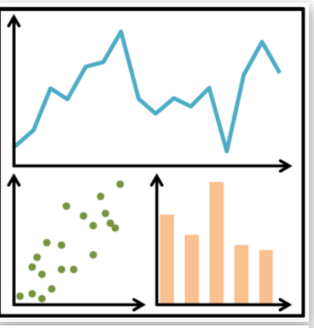
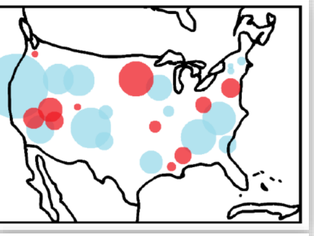
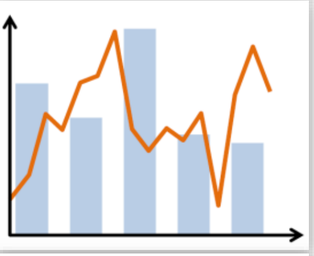
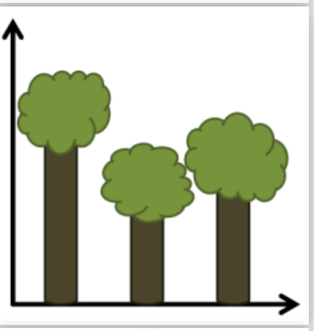
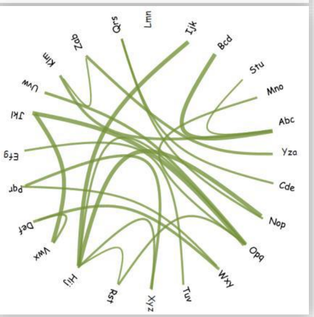






Marks & Channels, Data Types

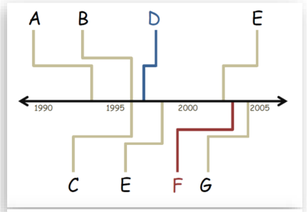
DS 4200

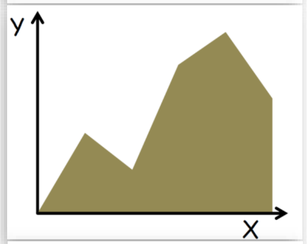
FALL 2020

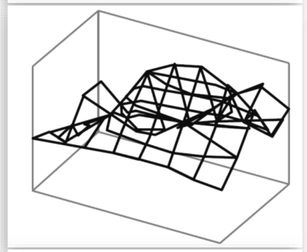
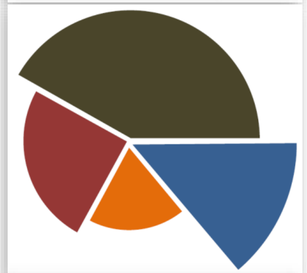
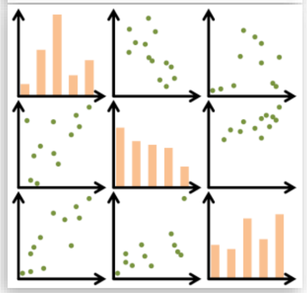
Prof. Cody Dunne

NORTHEASTERN UNIVERSITY

Slides and inspiration from Michelle Borkin, Krzysztof Gajos, Hanspeter Pfister, Miriah Meyer, Jonathan Schwabish, and David Sprague



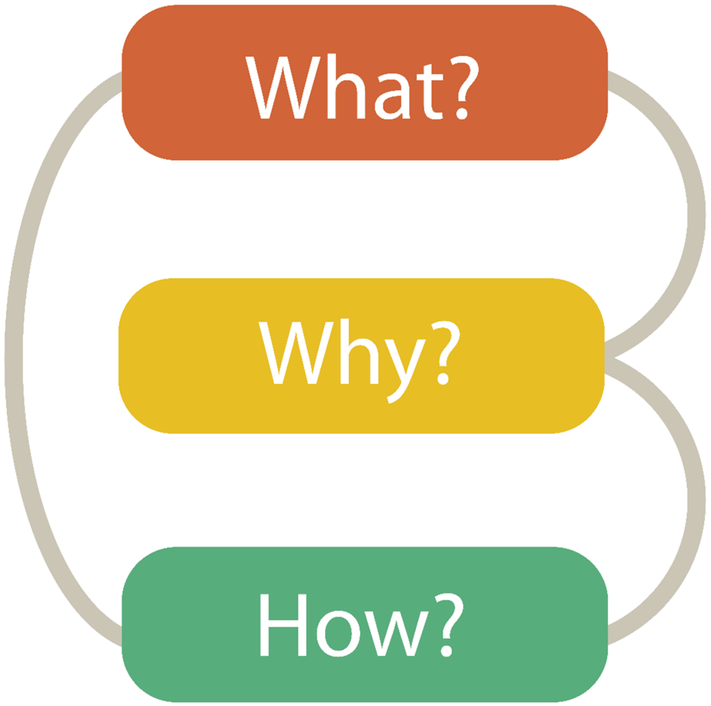


Check-in

PREVIOUSLY, ON DS 4200…

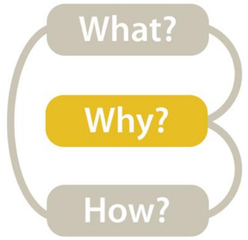
Analysis



DATA ABSTRACTION

TASK ABSTRACTION

VISUAL ENCODING



Task Analysis

Visualization for Public Transit Development

15m

INSTRUCTIONS:

- Break-out into groups of ~3 people in Teams.
- Pretend you are transportation engineers, e.g., for the MBTA, City of Boston.
- Discuss the user tasks and goals and abstract them using one of these taskonomies.
- Save your notes for a later exercise!!!

Low-level

Retrieve Value	*How long is the movie Gone with the Wind?*
Filter	*What comedies have won awards?*
Compute Derived Value	*How many awards have MGM studio won in total?*
Find Extremum	*What director/film has won the most awards?*
Sort	*Rank movies by most number of awards.*
Determine Range	*What is the range of film lengths?*
Characterize Distribution	*What is the age distribution of actors?*
Find Anomalies	*Are there exceptions to the relationship between number of awards won and total movies made by an actor?*
Cluster	*Is there a cluster of typical film lengths?*
Correlate	*Is there a trend of increasing film length over the years?*

Actions

High-level

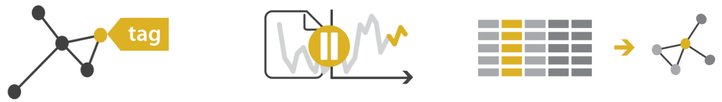
Analyze

→ Consume

→ *Discover* → *Present* → *Enjoy*

→ Produce

→ *Annotate* → *Record* → *Derive*



Mid-level

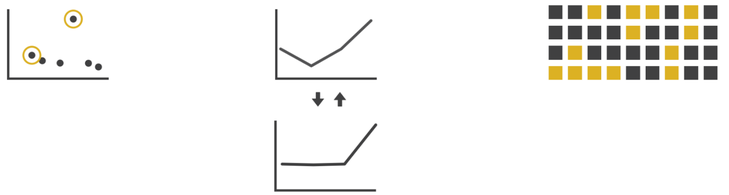
Search

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

Low-level

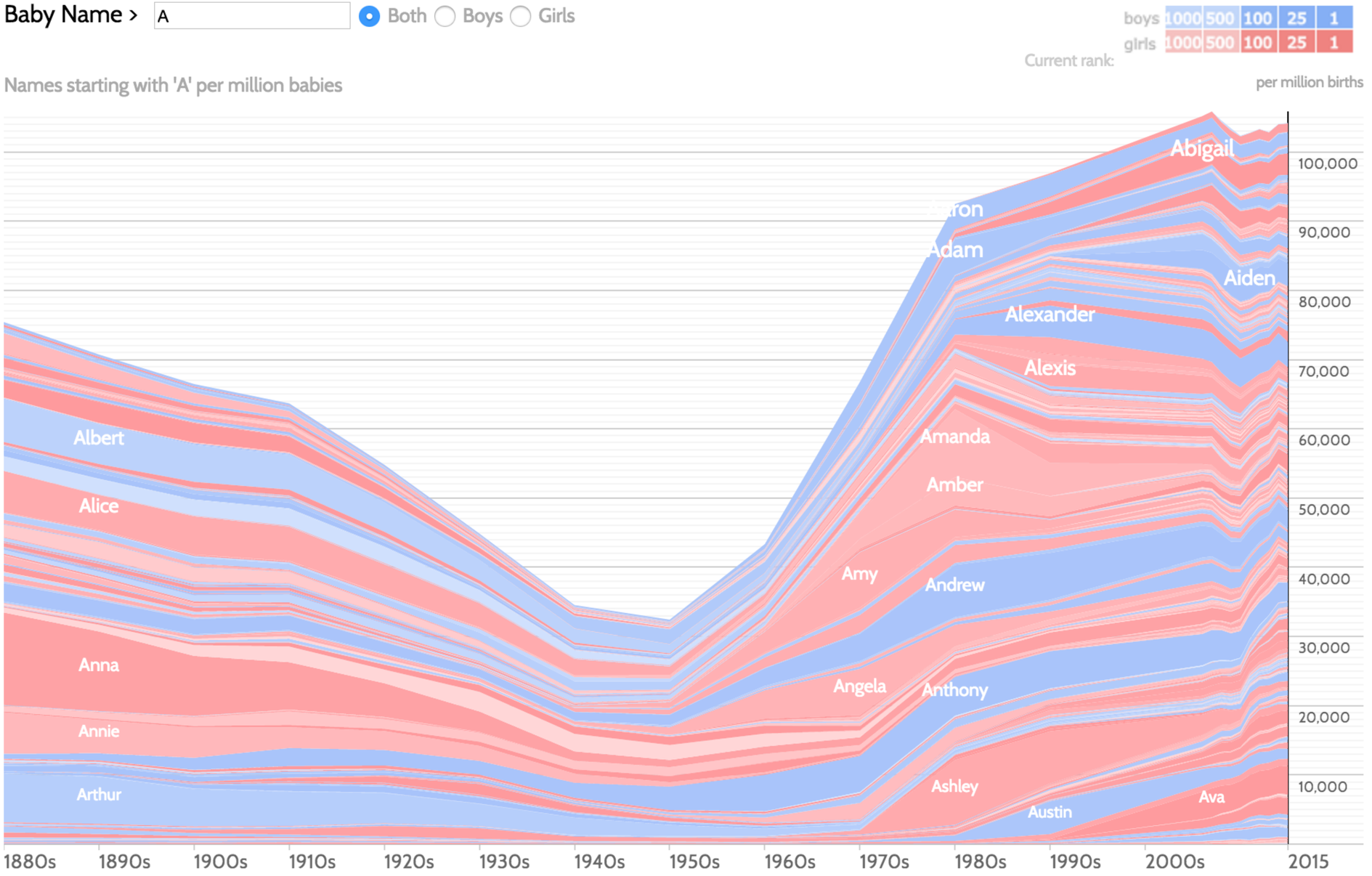
Query

→ Identify → Compare → Summarize



Now, on DS 4200…

Hall of Fame or Hall of Shame



http://www.babynamewizard.com/voyager

MARKS AND CHANNELS

Goals for Today

- Learn the basic visual primitives of visualizations (marks and channels)
- Understand how marks and channels are assembled to make visualizations
- Learn which marks and channels are most effective for a given task (“perceptual ordering”)

Visualization Building Blocks

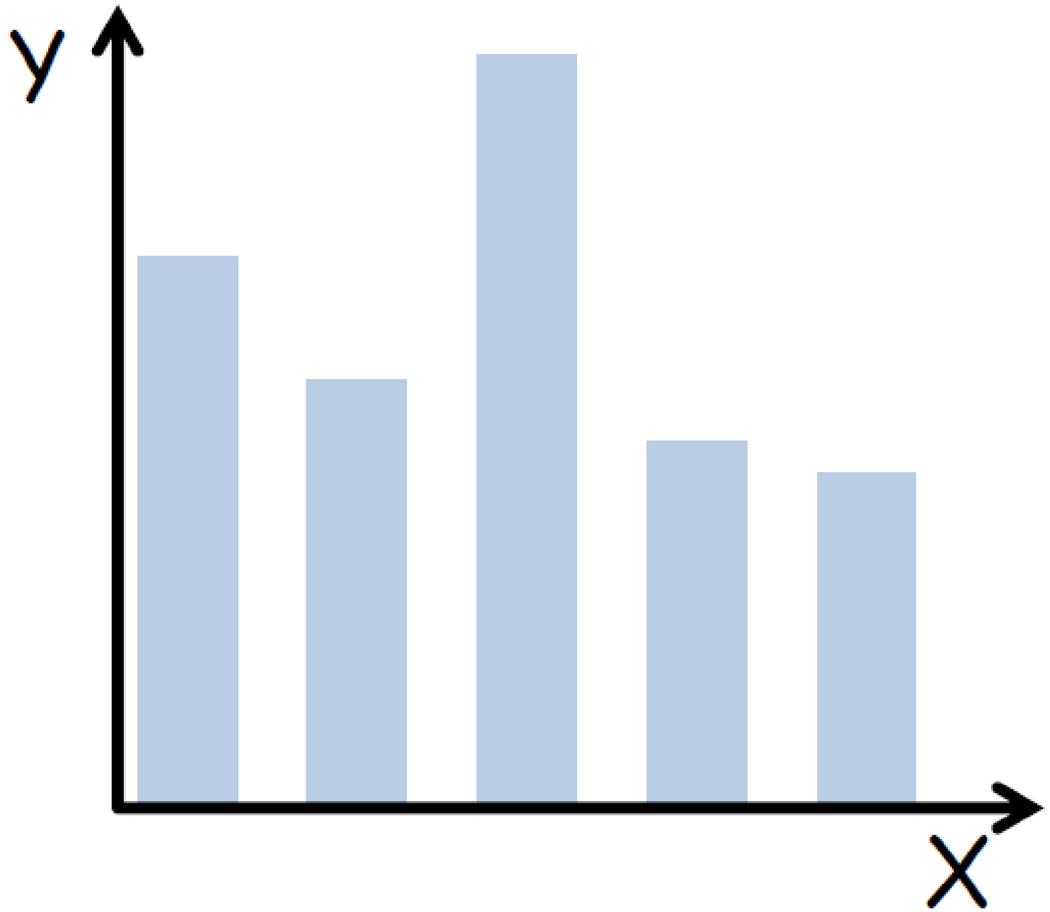
MARK = basic graphical element in an image

Visualization Building Blocks

CHANNEL = way to control the appearance of marks, independent of the dimensionality of the geometric primitive

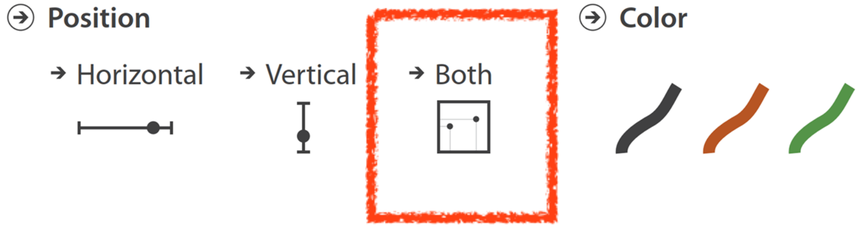
Visualization Building Blocks

of attributes encoded: 2



MARK:

CHANNEL :



Visualization Building Blocks

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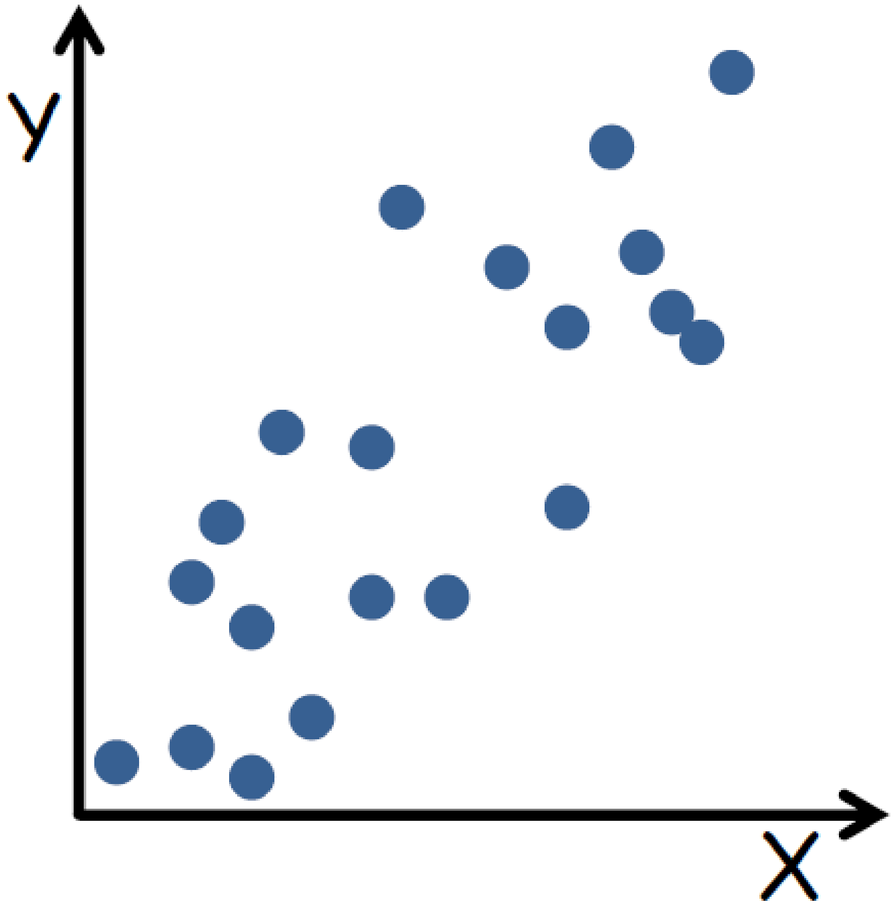

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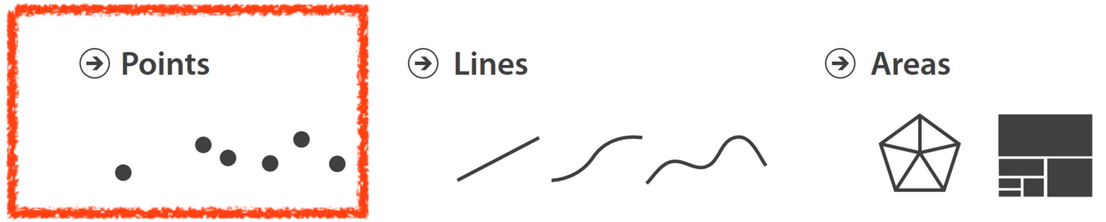

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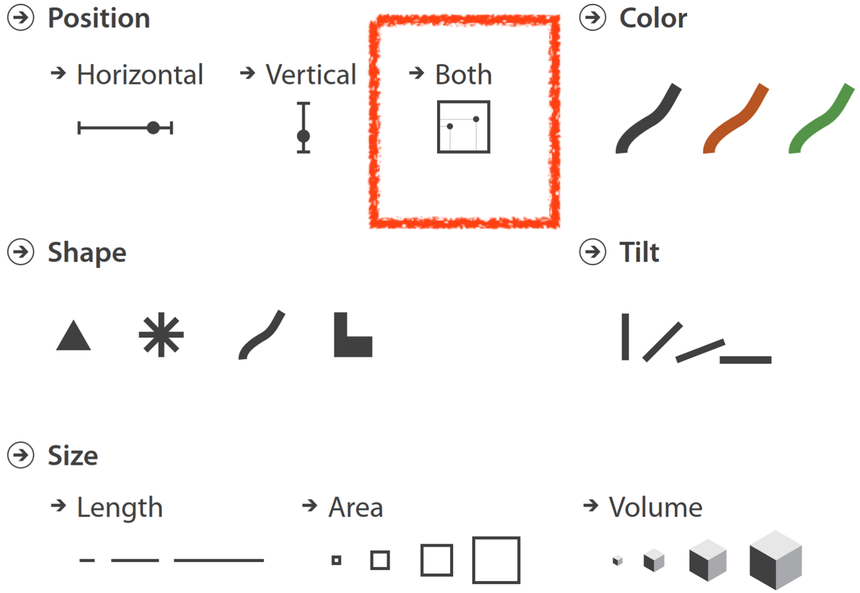

