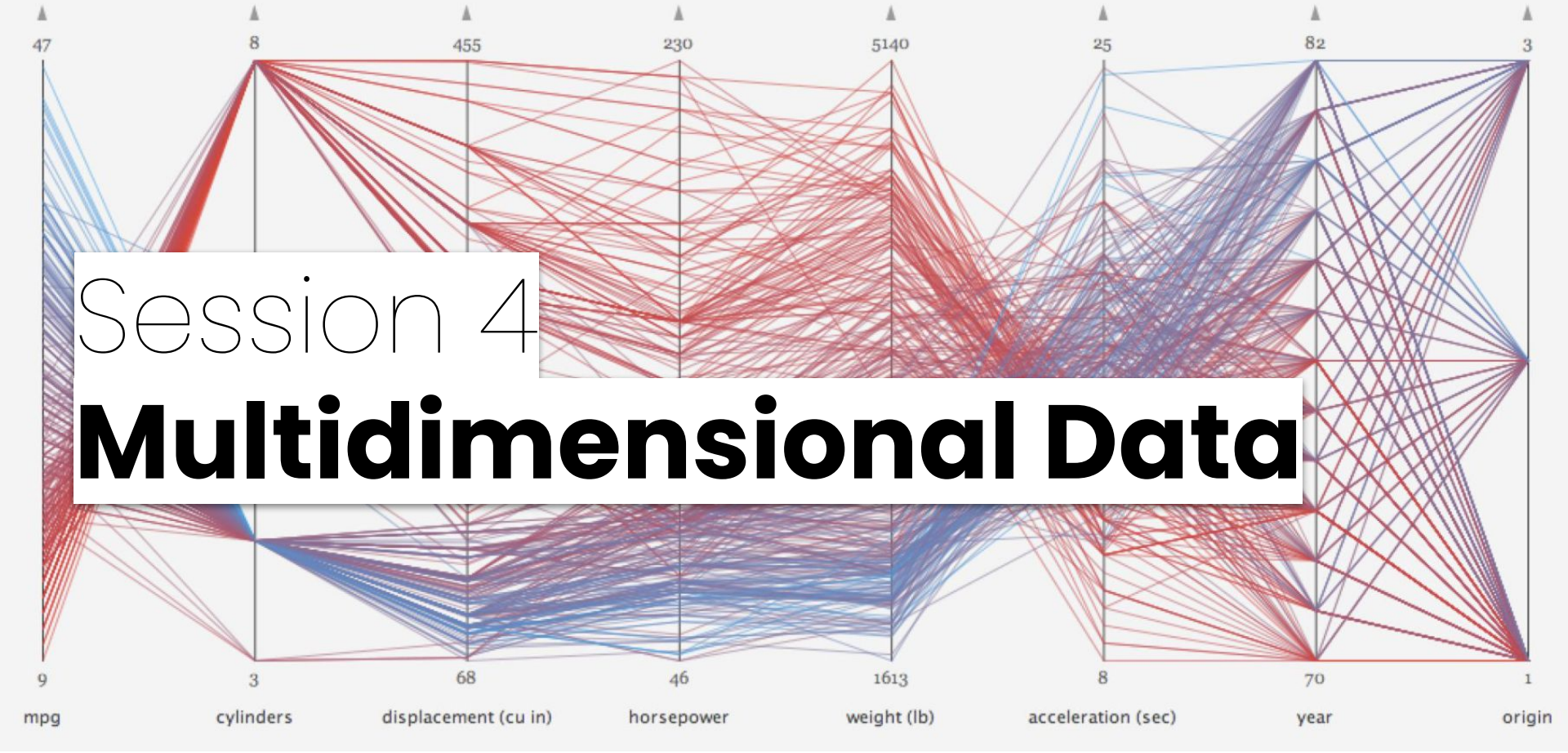

Session 4

Multidimensional Data

Online Course
Data Visualization for Professionals

THE UNIVERSITY of EDINBURGH

Benjamin Bach
June 2022
http://benjbach.me
https://datavis-online.github.io

Outline

How to visualize data with dimensions (many attributes)?

- Low-dimensions (<3)
- Higher dimensions (> 2)
- Dimensionality reduction (many!)

Outline

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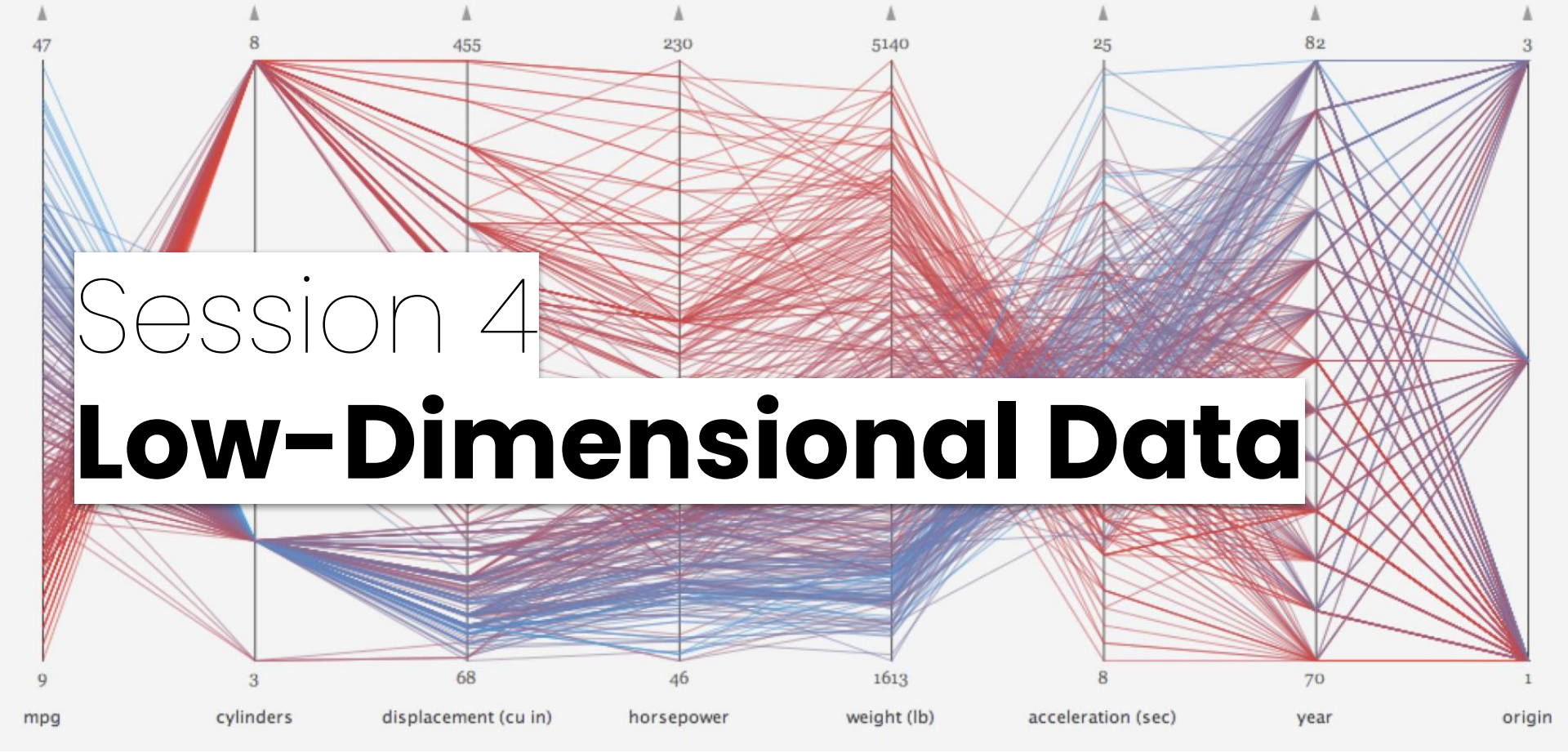

Session 4

Low-Dimensional Data

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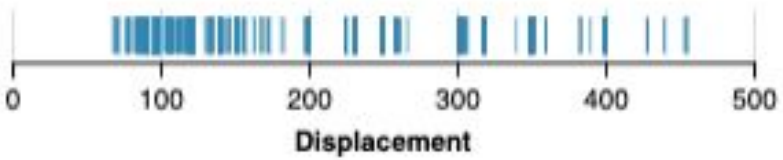
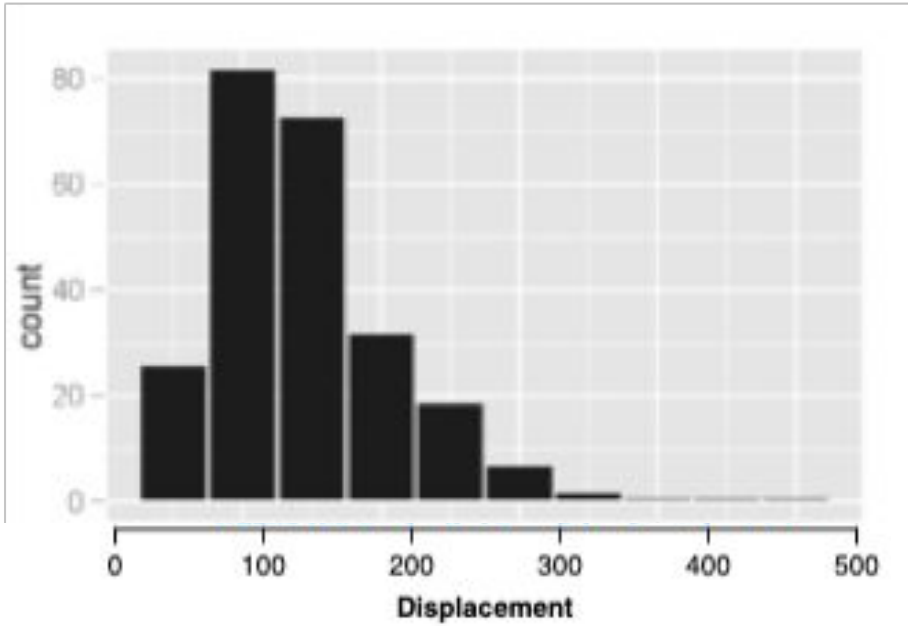
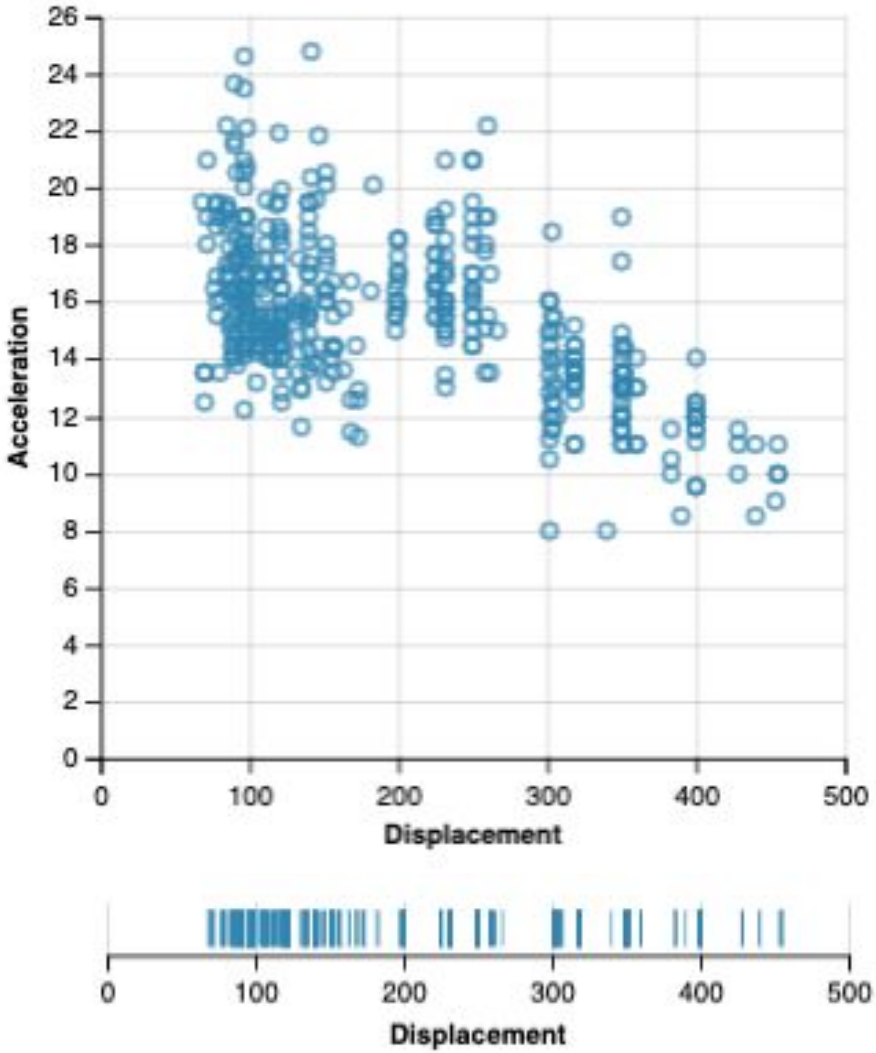
1 Dimension



