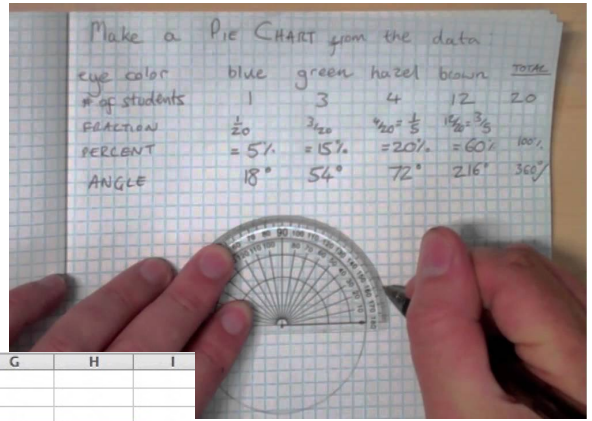
III. ANALYSE

# 10. Data Visualisation and Exploration

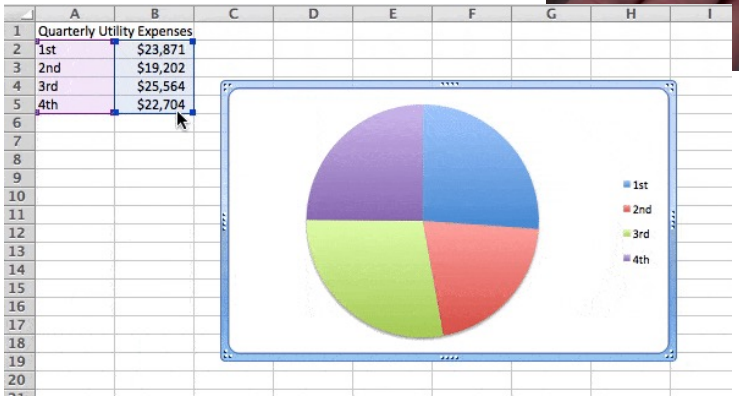
Prof. Dr. Martin Langner

Schreibman / Siemens / Unsworth (2004) Kap. 28;
Jannidis / Kohle / Rehbein (2017) Kap. 23

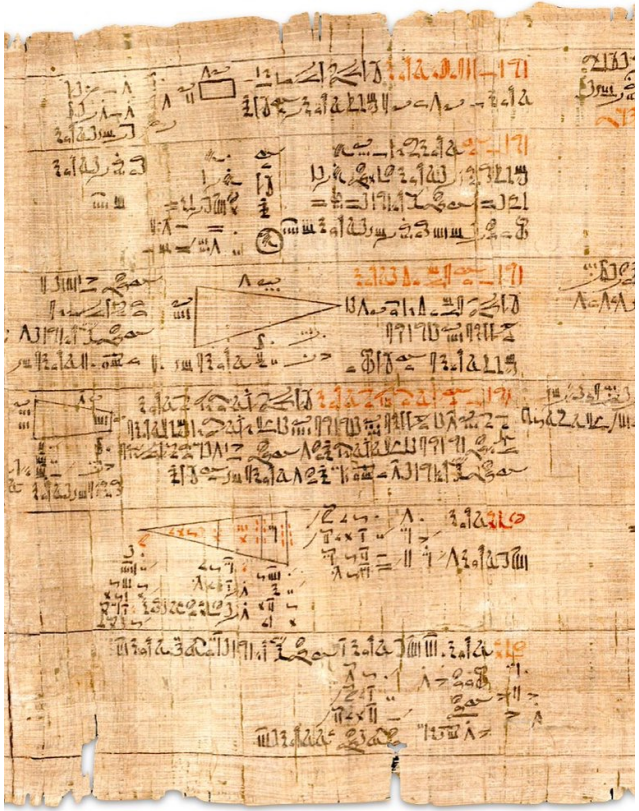
# EVERY VISUALISATION IS AN INTERPRETATION




https://i.ytimg.com/vi/-nLg7oJ8Tzw/maxresdefault.jpg




https://www.smartsheet.com/sites/default/files/ic-excel-pie-charts-change-

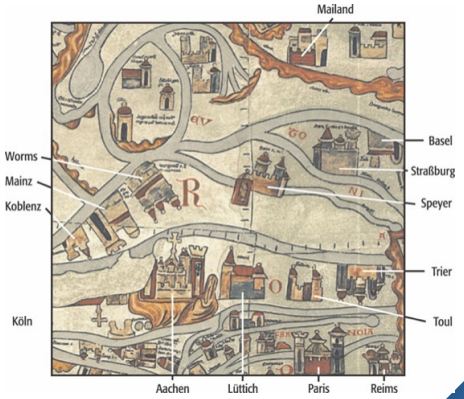


https://pbs.twimg.com/media/ELMEbDaX0AUdhyQ?format=jpg&name=large

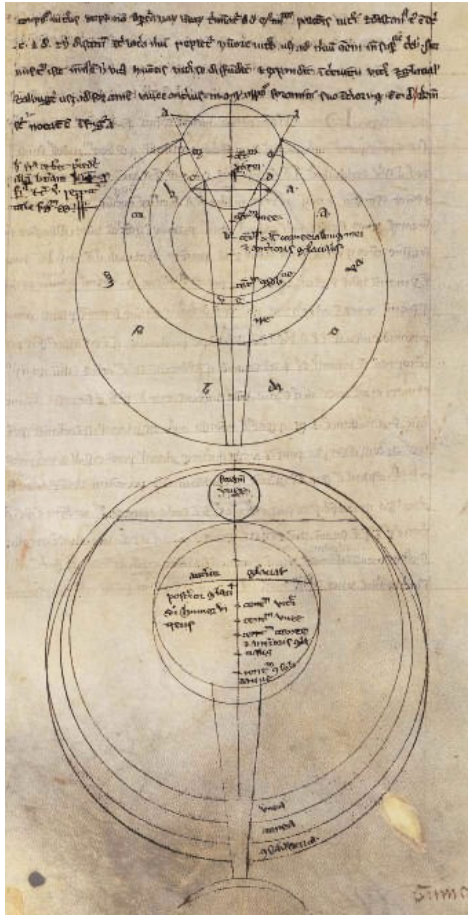
http://www.landschaftsmuseum.de/Bilder/Ebstorf/Ebstorf-neu_ganz-2.jpg

Ebstorf world map, around 1300

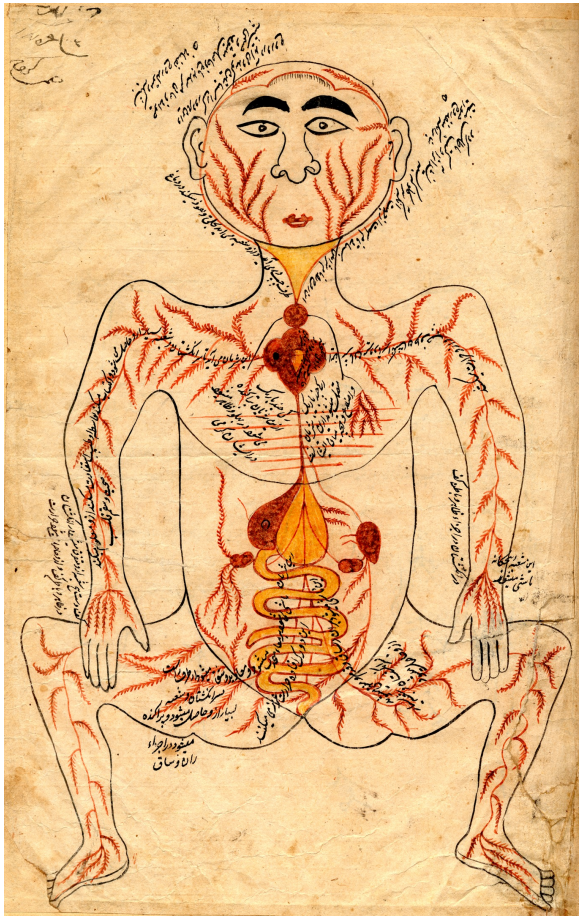
- Diagram instead of geographical map
- Medieval conception of the world (divided into three continents, with Christ / Jerusalem in the centre of the world)


https://www.spektrum.de/lexikon/kartographie-geomatik/ebstorfer-weltkarte/1106



https://upload.wikimedia.org/wikipedia/commons/b/bd/Roger_Bacon_optics01.jpg

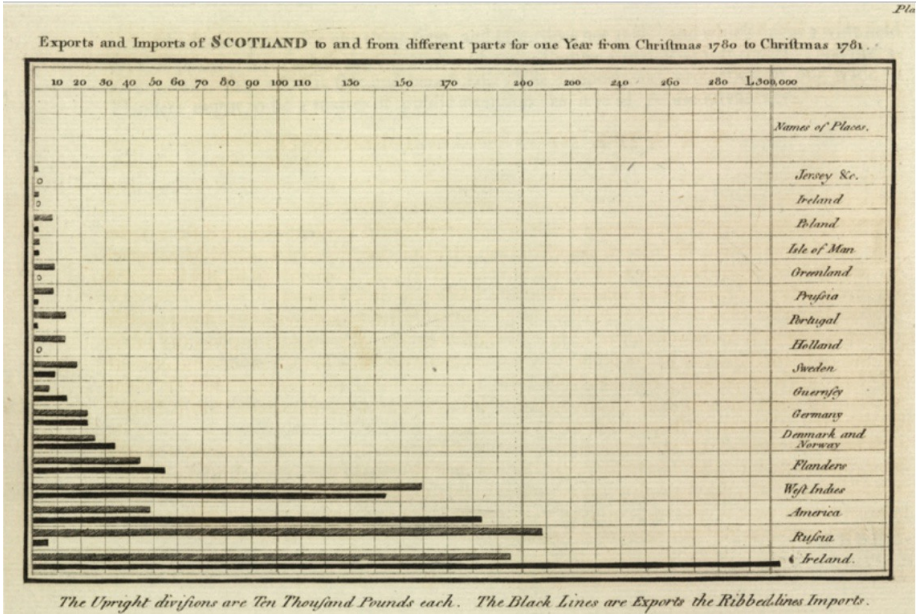


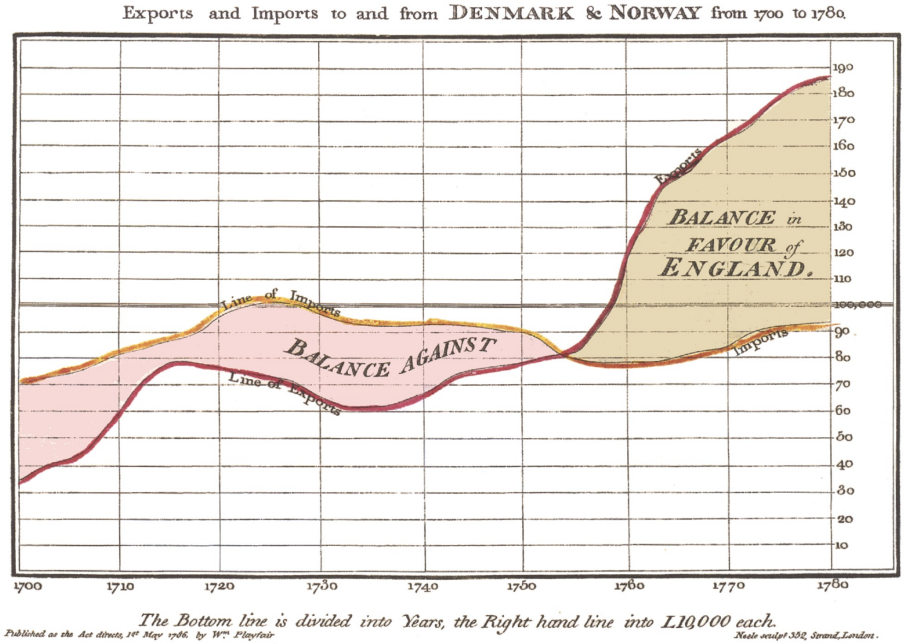
https://en.wikipedia.org/wiki/Anatomy_Charts_of_the_Arabs#/media/File:Organs.png

Technical drawings (Roger Bacon, Study of the Nature of Light, 1280; Anatomy of Mansur ibn Ilyas, c. 1400).