Visualization Building Blocks

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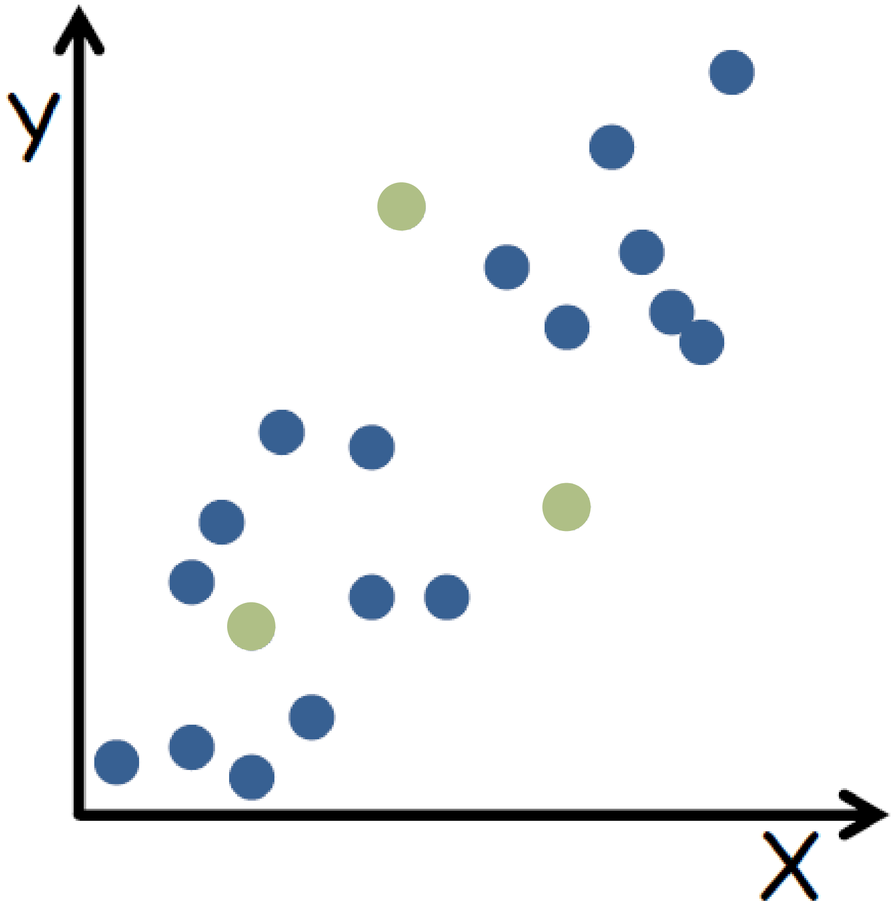

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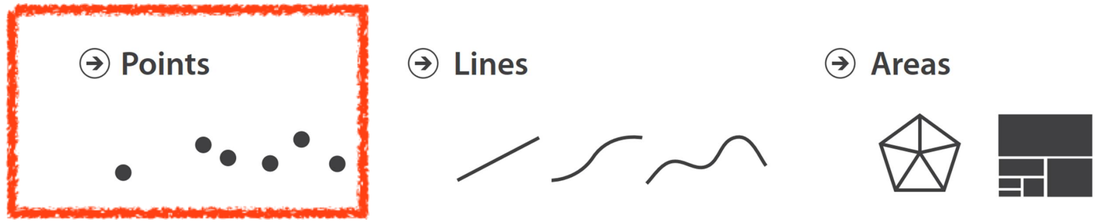

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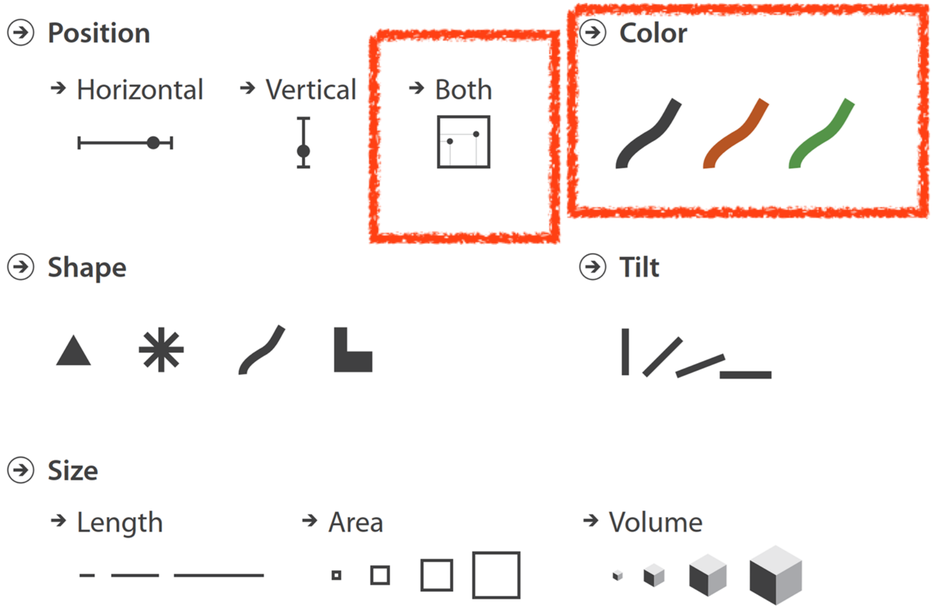

Visualization Building Blocks

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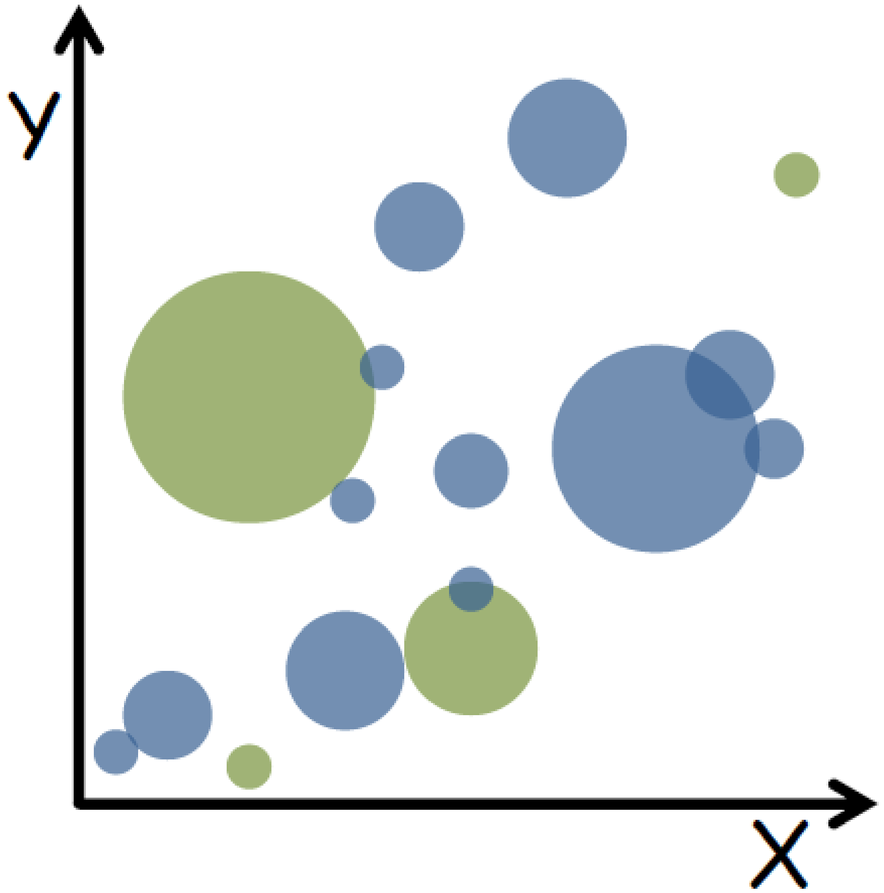

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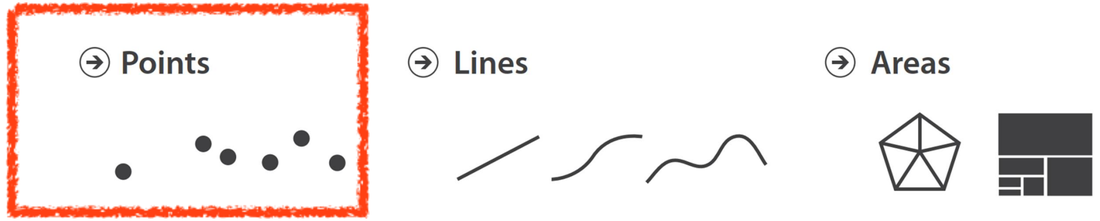

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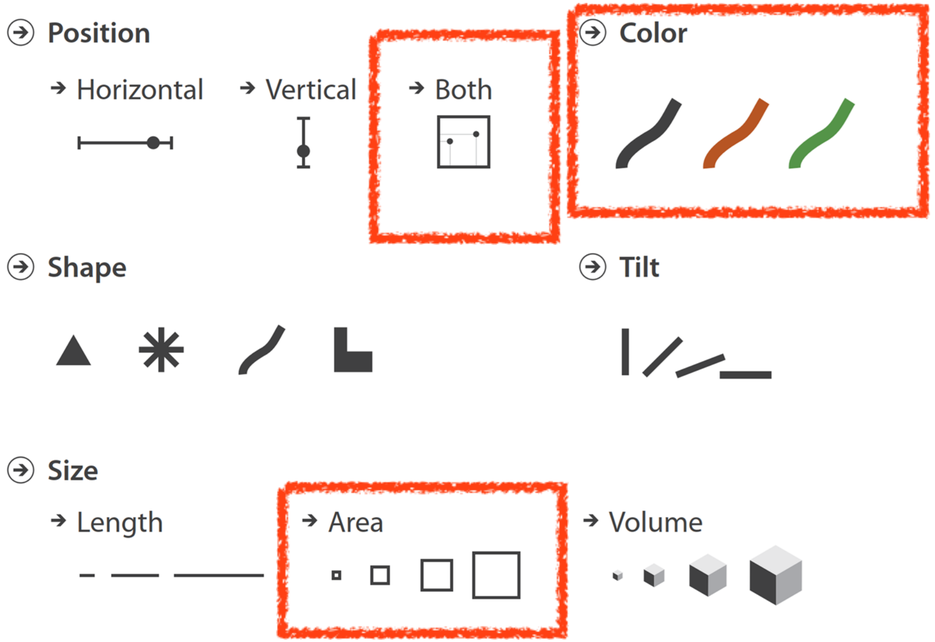
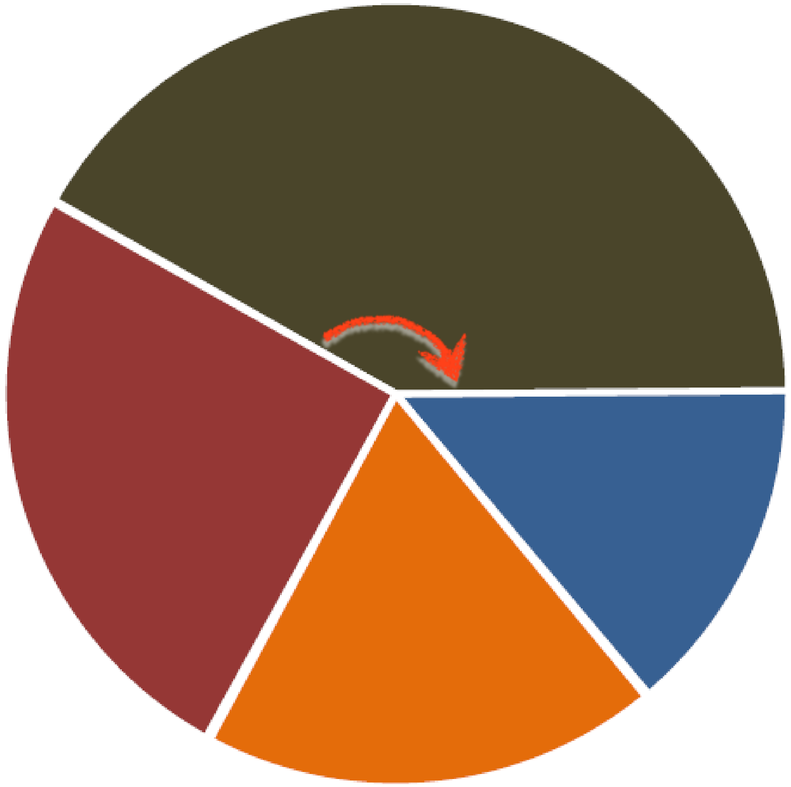


Visualization Building Blocks

of attributes encoded: 2



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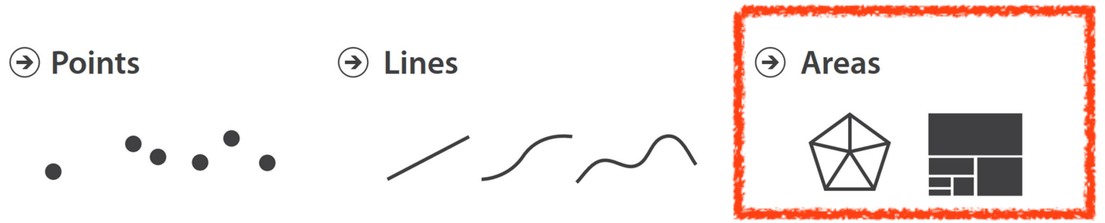

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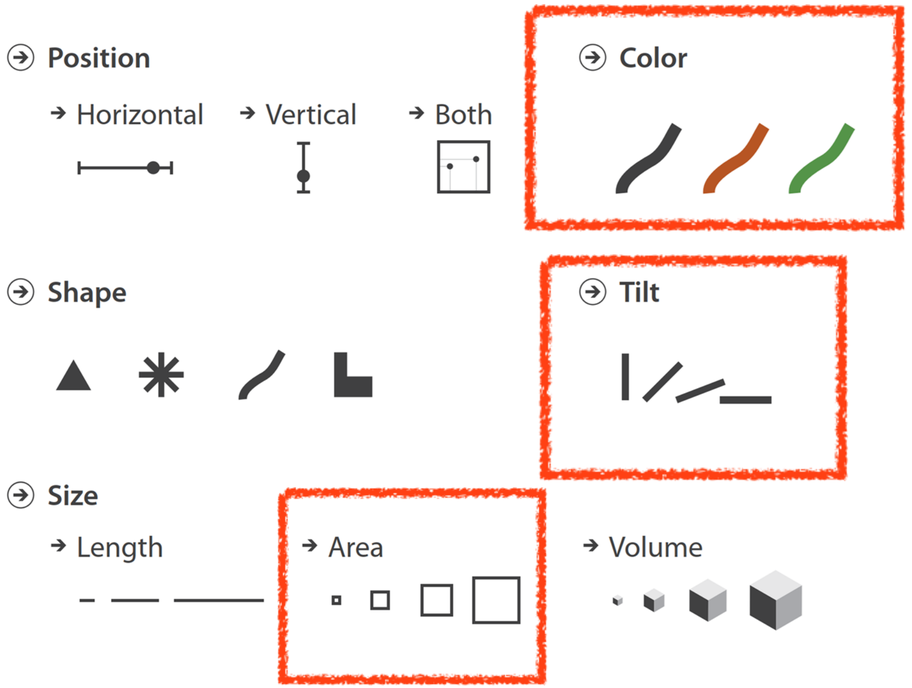

Visualization Building Blocks

of attributes encoded: 2

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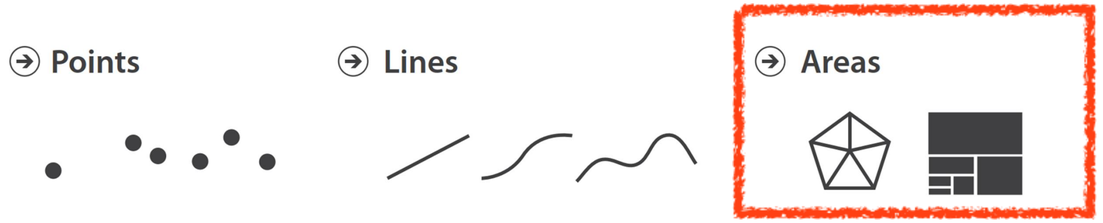

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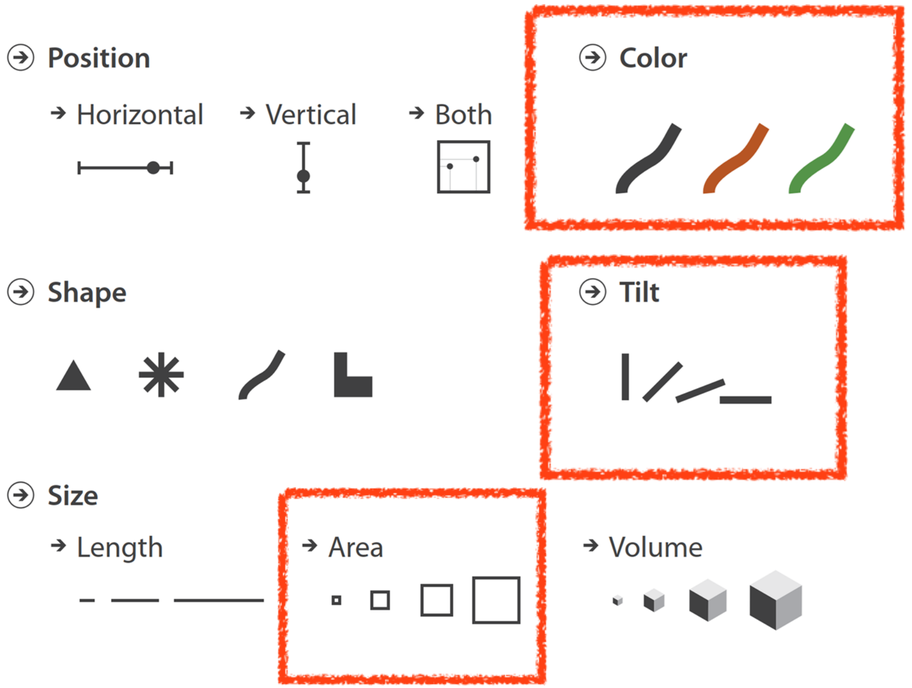
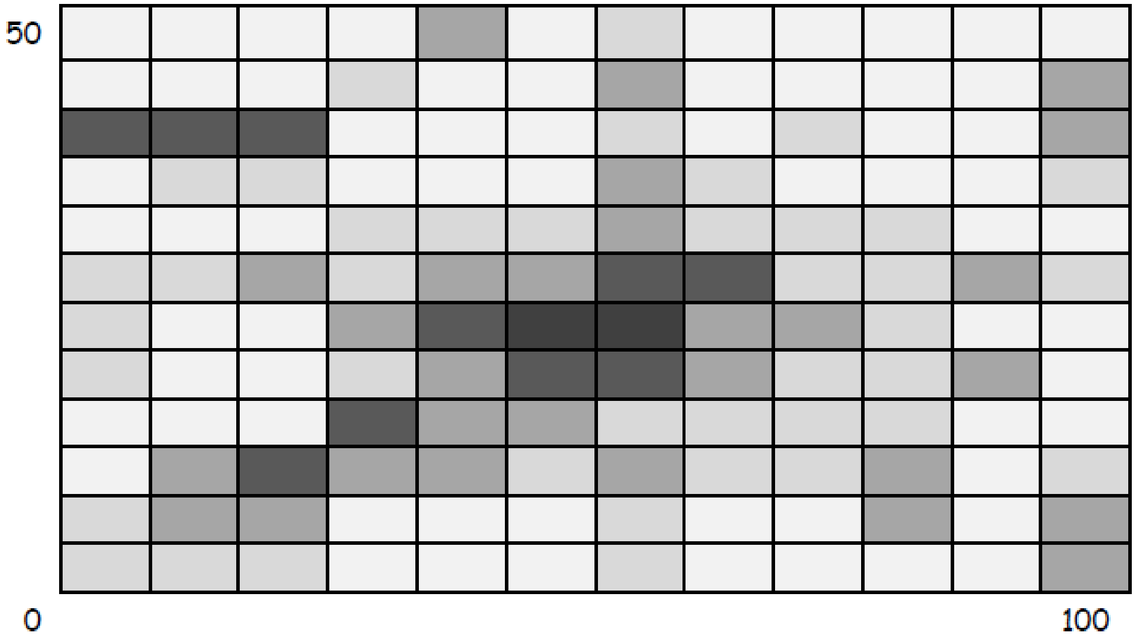


Visualization Building Blocks

of attributes encoded:



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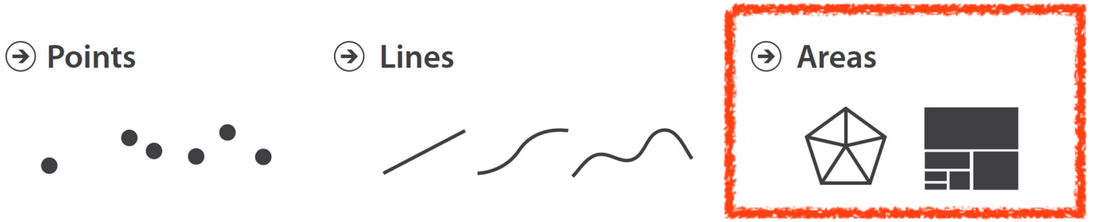

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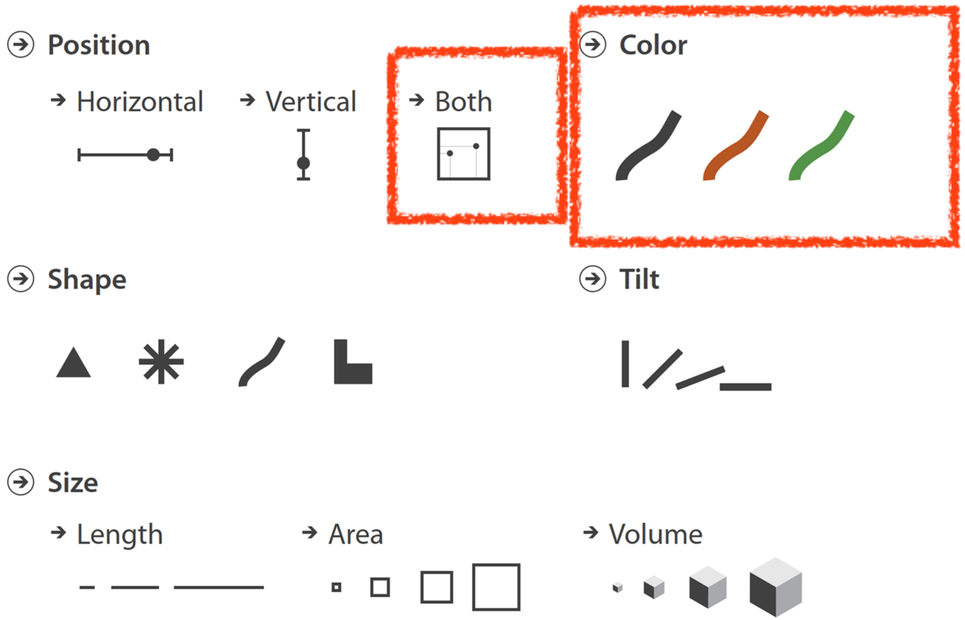


Visualization Building Blocks

of attributes encoded: ?

