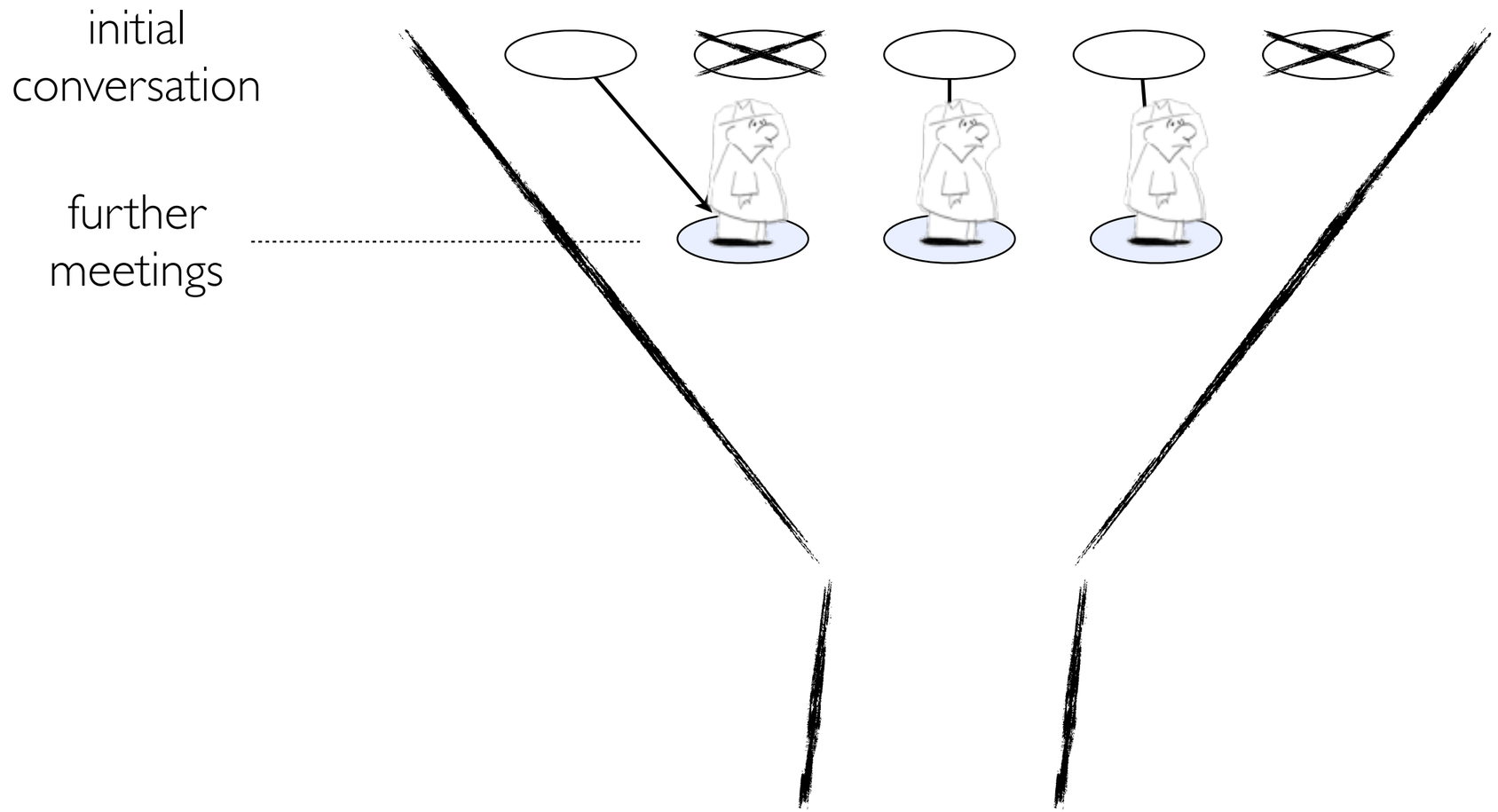

Are you a **user**???
... or maybe a **fellow tool builder**?
COLLABORATOR
MR. VIS