- Diagrams to illustrate and transmit knowledge

# Bar and Line Chart
# (William Playfair 1782/1786)

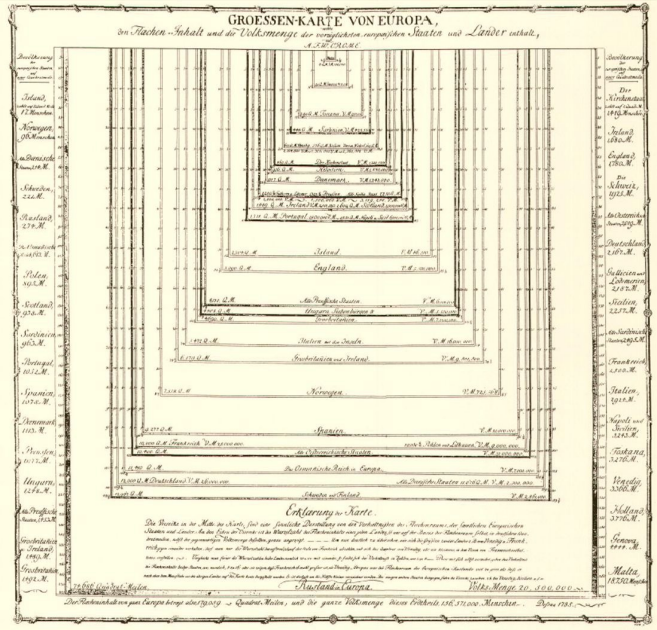



https://upload.wikimedia.org/wikipedia/commons/5/52/Playfair_TimeSeries-2.png

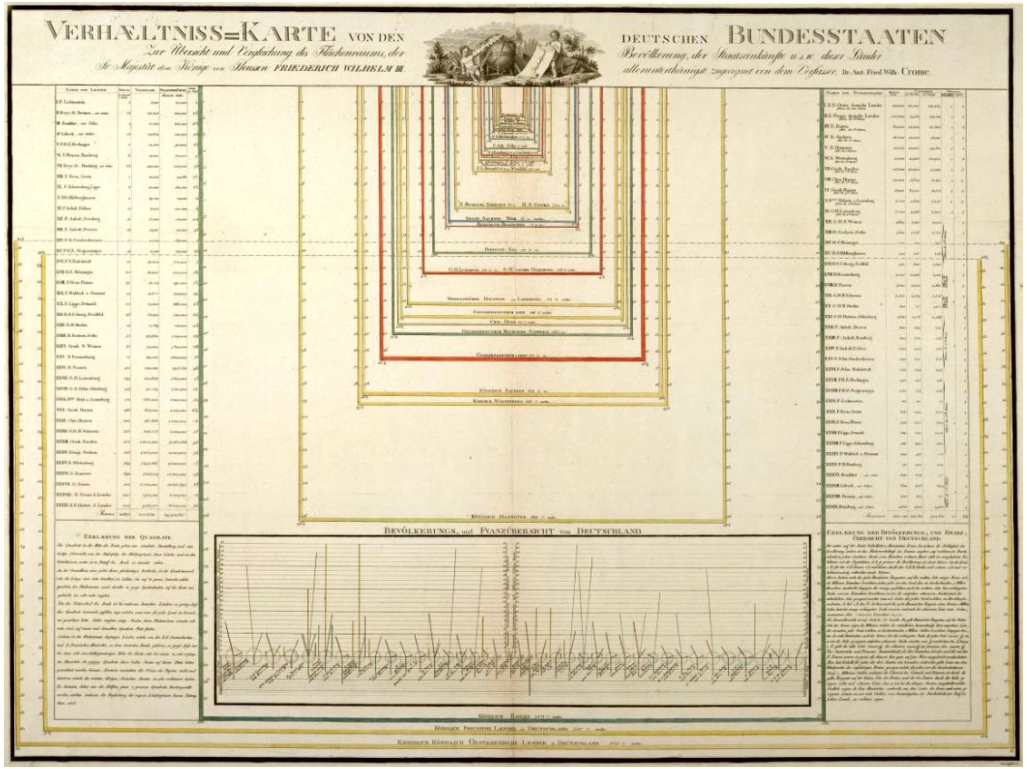
https://upload.wikimedia.org/wikipedia/commons/e/e0/1786_Playfair_-_Exports_and_Imports_of_Scotland_to_and_from_different_parts_for_one_Year_from_Christmas_1780_to_Christmas_1781.jpg

# Area Charts




https://upload.wikimedia.org/wikipedia/commons/d/d2/Groessen_Karte_von_Europa%2C_1785.jpg

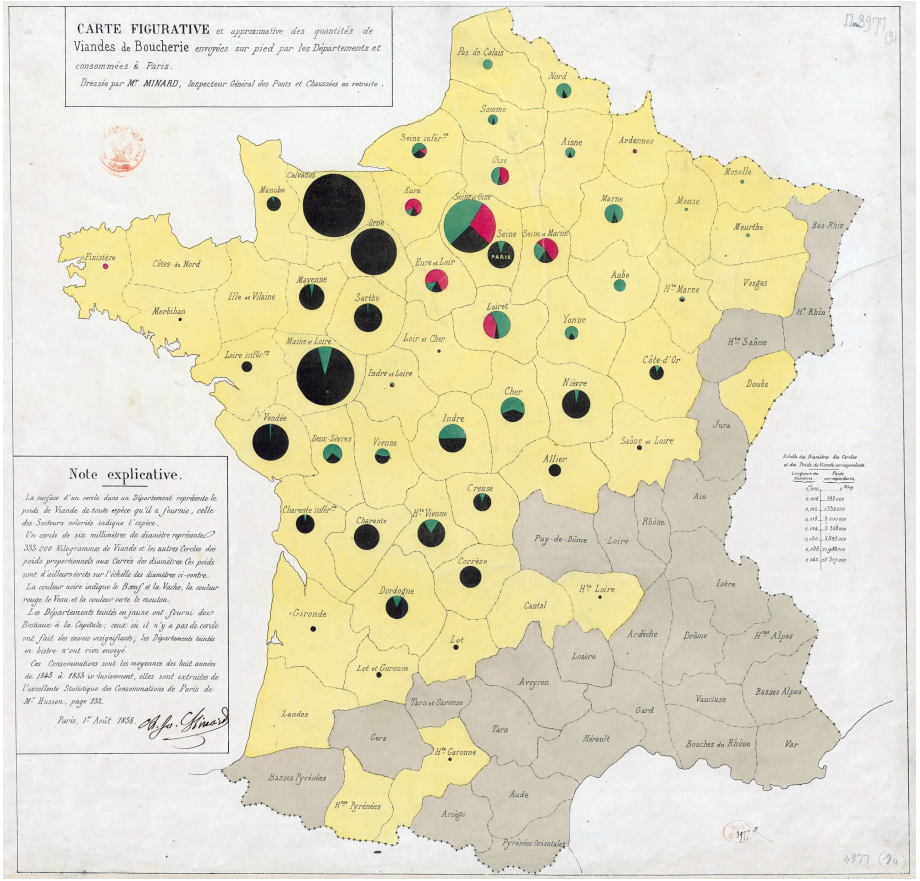
Größenkarte von Europa (1785)




August Friedrich Wilhelm Crome, Verhältniskarte von den deutschen Bundesstaaten (1820)

https://upload.wikimedia.org/wikipedia/commons/4/44/Verhaeltniss_Karte_von_den_deutschen_Bundesstaaten%2C_1820.jpg

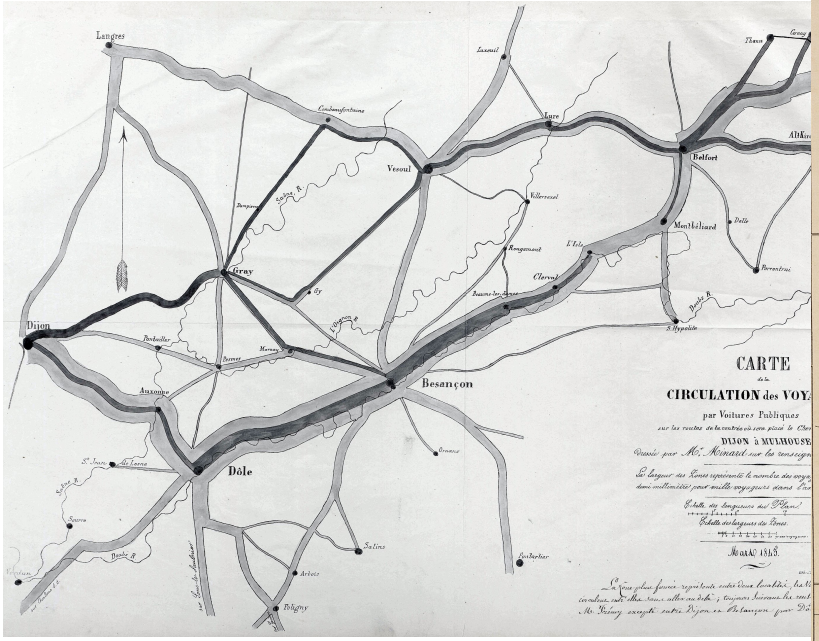
# Thematic maps and pie charts



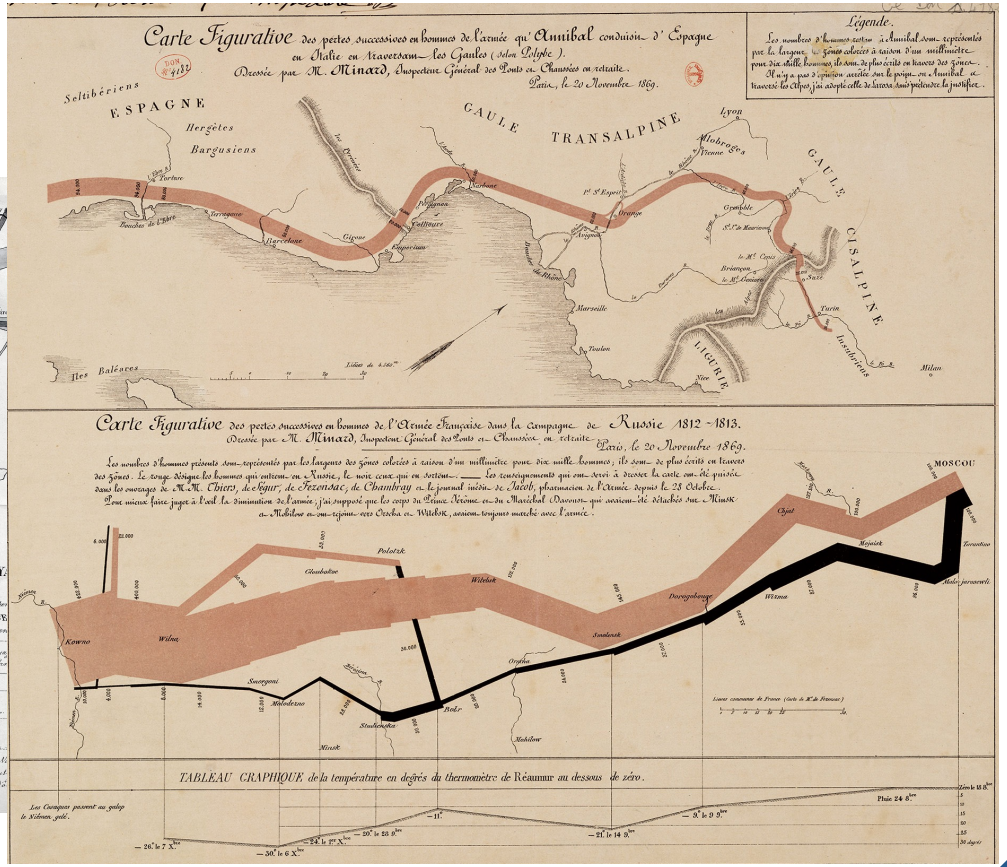

Charles Joseph Minard, "Carte figurative" mit der Darstellung des aus ganz Frankreich zum Verzehr nach Paris geschickten Viehs (1858)

https://upload.wikimedia.org/wikipedia/commons/1/1c/Minard-carte-viande-1858.png

# Mixed form of map and flow chart (Flow-Map)

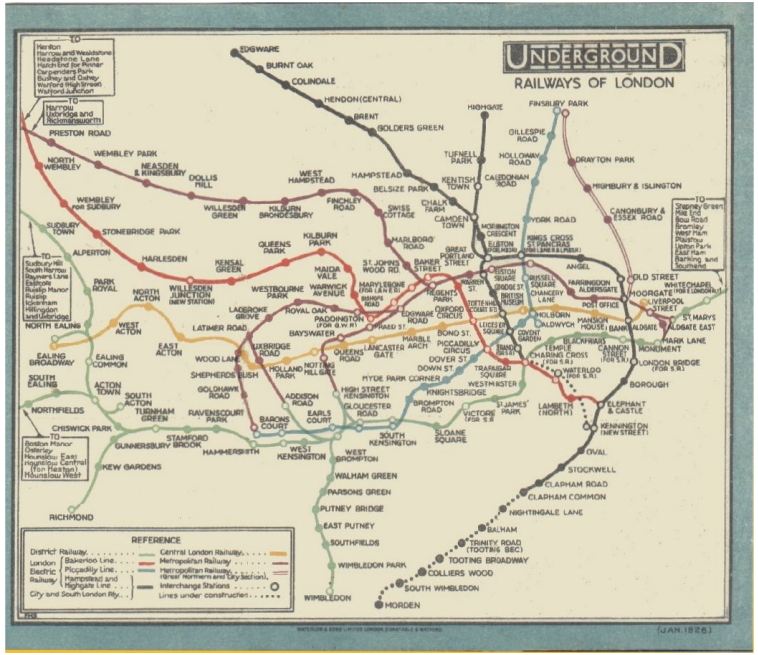



https://upload.wikimedia.org/wikipedia/commons/thumb/9/94/Carte_de_la_circulation_des_voyageurs_par_voitures_publiques_sur_les_routes_de_la_contrée_où_sera_placé_le_chemin_de_fer_de_Dijon_à_Mulhouse%2C_1845.jpg




https://www.nationalgeographic.com/content/dam/news/2017/03/14/map_post_minard/02_map_post_minard_napolean.jpg

