Ch 5: Marks and Channels
Paper: Polaris

Tamara Munzner
Department of Computer Science
University of British Columbia

CPSC 547, Information Visualization
Day 2: 15 September 2015

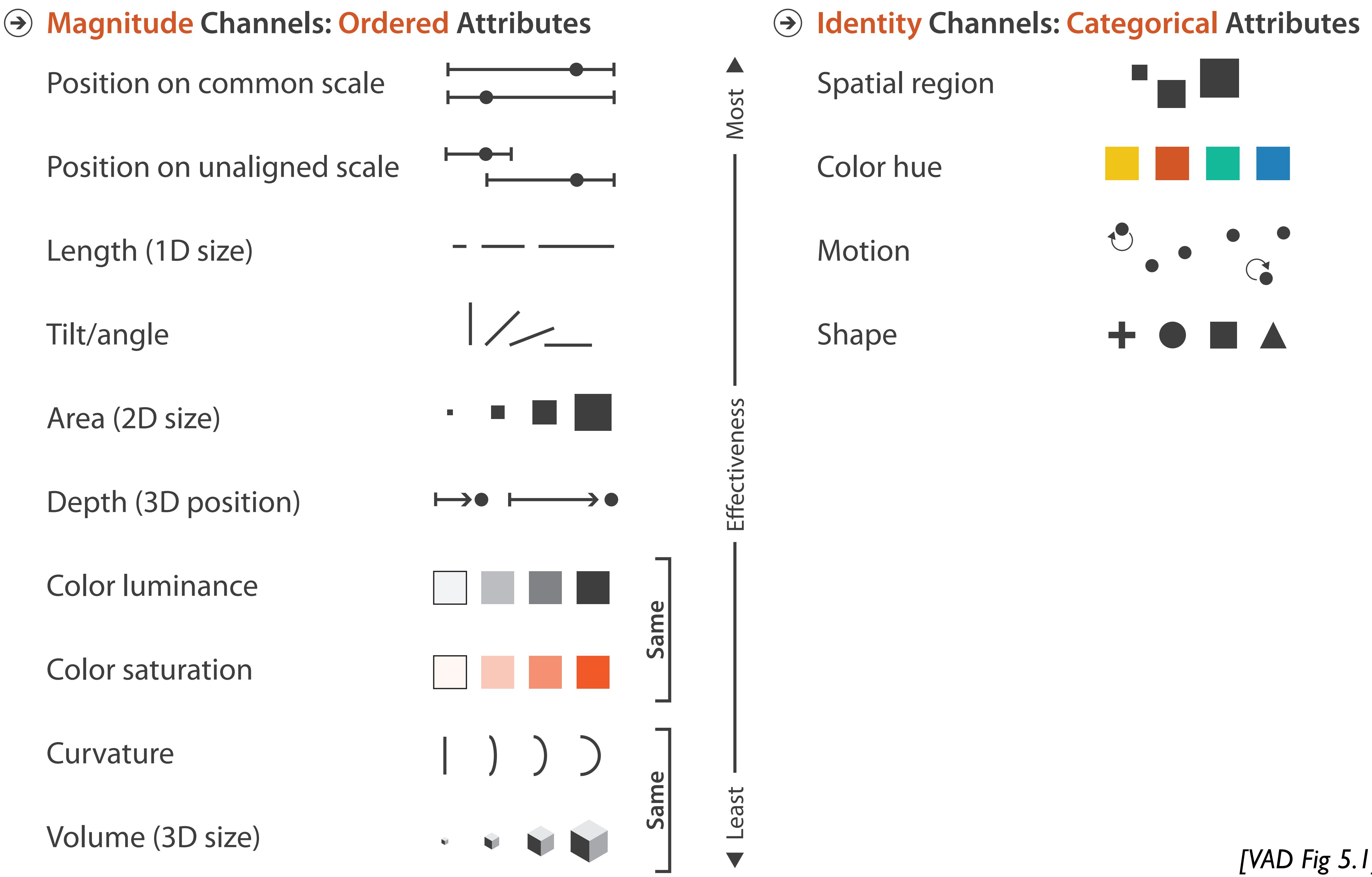
http://www.cs.ubc.ca/~tmm/courses/547-15

News

- Three copies of physical book available in Reading Room (ICICS/CS 262)
- Signup sheet: mark last column with new probabilities
  - add yourself at end if you weren't here last time
- Waitlist update: 38 registered so 2 slots open; 2 on waitlist
- Questions/comments were due at 1:30pm today
- Guest lecture from Robert Kosara on Tableau at 2:20
  - my section only 20 minutes

VAD Ch 5: Marks and Channels

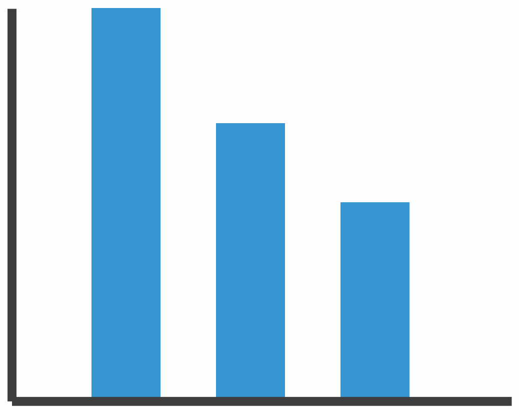
Channels: Expressiveness Types and Effectiveness Ranks

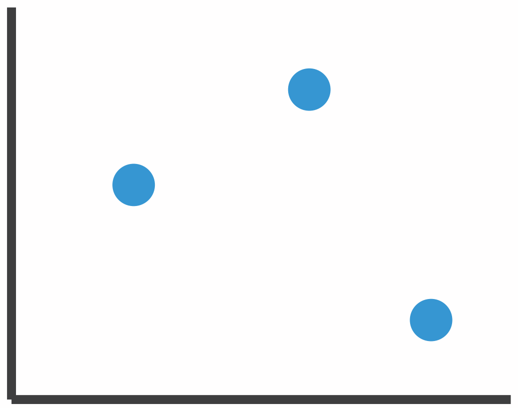


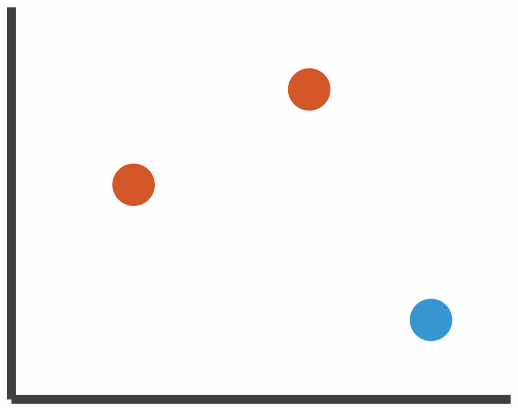
[VAD Fig 5.1]