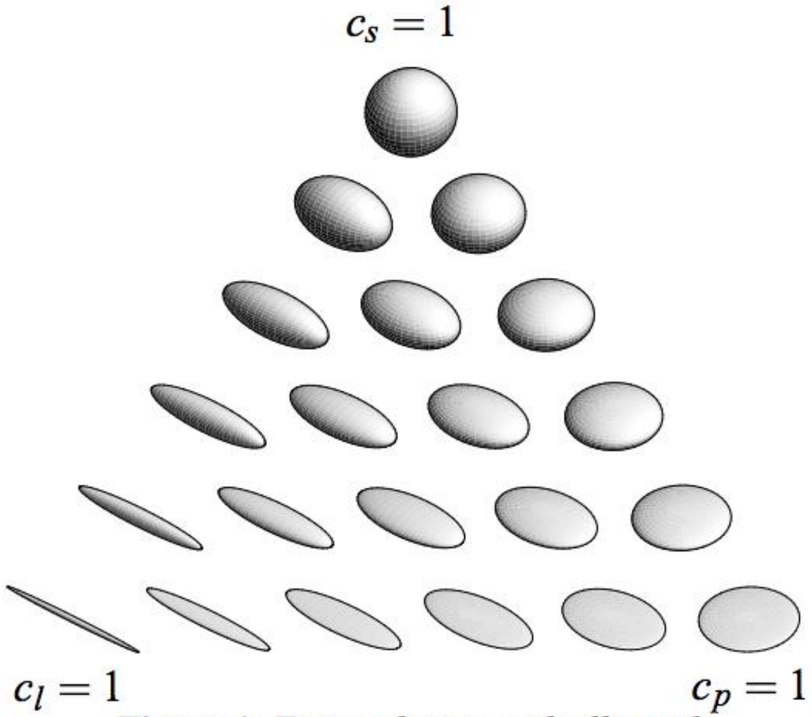
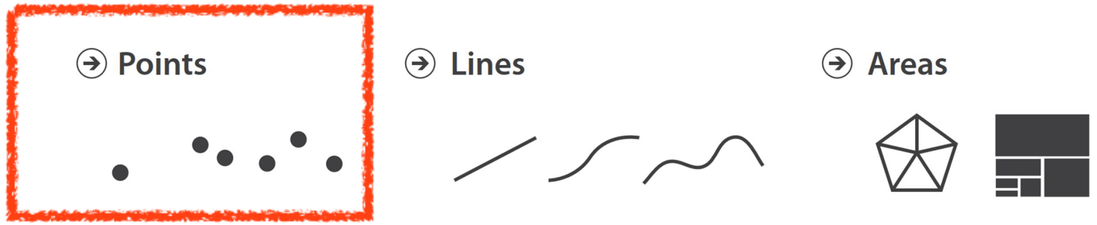


Figure 4: *Tensor shapes, with ellipsoids.*

+ position in 3D space

MARK:



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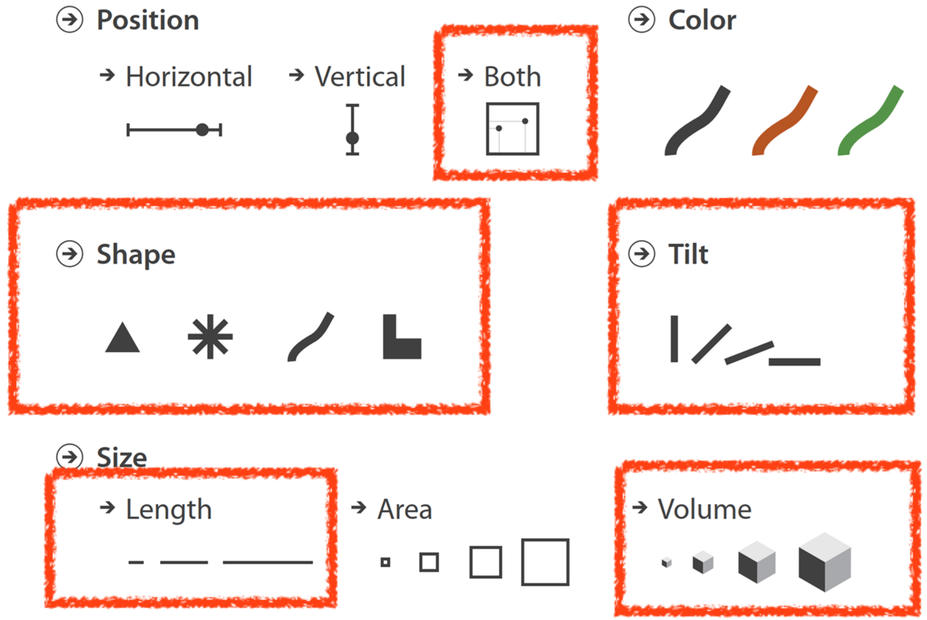


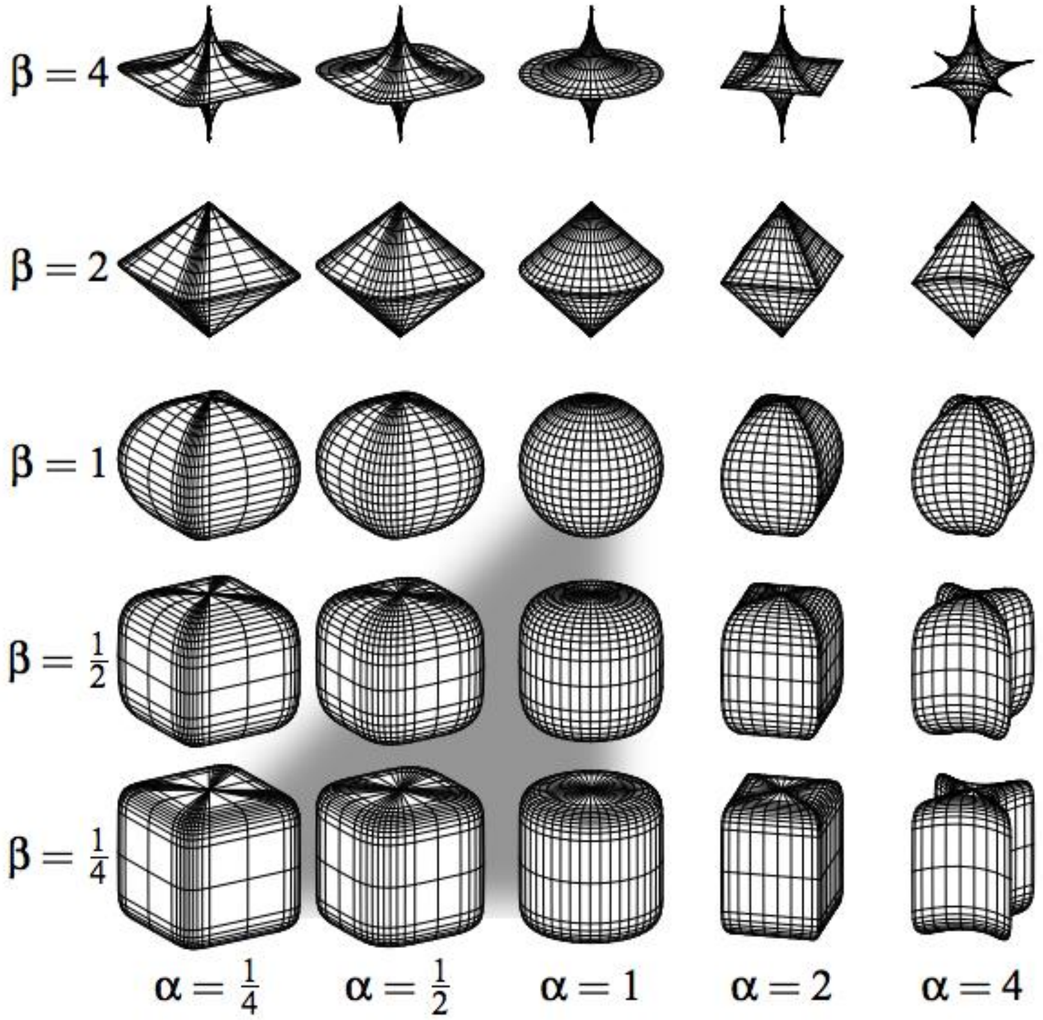
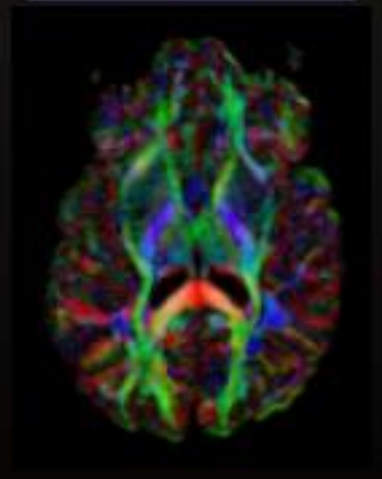
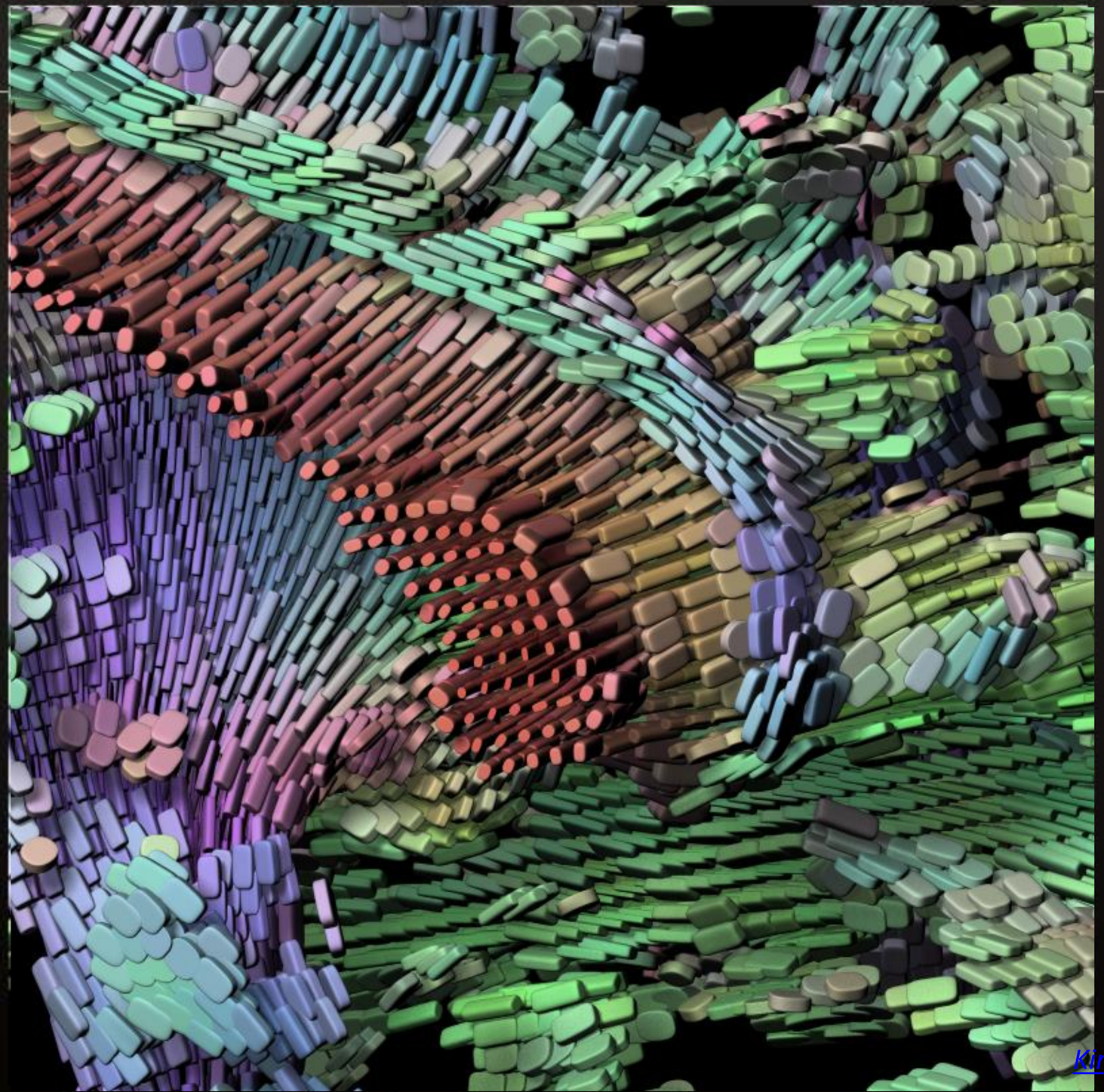


Figure 6: *Superquadrics defined by Equation 3. The gray triangle indicates the subset of the shape space employed by superquadric tensor glyphs. Edges indicate the tessellation resulting from uniform steps in* ϕ *and* θ.

Kindlmann (2004)

Results





Kindlmann (2004)

Visualization Building Blocks

Marks as Items/Nodes

- Points

- Lines

- Areas

Marks as Links

- Containment

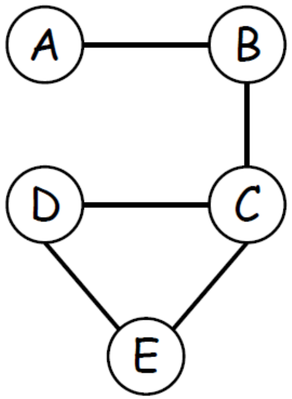
- Connection

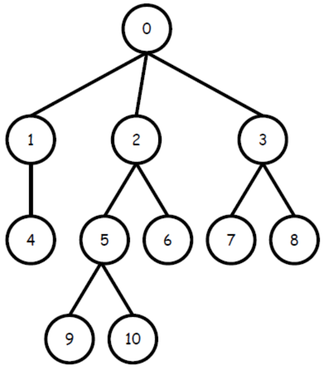
Visualization Building Blocks

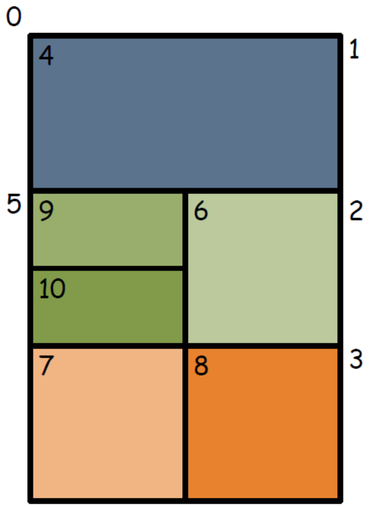
Marks as Links

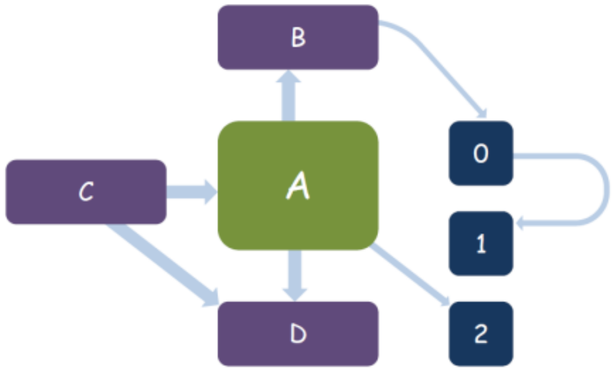
- Containment

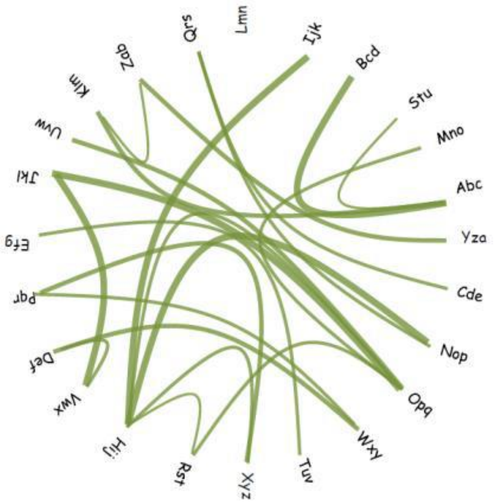
- Connection











Visualization Building Blocks

Marks as Items/Nodes

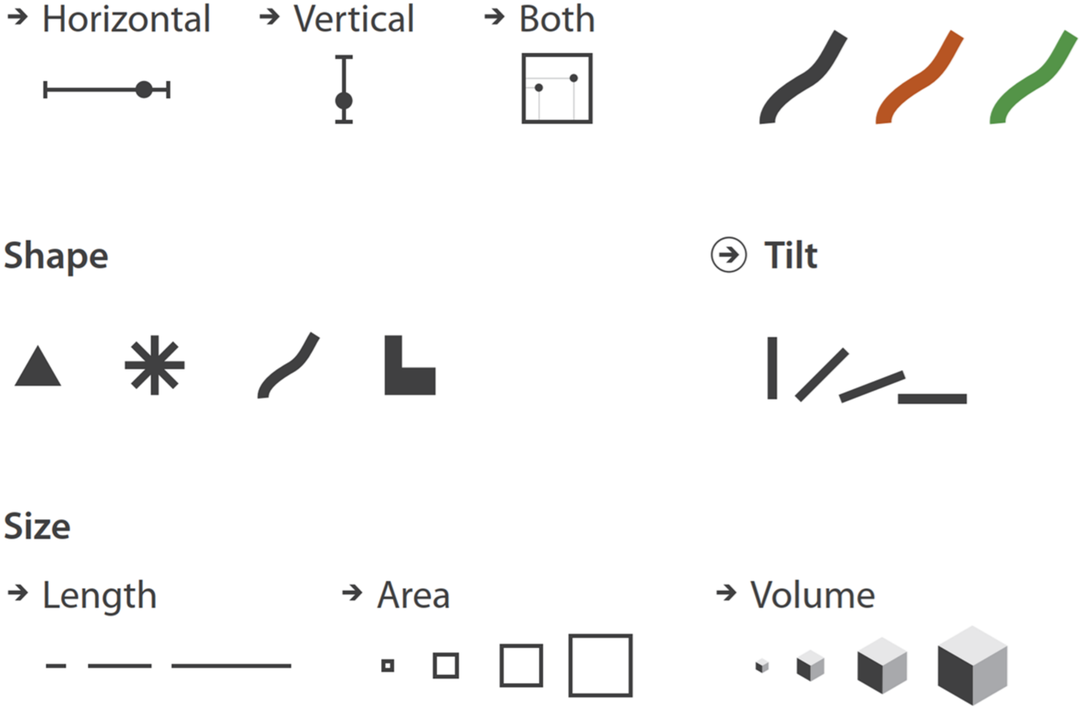
- Points
- Lines
- Areas

Marks as Links

- Containment
- Connection

Channels :

- Position
  - Horizontal
  - Vertical
  - Both
- Color
- Shape
- Tilt
- Size
  - Length
  - Area
  - Volume



Note: these are all really important concepts when it comes time to coding your visualizations...!

How do I pick *which* marks or channels to use?