Metaphor
Winnowing

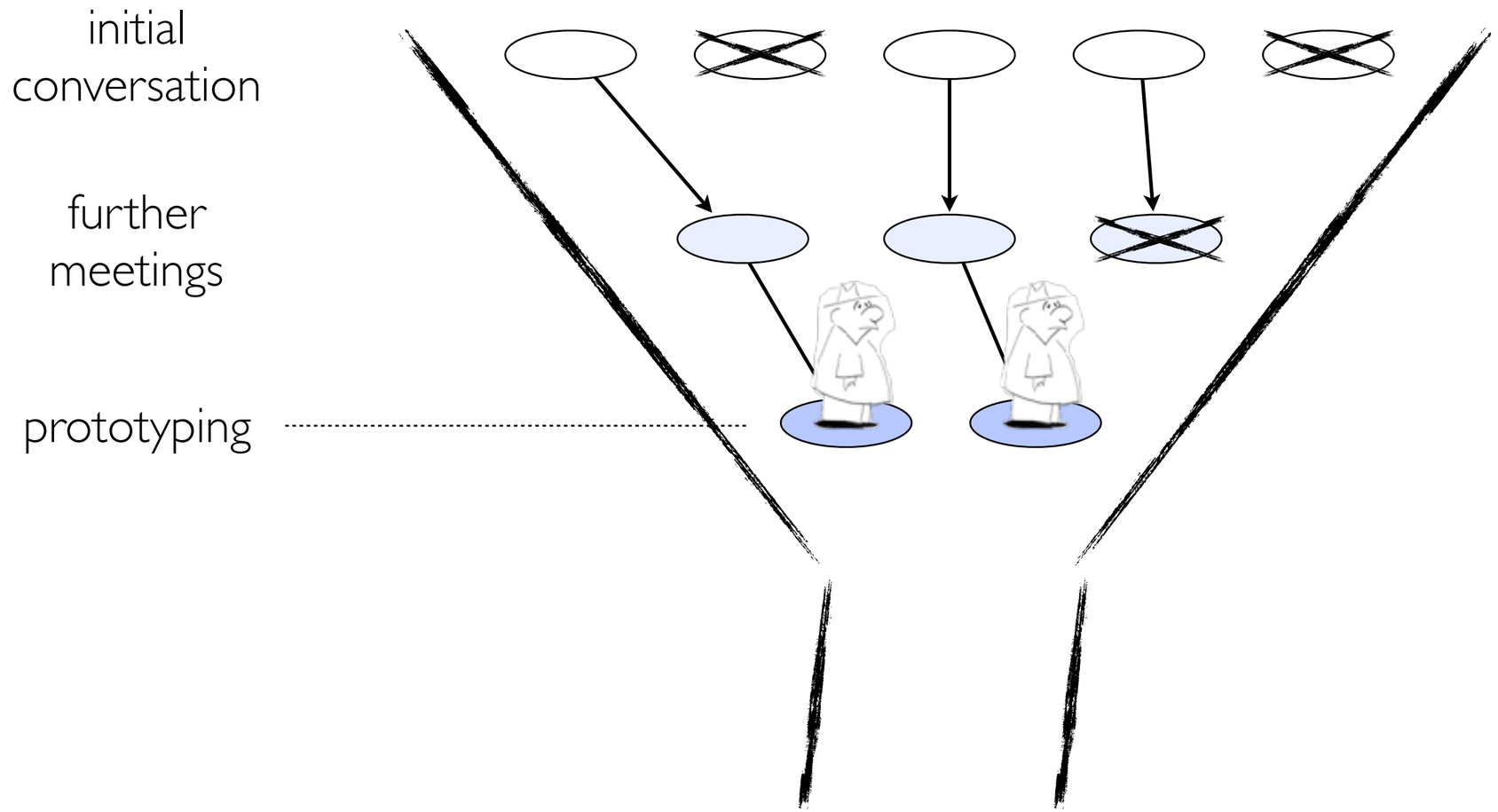
Collaborator winnowing



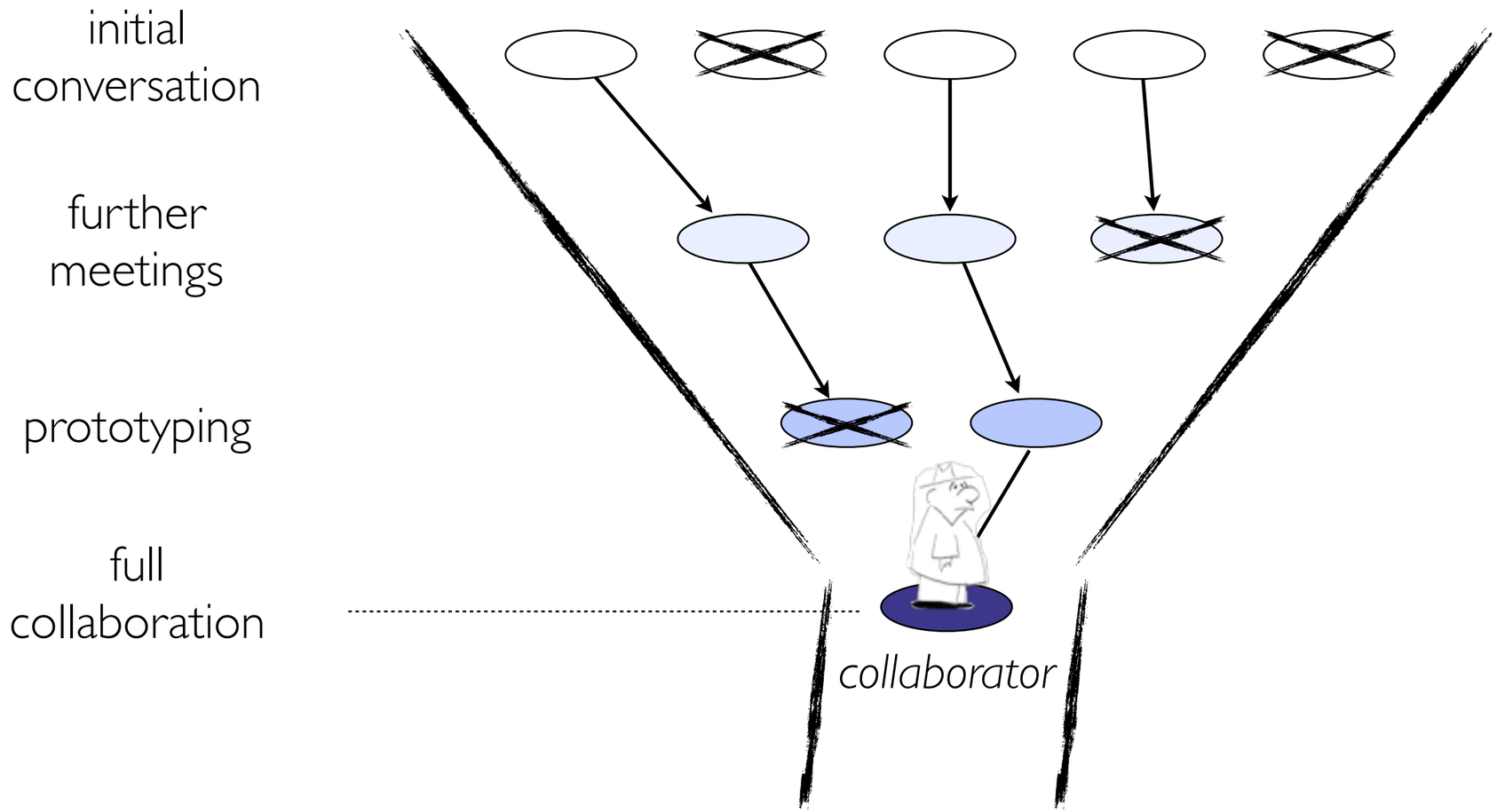
Collaborator winnowing



Collaborator winnowing



Collaborator winnowing



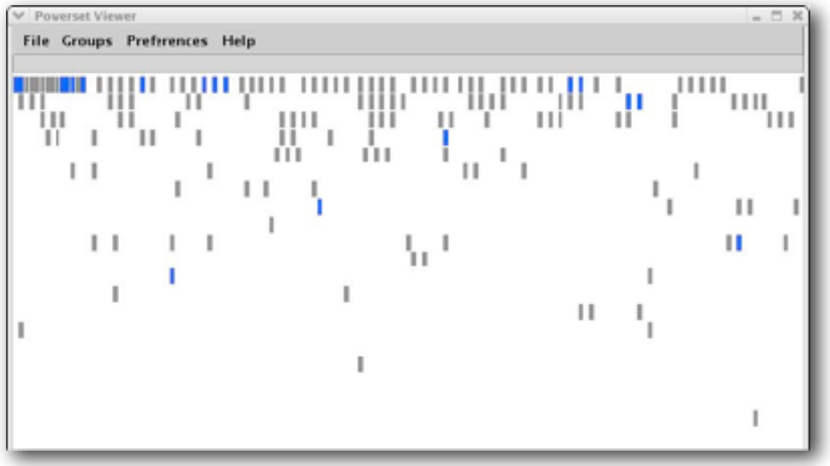
Collaborator winnowing

Talk with many, stay with few!

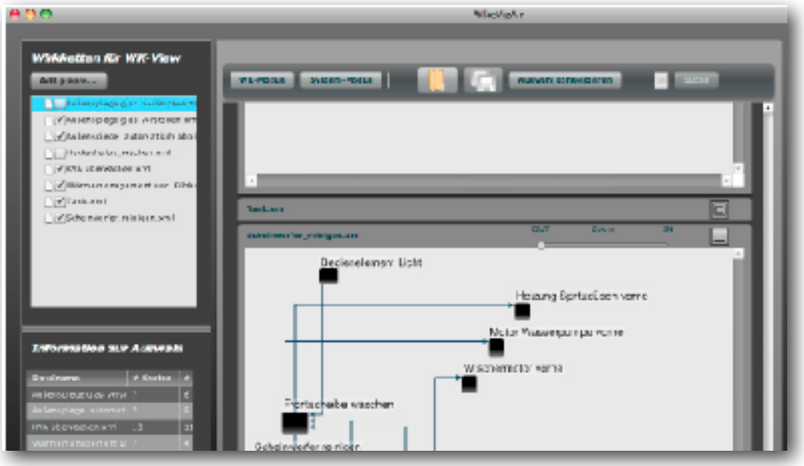
Example From The Trenches

Premature Collaboration!

PowerSet Viewer
2 years / 4 researchers



WikeVis
0.5 years / 2 researchers



Example From The Trenches

Premature Collaboration!

PowerSet Viewer
2 years / 4 researchers

WikeVis
0.5 years / 2 researchers

- Fellow tool builders

- Data promised

Design study methodology: 32 pitfalls