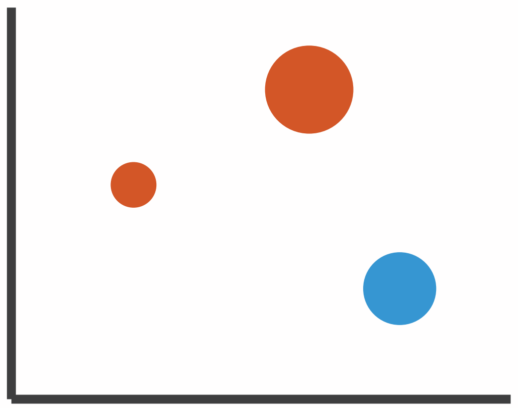
Encoding visually

- analyze idiom structure



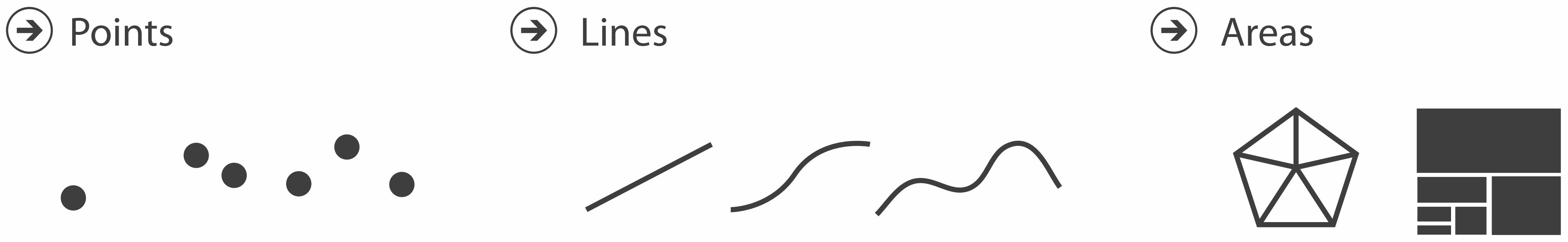




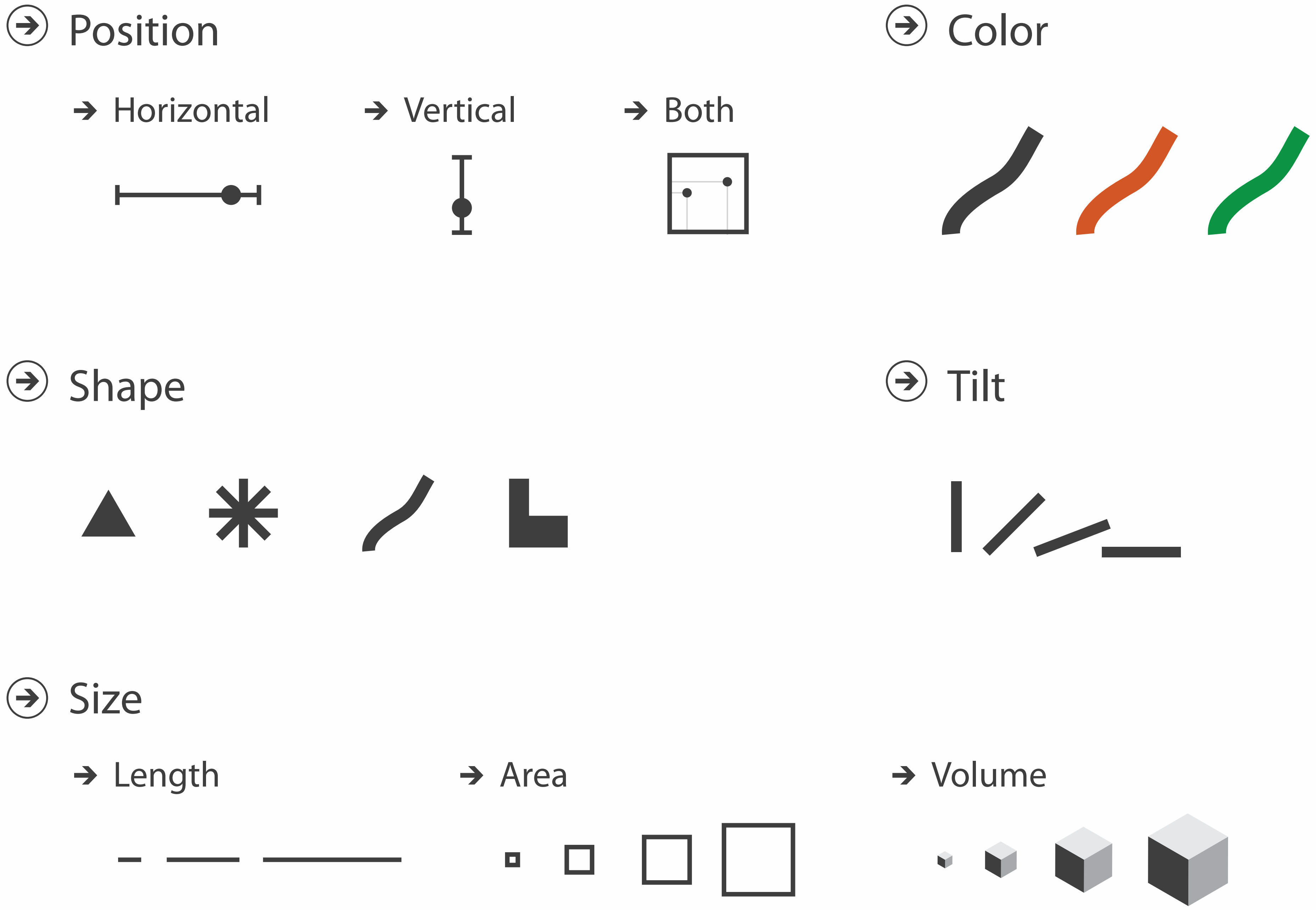


Definitions: Marks and channels

- marks
  - geometric primitives

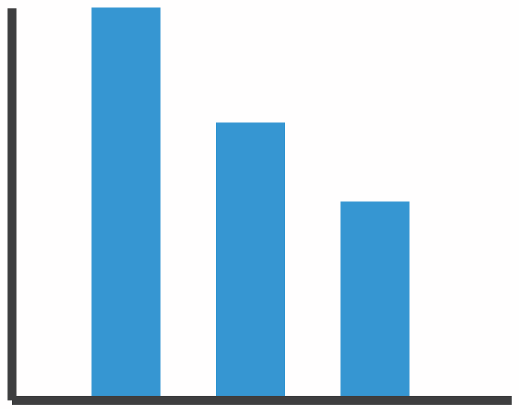


- channels
  - control appearance of marks



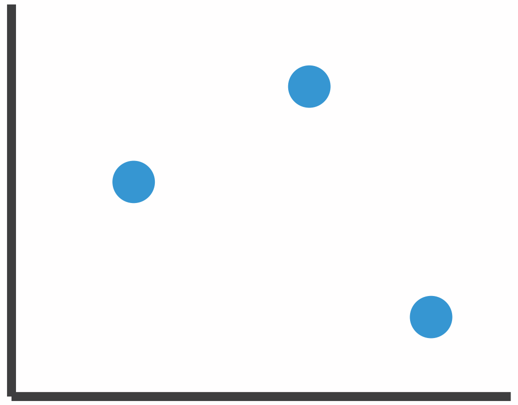
Encoding visually with marks and channels

- analyze idiom structure
  - as combination of marks and channels



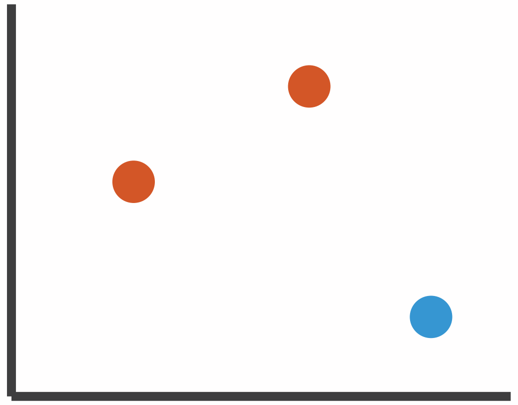
1:
vertical position

mark: line



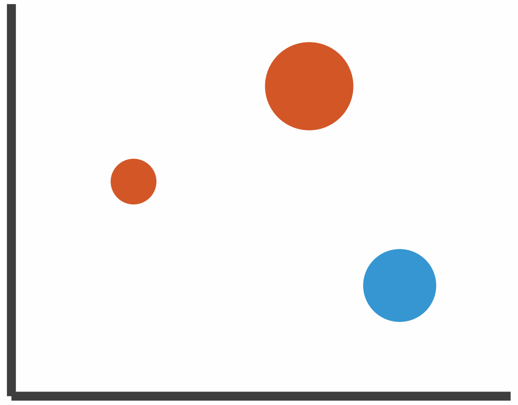
2:
vertical position
horizontal position