“Ordering of Elemental Perceptual Tasks”

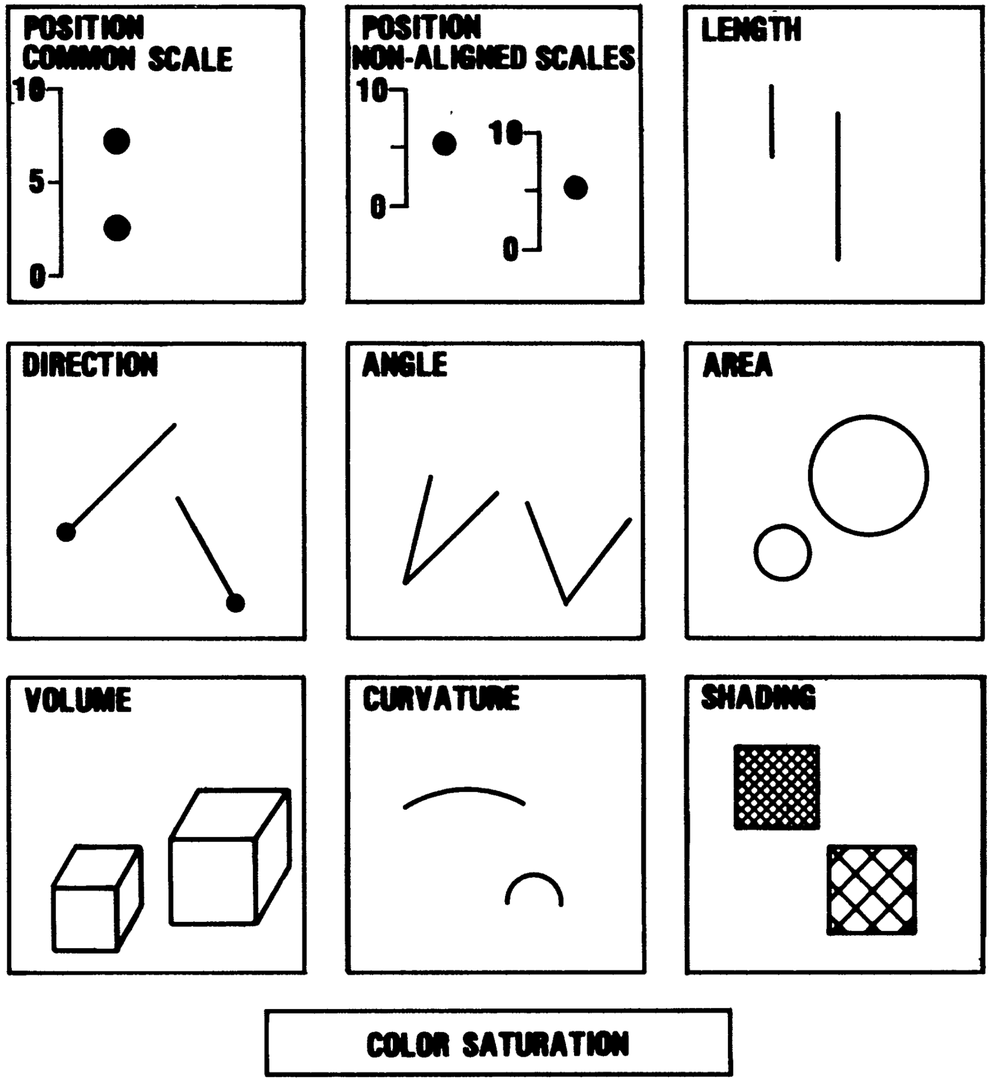


Figure 1. Elementary perceptual tasks.

[Cleveland & McGill (1984)]

“Ordering of Elemental Perceptual Tasks”

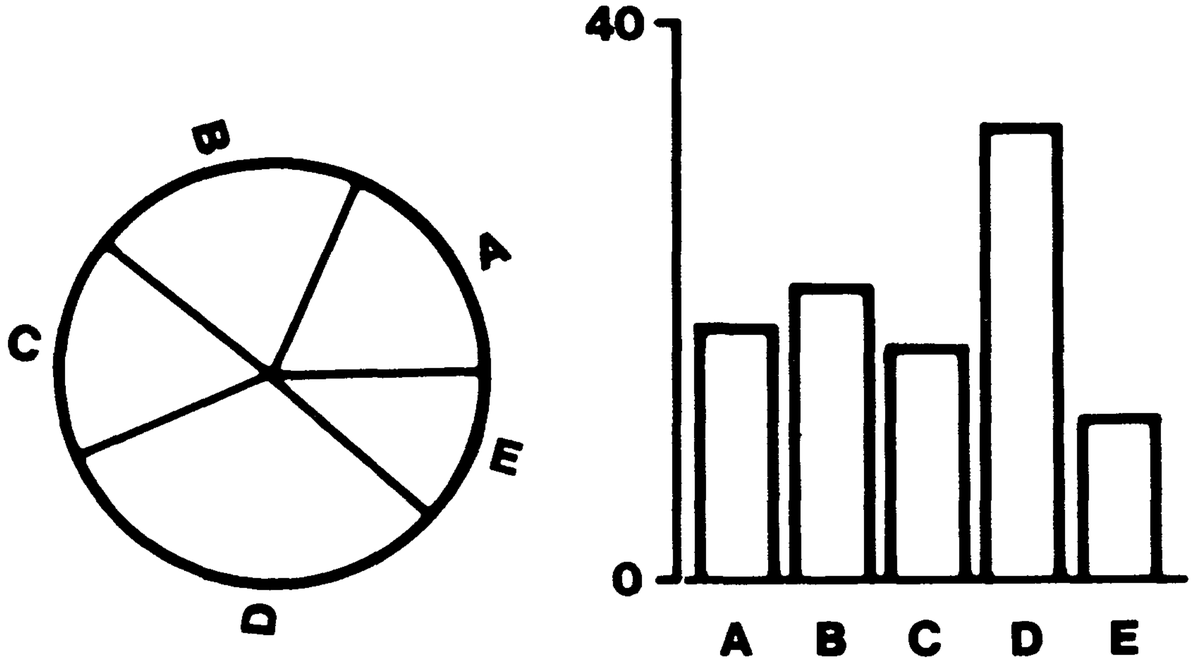


Figure 3. Graphs from position–angle experiment.

TASK: Which segment/bar is the maximum, and what is its percentage/value?

Cleveland & McGill (1984)

“Ordering of Elemental Perceptual Tasks”

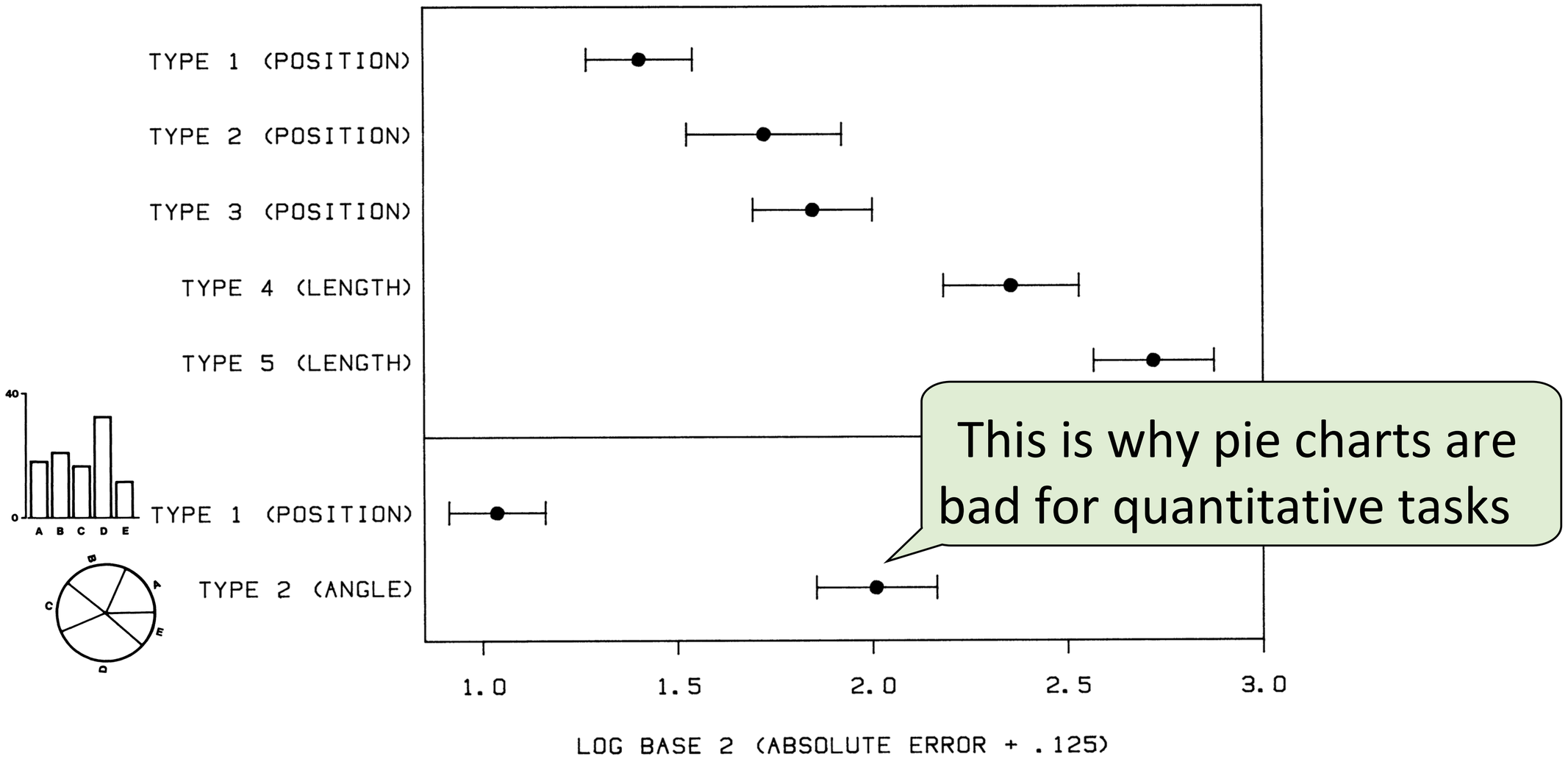
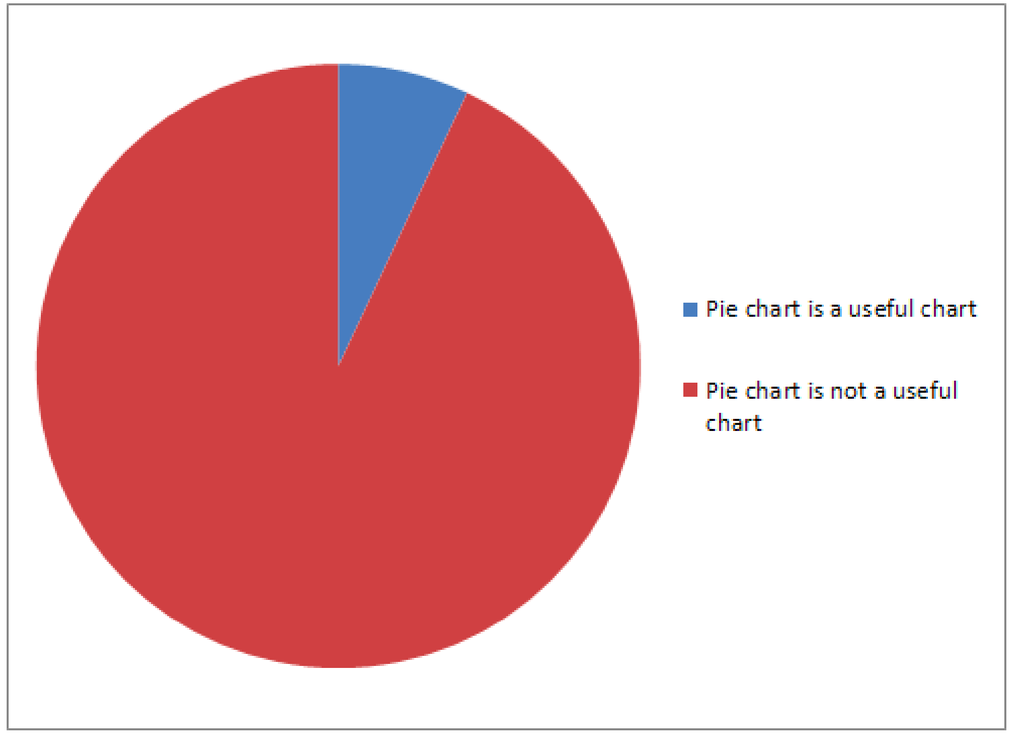
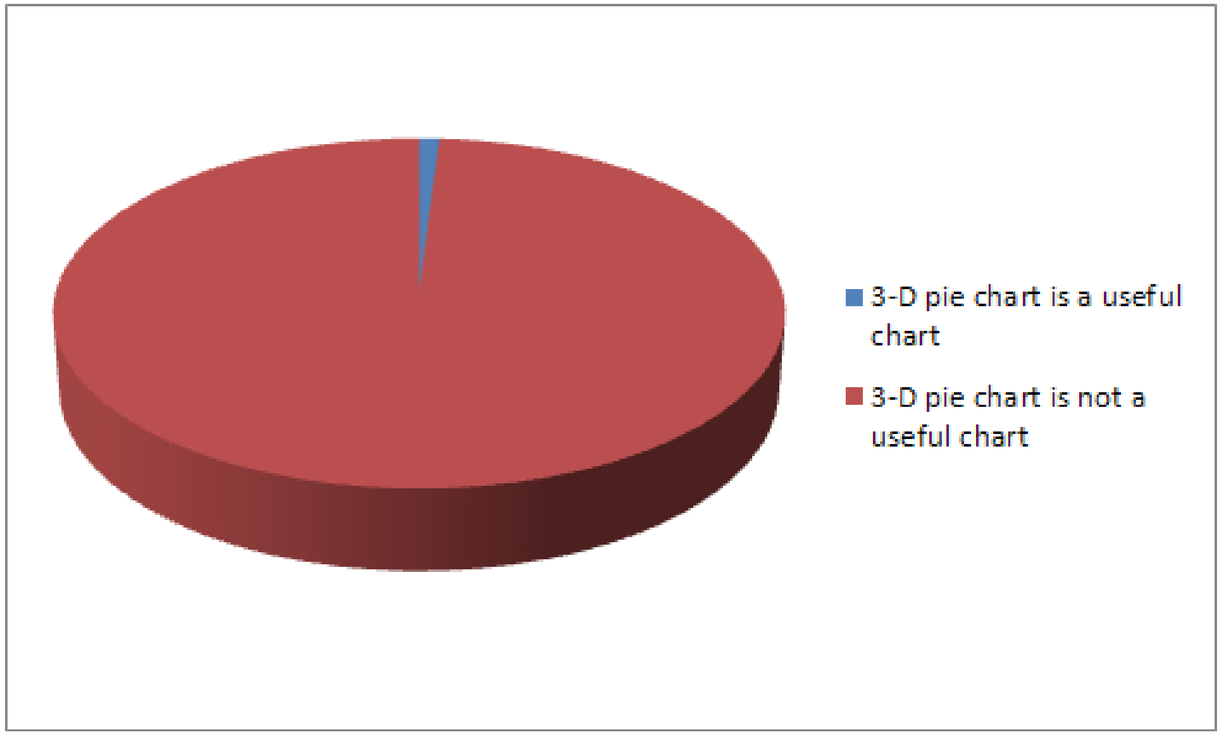


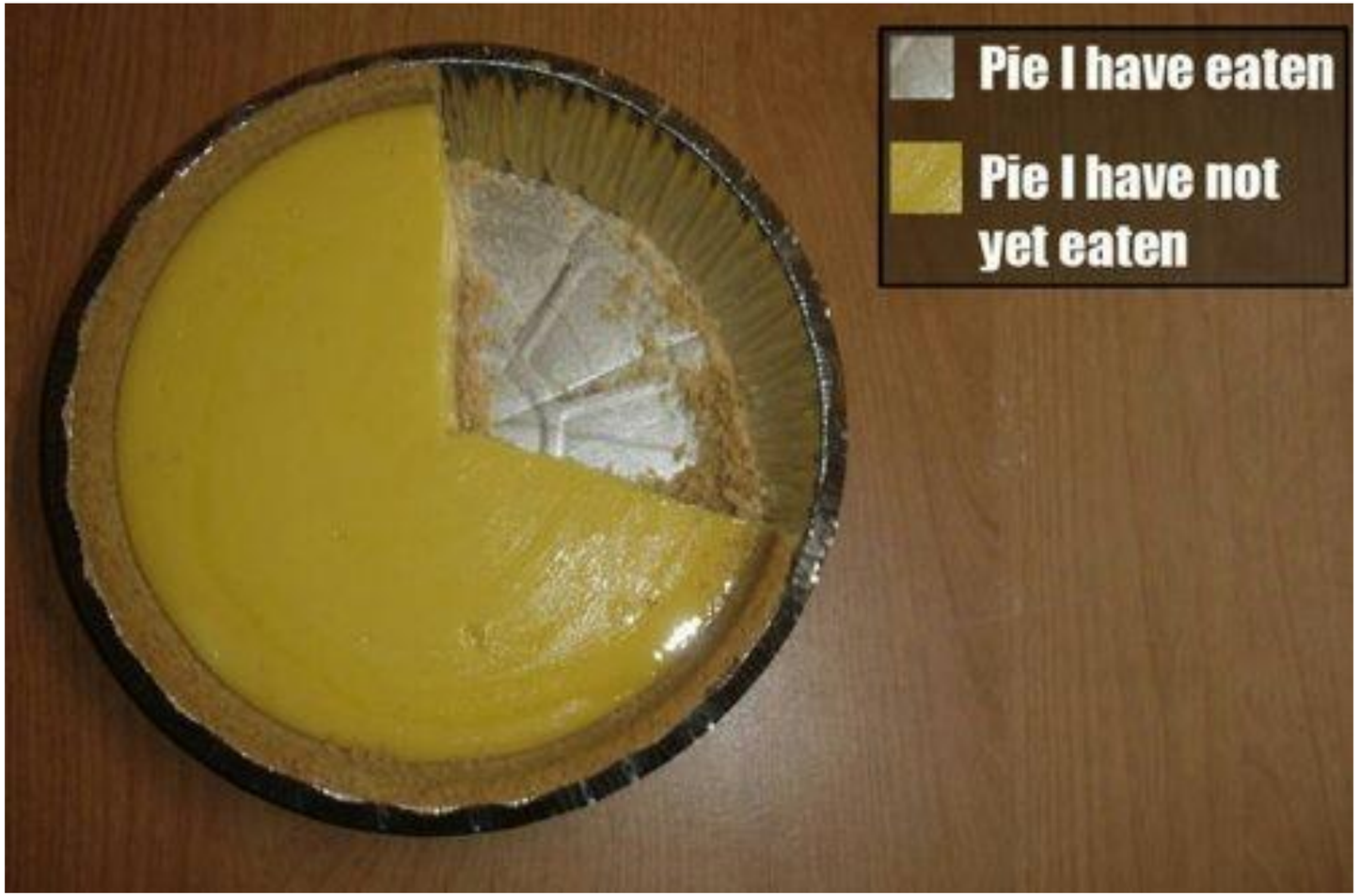
Figure 16. Log absolute error means and 95% confidence intervals for judgment types in position–length experiment (top) and position–angle experiment (bottom).