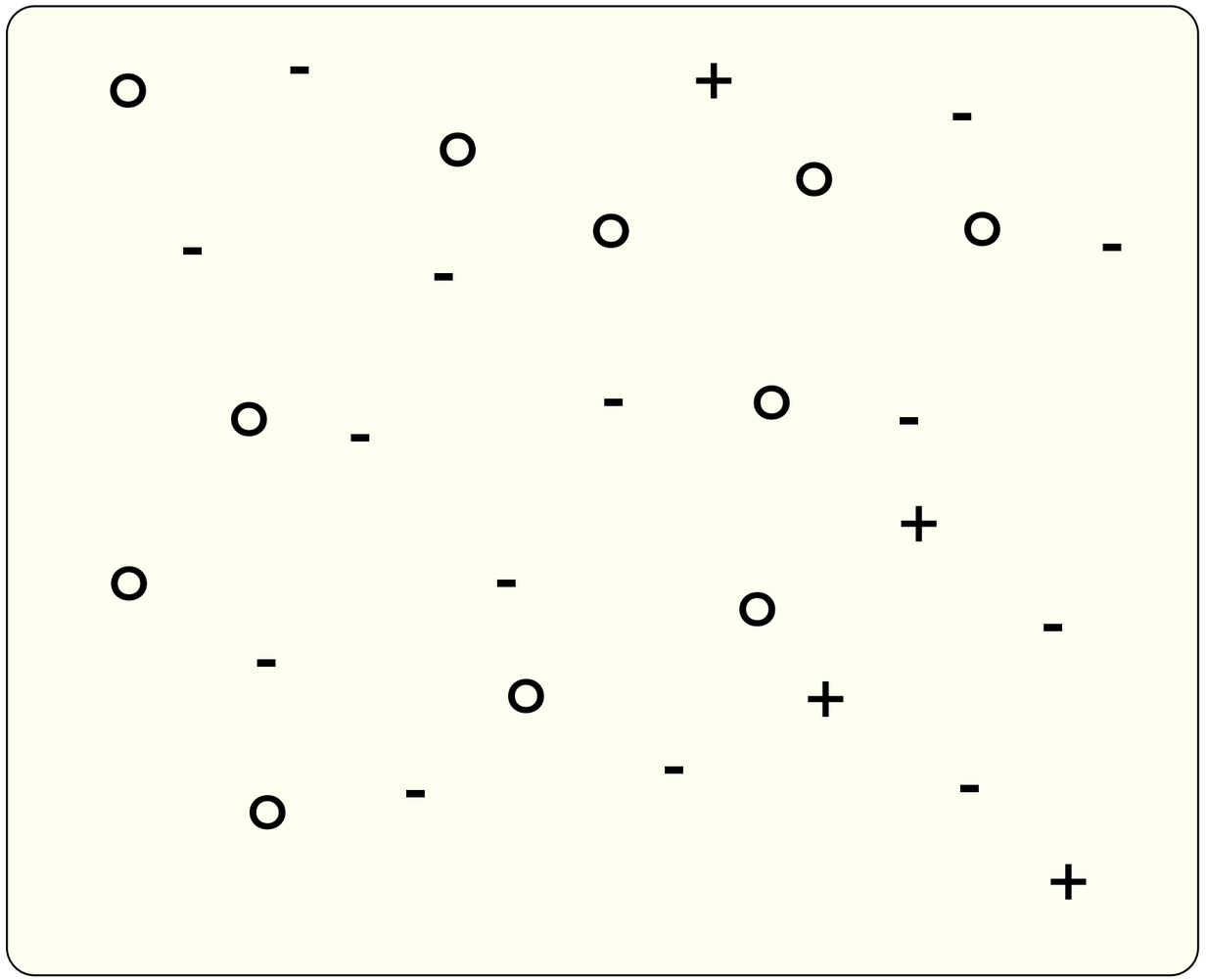
PF-10	no real/important/recurring task	winnow
PF-11	no rapport with collaborators	winnow
PF-12	not identifying front line analyst and gatekeeper before start	cast
PF-13	assuming every project will have the same role distribution	cast
PF-14	mistaking fellow tool builders for real end users	cast
PF-15	ignoring practices that currently work well	discover
PF-16	expecting *just talking* or *fly on wall* to work	discover
PF-17	experts focusing on visualization design vs. domain problem	discover
PF-18	learning their problems/language: too little / too much	discover
PF-19	abstraction: too little	design
PF-20	premature design commitment: consideration space too small	design