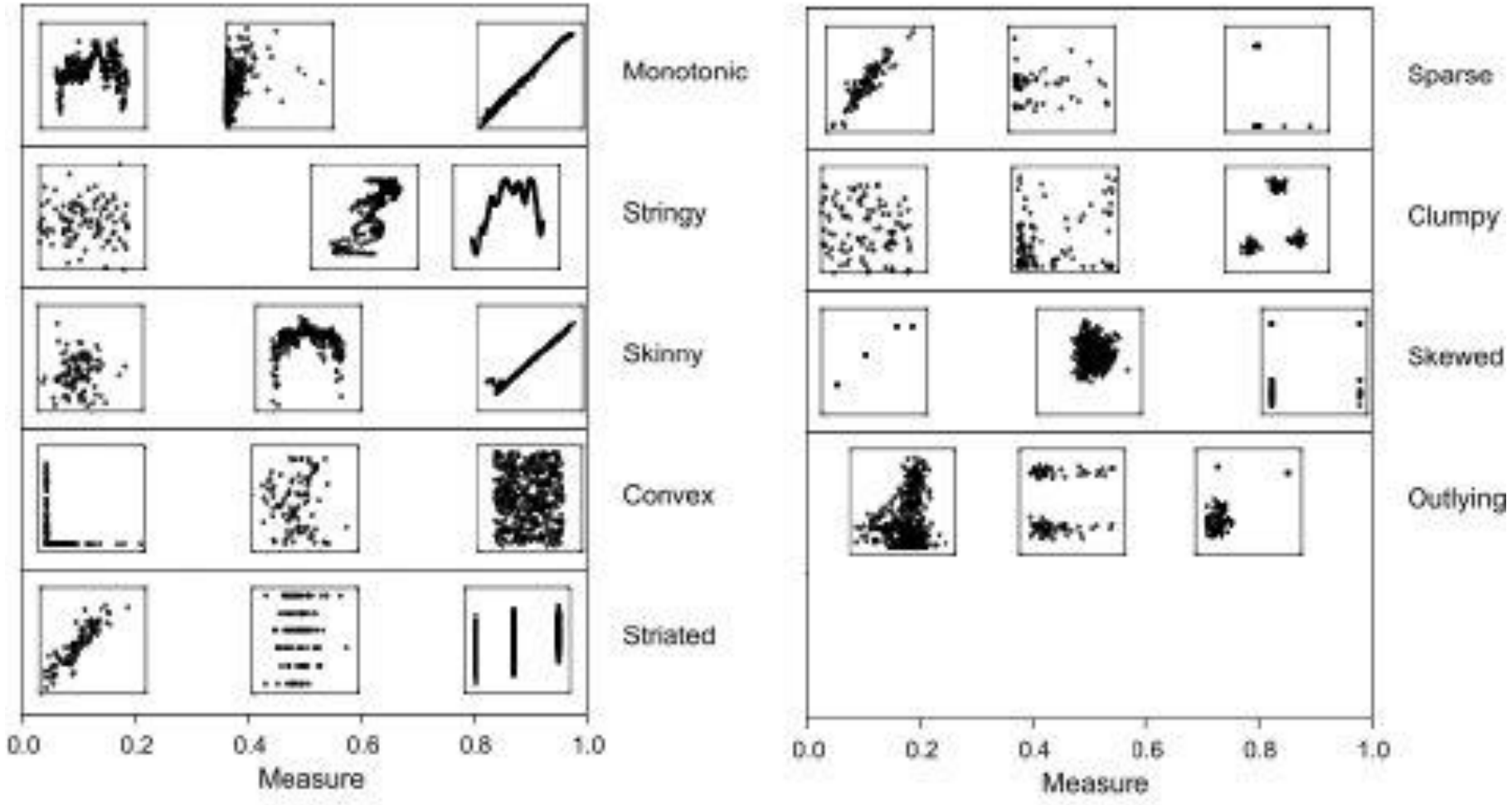
1 Dimension



2 Dimensions

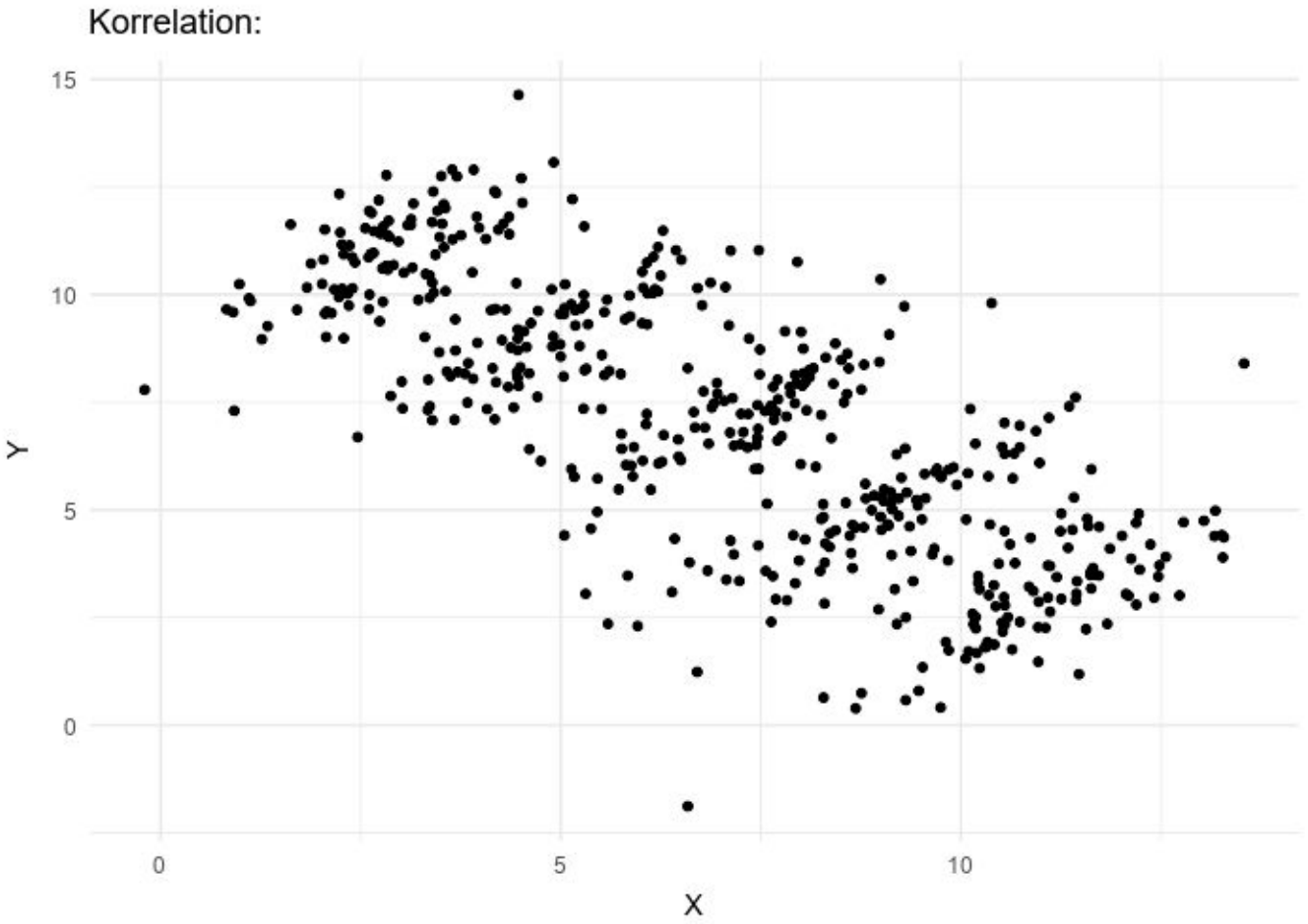


Quant + Quant: **Scatterplot**

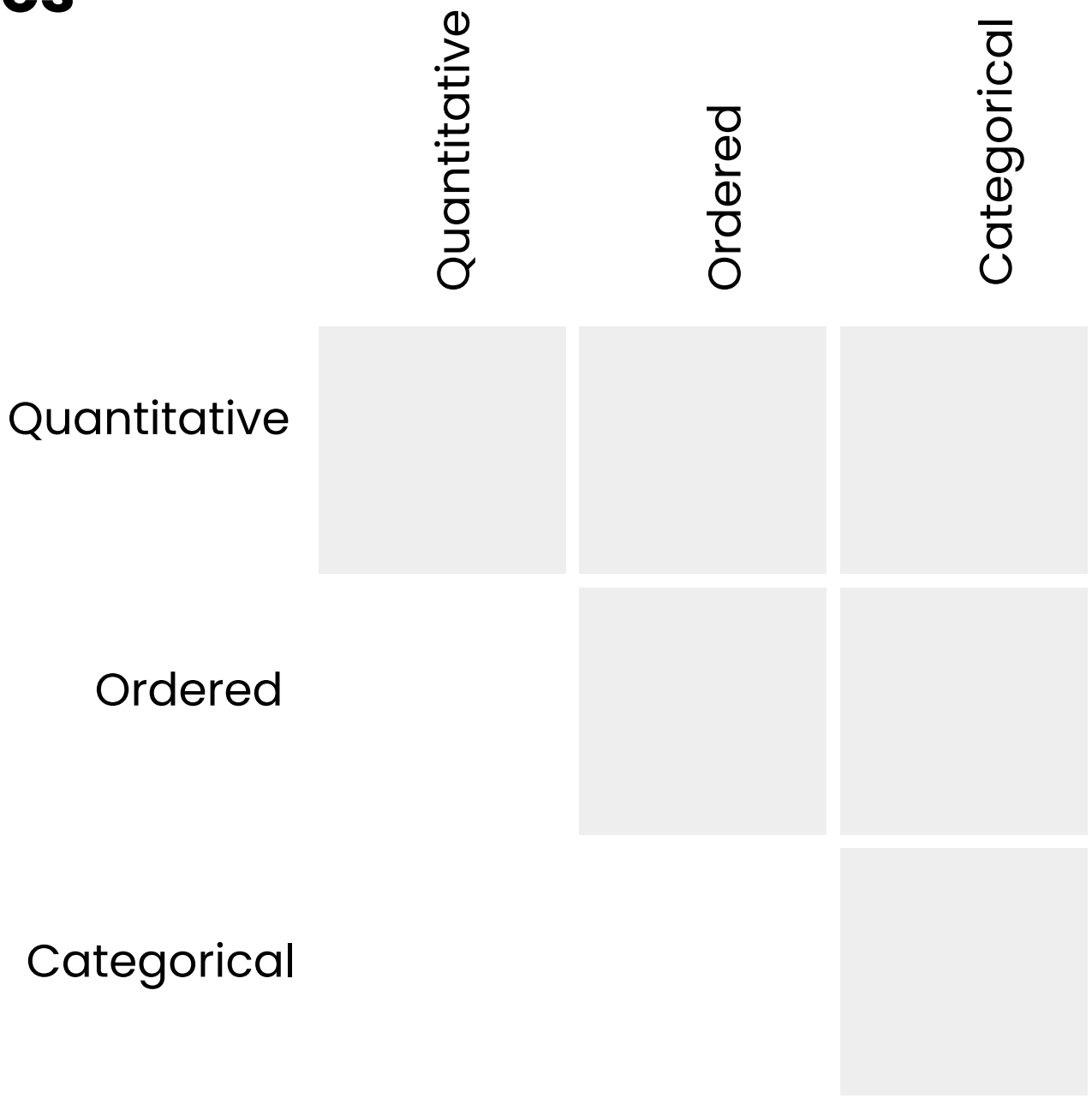


Simpson's Paradox

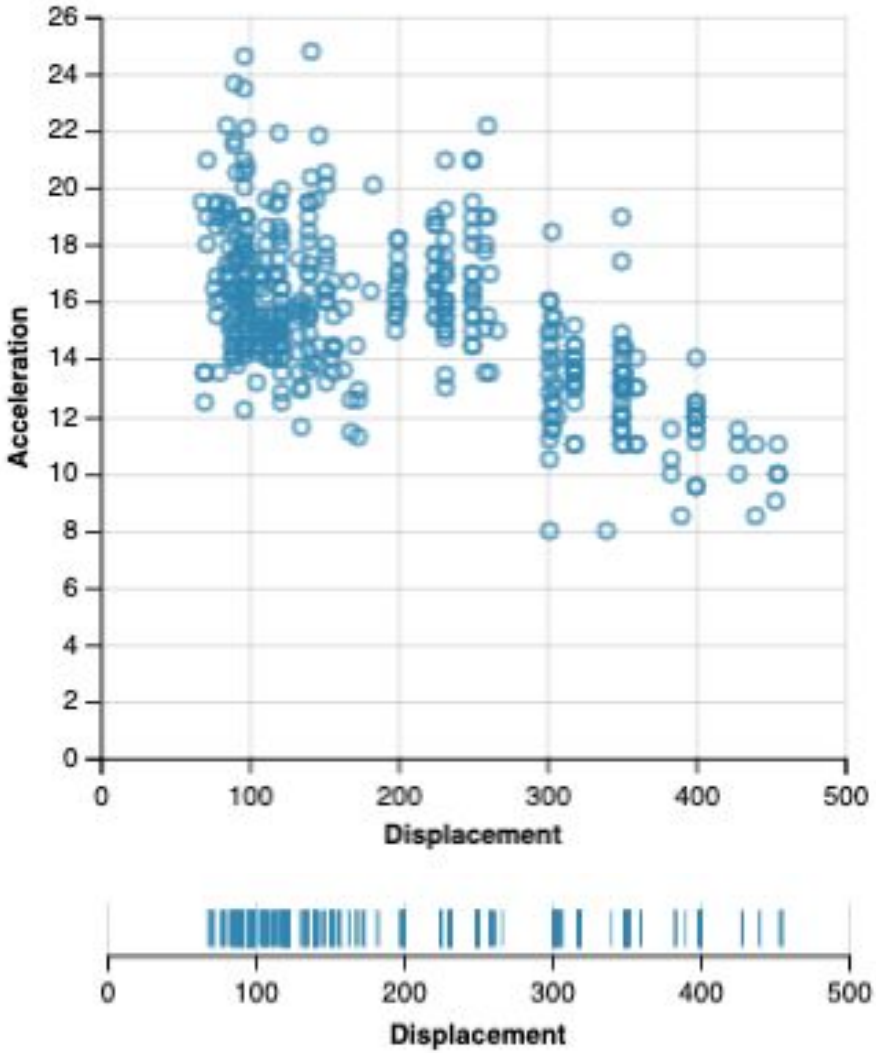
a trend appears in several different groups of data but disappears or reverses when these groups are combined.



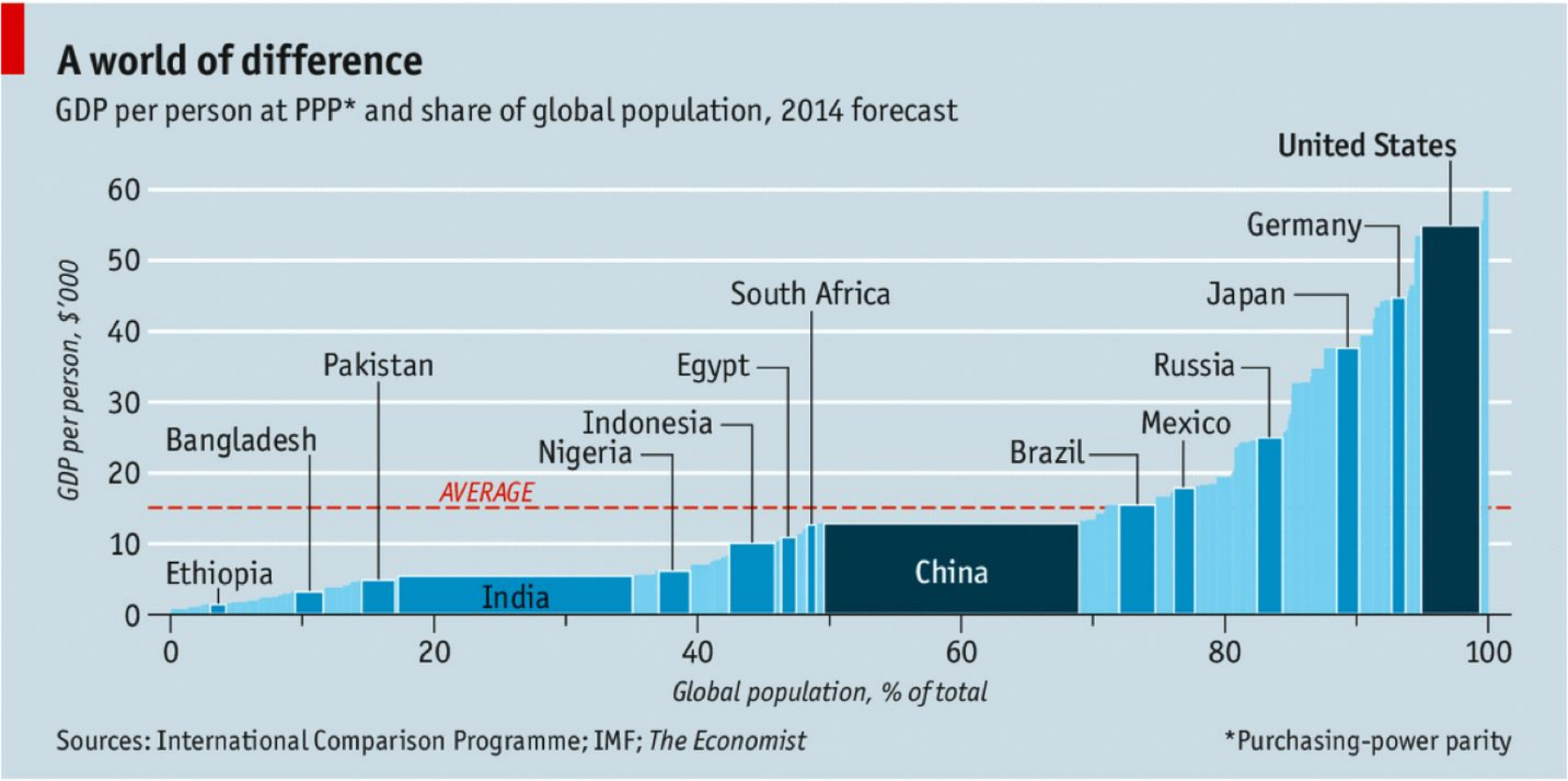
Data types


Quantitative
Ordered
Categorical
Quantitative
Ordered
Categorical

Quant x Quant: **Scatterplot**

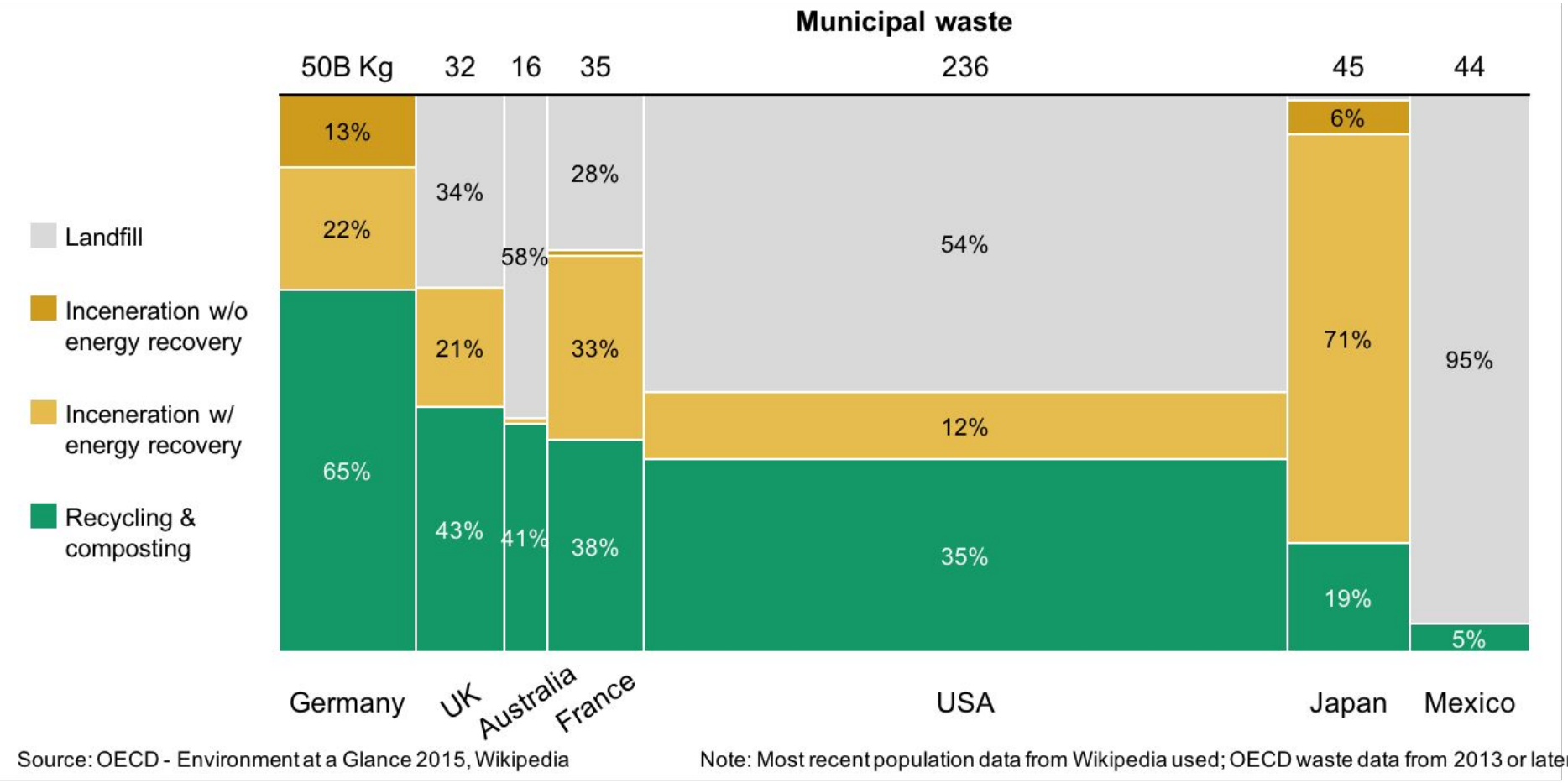


Quant x Quant: **Mekko Chart**



Two quantities that if multiplied give a third quantity.

Quant x Quant: **Mekko Chart**

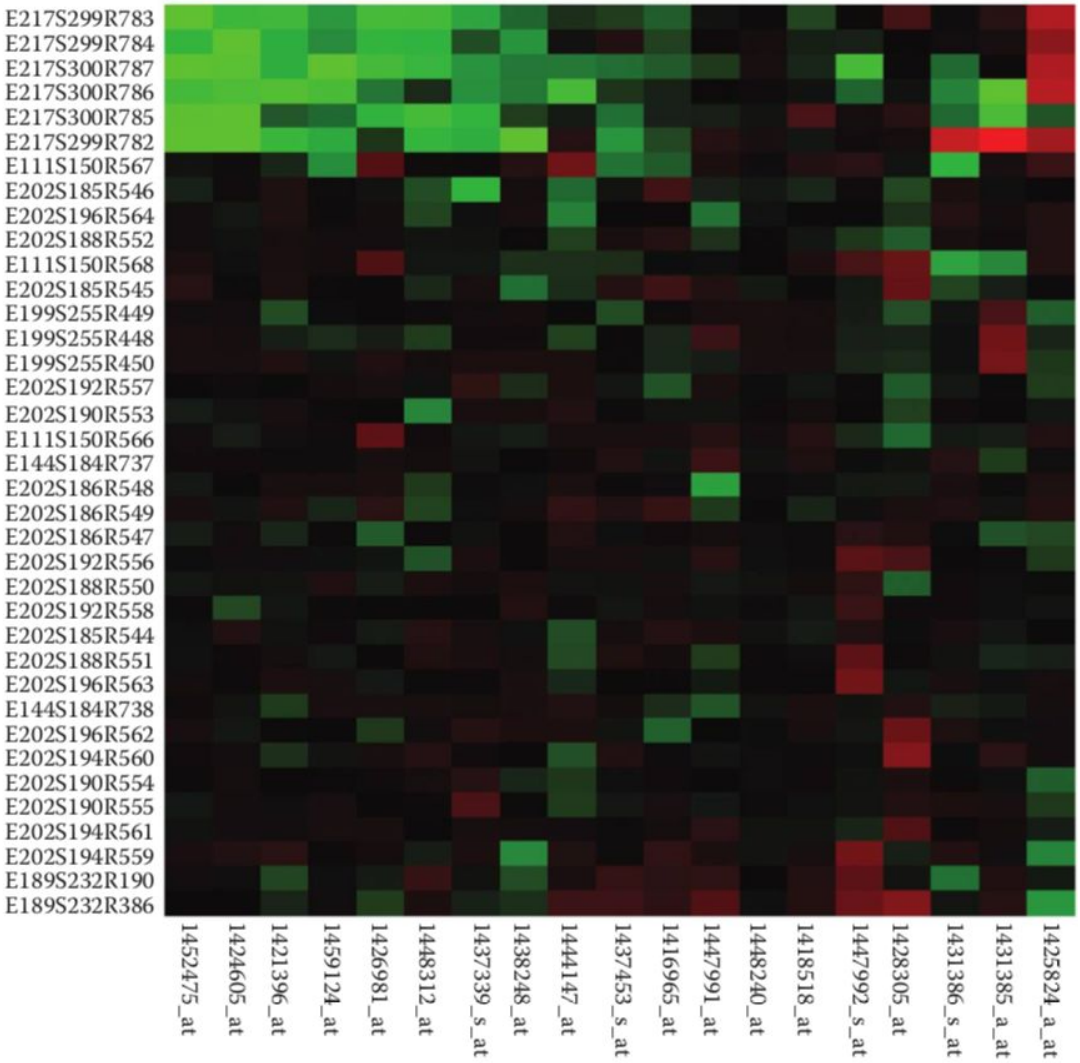


Two quantities that if multiplied give a third quantity.

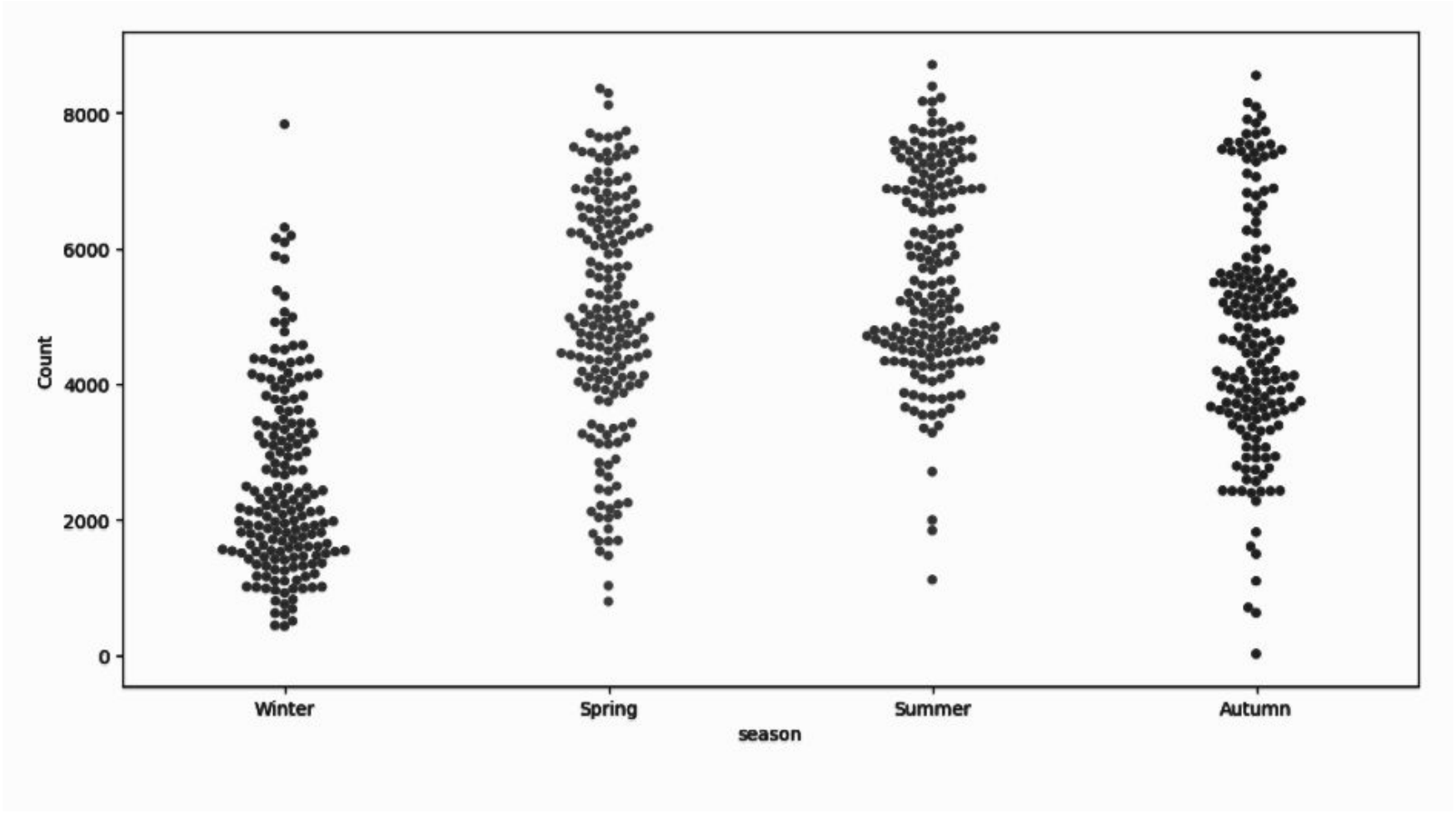
Q/C/O + O/C: **Heatmaps**

A quantity (cells), depending on two factors (ordered or categorical)

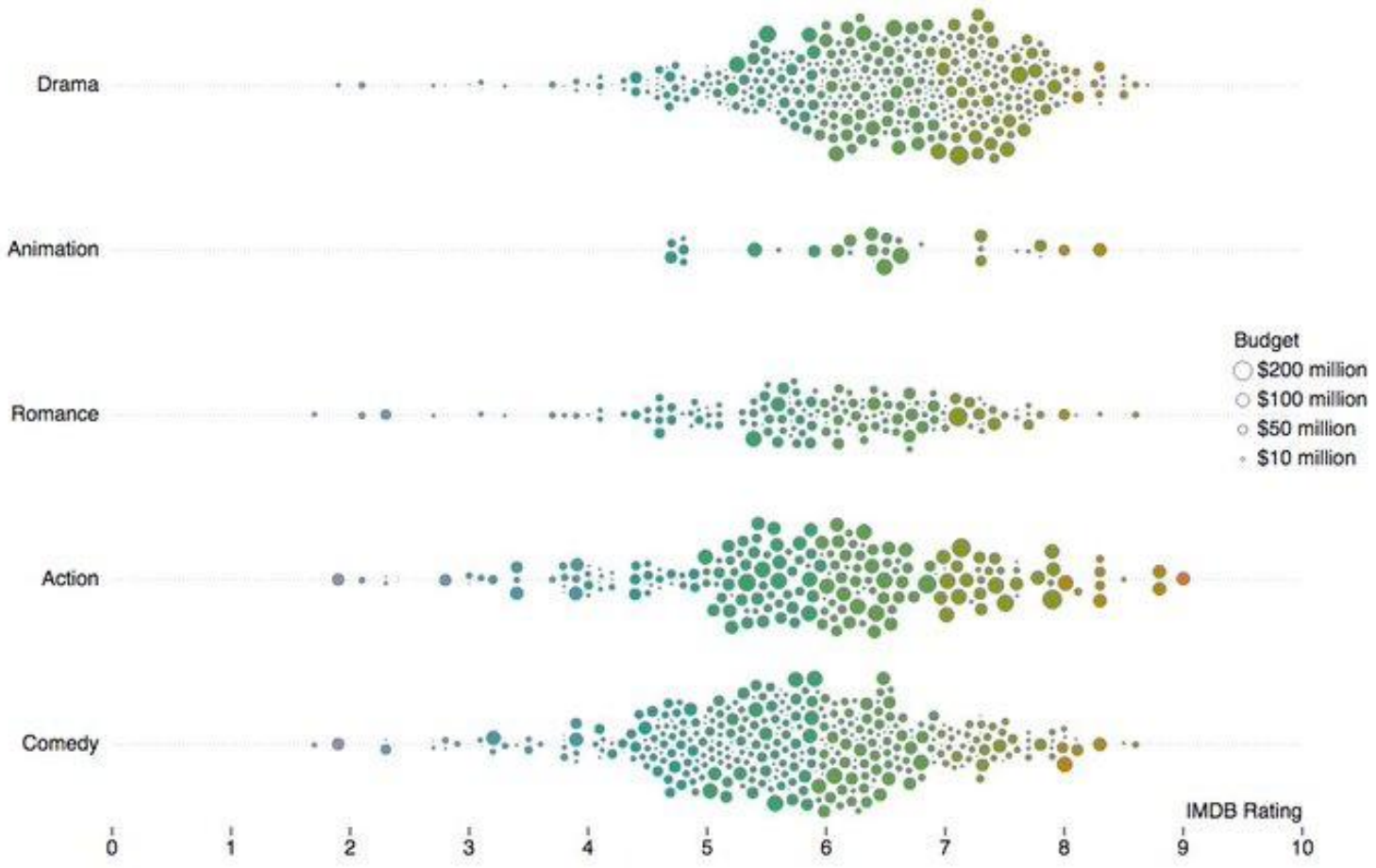
Requires complete field.