# Map Chart

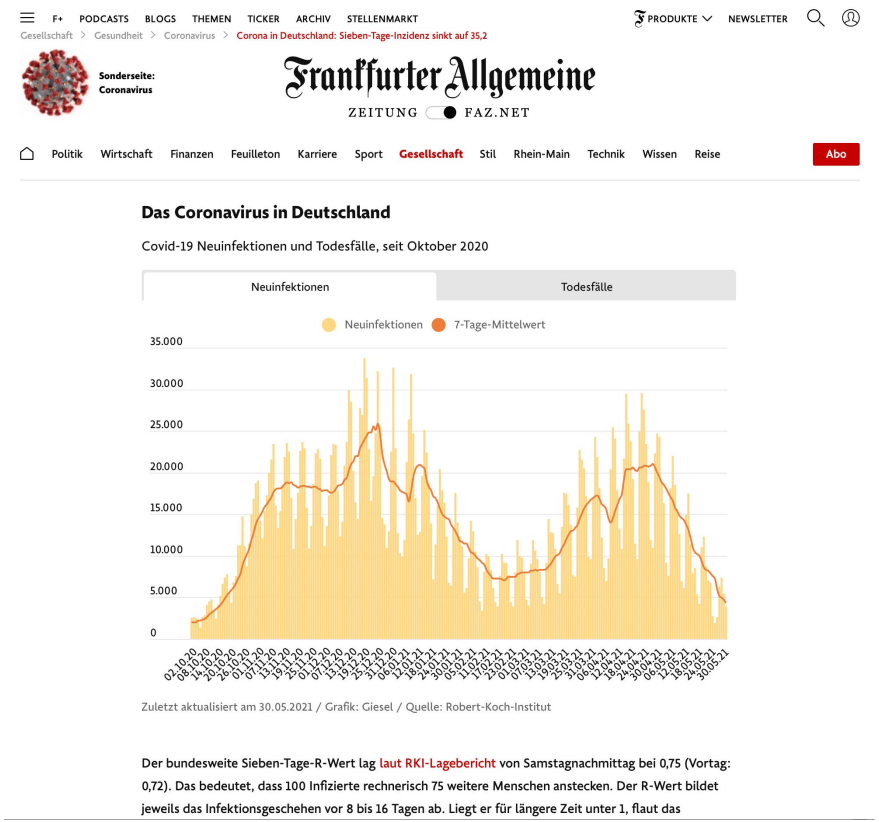



London Underground Tube Plan Map (1926)

https://upload.wikimedia.org/wikipedia/commons/8/85/Tube_map_1926.jpg


London Underground Tube Plan Map (1933, Harry Beck)

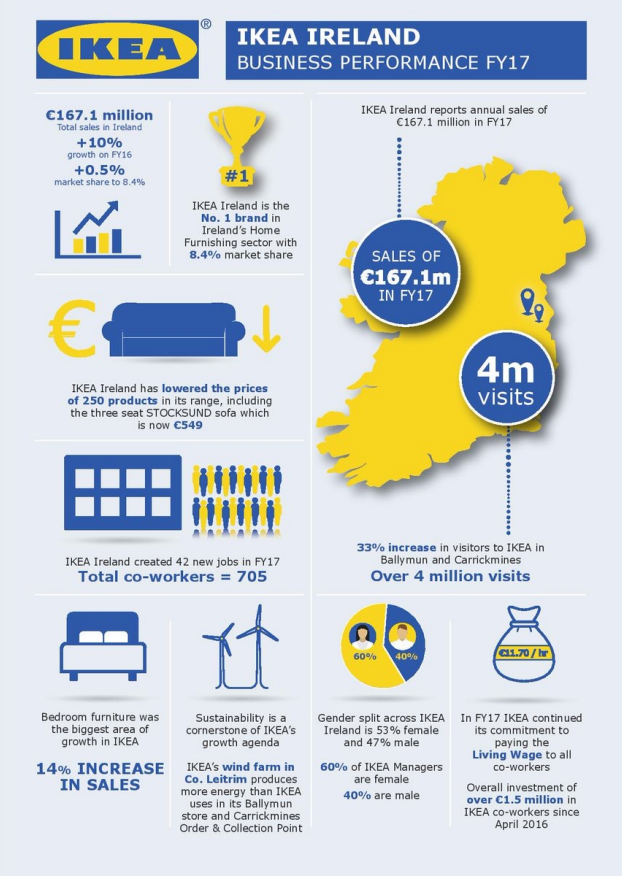
https://upload.wikimedia.org/wikipedia/en/0/06/Beck_Map_1933.jpg




https://www.faz.net/aktuell/gesellschaft/gesundheit/coronavirus/zahlen-zum-coronavirus-die-pandemie-im-ueberblick-16653240.html

The flood of information must be countered by an easily comprehensible visualisation of the facts. But this can only be done by concentrating on the main statements, i.e. by abstraction and information reduction.

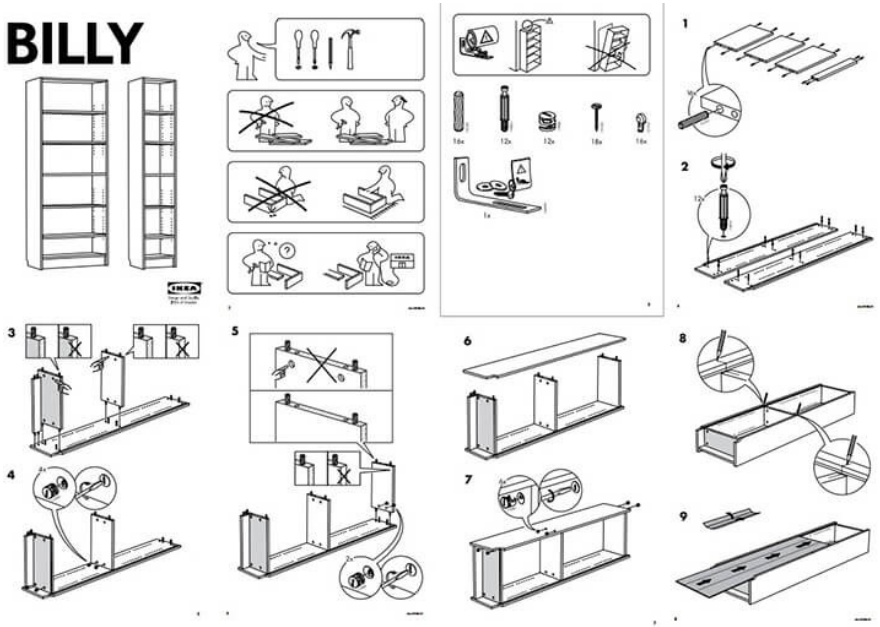
https://cdn4.vectorstock.com/images/1000x1000/06/48/23790648.jpg




https://pbs.twimg.com/media/DQg7C_oXcAAU9p6.jpg

- quantified, non-figurative, abstract (charts)

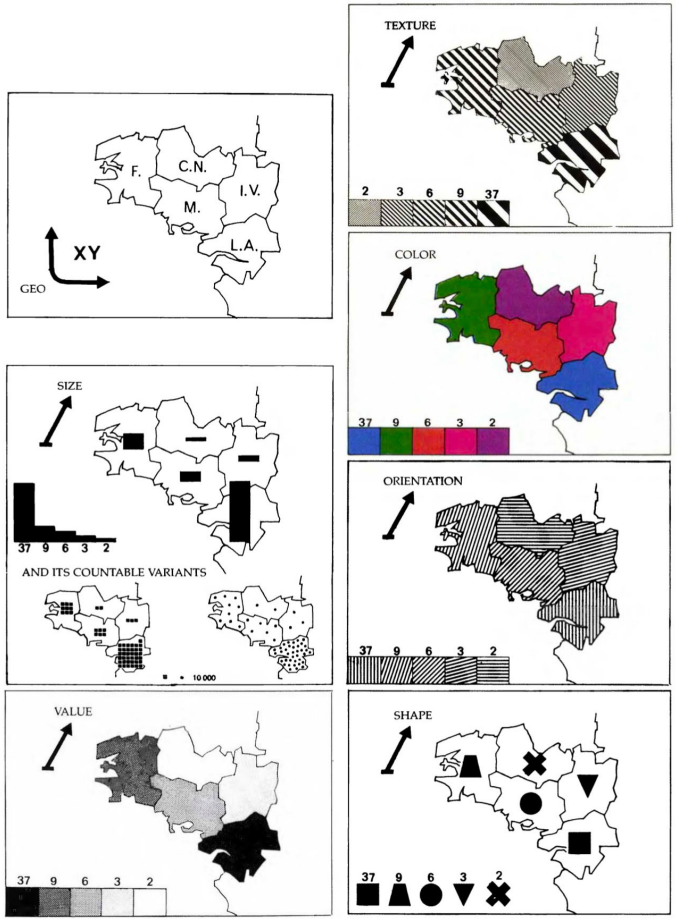
- qualitative, figurative, schematic (diagrams)

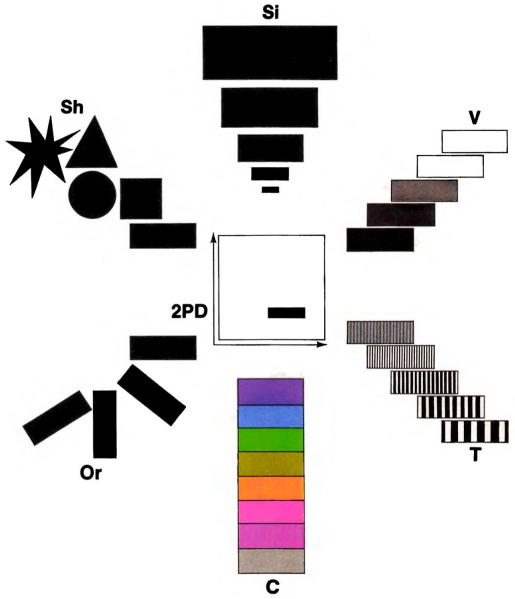



https://instrktiv.com/media/IKEA/2016-08-05_15-05-08.jpg

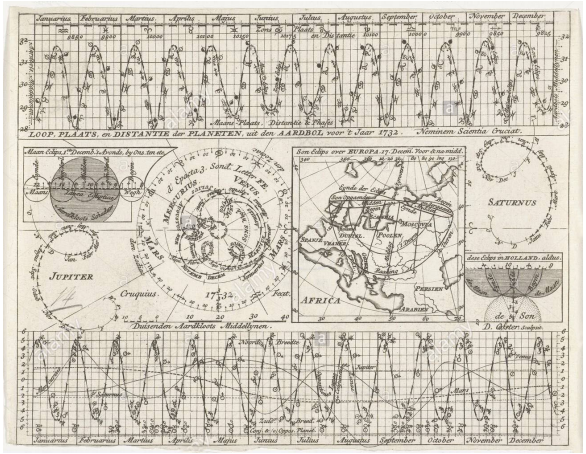
„Ce point est fondamental. C'est la mobilité interne de l'image qui caractérise la graphique moderne. On ne «dessine» plus un graphique une fois pour toutes. On le «construit» et on le reconstruit (on le manipule) jusqu'au moment où toutes les relations qu'il recèle ont été perçues."

Jacques Bertin 1967

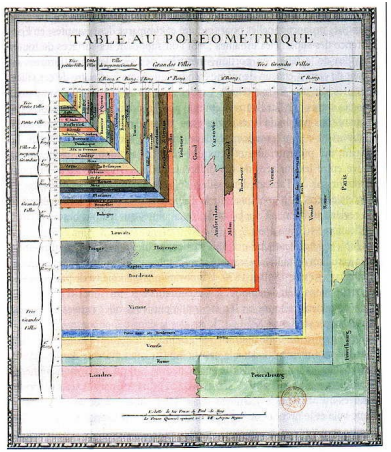


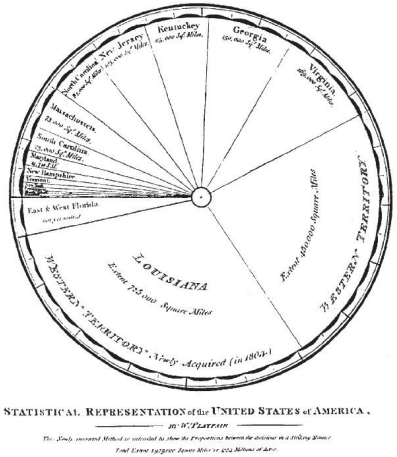

Jacques Bertin, Sémiologie graphique. Les diagrammes, les réseaux, les cartes (Paris, 1967) 16. 48. 60




1724 (Nicolaas Kruik)



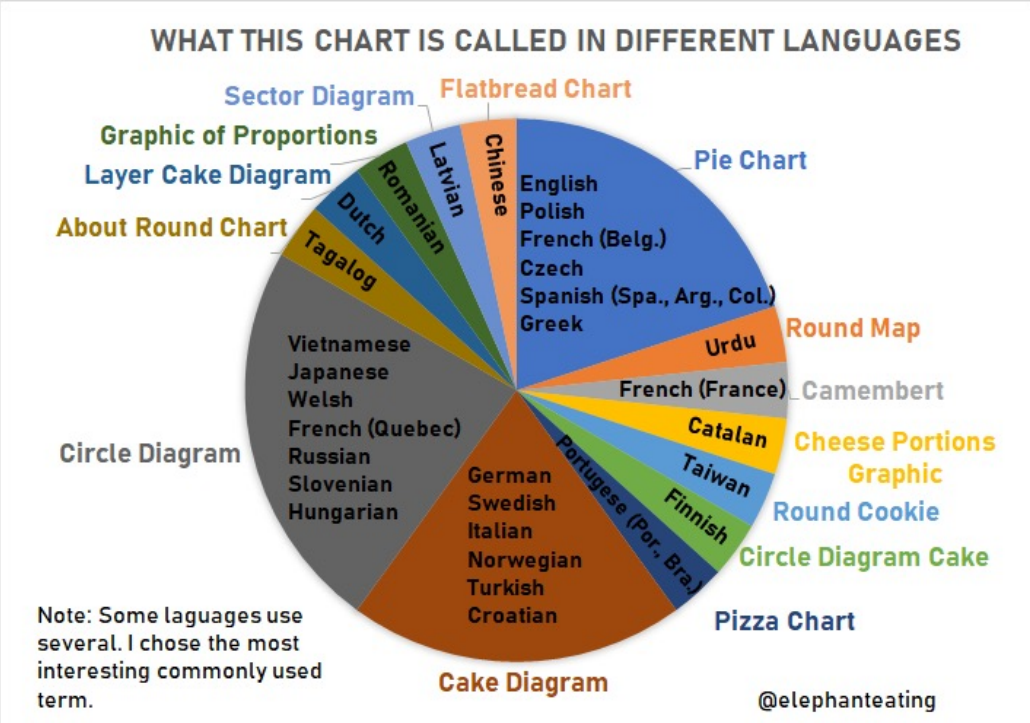

1786 (Charles de Fourcroy)




1801 (William Playfair)

- The first dimension is visualised in spatial extension, i.e. as size or direction.
- A second dimension is then added in another, non-spatial variable: as colour, brightness, texture or shape.