Pitfall

Premature Design Commitment

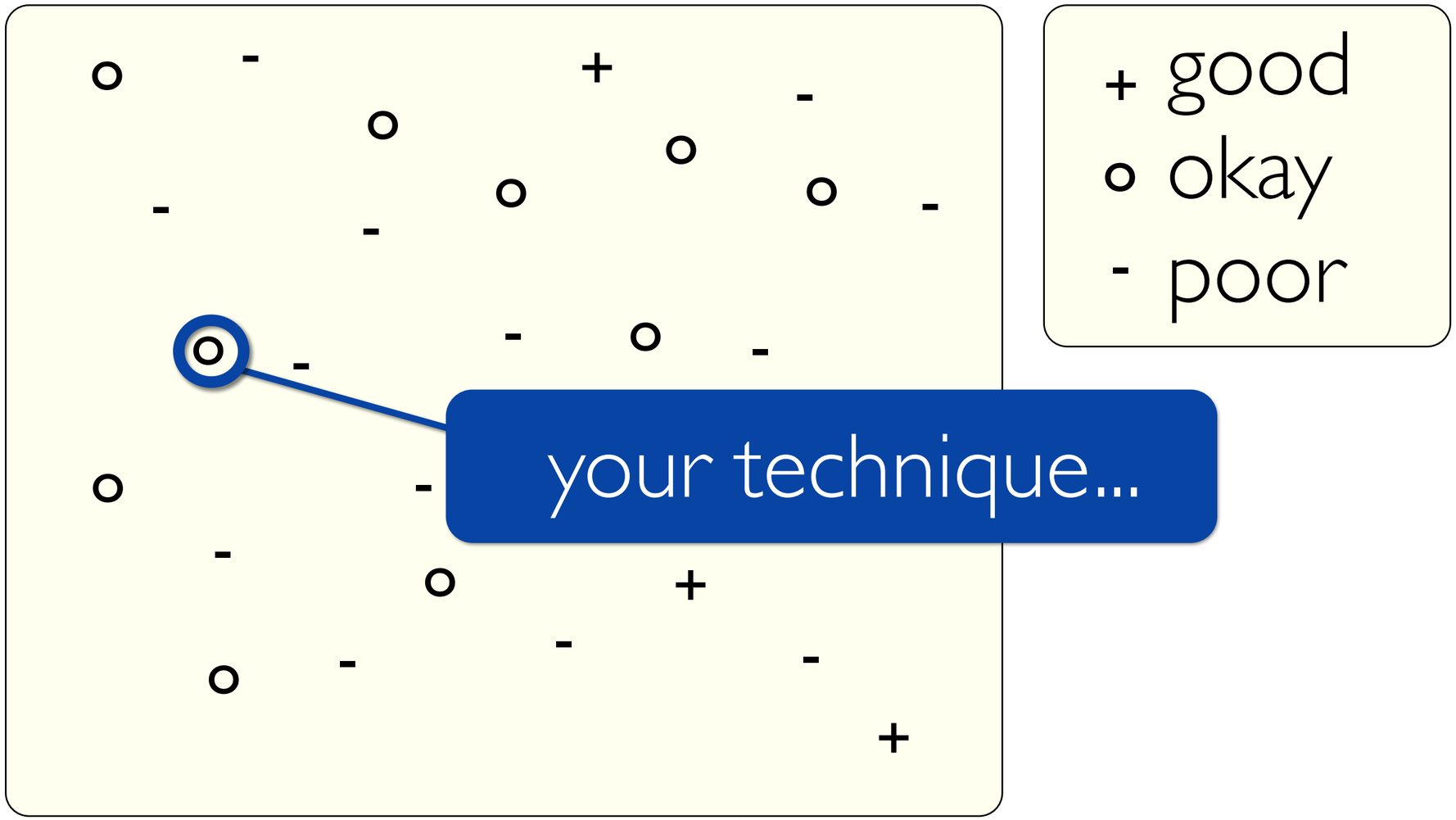
Of course they need the cool **technique** I built last year!