mark: point



3:
vertical position
horizontal position
color hue

mark: point

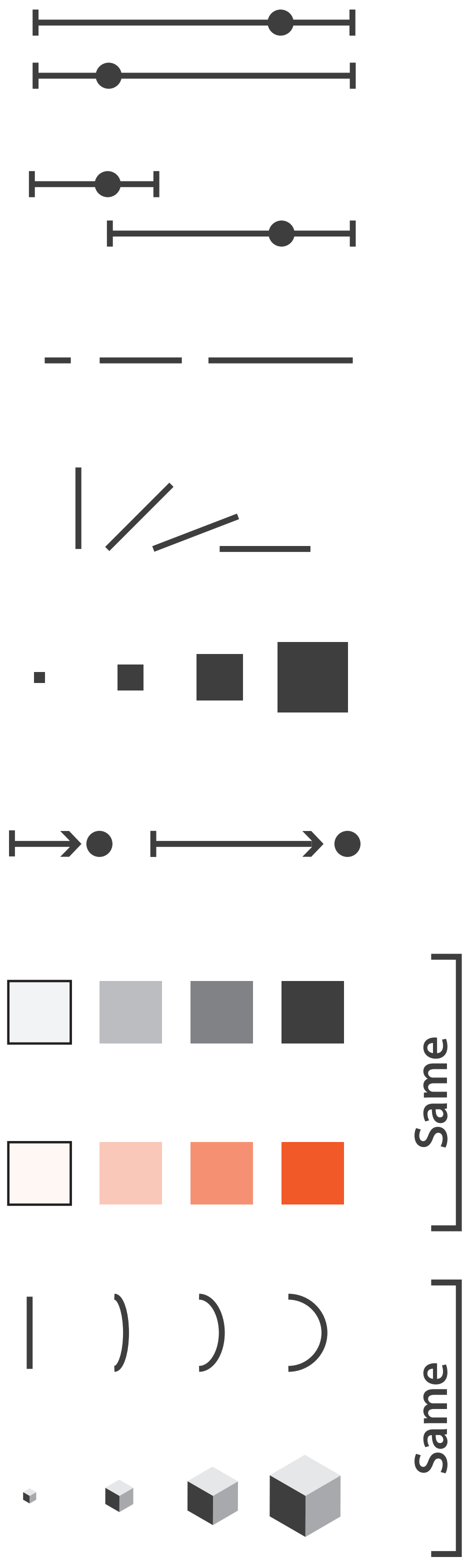


4:
vertical position
horizontal position
color hue
size (area)

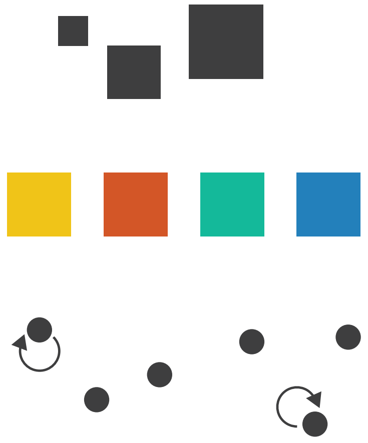
mark: point

Channels

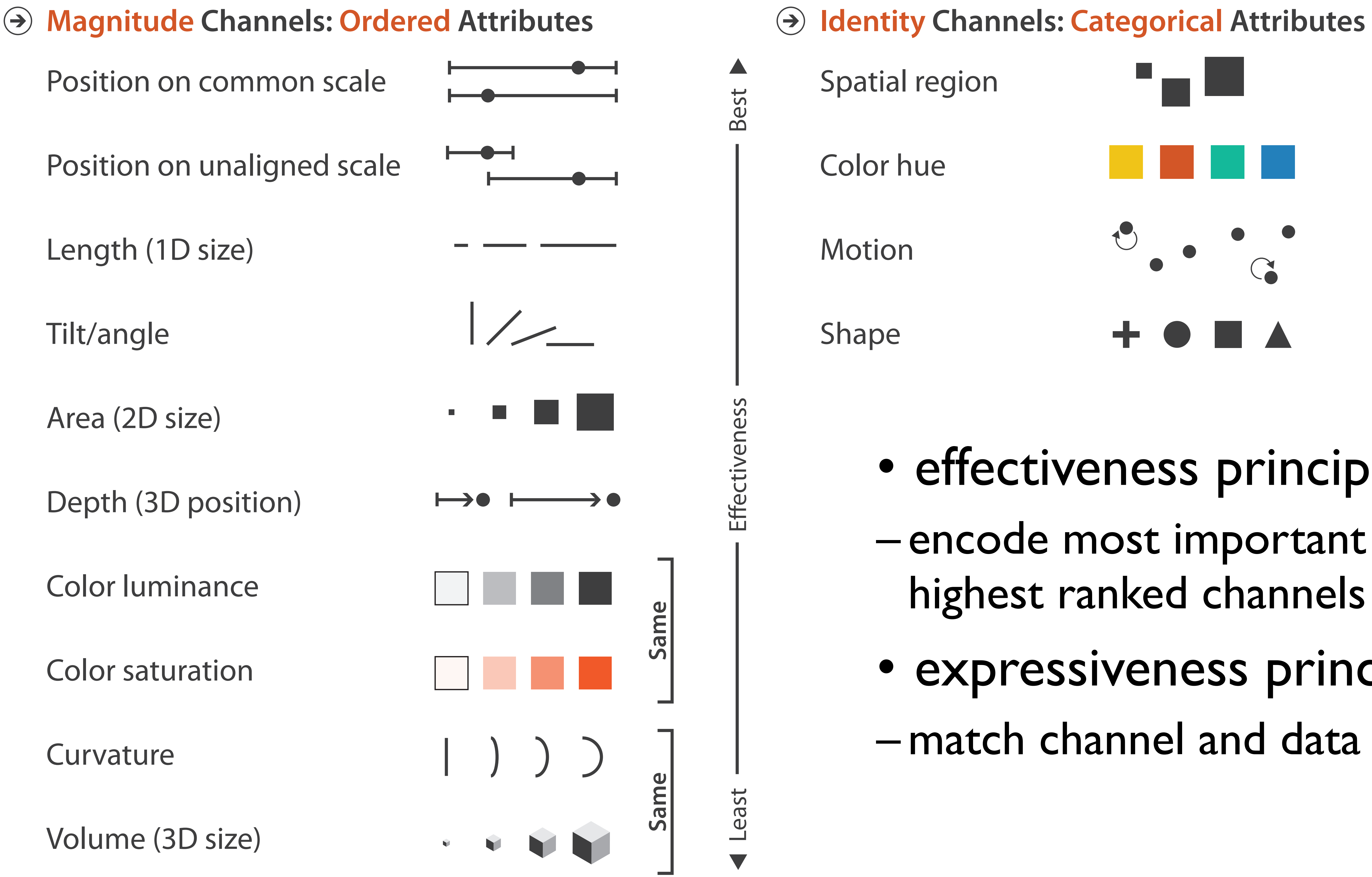
Position on common scale
Position on unaligned scale
Length (1D size)
Tilt/angle
Area (2D size)
Depth (3D position)
Color luminance
Color saturation
Curvature
Volume (3D size)