Michael Friendly, Daniel J. Denis, Milestones in the history of thematic cartography, statistical graphics, and data visualization (2001). Web document, http://www.datavis.ca/milestones/

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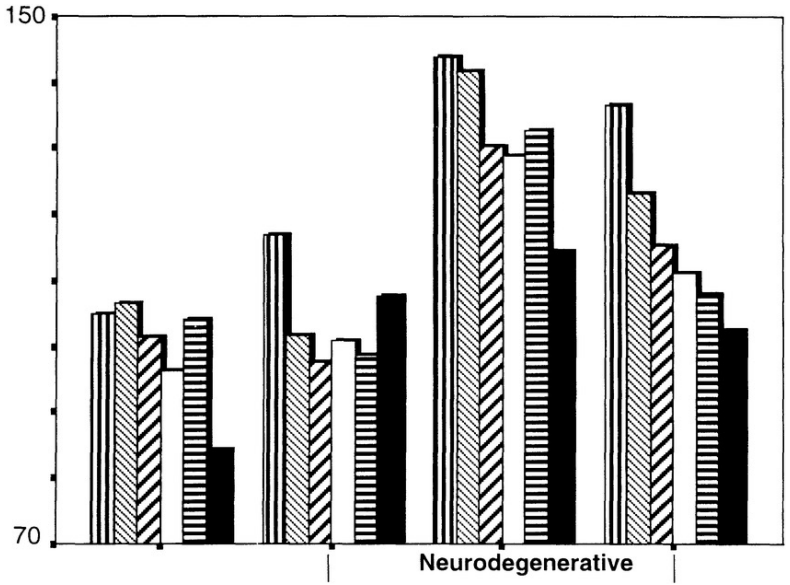
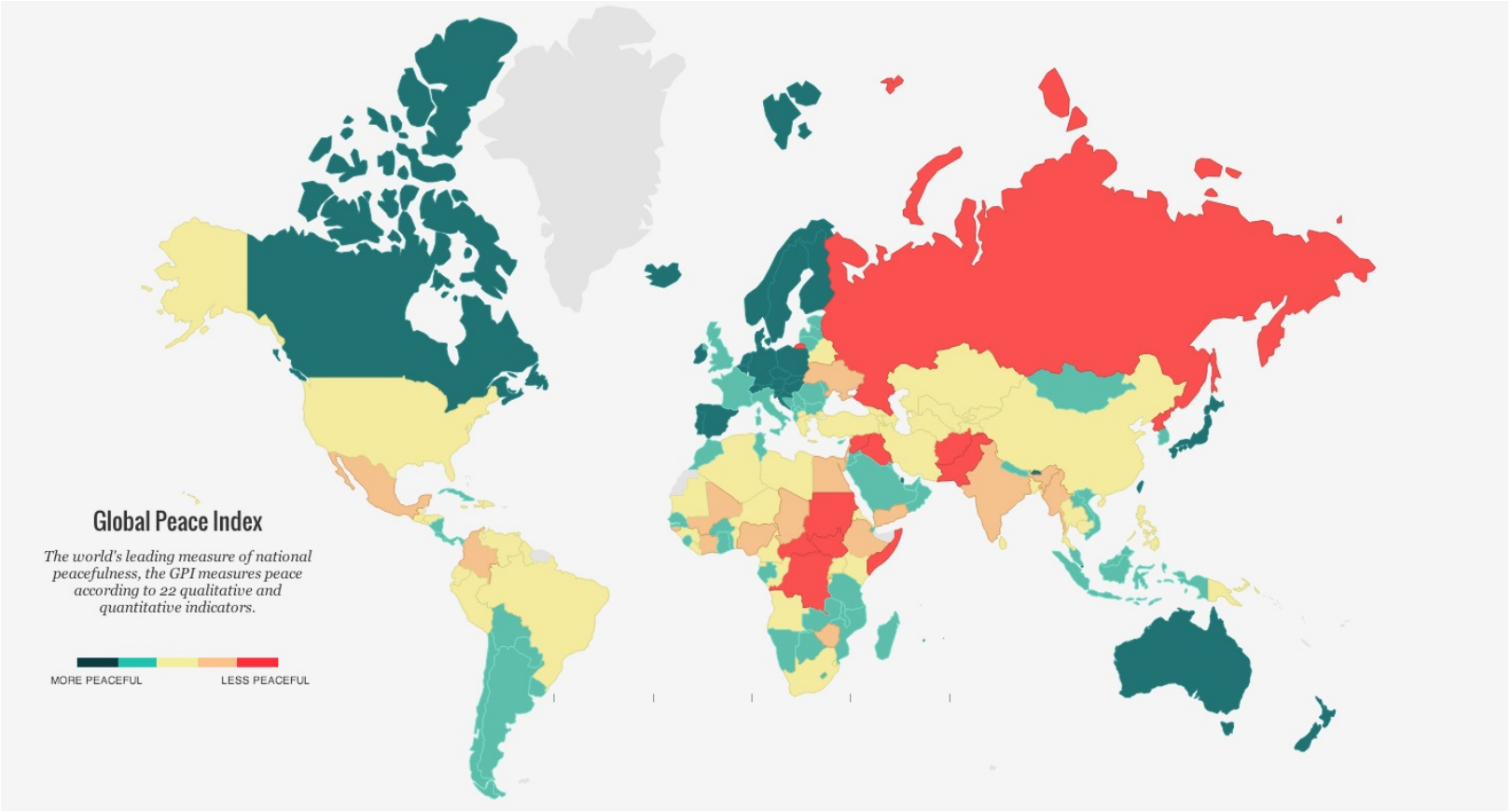



https://www.researchgate.net/profile/Fatima-Shawkat/publication/14440023/figure/fig2/AS:601722665828367@1520473271699/Bar-chart-of-mean-pattern-and-flash-V-EP-latencies-for-the-different-diagnostic.png




Source: http://dadaviz.com/i/129

## 1. MULTIVARIATE METHODS

Exploratory Statistics

Principal Component Analysis

Correspondence Analysis and Seriation

## 2. NETWORK ANALYSIS

Basics

Complex Systems

Social Network Analysis

Historical Network Analysis

## 3. DATA VISUALISATION

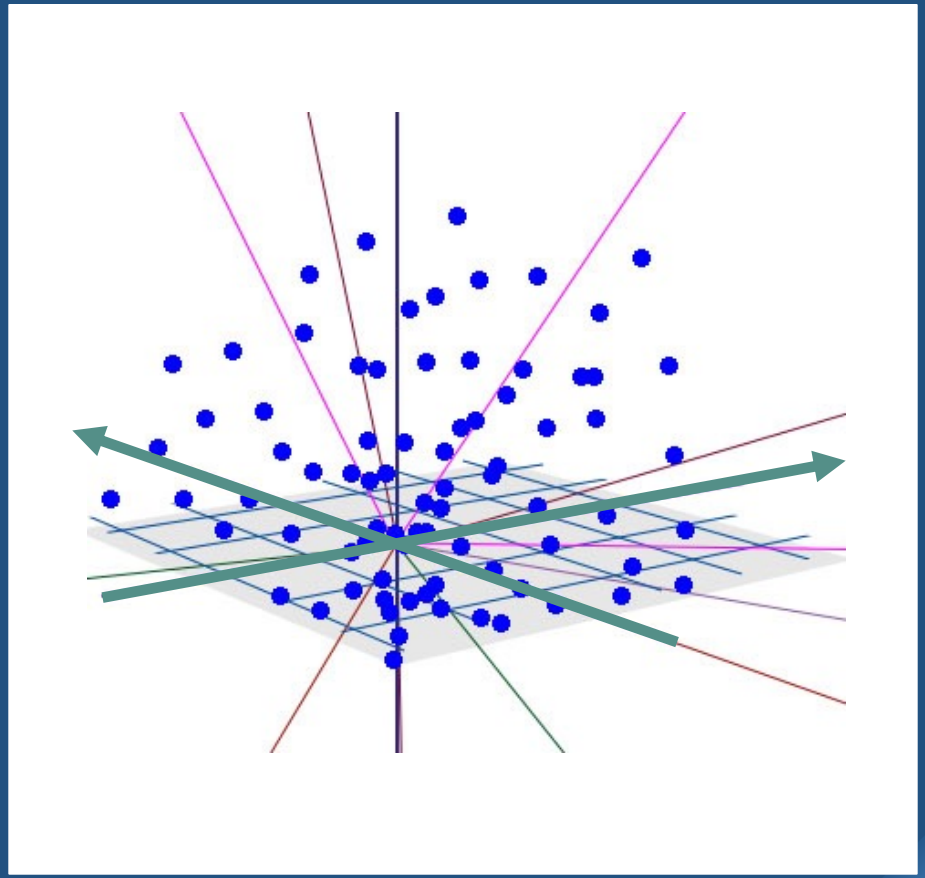
Data Visualisation in Comparison

Chart types

Basic Principles of Visualisation

Tools

# 1. MULTIVARIATE METHODS



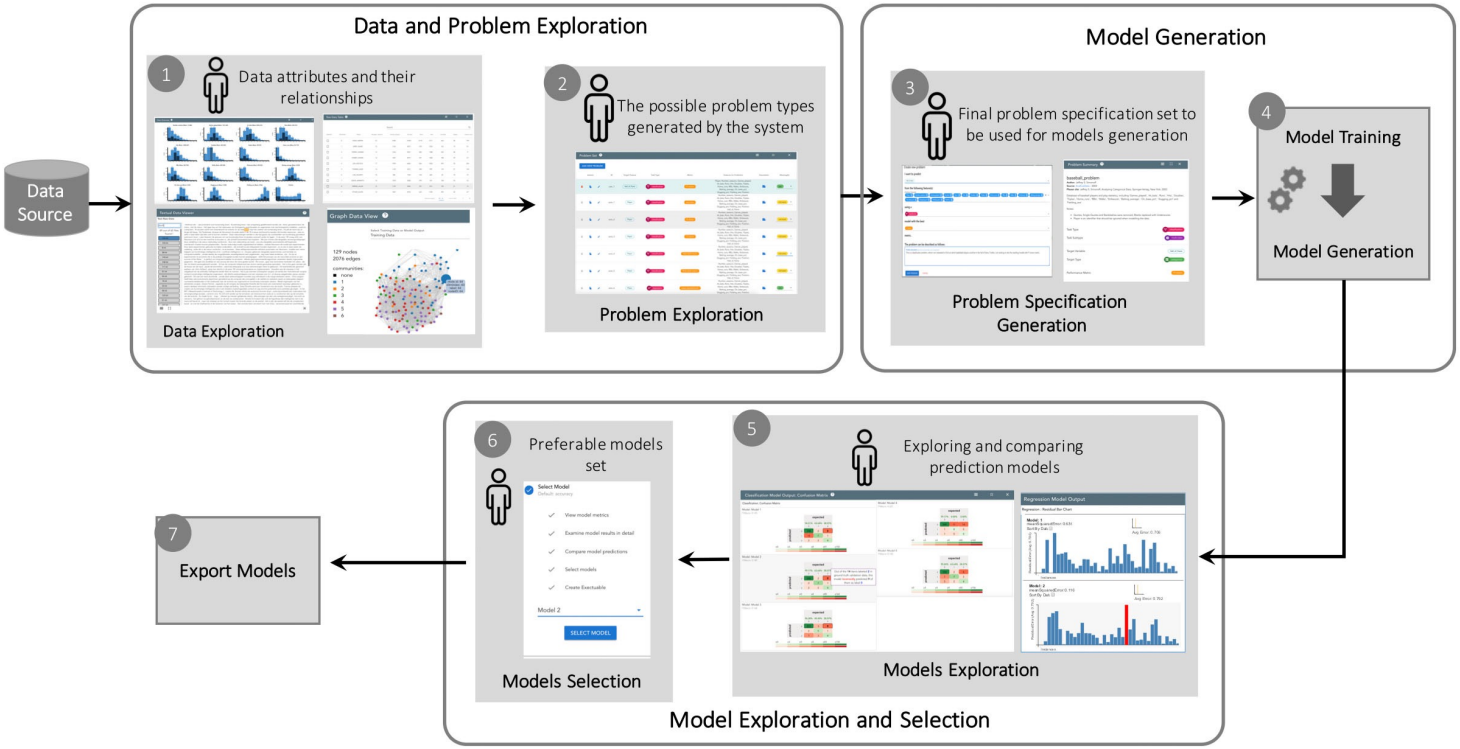
# EXPLORATORY STATISTICS

**Descriptive** statistics sort the data according to certain criteria and illustrate this in simple key figures, tables and graphs.

