Arranging space - I

Visualization
Sebastian Ratzenböck

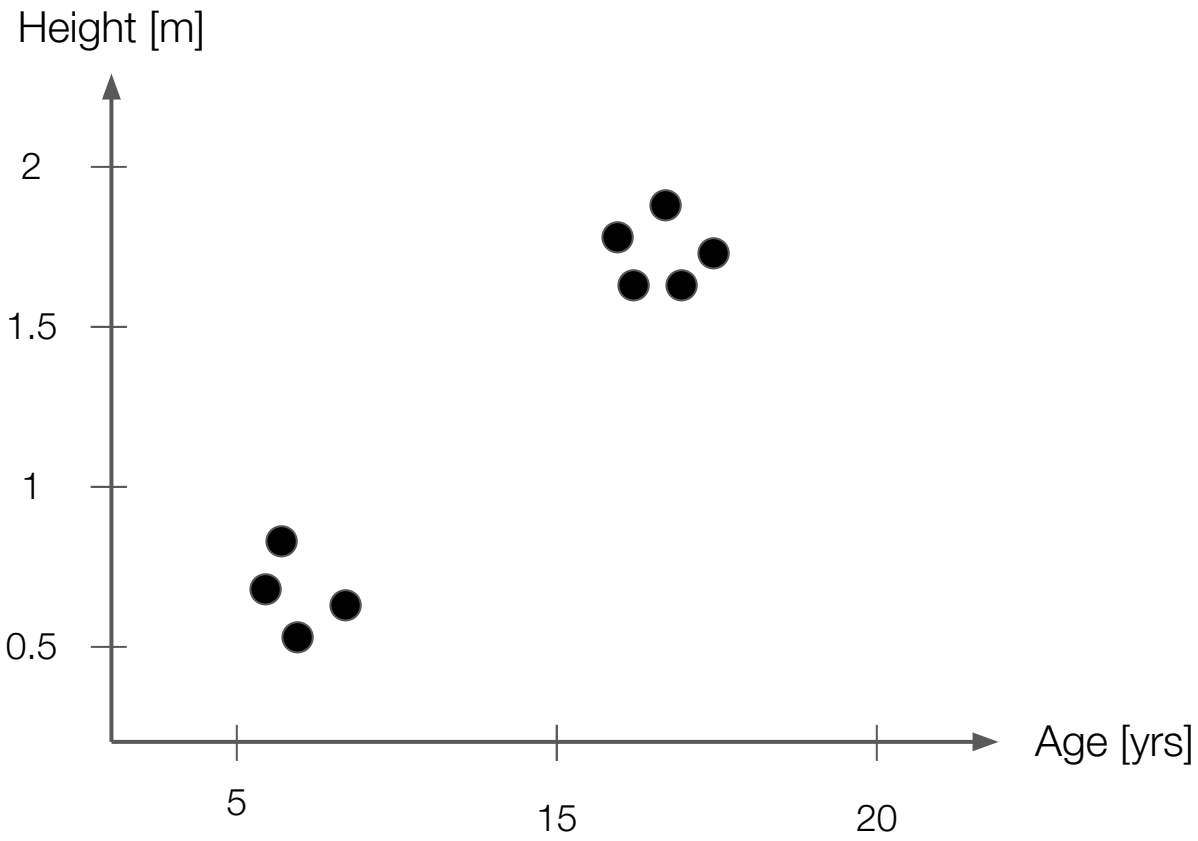
What do we mean by arranging space?

- Spatial channels for visual encoding
- Most effective encoding choice ↔ tied to effectiveness principle

Effectiveness principle

The most important attributes should be encoded with the most effective channels in order to be most noticeable.

What do we mean by arranging space?



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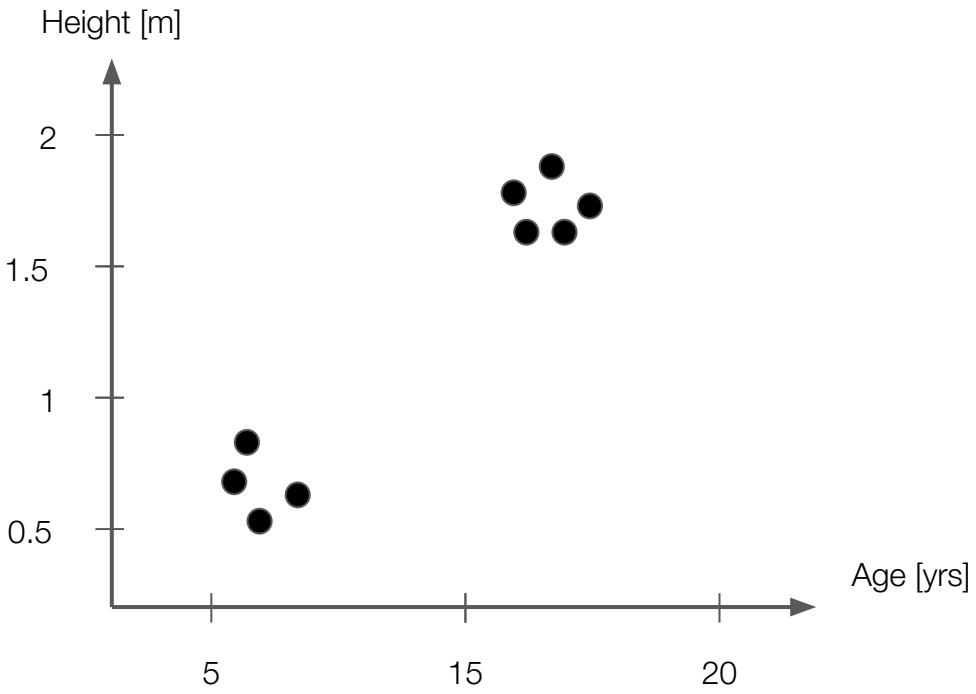
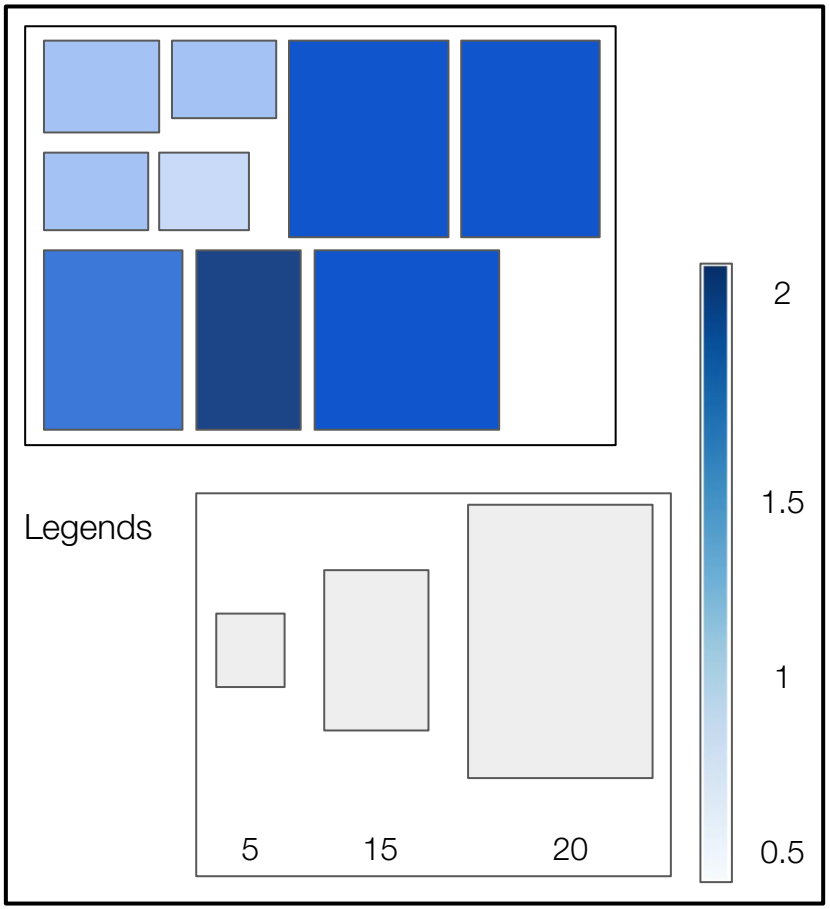




What do we mean by arranging space?

- Spatial channels for visual encoding
- Most effective encoding choice ↔ tied to **effectiveness principle**
- Spatial channel dominates the users mental model of the data set.

Readings

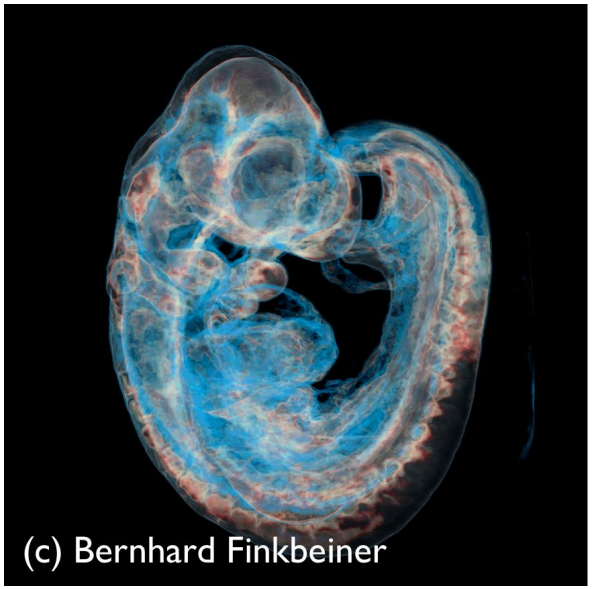
- Munzner, “Visualization Analysis and Design”:
  - Chapter 7 (Arrange Tables)
  - Chapter 8 (Arrange Spatial Data)

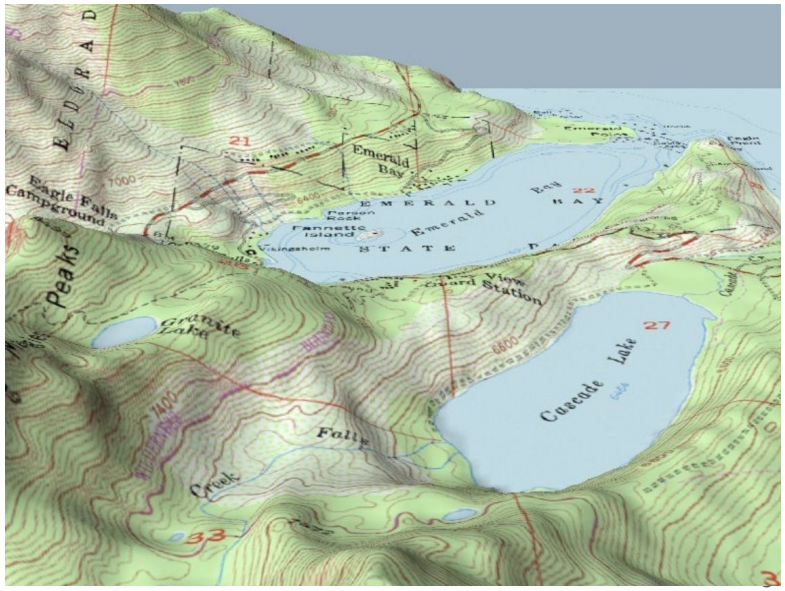
Overview

- Spatial attributes / keys
- quantitative vs. categorical attributes
- Keys: the importance of ordering
  - list (1D) vs. matrix (2D) vs. partition / subdivide
  - (multiple D)
- Spatial layout
  - Rectilinear
  - Parallel
  - Radial
- Spacefilling

Spatial attributes

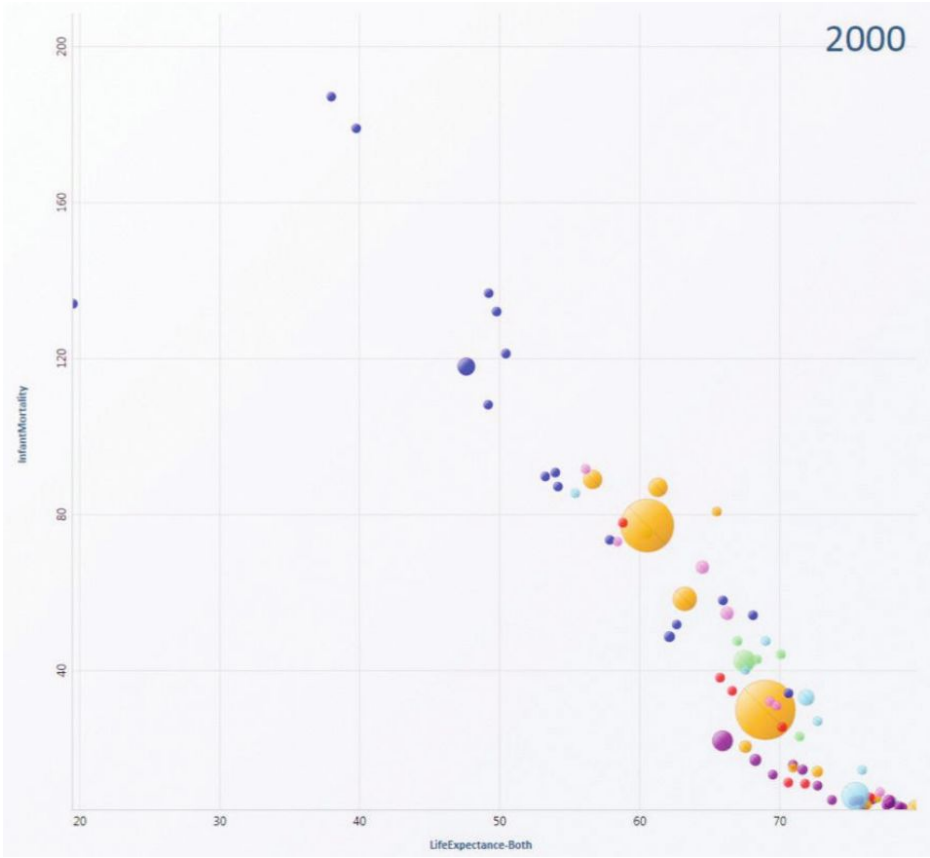
- 1D - line graphs
- 2D - cartographic views
- 3D - volumes
- scalar vs. vector vs. tensor data





