Week 1:
Intro, Tasks and Data, Marks and Channels

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University of British Columbia

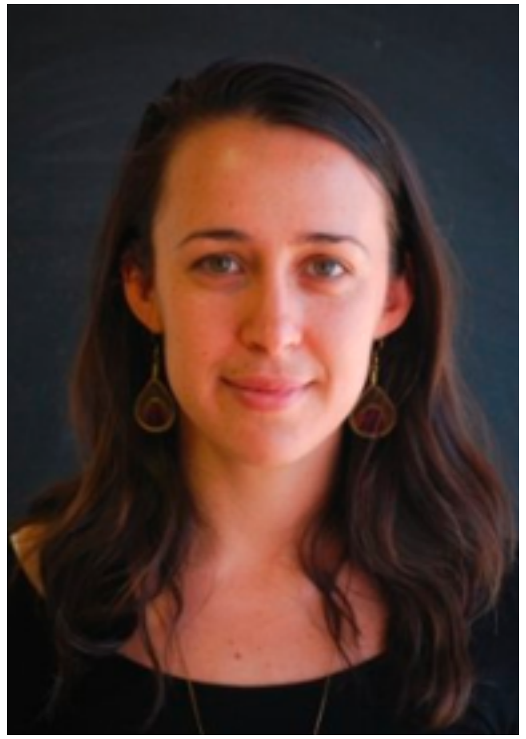
JRNL 520H, Special Topics in Contemporary Journalism: Data Visualization
Week 1: 13 September 2016

http://www.cs.ubc.ca/~tmm/courses/journ16

Who's who

- Instructor: Tamara Munzner
  - UBC Computer Science

- Instructor: Caitlin Havlak
  - Discourse Media



Class time

- 6 weeks, Sep 13 - Oct 18
  - once/week, 3 hr session 9:30am-12:30pm
- standard week
  - foundations lecture/discussion: 80 min
  - break: 15 min
  - demos: 45 min
  - lab: 30 min

- office hrs: 1-3pm most weeks

Structure

- participation, 10%
  - attend lectures and demos, discuss
    - tell us in advance if you'll miss class (and why)
    - tell when us recover if you were ill
- homework, 90%
  - gradual transition from structured to open-ended
  - 60%: 5 assignments
    - best 4 out of 5 marks used, so15% each
    - start in lab time, finish over the subsequent week
    - due just before next class session (9am)
    - some solo, some in groups of 2
  - 30%: final assignment
    - find your own interesting data and design your own visualization for it

Further reading

- optional textbook for following up on visualization foundations lectures
  - Tamara Munzner. Visualization Analysis and Design. CRC Press, 2014.
    - http://www.cs.ubc.ca/~tmm/vadbook/
  - library has multiple ebook copies
  - to buy yourself, see course page
- optional textbook for more about Tableau software
  - Ben Jones, Communicating Data with Tableau. O'Reilly, 2014.
    - http://dataremixed.com/books/cdwt/
- optional papers/books
  - links and references posted on course page
  - if DL links, use library EZproxy from off campus

Finding us

- office hours in Sing Tao bldg
  - 1-3pm Tuesdays: Tamara and/or Caitlin
  - by appointment: Tamara in ICICS/CS bldg Room X661
- email other times
  - tmm@cs.ubc.ca, caitlin@discoursemedia.org
- course page is font of all information
  - don't forget to refresh, frequent updates
  - http://www.cs.ubc.ca/~tmm/courses/journ16

Topics

- Week 1
  - Intro
  - Tasks and Data
  - Marks and Channels
- Week 2
  - Arrange Data Tables
- Week 3
  - Color
  - Arrange Spatial Data
- Week 4
  - Manipulate, Facet, Reduce
- Week 5
  - Wrangle
  - Stories
  - Rules of Thumb
- Week 6
  - Networks
  - Regression Lines
  - Vis in Newsrooms

Introduction: Defining visualization (vis)

Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.

Why?...

Why have a human in the loop?

Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.

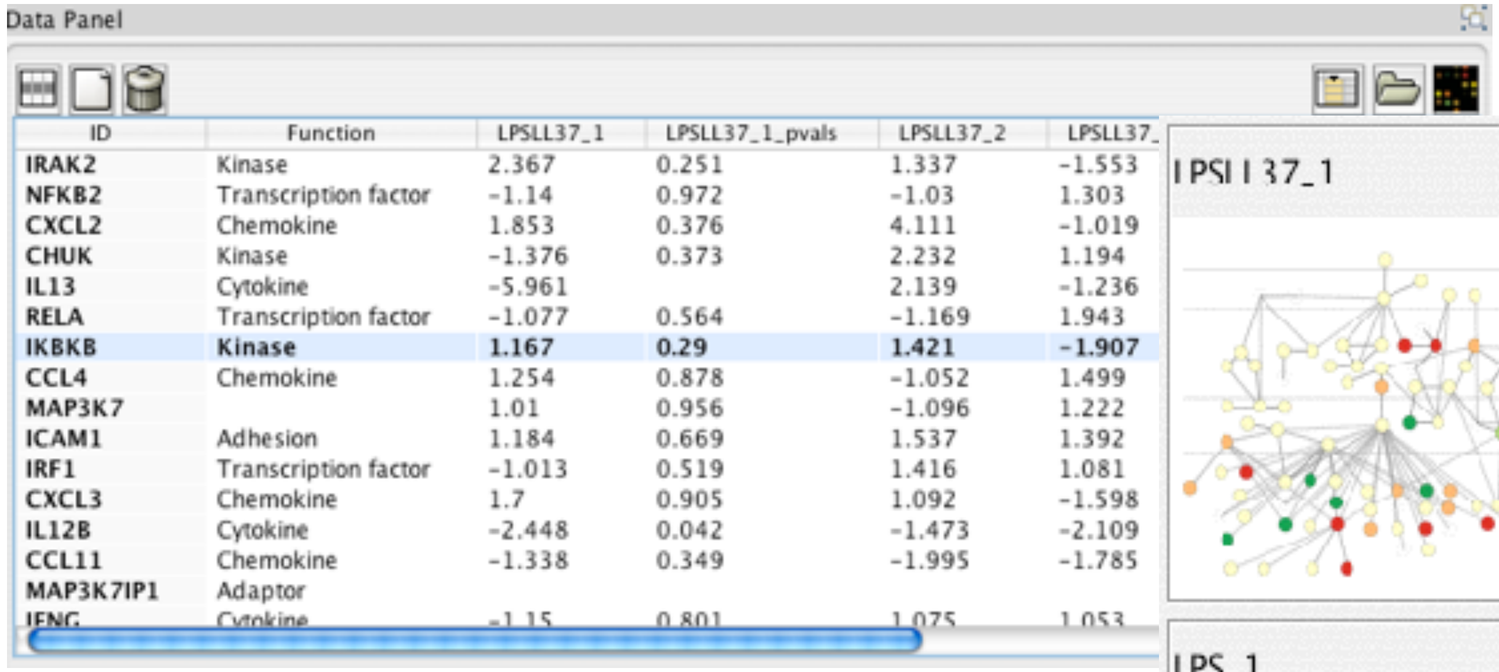
Visualization is suitable when there is a need to augment human capabilities rather than replace people with computational decision-making methods.

- don't need vis when fully automatic solution exists and is trusted
- many analysis problems ill-specified
  - don't know exactly what questions to ask in advance
- possibilities
  - long-term use for end users (e.g. exploratory analysis of scientific data)
  - *presentation of known results*
  - stepping stone to better understanding of requirements before developing models
  - help developers of automatic solution refine/debug, determine parameters
  - help end users of automatic solutions verify, build trust

Why use an external representation?

Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.

- external representation: replace cognition with perception



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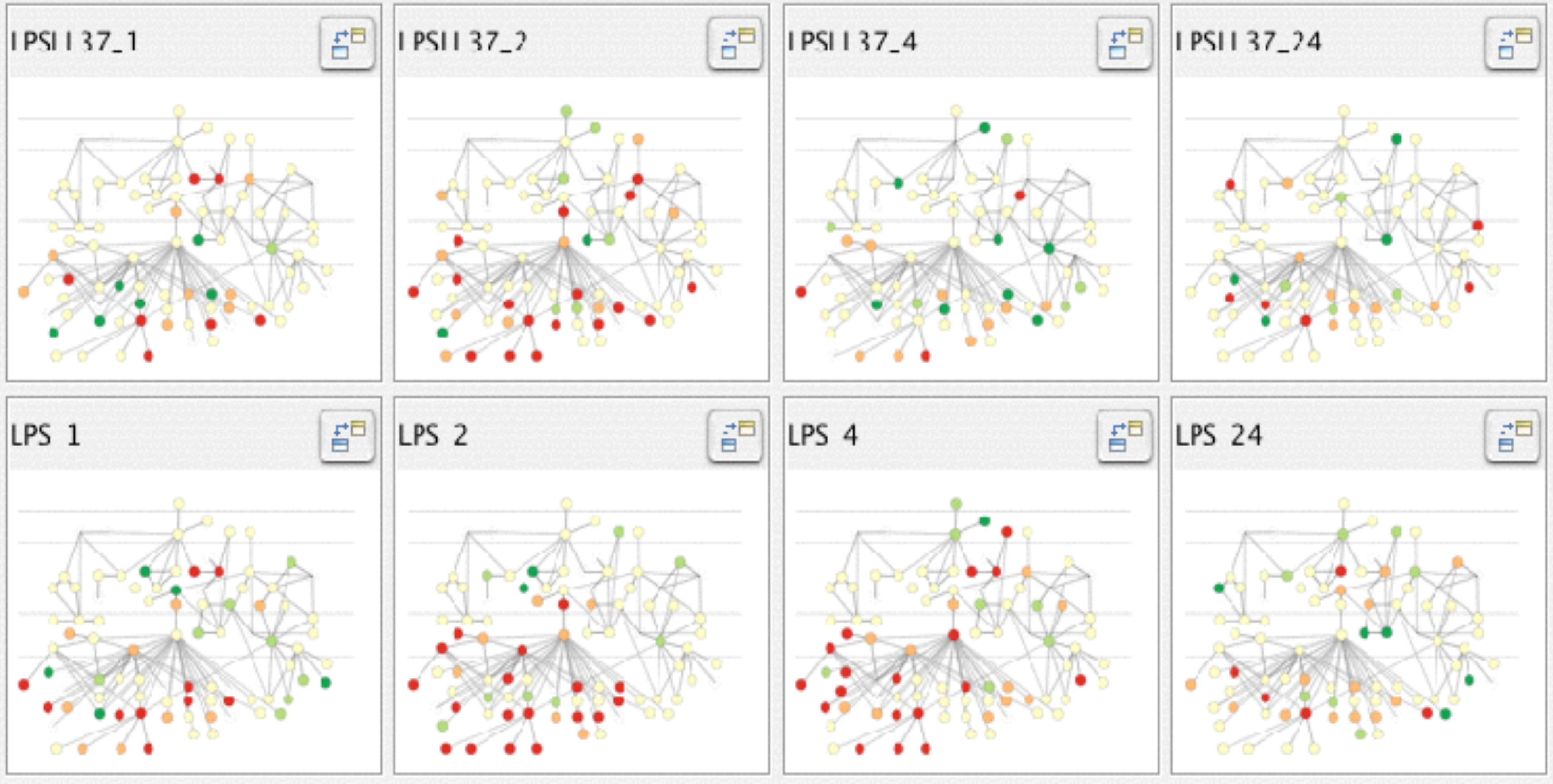
NFKB2	Transcription factor	-1.14	0.972	-1.03	1.303
CXCL2	Chemokine	1.853	0.376	4.111	-1.019
CHUK	Kinase	-1.376	0.373	2.232	1.194
IL13	Cytokine	-5.961		2.139	-1.236
RELA	Transcription factor	-1.077	0.564	-1.169	1.943
IKBKB	Kinase	1.167	0.29	1.421	-1.907
CCL4	Chemokine	1.254	0.878	-1.052	1.499
MAP3K7		1.01	0.956	-1.096	1.222
ICAM1	Adhesion	1.184	0.669	1.537	1.392
IRF1	Transcription factor	-1.013	0.519	1.416	1.081
CXCL3	Chemokine	1.7	0.905	1.092	-1.598
IL12B	Cytokine	-2.448	0.042	-1.473	-2.109
CCL11	Chemokine	-1.338	0.349	-1.995	-1.785
MAP3K7IP1	Adaptor				
IFNG	Cytokine	-1.15	0.801	1.075	1.053



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

Why depend on vision?

Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.

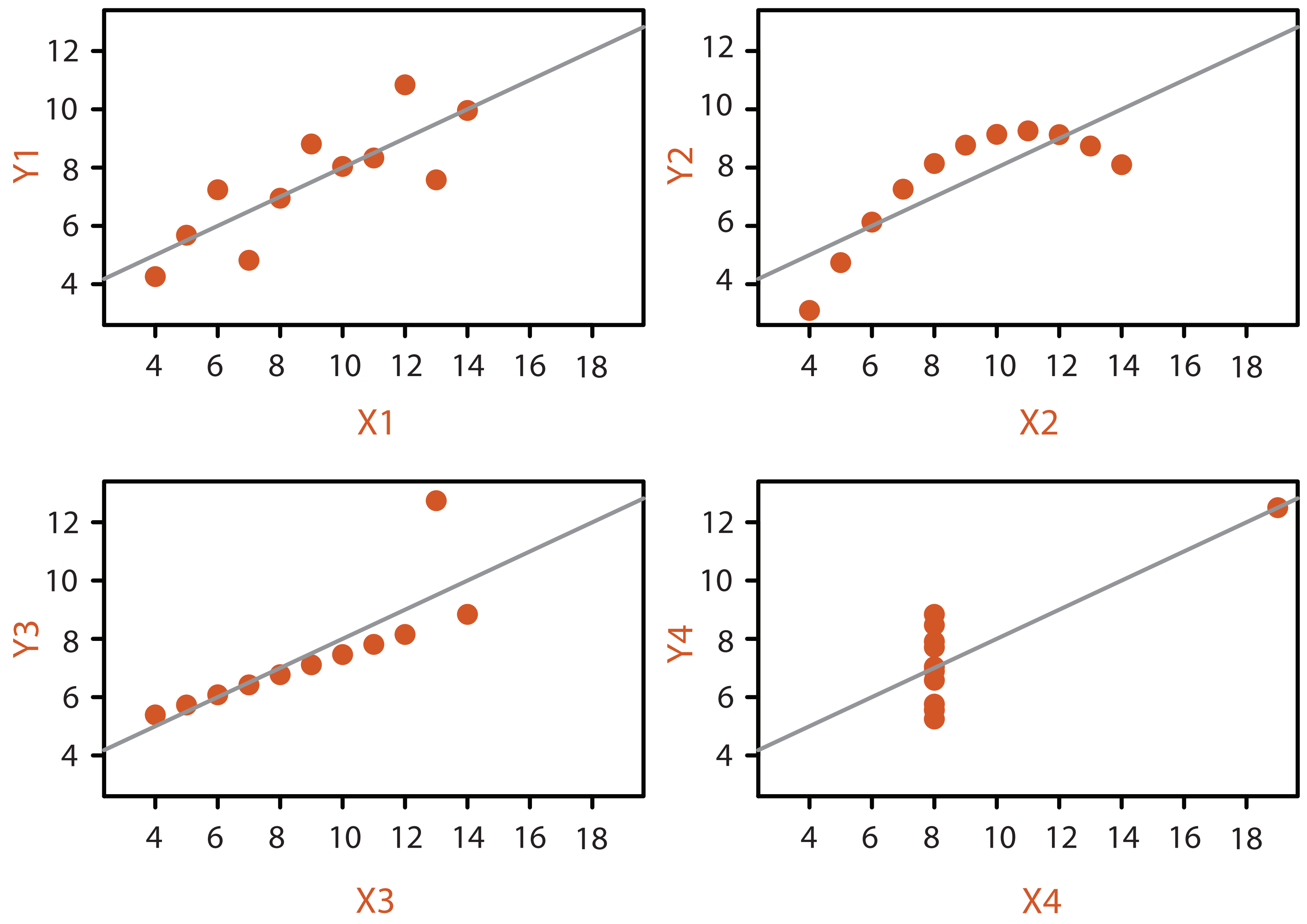
- human visual system is high-bandwidth channel to brain
  - overview possible due to background processing
    - subjective experience of seeing everything simultaneously
    - significant processing occurs in parallel and pre-attentively
- sound: lower bandwidth and different semantics
  - overview not supported
    - subjective experience of sequential stream
- touch/haptics: impoverished record/replay capacity
  - only very low-bandwidth communication thus far
- taste, smell: no viable record/replay devices

Why show the data in detail?

- summaries lose information
  - confirm expected and find unexpected patterns
  - assess validity of statistical model

Anscombe's Quartet

Identical statistics	
x mean	9
x variance	10
y mean	7.5
y variance	3.75
x/y correlation	0.816



Why focus on tasks and effectiveness?

Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.