Spatial region
Color hue
Motion
Shape



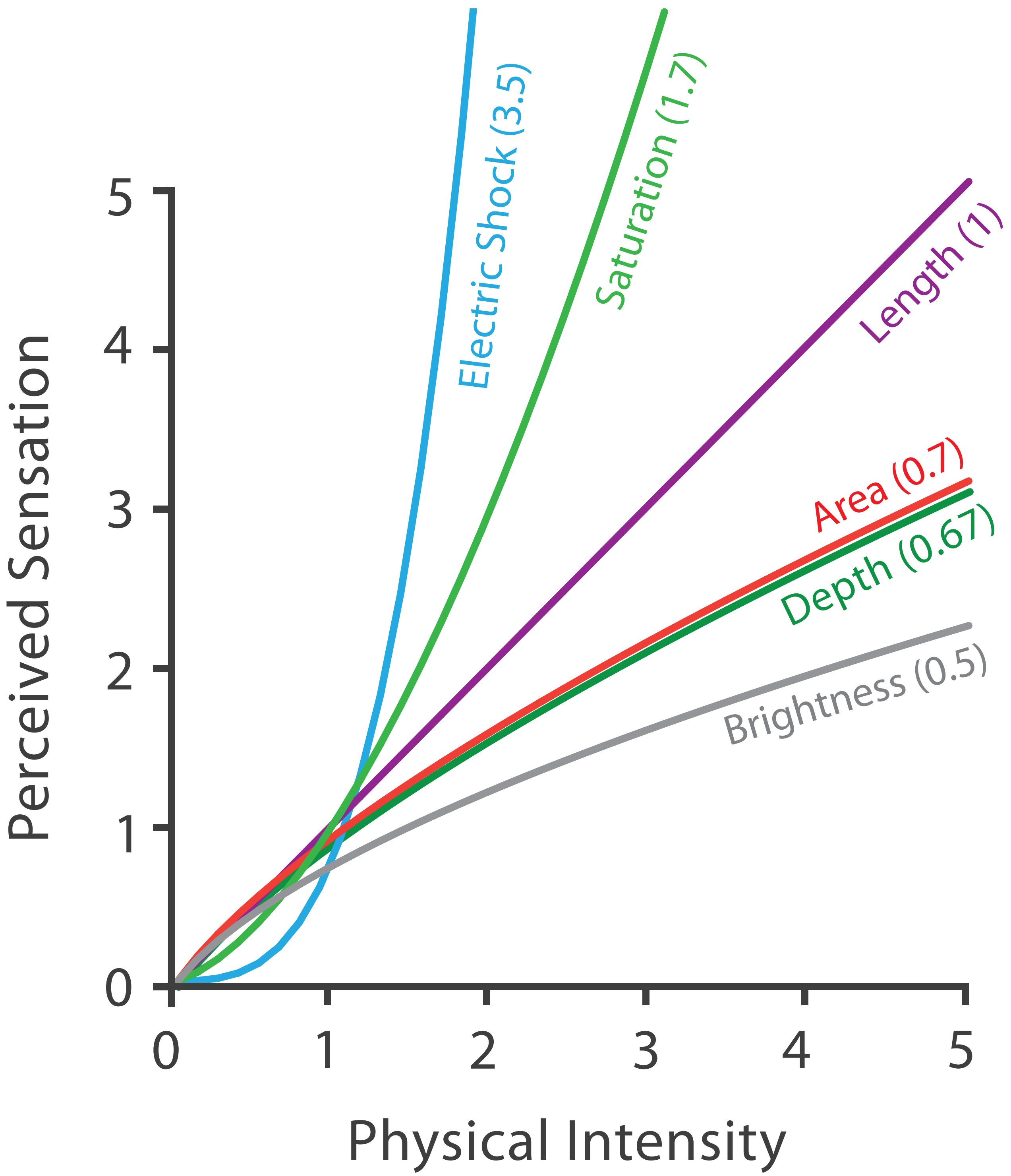
Channels: Rankings



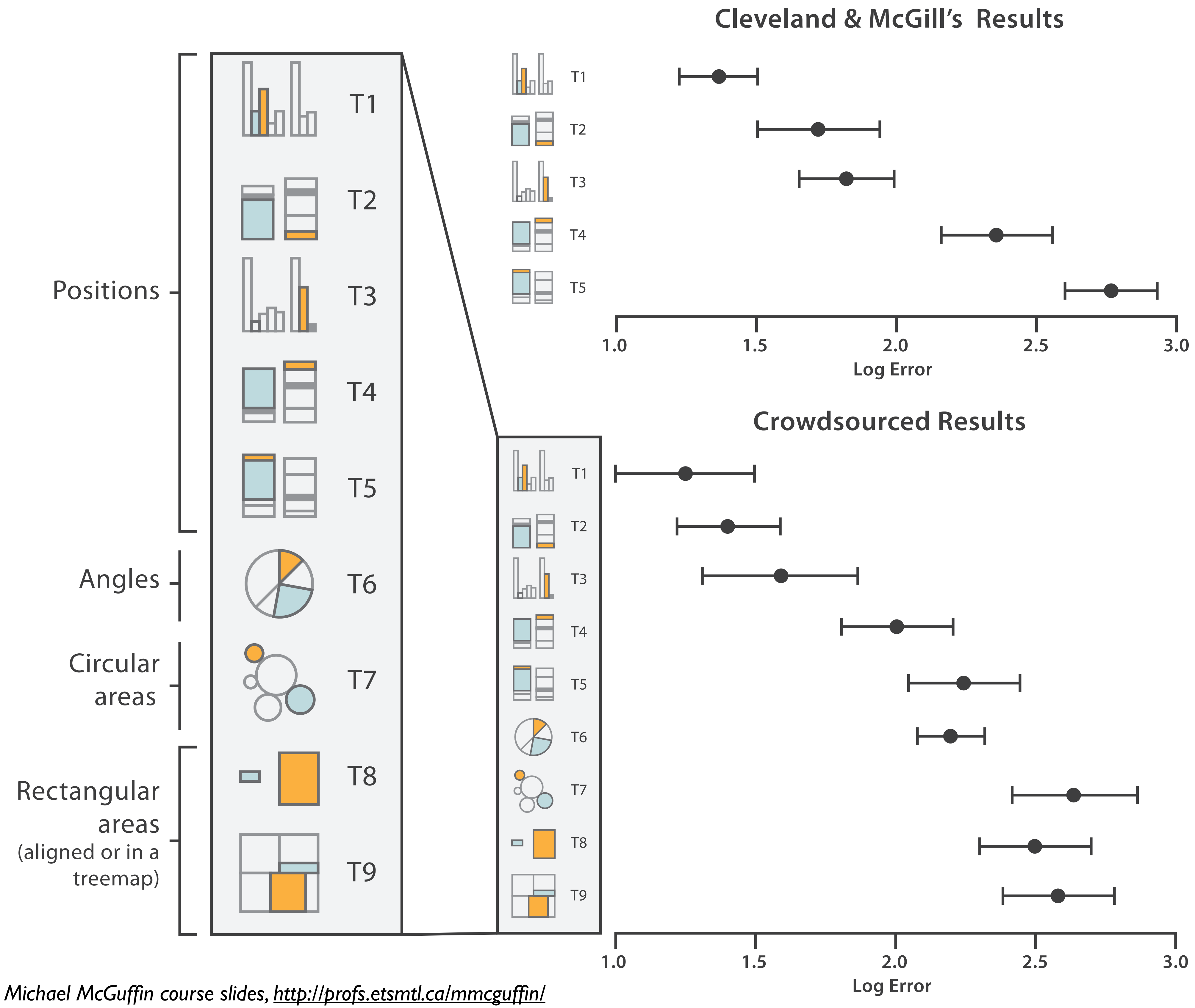
- effectiveness principle
  – encode most important attributes with highest ranked channels
- expressiveness principle
  – match channel and data characteristics