[Cleveland & McGill (1984)](#)

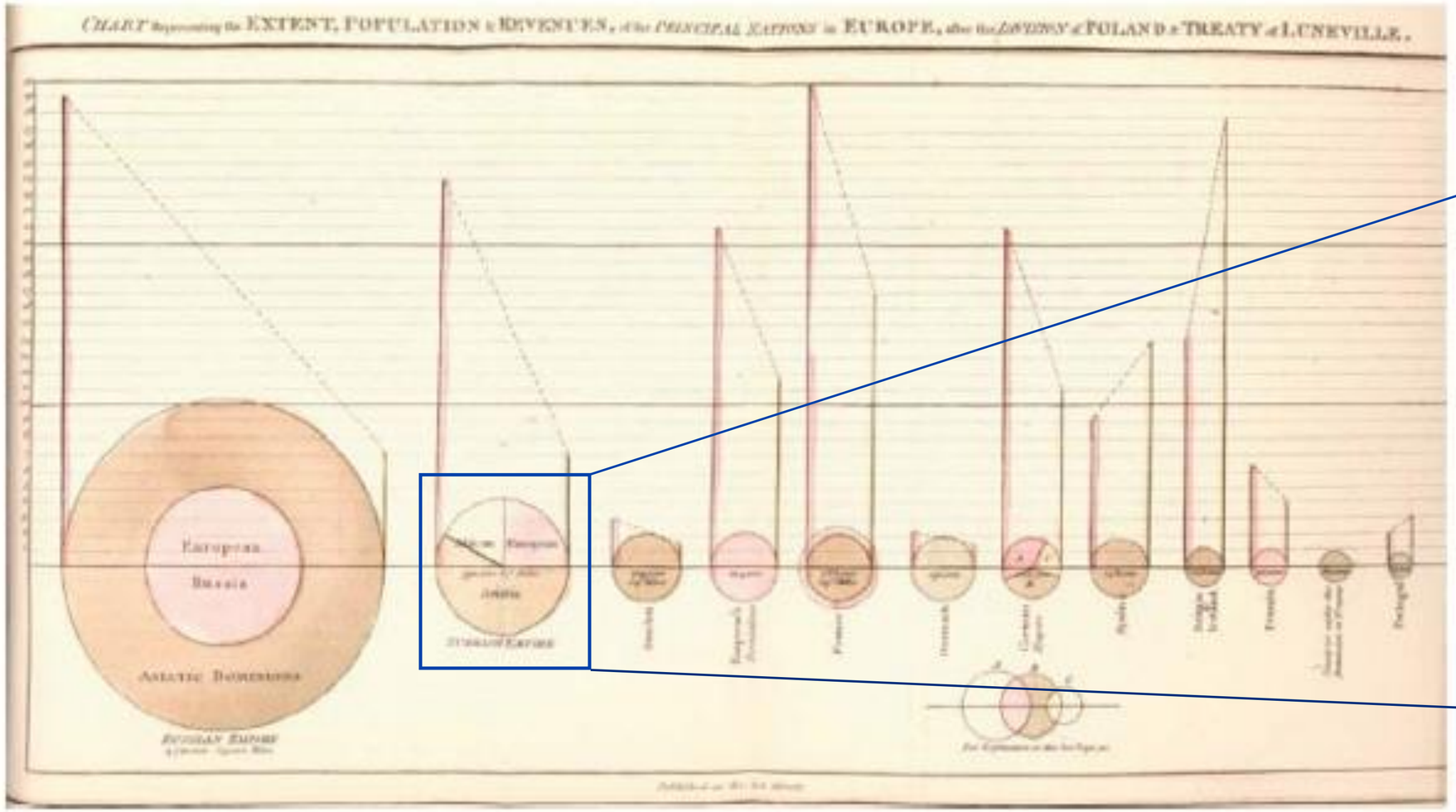


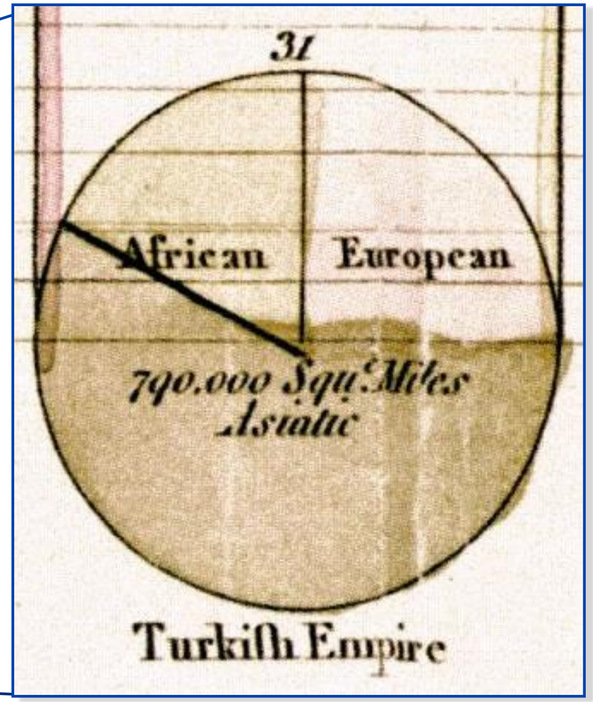


https://www.washingtonpost.com/news/wonk/wp/2013/06/17/the-usefulness-of-pie-charts-in-two-pie-charts/



http://www.datasciencecentral.com/profiles/blogs/10-resources-to-help-you-stop-doing-pie-charts





William Playfair (1801)

“Ordering of Elemental Perceptual Tasks”

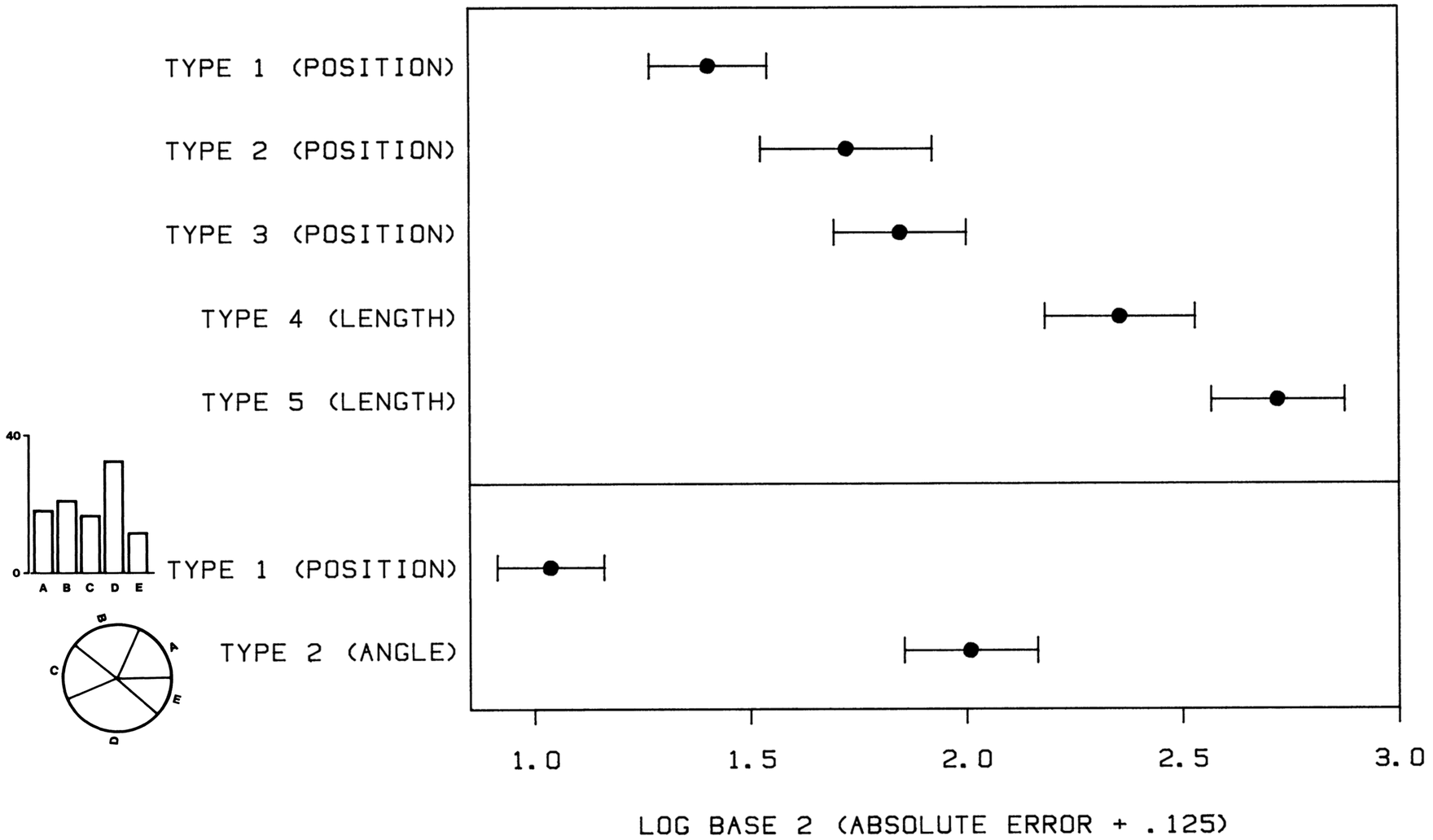
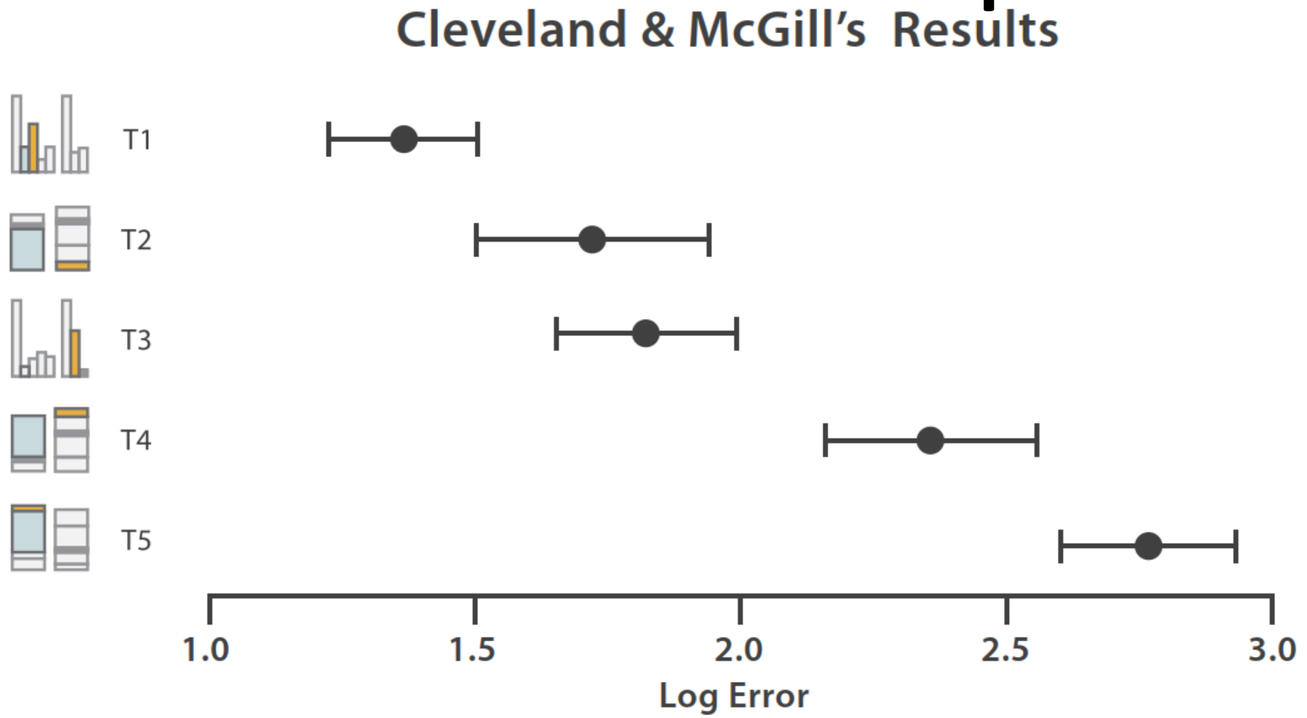


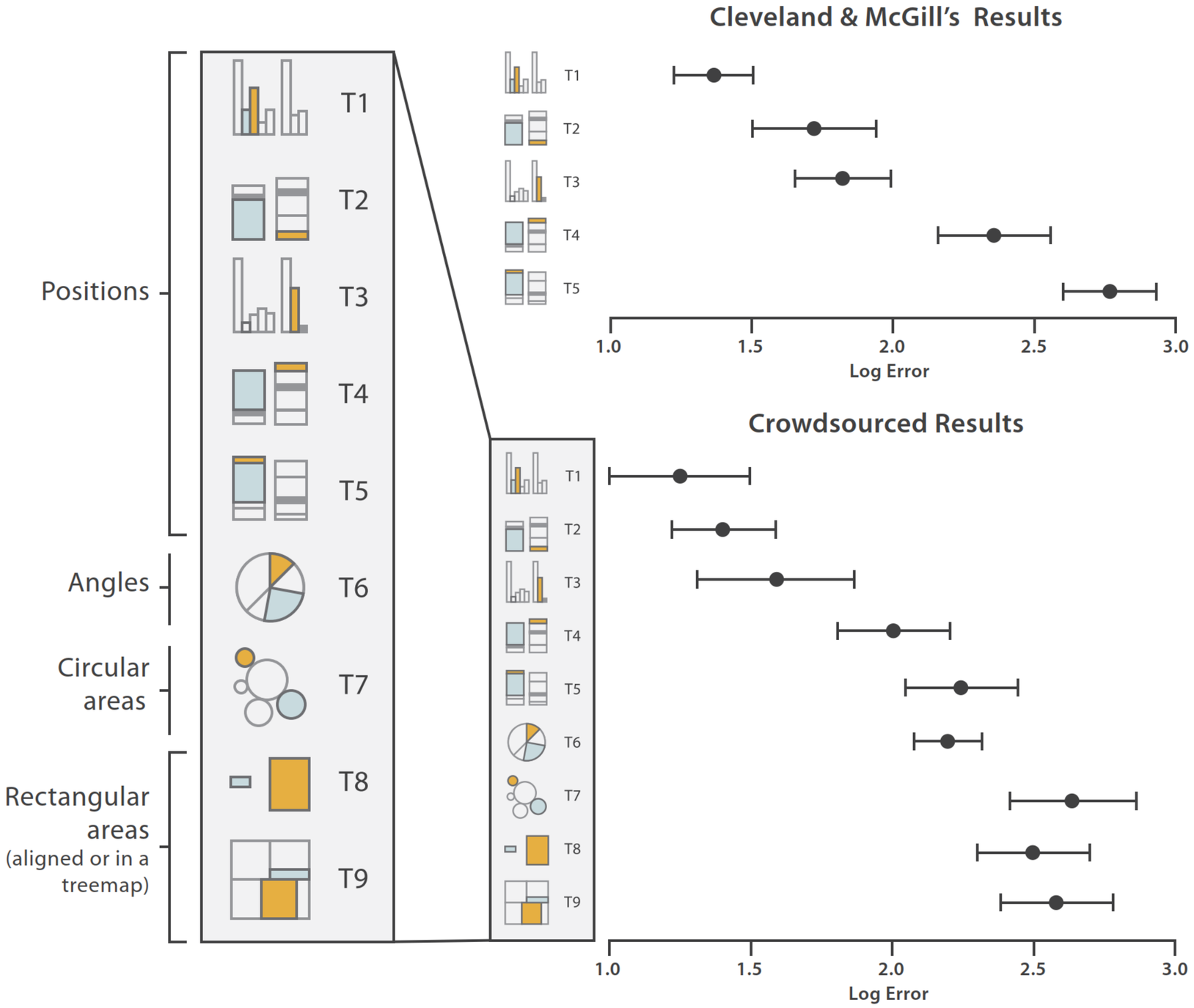
Figure 16. Log absolute error means and 95% confidence intervals for judgment types in position–length experiment (top) and position–angle experiment (bottom).

[Cleveland & McGill (1984)](#)

“Ordering of Elemental Perceptual Tasks”



Heer & Bostock (2010)



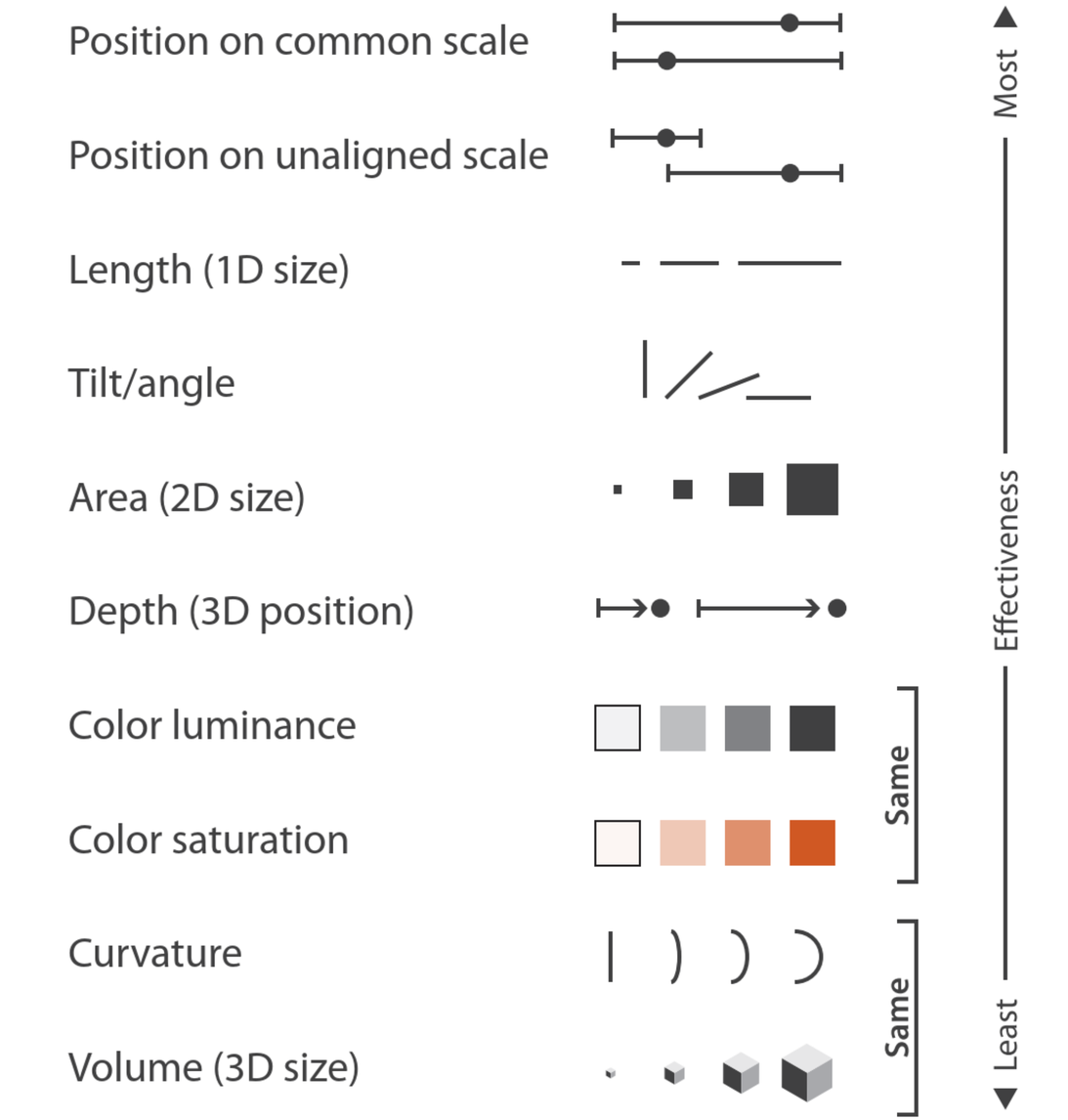
[Heer & Bostock (2010)]

Channels: Expressiveness Types and Effectiveness Ranks

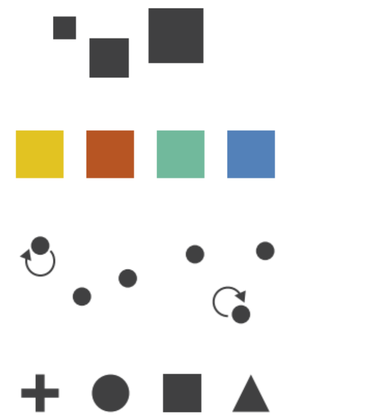
- **Magnitude Channels: Ordered Attributes**

Channels: Expressiveness Types and Effectiveness Ranks

Magnitude Channels: Ordered Attributes



Identity Channels: Categorical Attributes



Expressiveness and Effectiveness

Effectiveness principle: the importance of the attribute should match the salience of the channel; that is, its noticeability.
(i.e., encode most important attributes with highest ranked channels)

Expressiveness principle: the visual encoding should express all of, and only, the information in the dataset attributes.
(i.e., data characteristics should match the channel)

Mackinlay (1986)