- tasks serve as constraint on design (as does data)
  - idioms do not serve all tasks equally!
  - challenge: recast tasks from domain-specific vocabulary to abstract forms
- most possibilities ineffective
  - validation is necessary, but tricky
  - increases chance of finding good solutions if you understand full space of possibilities
- what counts as effective?
  - novel: enable entirely new kinds of analysis
  - faster: speed up existing workflows

What resource limitations are we faced with?

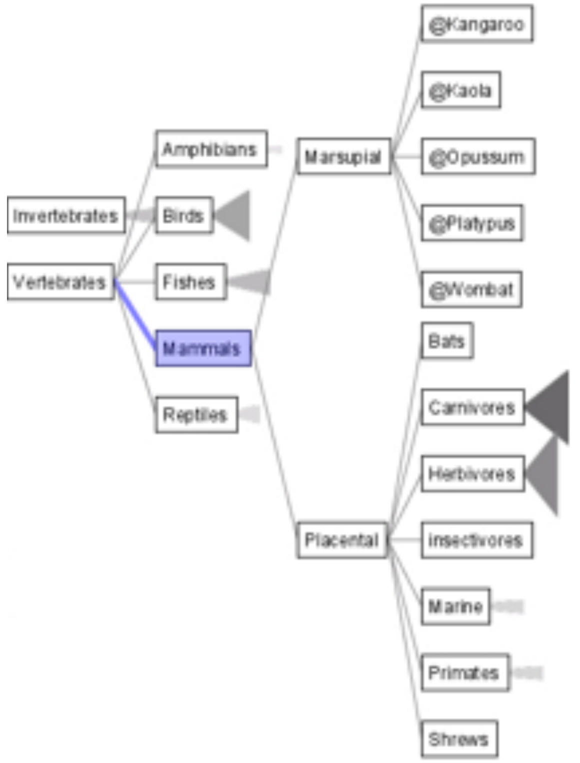
Vis designers must take into account three very different kinds of resource limitations: those of computers, of humans, and of displays.

- computational limits
  - processing time
  - system memory
- human limits
  - human attention and memory
- display limits
  - pixels are precious resource, the most constrained resource
  - **information density**: ratio of space used to encode info vs unused whitespace
    - tradeoff between clutter and wasting space, find sweet spot between dense and sparse

Why analyze?

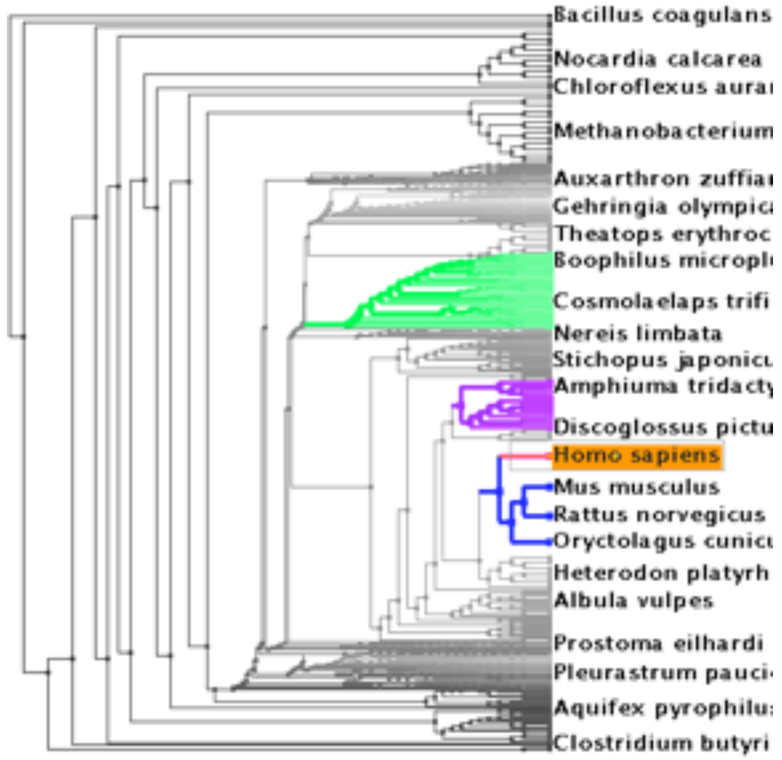
- imposes structure on huge design space
  - scaffold to help you think systematically about choices
  - analyzing existing as stepping stone to designing new
  - most possibilities ineffective for particular task/data combination

SpaceTree



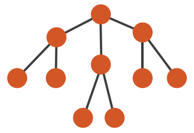
[SpaceTree: Supporting Exploration in Large Node Link Tree, Design Evolution and Empirical Evaluation. Grosjean, Plaisant, and Bederson. Proc. InfoVis 2002, p 57–64.]

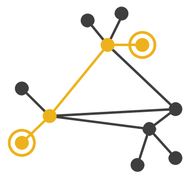
TreeJuxtaposer

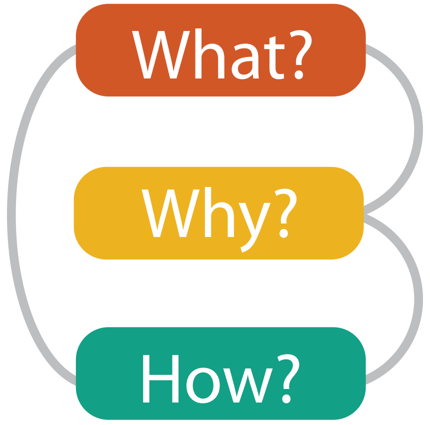


[TreeJuxtaposer: Scalable Tree Comparison Using Focus +Context With Guaranteed Visibility. ACM Trans. on Graphics (Proc. SIGGRAPH) 22:453– 462, 2003.]

What?	Why?	How?
➔ Tree	➔ Actions: ➔ Present ➔ Locate ➔ Identify	➔ SpaceTree: ➔ Encode ➔ Navigate ➔ Select ➔ Filter ➔ Aggregate
	➔ Targets: ➔ Path between two nodes	➔ TreeJuxtaposer: ➔ Encode ➔ Navigate ➔ Select ➔ Arrange

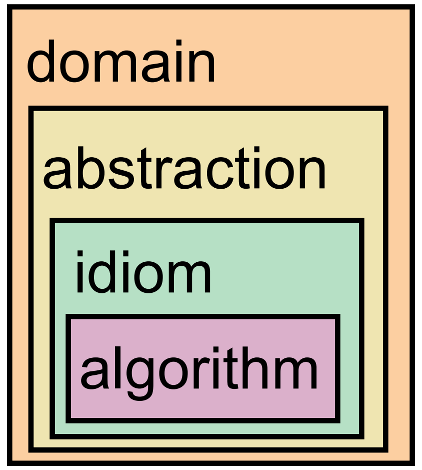




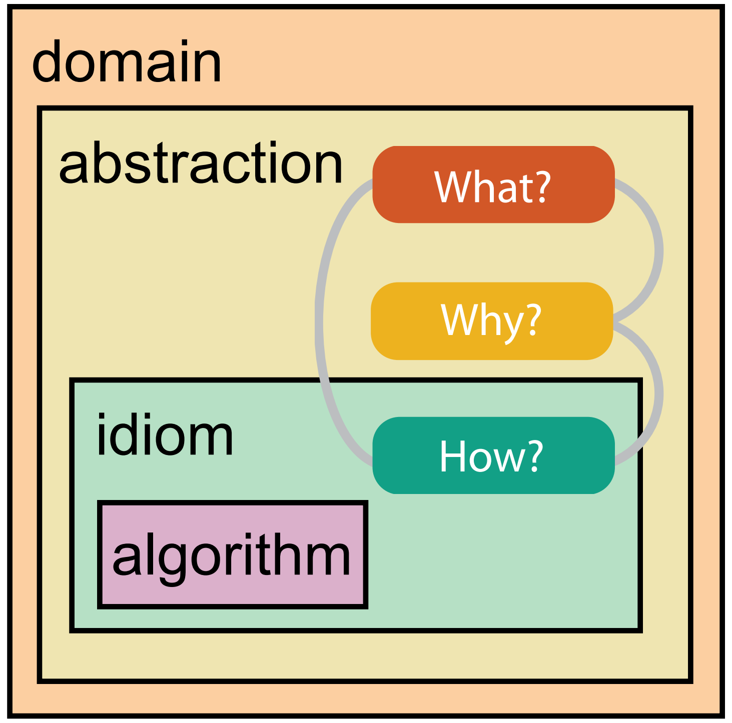


Analysis framework: Four levels, three questions

- *domain* situation
  - who are the target users?
- *abstraction*
  - translate from specifics of domain to vocabulary of vis
- what is shown? **data abstraction**
  - often don't just draw what you're given: transform to new form
- why is the user looking at it? **task abstraction**
- *idiom*
- how is it shown?
  - **visual encoding idiom**: how to draw
  - **interaction idiom**: how to manipulate
- *algorithm*
  - efficient computation



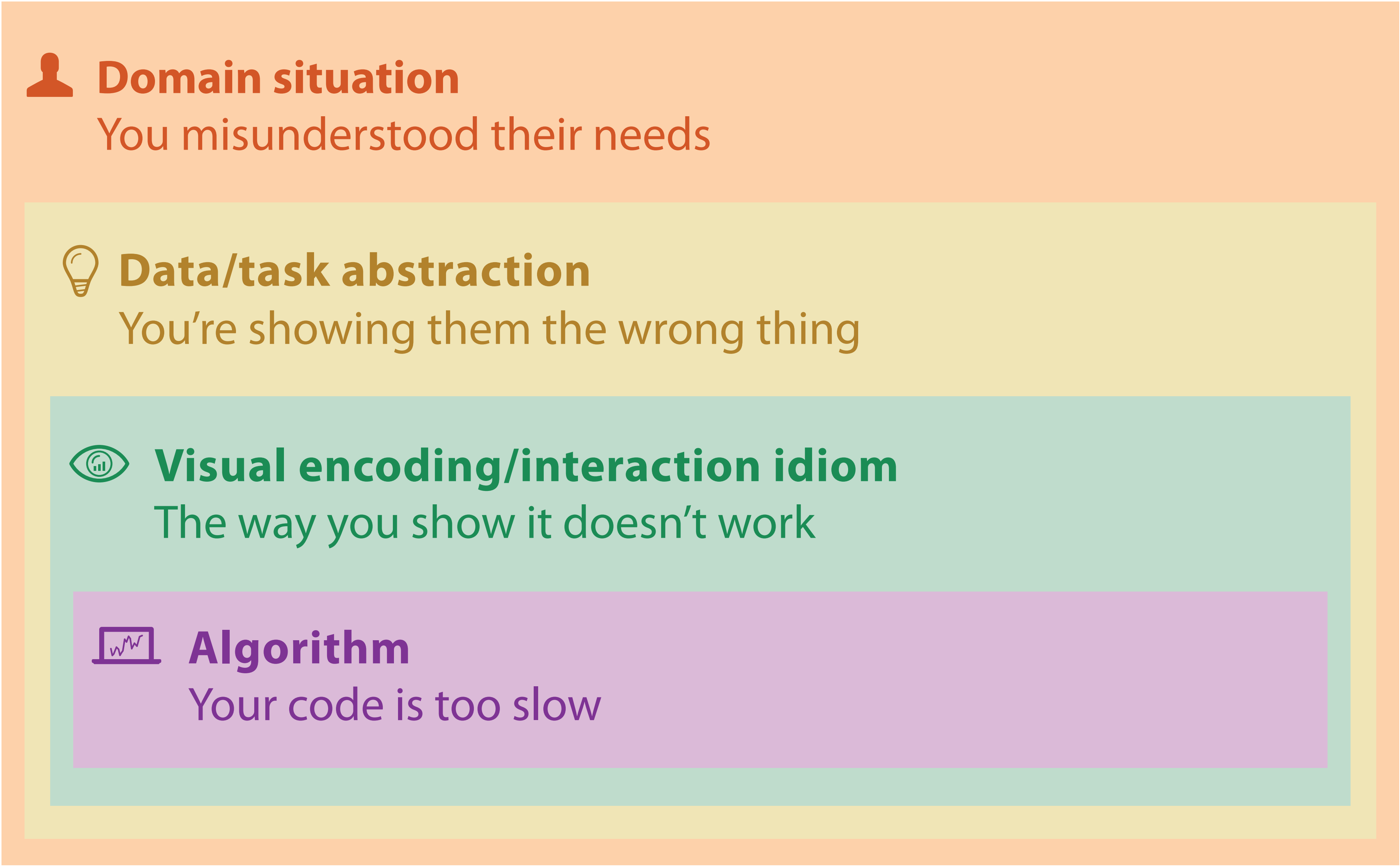
[A Nested Model of Visualization Design and Validation.
Munzner. IEEE TVCG 15(6):921-928, 2009 (Proc. InfoVis 2009).]



[A Multi-Level Typology of Abstract Visualization Tasks
Brehmer and Munzner. IEEE TVCG 19(12):2376-2385, 2013 (Proc. InfoVis 2013).]

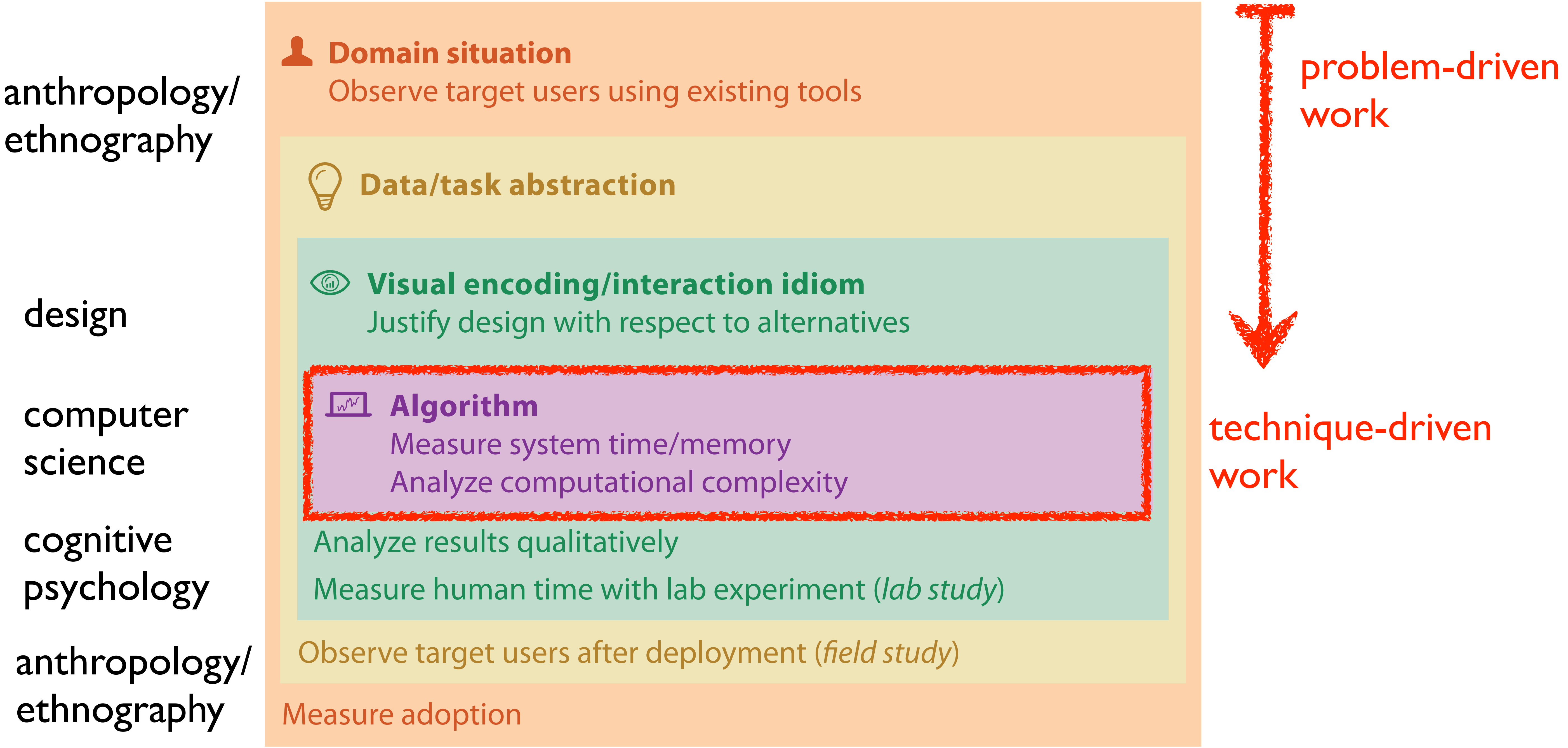
Why is validation difficult?