Quantitative vs. categorical

- quantitative: express 
  - e.g. dot plot, scatterplot



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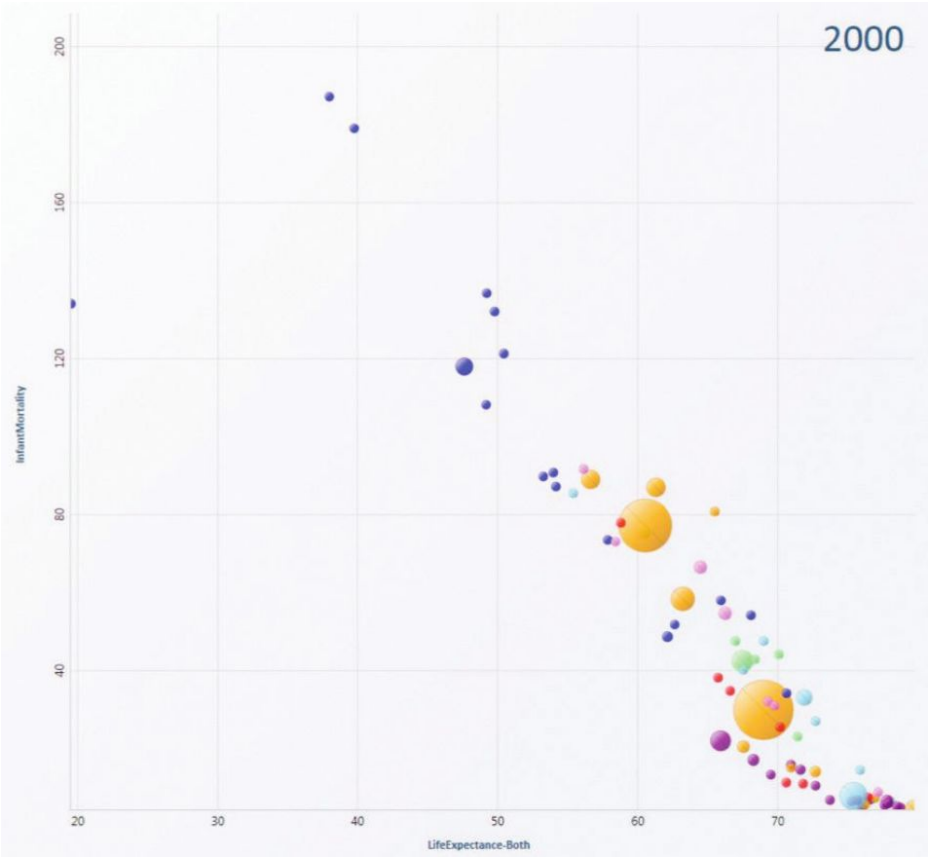
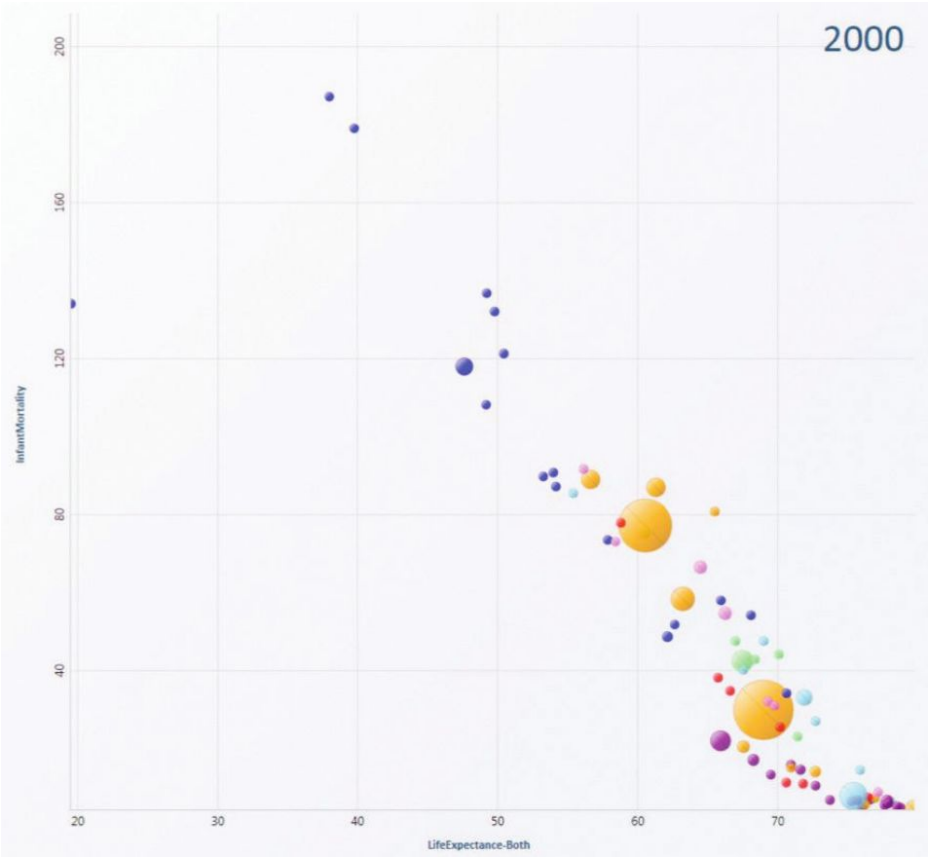


How does the **effectiveness principle** apply here?

Quantitative vs. categorical

- quantitative: express 
  - e.g. dot plot, scatterplot



Attributes

- Life expectancy
- Infant mortality
- Country size
- Continent

Quantitative vs. categorical

- Encoding categorical attributes like quantitative ones forces order that does not exist!

↳ violates principle of expressiveness

Principle of expressiveness

The visual encoding should express all of, and only, the information in the dataset attributes.

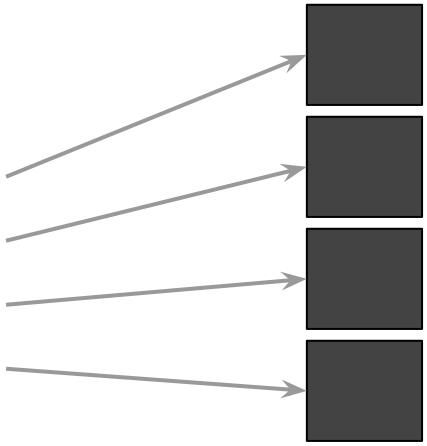
Quantitative vs. categorical

- quantitative: express 
  - e.g. dot plot, scatterplot
- Categorical
  - separate 2D space into regions
  - order along an axis
  - align along an axis

Separate 2D space into regions

- Regions: bounded areas distinct from another
- Draw all items with same value into one region

	A	B
1	Name	Age
2	Kevin	15
3	Lucy	24
4	Marc	11
5	Maria	13



➔ Separate

Quantitative vs. categorical

- Categorical
  - separate 2D space into regions
  - order along an axis
  - align along an axis

1D keys

- 1 key - 1 value → one region per key-value pair

	A	B
1	Name	Age
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→ 

→ Arrange region into 1D list alignment

1D keys

- 1 key - 1 value → one region per key-value pair

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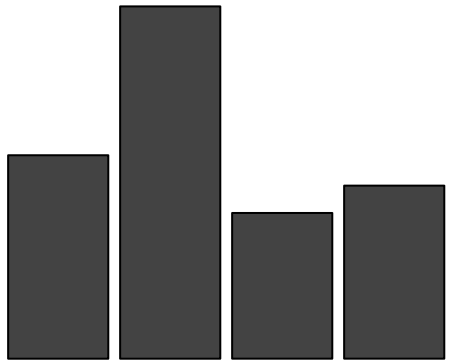
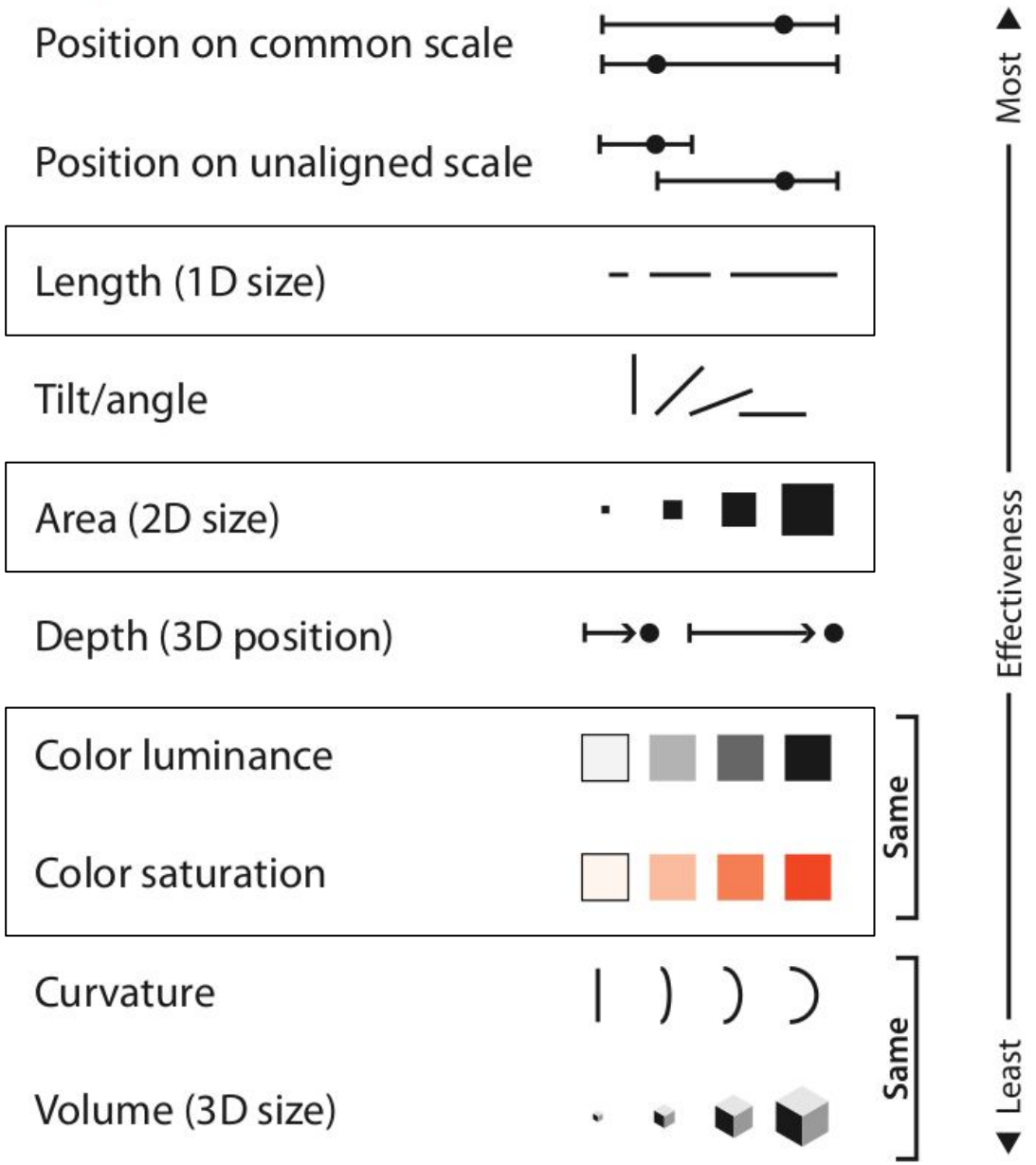
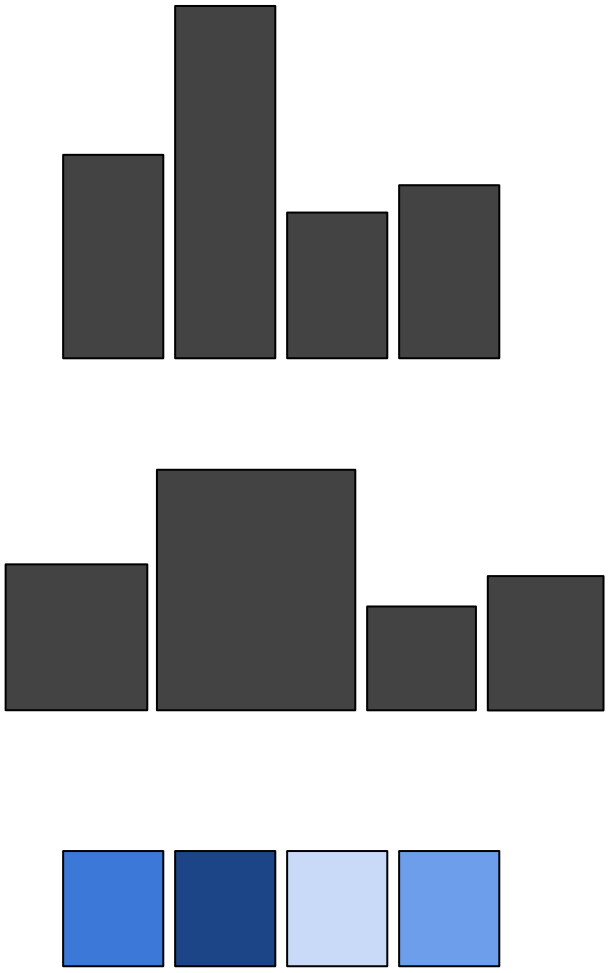
→ 

→ Arrange region into 1D list alignment

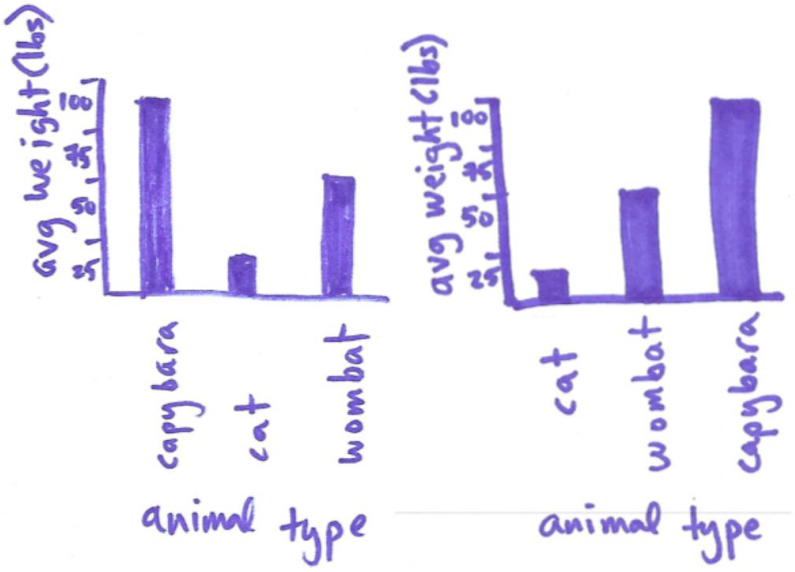
Magnitude Channels: Ordered Attributes





1D keys

- categorical: bar charts
  - aligned / ordered

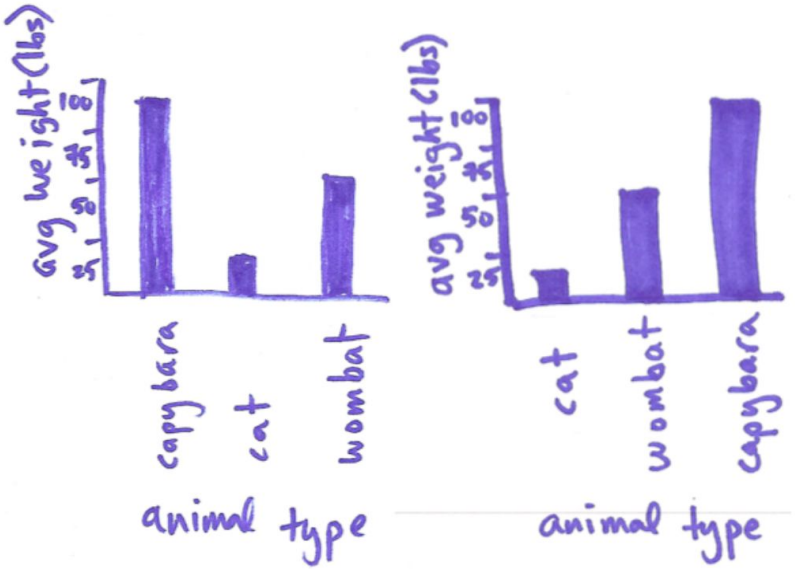


Bar chart
Line marks
Length channel

? ?