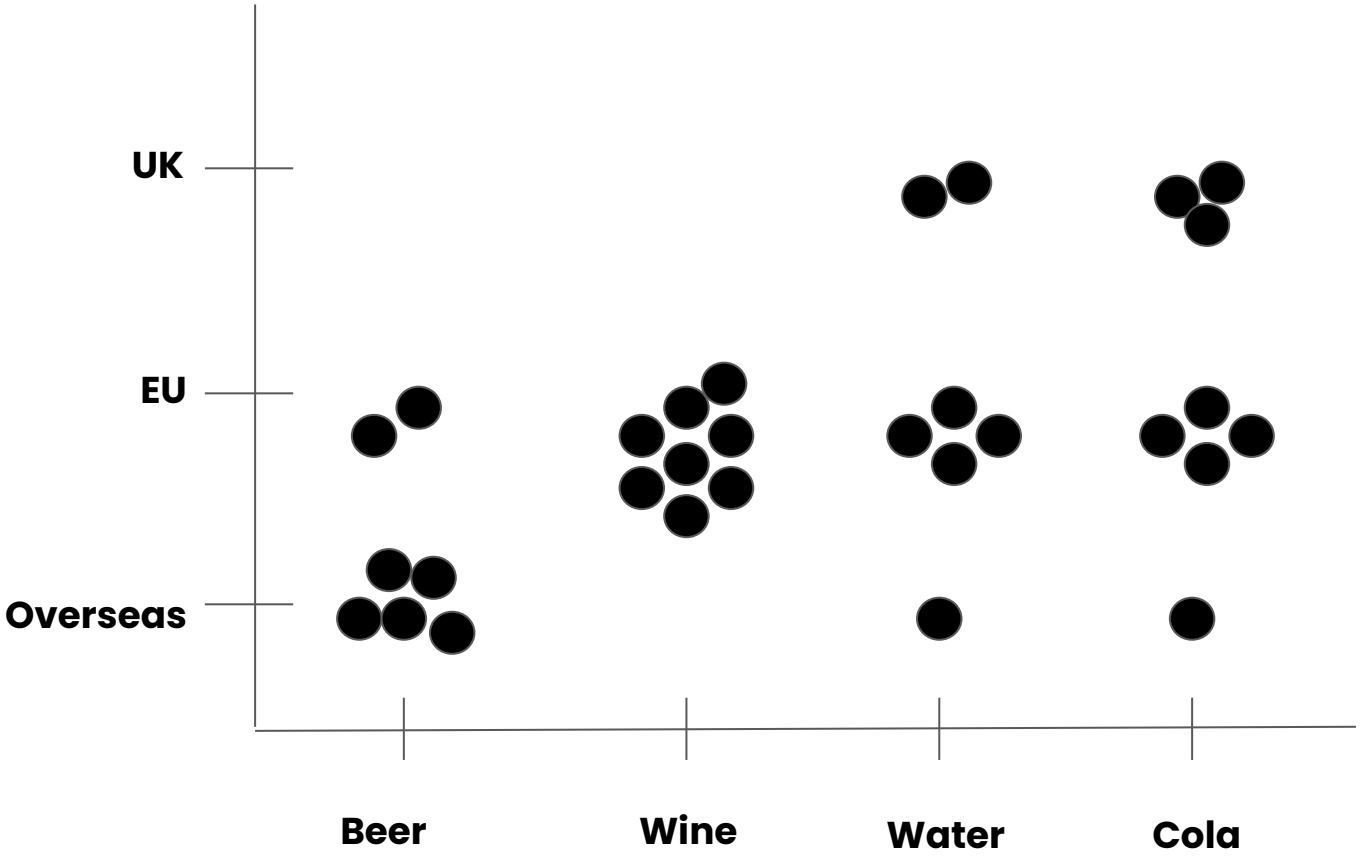
Quant + Ordered/Categorical: **Beeplots**



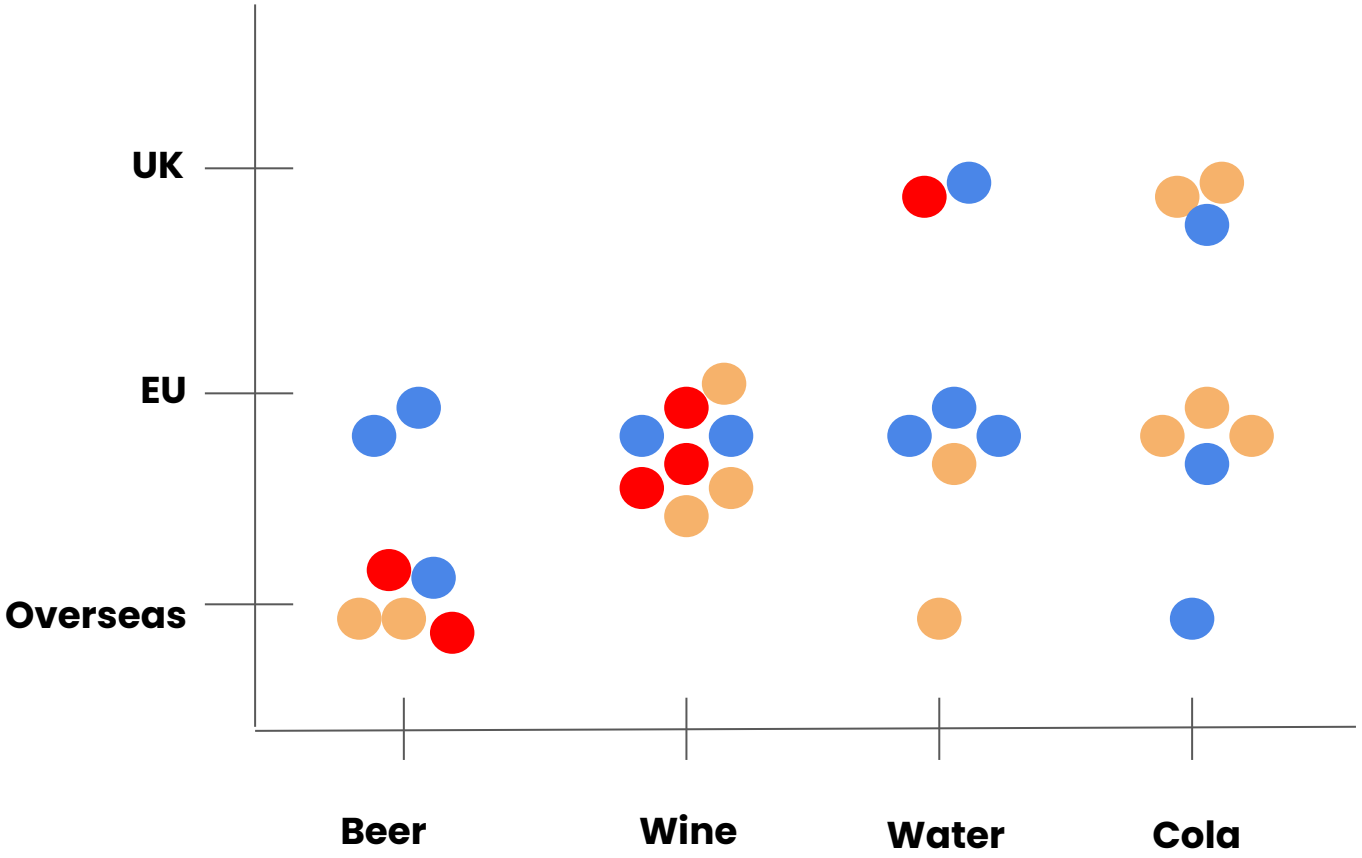
Quant + Ordered/Categorical: **Swarm plots**



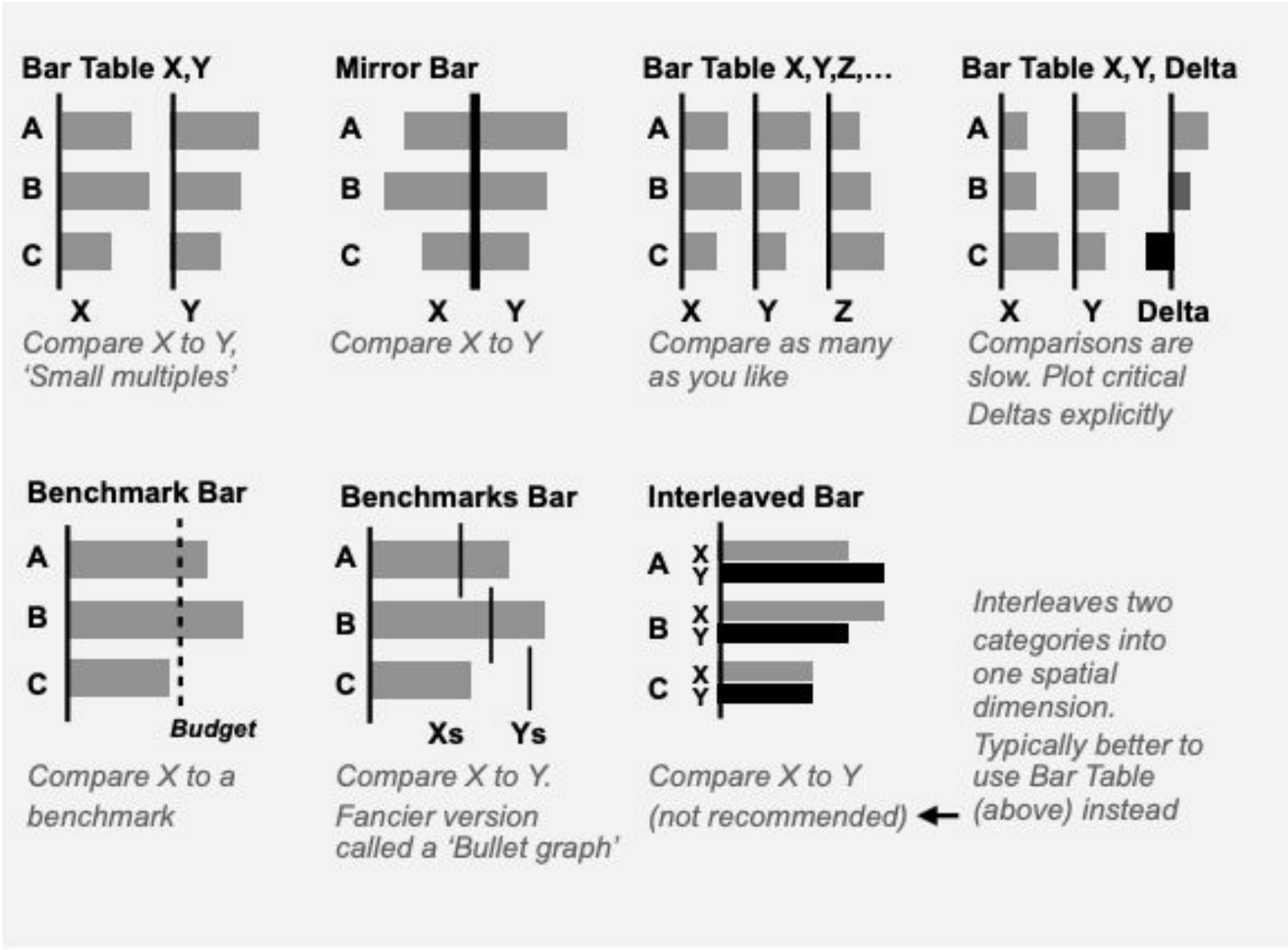
Categorical + Categorical: ***Swarm plots???***



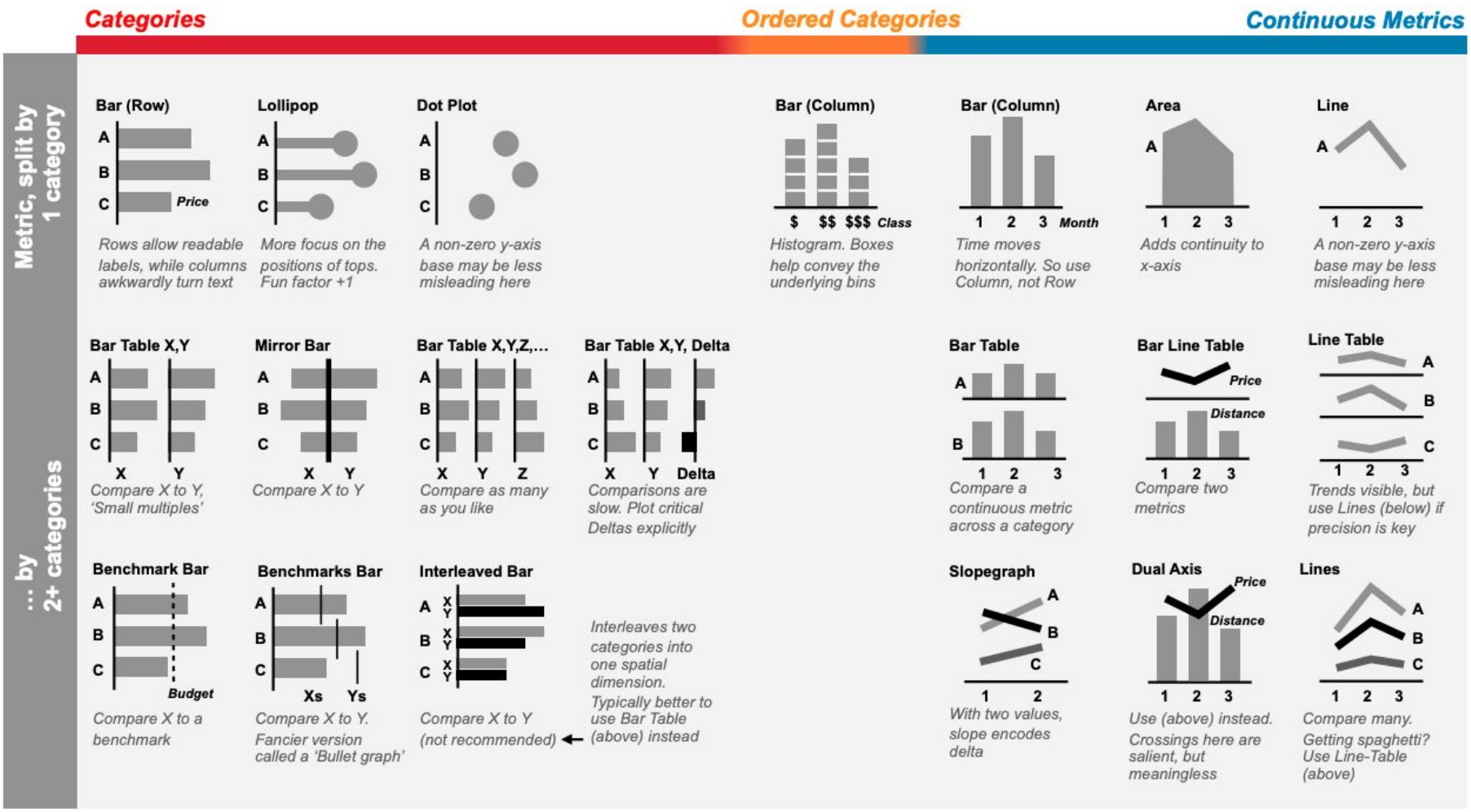
Categorical + Categorical: ***Swarm plots???***



And again: **bar charts**

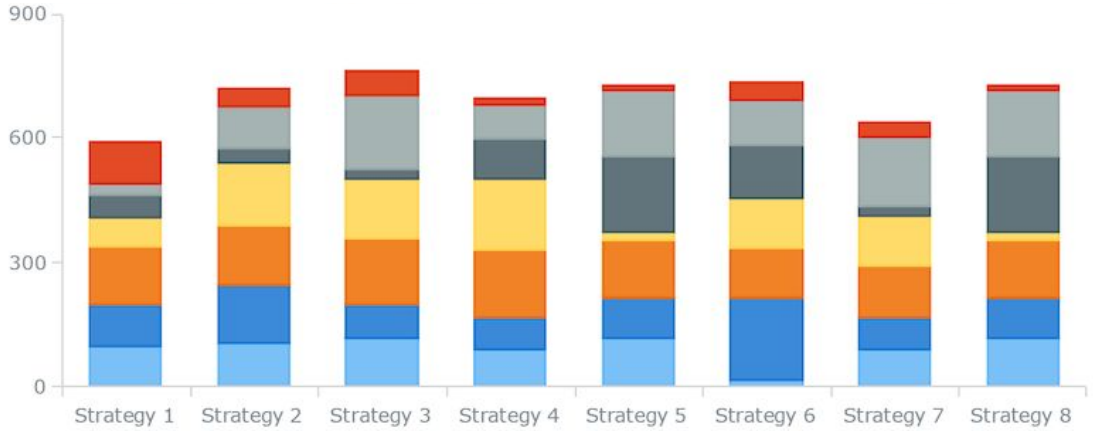


… and many more!



http://experception.net/

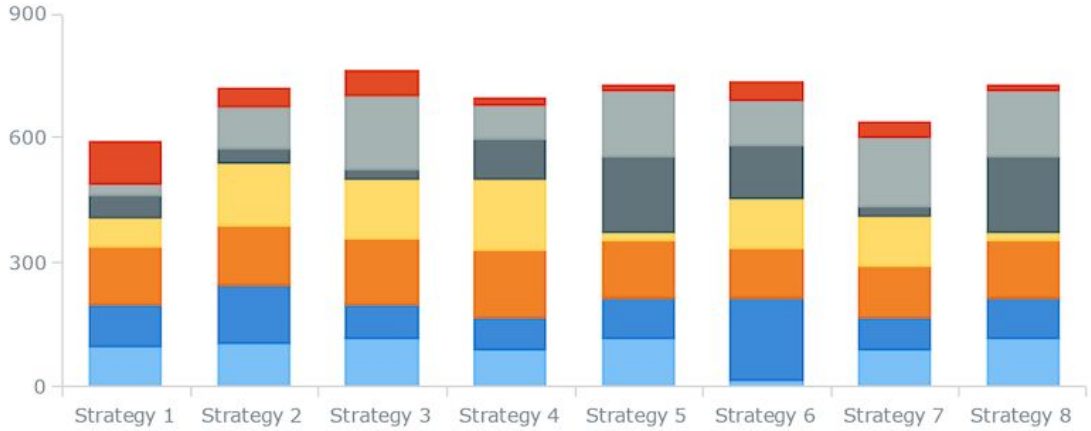
Stacked Bar Charts



- Individual distributions
- Individual value comparison
- Details

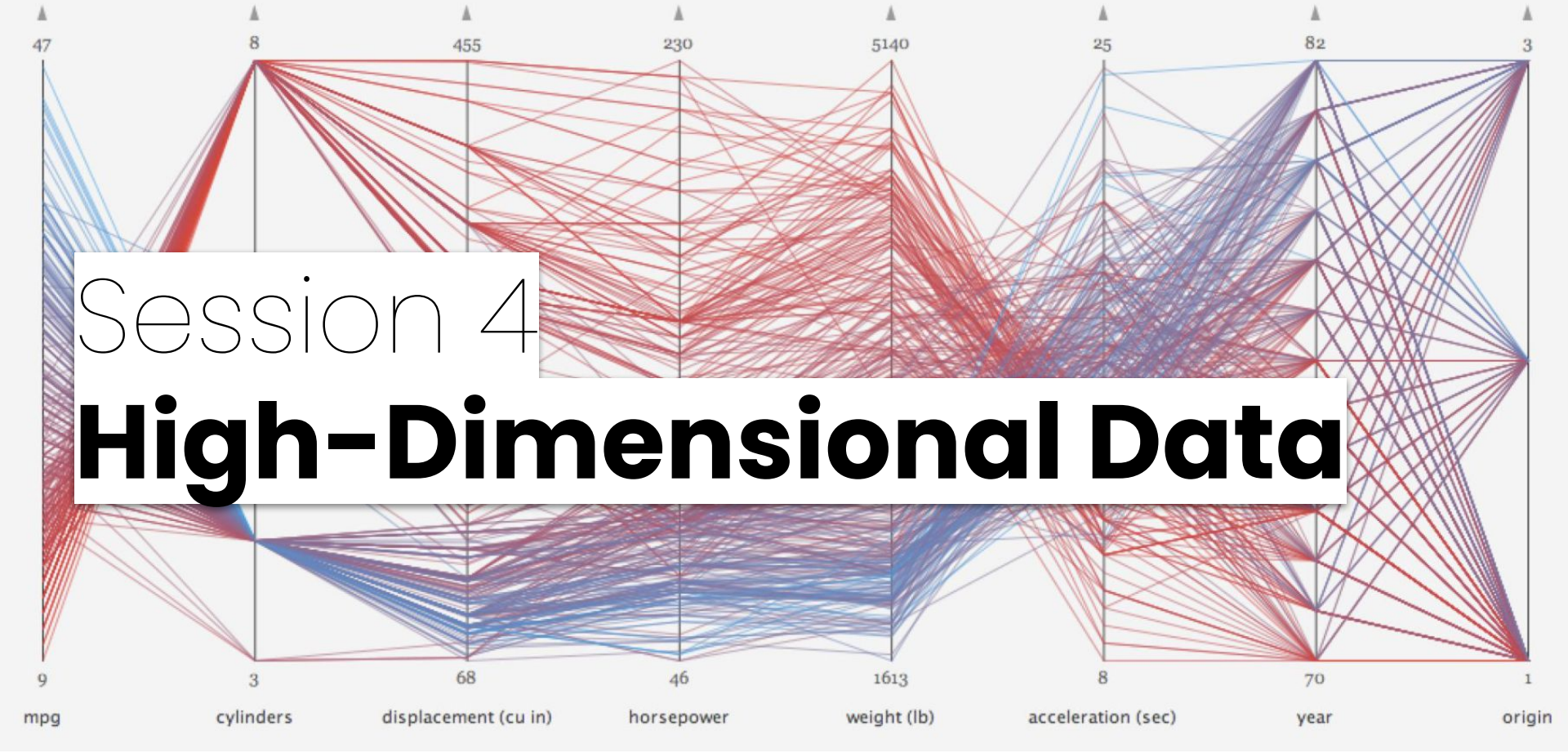
Stacked Bar Charts

- Individual distributions
- Individual value comparison
- Details



- Sum comparison
- Overview

> requires good color pallette!