- different ways to get it wrong at each level

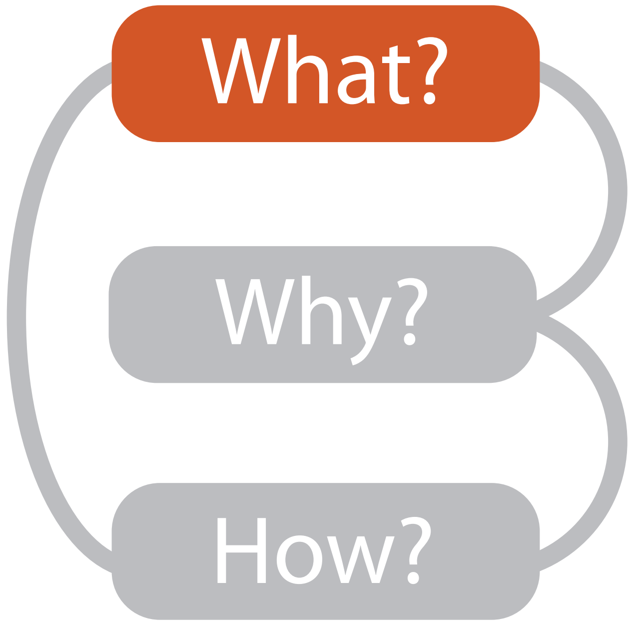


Why is validation difficult?

- solution: use methods from different fields at each level



[A Nested Model of Visualization Design and Validation. Munzner. IEEE TVCG 15(6):921-928, 2009 (Proc. InfoVis 2009).]



What?

Datasets

Data Types

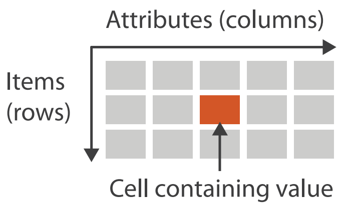
→ Items → Attributes → Links → Positions → Grids

Data and Dataset Types

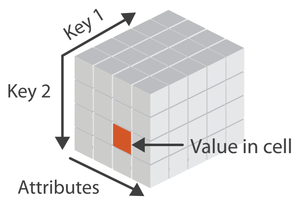
Tables	Networks & Trees	Fields	Geometry	Clusters, Sets, Lists
Items	Items (nodes)	Grids	Items	Items
Attributes	Links	Positions	Positions	
	Attributes	Attributes		

Dataset Types

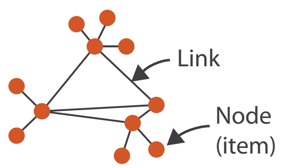
→ Tables



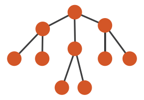
→ *Multidimensional Table*



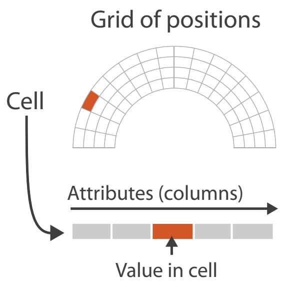
→ Networks



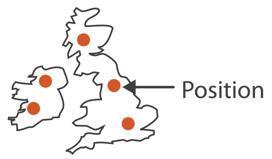
→ *Trees*



→ Fields (Continuous)



→ Geometry (Spatial)



Dataset Availability

→ Static

→ Dynamic

Attributes

Attribute Types

→ Categorical

→ Ordered

→ *Ordinal*

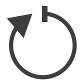
→ *Quantitative*

Ordering Direction

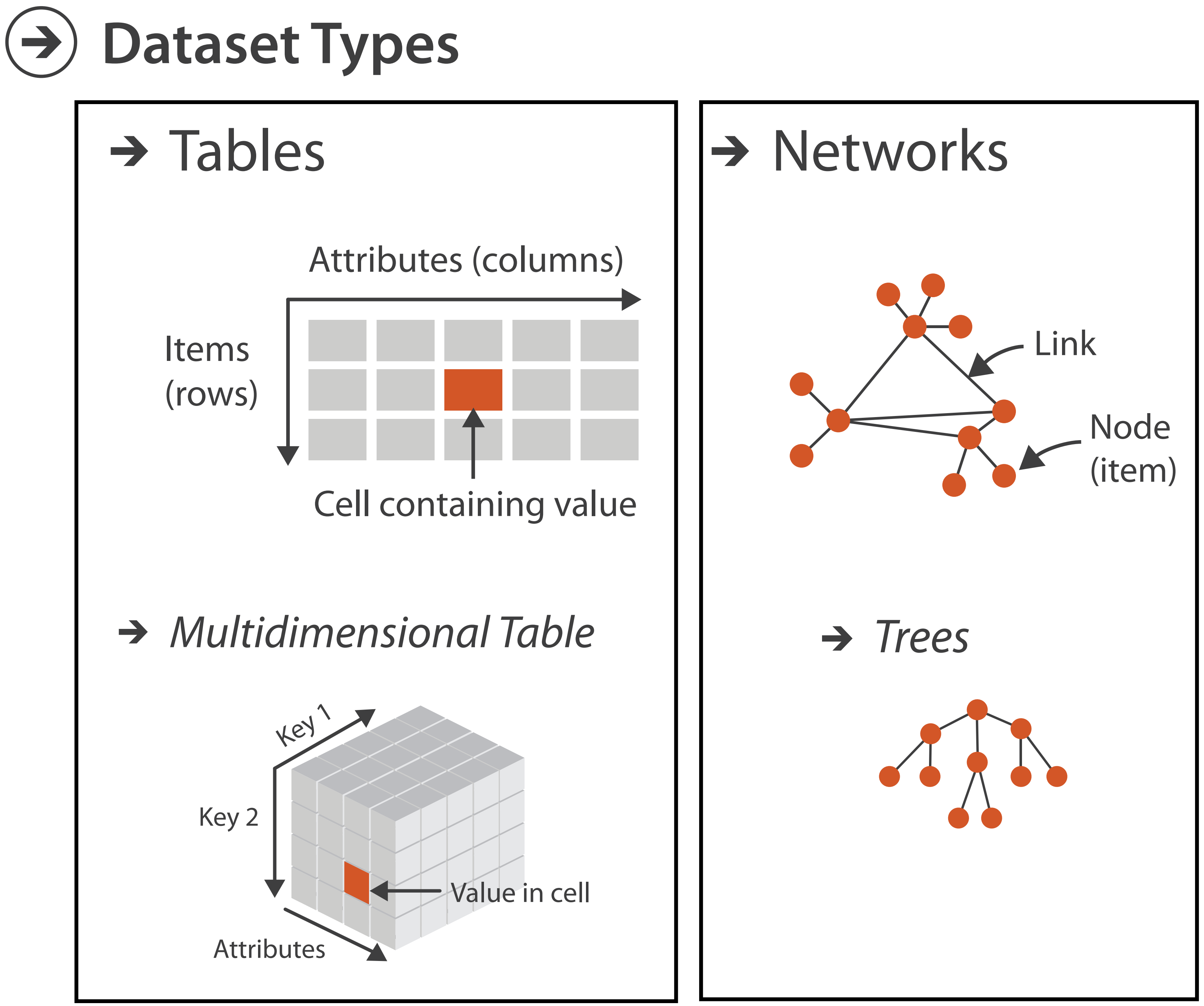
→ Sequential

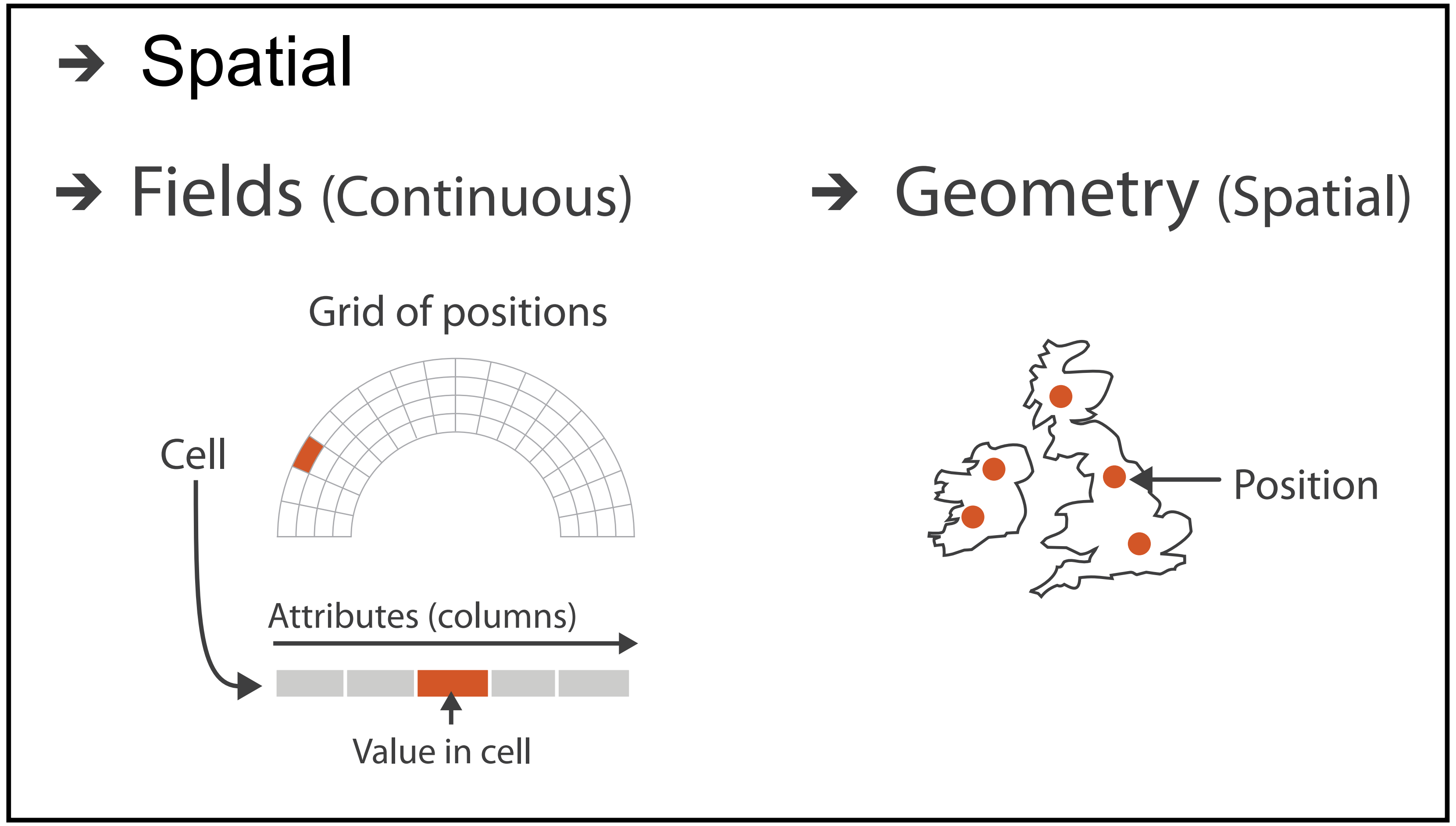
→ Diverging

→ Cyclic



Three major datatypes





- visualization vs computer graphics
  - –geometry is design decision

Dataset and data types

➔ Data and Dataset Types

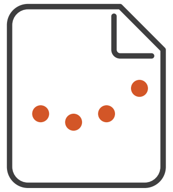
Tables	Networks & Trees	Fields	Geometry	Clusters, Sets, Lists
Items	Items (nodes)	Grids	Items	Items
Attributes	Links	Positions	Positions	
	Attributes	Attributes		

➔ Data Types

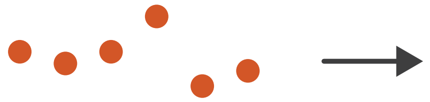
➔ Items ➔ Attributes ➔ Links ➔ Positions ➔ Grids