1D keys

- categorical: bar charts
  - aligned / ordered

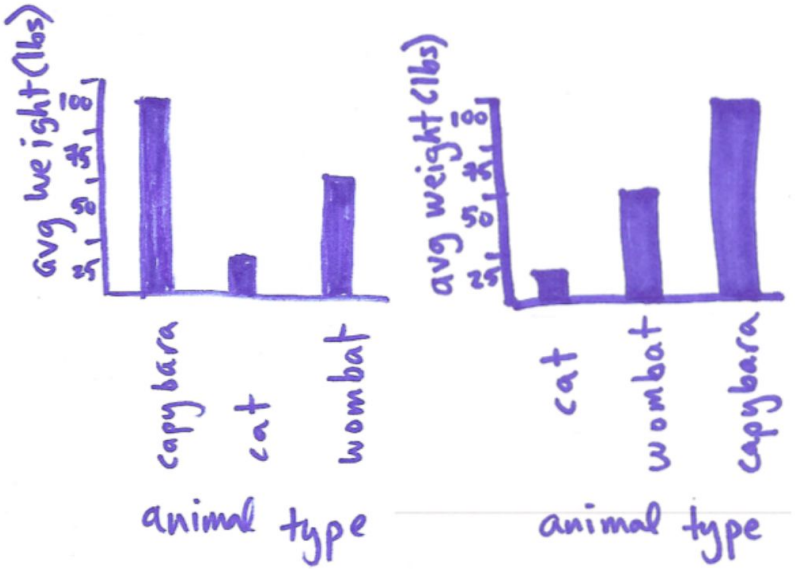


Lookup value

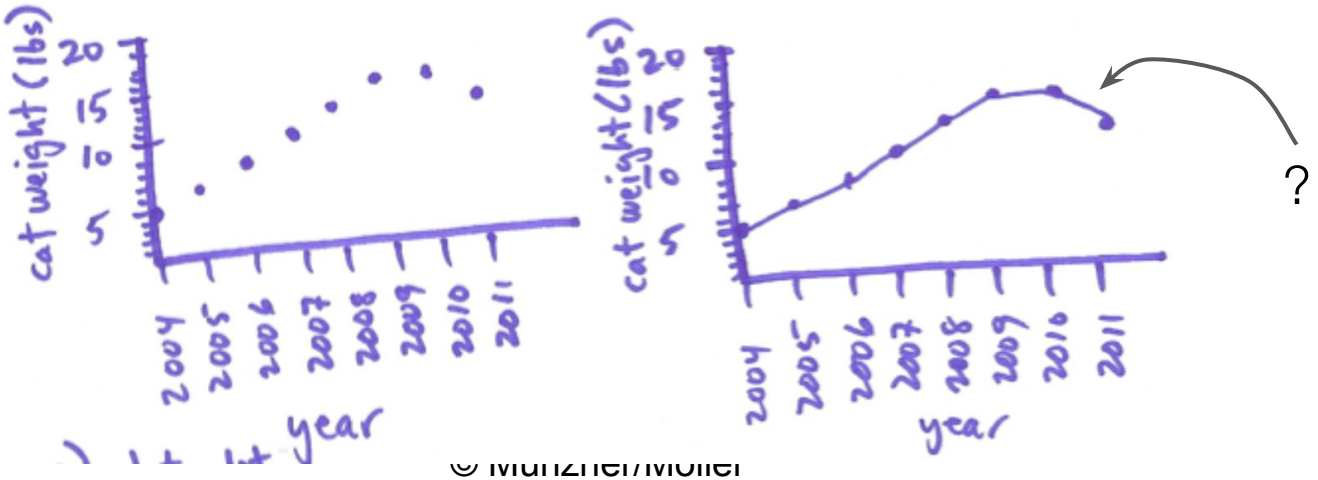
Spot trends

1D keys

- categorical: bar charts
  - aligned / ordered



- quantitative/ ordered: dot plot / line chart



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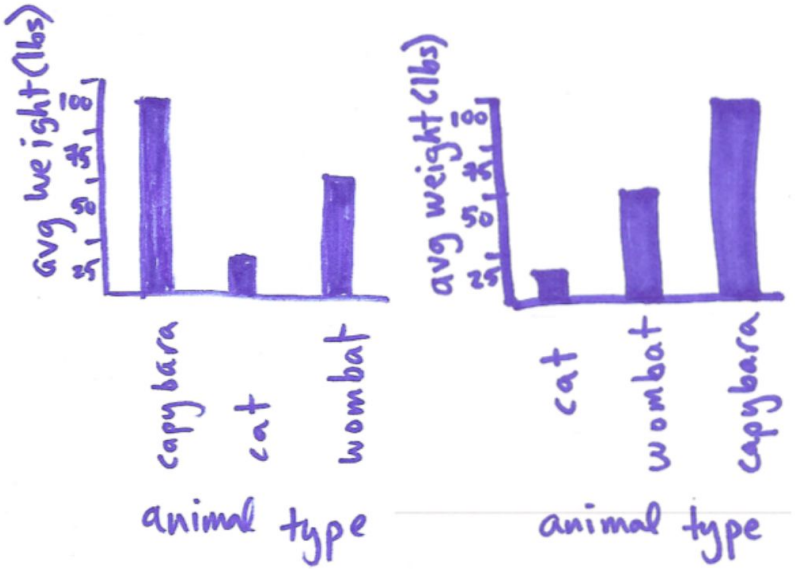

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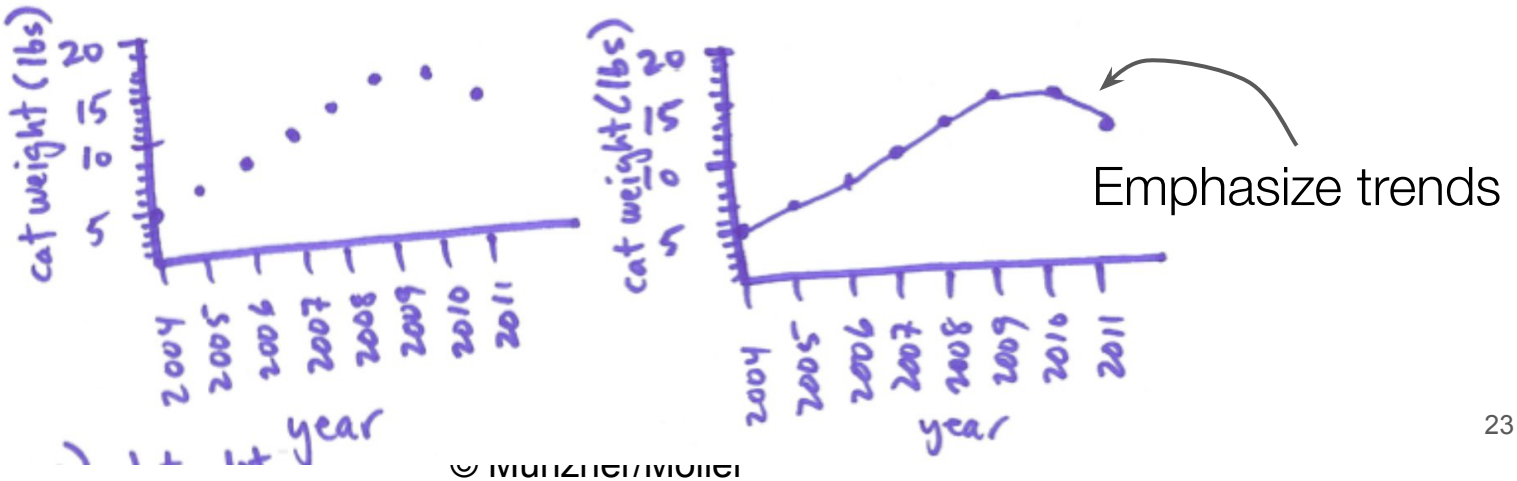
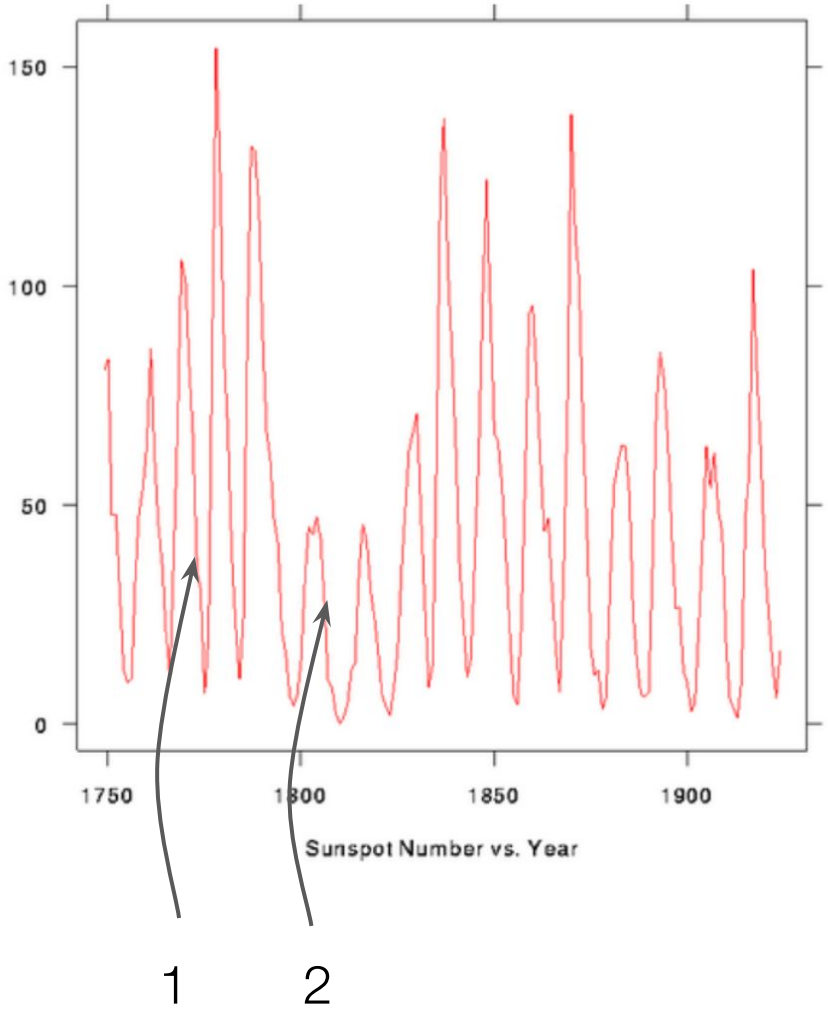


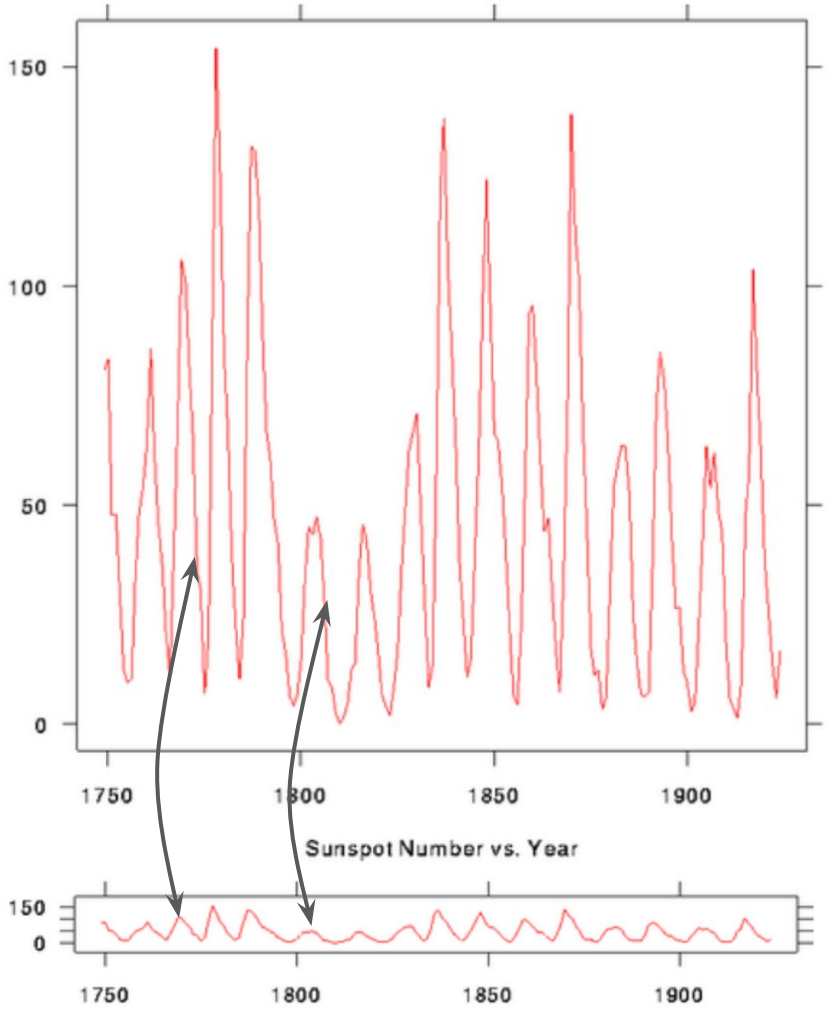
Line plots: aspect ratio

- Aspect ratio is important
- Which of these two lines is steeper, 1 or 2?



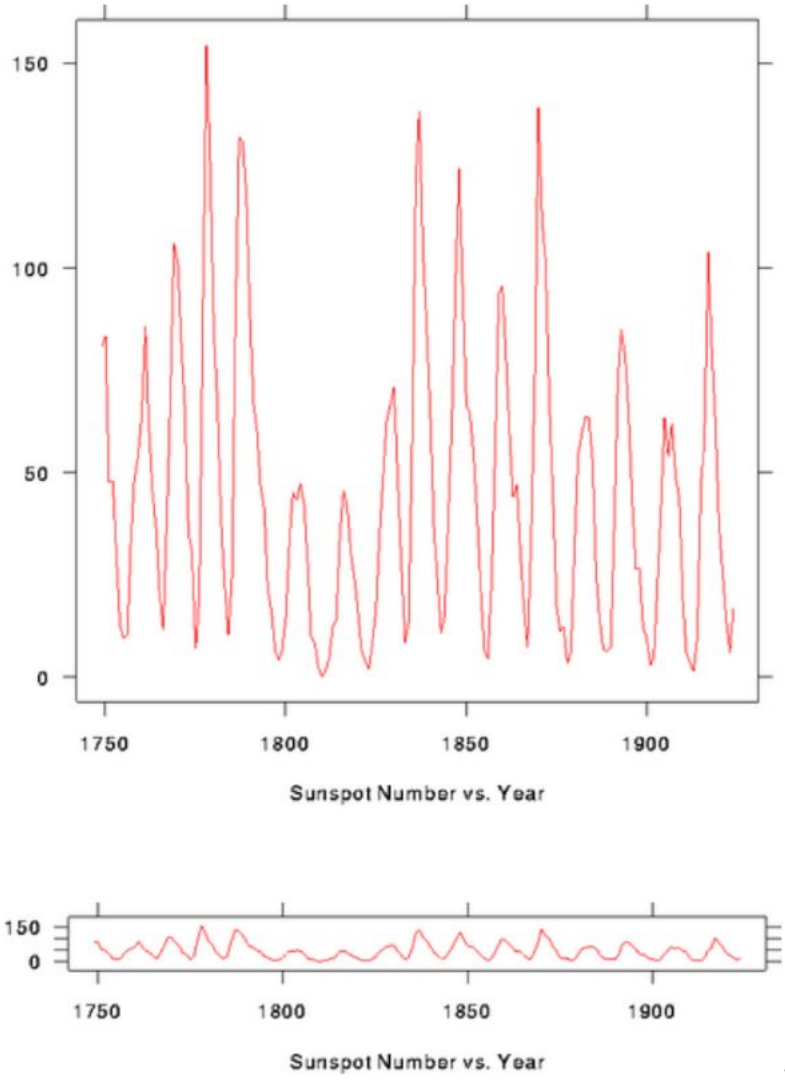
Line plots: aspect ratio

- Aspect ratio is important
- Which of these two lines is steeper, 1 or 2?
- Did the aspect ratio influence the task?