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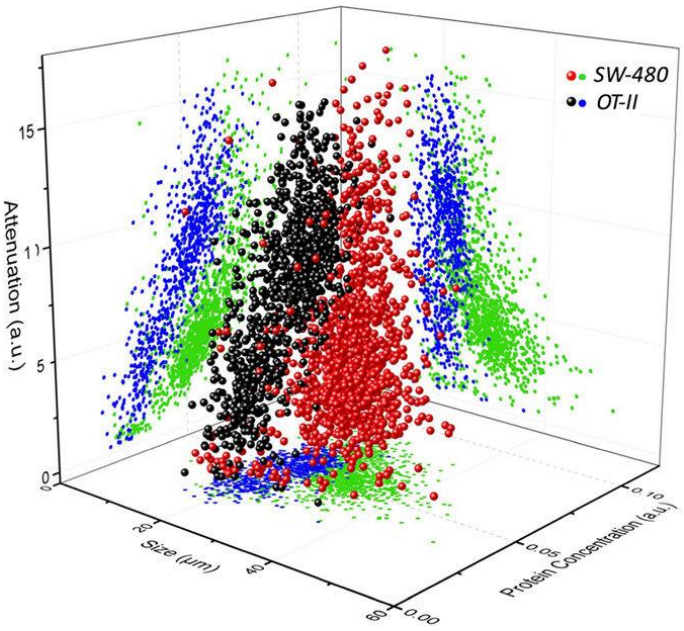
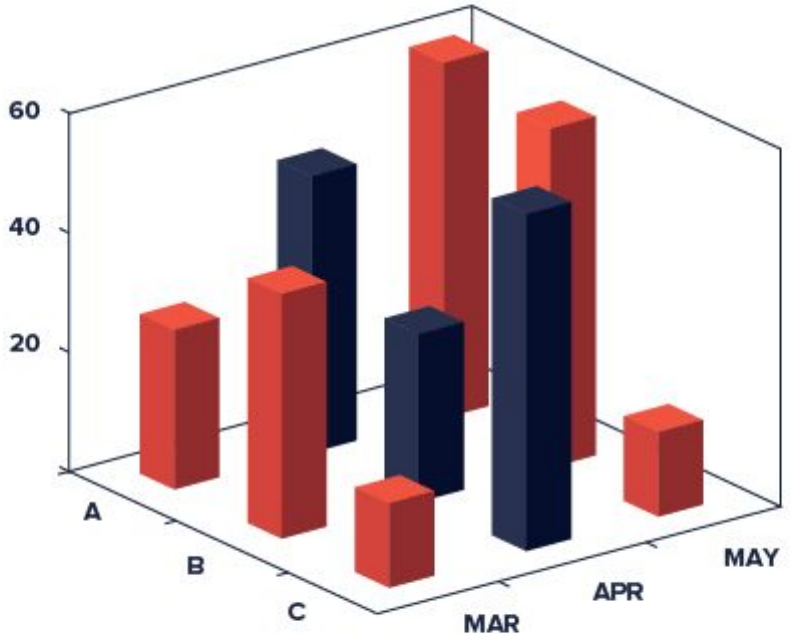
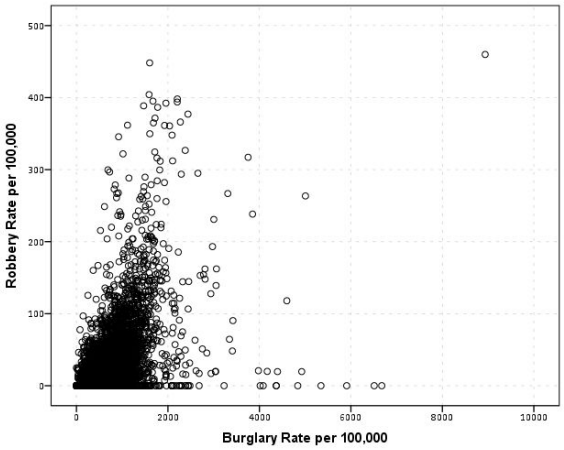
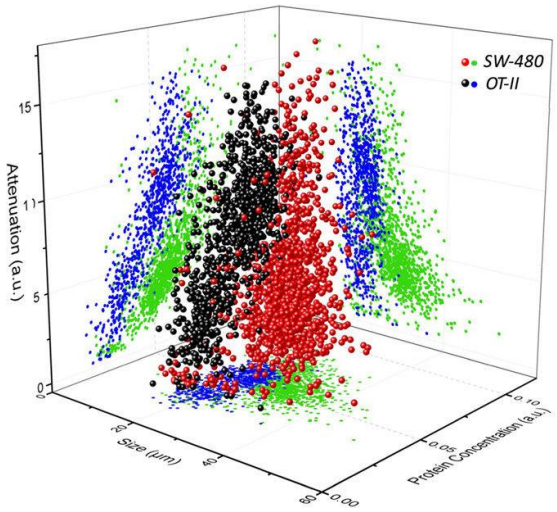
3 Dimensions...





...4 Dimensions?

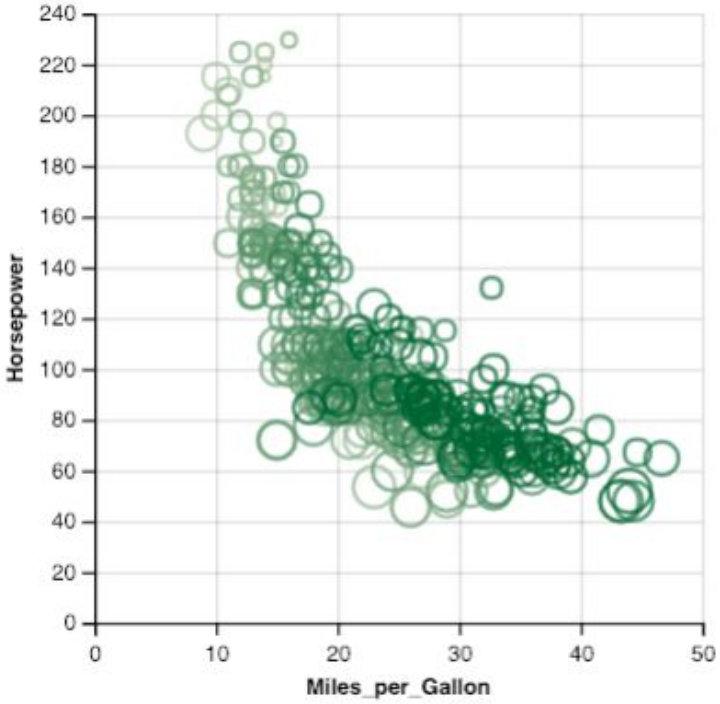




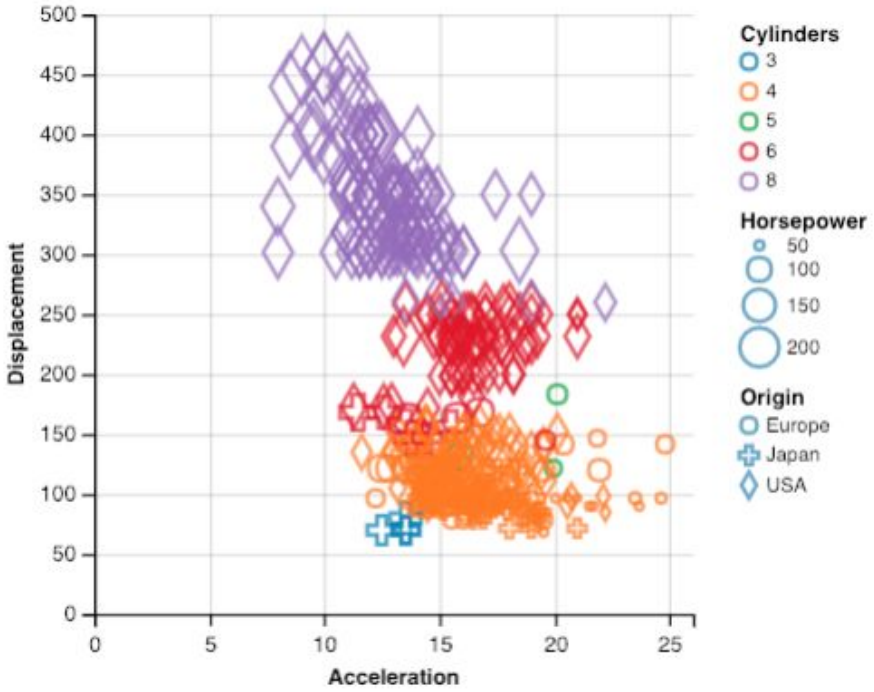
?

2-dimensional **3-dimensional** **3-dimensional**

1. Additional Visual Variable(s)

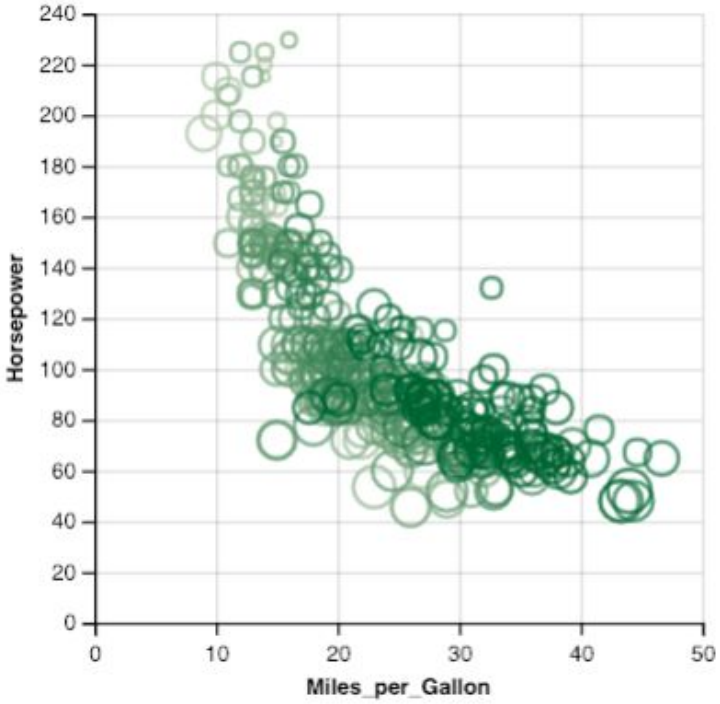


2-dimensional
+ 1 dimension (size)



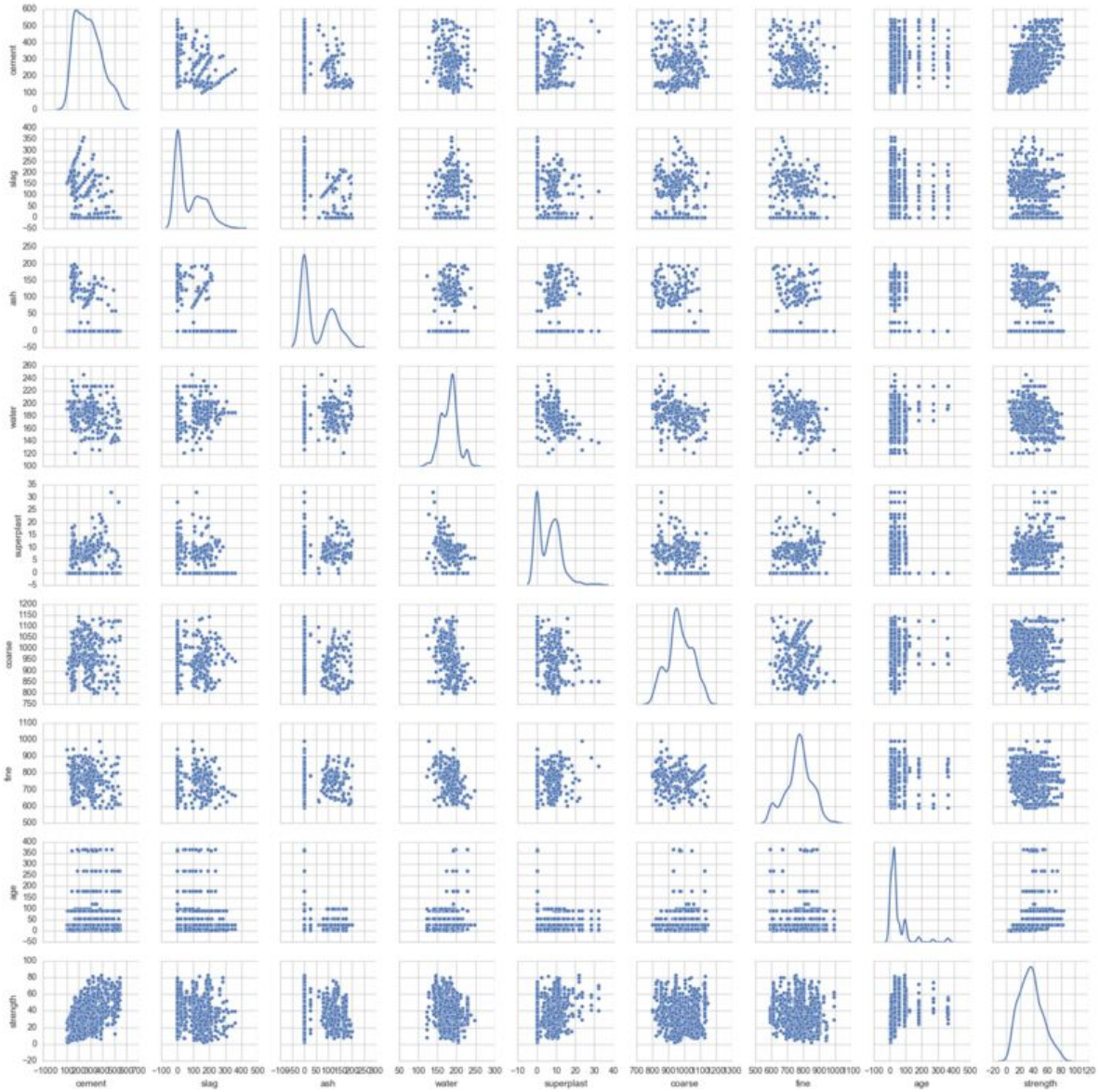
2-dimensional
+ 3 dimension (shape + color + size)

1. Additional Visual Variable(s)



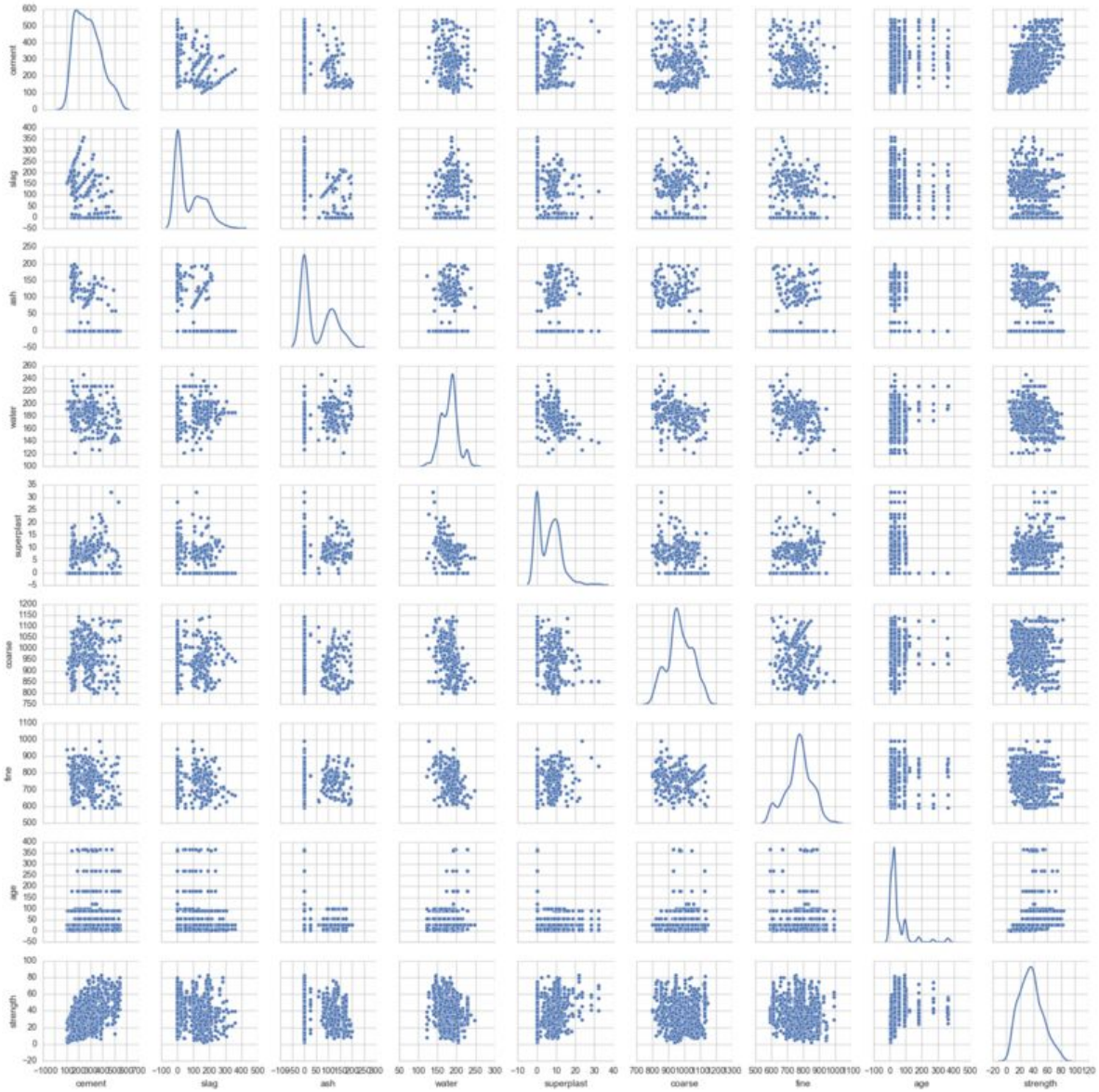
2-dimensional
\+ 1 dimension (size)

2. Pairwise comparison: **Scatterplot Matrix**



+ Scalable
+ Provides overview
+ Can use additional visualizations
+ Easy to understand and decode