➔ Dataset Availability

➔ Static



➔ Dynamic

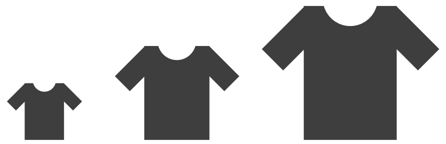


Attribute types

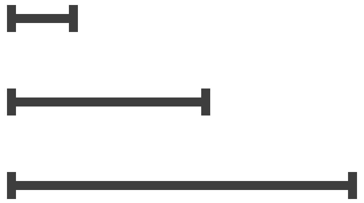
Attribute Types

- Categorical

- Ordered
  - *Ordinal*



  - *Quantitative*

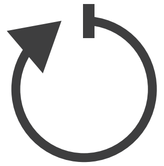


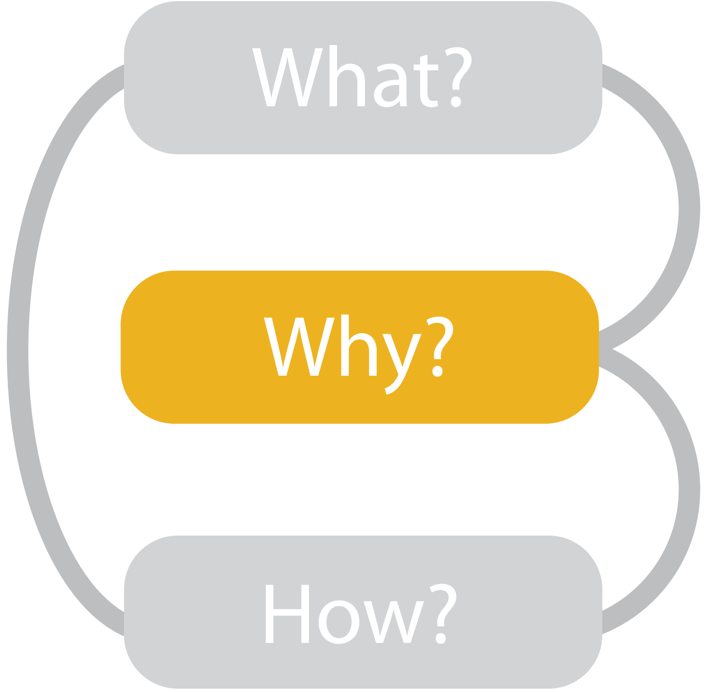
Ordering Direction

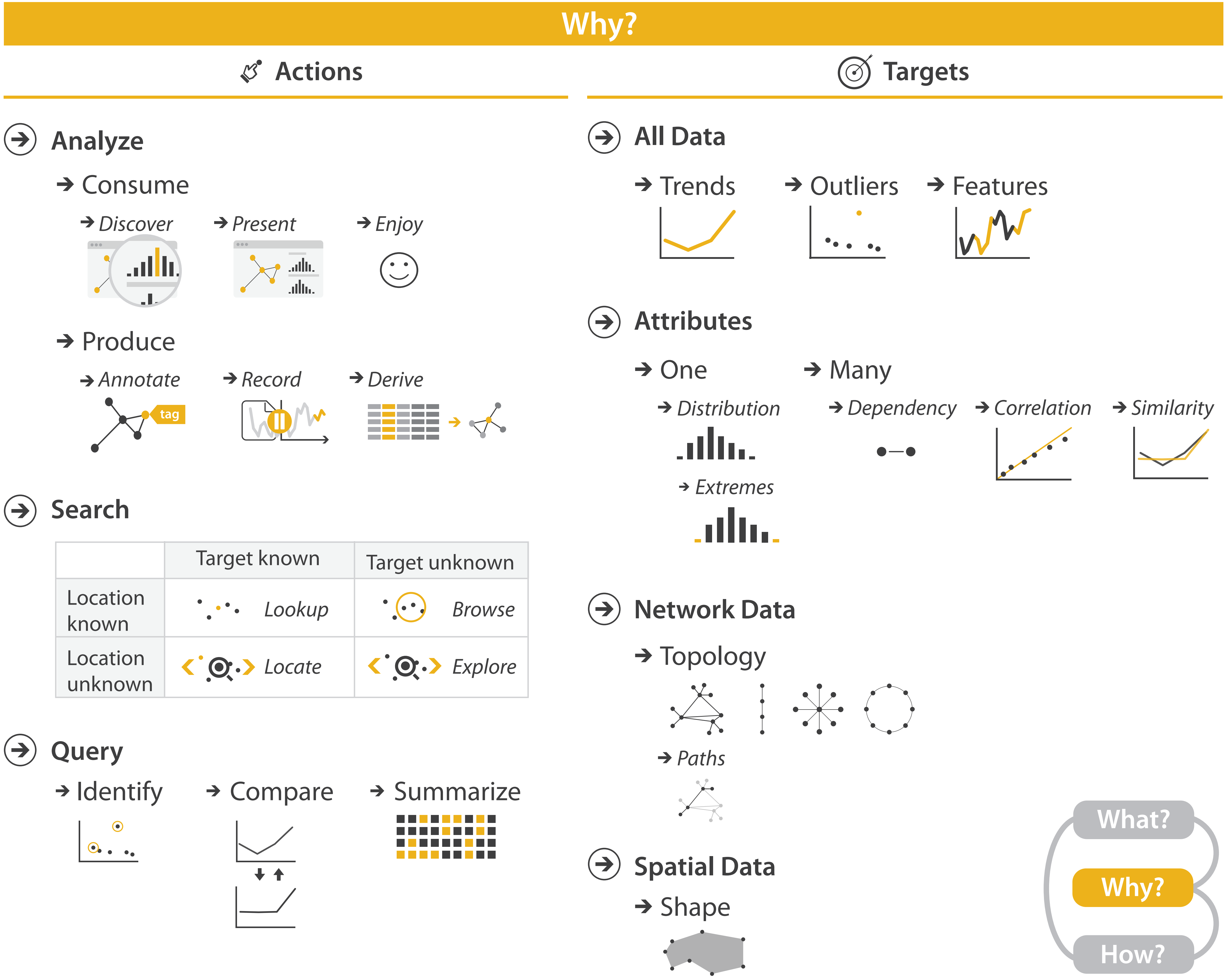
- Sequential

- Diverging

- Cyclic





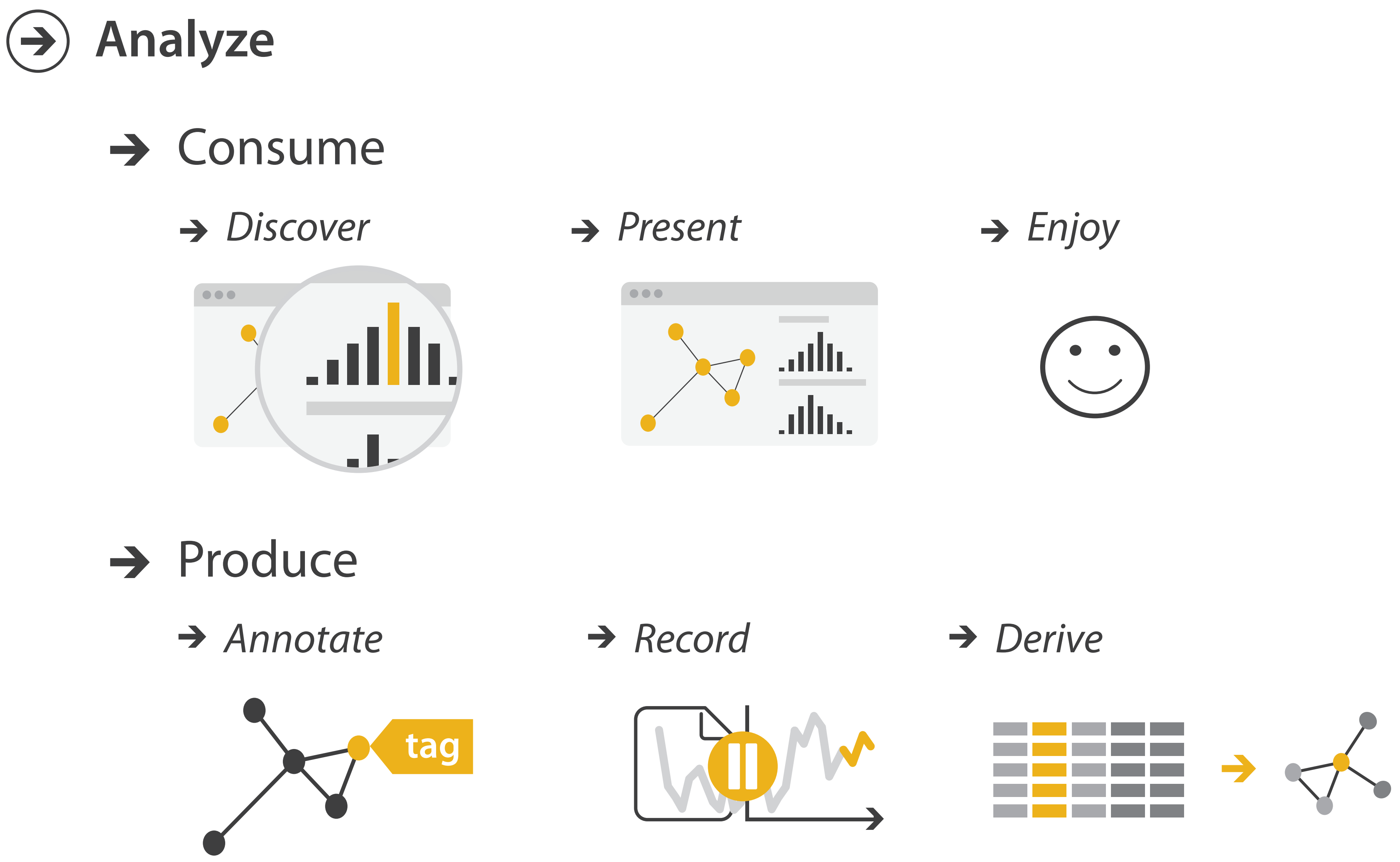


- {action, target} pairs
  - *discover distribution*
  - *compare trends*
  - *locate outliers*
  - *browse topology*

Actions: Analyze

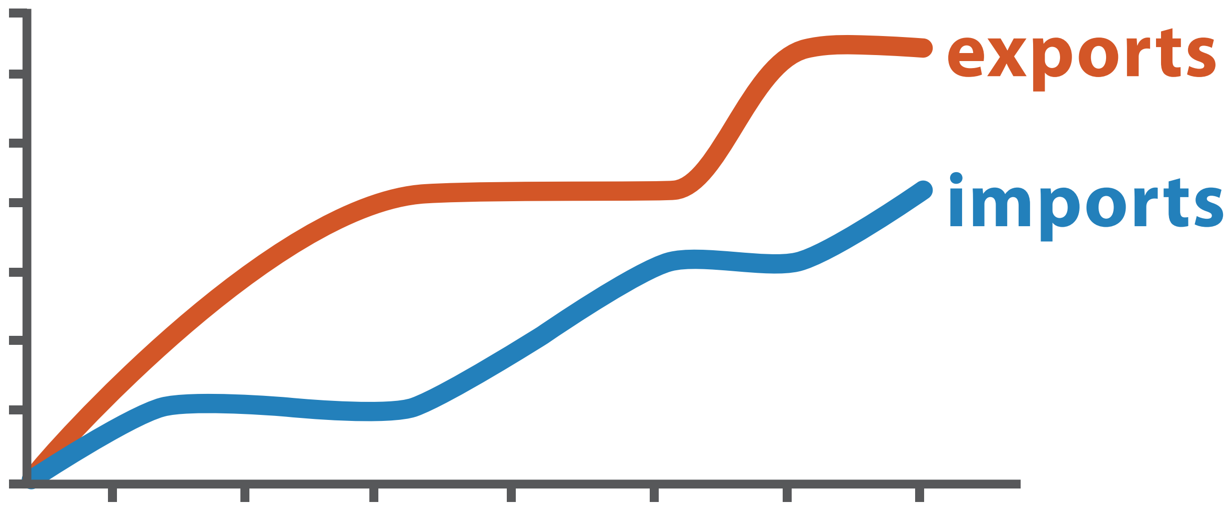
- consume
  - discover vs present
    - classic split
    - aka explore vs explain
  - enjoy
    - newcomer
    - aka casual, social

- produce
  - annotate, record
  - derive
    - crucial design choice

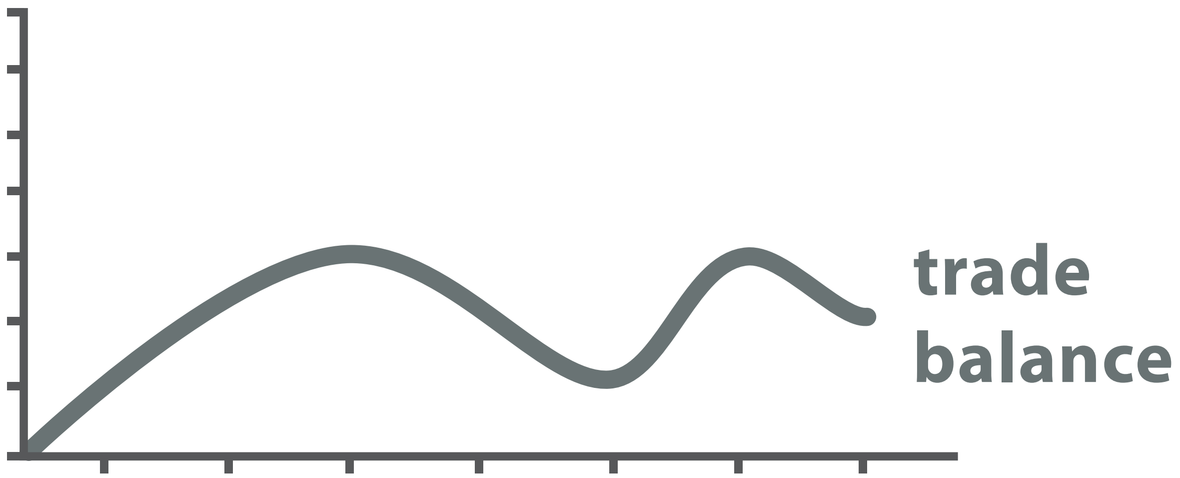


Derive

- don't just draw what you're given!
  - decide what the right thing to show is
  - create it with a series of transformations from the original dataset
  - draw that
- one of the four major strategies for handling complexity



Original Data



trade balance = exports − imports

Derived Data

Actions: Search, query

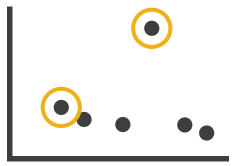
- what does user know?
  - target, location
- how much of the data matters?
  - one, some, all
- independent choices for each of these three levels
  - analyze, search, query
  - mix and match

Search

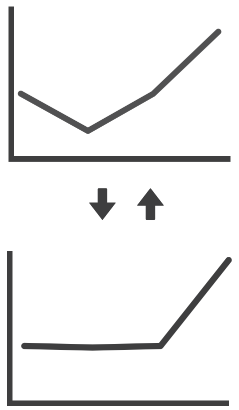
	Target known	Target unknown
Location known	*Lookup*	*Browse*
Location unknown	*Locate*	*Explore*

Query

→ Identify



→ Compare

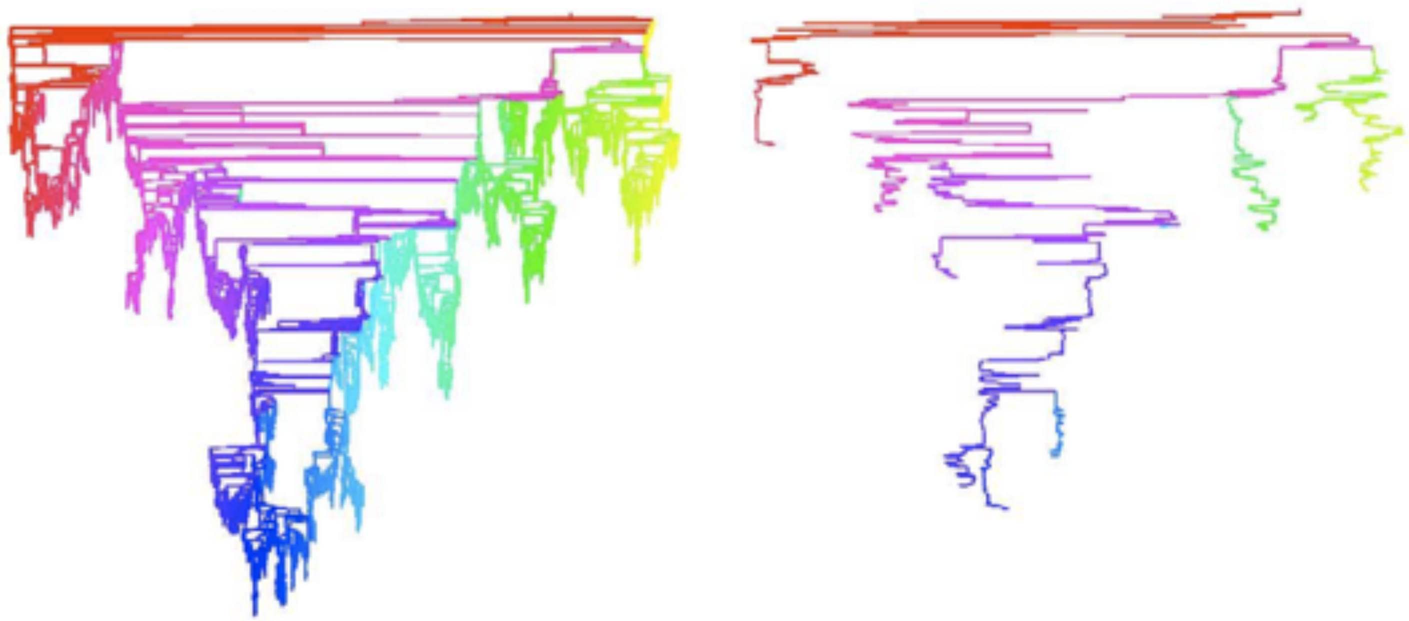


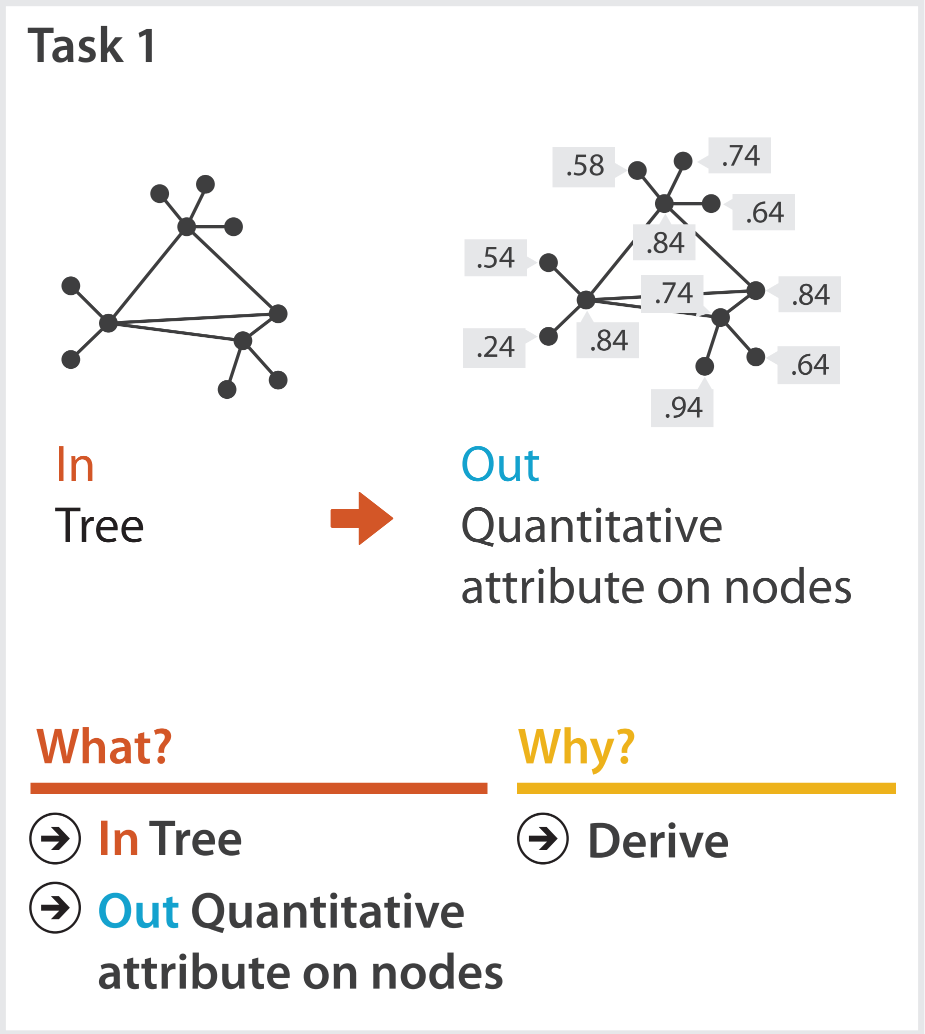
→ Summarize

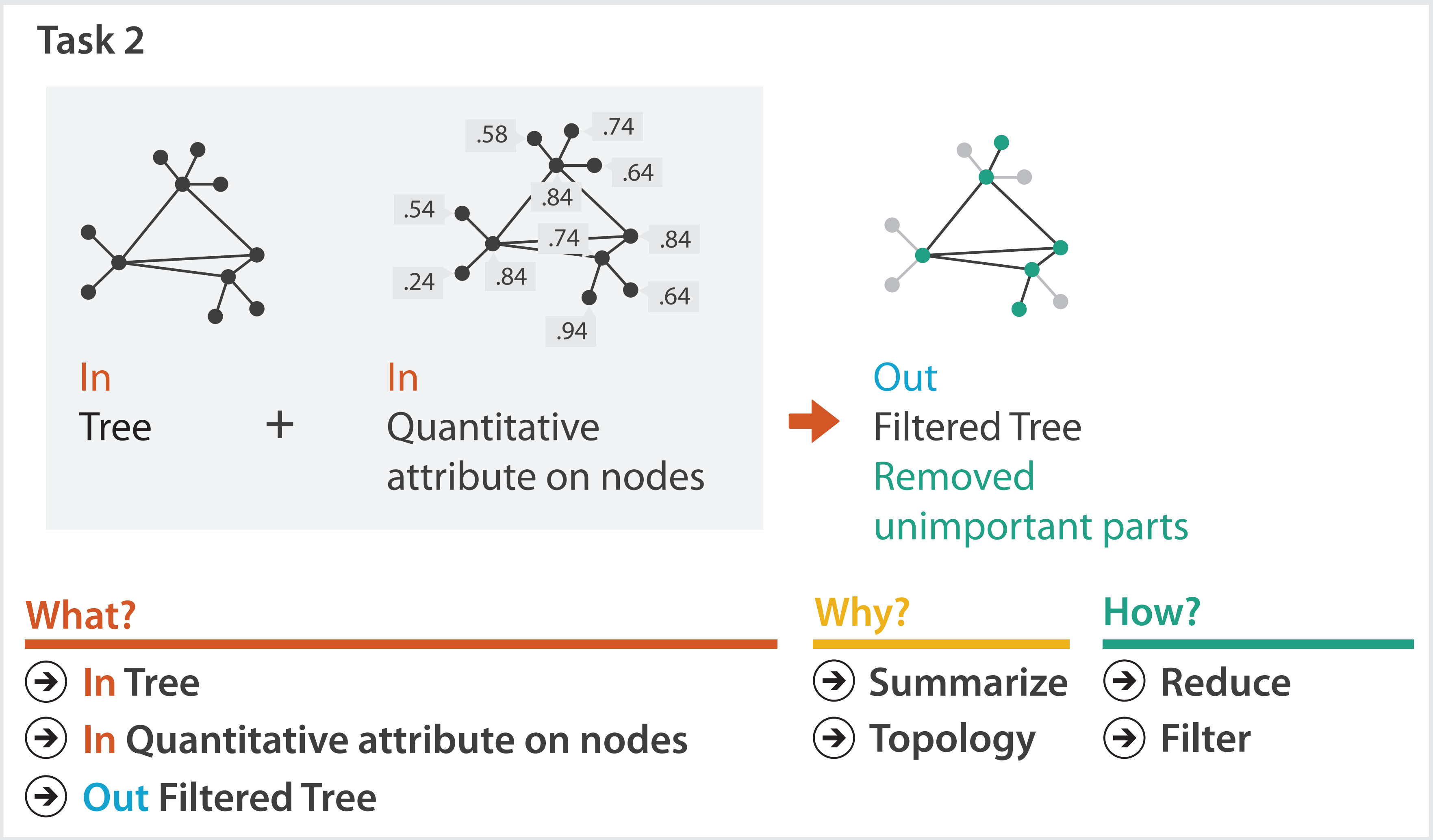
Analysis example: Derive one attribute

- Strahler number
  - centrality metric for trees/networks
  - derived quantitative attribute
  - draw top 5K of 500K for good skeleton

[Using Strahler numbers for real time visual exploration of huge graphs. Auber. Proc. Intl. Conf. Computer Vision and Graphics, pp. 56–69, 2002.]