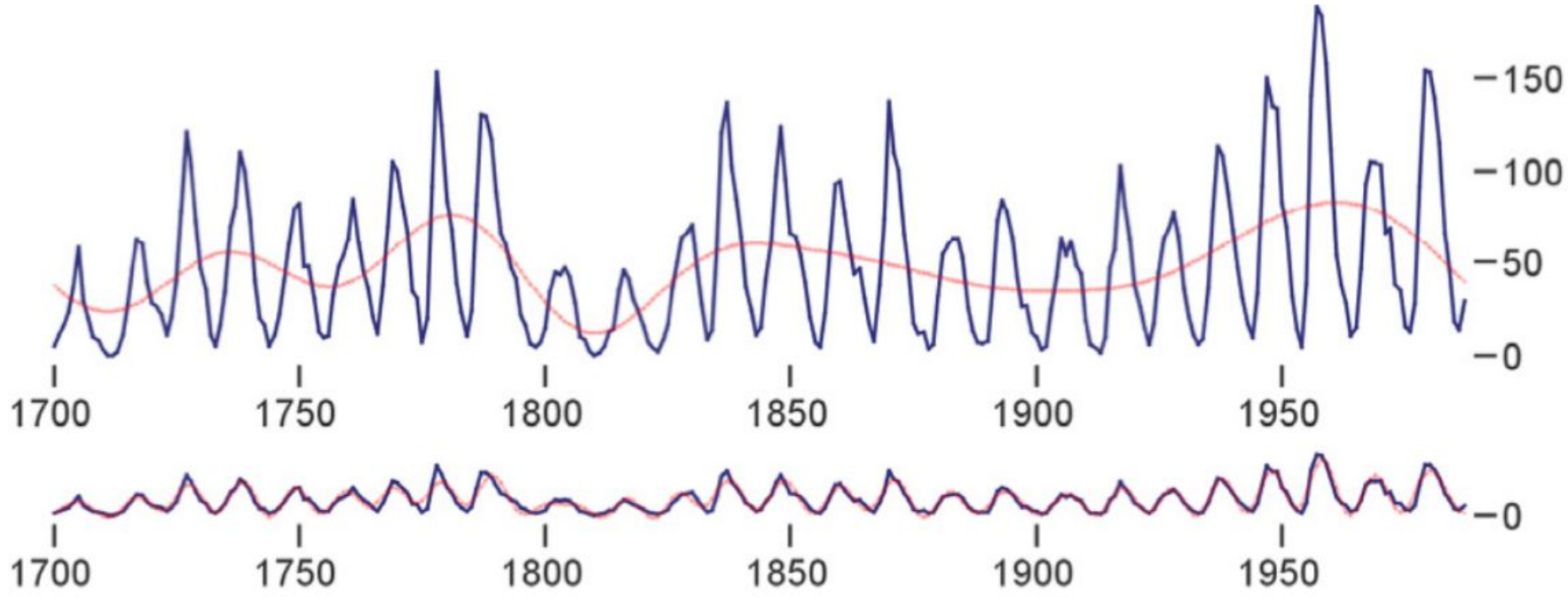
Banking to 45 degrees

- Perceptual principle:
  - Most accurate angle judgement at 45°
- Maximize the number of line segments that fall close to 45°
  → adjust aspect ratio accordingly



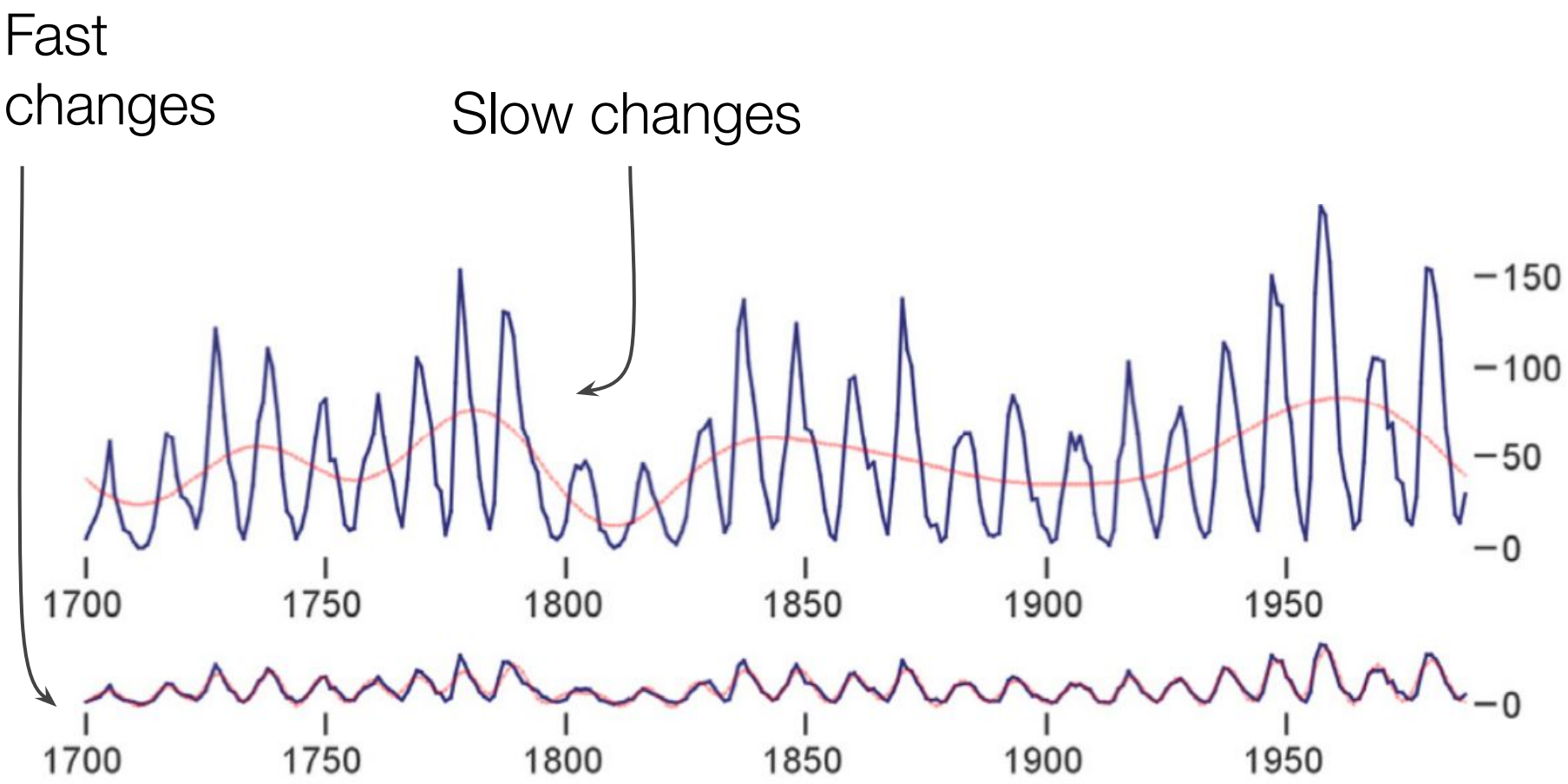
Banking to 45 degrees

What is the difference between the two ARs?



Multi-Scale Banking to 45 Degrees. Heer and Agrawala, Proc InfoVis 2006 vis.berkeley.edu/papers/banking

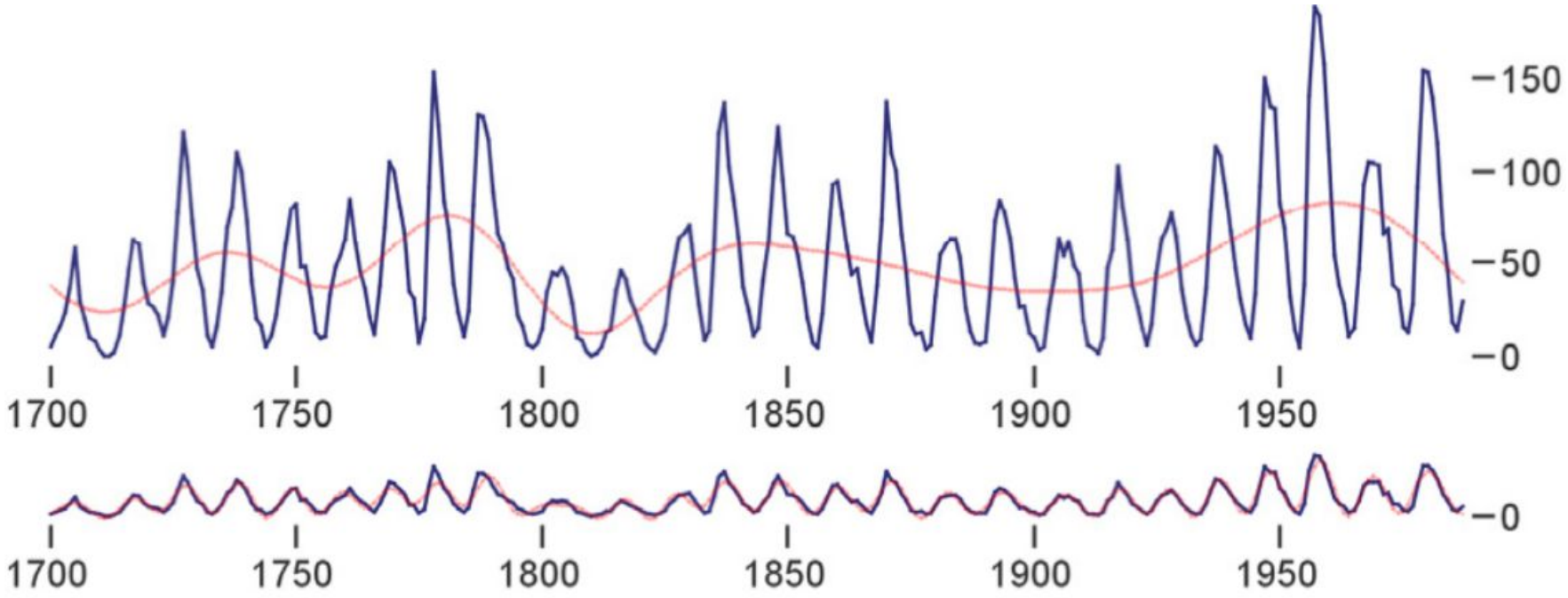
Banking to 45 degrees



Multi-Scale Banking to 45 Degrees. Heer and Agrawala, Proc InfoVis 2006 vis.berkeley.edu/papers/banking

Banking to 45 degrees

- frequency analysis → find dominant frequencies
- Each frequency corresponds to aspect ratio
- AR = 3.96 vs. AR = 22.35



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Quantitative vs. categorical

- Encoding categorical attributes like quantitative ones forces order that does not exist!*

↳ violates principle of expressiveness

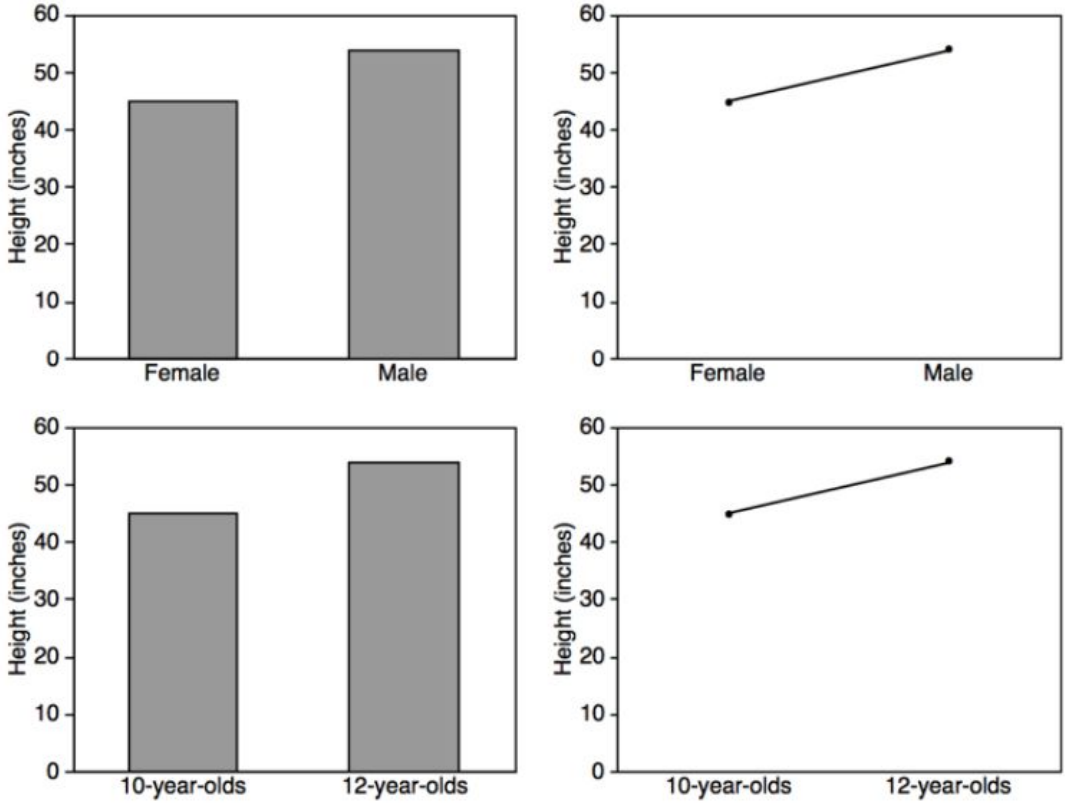
Principle of expressiveness

The visual encoding should express all of, and only, the information in the dataset attributes.

* This implication is in fact so strong that it can override common knowledge.

Bar vs. line charts

- line implies trend, not appropriate for categorical data



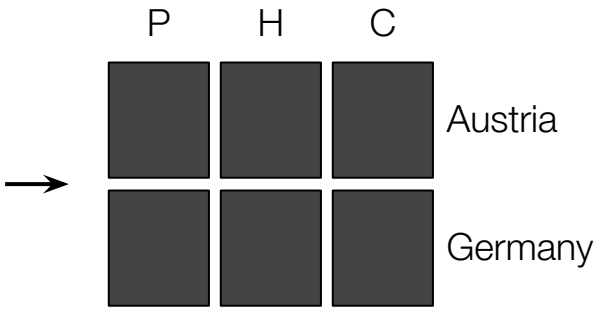
Zacks and Tversky. Bars and Lines: A Study of Graphic Communication. Memory and Cognition 27(6):1073-1079, 1999.

2D keys

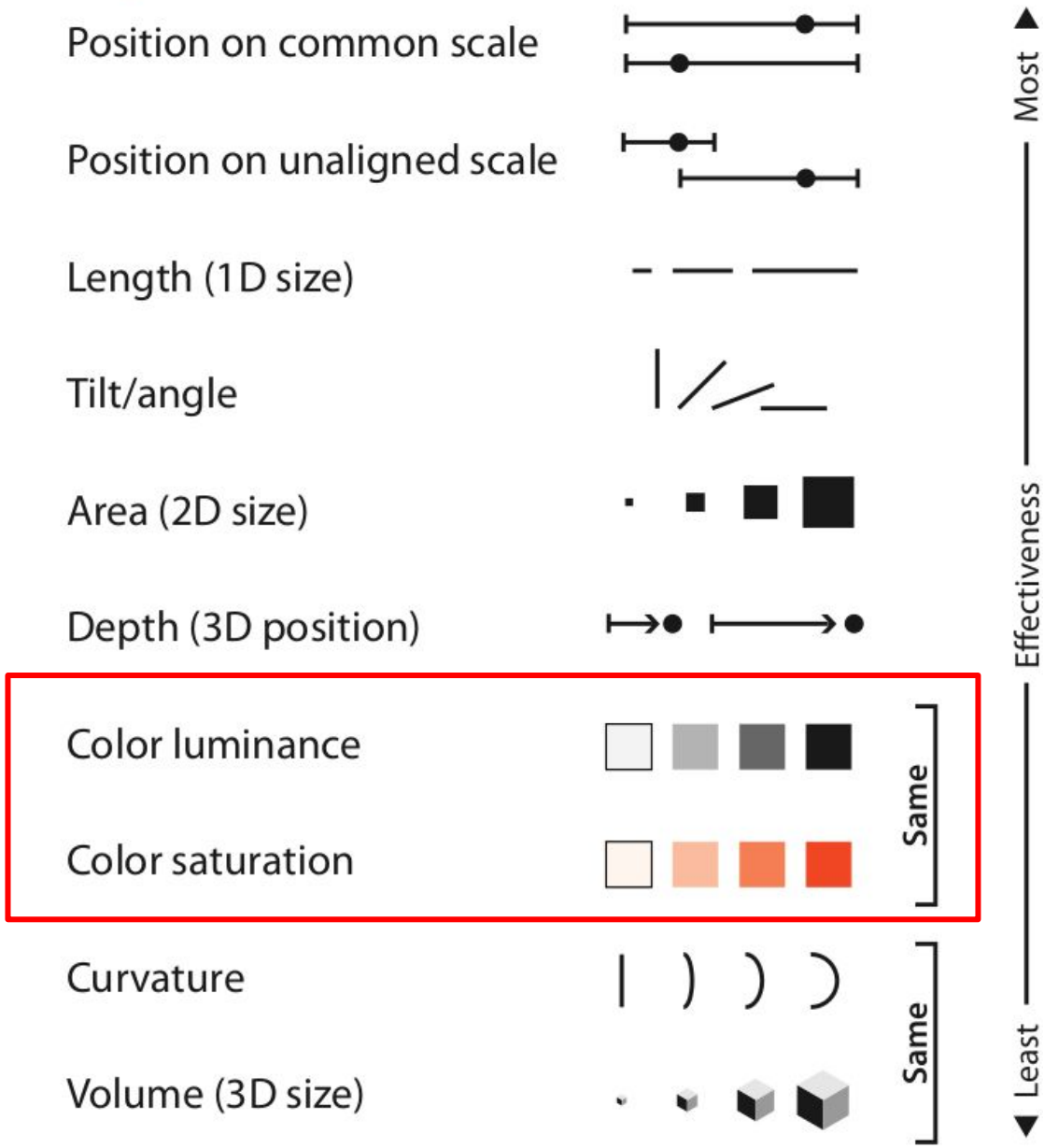
2D keys

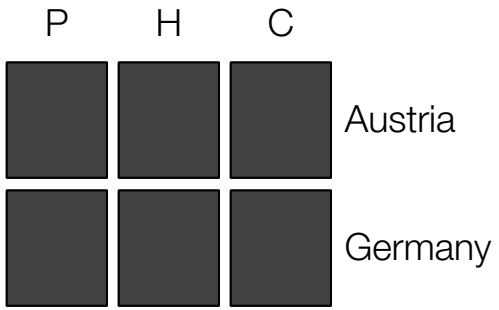
- 2 keys - 1 value → 2D matrix alignment