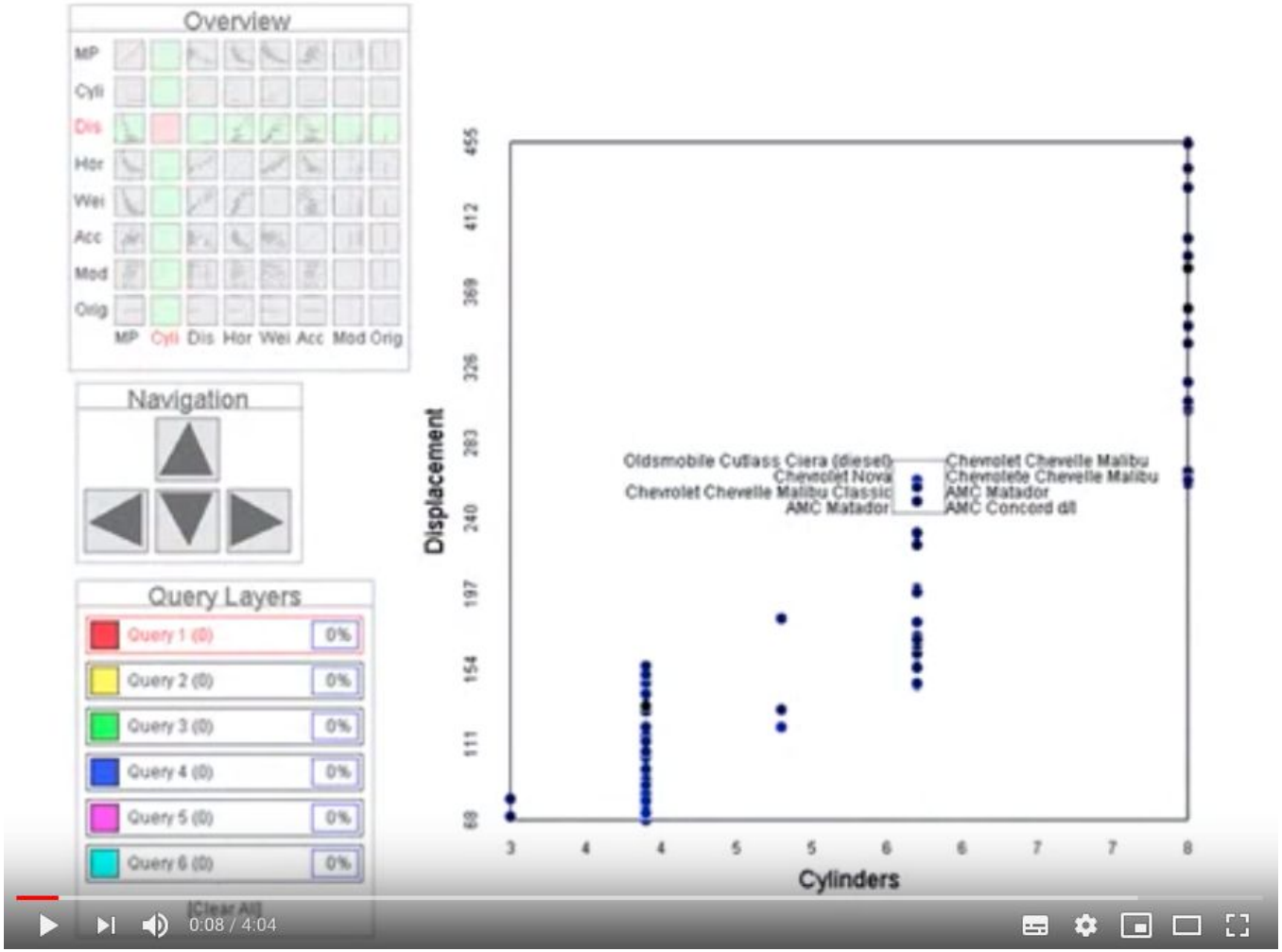
2. Pairwise comparison: **Scatterplot Matrix**



+ Scalable
+ Provides overview
+ Can use additional visualizations
+ Easy to understand and decode

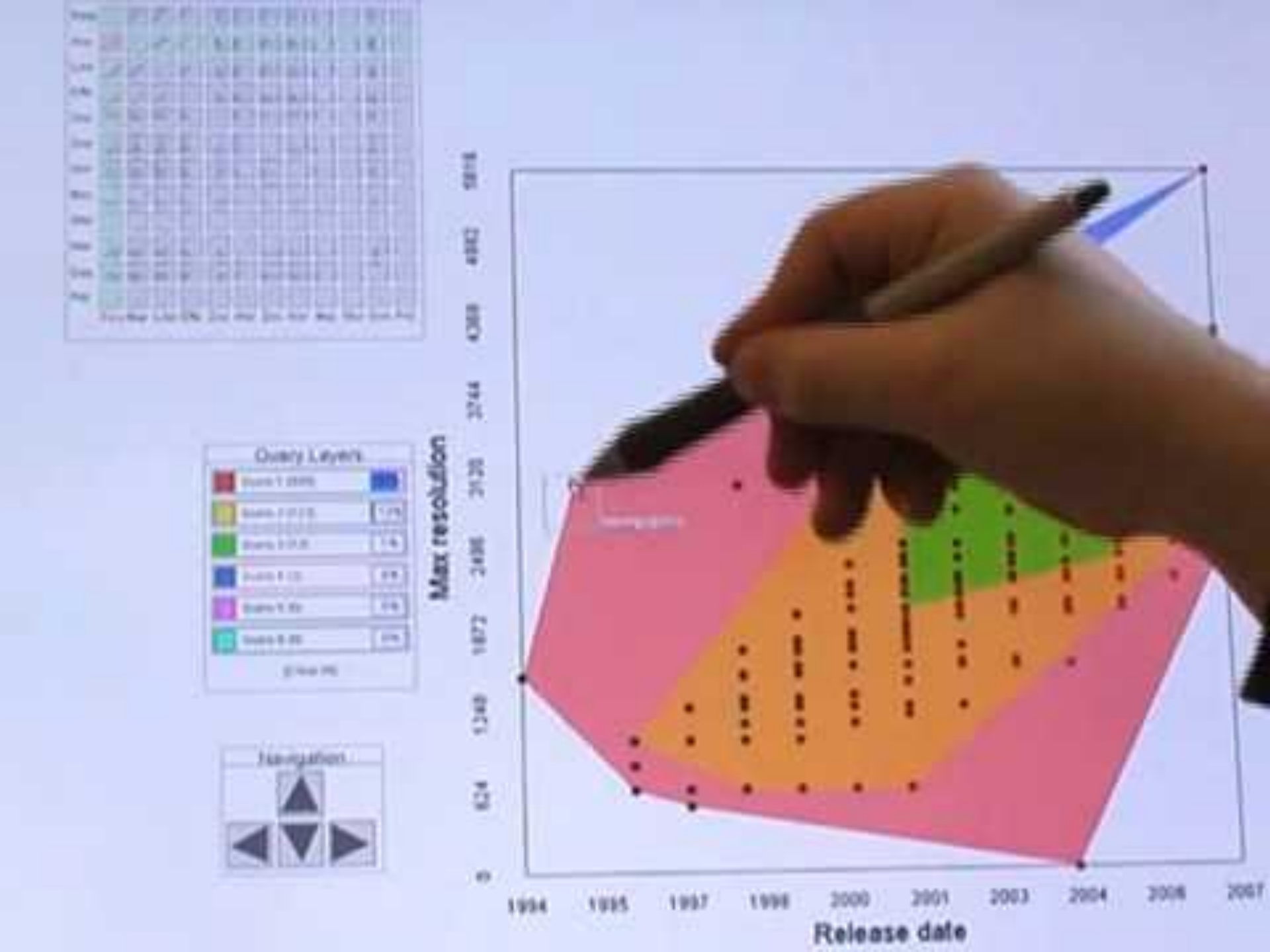
- Many dimensions require pan+zoom

Scatterplot Navigation: **Scatterdice**

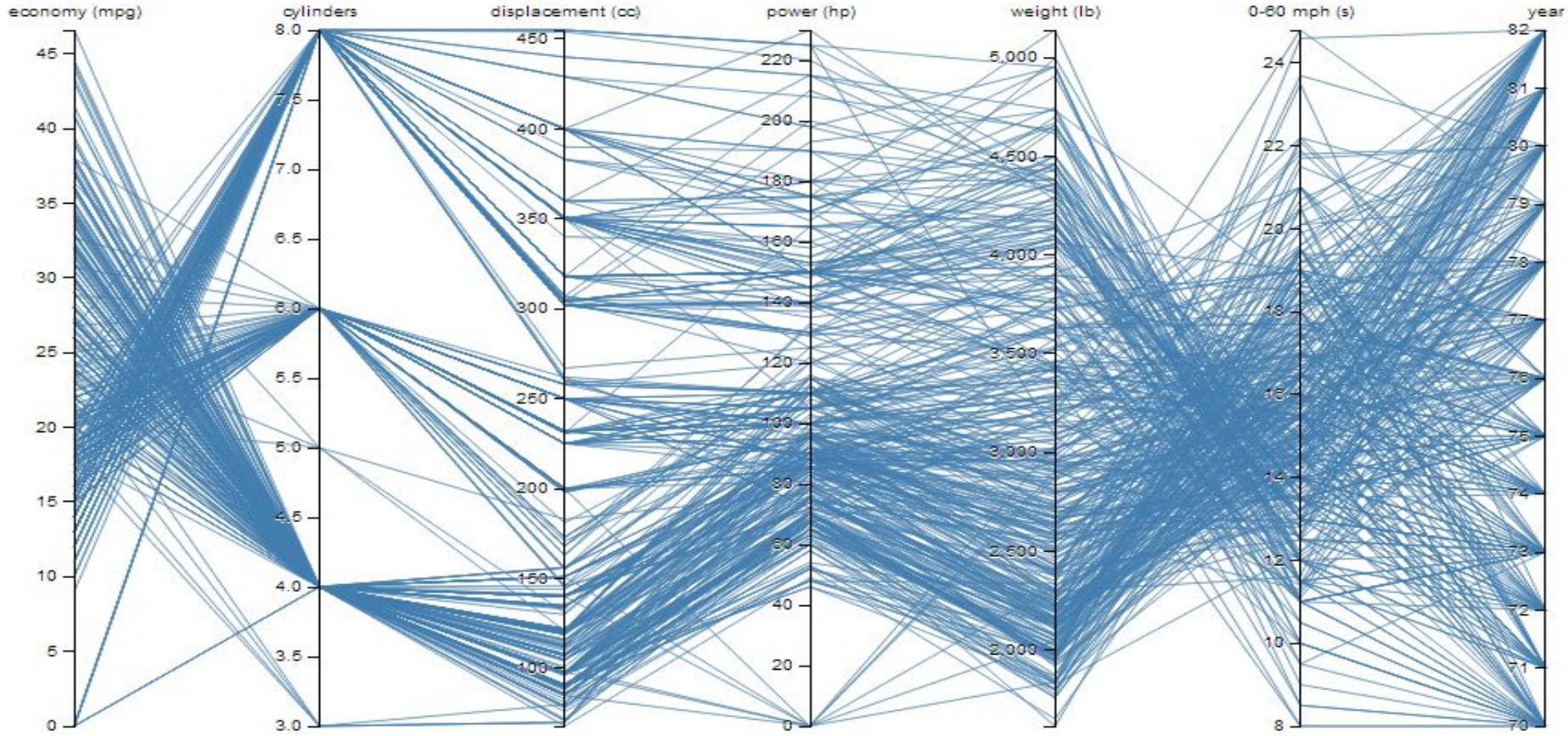


https://www.youtube.com/watch?v=2bYIRcO-gwg

Elmqvist, Niklas, Pierre Dragicevic, and Jean-Daniel Fekete. "Rolling the dice: Multidimensional visual exploration using scatterplot matrix navigation." *IEEE transactions on Visualization and Computer Graphics* 14.6 (2008): 1539-1148.


Query Layers
Navigation
Max resolution
0
624
1248
1872
2496
3120
3744
4368
4992
5616
1994
1995
1997
1998
2000
2001
2003
2004
2006
2007
Release date

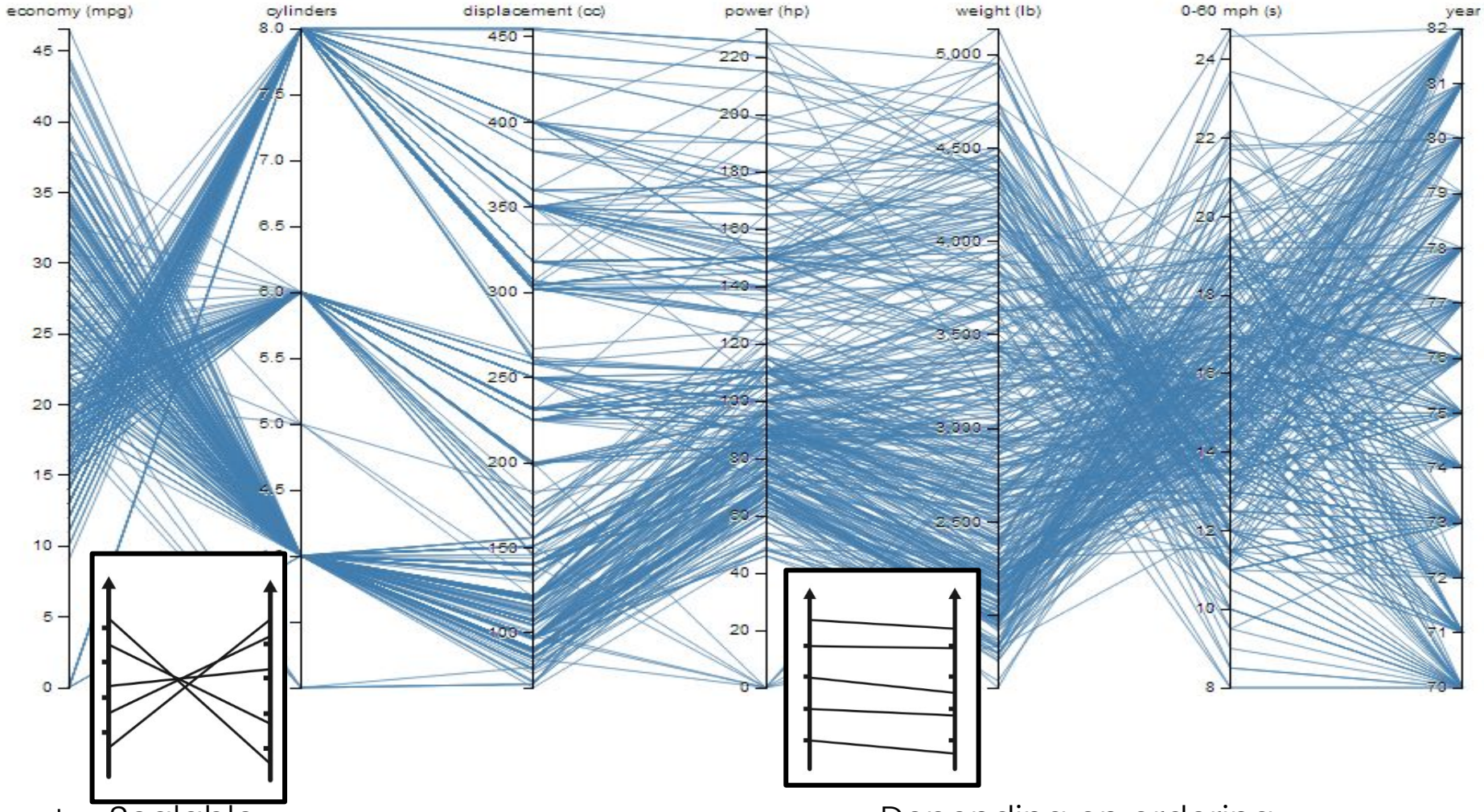
4. Parallel Coordinates Plot (PCP)



4. Parallel Coordinates Plot (PCP)

+ Scalable
+ Consise
+ Good overview

4. Parallel Coordinates Plot (PCP)

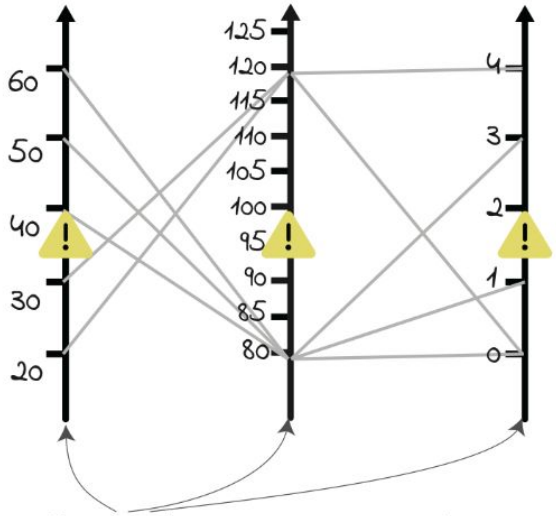


+ Scalable
+ Consise
+ Good overview

- Depending on ordering
- Can suffer from clutter
- Visual path following can be hard

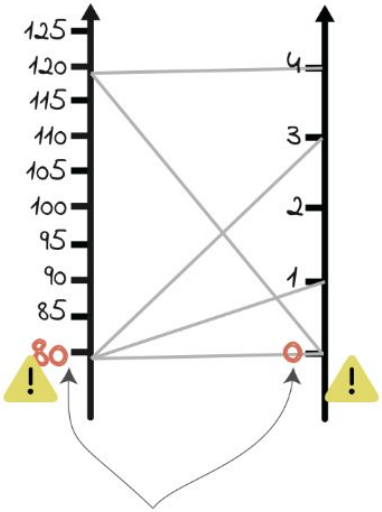
PCPs Pitfalls

Axis scales



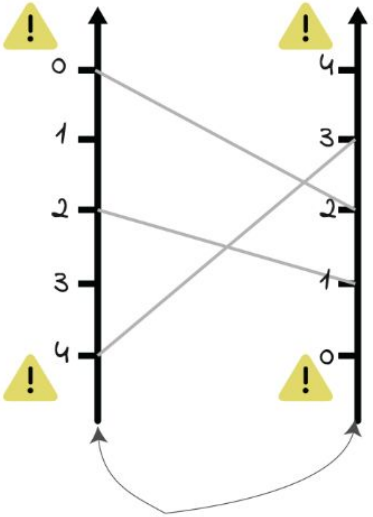
Different dimensions usually have different scales and units.

Truncated axes



Values on axes can start form values other than '0'.

Axes order



Values on axes can be either decending or acending.

https://visualizationcheatsheets.github.io/pcp.html

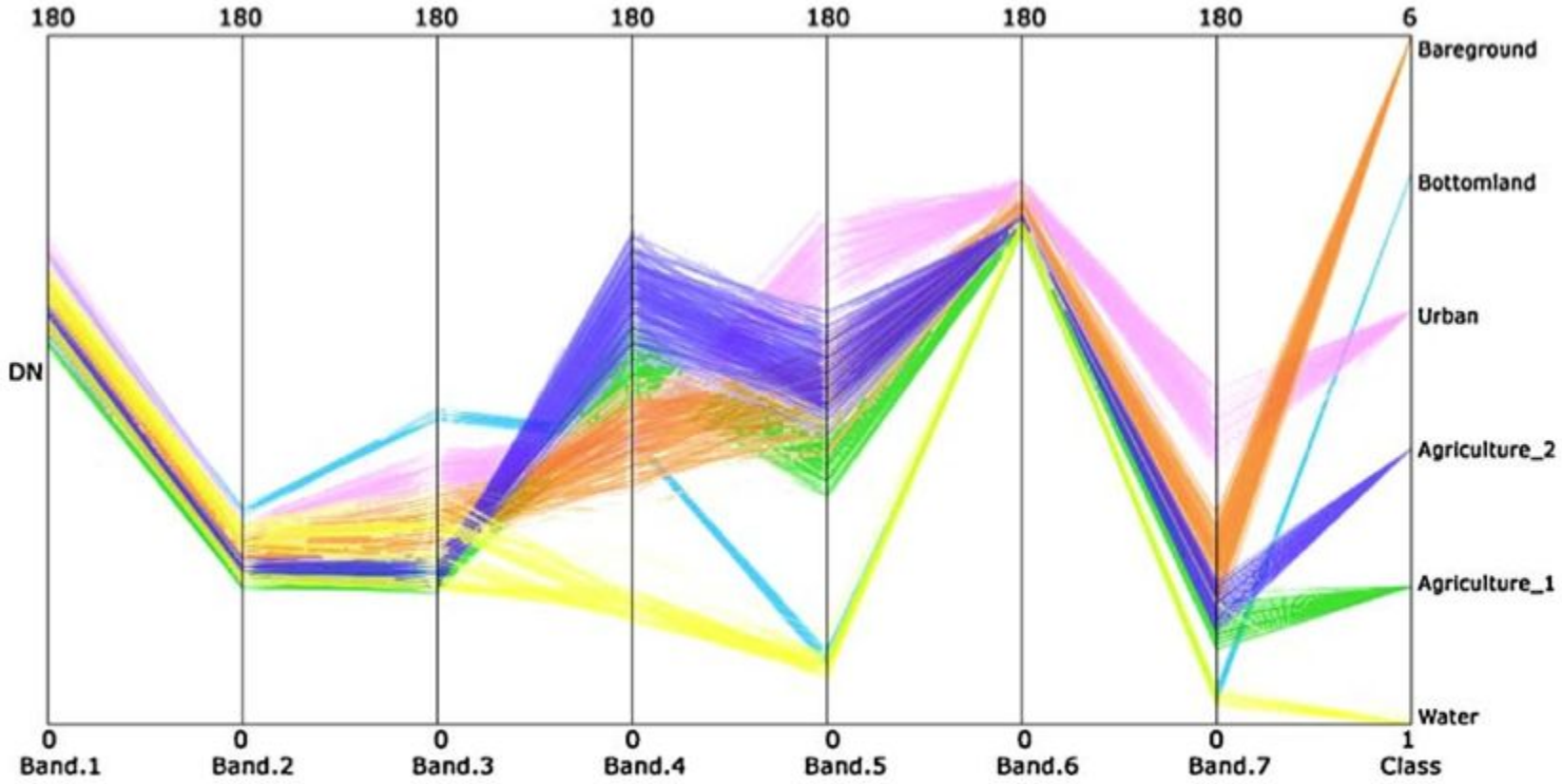
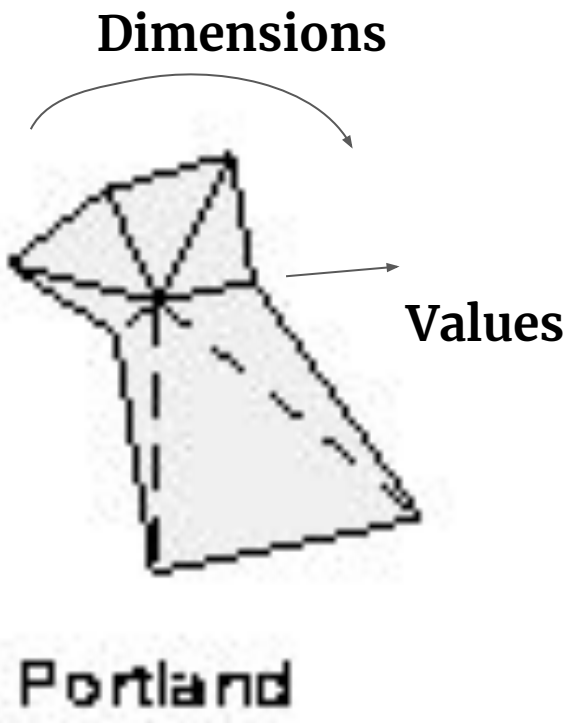


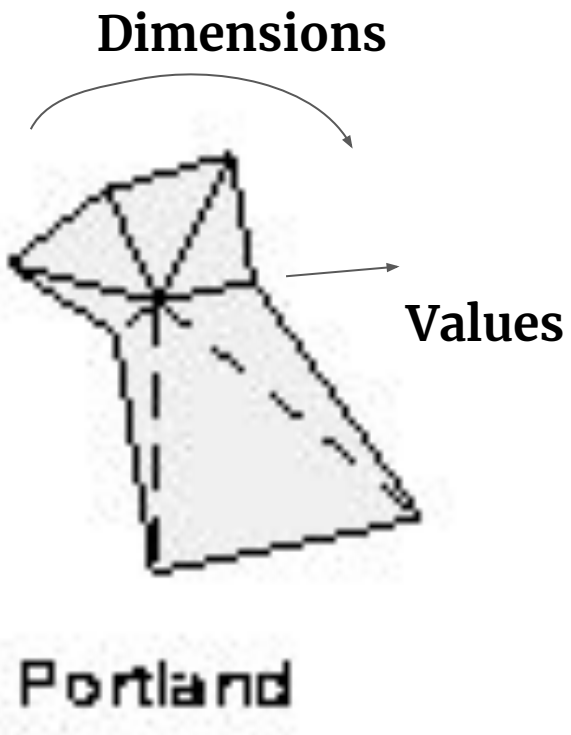
Fig. 3. PCP of sample data.