**Inductive** or inferential statistics, on the other hand, ask to what extent what is measured corresponds to reality by deriving properties of a population from the data of a sample.

Exploratory or hypothesis-generating statistics systematically searches for significant patterns in Big Data, i.e. for possible correlations and differences in the data.
These initially hypothetical statements can only be considered certain after additional inductive investigations.

# VISUAL ANALYTICS



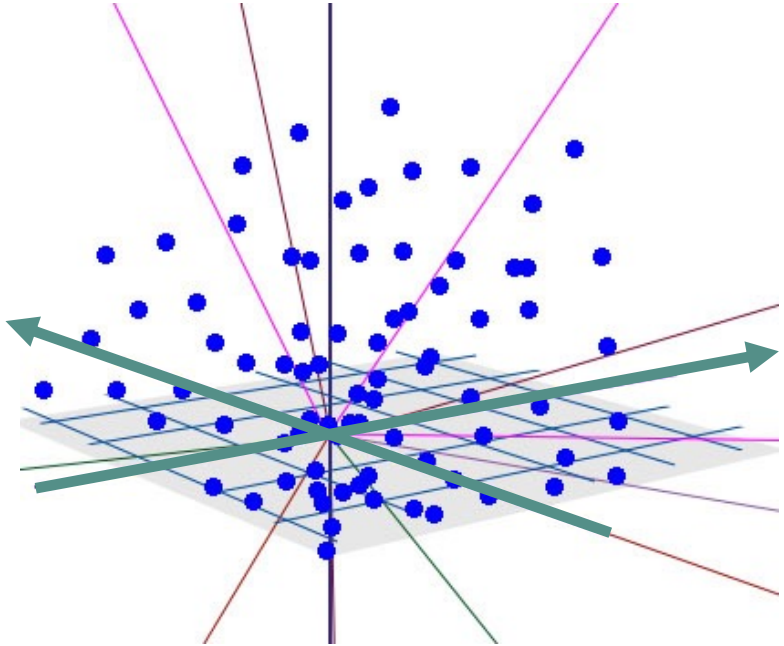

J. J. Thomas, K. A. Cook (Hrsg.), Illuminating the path. The research and development agenda for visual analytics (IEEE Computer Society 2005): https://ils.unc.edu/courses/2017_fall/inls641_001/books/RD_Agenda_VisualAnalytics.pdf

https://www.cs.tufts.edu/~remco/publications/2019/EuroVis2019-Snowcat.pdf

Mondrian's paintings of his early period 1905-1917, sorted according to subjective criteria

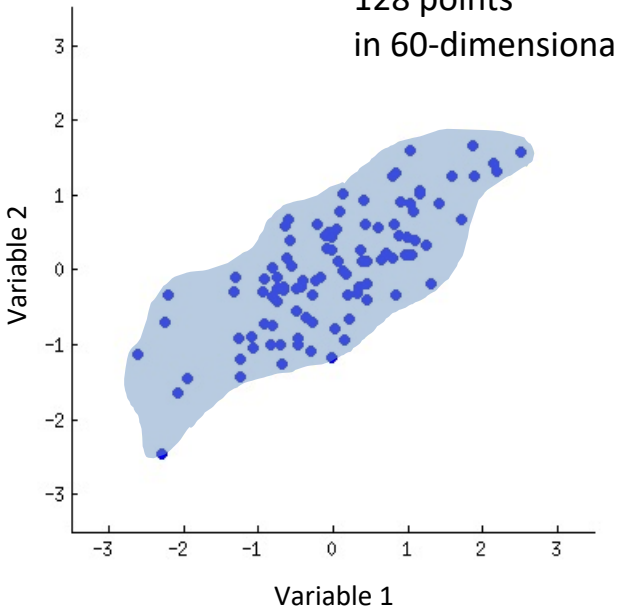
# PRINCIPAL COMPONENT ANALYSIS (PCA)

summarises a large number of statistical variables (using mathematical approximation) in a smaller number of linear combinations that are as meaningful as possible.
A group of components thus becomes a principal component and is illustrated in a coordinate system.

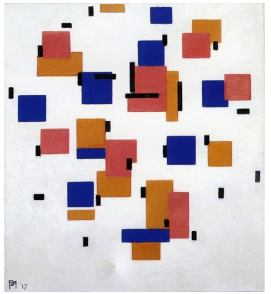


# PRINCIPAL COMPONENT ANALYSIS

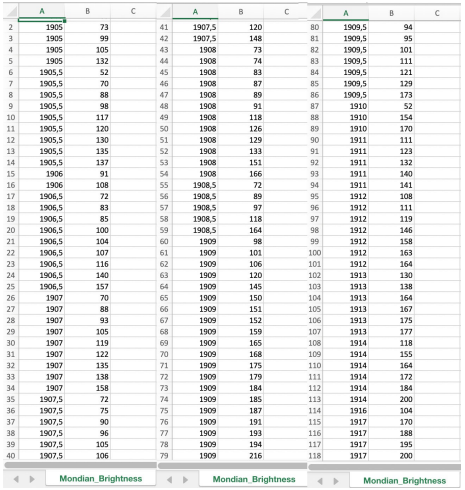
128 points
in 60-dimensional space




https://ichi.pro/assets/images/max/724/1*T7CqlFV5aRm6MxO5nJt7Qw.gif



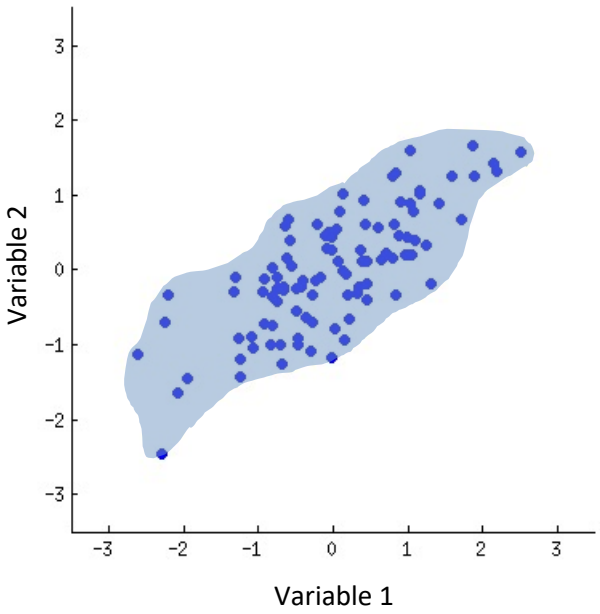
128 paintings by Piet Mondrian (1905–1917)

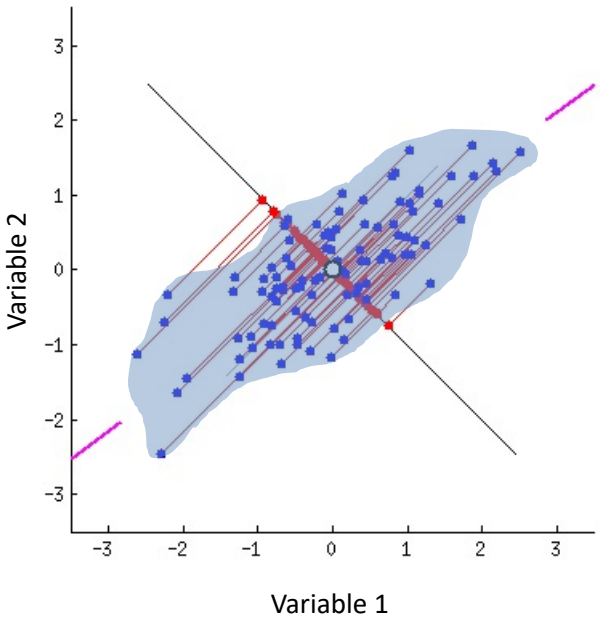


60 features =
7680 measured values

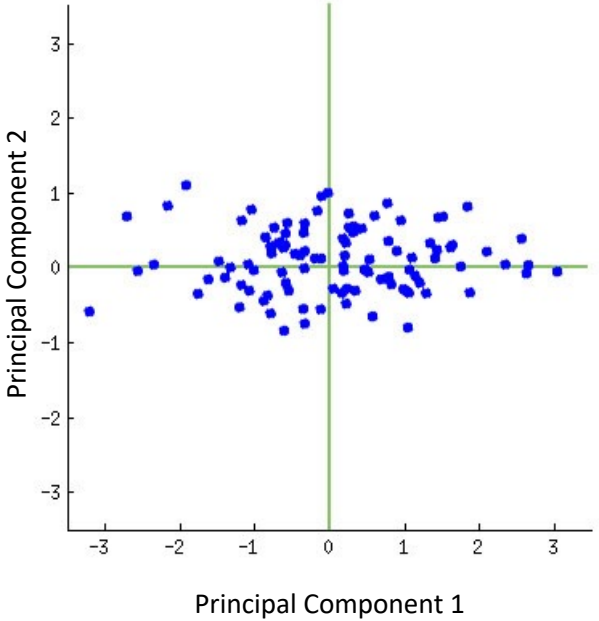
# PRINCIPAL COMPONENT ANALYSIS

Scatter plot (unrotated)




Scatter plot (rotated)




https://ichi.pro/assets/images/max/724/1*T7CqlFV5aRm6MxO5nJt7Qw.gif

# PRINCIPAL COMPONENT ANALYSIS

| Komponente | Anfängliche Eigenwerte | | | Summen von quadrierten Faktorladungen für Extraktion | | | Rotierte Summe der quadrierten Ladungen | | |
|---|---|---|---|---|---|---|---|---|---|
| | Gesamt | % der Varianz | Kumulierte % | Gesamt | % der Varianz | Kumulierte % | Gesamt | % der Varianz | Kumulierte % |
| 1 | 8,511 | 42,553 | 42,553 | 8,511 | 42,553 | 42,553 | 6,484 | 32,421 | 32,421 |
| 2 | 3,579 | 17,897 | 60,450 | 3,579 | 17,897 | 60,450 | 3,792 | 18,960 | 51,381 |
| 3 | 1,156 | 5,780 | 66,230 | 1,156 | 5,780 | 66,230 | 2,238 | 11,189 | 62,569 |
| 4 | 1,055 | 5,274 | 71,504 | 1,055 | 5,274 | 71,504 | 1,787 | 8,934 | 71,504 |
| 5 | | | | | | | | | |
| 6 | ,773 | 3,864 | 80,143 | | | | | | |
| 7 | ,593 | 2,963 | 83,106 | | | | | | |
| 8 | ,501 | 2,507 | 85,613 | | | | | | |
| 9 | ,493 | 2,467 | 88,080 | | | | | | |
| 10 | ,423 | 2,114 | 90,193 | | | | | | |
| 11 | ,364 | 1,819 | 92,013 | | | | | | |
| 12 | ,314 | 1,569 | 93,581 | | | | | | |
| 13 | ,254 | 1,272 | 94,853 | | | | | | |
| 14 | ,226 | 1,131 | 95,984 | | | | | | |
| 15 | ,224 | 1,121 | 97,105 | | | | | | |
| 16 | ,190 | ,952 | 98,057 | | | | | | |
| 17 | ,132 | ,662 | 98,720 | | | | | | |
| 18 | ,105 | ,527 | 99,247 | | | | | | |
| 19 | ,084 | ,418 | 99,664 | | | | | | |
| 20 | ,067 | ,336 | 100,000 | | | | | | |

| Gesamt | % der Varianz |
|---|---|
| 8,511 | 42,553 |
| 3,579 | 17,897 |
| 1,156 | 5,780 |
| 1,055 | 5,274 |

Eigenvalues > 1 (Kaiser-Guttman criterion)