Country	Education level	Percentage
Austria	Primary school	99
Austria	High school	60
Austria	College	20
Germany	Primary school	98
Germany	High school	65
Germany	College	25



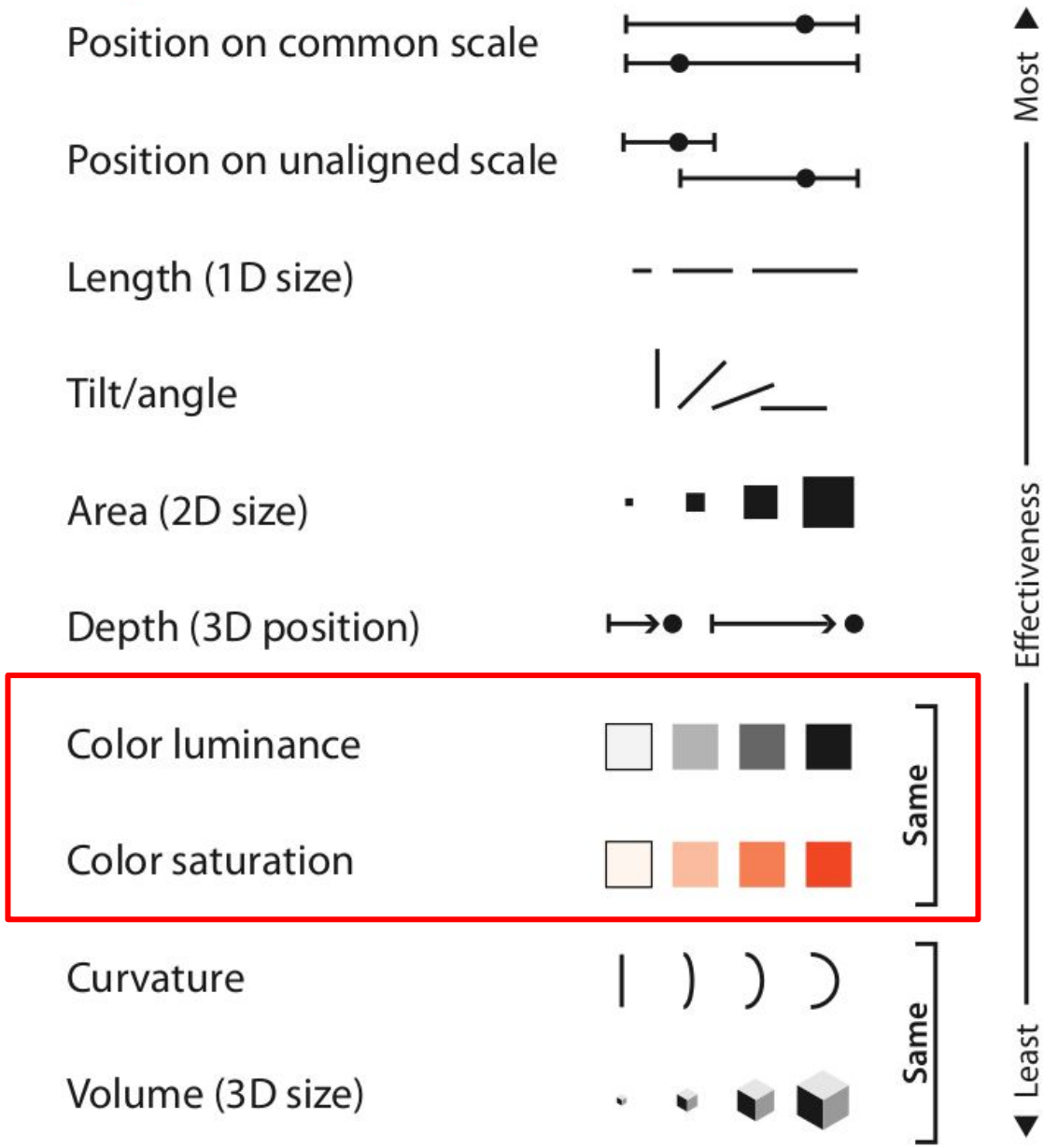
Magnitude Channels: Ordered Attributes

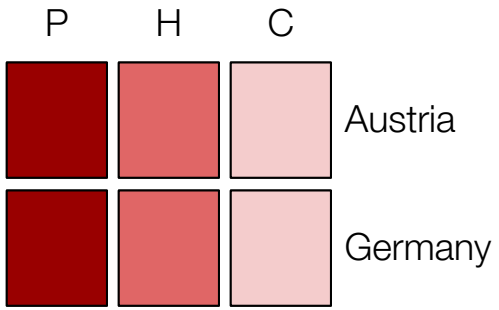




→ Heatmap

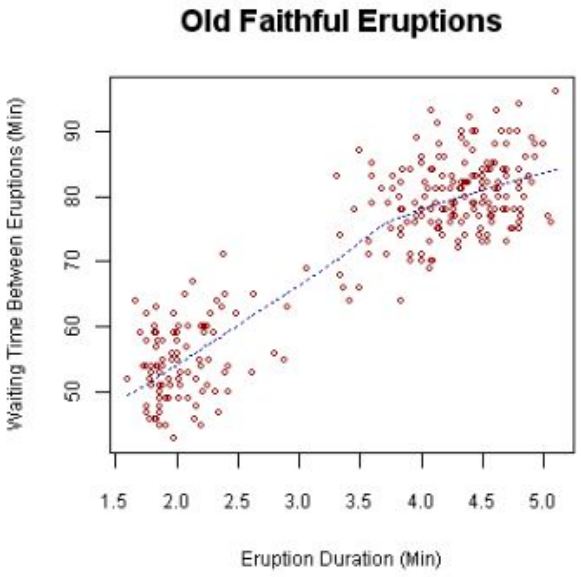
Magnitude Channels: Ordered Attributes

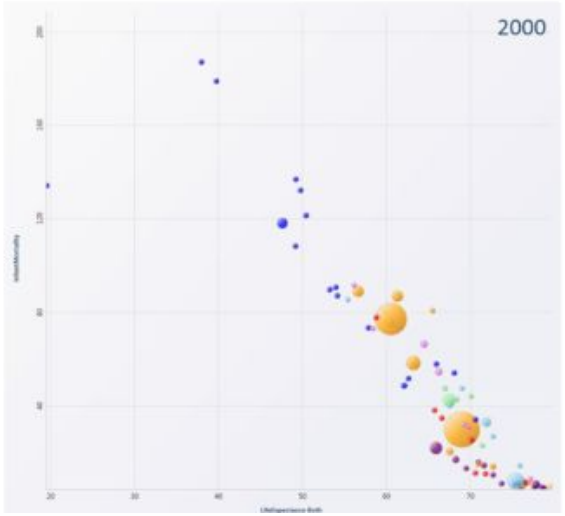




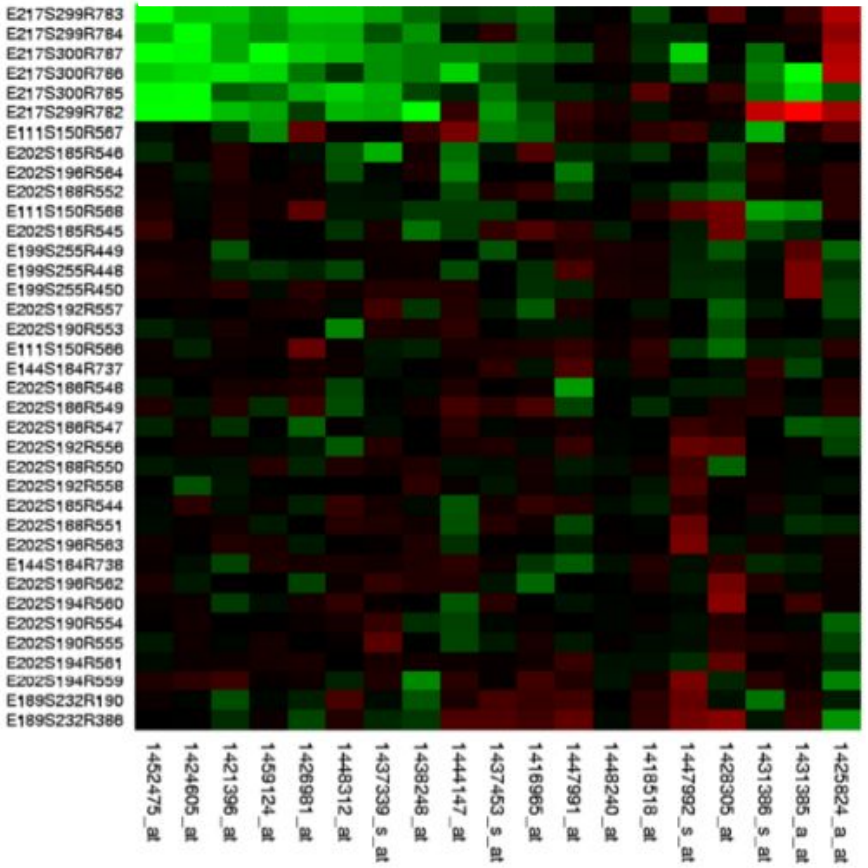
→ Heatmap

2D keys examples: tasks, size

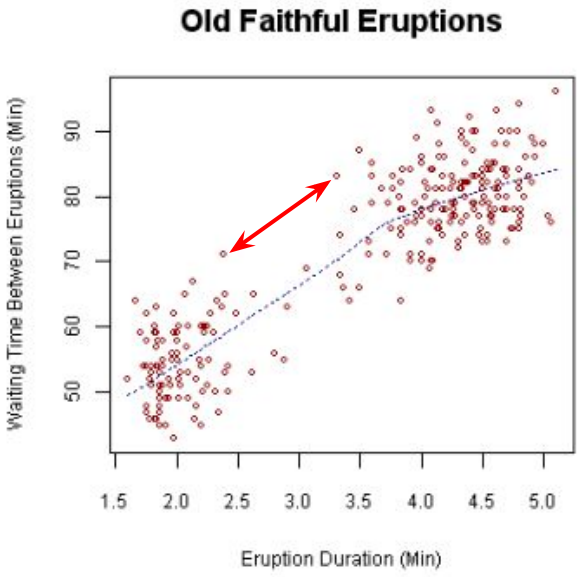


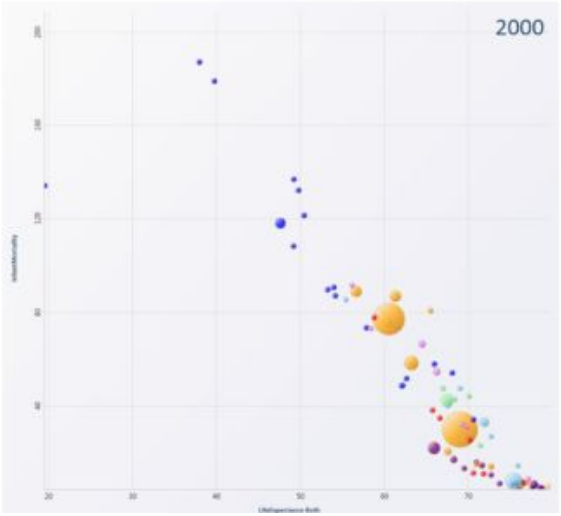


Heatmap

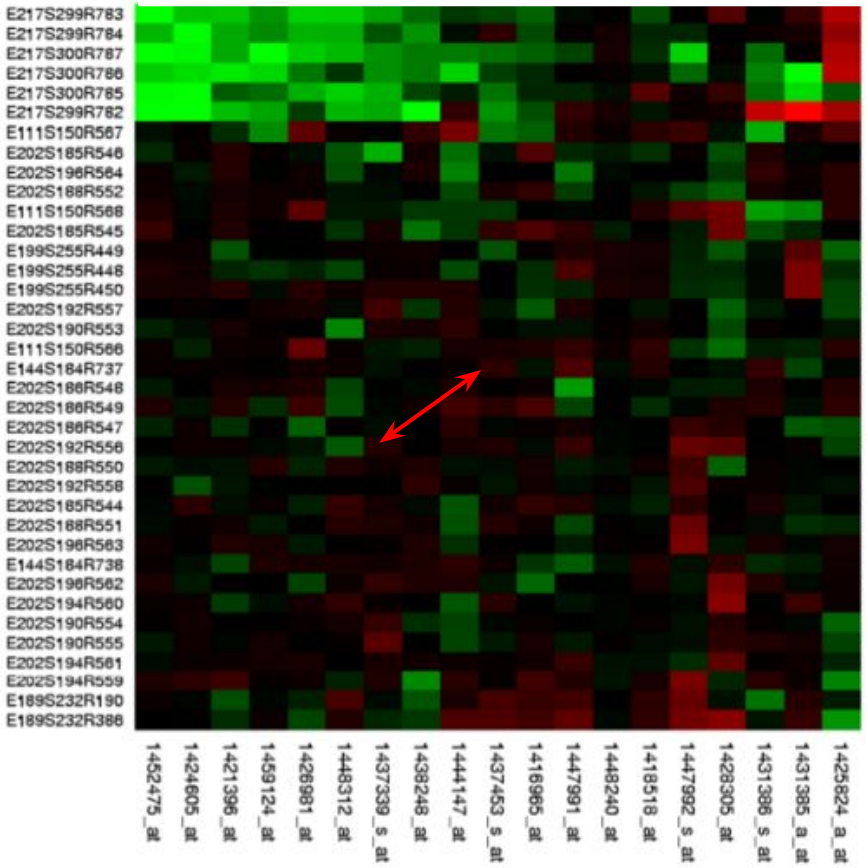


Meaning of distances



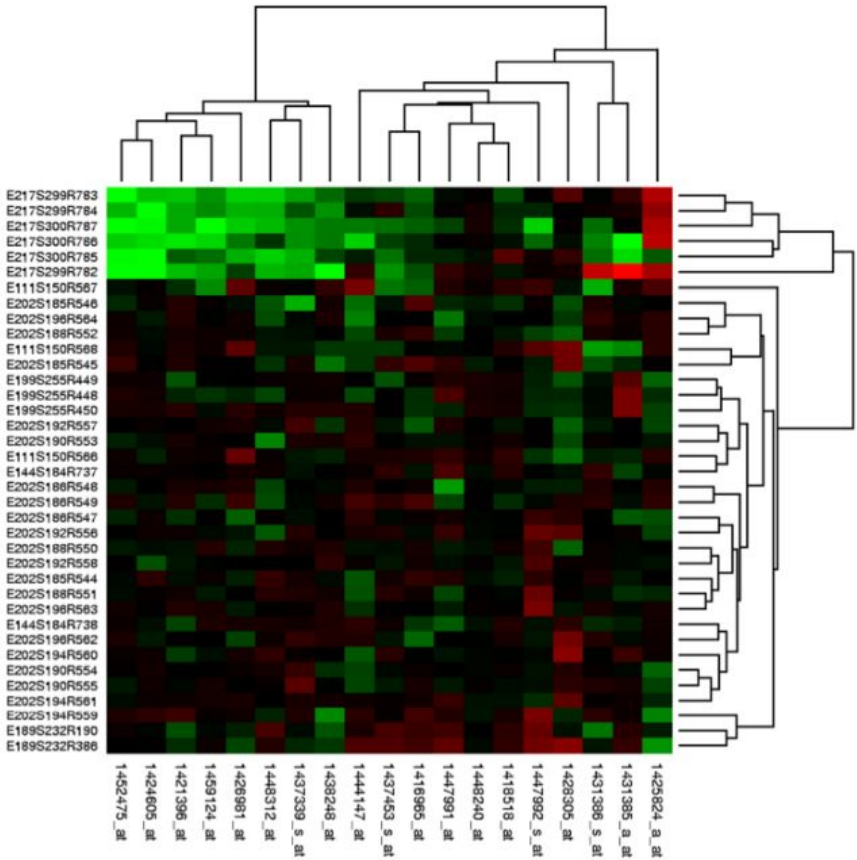


Heatmap



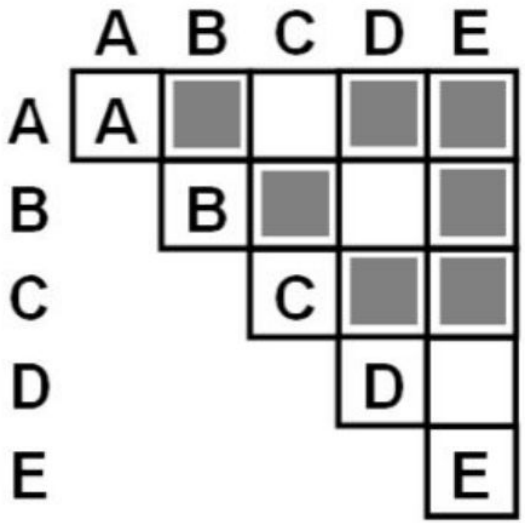
Heatmaps

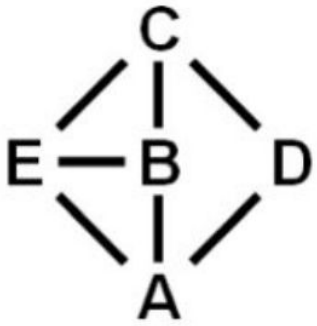
- Very compact
  - Limit: area mark=pixel
  - Good data overview
- Find structure in data
  - Outliers, clusters, etc.
  - Needs sorted rows & columns
    → cluster heatmap