My Summary: Prioritize choosing the most appropriate channel for each attribute

Expressiveness and Effectiveness

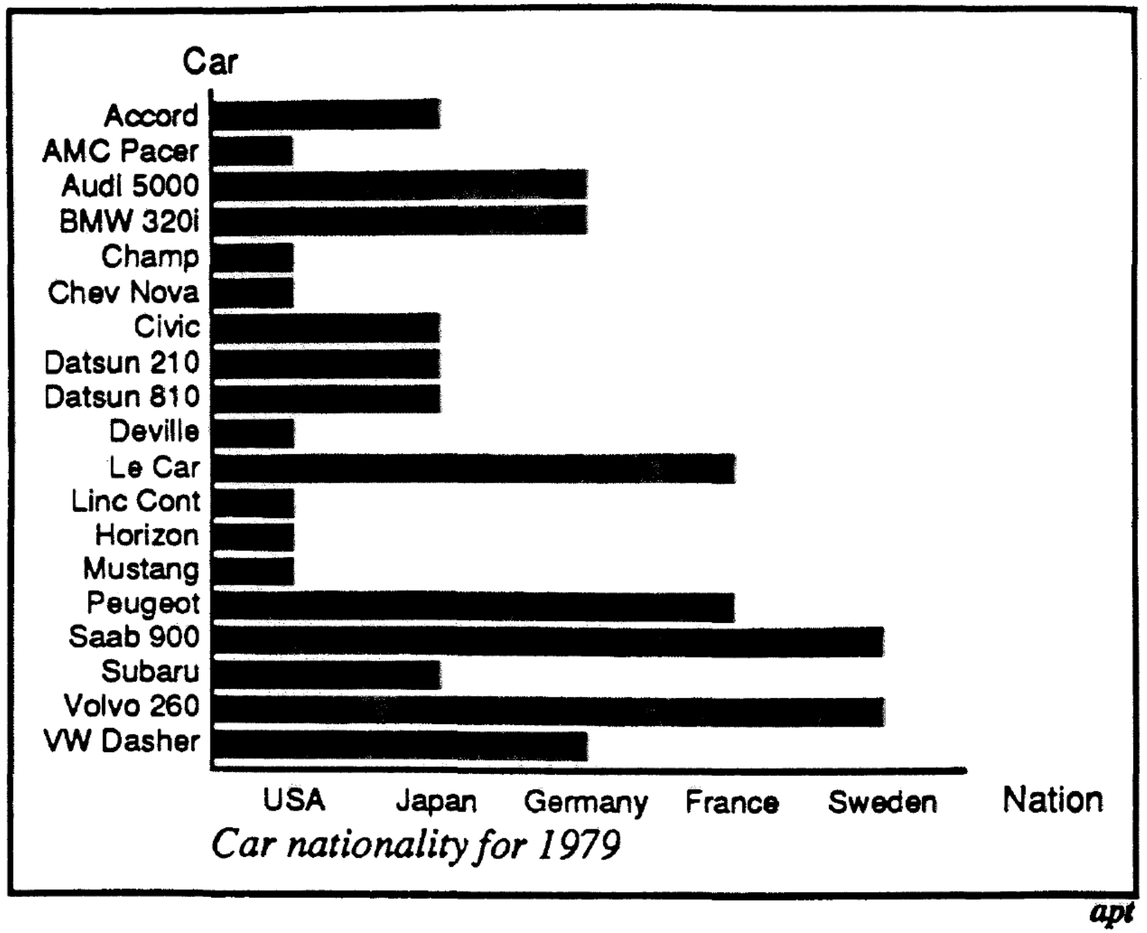


Figure 11: Incorrect Use of a Bar Chart for the Nation Relation. *The lengths of the bars suggest an ordering on the vertical axis, as if the* USA *cars were longer or better than the other cars, which is not true for the Nation relation.*

Mackinlay (1986)

Expressiveness and Effectiveness

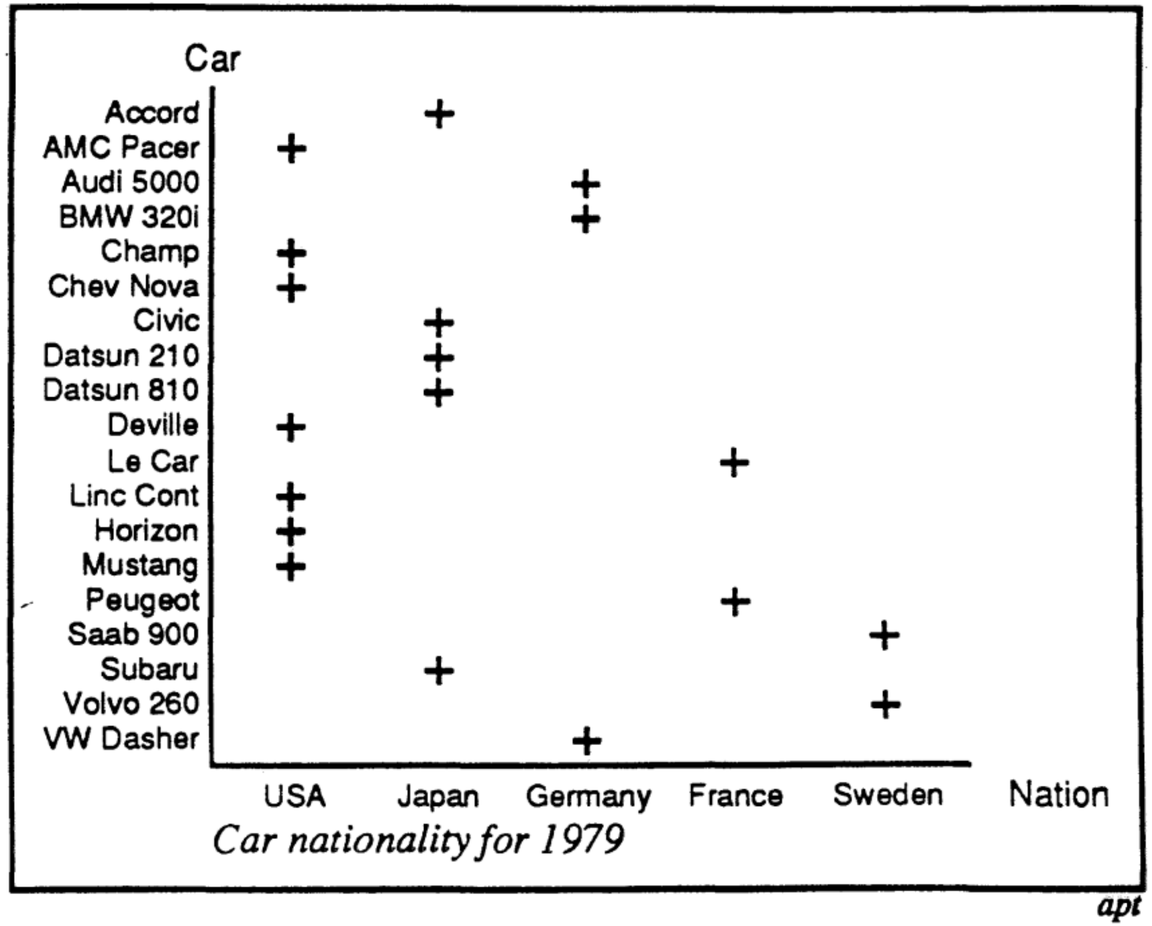
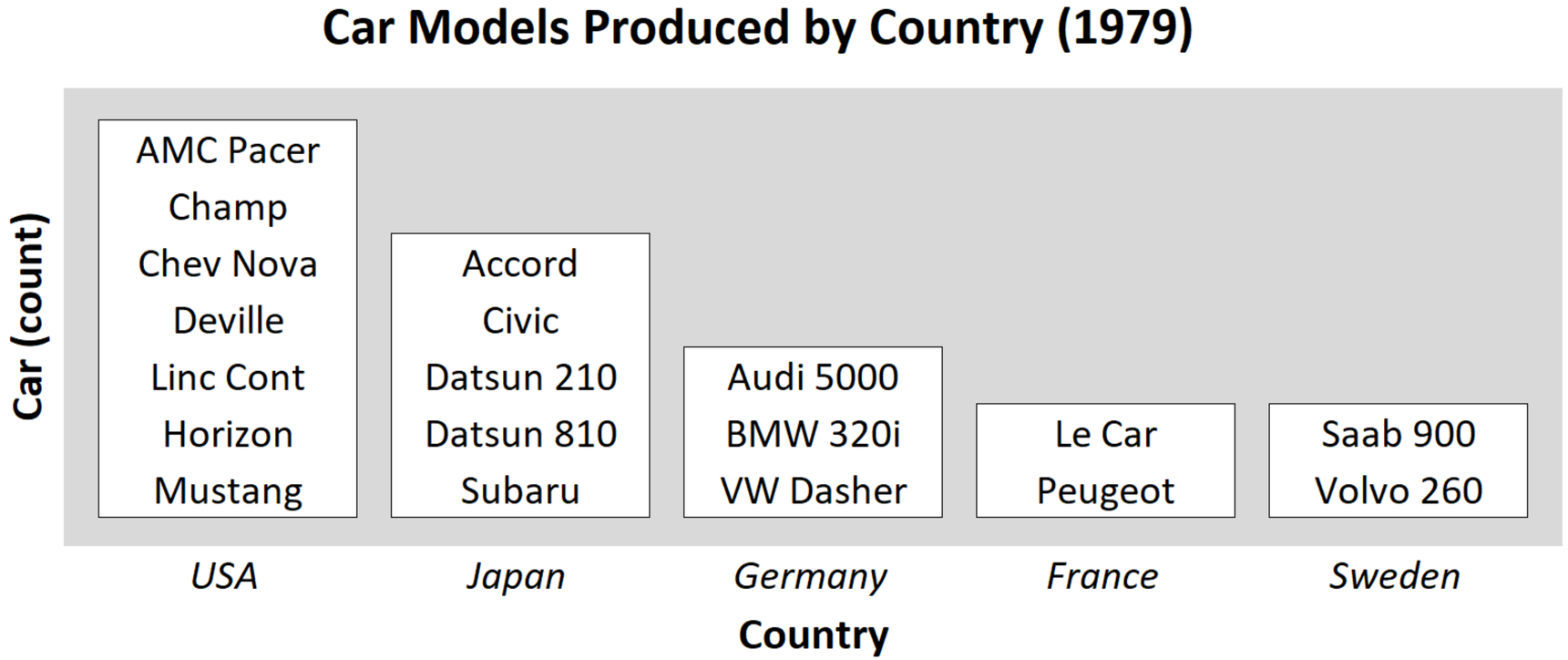


Figure 12: Correct Use of a Plot Chart for the Nation Relation. *Since bar charts encode ordered domain sets, plot charts are conventionally used to encode nominal domain sets. The ordering of the labels on the axes is ignored.*

Mackinlay (1986)

Expressiveness and Effectiveness



IN-CLASS EXERCISE

3, 12, 42

3, 12, 42

In-class Sketching: “Three numbers”

20m

1. **Individually** *(10m) u*se pens & post-it notes to sketch as many possible visualizations as you can of these three numbers.
2. No upload required
3. **As a class** *(10m)* I will call on some of you to show your designs and discuss common themes.

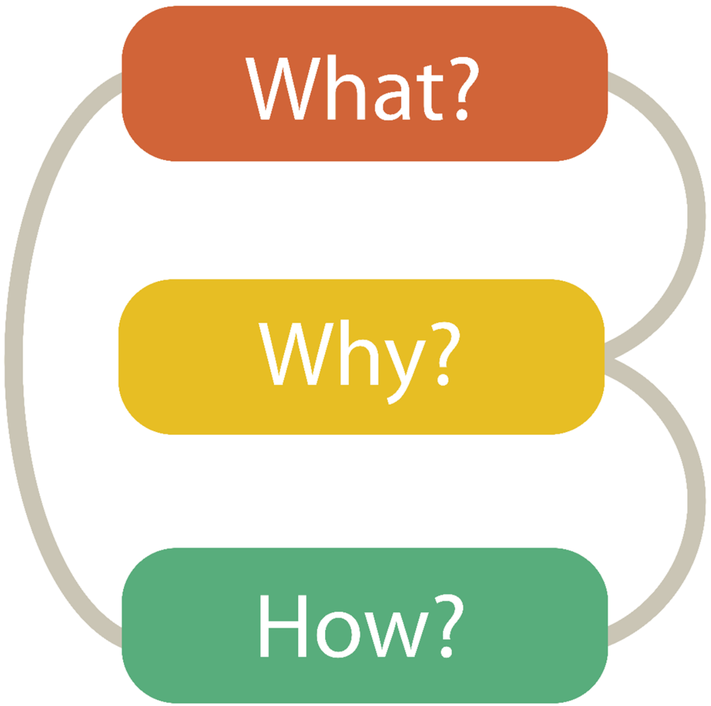
Jonathan Schwabish

Data Types

Goals for Today

- Learn what are data types and dataset types
- Learn what are attribute types
- Learn how to pick appropriate visual representations based on attribute type and perceptual properties

Analysis

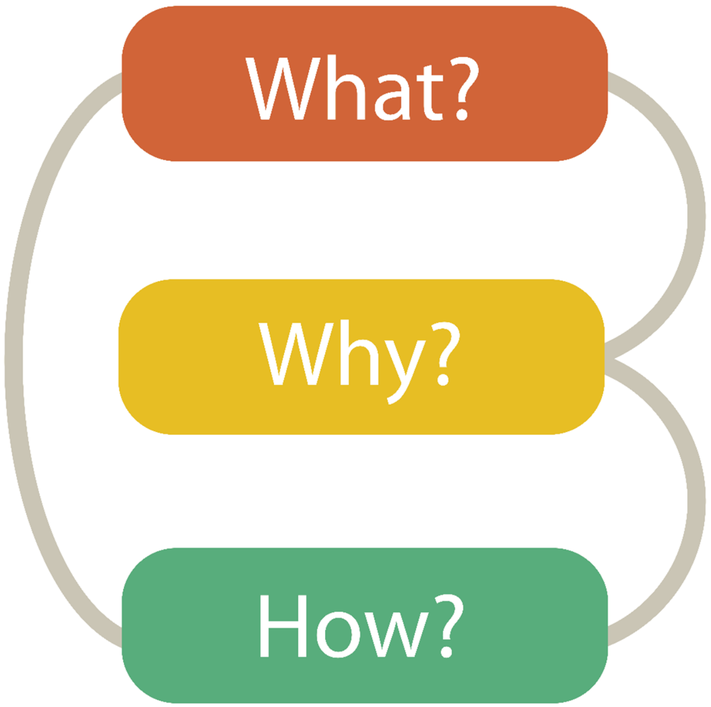


What data is shown?

Why is the user analyzing / viewing it?

How is the data presented?

Analysis

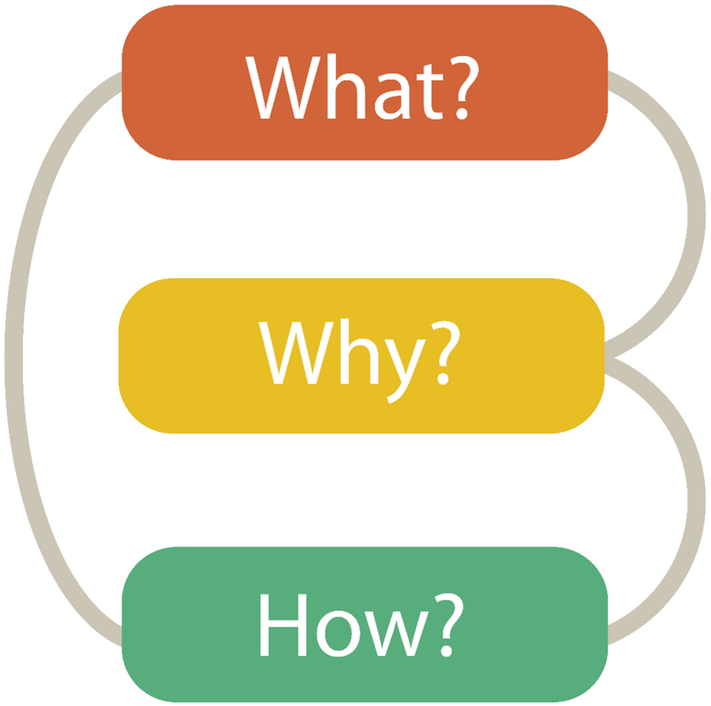


DATA ABSTRACTION

TASK ABSTRACTION

VISUAL ENCODING

Analysis



DATA ABSTRACTION

TASK ABSTRACTION

VISUAL ENCODING

Data Types

TYPE = structural or mathematical interpretation of the data

Data Types

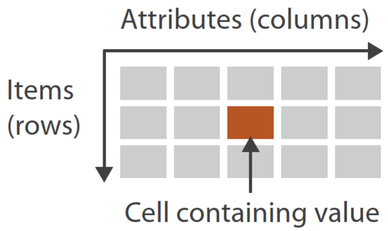
➔ Items	➔ Attributes	➔ Links	➔ Positions	➔ Grids
(row, node)	*(variable, data dimension)*	*(relationship)*	*(spatial location)*	*(sampling)*

Data Types

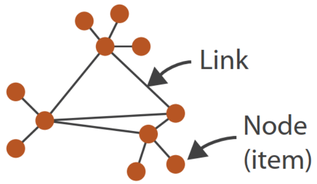
DATASET = collection of information that is the target of analysis

Dataset Types

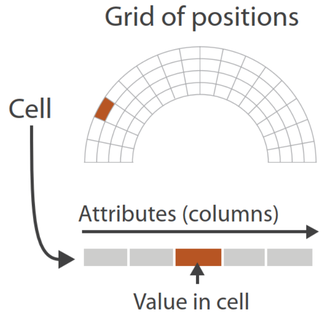
Tables



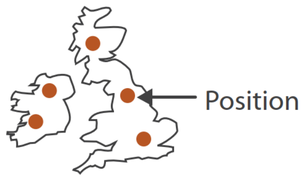
Networks



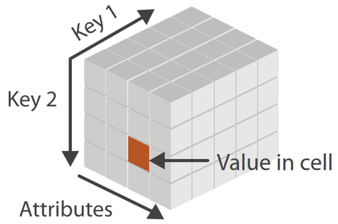
Fields (Continuous)



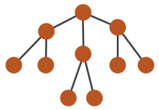
Geometry (Spatial)



Multidimensional Table

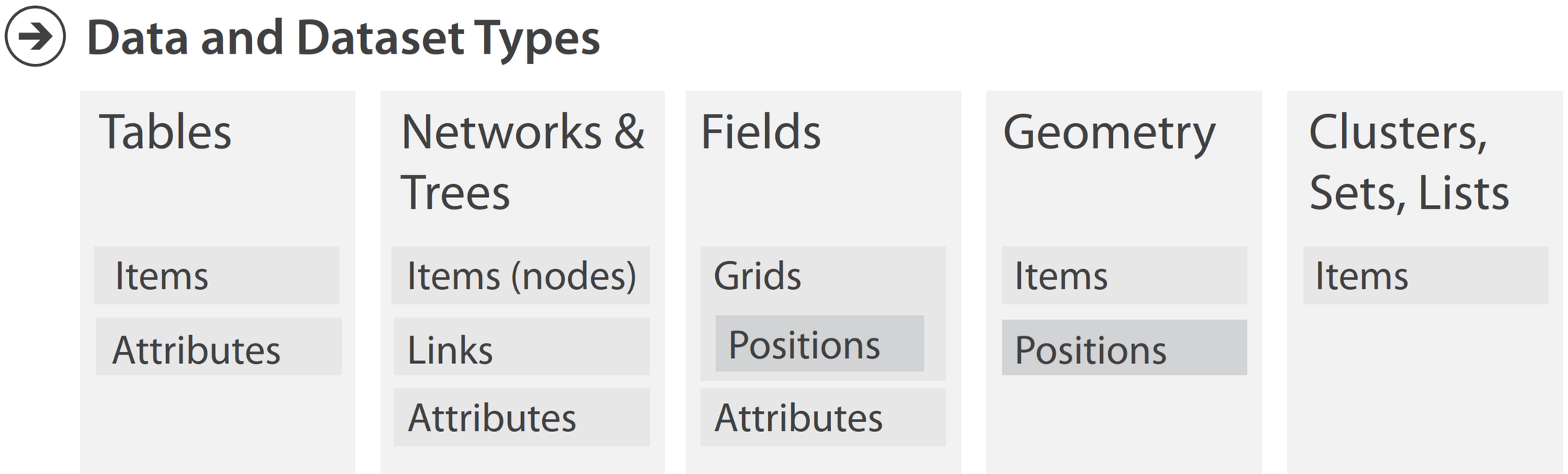


Trees



Data Types

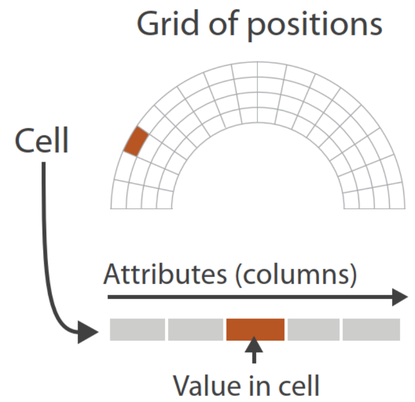
DATASET = collection of information that is the target of analysis



grid types

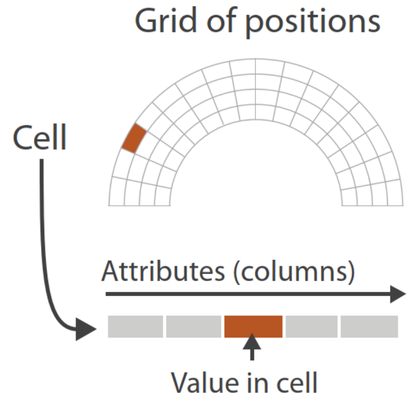
Relevant to anyone in the sciences!