Accuracy: Fundamental Theory

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



Accuracy: Vis experiments

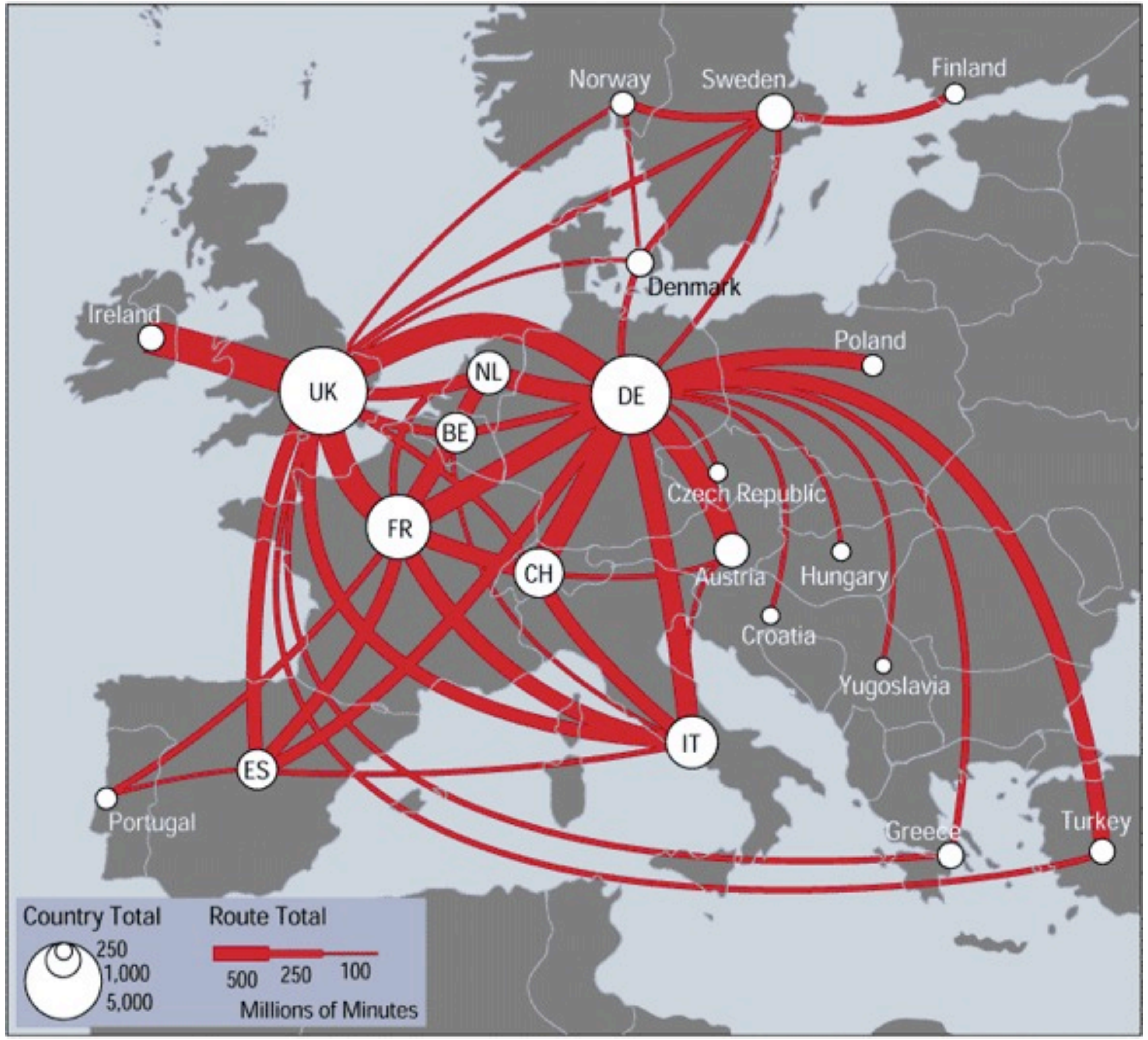


[Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design. Heer and Bostock. Proc ACM Conf. Human Factors in Computing Systems (CHI) 2010, p. 203–212.]

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

Discriminability: How many usable steps?

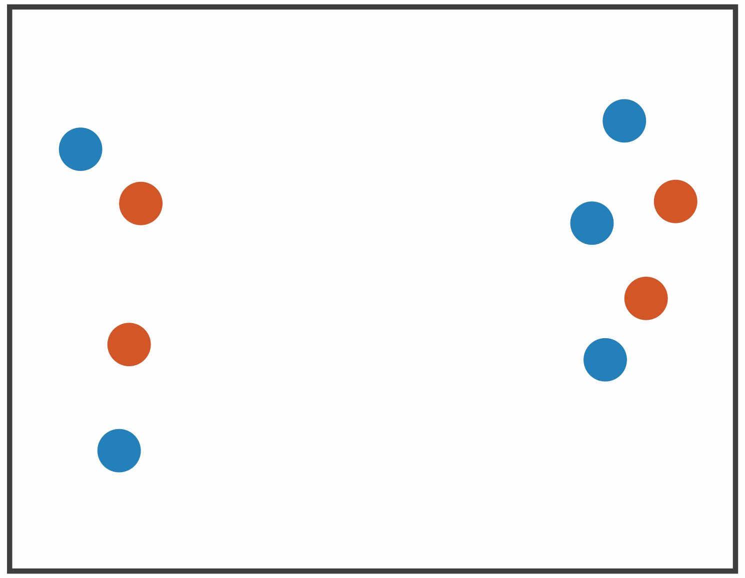
- must be sufficient for number of attribute levels to show
  - linewidth: few bins



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

Separability vs. Integrality

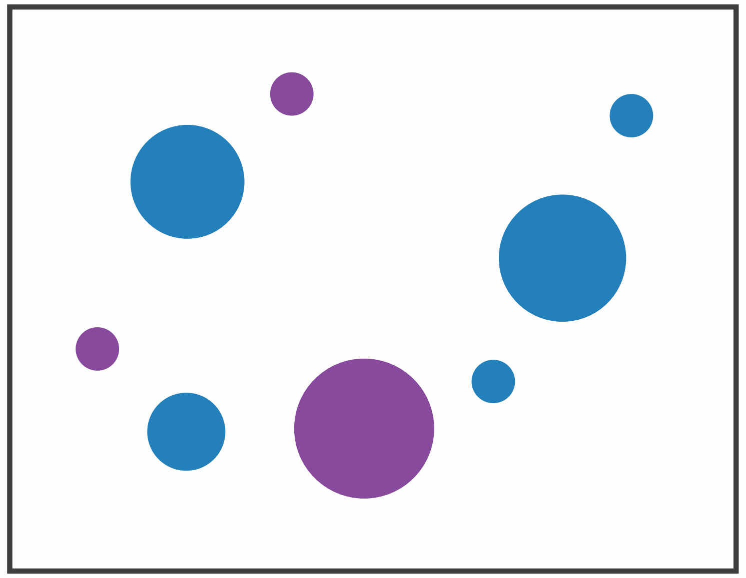
Position
+ Hue (Color)



Fully separable

2 groups each

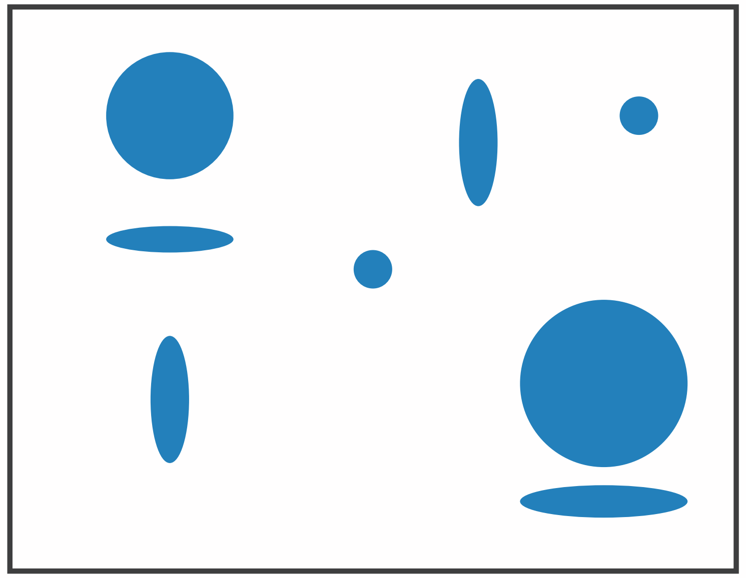
Size
+ Hue (Color)