2D keys - network matrix

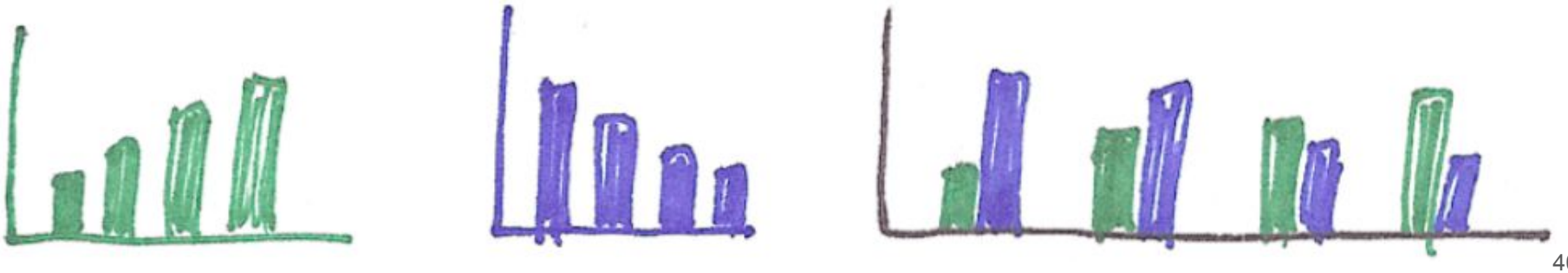
- Value attribute: link exists yes/no
- Weighted networks: e.g. color coding
- Undirected networks: half matrix
- Directed networks: full matrix
- Avoids hairball effect



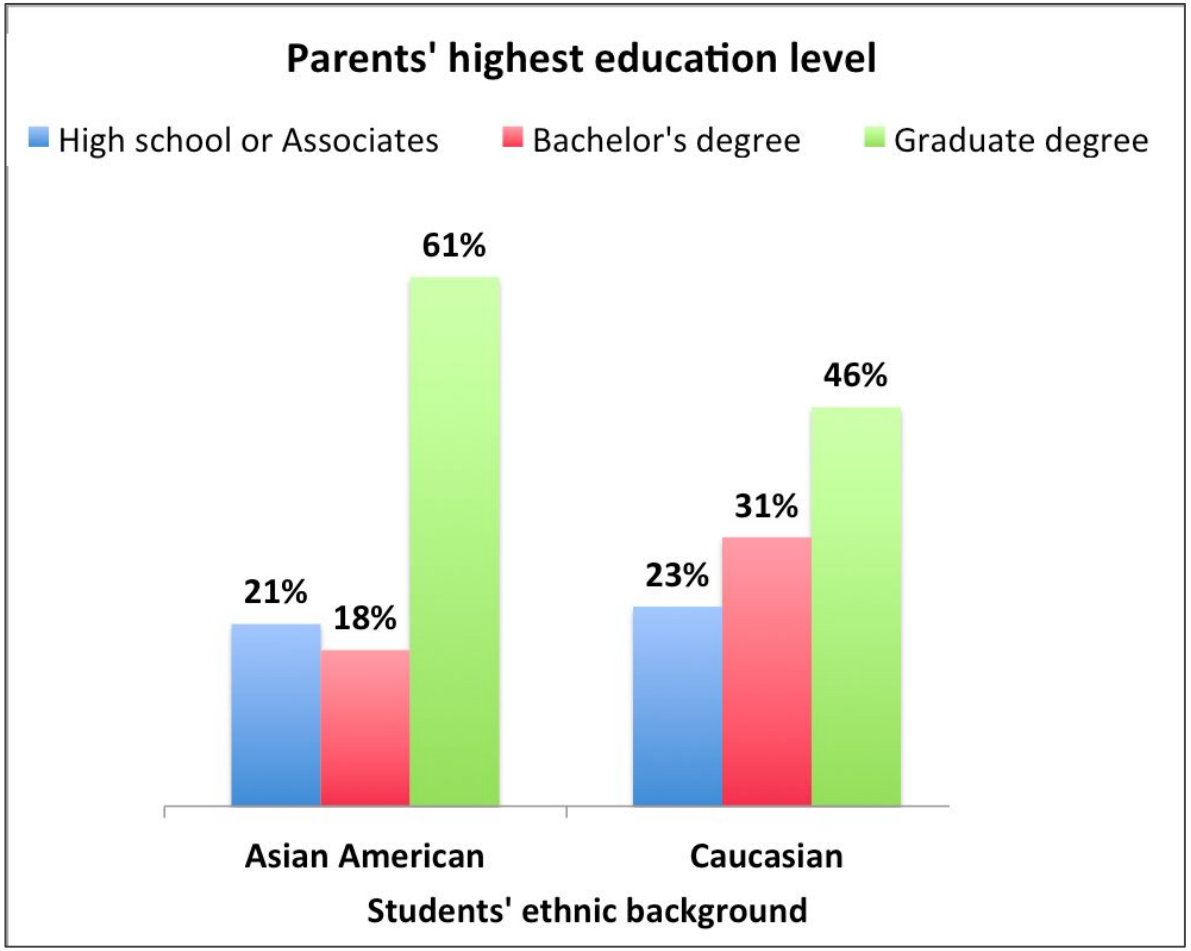


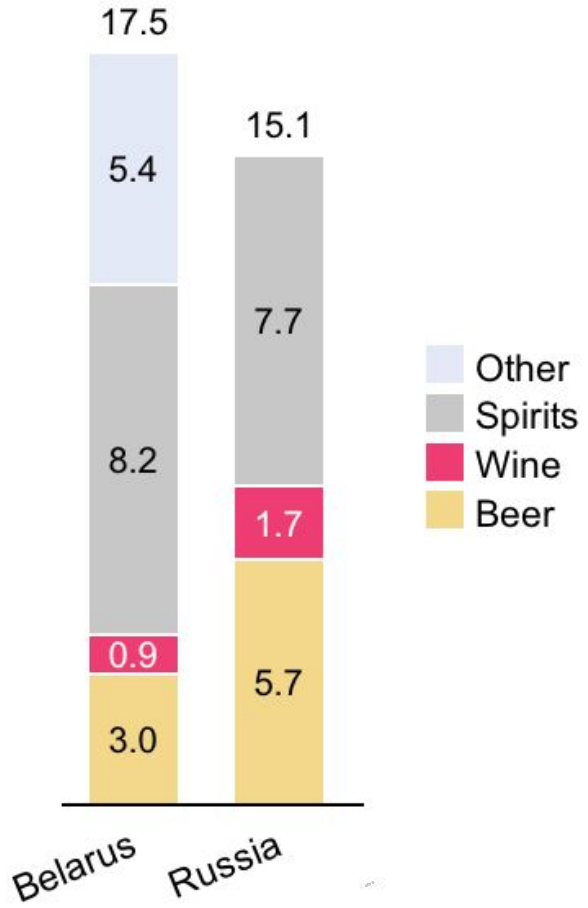
multiple keys - partitioning / subdivide

- e.g. 2 keys
  - use two perpendicular axis OR
  - use alignment on one axis
    - separate by A first and then by B (left)
    - separate by B first and then by A (right)
- also known as **dimensional stacking**



2D keys - 1D list alignment





© https://cra.org/crn/wp-content/uploads/sites/7/2015/06/Feb-2015.png

Source: Wikipedia, 2010

Graphical perception

- Human capacity to visually interpret information on graphs and charts.
  - ↳ Graph & encoding choice determines ability to obtain “correct” information from chart

Experiment: graphical perception

- Goal: Investigate effect the different layouts on the ability to compare
- Study:
  - make a quick visual judgment
  - judge the percentage difference of two highlighted bars
  - 3 seconds for each task

free online polls

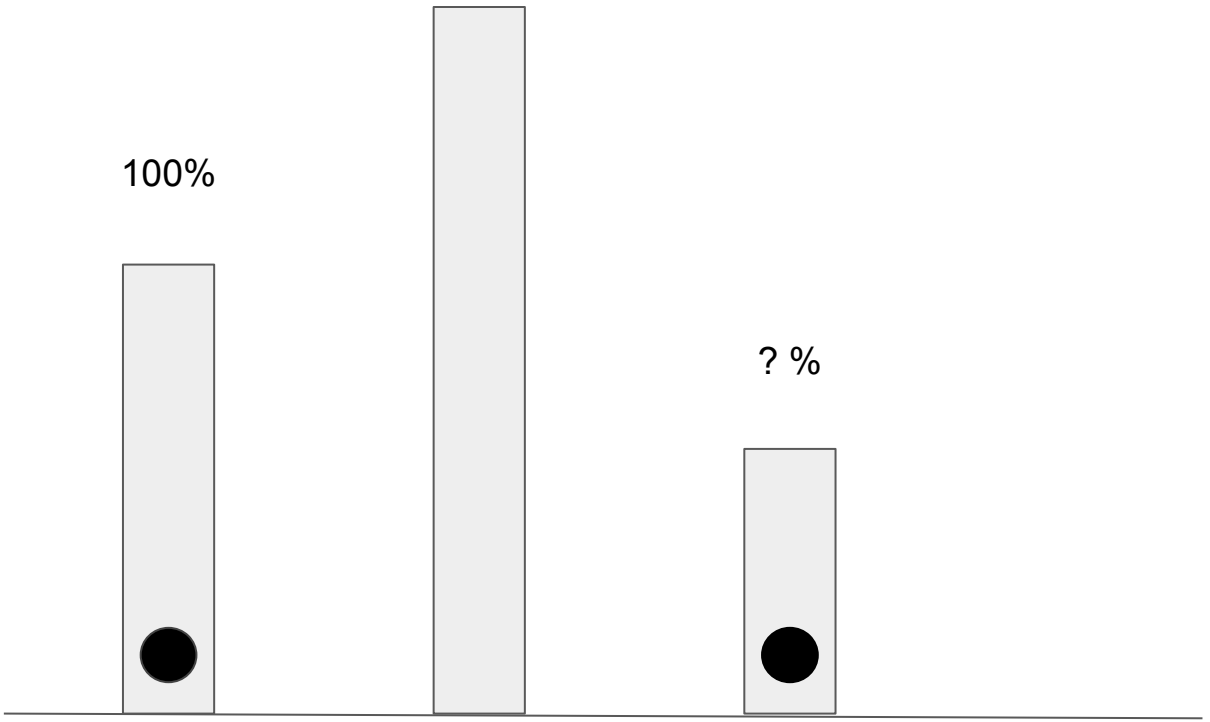
easypolls

T1

- 5
- 10
- 15
- 20
- 25
- 30
- 35
- 40
- 45
- 50
- 55
- 60
- 65
- 70
- 75
- 80
- 85
- 90
- 95

See results vote

Task layout



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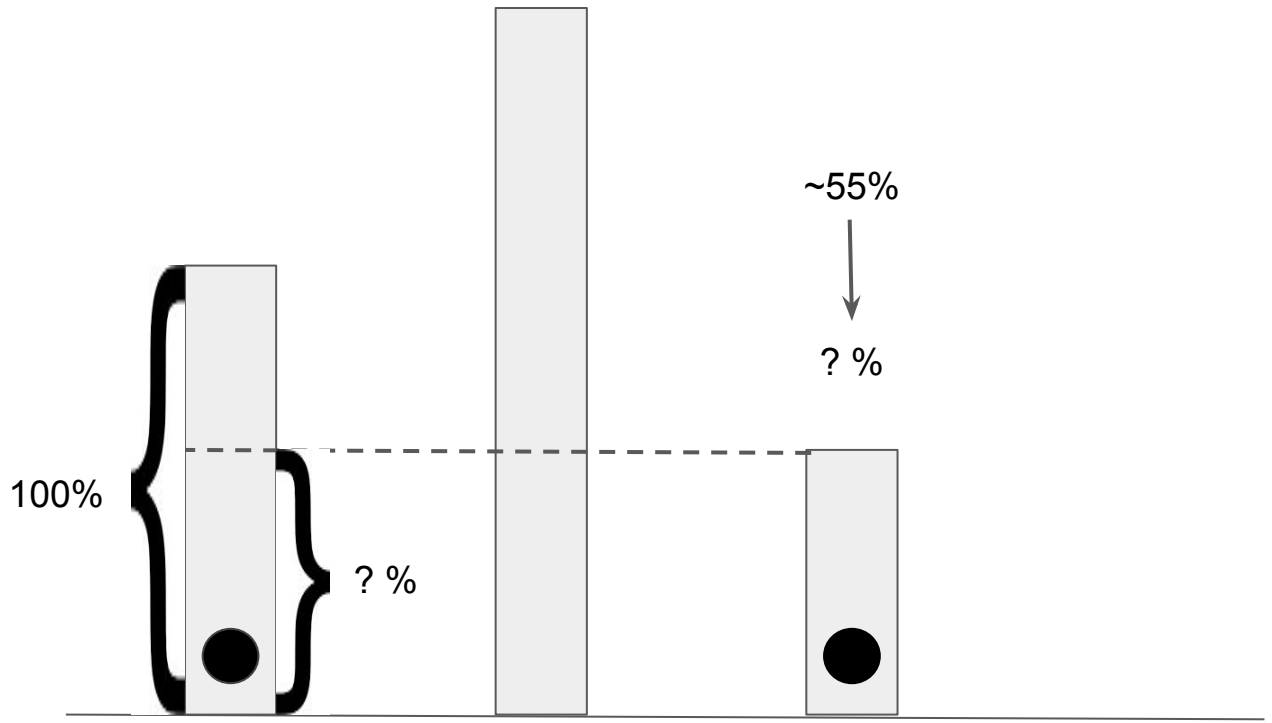