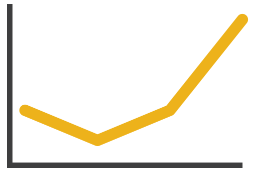




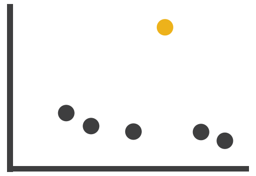
Why: Targets

➔ All Data

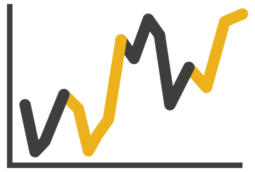
➔ Trends



➔ Outliers



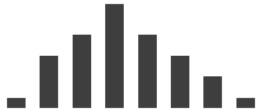
➔ Features



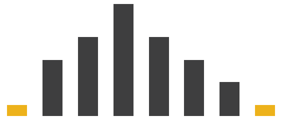
➔ Attributes

➔ One

➔ *Distribution*



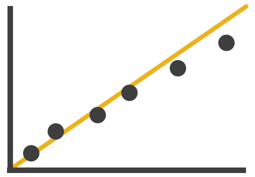
➔ *Extremes*



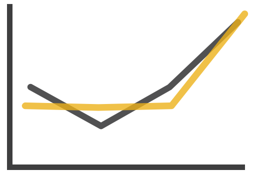
➔ Many

➔ *Dependency*

➔ *Correlation*

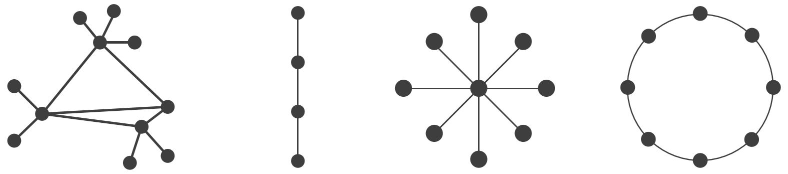


➔ *Similarity*

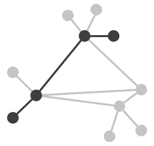


➔ Network Data

➔ Topology

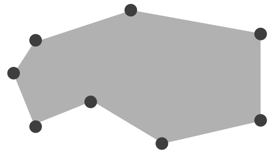


➔ *Paths*



➔ Spatial Data

➔ Shape



How?

Encode

Arrange
- Express
- Separate
- Order
- Align
- Use

Map
from categorical and ordered attributes

- Color
  - *Hue*
  - *Saturation*
  - *Luminance*
- Size, Angle, Curvature, ...
- Shape
- Motion
  Direction, Rate, Frequency, ...

Manipulate

Change

Select

Navigate

Facet

Juxtapose

Partition

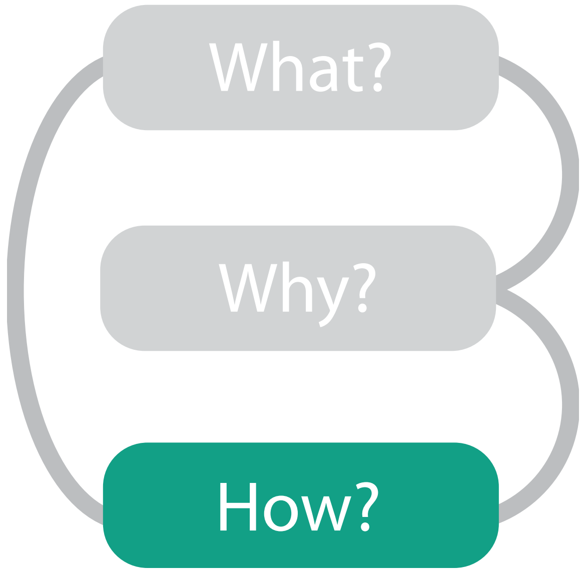
Superimpose

Reduce

Filter

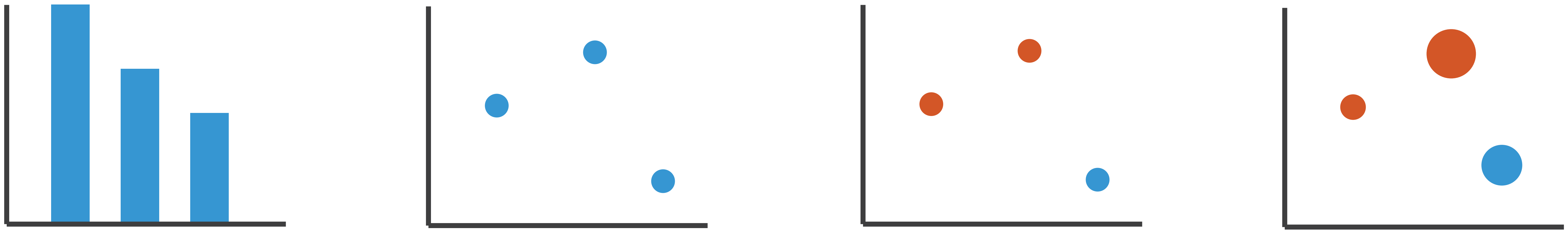
Aggregate

Embed



Encoding visually

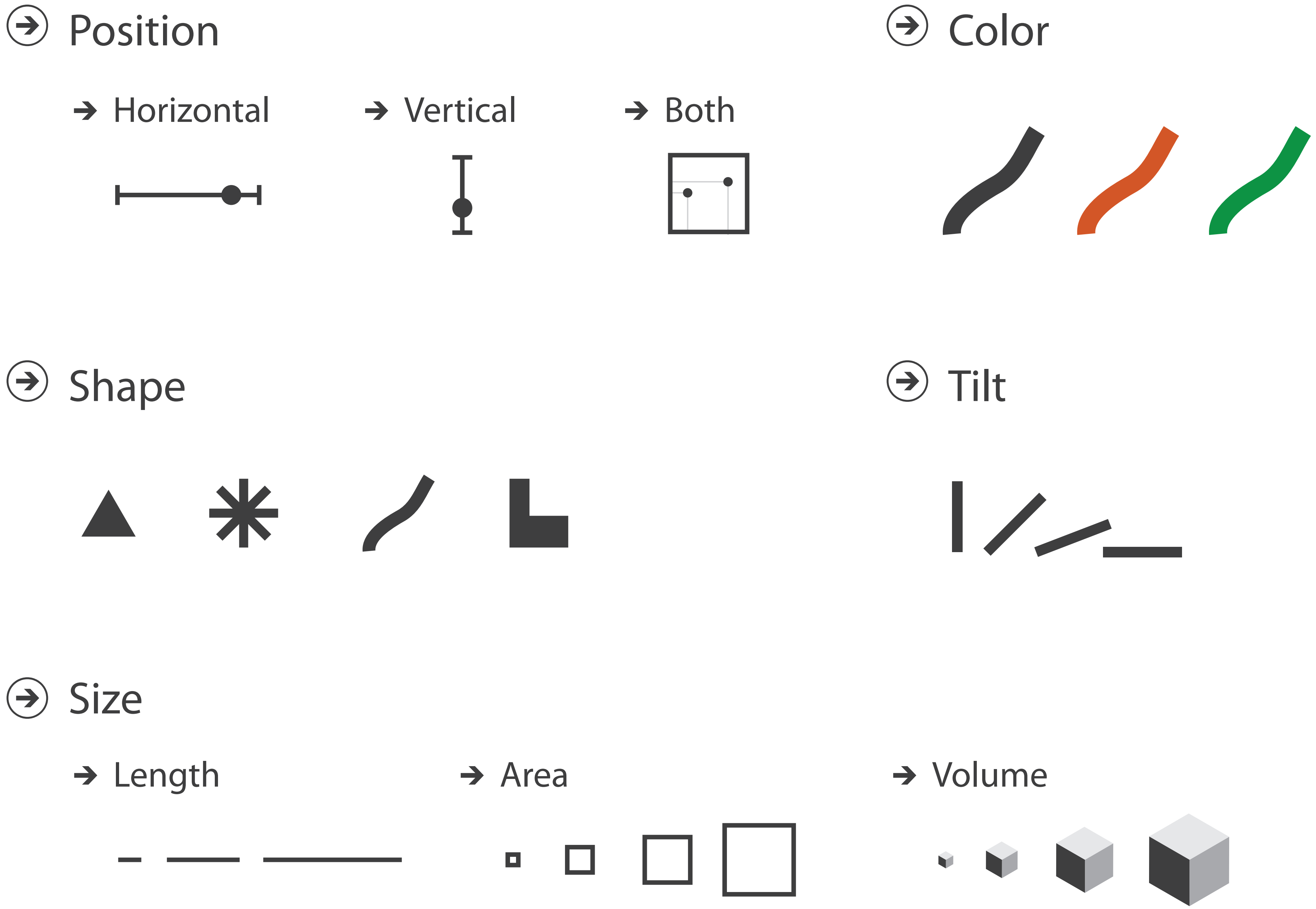
- analyze idiom structure



Definitions: Marks and channels

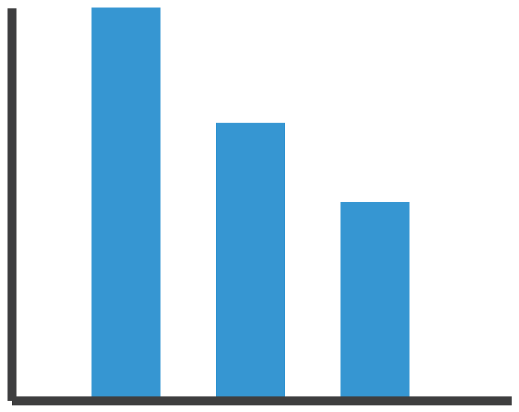
- marks
  - geometric primitives

- channels
  - control appearance of marks



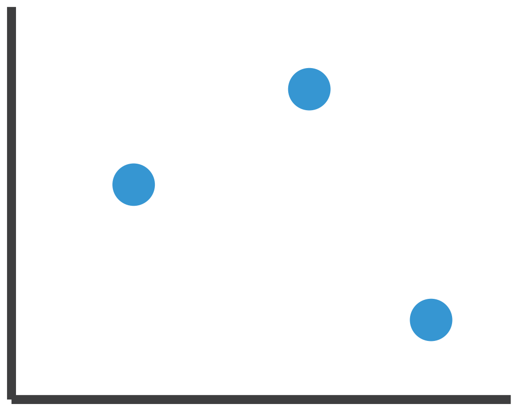
Encoding visually with marks and channels

- analyze idiom structure
  - as combination of marks and channels



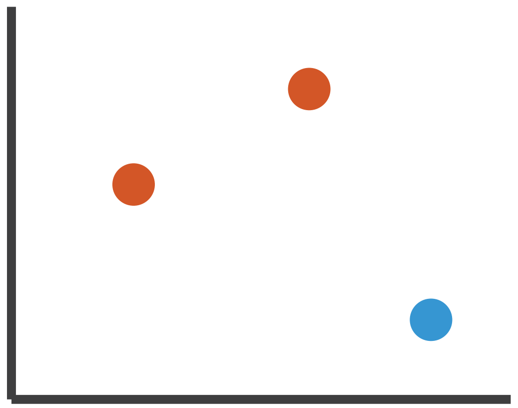
1:
vertical position

mark: line



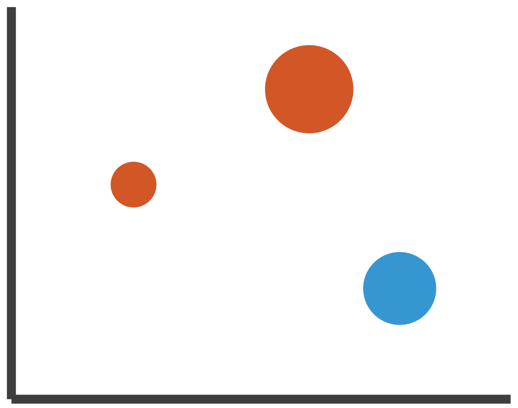
2:
vertical position
horizontal position