Some interference

2 groups each

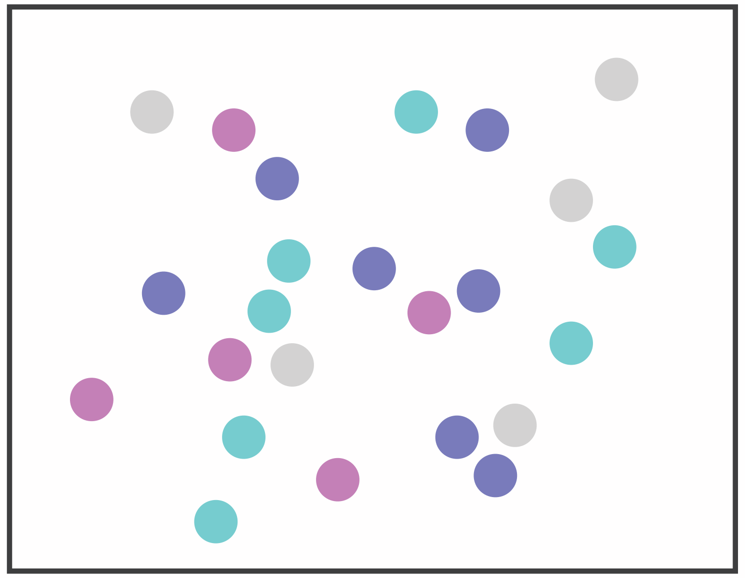
Width
+ Height



Some/significant interference

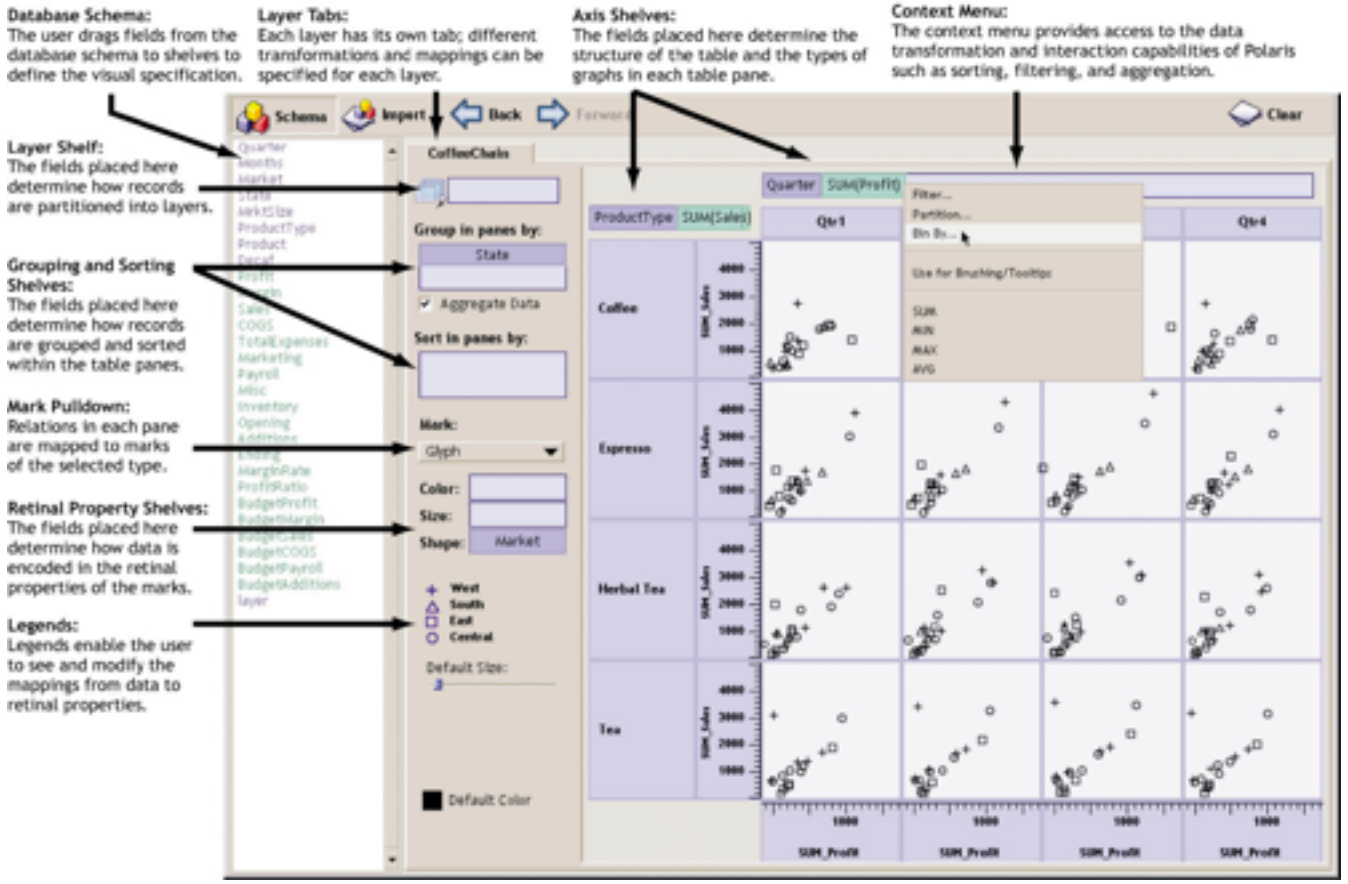
3 groups total: integral area

Red
+ Green



Major interference

4 groups total: integral hue



Polaris

A System for Query, Analysis and Visualization of Multi-dimensional Relational Databases

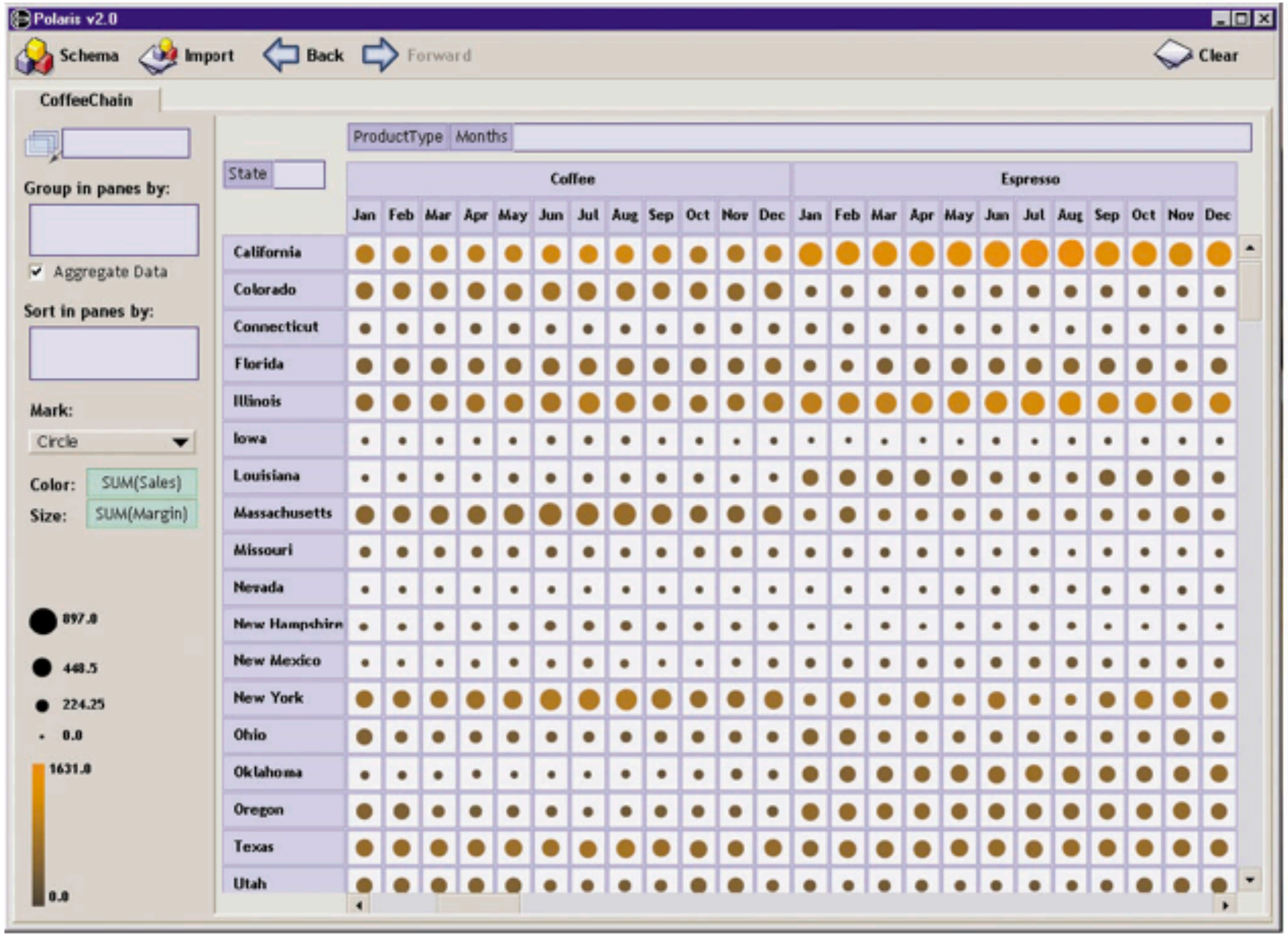
Chris Stolte, Diane Tang, Pat Hanrahan

http://www.graphics.stanford.edu/projects/polaris/

Polaris: A System for Query, Analysis and Visualization of Multi-dimensional Relational Databases.
Stolte, Tang and Hanrahan, IEEE TVCG 8(1):52-65 2002