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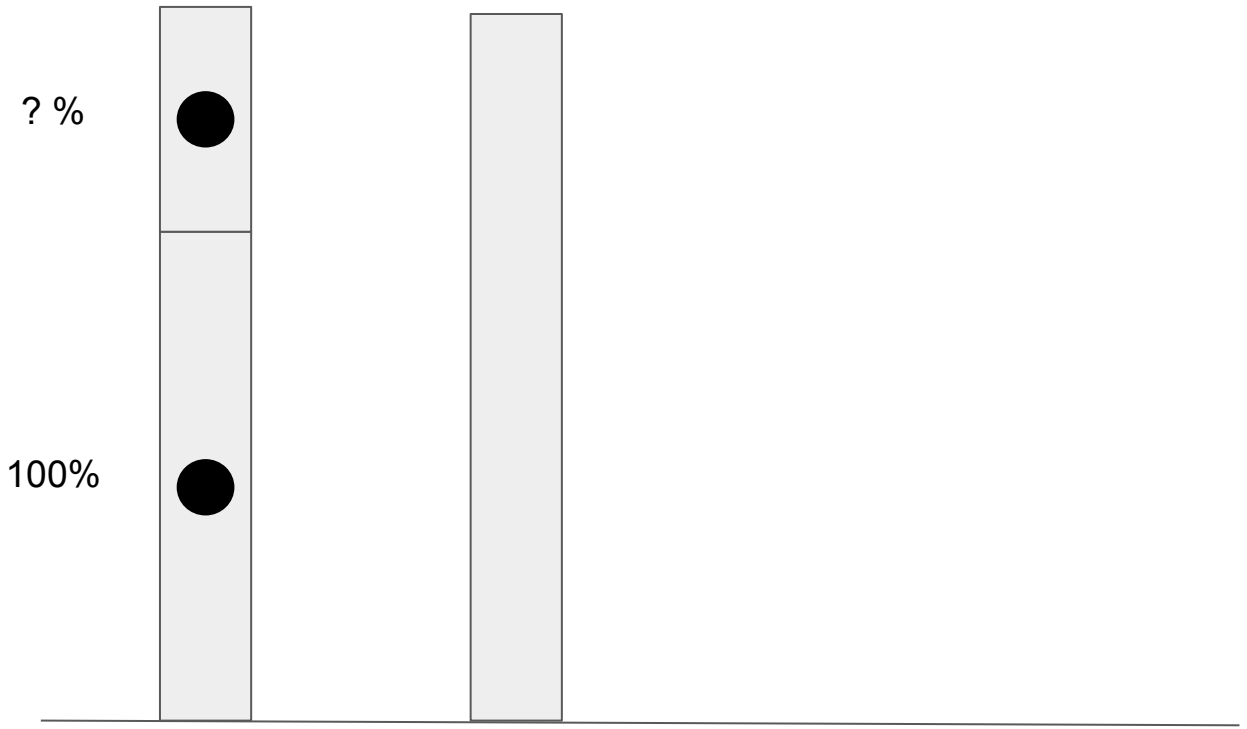

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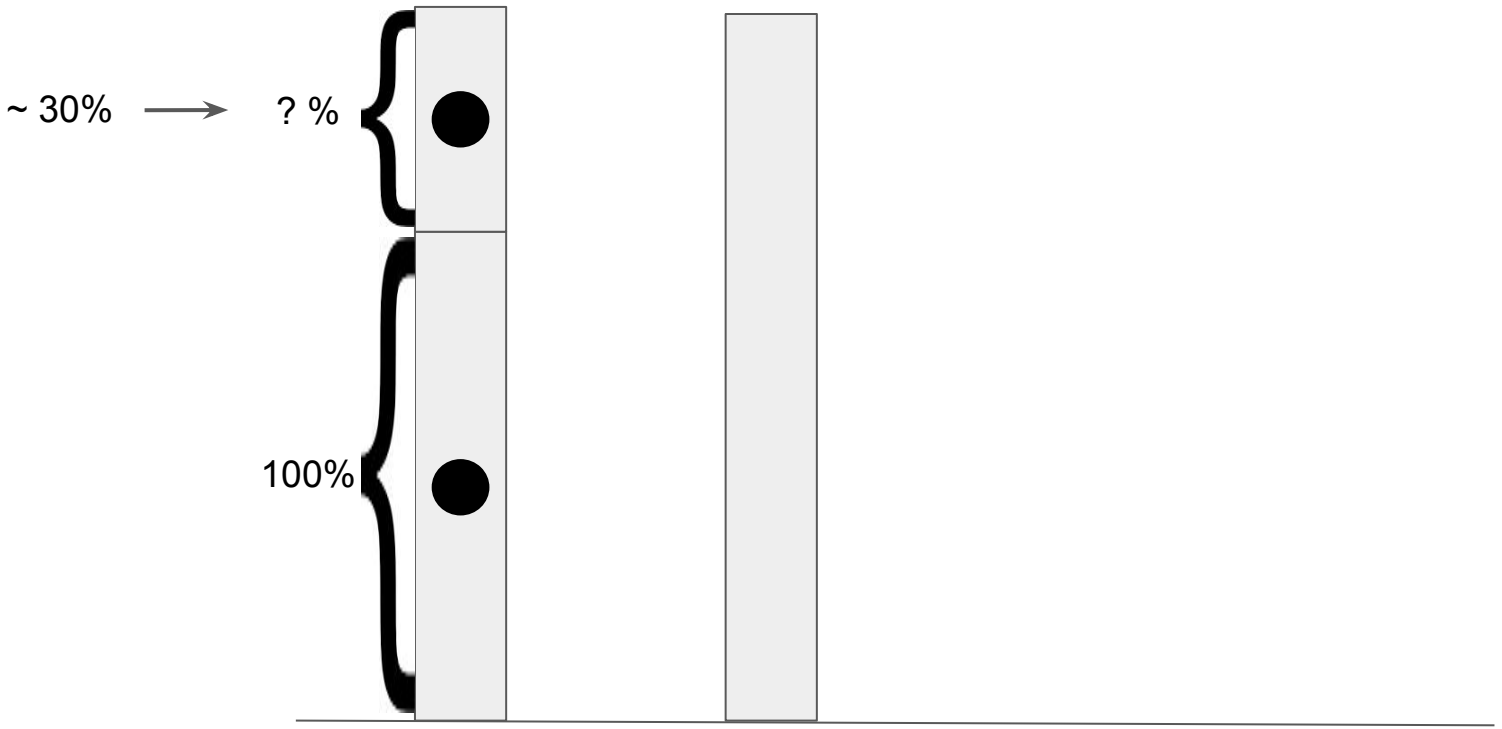
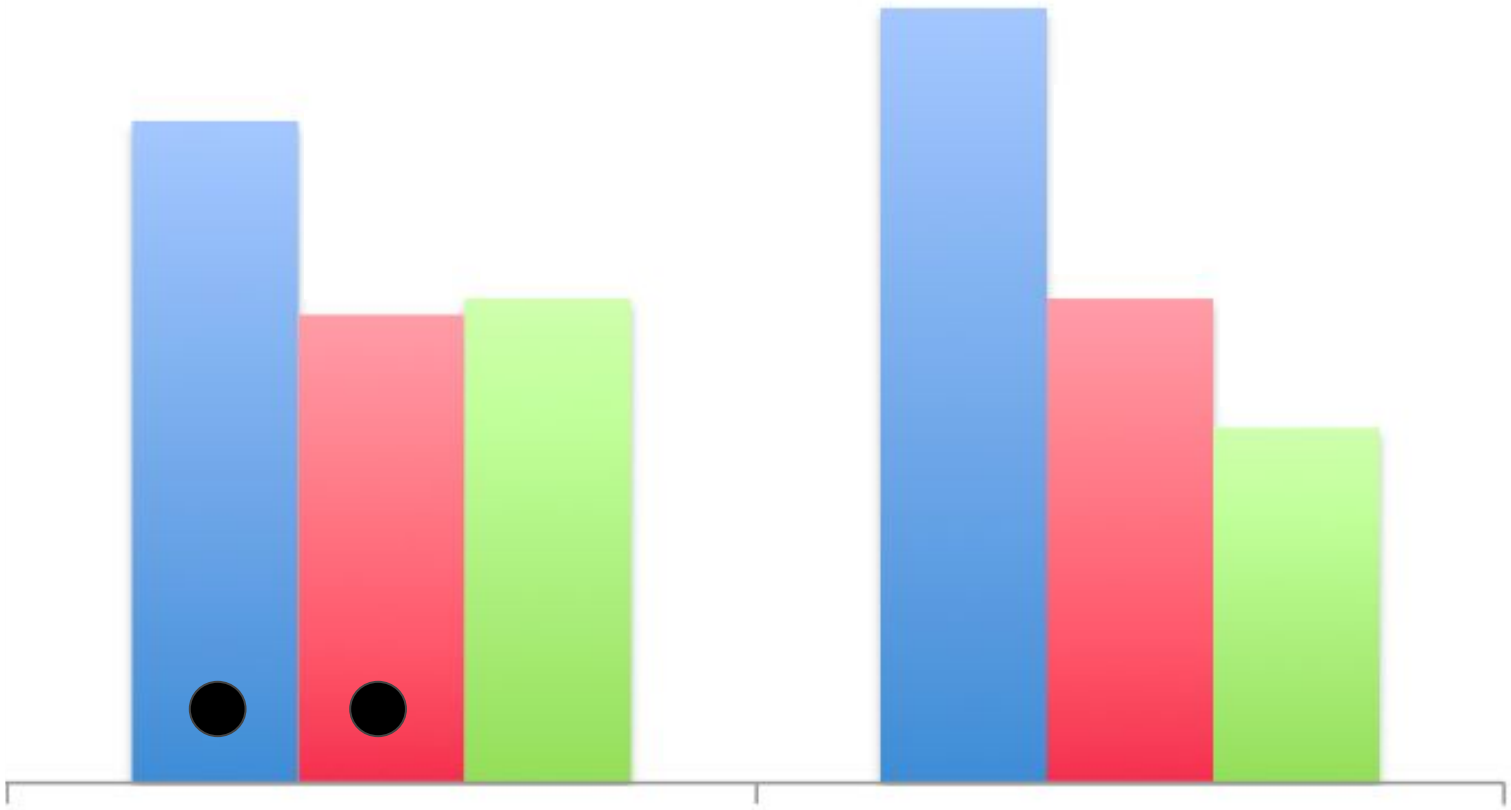
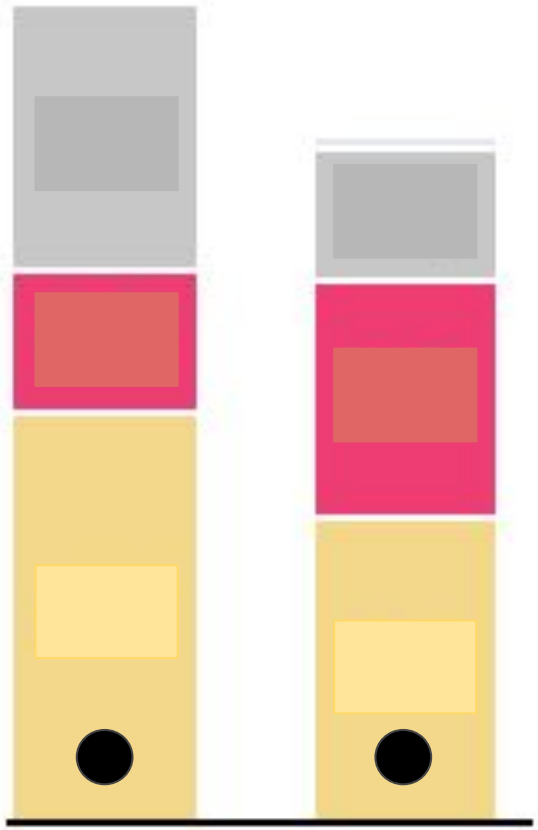