➔ Fields (Continuous)



grid choices impact how continuous data is interpreted

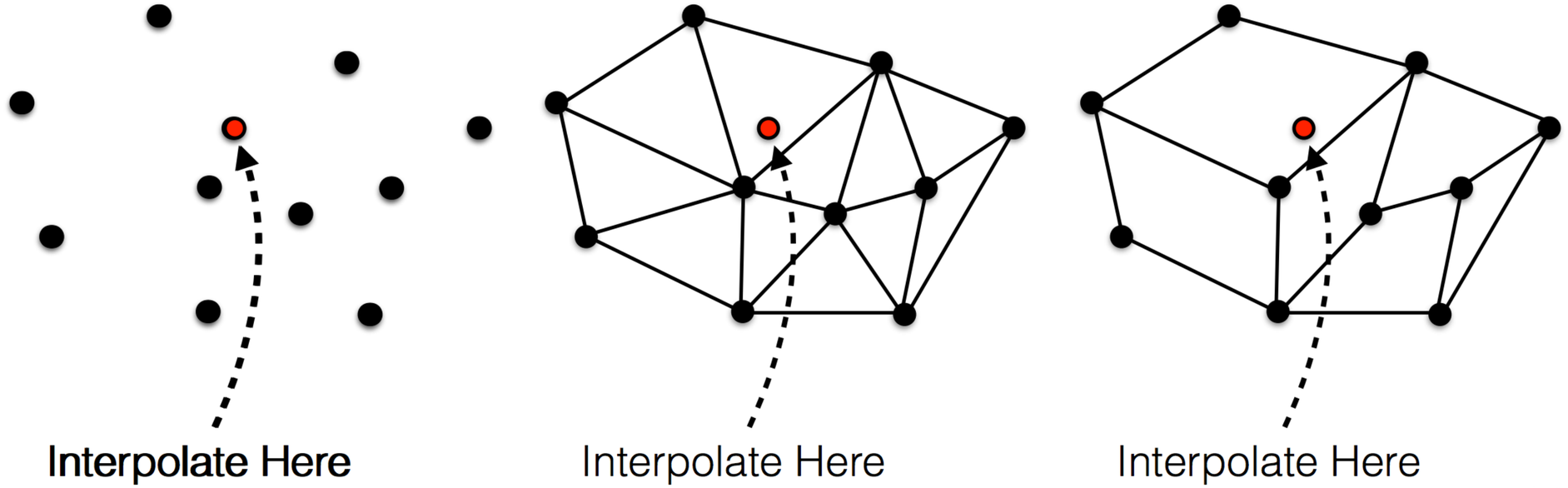
➔ Fields (Continuous)



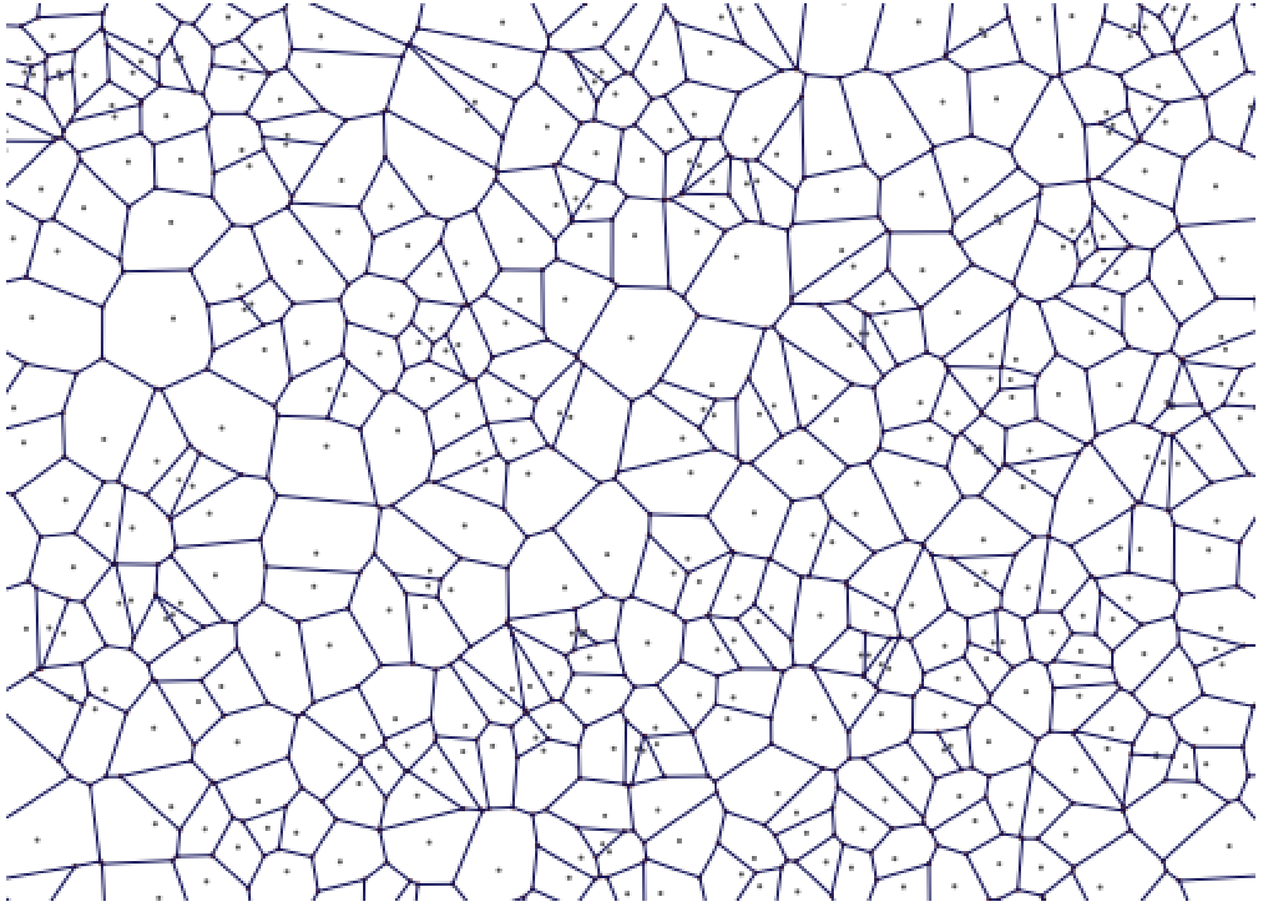
two key considerations:

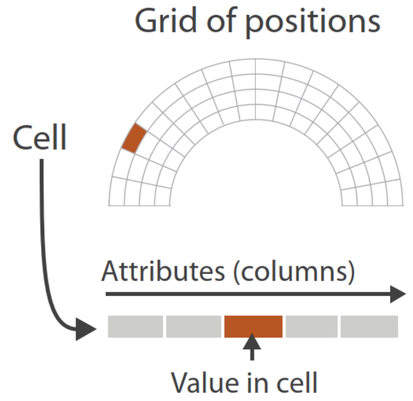
sampling, or the choice of where attributes are measured

interpolation, or how to model the attributes in the rest of space



“Voronoi Tessellation”

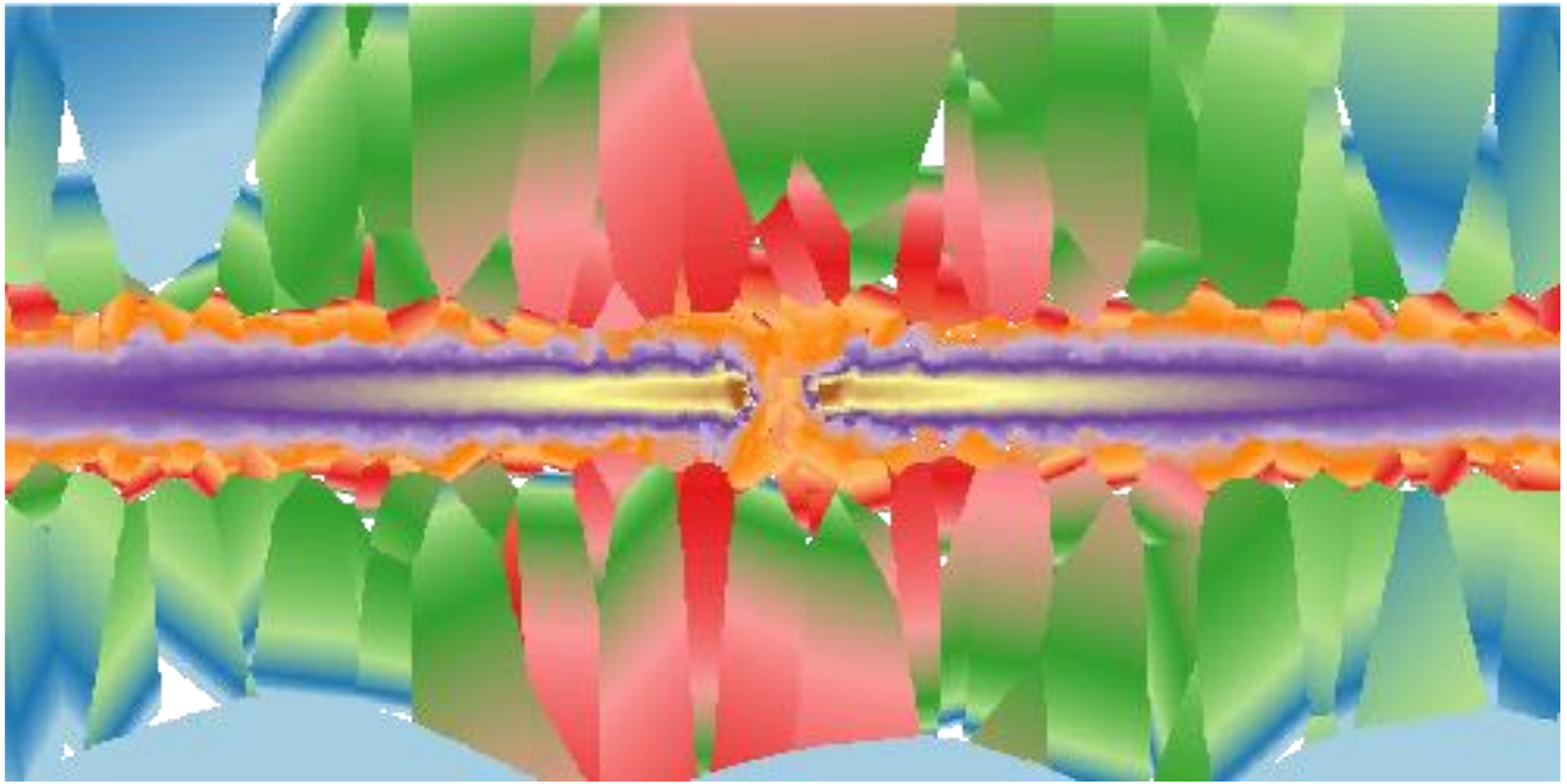




https://en.wikipedia.org/wiki/Voronoi_diagram

➔ Fields (Continuous)

Voronoi Tessellation for Galaxy Evolution Simulation



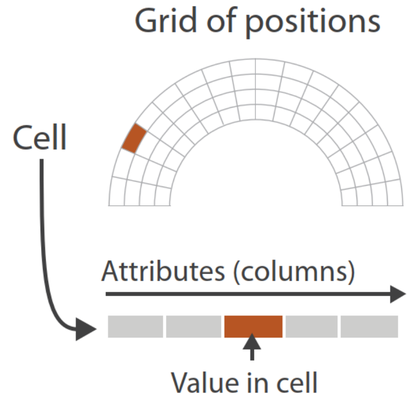
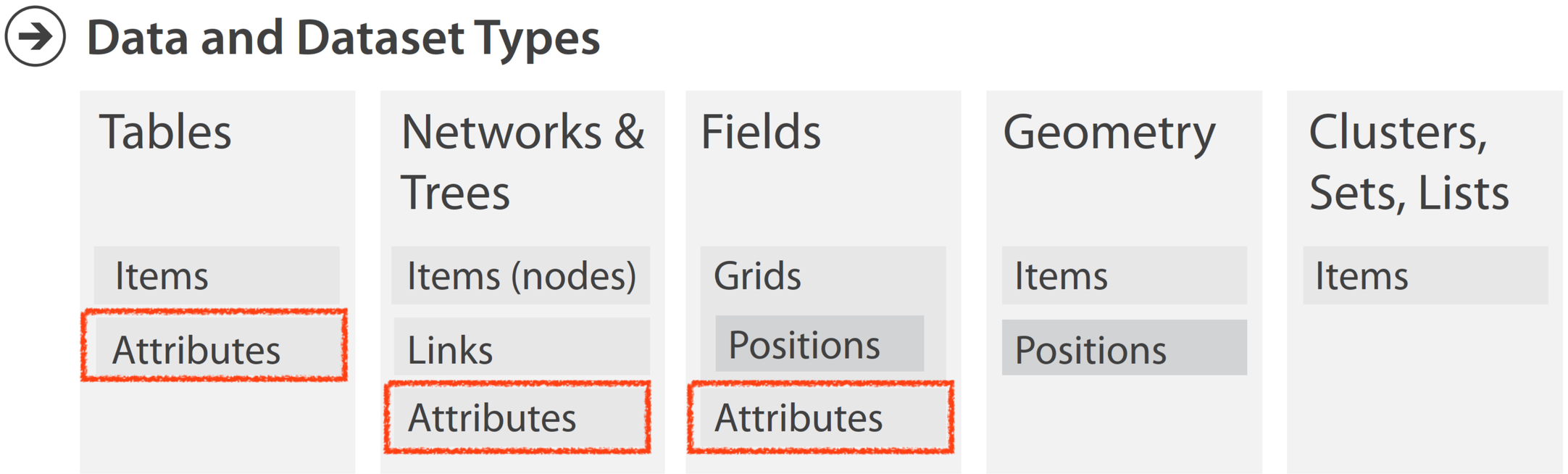


Image courtesy of Patrik Jonsson

Data Types

DATASET = collection of information that is the target of analysis



Attribute Types

➔ Categorical

e.g.,
fruit (apple, pear, grape),
colleges (CAMD, Khoury, COE)

➔ Ordered

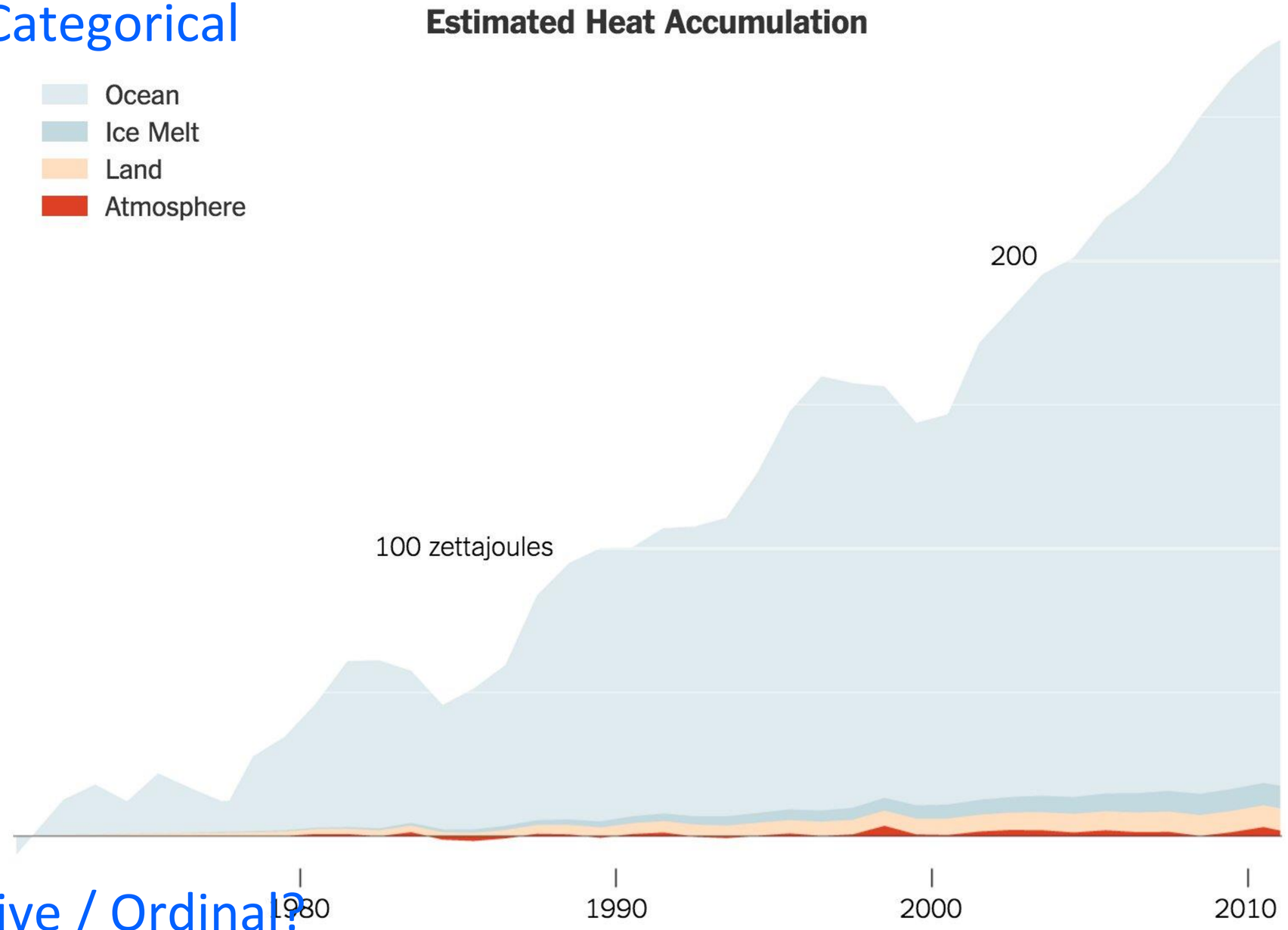
➔ *Ordinal*

e.g.,
sizes (xs, s, m, l, xl),
months (J, F, M)

➔ *Quantitative* *(continuous)*

e.g.,
lengths (1’, 2.5’, 5’),
population

Categorical



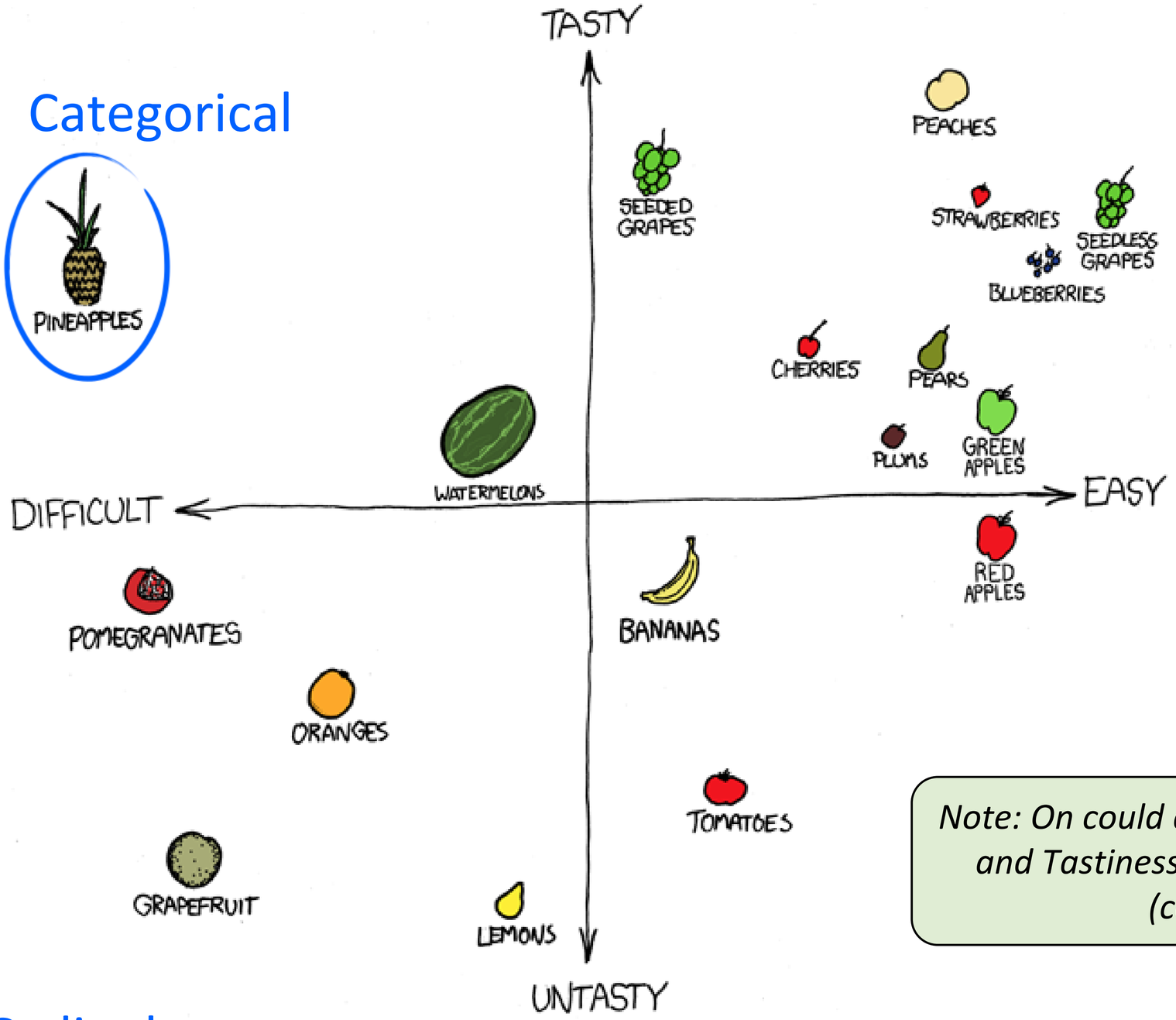
Quantitative

?Quantitative / Ordinal?