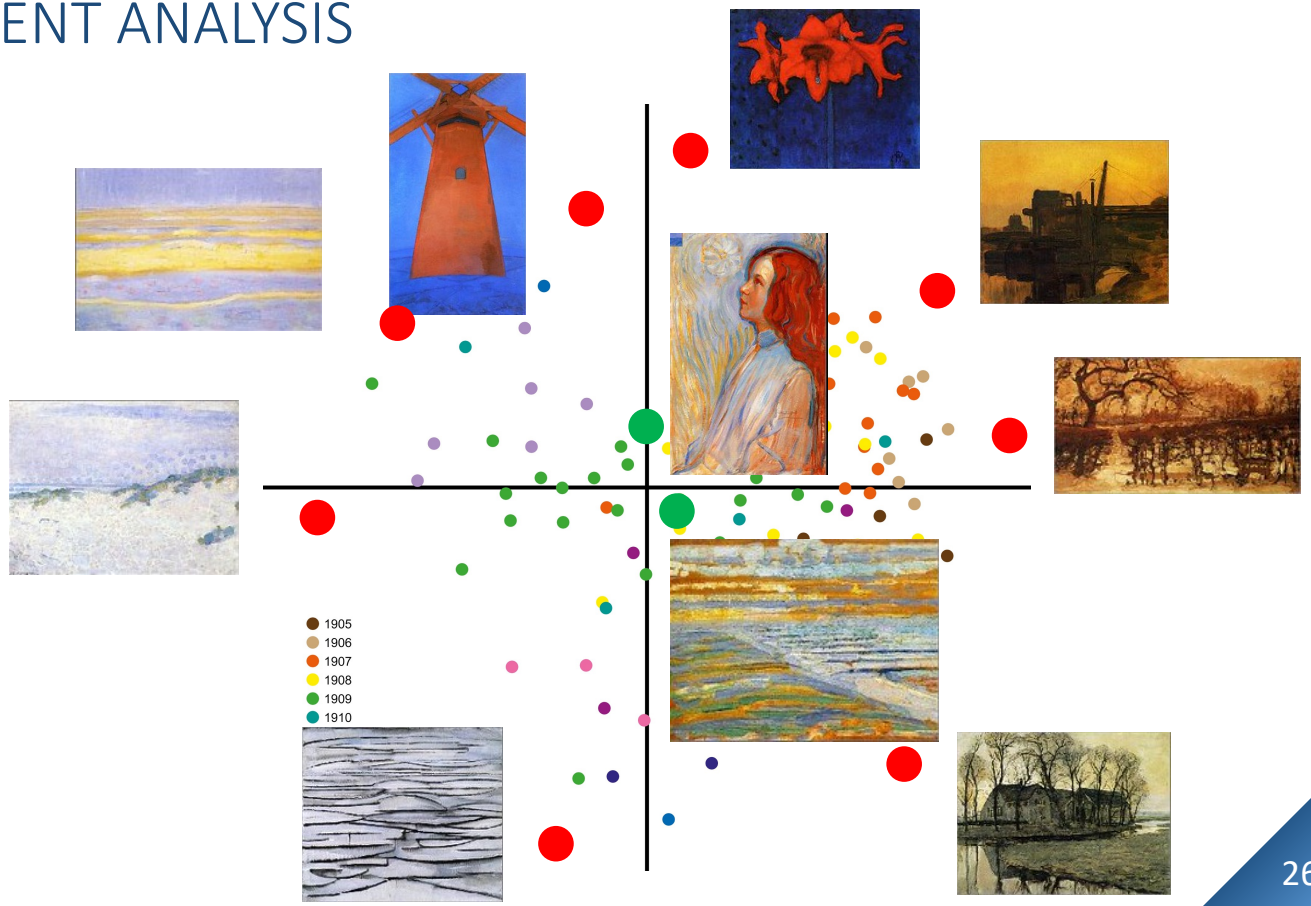
https://statistikguru.de/spss/hauptkomponentenanalyse/faktoren-extrahieren.html

# PRINCIPAL COMPONENT ANALYSIS

• a good method to search exploratively for common features in large image sets or complex groups of objects by modelling the degree of variance differently accordingly.

# PRINCIPAL COMPONENT ANALYSIS

The two axes divide the points into four quadrants, which roughly divide the data into four groups. The further two points are from the centre of the coordinate system, the more dissimilar they are.



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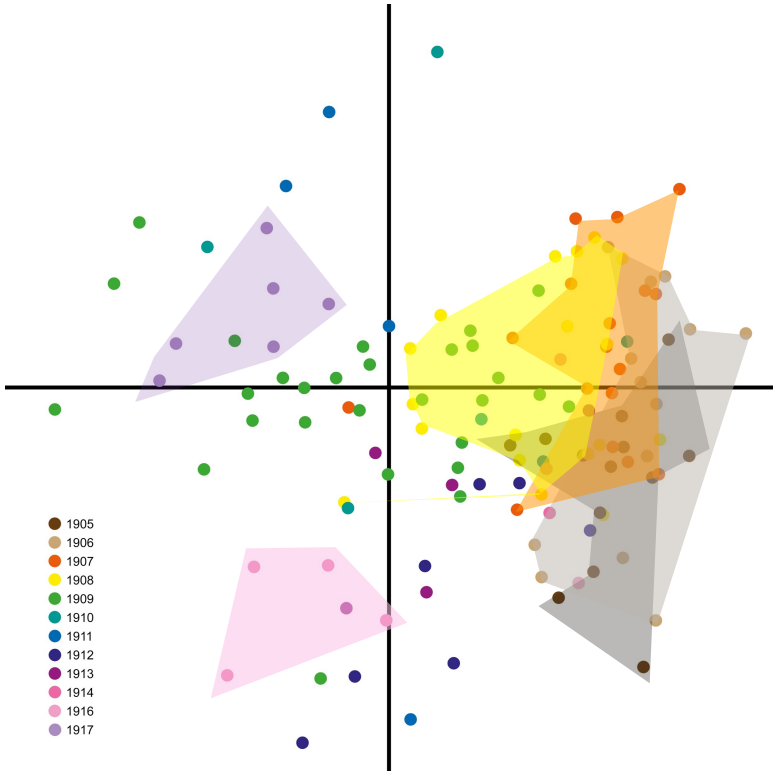
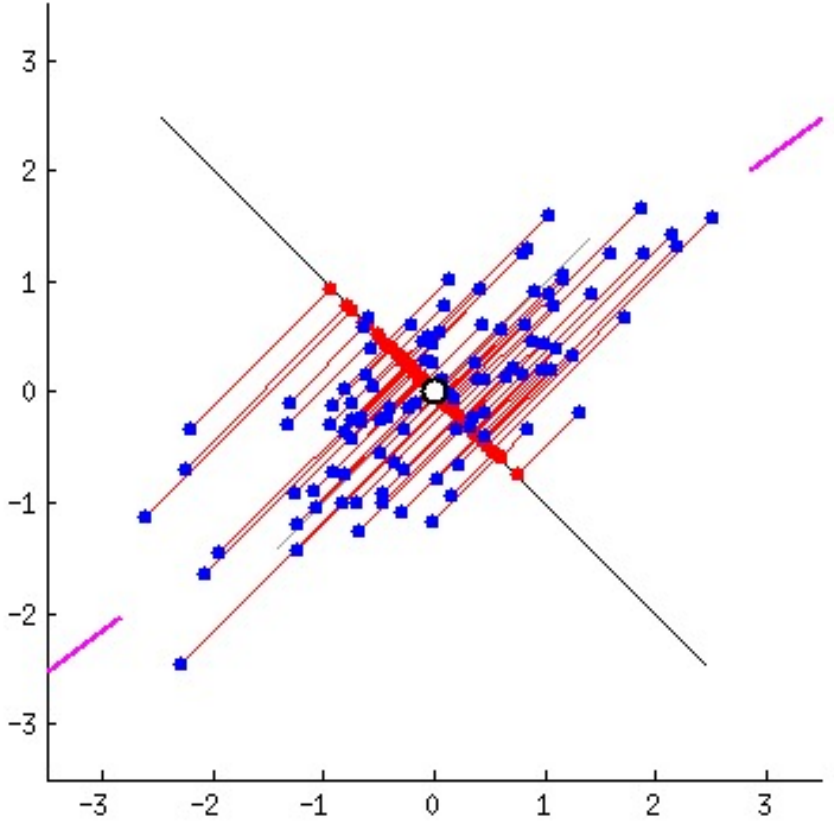


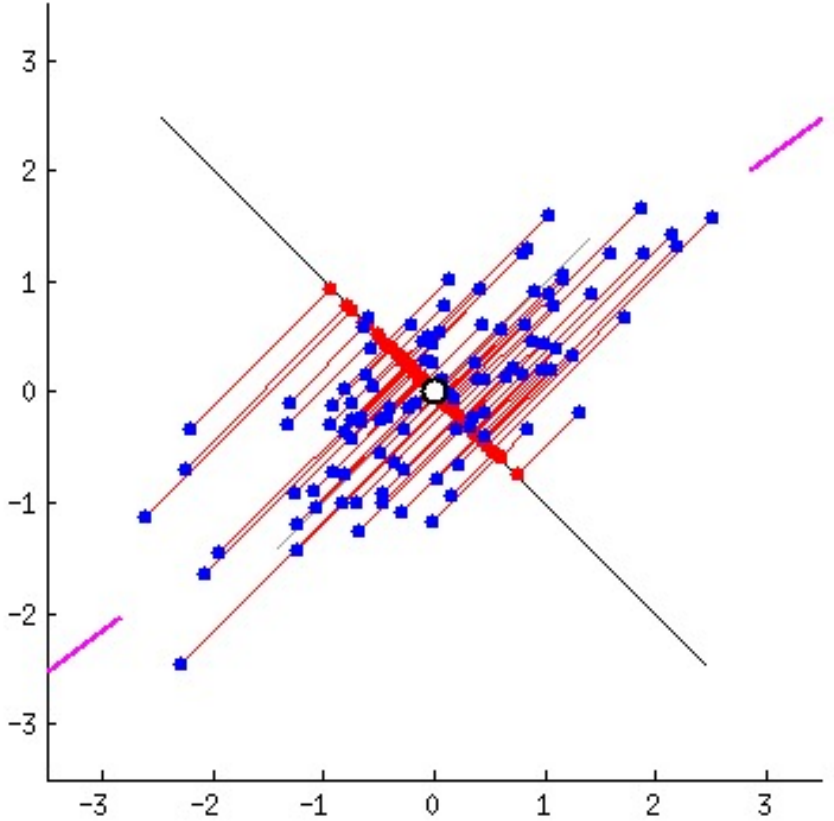
# PRINCIPAL COMPONENT ANALYSIS

uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components.



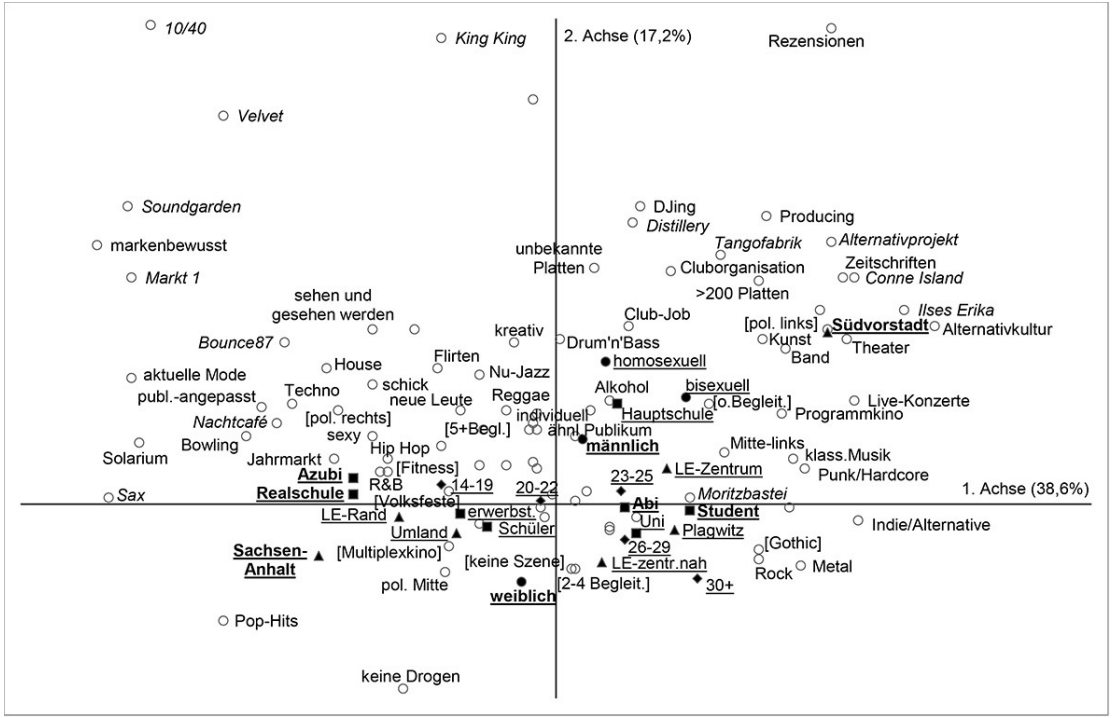
# PRINCIPAL COMPONENT ANALYSIS

This transformation is defined in such a way that the first principal component has the largest possible variance (that is, accounts for as much of the variability of the data as possible) and each subsequent component in turn has the largest possible variance under the constraint that it is orthogonal to the previous components.