METAPHOR
Design Space



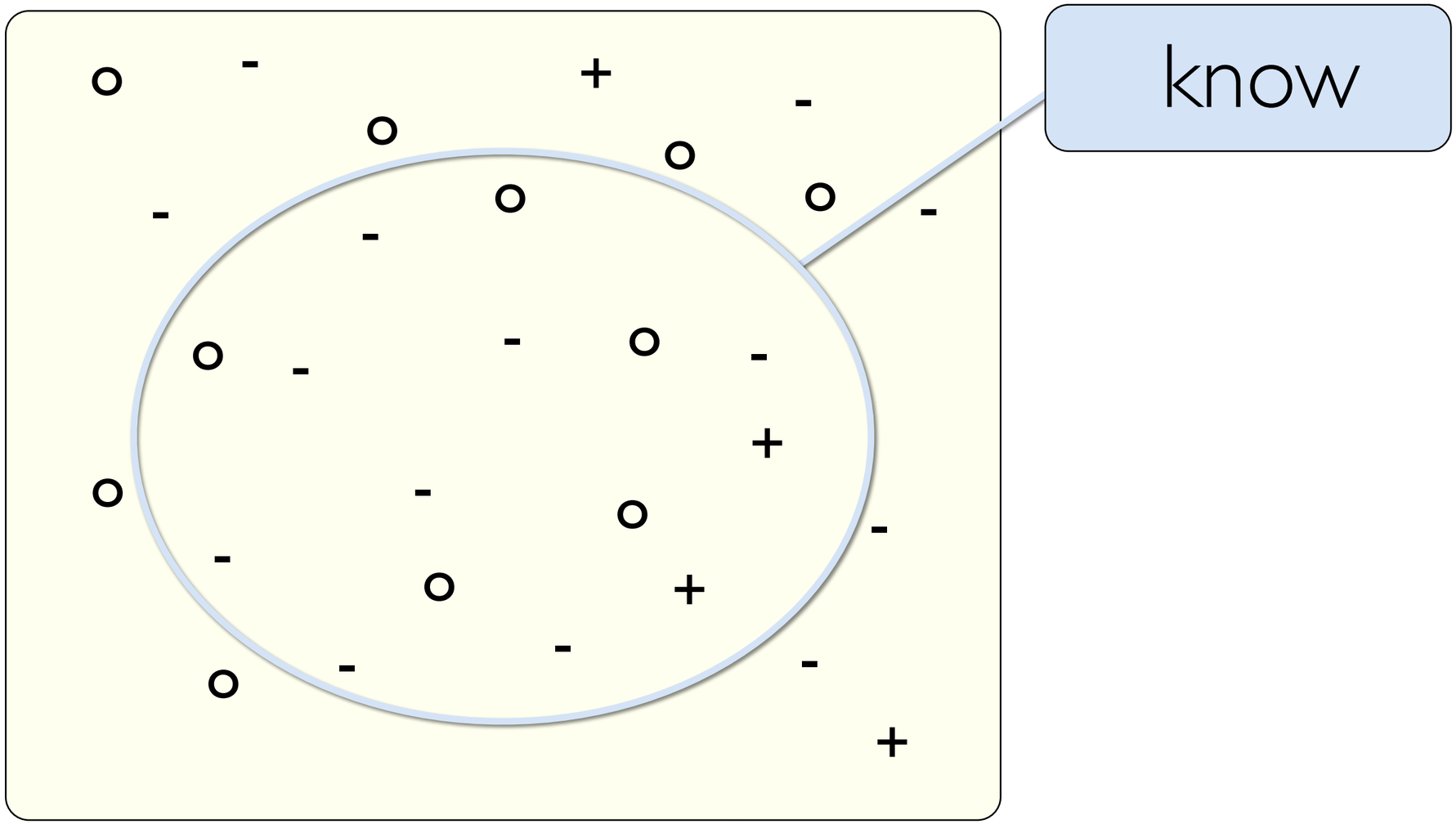
+ good
o okay
- poor

METAPHOR
Design Space



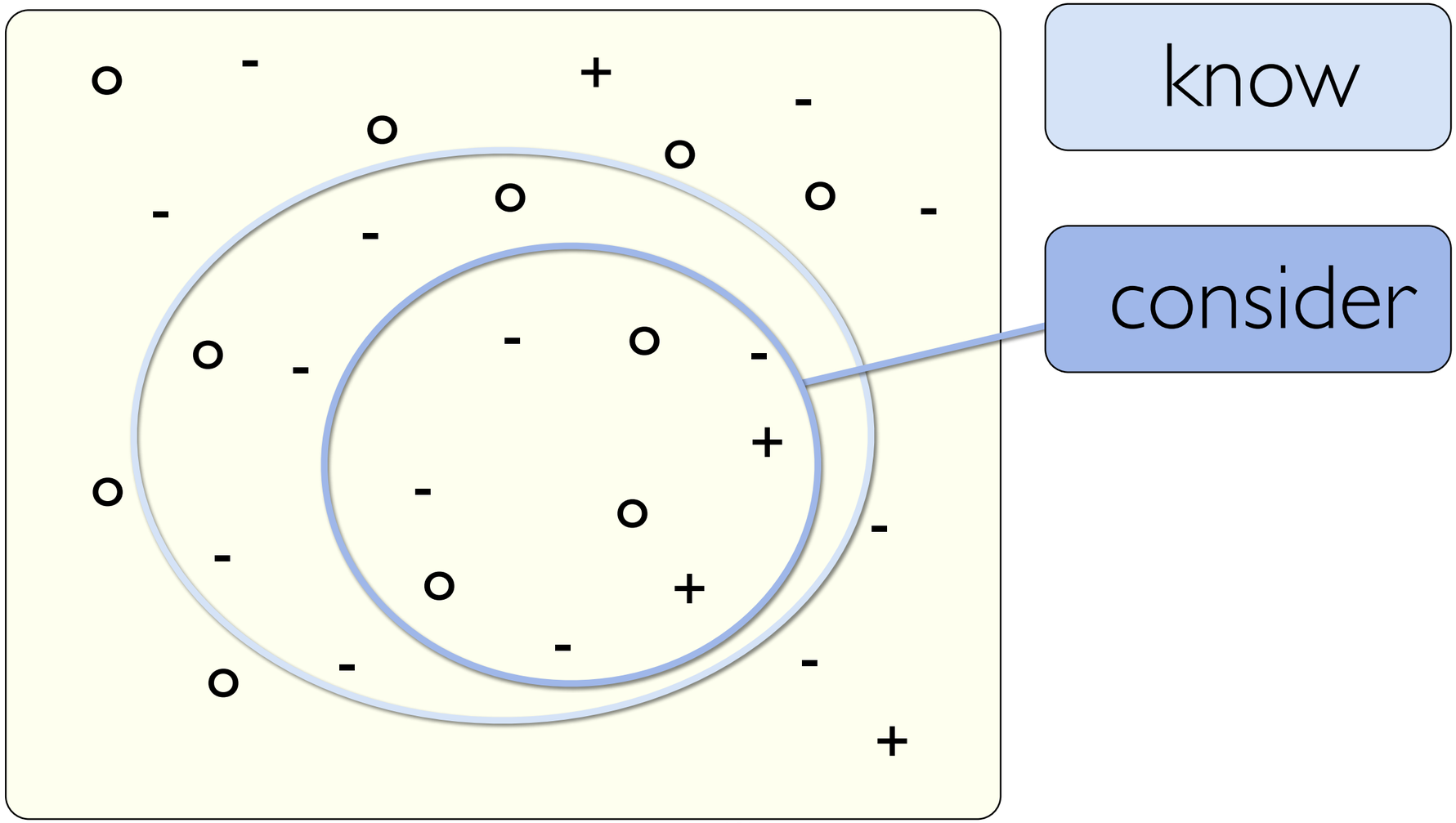
METAPHOR

Design Space

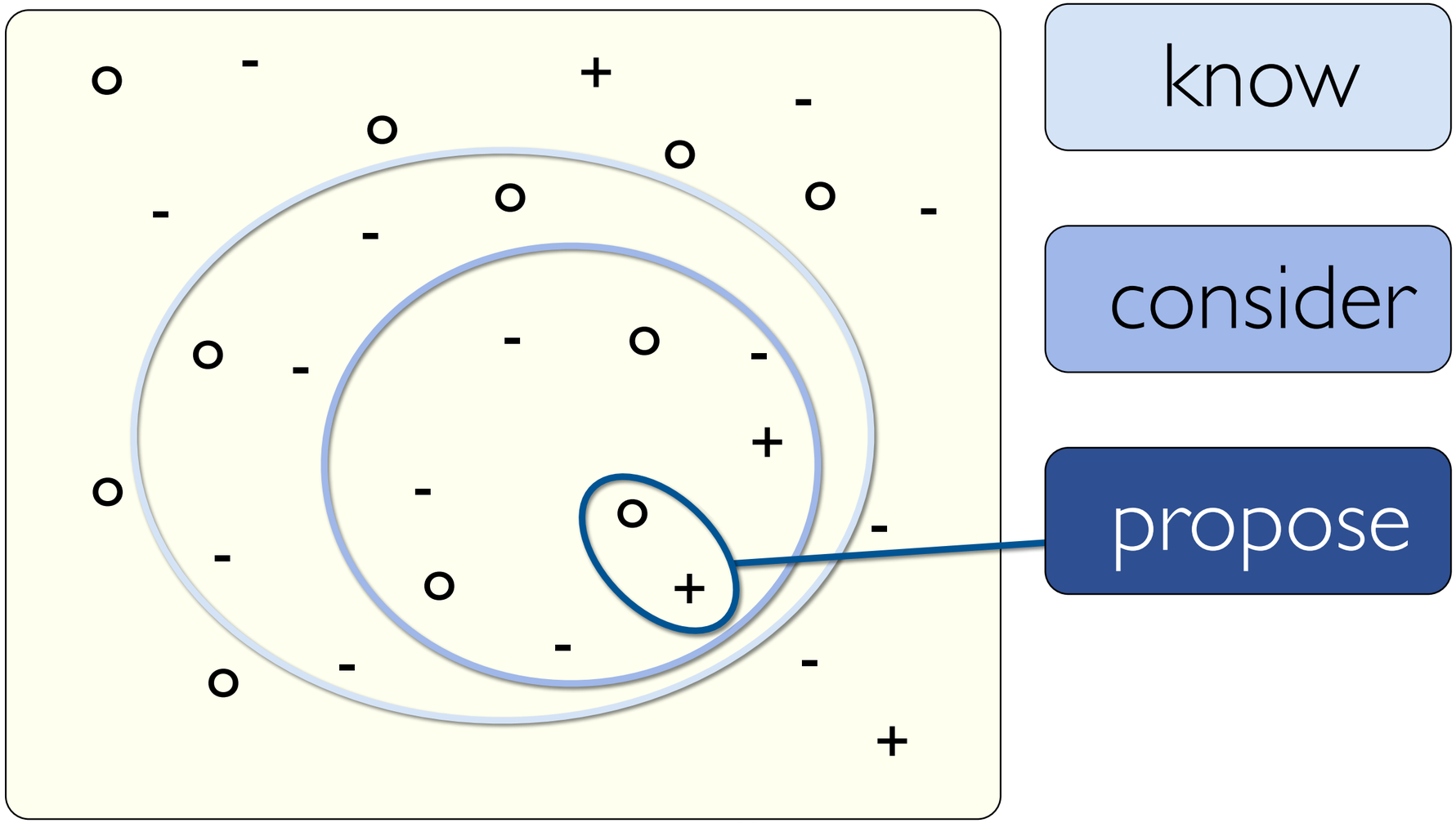


METAPHOR

Design Space

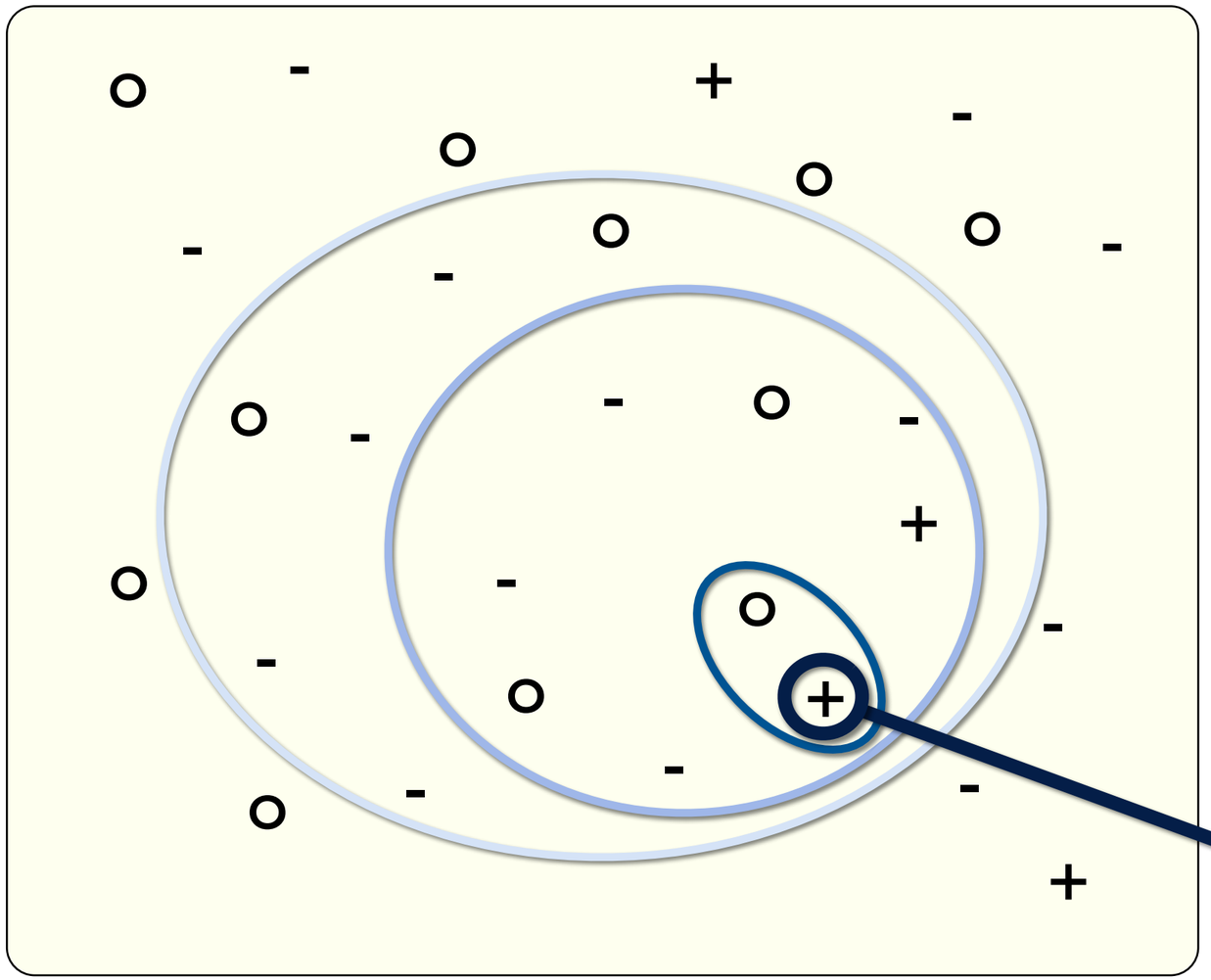


METAPHOR
Design Space



METAPHOR

Design Space



know

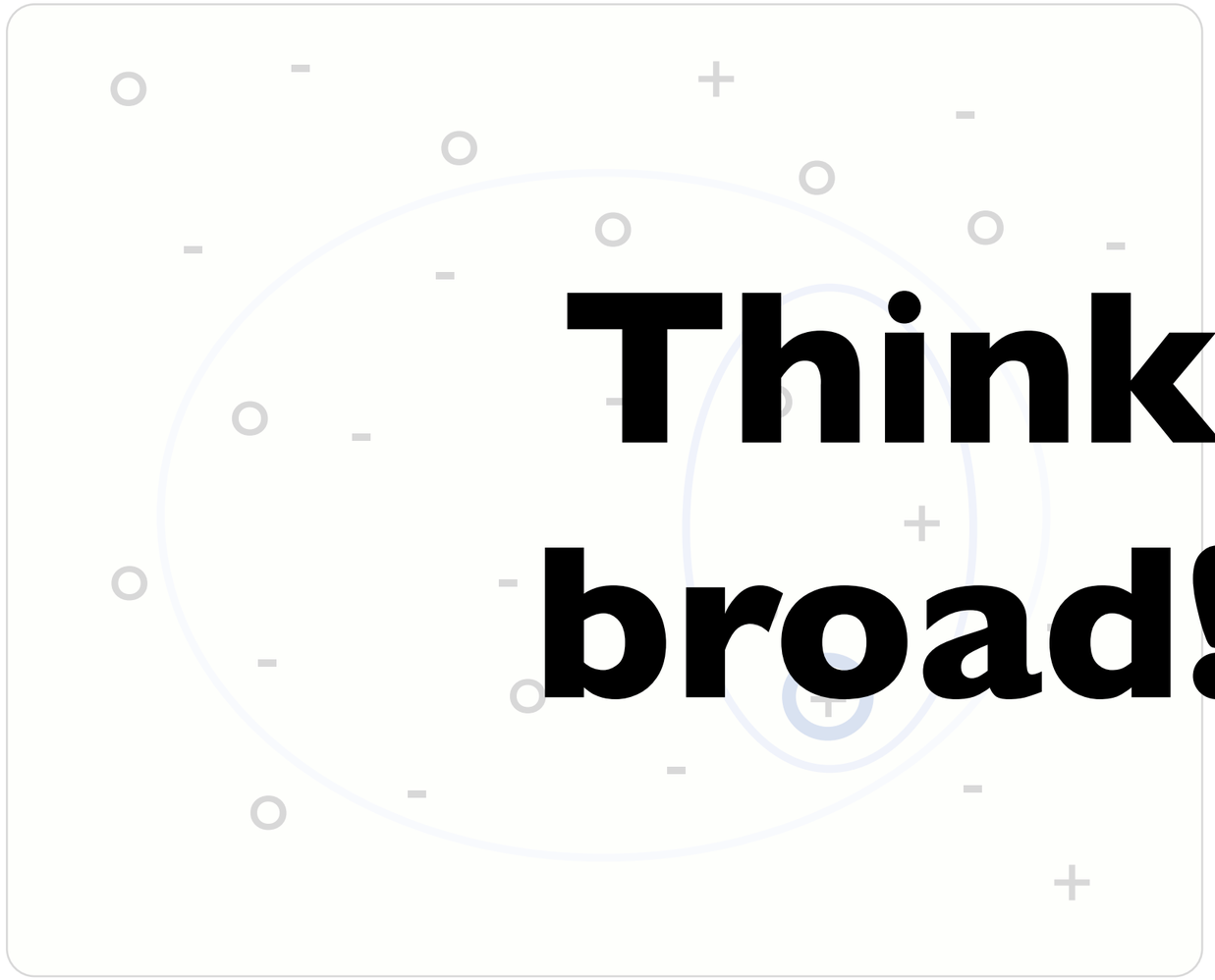
consider

propose

select

METAPHOR

Design Space



Think broad!

+ good
o okay
- poor

consider

propose

select

Design study methodology: 32 pitfalls

PF-21	mistaking technique-driven for problem-driven work	design
PF-22	nonrapid prototyping	implement