3. Glyphs: Star glyphs



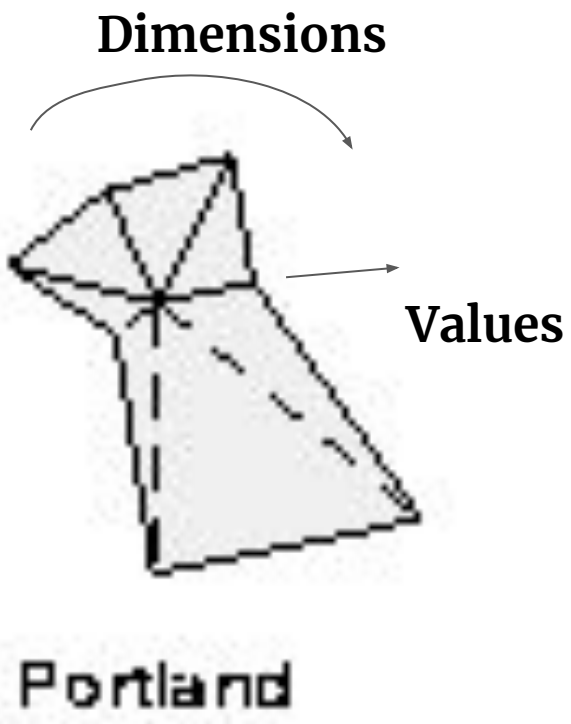
1) Data glyphs are [a] technique, in which single data points are encoded individually by assigning their dimensions to one or more marks and their visual variables

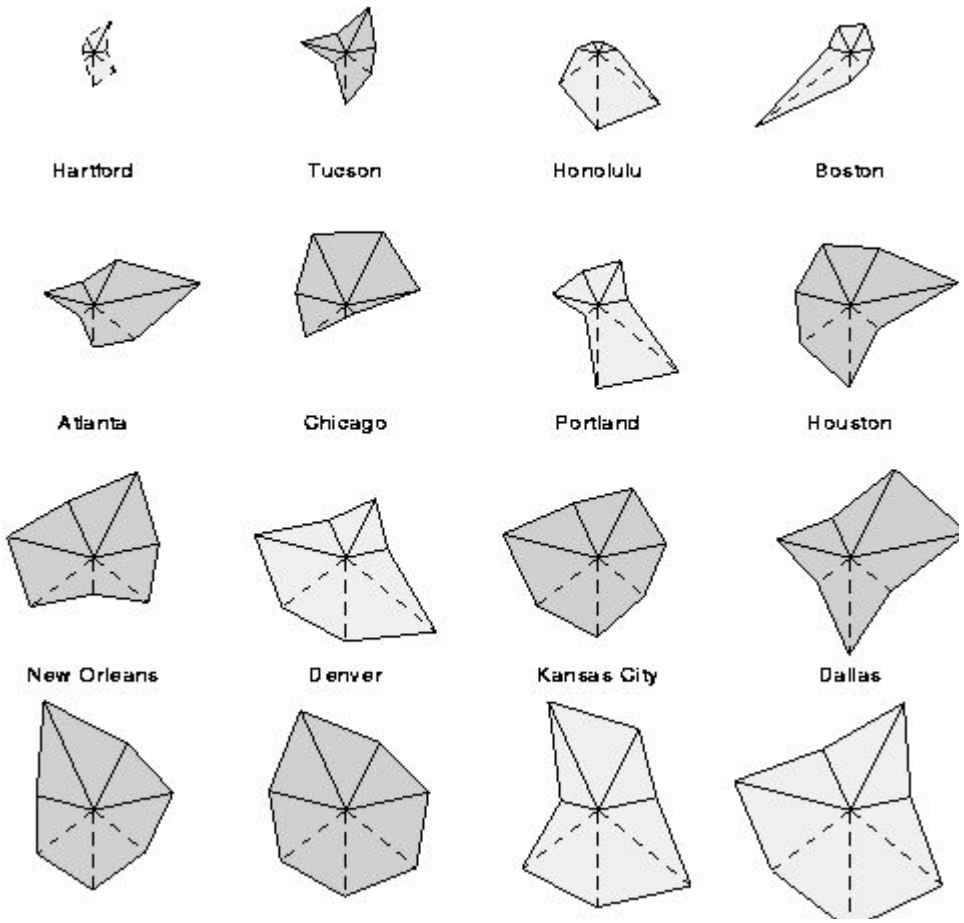
3. Glyphs: Star glyphs



1) Data glyphs are [a] technique, in which single data points are encoded individually by assigning their dimensions to one or more marks and their visual variables
2) Each glyph can be placed spatially independently from others

3. Glyphs: Star glyphs

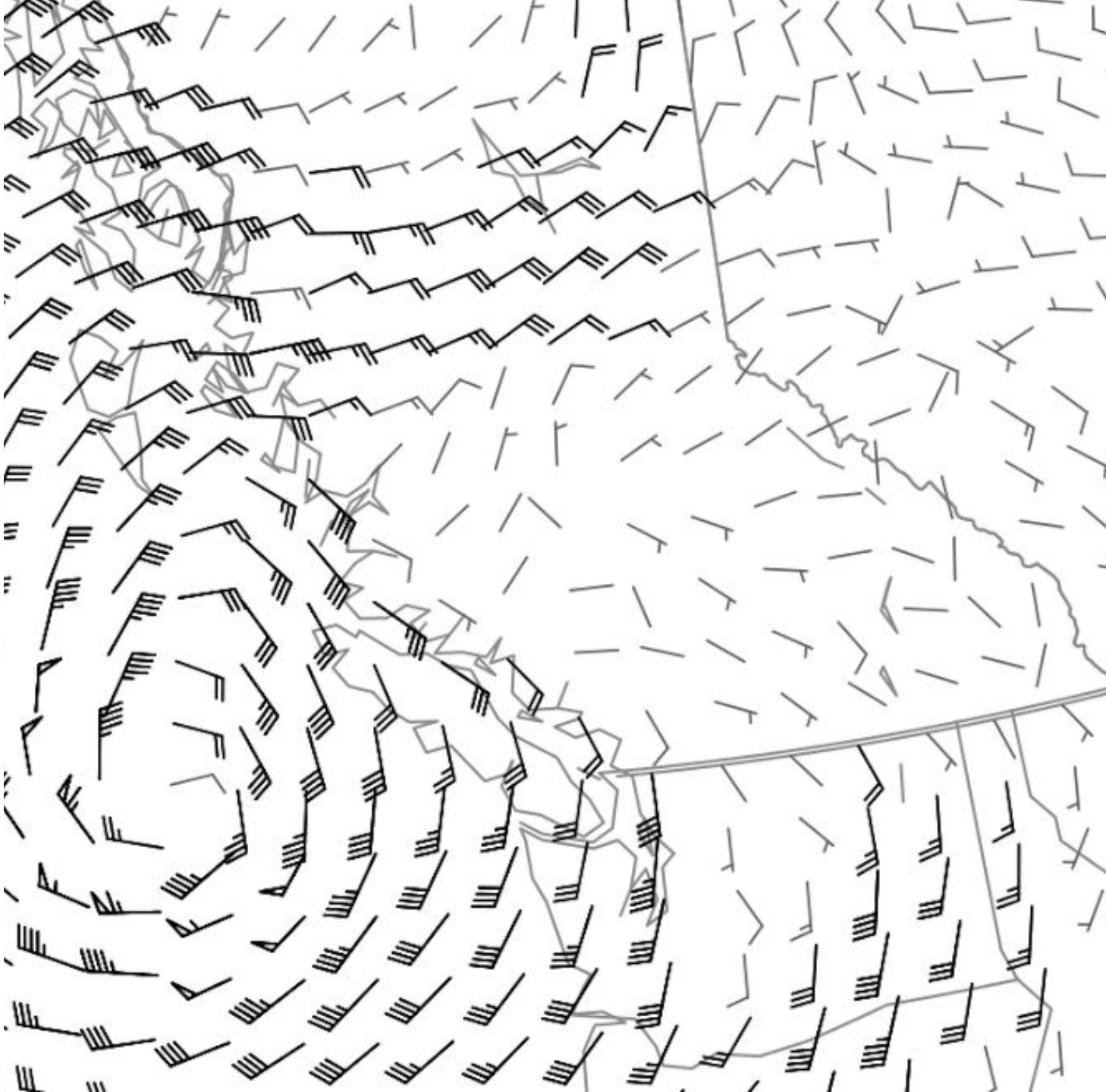




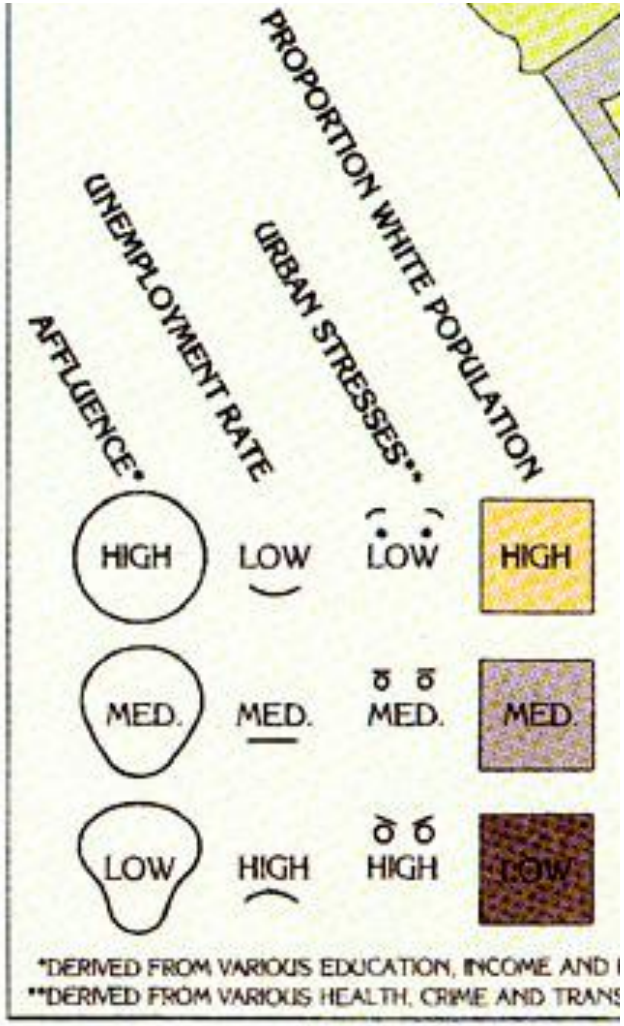
+ Comparison
+ Outlier, Trends
+ Individual values

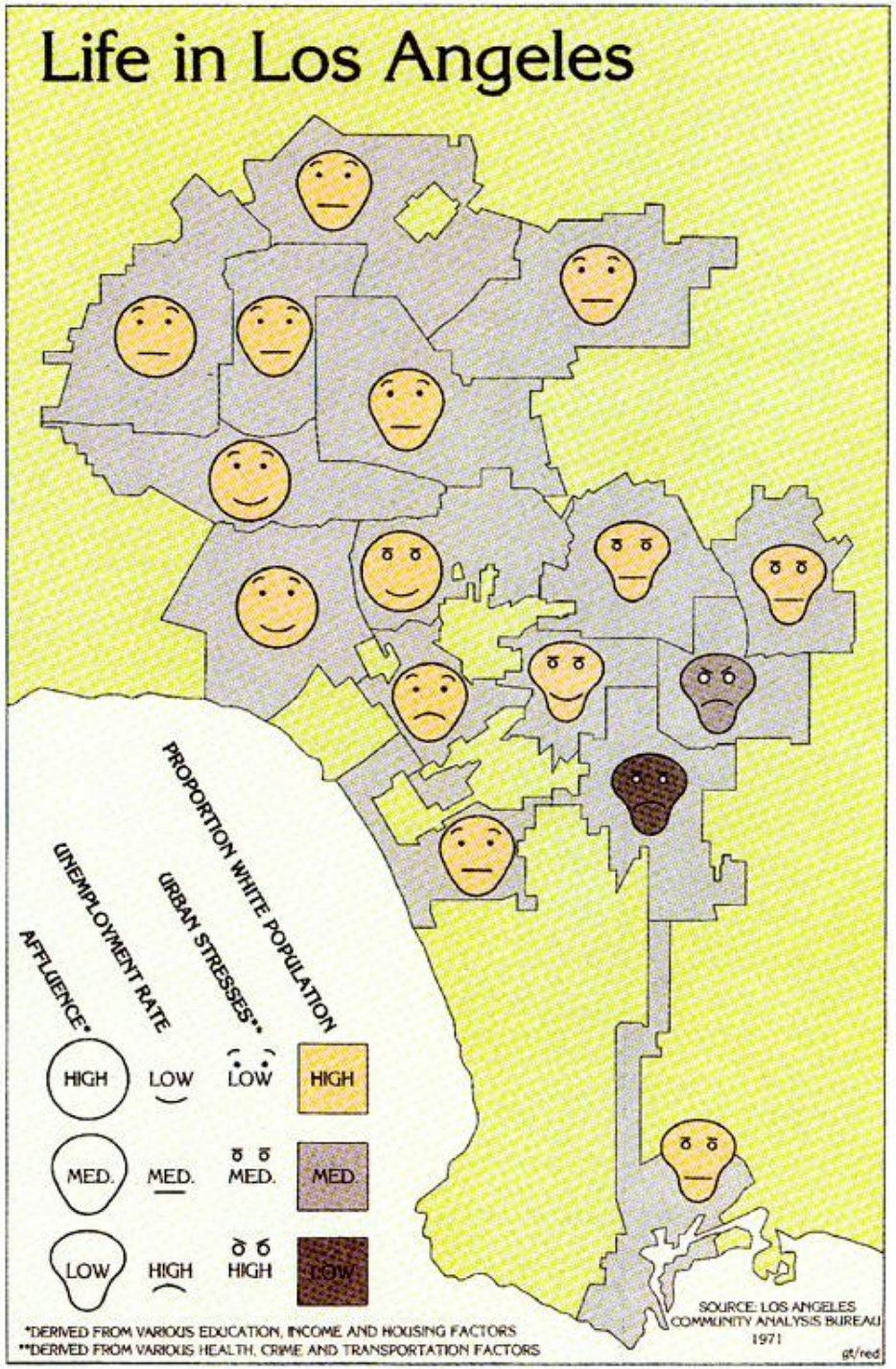
- Precise comparison
- Cluster dimensions

Weather glyphs



Chernoff Faces
(Glyphs for geodata)

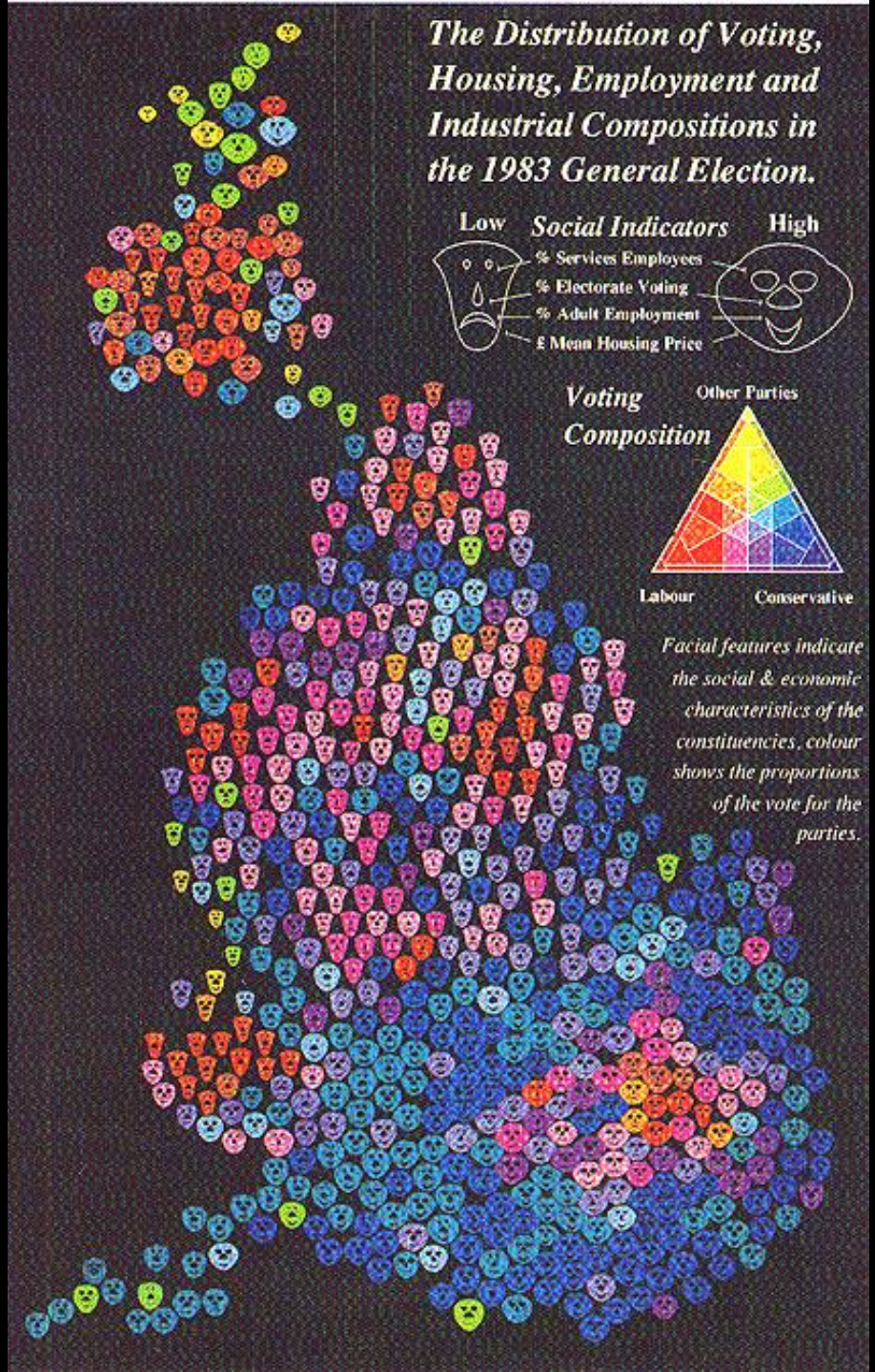




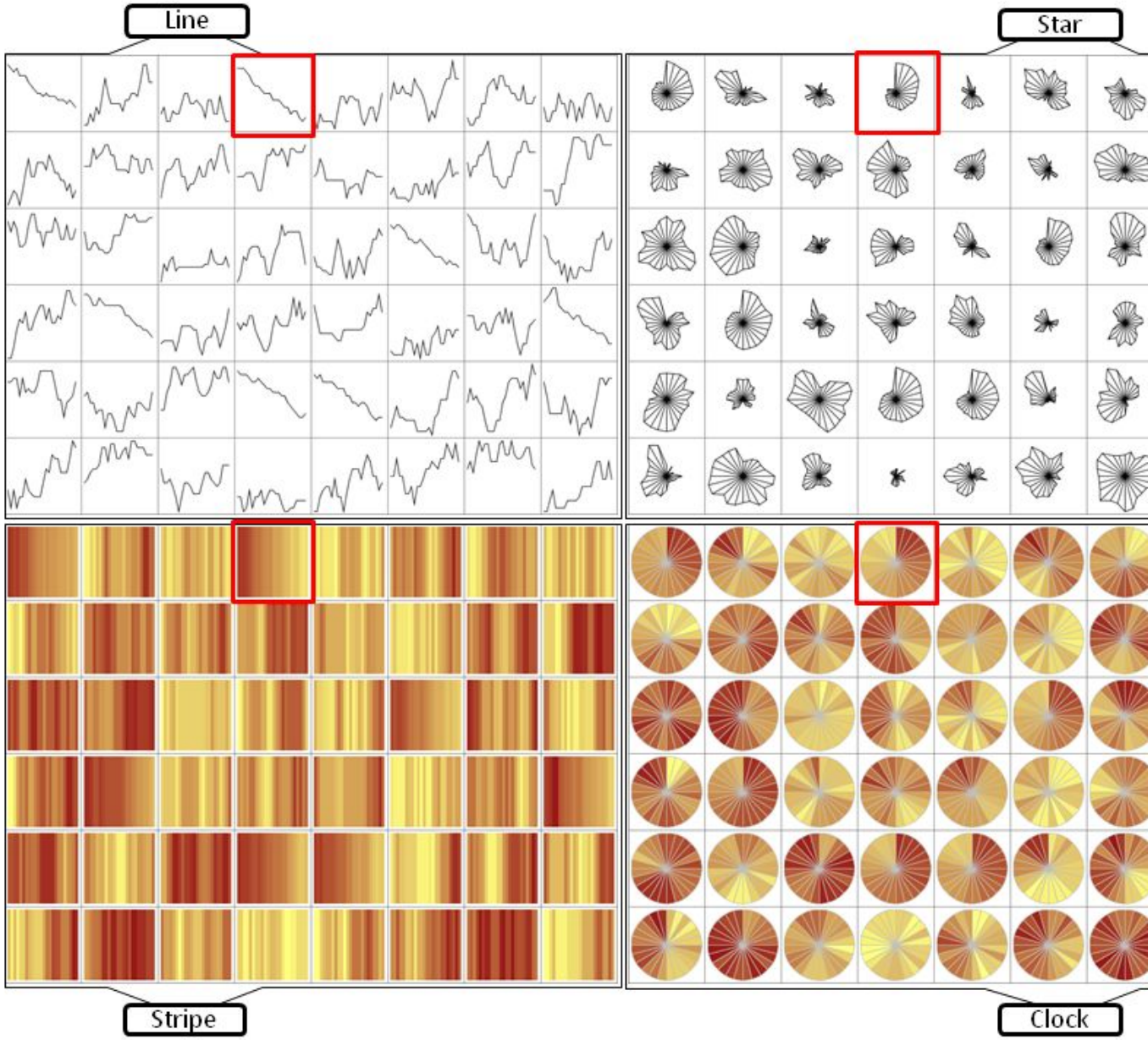
Chernoff Faces
(Glyphs for geodata)