mark: point



3:
vertical position
horizontal position
color hue

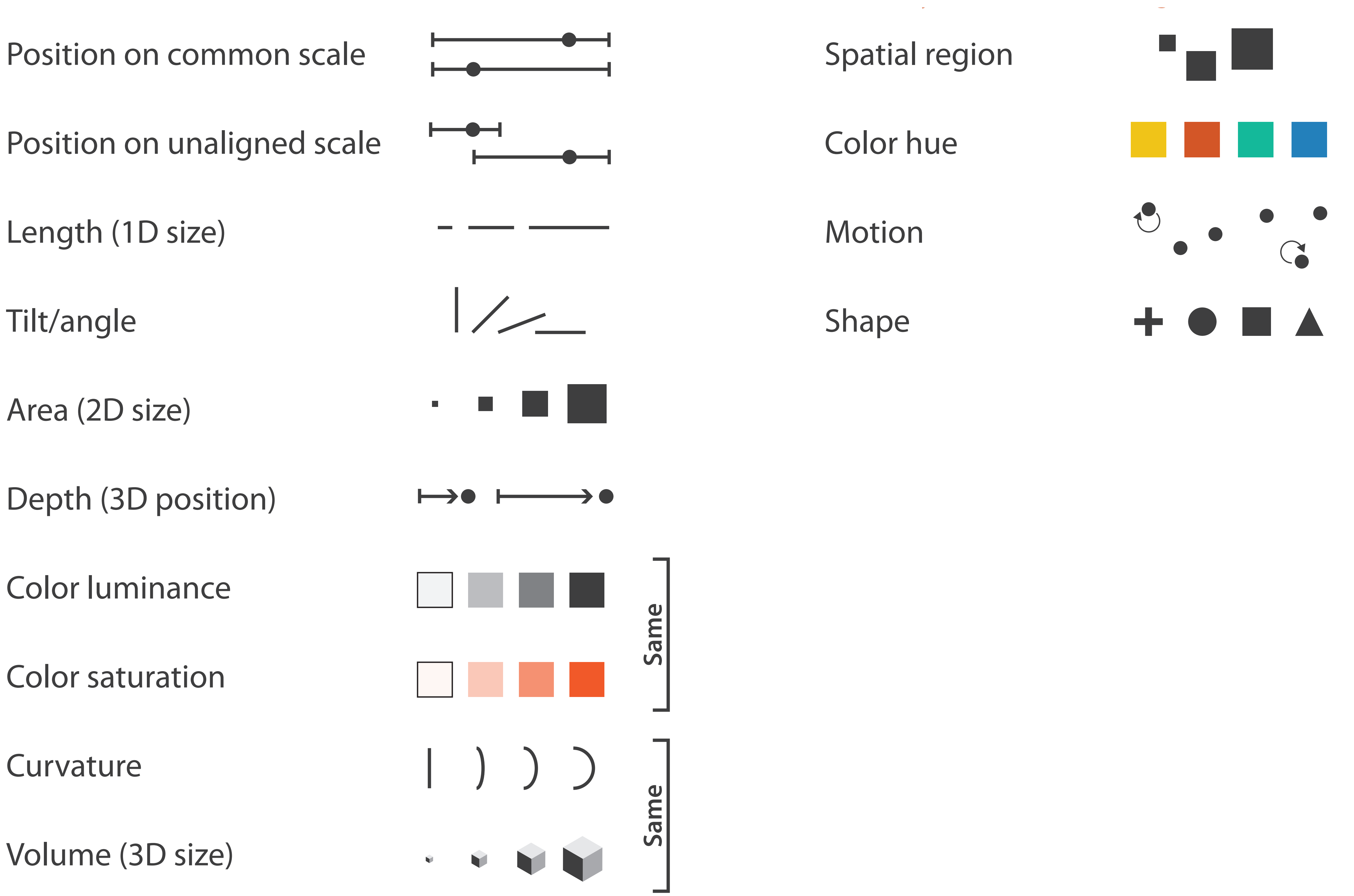
mark: point



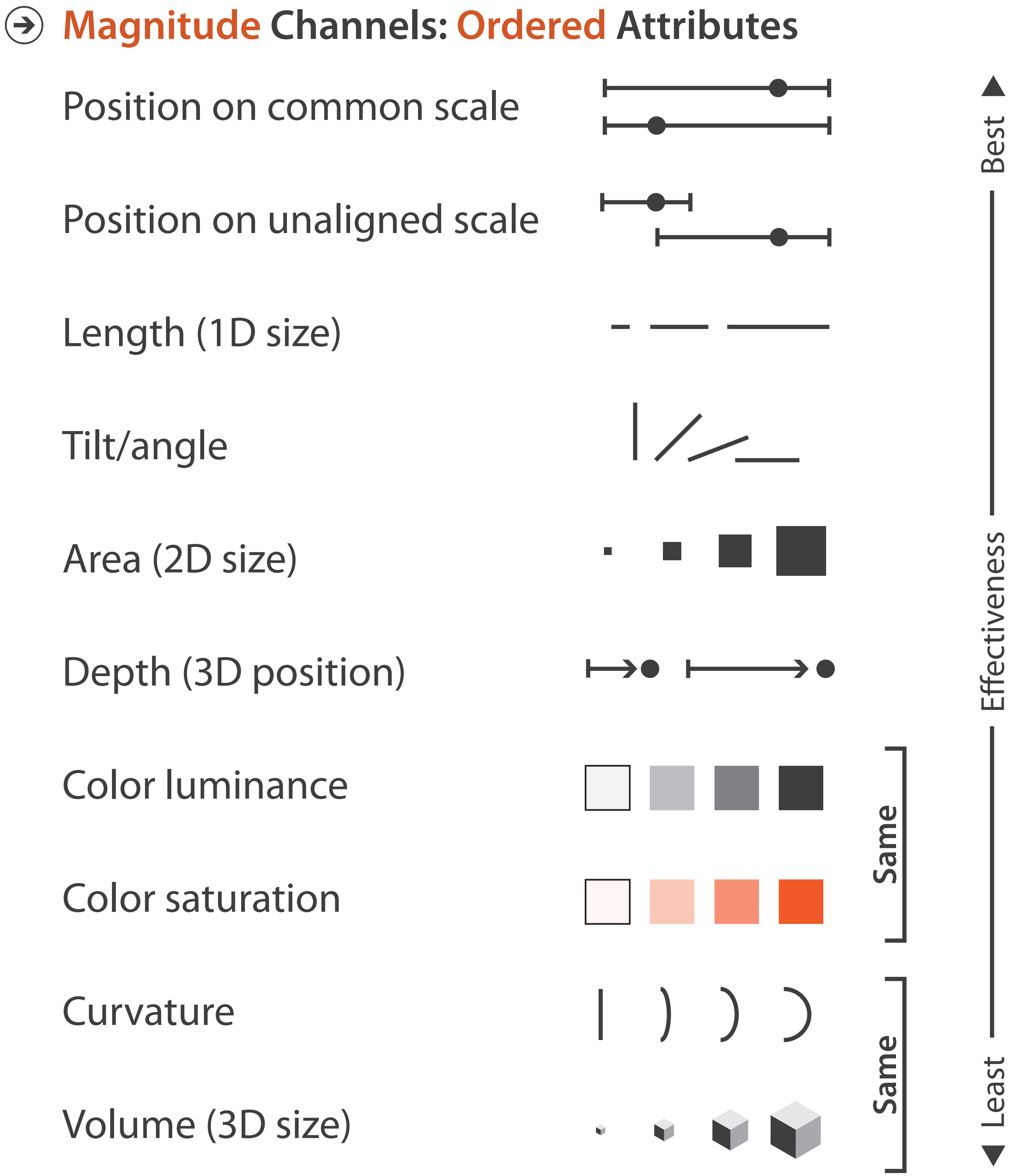
4:
vertical position
horizontal position
color hue
size (area)

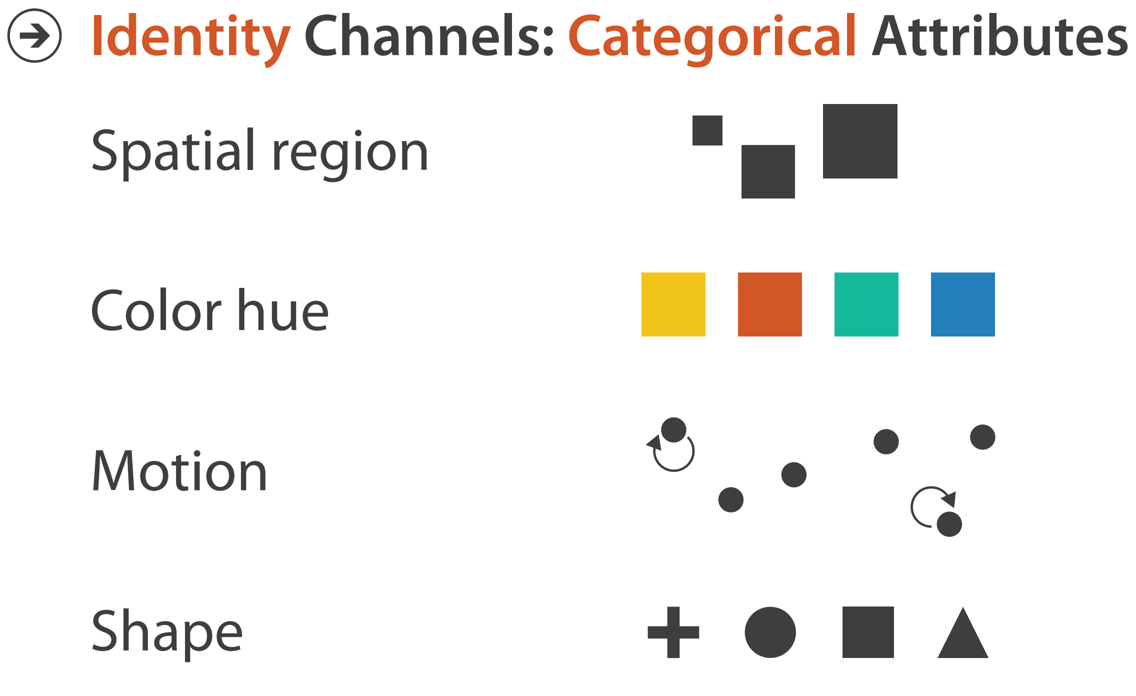
mark: point

Channels


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

Channels: Rankings

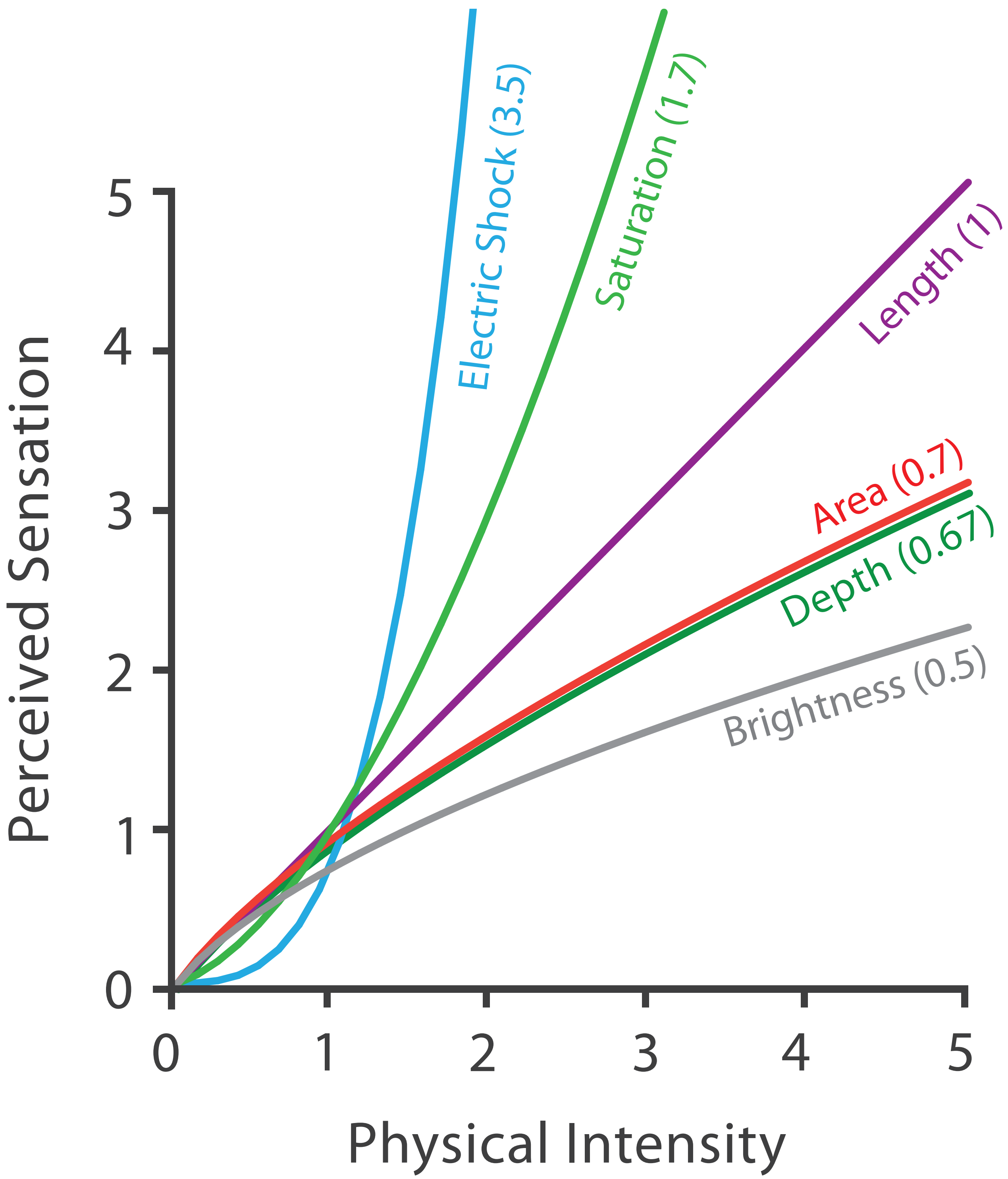




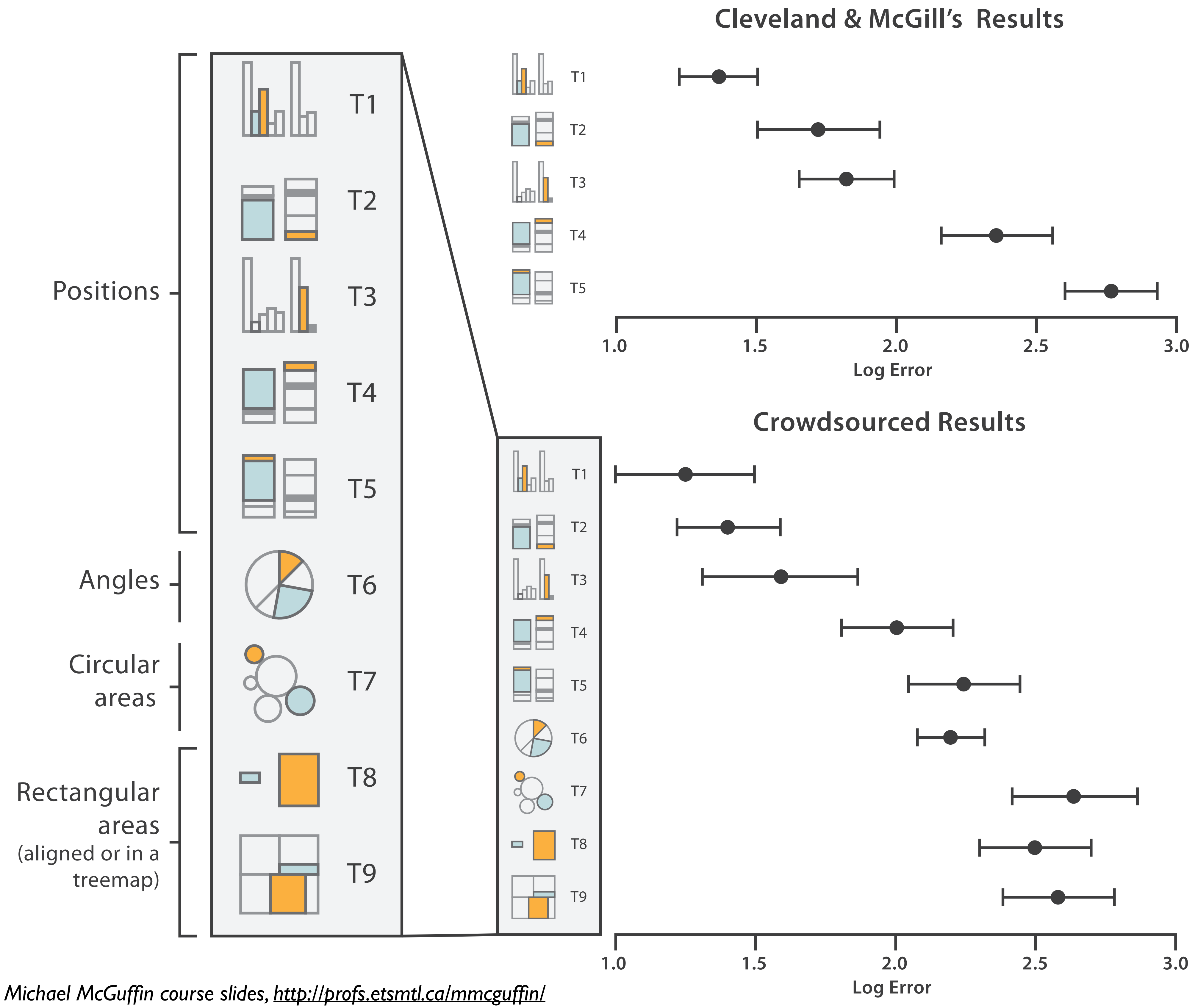
- effectiveness principle
  - encode most important attributes with highest ranked channels
- expressiveness principle
  - match channel and data characteristics

Accuracy: Fundamental Theory

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



Accuracy: Vis experiments

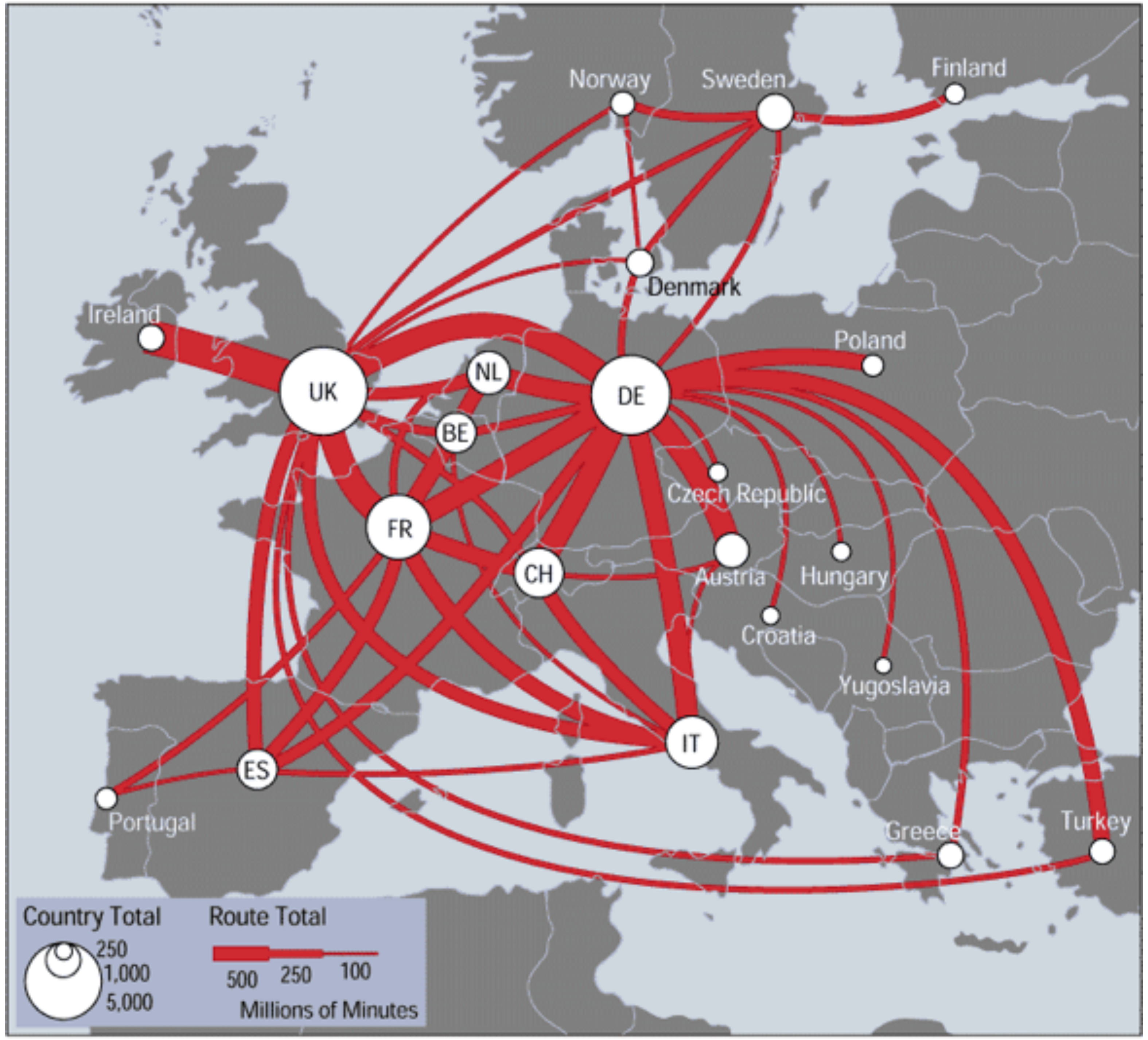


[Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design. Heer and Bostock. Proc ACM Conf. Human Factors in Computing Systems (CHI) 2010, p. 203–212.]