Polaris: Stolte, Tang, and Hanrahan

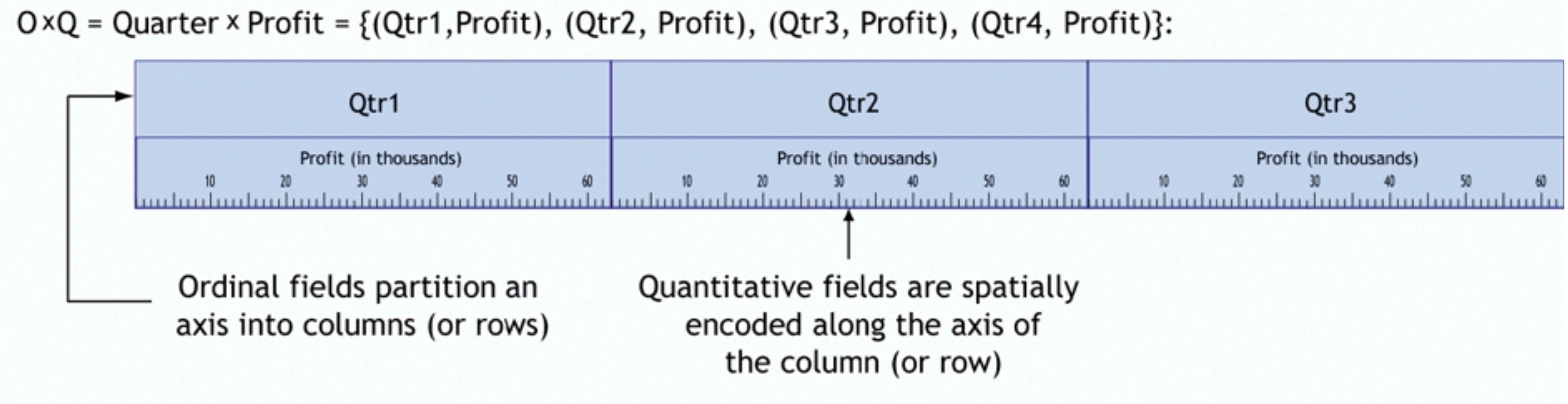
- infovis spreadsheet
  - table cells have graphical elements, not just numbers
  - wide range of channels and marks
- example
  - marks: circles
  - color channel: saturation
  - size channel: area
  - partition: state x product:month
    - ord x ord



[Fig 3a. Polaris: A System for Query, Analysis and Visualization of Multi-dimensional Relational Databases. Stolte, Tang and Hanrahan, IEEE TVCG 8(1):52-65 2002.]

Table Algebra :: Interactive Interface

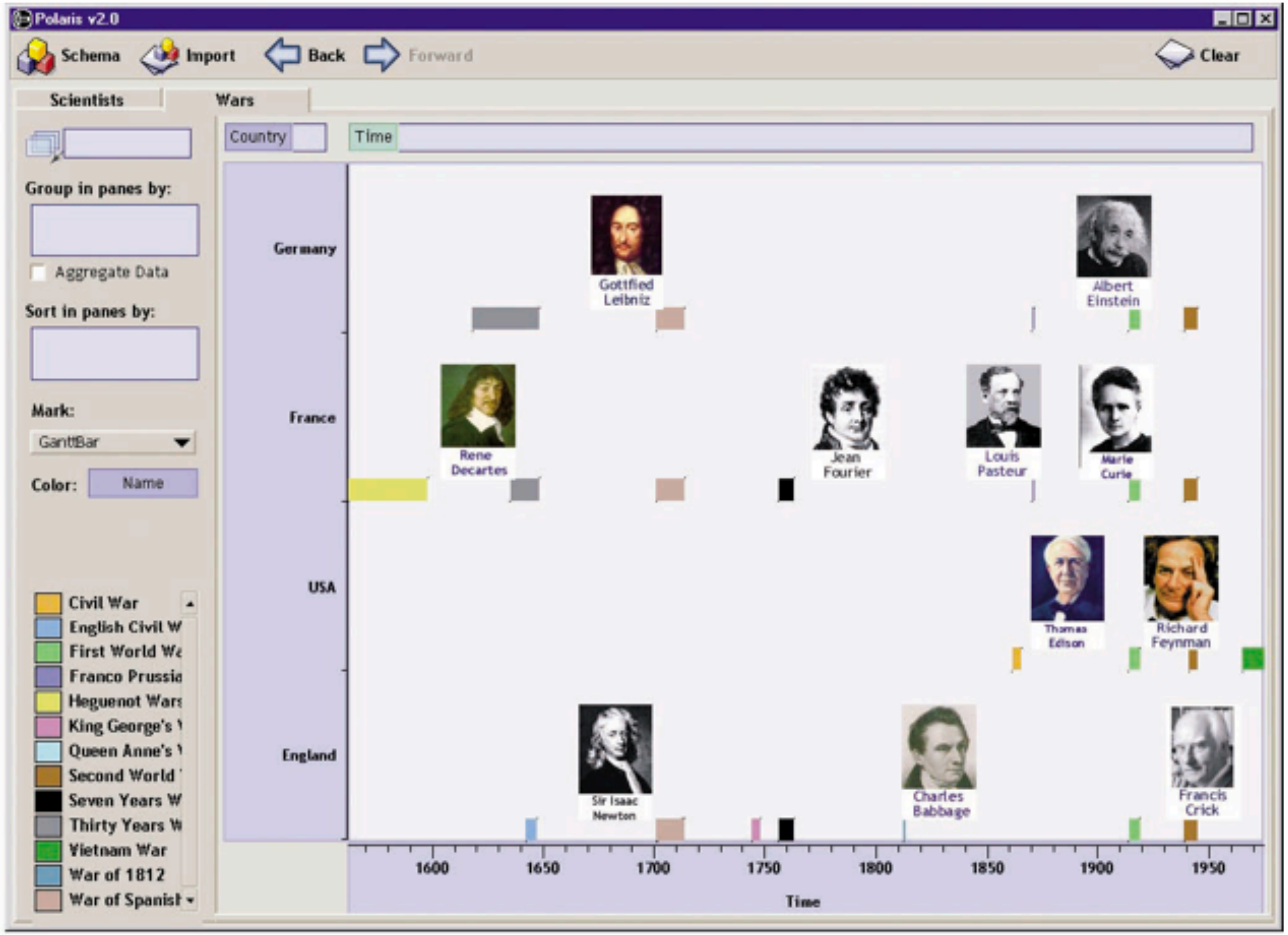
- drag and drop actions map to formal language underneath
  - partitioning using shelves
  - different results for ord vs quant



[Fig 2. Polaris: A System for Query, Analysis and Visualization of Multi-dimensional Relational Databases. Stolte, Tang and Hanrahan, IEEE TVCG 8(1):52-65 2002.]