+ Individual values
+ Spatial correlation

- Some vis-variables are more prominent
- Some vis-variables are hard to perceive and estimate



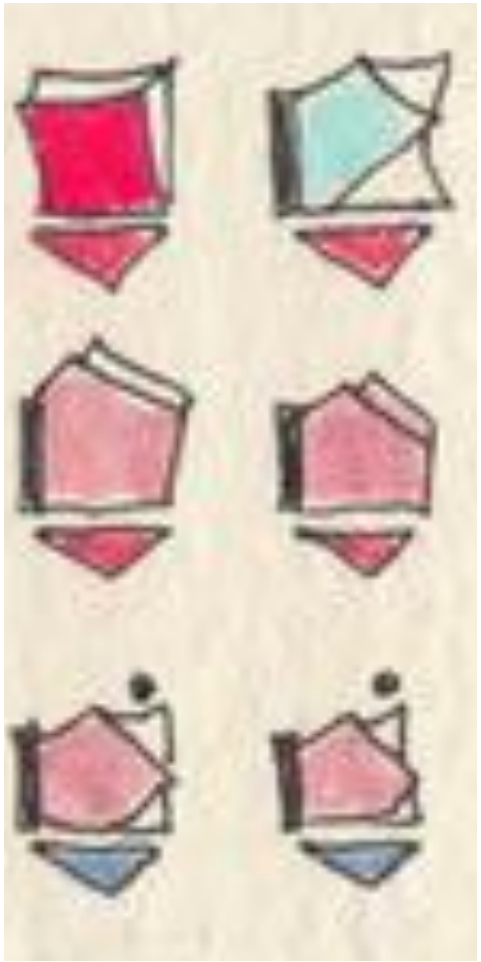
Glyphs for Temporal data

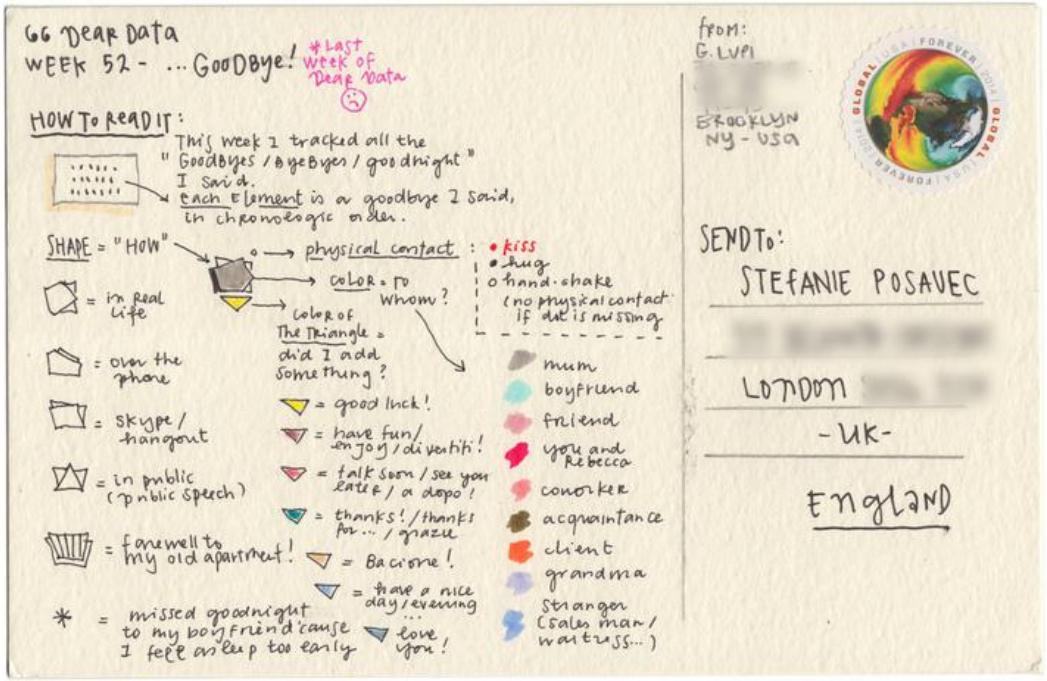


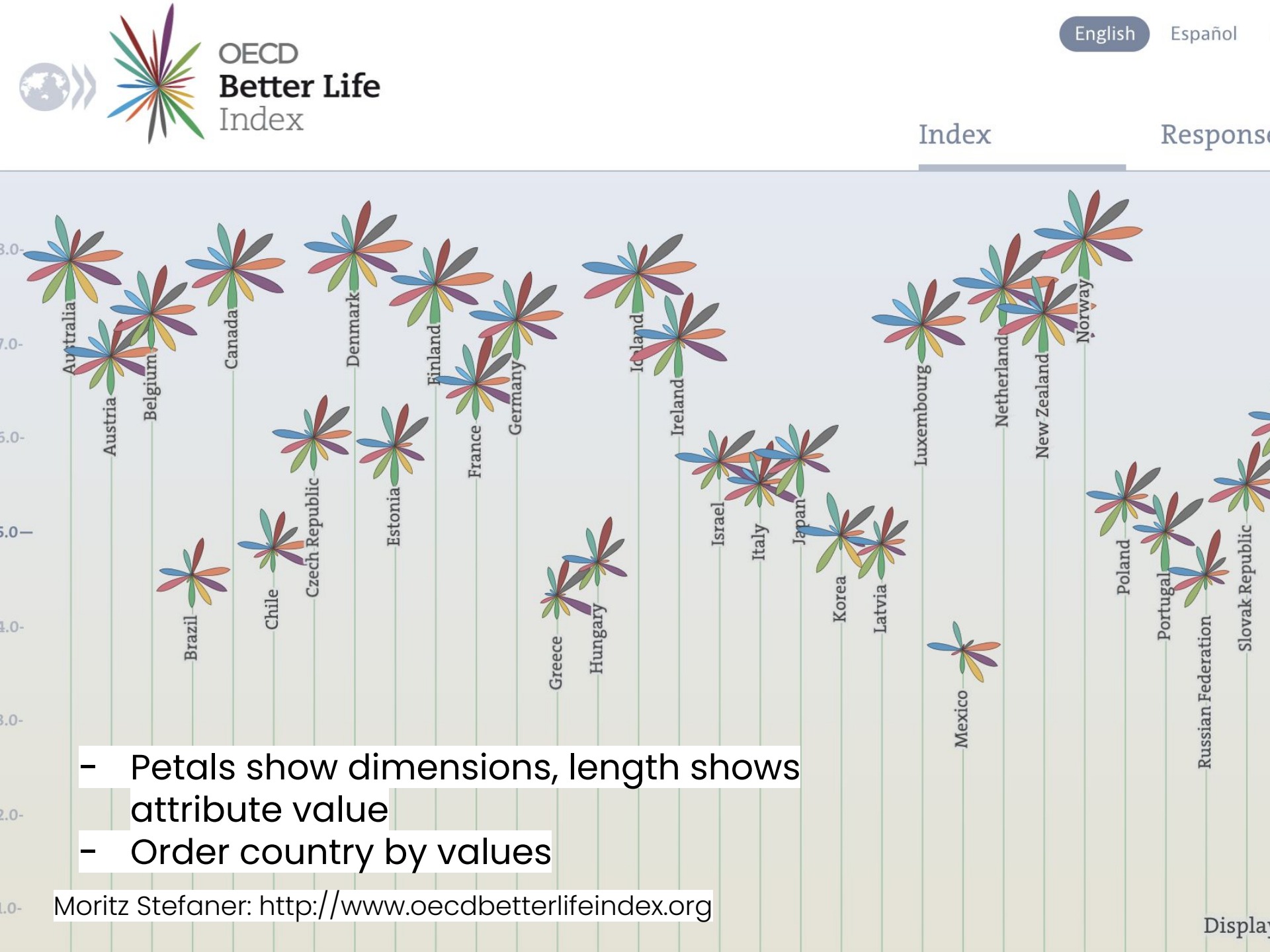
- Line glyhs for trends and peaks
- Radial for value look-up

Fuchs, Johannes, et al. "Evaluation of alternative glyph designs for time series data in a small multiple setting." *Proceedings of the SIGCHI conference on human factors in computing systems*. 2013.

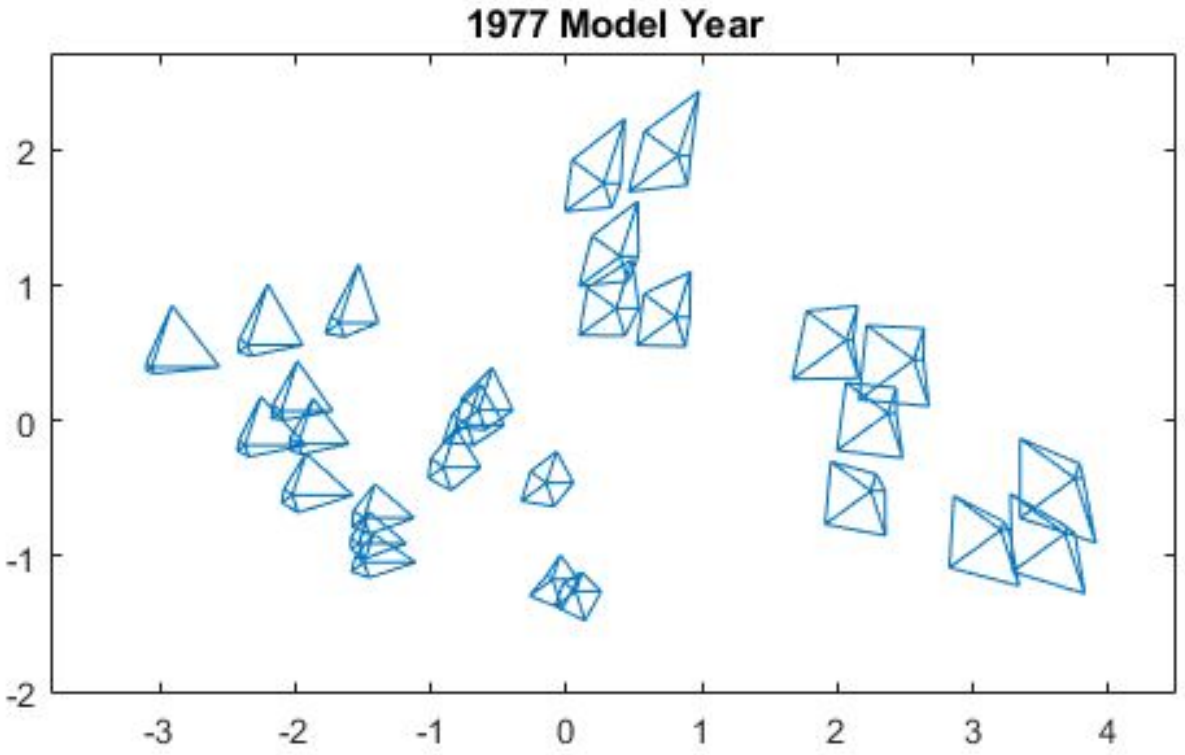
Dear Data
(fantastic glyphs)



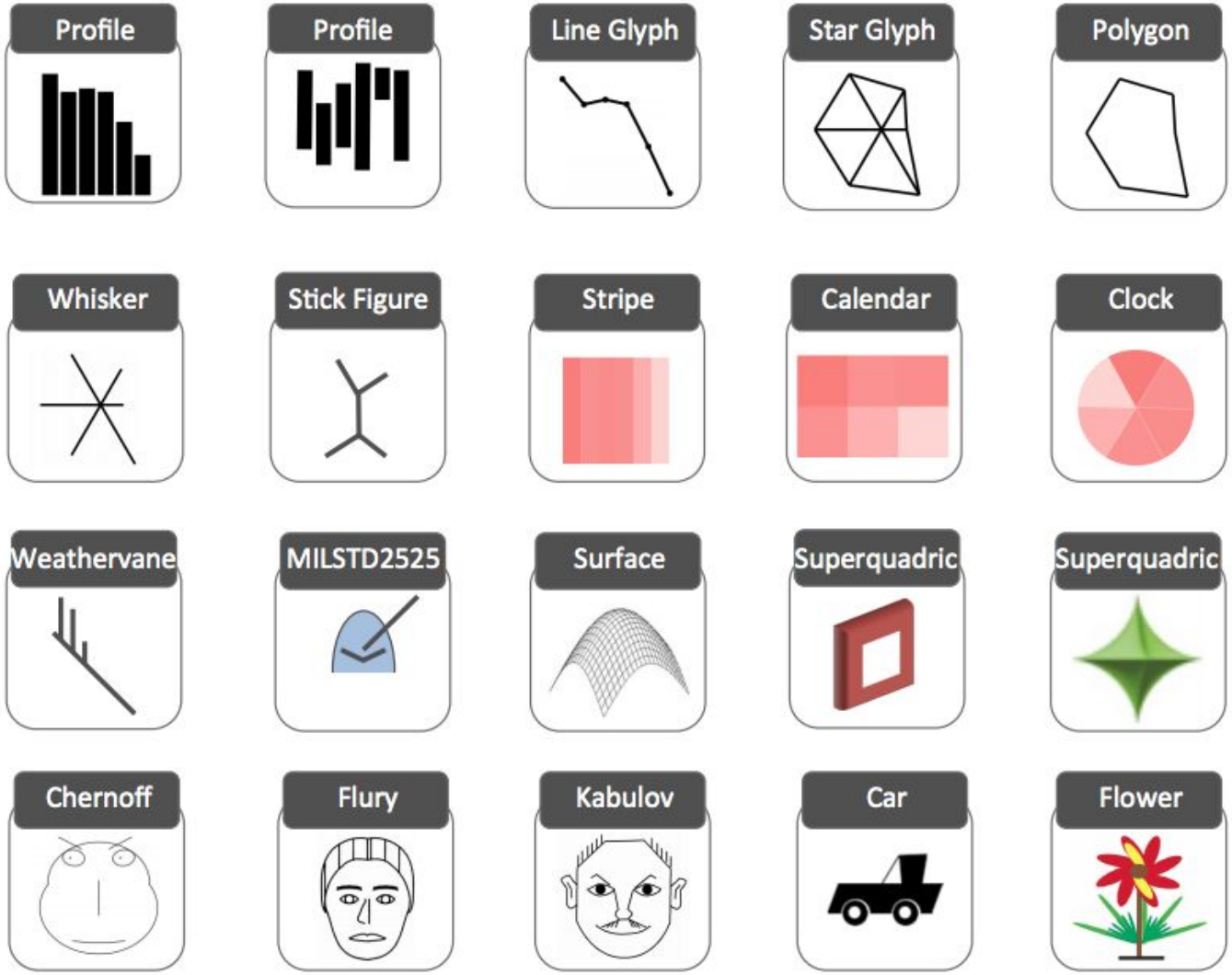



OECD
Better Life
Index
English
Español
Index
Respons
Australia
Austria
Belgium
Brazil
Canada
Chile
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Iceland
Ireland
Israel
Italy
Japan
Korea
Latvia
Luxembourg
Mexico
Netherland
New Zealand
Norway
Poland
Portugal
Russian Federation
Slovak Republic
- Petals show dimensions, length shows attribute value
- Order country by values
Moritz Stefaner: http://www.oecdbetterlifeindex.org

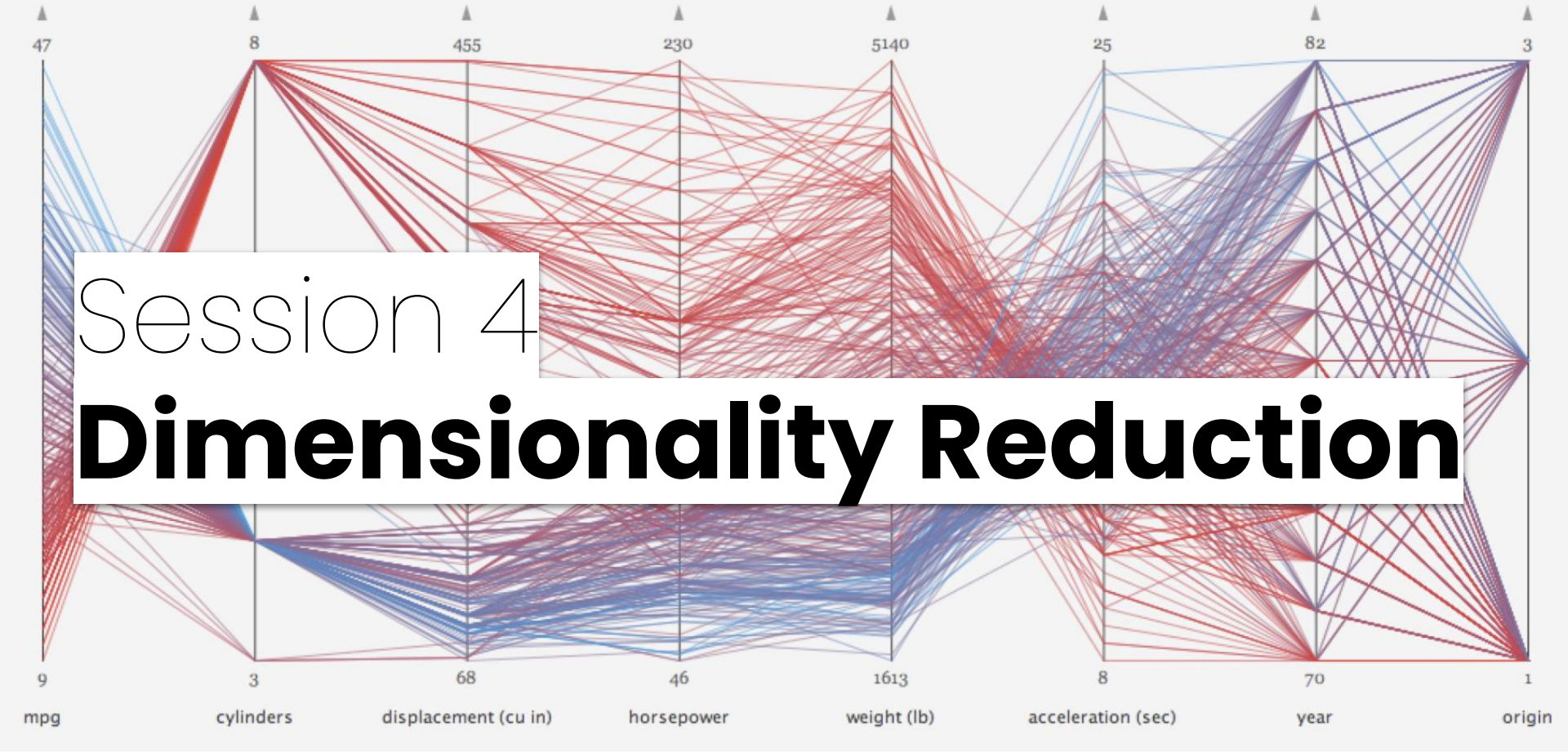
Glyphs in Scatterplots



Glyph Design



Fuchs, Johannes, et al. "A systematic review of experimental studies on data glyphs." *IEEE transactions on visualization and computer graphics* 23.7 (2016): 1863-1879.