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

Discriminability: How many usable steps?

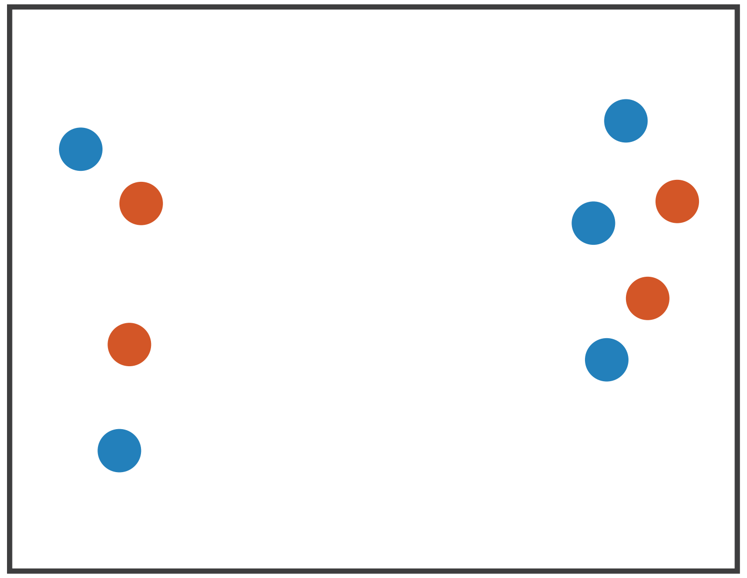
- must be sufficient for number of attribute levels to show
  - linewidth: few bins



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

Separability vs. Integrality

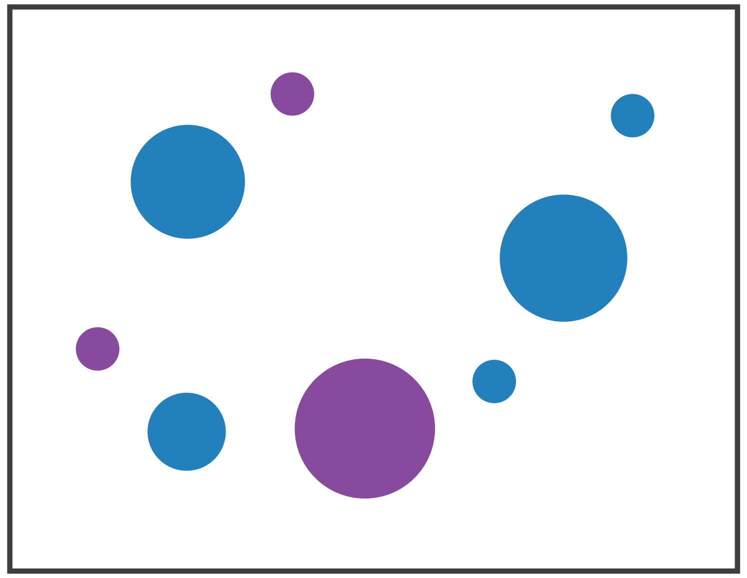
Position
+ Hue (Color)



Fully separable

2 groups each

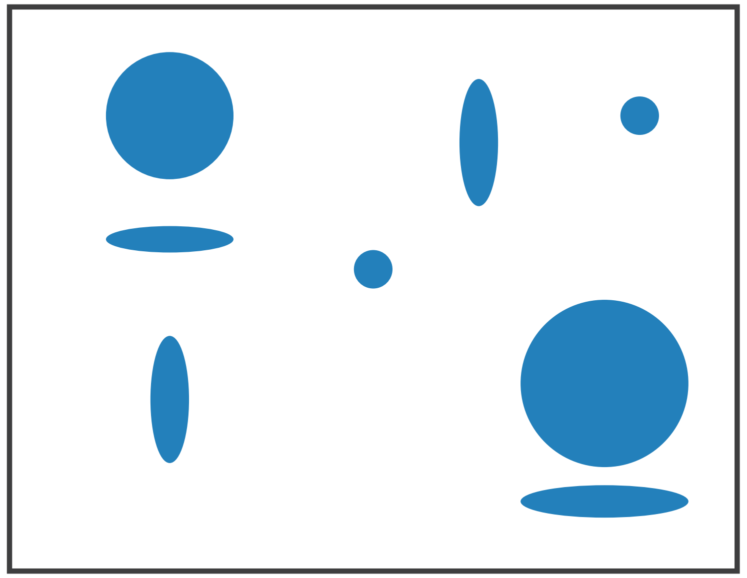
Size
+ Hue (Color)



Some interference

2 groups each

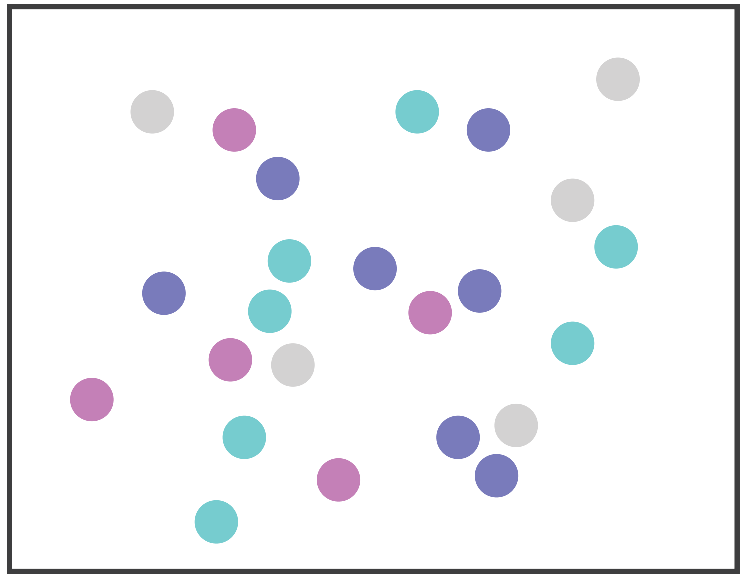
Width
+ Height



Some/significant interference

3 groups total: integral area

Red
+ Green

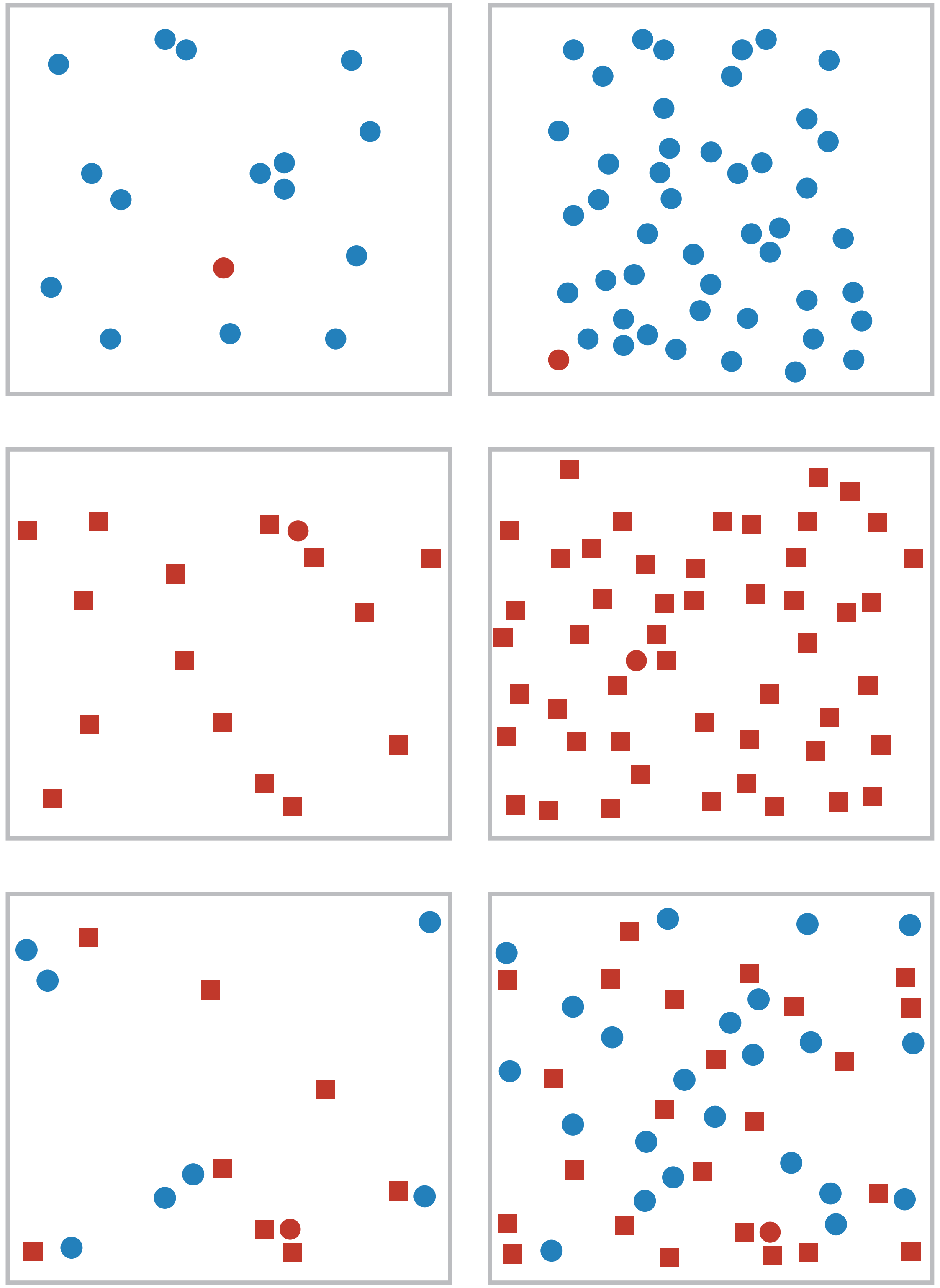


Major interference

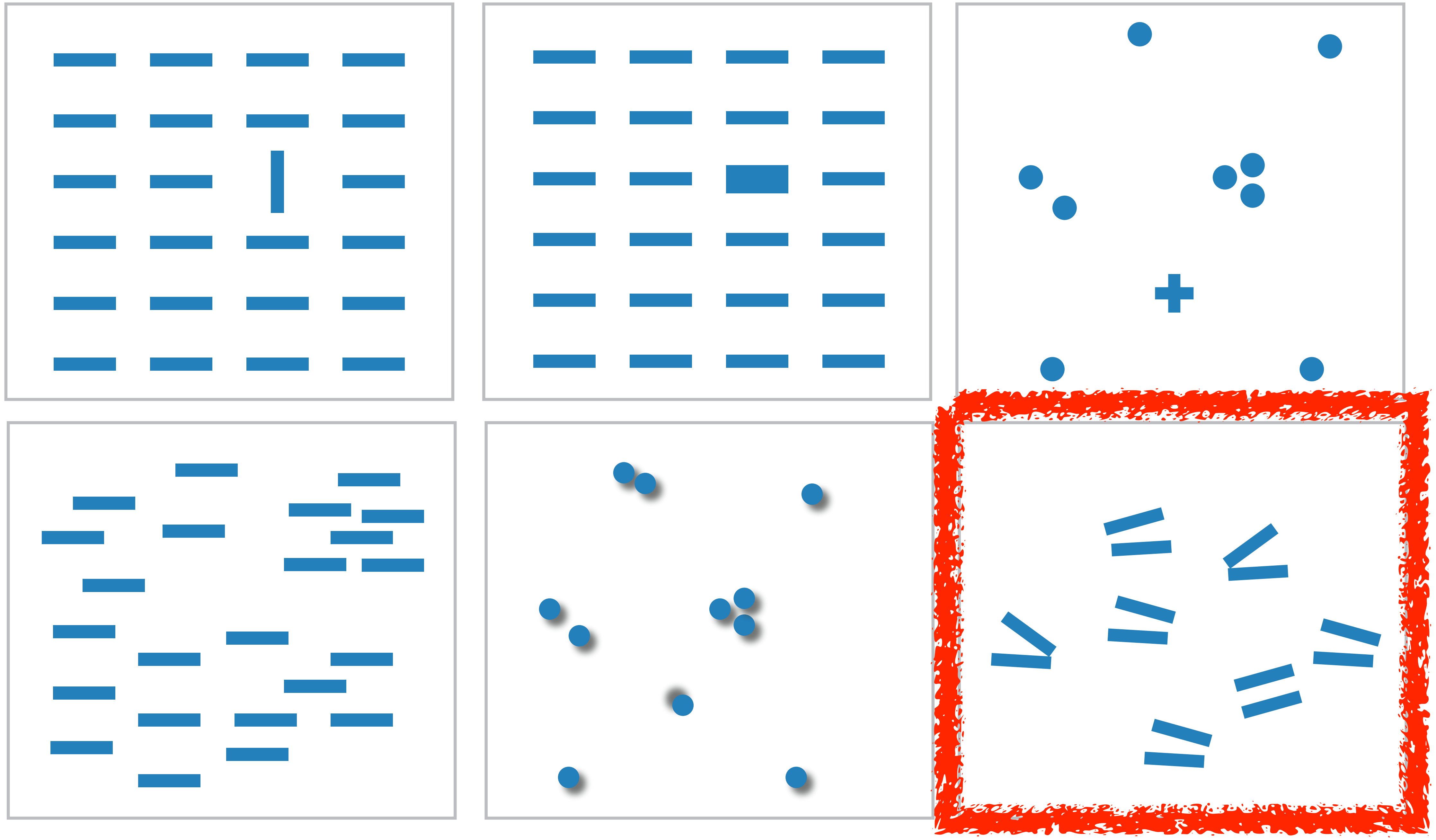
4 groups total: integral hue

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



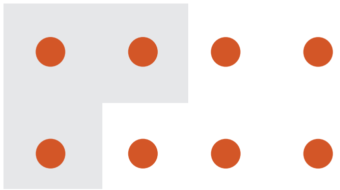
- many channels: tilt, size, shape, proximity, shadow direction, ...
- but not all! parallel line pairs do not pop out from tilted pairs

Grouping

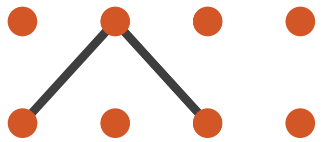
- containment
- connection
- proximity
  - same spatial region
- similarity
  - same values as other categorical channels