Polaris

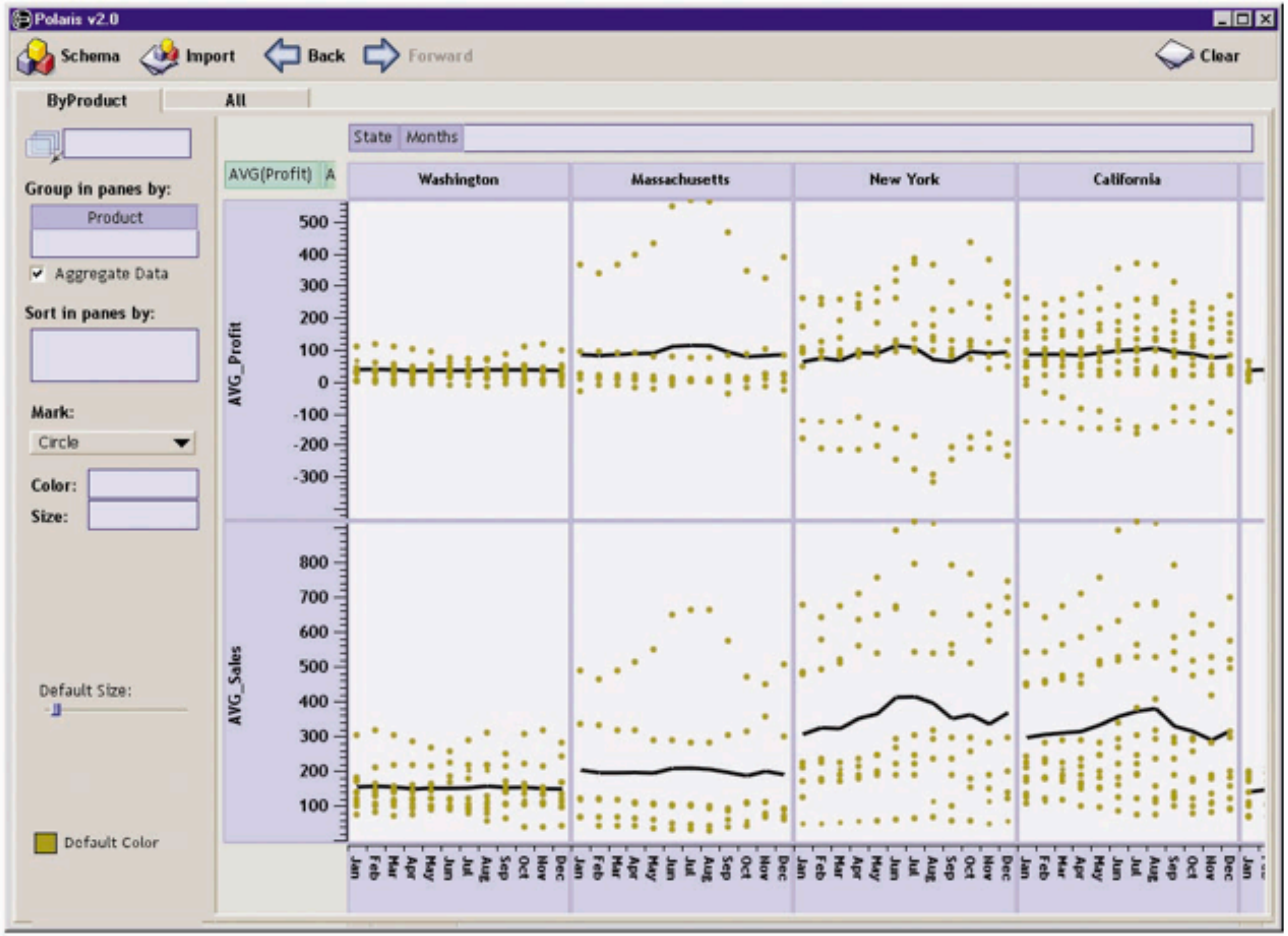
- example
  - marks: Gantt chart bars
  - color channels: nominal / categorical
  - spatial position channels: country x year
    - ord x quant



[Fig 3b. Polaris: A System for Query, Analysis and Visualization of Multi-dimensional Relational Databases. Stolte, Tang and Hanrahan, IEEE TVCG 8(1):52-65 2002.]

Polaris

- example
  - views: scatterplots
  - marks: points
  - spatial position channels: profit x month
    - quant x (2 ord)



[Fig 3d Polaris: A System for Query, Analysis and Visualization of Multi-dimensional Relational Databases. Stolte, Tang and Hanrahan, IEEE TVCG 8(1):52-65 2002.]

Terminology I: Now and Upcoming

- Marks and Channels
  - retinal variables/properties: *visual channels*
  - mark: *mark*
- Data Abstraction
  - column or field: *attribute*
    - nominal: *categorical*
    - ordinal: *ordered*
    - quantitative: *quantitative*
  - row or record: *item*
  - dimension / independent / ordinal: *key attribute*
    - all ordinal fields treated as dimensions in Polaris
  - measure / dependent : *value attribute*
    - all quantitative fields treated as measures in Polaris

Terminology II: Upcoming

- Data Abstraction
  - deriving data
- Map Color and Other Channels
  - hue: *hue*
  - value: *saturation*
  - brightness: *luminance*
- Manipulate View
  - sorting
- Facet Into Multiple Views
  - pane: *view*
  - partitioning
  - brushing: *linked highlighting*
- Reduce Items and Attributes
  - aggregation, filtering

Polaris: Pre and post

- influences
  - Bertin’s Semiology of Graphics book (1967 / 1998)
  - Wilkinson’s Grammar of Graphics book (1999 / 2005)
  - Mackinlay’s APT paper/system (1986)
  - Cleveland’s Visualizing Data book (1993)
- Stolte and Hanrahan commercialized as Stanford spinoff Tableau Software
  - major success story in vis, $2B IPO in 2013
  - Mackinlay joined in 2004, Wilkinson joined in 2014
- Tableau use in this course
  - very useful for analysis projects
  - possible sandbox for experimentation when starting programming projects
  - you can request free student license, good for one year
    - http://www.tableau.com/academic/students

Further reading: Articles

- Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design. Jeffrey Heer and Michael Bostock. Proc. CHI 2010
- Graphical Perception: Theory, Experimentation and the Application to the Development of Graphical Models. William S. Cleveland, Robert McGill, J. Am. Stat. Assoc. 79:387, pp. 531-554, 1984.
- A Model for Studying Display Methods of Statistical Graphics (with Discussion). William S. Cleveland. Journal of Computational and Statistical Graphics 2(4):323-364 1993.
- Automating the Design of Graphical Presentations of Relational Information. Jock Mackinlay, ACM Transaction on Graphics, vol. 5, no. 2, April 1986, pp. 110-141.
- Taxonomy-Based Glyph Design---With a Case Study on Visualizing Workflows of Biological Experiments. Eamonn Maguire, Philippe Rocca-Serra, Susanna-Assunta Sansone, Jim Davies, and Min Chen. IEEE TVCG (Proc. InfoVis 12) 18(12):2603-2612 2012.
- Glyph-Based Visualization: Foundations, Design Guidelines, Techniques and Applications. Rita Borgo, Johannes Kehrer, David H.S. Chung, Eamonn Maguire, Robert S. Laramee, Helwig Hauser, Matthew Ward, and Min Chen. Eurographics State of the Art Reports (STAR):39-63 2013.
- On the Theory of Scales of Measurement. S. S. Stevens. Science 103(2684):677-680, 1946.
- Perception in Vision web page with demos, Christopher Healey. (see also Attention and Visual Memory in Visualization and Computer Graphics, Christopher G. Healey and James T. Enns, IEEE TVCG 18(7):1170-1188 2012.)
- Feature Analysis in Early Vision: Evidence from Search Asymmetries. Treisman and Gormican. Psychological Review 95(1): 15-48, 1988.

Further reading: Books

- Visualization Analysis and Design. Munzner. CRC Press, 2014.
  - *Chap 5: Marks and Channels*
- The Grammar of Graphics, Leland Wilkinson, Springer-Verlag 1999.
- Semiology of Graphics, Jacques Bertin, Gauthier-Villars 1967, EHESS 1998.
- Psychophysics: Introduction to its Perceptual, Neural, and Social Prospects. Stevens. Wiley, 1975.
- Visual Thinking for Design. Ware. Morgan Kaufmann, 2008.
- Information Visualization: Perception for Design, 3rd edition. Ware. Morgan Kaufmann /Academic Press, 2013.
- How Maps Work: Representation, Visualization, and Design. Alan M. MacEachren. Guilford Press, 1995.

Next Time

- to read
  - VAD Ch. 1: What's Vis, and Why Do It? (review, mostly covered in first class)
  - VAD Ch. 2: Data Abstraction (new material)

Now

- Guest lecture/demo from Robert Kosara on Tableau