# CORRESPONDENCE ANALYSIS

Principal component analysis of categorical data



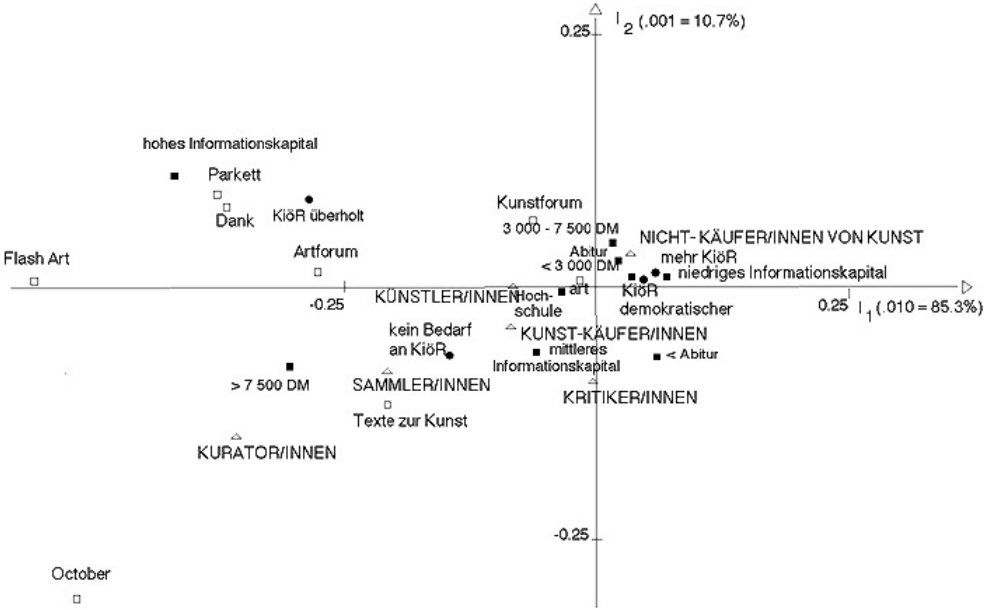

Milieu study on the German music scene

https://kaput-mag.com/stories-de/gunnar-otte_fuehlst-du-dich-einer-musikszene-zugehoerig/

# CORRESPONDENCE ANALYSIS

Two-dimensional representation of tables with more than one dependency on each other as a graph

Graphik 2: Bewertung von Kunst im öffentlichen Raum (KiöR), nach Informationskapital, ökonomischem und kulturellem Kapital, Kunstweltgruppen und Kunstzeitschriften. Hamburg 1993 / 1994 (Korrespondenzanalyse, Q = 96%)




https://www.visarteost.ch/-/andereorte/texte/uwuggenig/images/graphik2.gif

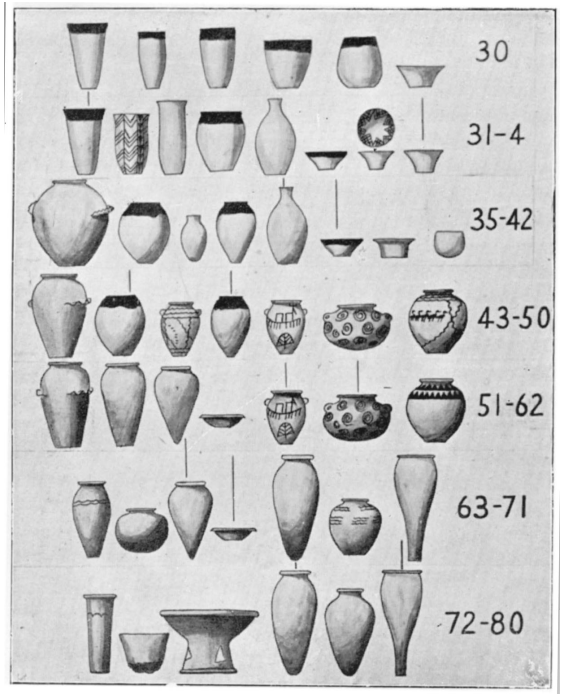
# CONTEXTUAL SERIATION

of the named vessel types and graves 1-7:
1 = Context contains the vessel type
0 = Context does not contain the vessel type

| | ABCDEFG | |
|---|---|---|
| beaker | 0000110 | beaker |
| blackrim | 1000110 | blackrim |
| bottle | 1000100 | bottle |
| handle | 0101000 | handle |
| spirals | 1001001 | spirals |
| flatpot | 0111000 | flatpot |
| pointed | 0001001 | pointed |
| | ABCDEFG | |

| | ABCDEFG | |
|---|---|---|
| beaker | ..**... | beaker |
| blackrim | *..**.. | blackrim |
| bottle | *...*.. | bottle |
| handle | .*.*... | handle |
| spirals | *..*..* | spirals |
| flatpot | .***... | flatpot |
| pointed | ...*..* | pointed |
| | ABCDEFG | |

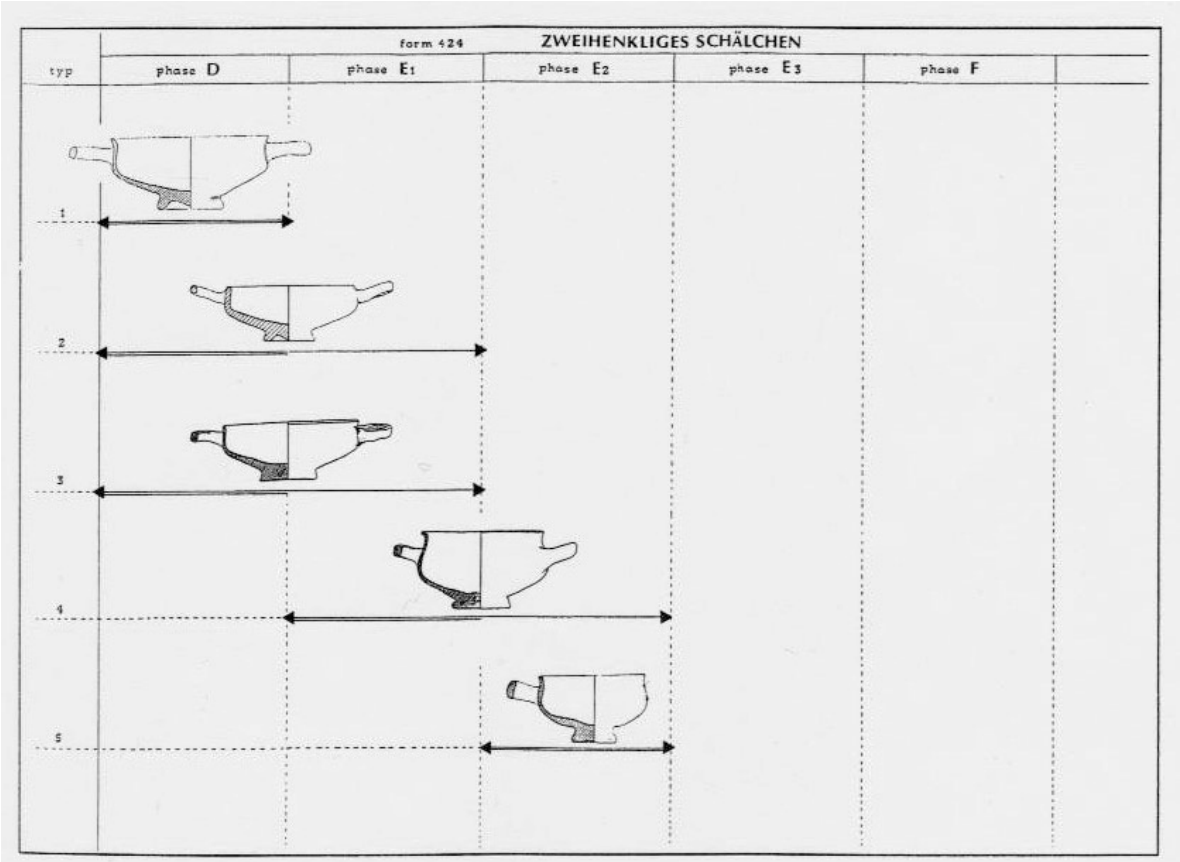
| | FEAGDBC | |
|---|---|---|
| beaker | **..... | beaker |
| blackrim | ***.... | blackrim |
| bottle | .**.... | bottle |
| flatpot | ..***.. | flatpot |
| handle | ...**.. | handle |
| pointed | ....**. | pointed |
| spirals | ....*** | spirals |
| | FEAGDBC | |




Flinders W. M. Petrie, Sequences in prehistoric remains. Journal of the Anthropological Institute 29, 1899, 295–301; C. Renfrew – P. Bahn, Archaeology. Theories, Methods, and Practice (London 1996) 117; Johannes Müller – Andreas Zimmermann (Hrsg.), Archäologie und Korrespondenzanalyse. Beispiele, Fragen, Perspektiven (Rahden/Westf. 1997); K. Kris Hirst, An Introduction to Seriation (http://archaeology.about.com/od/dating/ss/seriation.htm)

# SERIATION

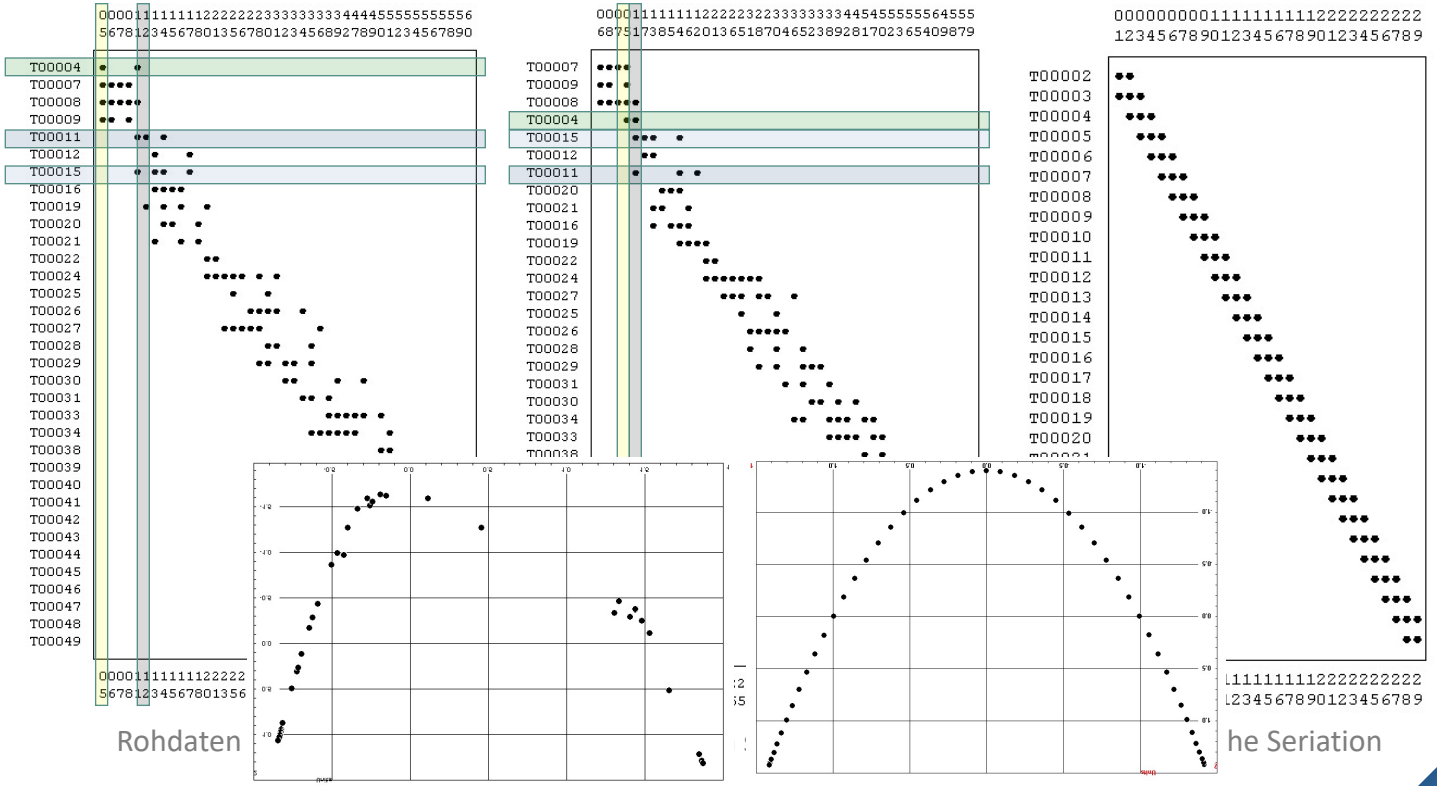
of grave goods using the example of Taranto




Daniel Graepler, Relativchronologische Ordnung hellenistischer Keramik aus der Nekropole von Tarent mit Hilfe der Korrespondenzanalyse, in: Δ' επιστημονικη συναντηση για την ελληνιστικη κεραμικη, Mytilene 1994, Praktika (Athen 1997) 170 Vgl. auch D. Graepler, Tonfiguren im Grab (München 1997) 67 f. und 76 f. zum Typenbegriff.

# SERIATION

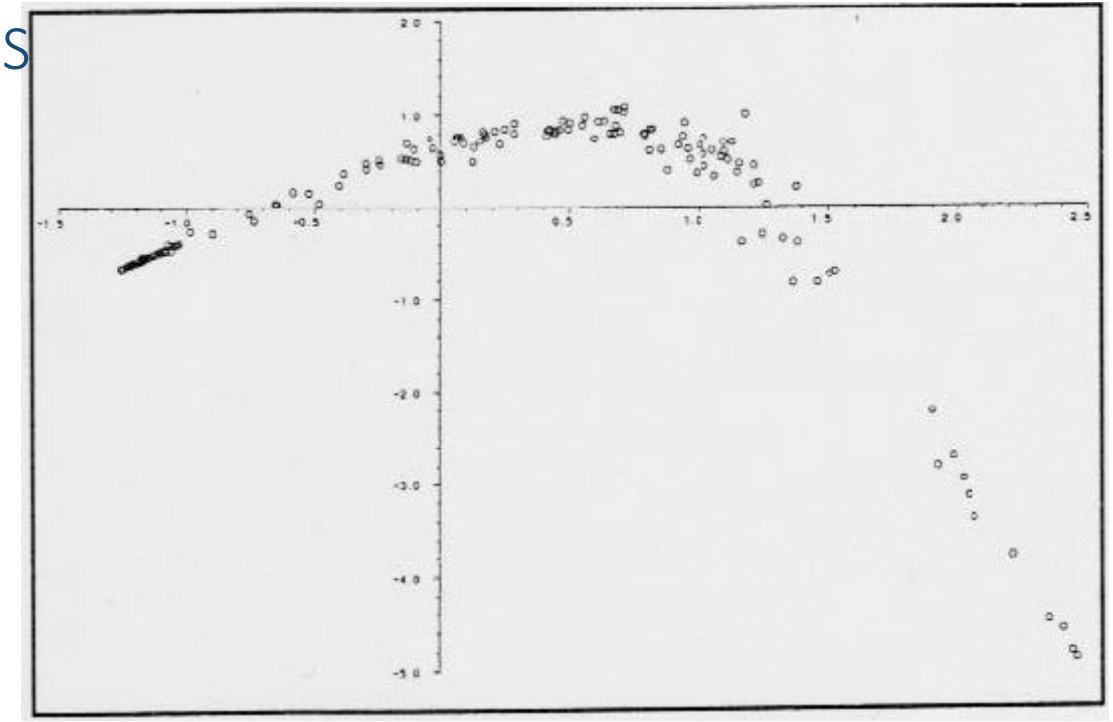
reordering rows and columns of the table to form a diagonal in the table




C. K. Jensen, K. Høilund Nielsen (eds.) Burial and Society: The Chronological and Social Analysis of Archaeological Burial Data (Aarhus University Press, 1997), 29–61

# CORRESPONDENCE ANALYSIS

Regional deviations, gender-specific or e.g. ethnic differences distort the result (best to use data from one location!)