http://www.nytimes.com/interactive/2016/09/12/science/earth/ocean-warming-climate-change.html

Categorical

Ordinal



Ordinal

Note: On could also argue that Difficulty and Tastiness could be quantitative (continuous)

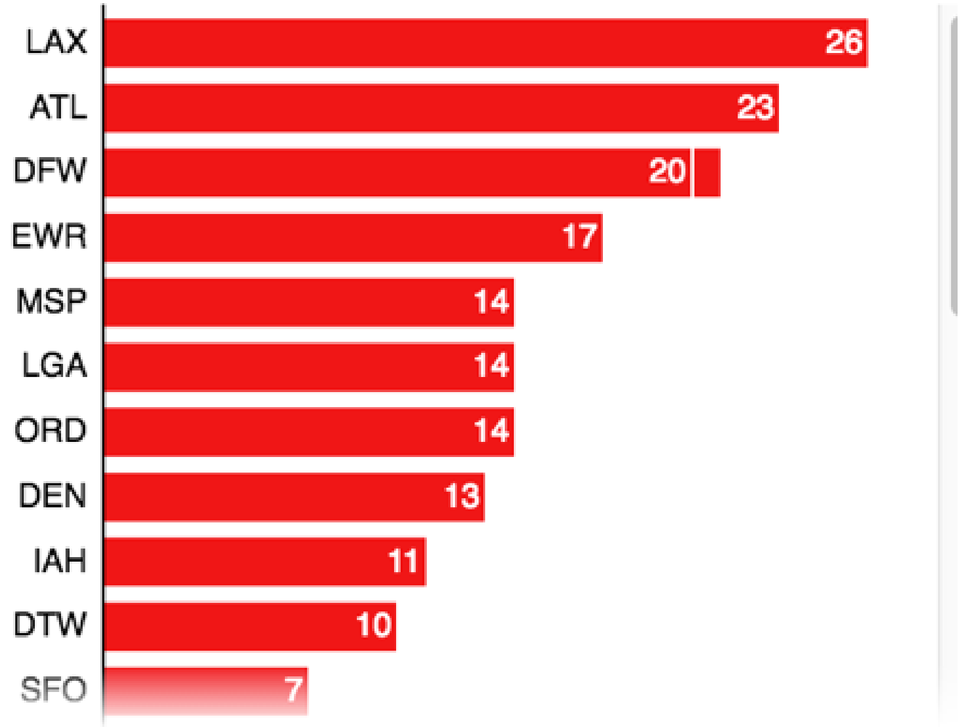
https://xkcd.com/388/

FlightAware MiseryMap
Back to main site

236
DELAYS

1
CANCELLATIONS

between 3 PM and 7 PM (all cancellations today) (all delays today)

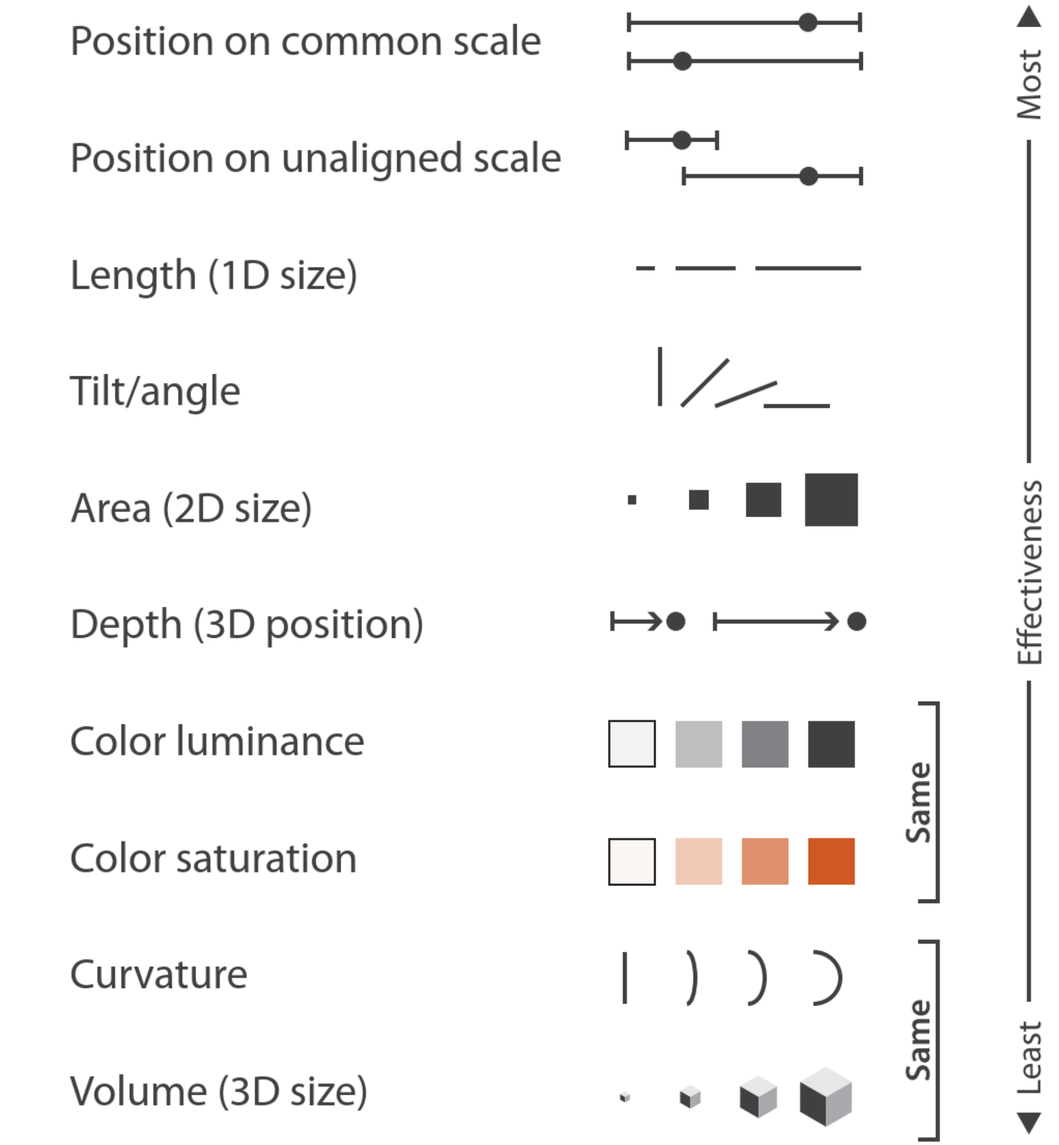


Categorical

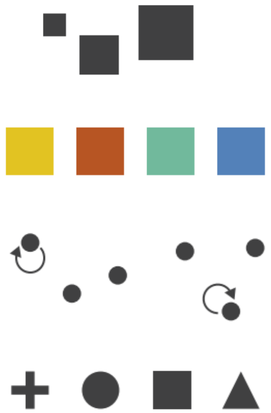
Quantitative

Channels: Expressiveness Types and Effectiveness Ranks

Magnitude Channels: Ordered Attributes



Identity Channels: Categorical Attributes



Channel Ranking by Data Type

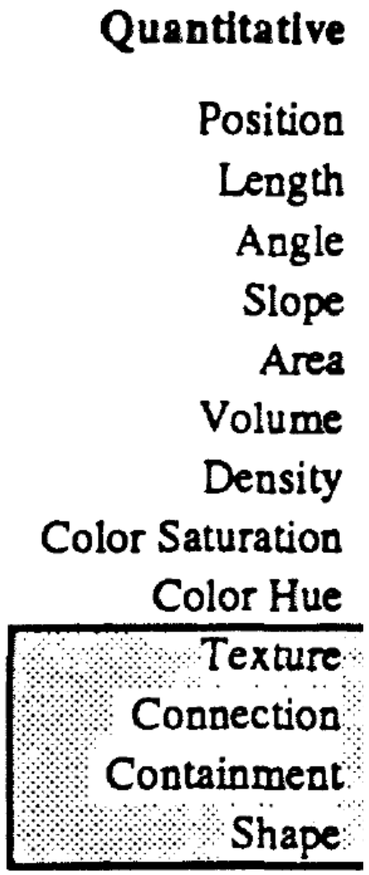
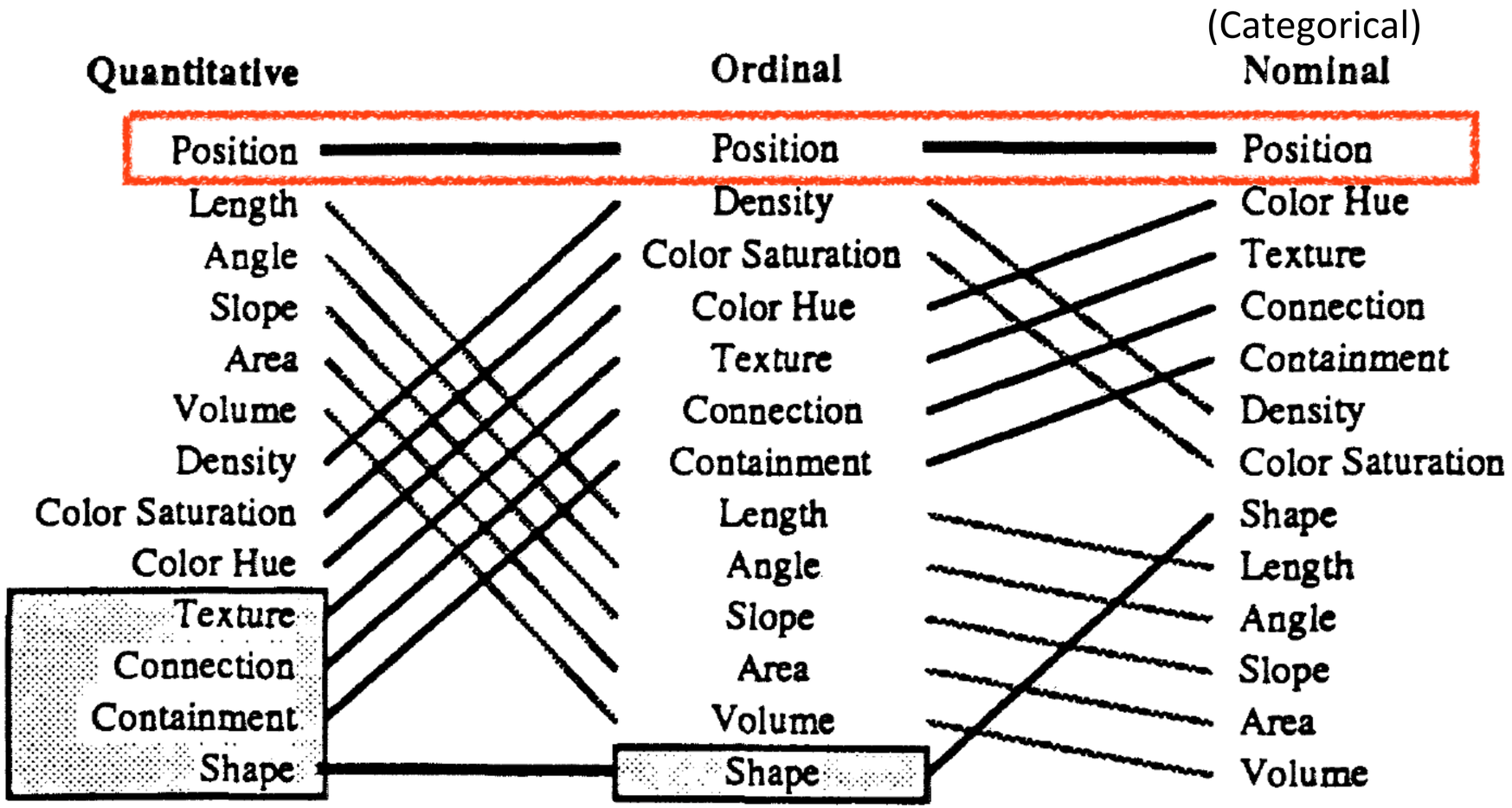


Figure 15: Ranking of Perceptual Tasks. *The tasks shown in the gray boxes are not relevant to that type of data.*

Mackinlay (1986)

Channel Ranking by Data Type



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[Mackinlay (1986)](#)

Channel Ranking by Data Type

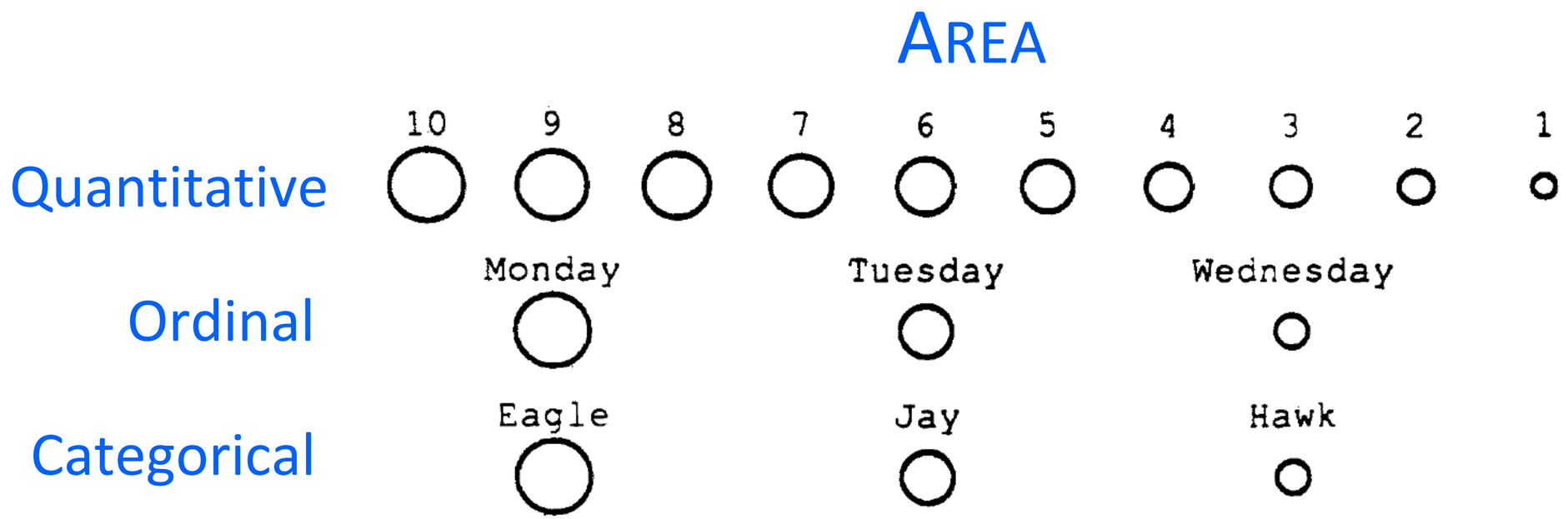


Figure 16: Analysis of the Area Task.

Mackinlay (1986)

Channel Ranking by Data Type

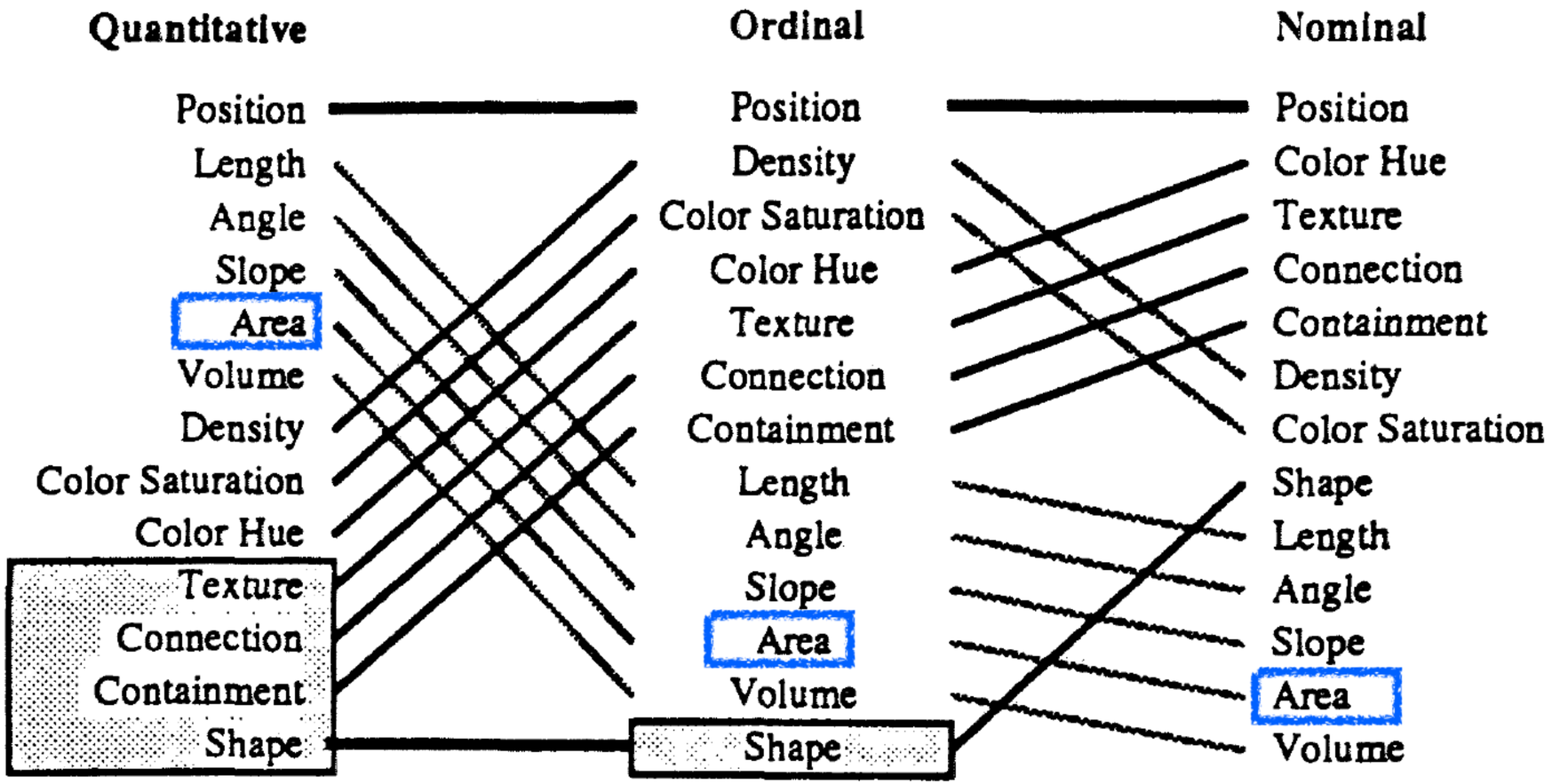


Figure 15: Ranking of Perceptual Tasks. *The tasks shown in the gray boxes are not relevant to that type of data.*

Mackinlay (1986)

Data Abstraction

What?

Datasets

Data Types

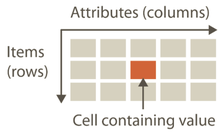
- Items
- Attributes
- Links
- Positions
- Grids

Data and Dataset Types

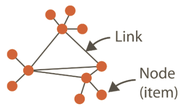
Tables	Networks & Trees	Fields	Geometry	Clusters, Sets, Lists
Items	Items (nodes)	Grids	Items	Items
Attributes	Links	Positions	Positions	
	Attributes	Attributes		

Dataset Types

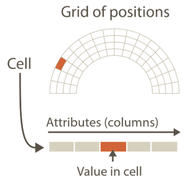
- Tables



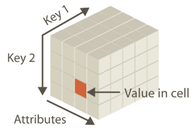
- Networks



- Fields (Continuous)



- *Multidimensional Table*



- *Trees*

- Geometry (Spatial)

Dataset Availability

- Static

- Dynamic

Attributes

Attribute Types

- Categorical

- Ordered
  - *Ordinal*

  - *Quantitative*

Ordering Direction

- Sequential

- Diverging

- Cyclic

Upcoming Assignments & Communication

A look at the upcoming assignments and deadlines

- Textbook, Readings & Reading Quizzes
- 2020-10-20
  Assignment 6 — D3 Event Handling
  Project 3 — Interview & Task Analysis
- 2020-10-26 No Class — Attend IEEE VIS
- 2020-10-27
  ~~Assignment 7a — Critique "Energy Portfolio Analysis"~~
  ~~Assignment 7b — Critique "Color *Theory*“~~
  Project 4 — Data Collection & Exploration, Sketches
- 2020-10-28 No Class — Attend IEEE VIS
- 2020-10-30
  !New! Assignment 7 — IEEE VIS Session Critiques
- 2020-11-03
  Assignment 8 — Brushing and Linking in D3

https://c.dunne.dev/ds4200f20

Everyday Required Supplies:

- 5+ colors of pen/pencil
- White paper
- Laptop and charger

Use **Canvas Discussions** for general questions,
email the **instructor & TAs** for questions **specific to you**.