Session 4

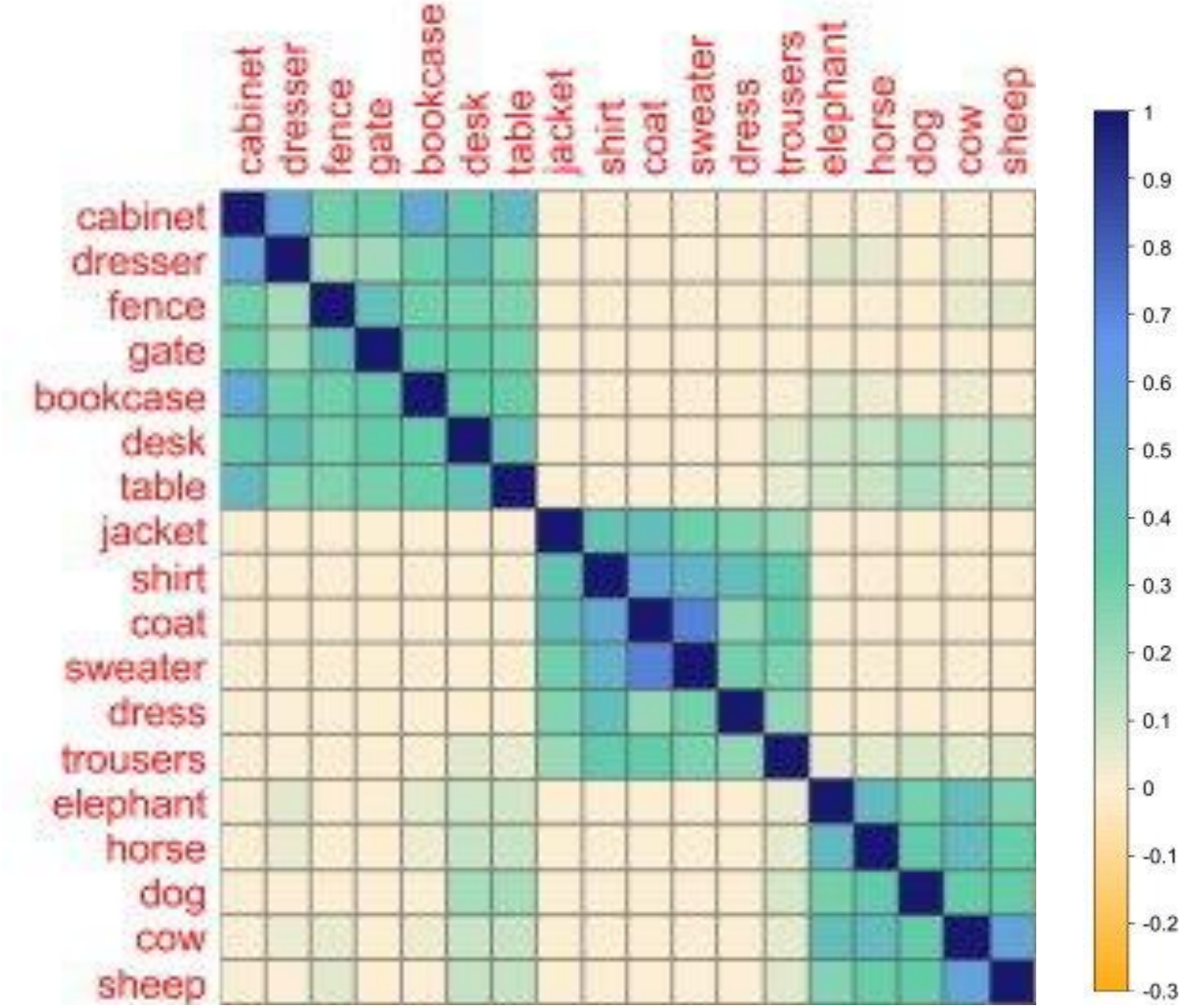
Dimensionality Reduction

Online Course
Data Visualization for Professionals

THE UNIVERSITY of EDINBURGH

Benjamin Bach
June 2022
http://benjbach.me
https://datavis-online.github.io

5. Dimensionality Reduction: Similarity

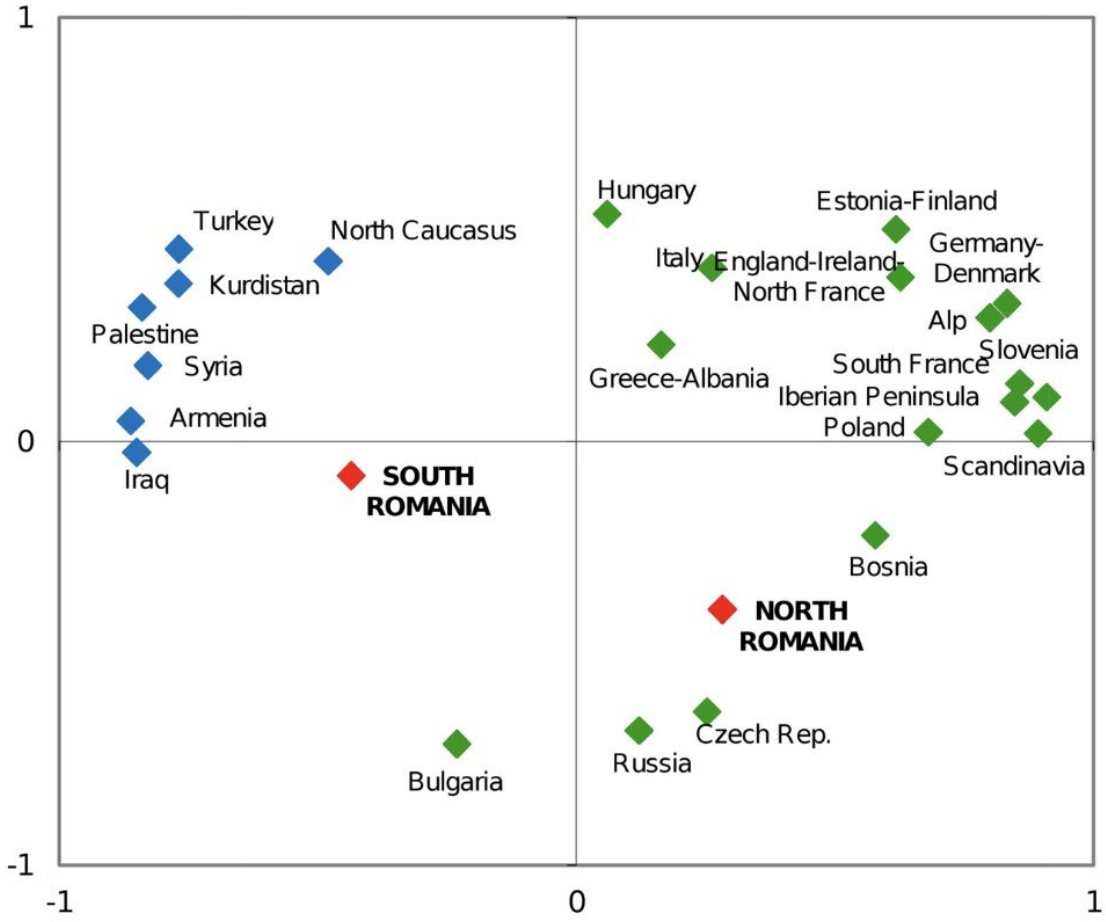


5. Dimensionality Reduction: MDS

Hervella Afonso, Montserrat, et al. "The Carpathian range represents a weak genetic barrier in South-East Europe." (2014).

5. Dimensionality Reduction: MDS

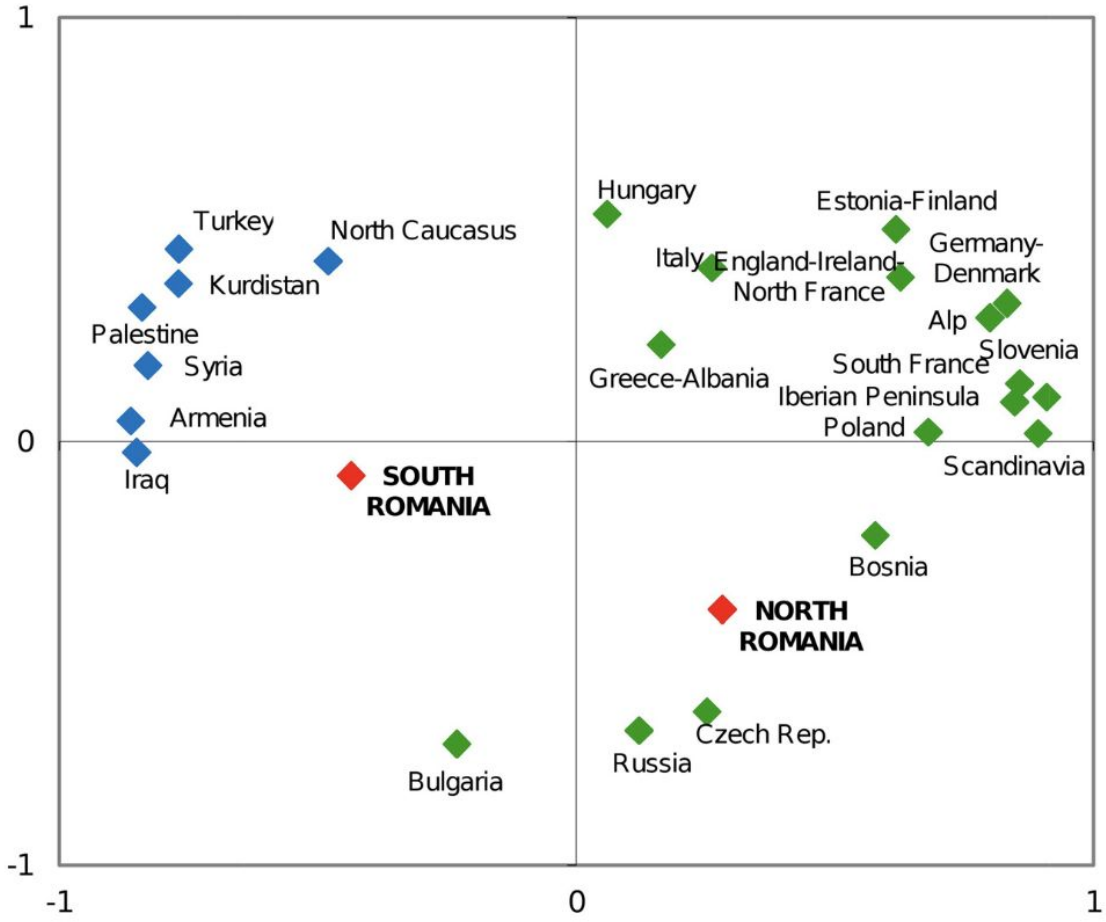
+ Dimension reduction
+ Can be 2D or 3D
+ Visual clustering



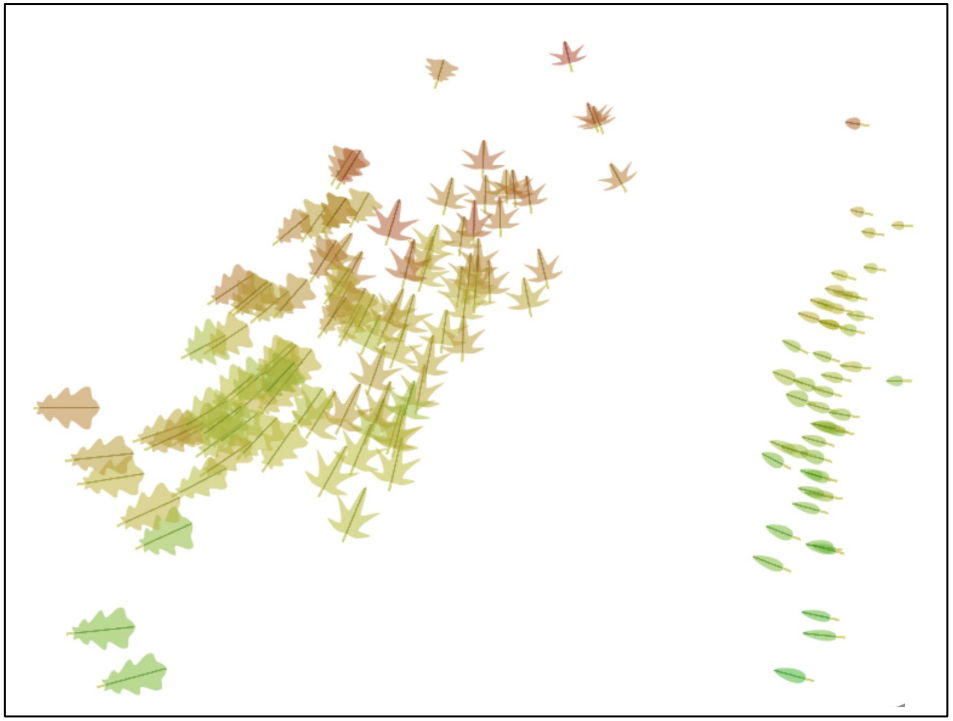
5. Dimensionality Reduction: MDS

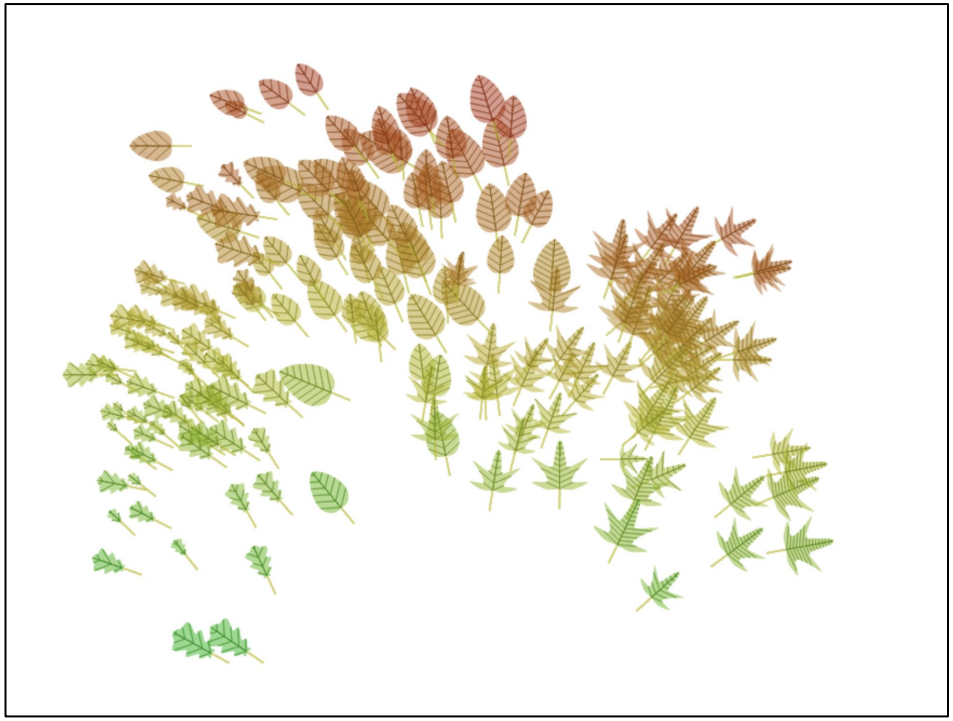
+ Dimension reduction
+ Can be 2D or 3D
+ Visual clustering

- Information loss
- Artifacts: **false neighbors** and **tears**

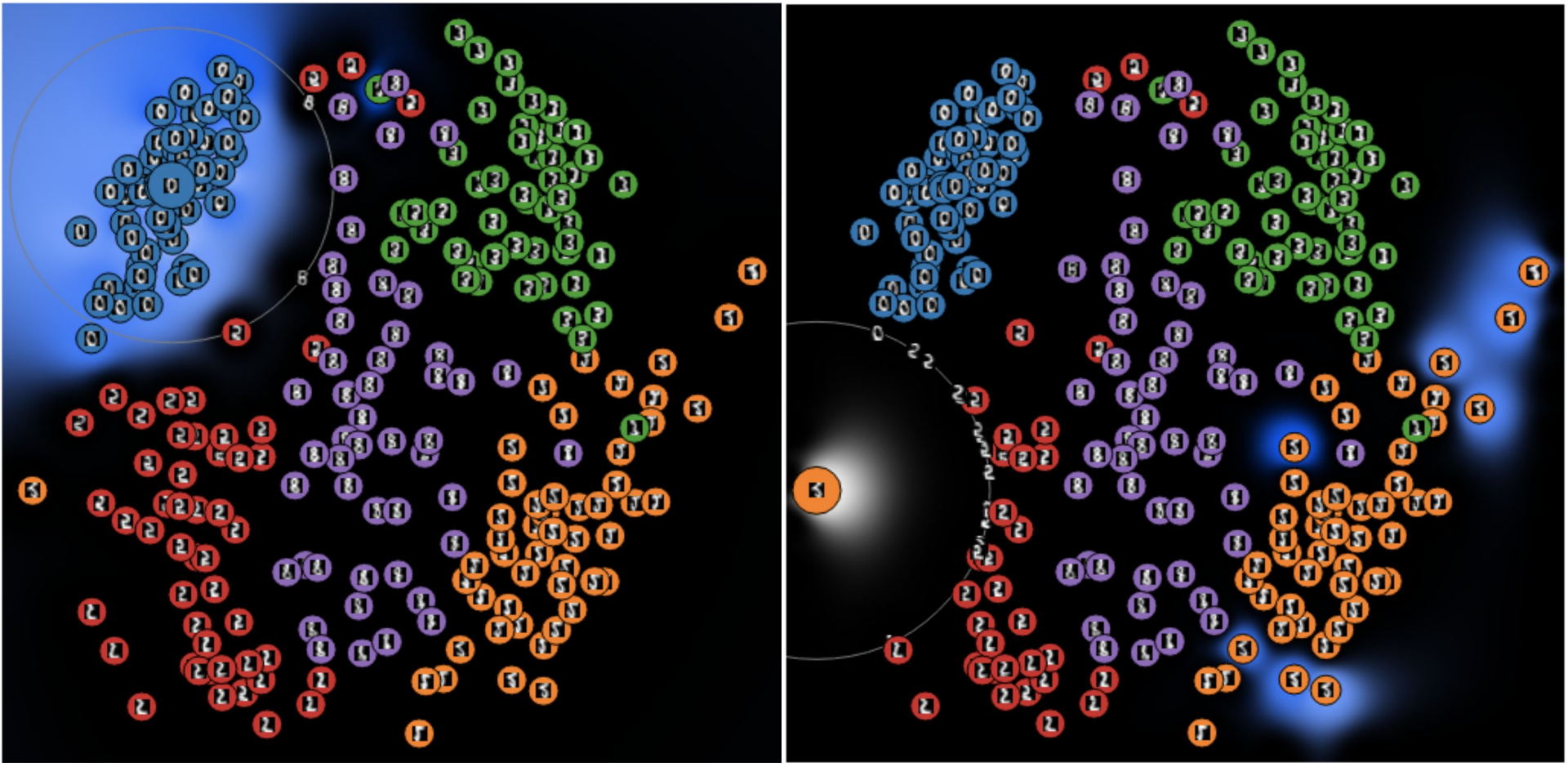


5. Dimensionality Reduction: Glyphs

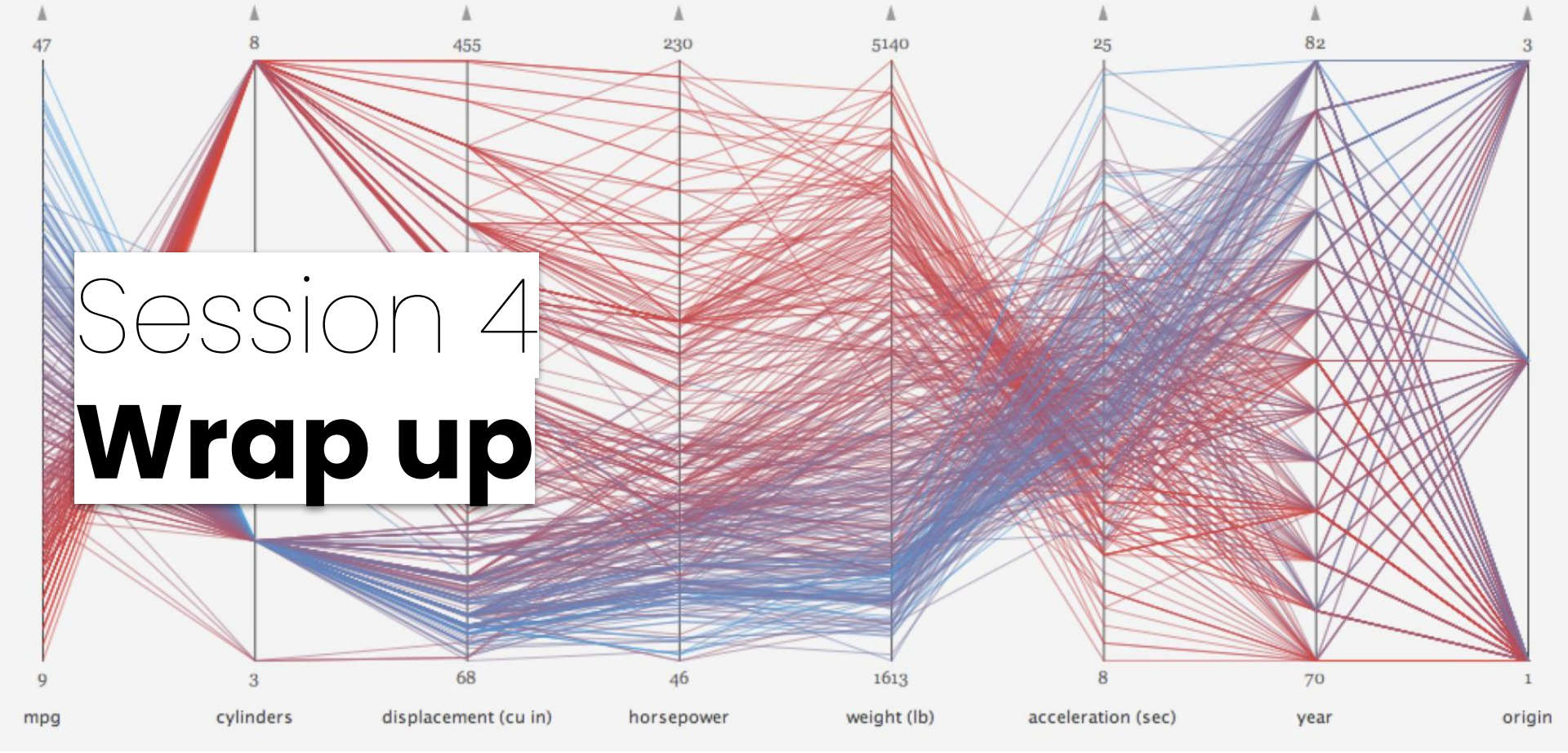




5. Dimensionality reduction: Interaction



Heulot, Nicolas, Michael Aupetit, and Jean-Daniel Fekete. "Proxilens: Interactive exploration of high-dimensional data using projections." *VAMP: EuroVis Workshop on Visual Analytics using Multidimensional Projections*. The Eurographics Association, 2013.



Session 4

Wrap up

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THE UNIVERSITY of EDINBURGH

Benjamin Bach
June 2022
http://benjbach.me
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-- Not for external use --

Outline

How to visualize data with dimensions (many attributes)?

- Low-dimensions
  - Scatterplot, Mekko chart, heatmap, Beeplots
- Higher dimensions (> 2)
  - Visual variables, scatterplot matrix, PCP, glyphs,
- Dimensionality reduction (many!)
  - + glyphs

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Further Readings

- Shneiderman, Ben. "The eyes have it: A task by data type taxonomy for information visualizations." *Proceedings 1996 IEEE symposium on visual languages*. IEEE, 1996.
- Fuchs, Johannes, et al. "A systematic review of experimental studies on data glyphs." *IEEE transactions on visualization and computer graphics* 23.7 (2016): 1863-1879.
- Heinrich, Julian, and Daniel Weiskopf. "State of the Art of Parallel Coordinates." *Eurographics (STARs)*. 2013.
- https://visualizationcheatsheets.github.io/pcp.html