PF-23	usability: too little / too much	implement
PF-24	premature end: insufficient deploy time built into schedule	deploy
PF-25	usage study not case study: non-real task/data/user	deploy
PF-26	*liking* necessary but not sufficient for validation	deploy
PF-27	failing to improve guidelines: confirm, refine, reject, propose	reflect
PF-28	insufficient writing time built into schedule	write
PF-29	no technique contribution $\neq$ good design study	write
PF-30	too much domain background in paper	write
PF-31	story told chronologically vs. focus on final results	write
PF-32	premature end: win race vs. practice music for debut	write

PITFALL

PREMATURE PUBLISHING

I can write a design study **paper** in a week!

"writing is research"

[Wolcott: Writing up qualitative research, 2009]

METAPHOR

Horse Race vs. Music Debut

Must be first!

http://www.alaineknipes.com/interests/violin_concert.jpg

technique-driven

Am I ready?

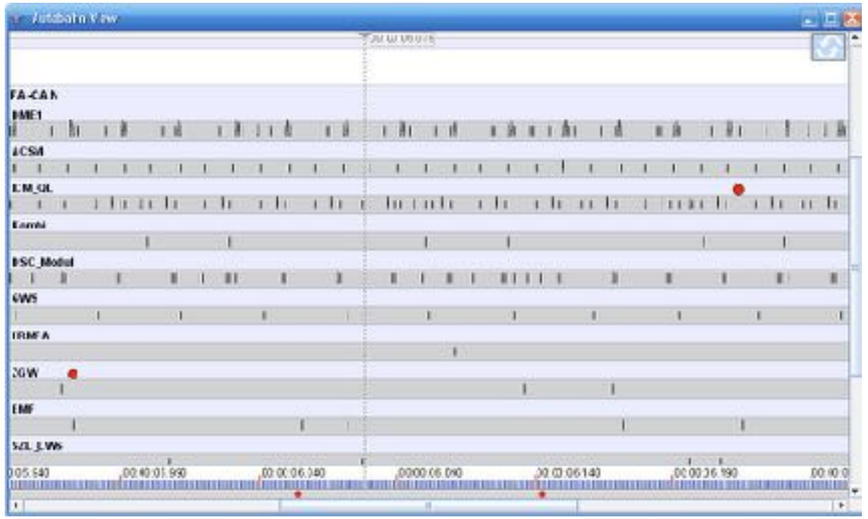
http://www.prlog.org/10480334-wolverhampton-horse-racing-live-streaming-wolverhampton-handicap-8-jan-2010.html

problem-driven

EXAMPLE FROM THE TRENCHES

Don’t step on your own toes!

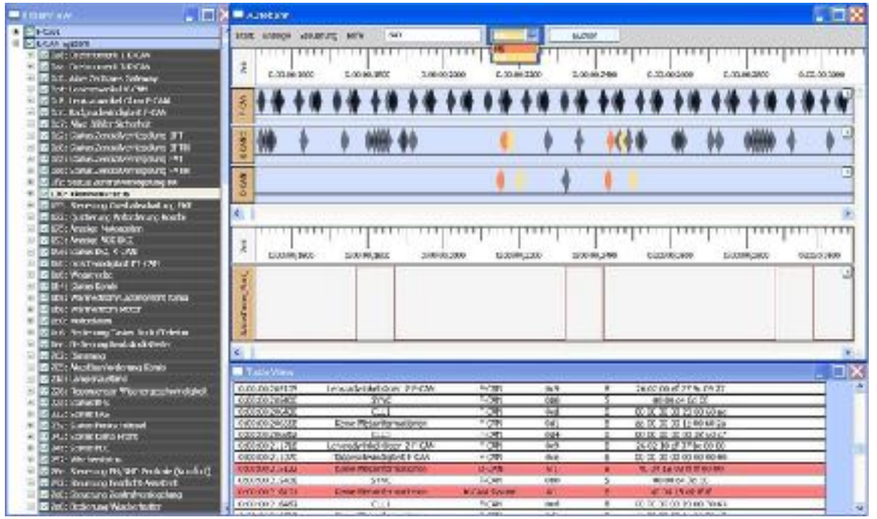
First design round published



AutobahnVis 1.0

[Sedlmair et al., Smart Graphics, 2009]

Subsequent work not stand-alone paper



AutobahnVis 2.0

[Sedlmair et al., Information Visualization 10(3), 2011]

Reflections from the stacks: Wholesale adoption inappropriate

- ethnography
  - rapid, goal-directed fieldwork
- grounded theory
  - not empty slate: vis background is key
- action research
  - aligned
    - intervention as goal
    - transferability not reproducibility
    - personal involvement is key
  - opposition
    - translation of participant concepts into visualization language
    - researcher lead not facilitate design
    - orthogonal to vis concerns: participants as writers, adversarial to status quo, postmodernity