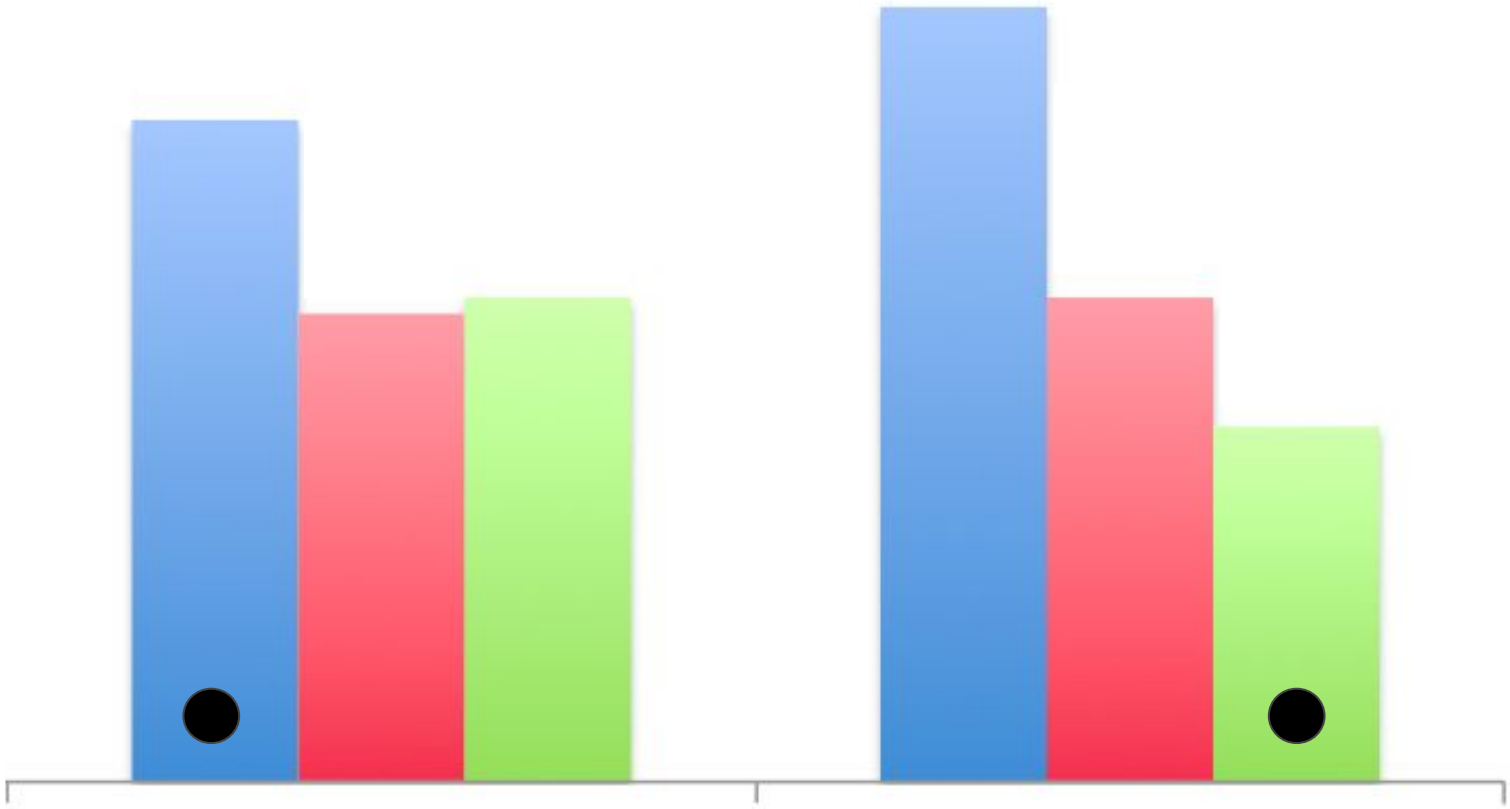
T1



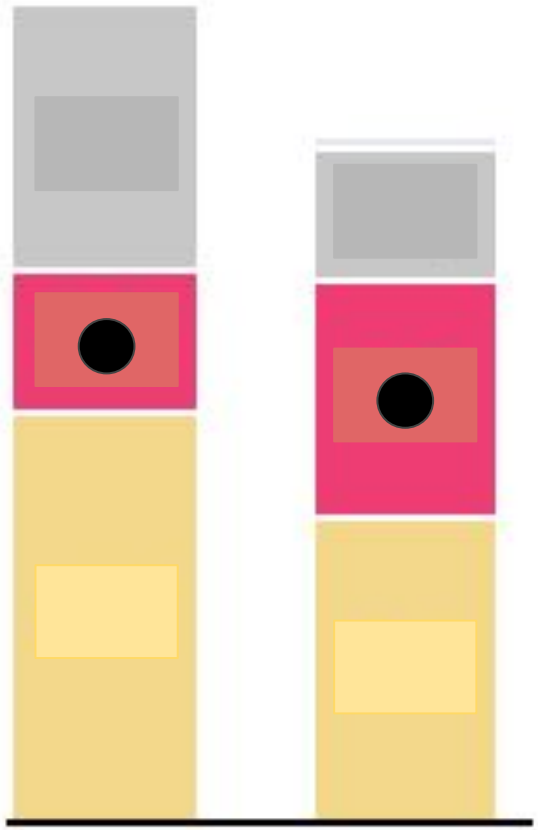
T2



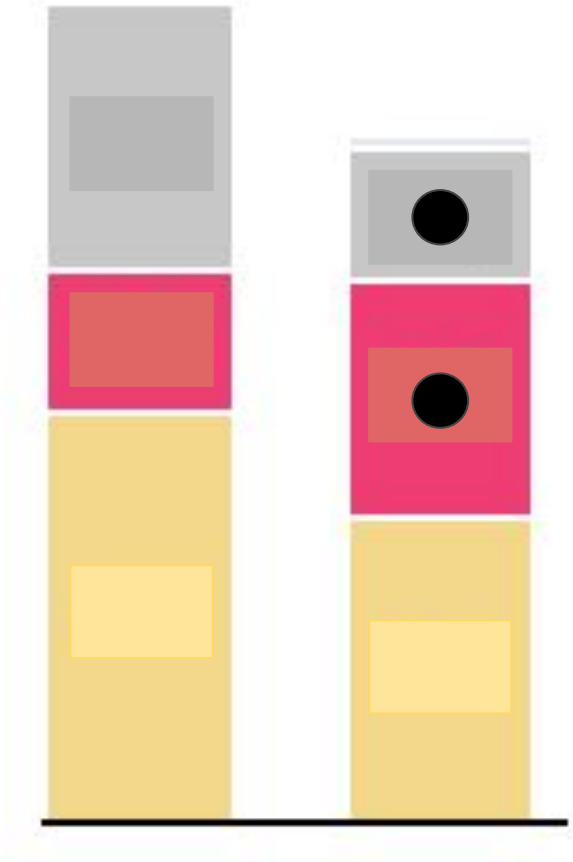
T3



T4



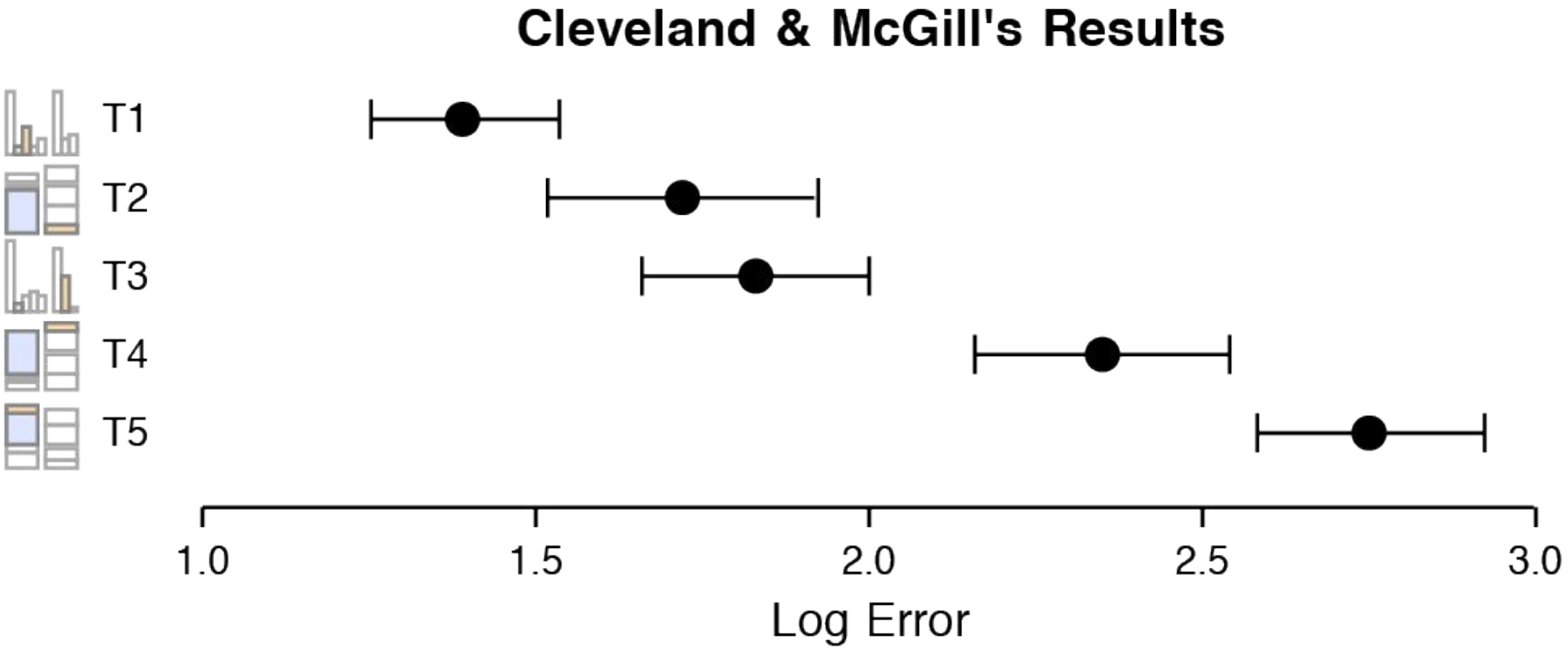
T5



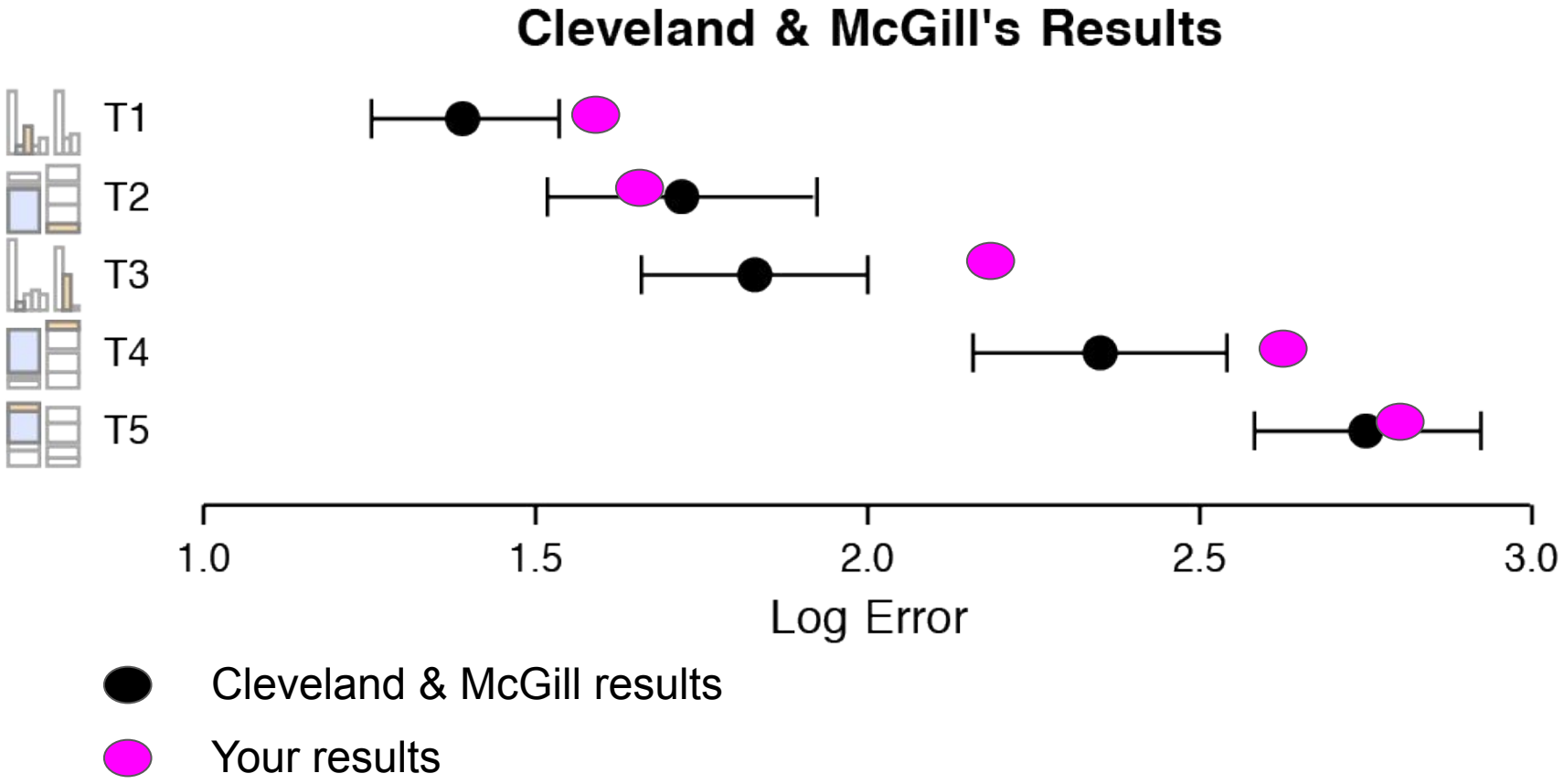
Discussion

- Gather impressions
  - What made a task particularly easy or difficult?
  - What do you expect the results will be?

Results



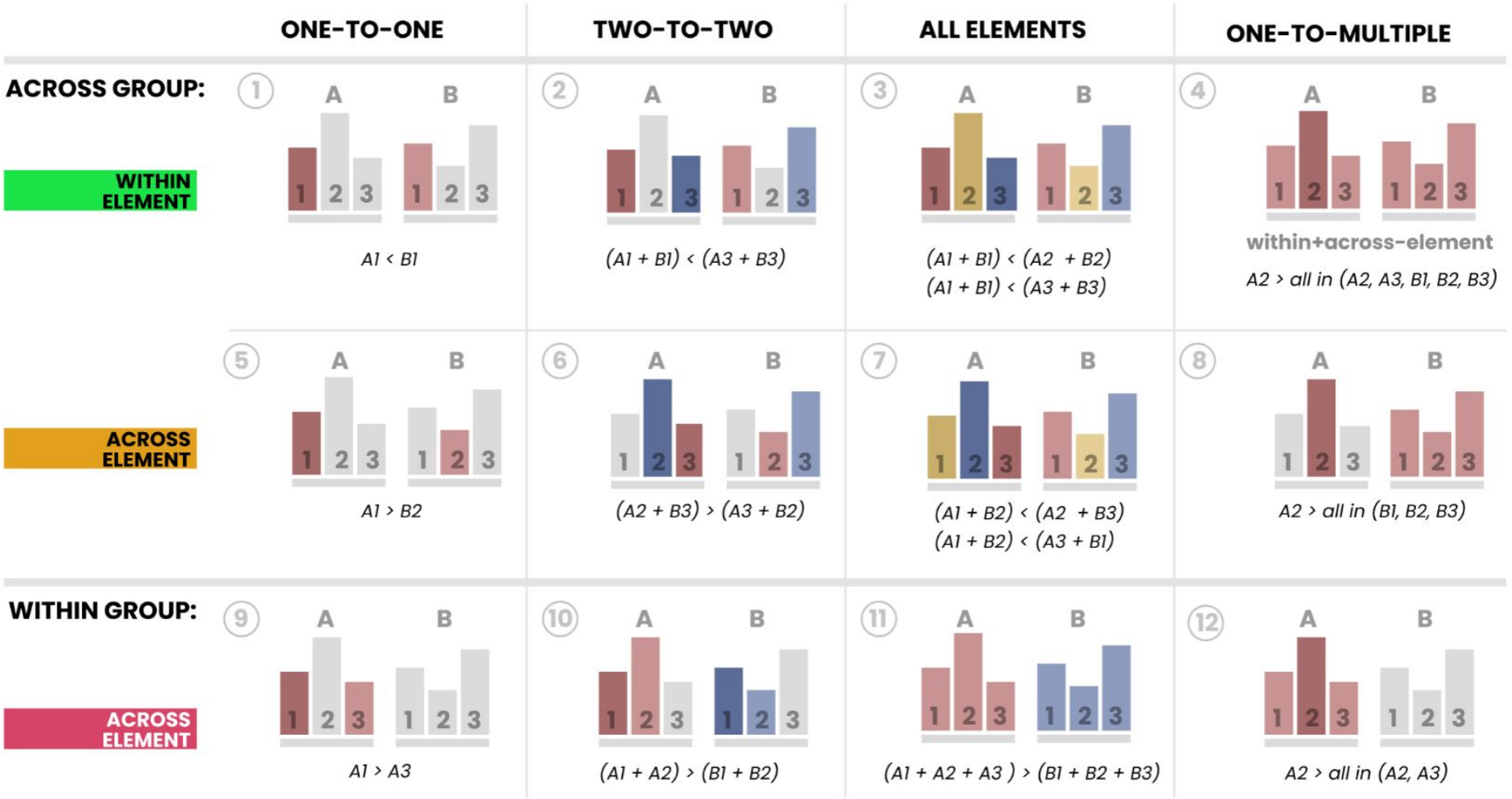
Results



Results summary

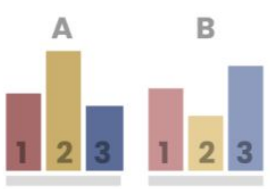
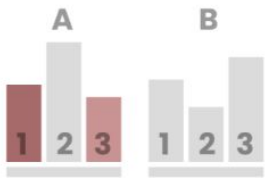
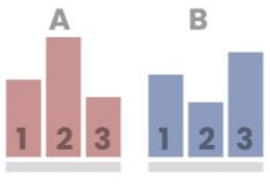
- Comparing by using **aligned position channel** against a common scale is the most accurately perceived visual channel.
- Comparing by using **unaligned position channel** adds mental overhead of due to different start and the end of each bar → reduced accuracy.

Apply what you just learned



C. Xiong, et al.,"Visual Arrangements of Bar Charts Influence Comparisons in Viewer Takeaways" in IEEE Transactions on Visualization & Computer Graphics, vol. , no. 01, 2021, pp. 1-1, 5555.

Apply what you just learned

	ONE-TO-ONE	TWO-TO-TWO	ALL ELEMENTS	ONE-TO-MULTIPLE
ACROSS GROUP: **WITHIN ELEMENT**	1  *A1 < B1*		3  *(A1 + B1) < (A2 + B2)* *(A1 + B1) < (A3 + B3)*	
ACROSS ELEMENT				
WITHIN GROUP: **ACROSS ELEMENT**	9  *A1 > A3*		11  *(A1 + A2 + A3) > (B1 + B2 + B3)*	

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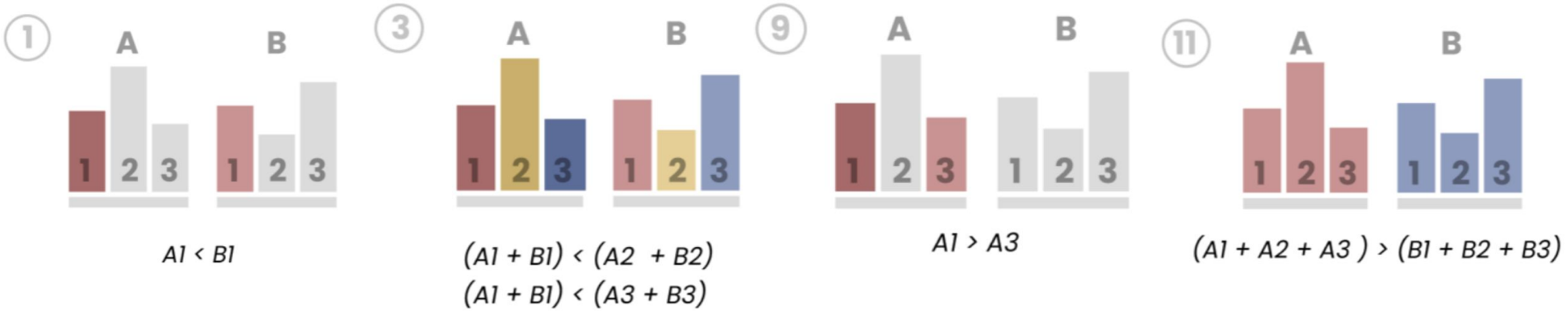
Apply what you just learned



A & B Companies | 1,2,3 Continents | Bar height: revenue

1. Comparing revenue between companies A & B in continent 1.
2. Comparing total revenue of A & B in given continent.
3. Comparing revenue of company A among different continents.
4. Comparing the global revenue of company A to B

Apply what you just learned