Marks as Links

Containment



Connection



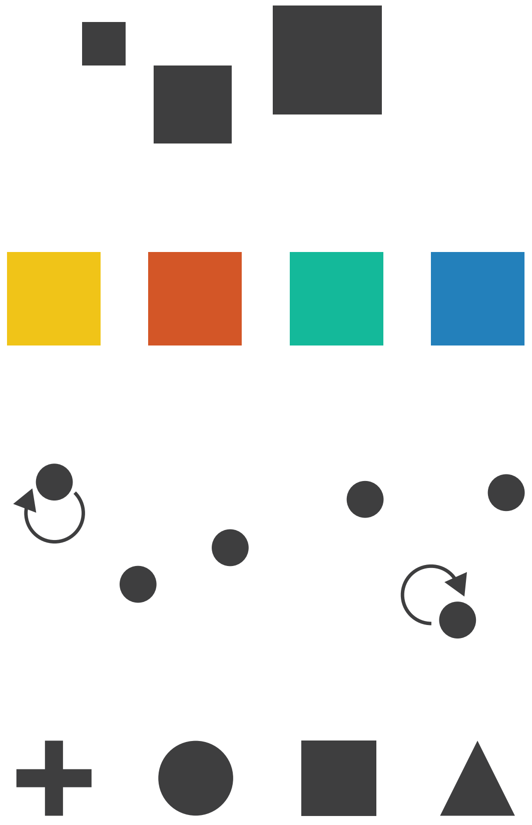
Identity Channels: Categorical Attributes

Spatial region

Color hue

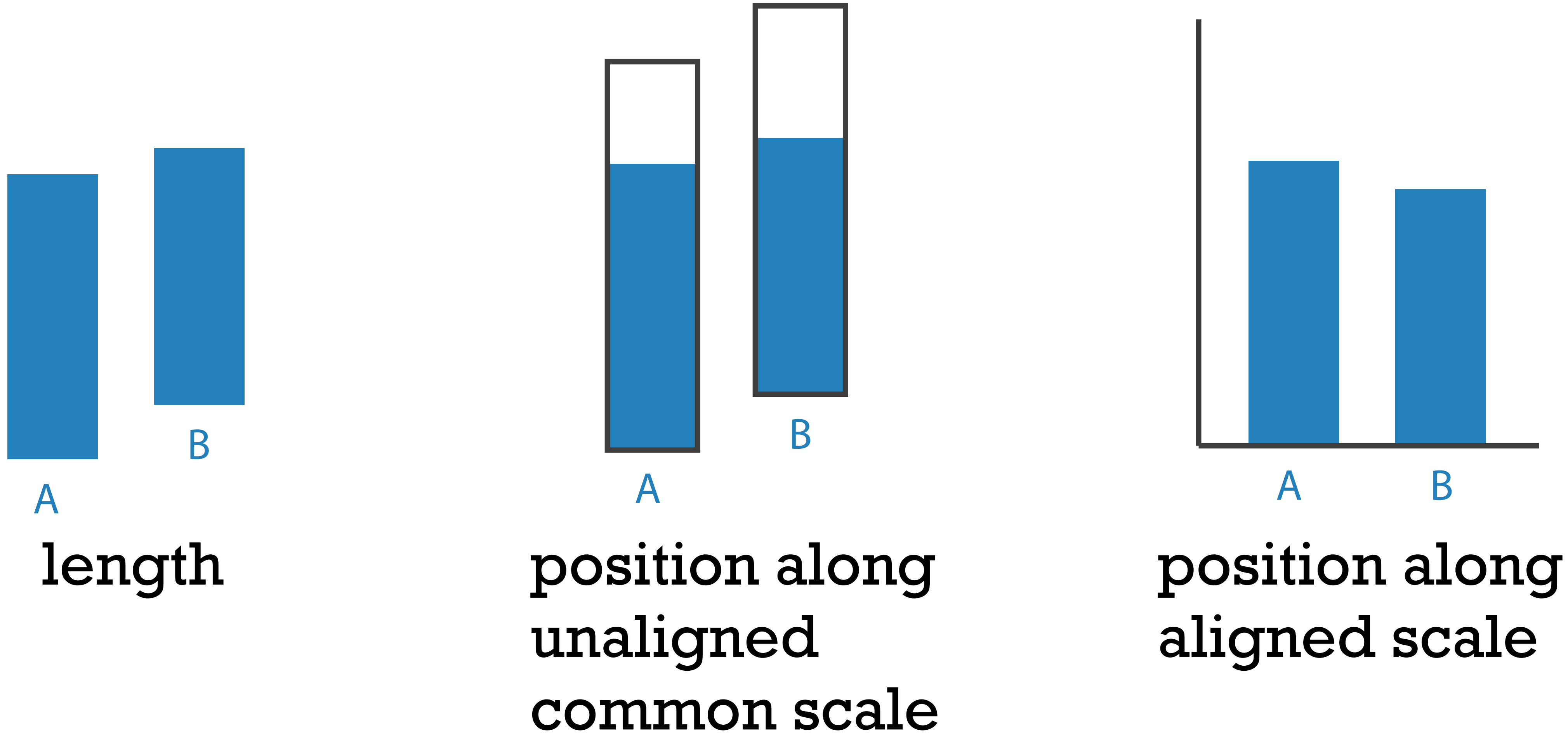
Motion

Shape



Relative vs. absolute judgements

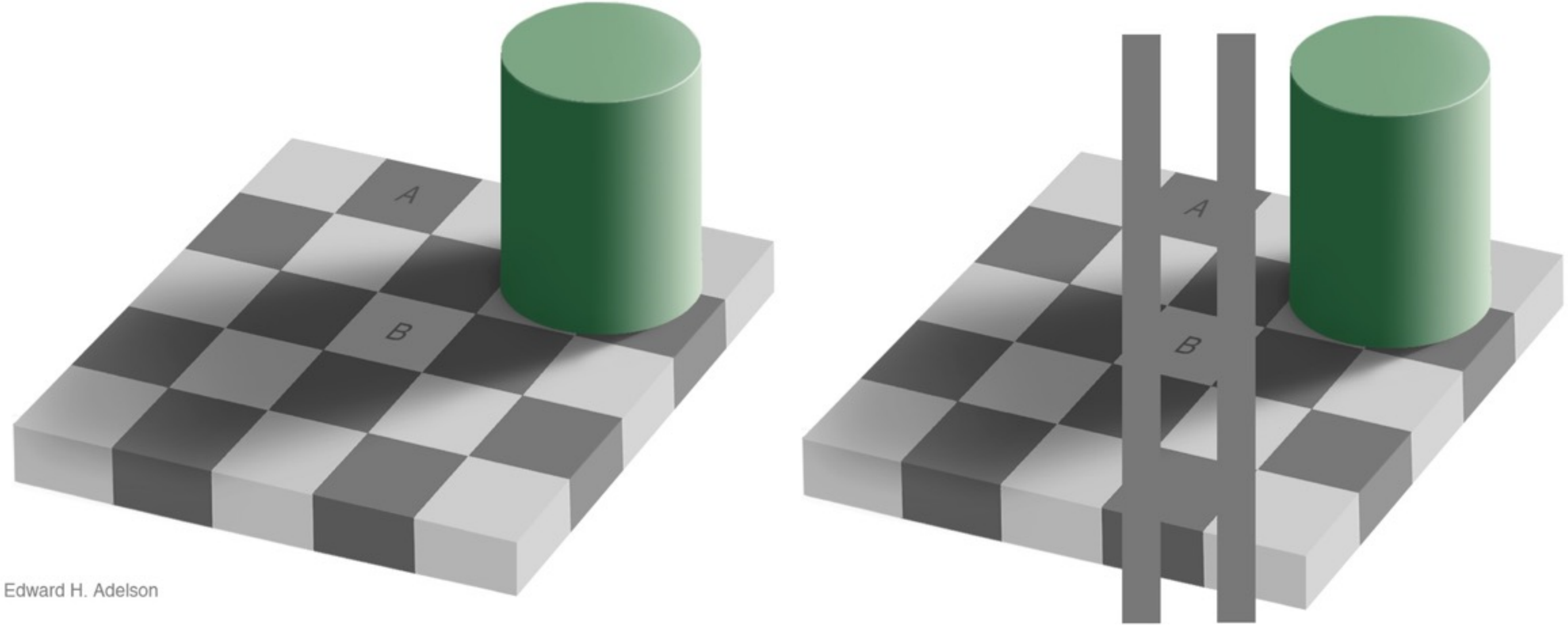
- perceptual system mostly operates with relative judgements, not absolute
  - that's why accuracy increases with common frame/scale and alignment
  - Weber's Law: ratio of increment to background is constant
    - filled rectangles differ in length by 1:9, difficult judgement
    - white rectangles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



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 luminance judgements

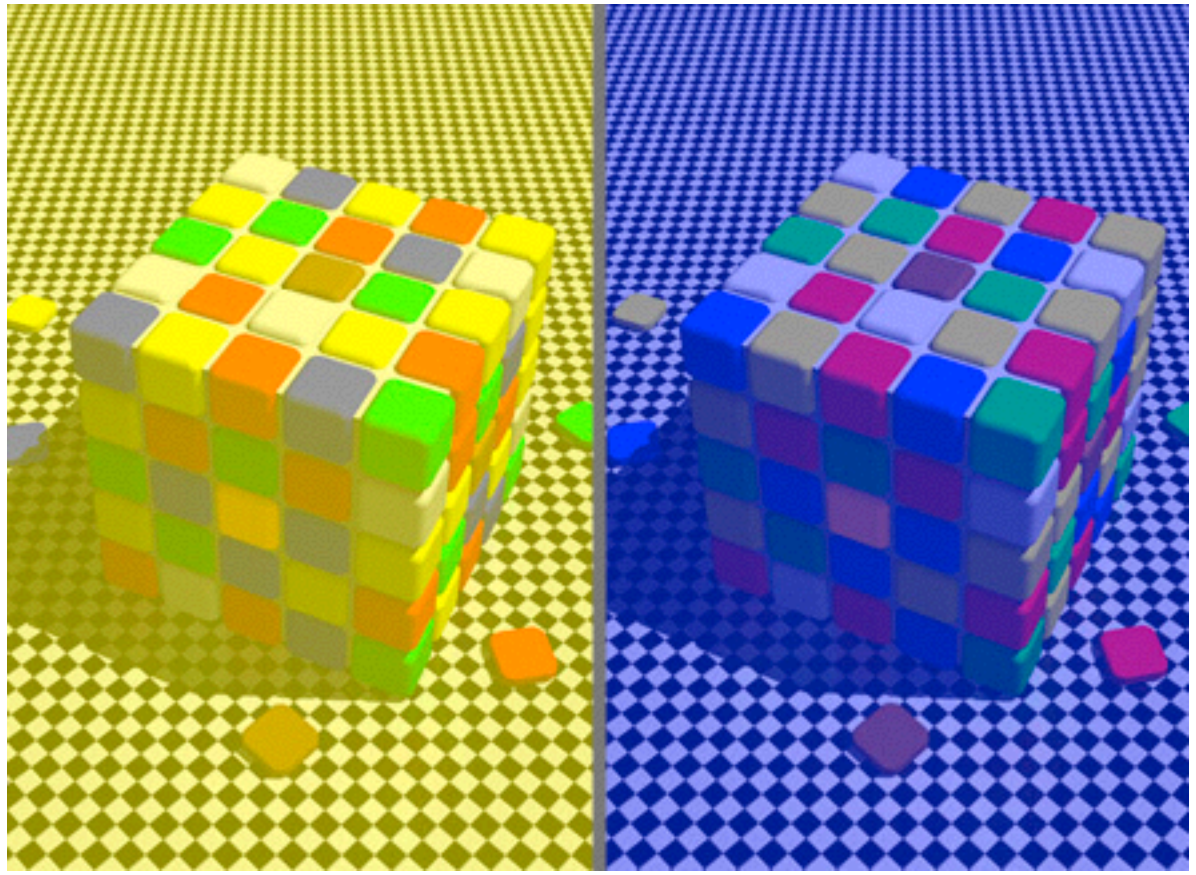
- perception of luminance is contextual based on contrast with surroundings

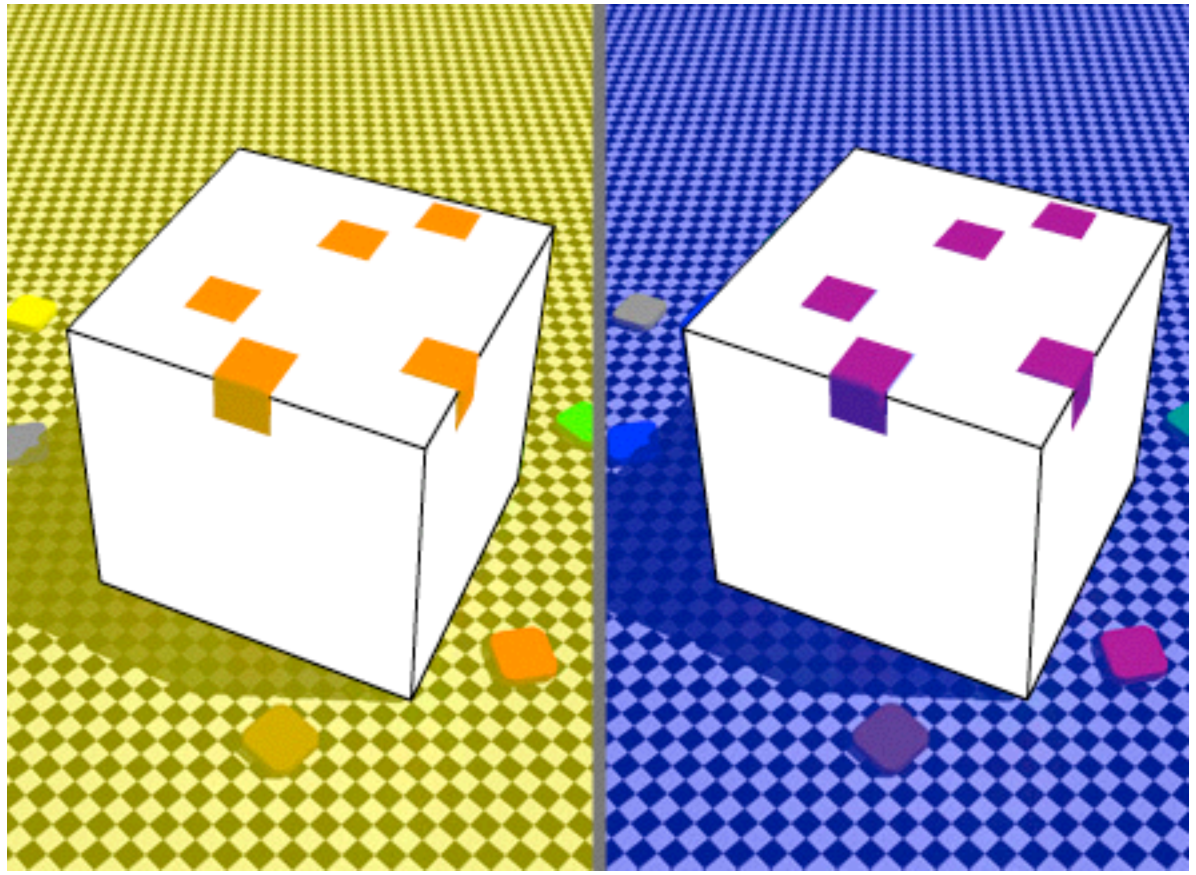


http://persci.mit.edu/gallery/checkershadow

Relative color judgements

- color constancy across broad range of illumination conditions





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

Further reading

- Visualization Analysis and Design. Tamara Munzner. CRC Press, 2014.
  - *Chap 1, What's Vis, and Why Do It?*
  - *Chap 2, What: Data Abstraction*
  - *Chap 3, Why: Task Abstraction*
  - *Chap 4, Analysis: Four Levels for Validation*
  - *Chap 5, Marks and Channels*

- Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design. Jeffrey Heer and Michael Bostock. Proc. CHI 2010
- Perception in Vision web page with demos, Christopher Healey.
- Visual Thinking for Design. Colin Ware. Morgan Kaufmann, 2008.

Next

- Break (15 min)

- Demos (45 min)
  - Caitlin will walk through Tableau demos
  - you follow along step by step on your own laptop
  - Tamara will rove the room to help out folks who get stuck

- Lab (30 min)
  - you'll get started on Tableau assignment

Demo 1: Basic Visual Encoding & Dashboarding

- Tableau Lessons
  - Dimensions (categorical) and Measures (quantitative)
  - drag and drop to create visual encodings
  - combining multiple charts side by side into dashboards

- Big Ideas
  - see different patterns with different visual encodings

Demo 2: Vancouver Election Results

- Tableau Lessons
  - sorting along axis
  - disaggregate into multiple charts

- Big Ideas
  - absolute numbers can sometimes mislead
  - check hunches with relative percentages!

Demo 3: Vancouver Crime

- Tableau Lessons
  - multiple pills on a shelf, pill ordering
  - show filters
  - undo
  - duplicate & rename tabs

- Big Ideas
  - underlying causes can be tricky to understand

Demo 4: Back to the Future

- Tableau Lessons
  - simple analytics: totals
  - more disaggregation practice
  - Show Me

- Big Ideas
  - beyond simple bars
  - challenges of missing data

Assignment

- Music Sales
  - work through workbook on your own
  - submit finished version (in workbook .twbx format)
- Vancouver Crime
  - analyze further on your own
  - write up brief news story (submit in PDF format)
    - < 500 words
    - up to 2 screenshots from Tableau
  - write up reflections (submit in PDF format)
    - discuss dead ends
    - include Tableau screenshots
- submit before next class (9am Tue Sep 20)
  - email tmm@cs.ubc.ca and caitlin@discoursemedia.org with subject JOURN Week 1