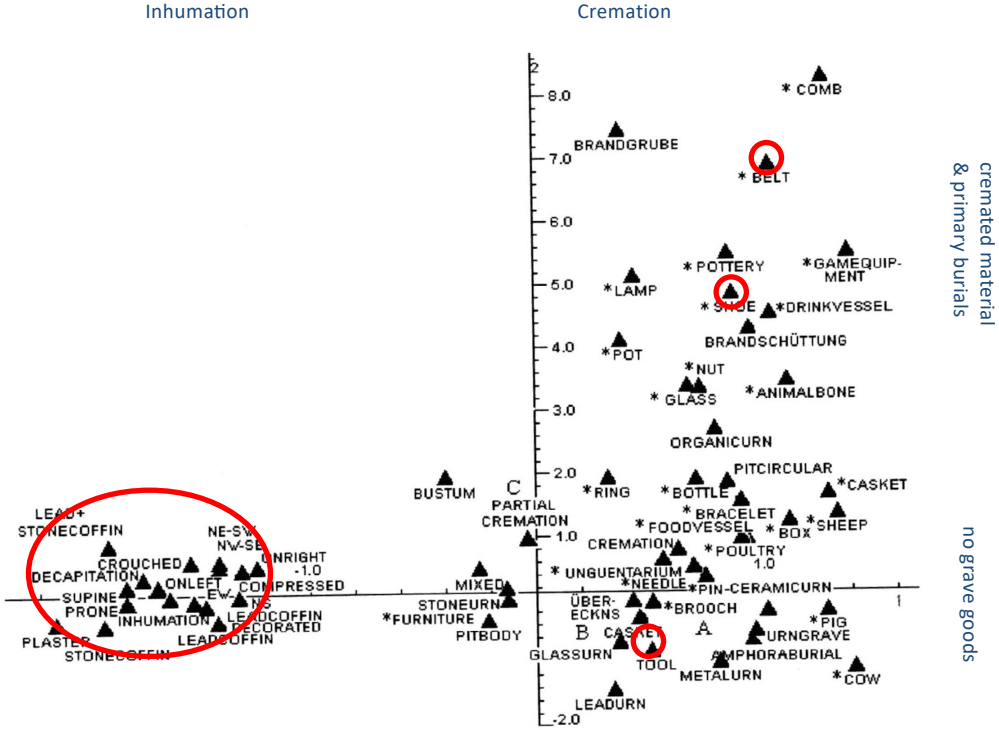
Graph der Korrespondenzanalyse, Gräber der Phasen D–F in Tarent

K.G. Hempel, Keramik des 2. und 1. Jhs. v.Chr. aus der Nekropole von Tarent (http://www.uni-koeln.de/~al001/basp.html)

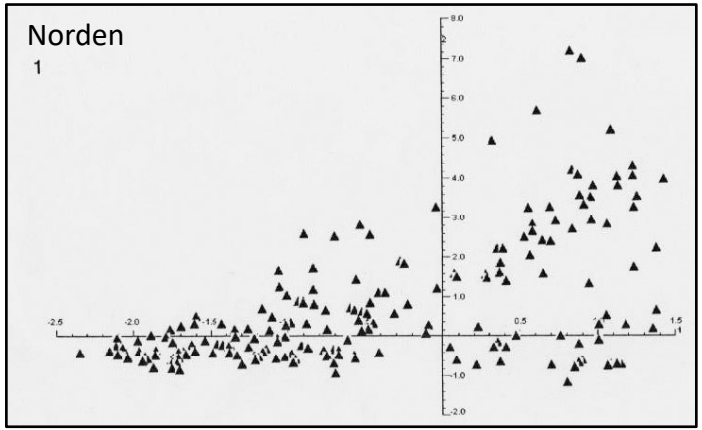
# MULTIVARIATE SERIATION

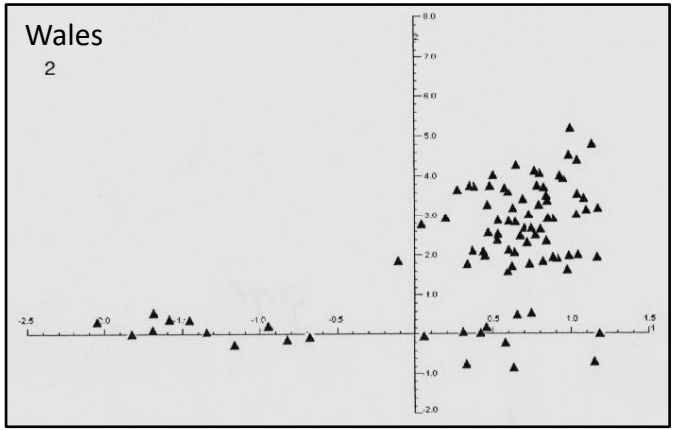
The simultaneous observation and analysis of more than one outcome variable

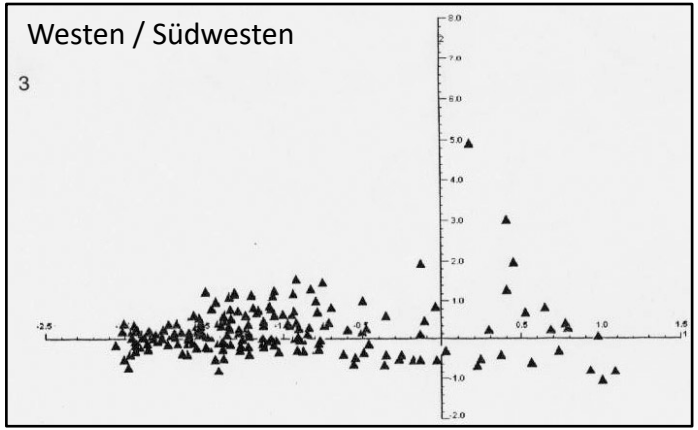
e.g. grave goods and customs in Britain under Roman rule

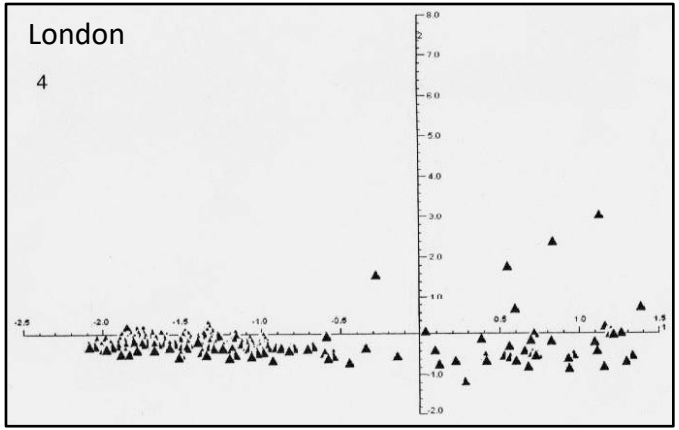



M. Struck, Der Einsatz der Korrespondenzanalyse bei der Untersuchung römerzeitlicher Gräber aus Britannien (Rahden 2002)

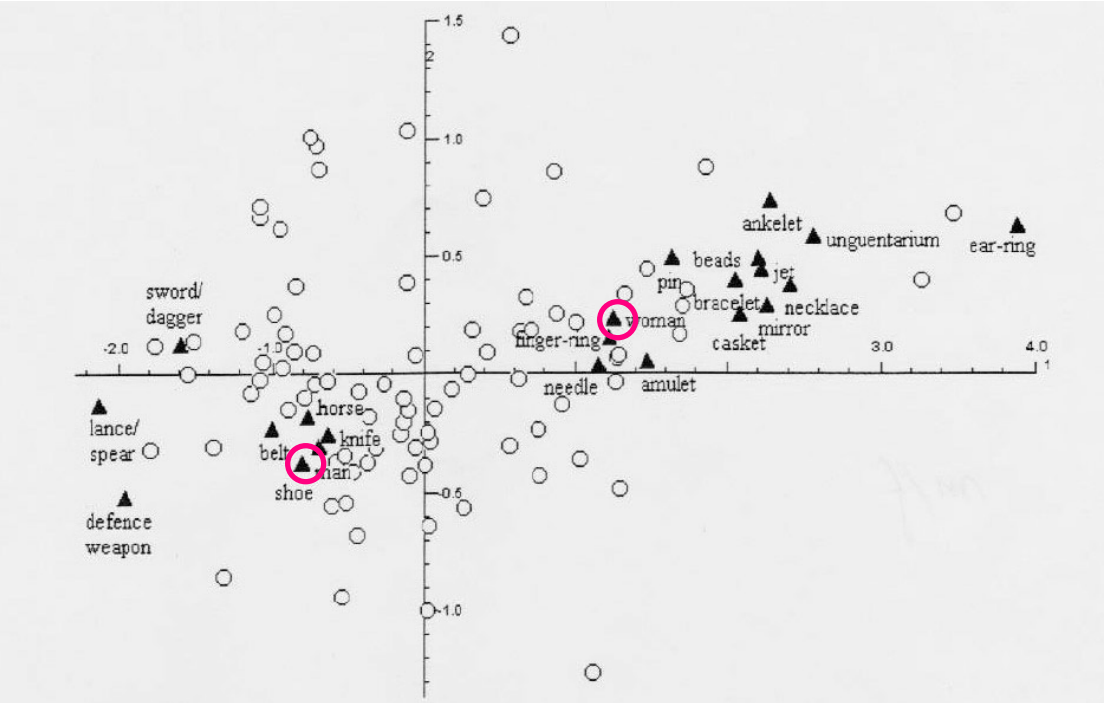

Norden
1


Wales
2


Westen / Südwesten
3


London
4

# Evaluation according to gender




Romano-British inhumations of the 1st-3rd century: grave goods and mores.
Triangle: female-specific features, square: male-specific features.

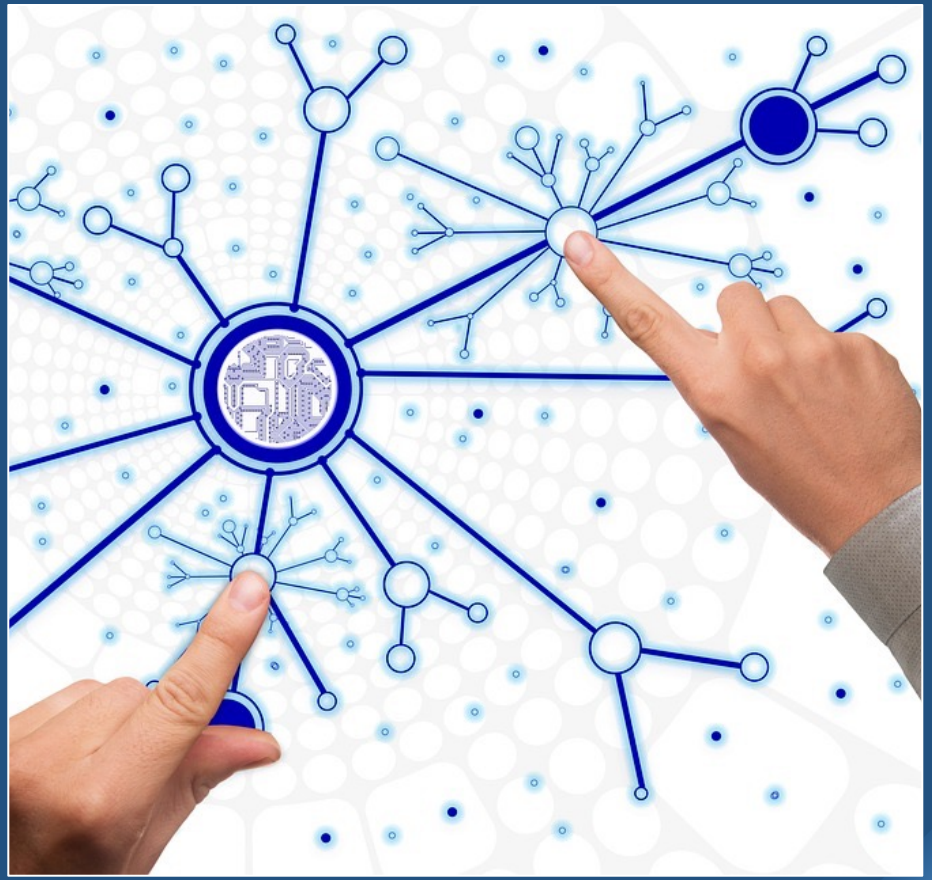
# CORRESPONDENCE ANALYSIS

„Correspondence analysis is an explorative procedure for the graphical and numerical representation of rows and columns of any contingency table. [...] (There is) a distance interpretation between the variables in this procedure – and likewise one between the objects.“

Jörg Blasius, Die Korrespondenzanalyse (München 2001) 6

Software:
- The Bonn Archaeological Software Package zur Kartierung, Seriation und Korrespondenzanalyse (WINBASP, Windows, http://www.uni-koeln.de/~al001/)
- Correspondence Analysis. Principal Components Analysis (CAPCA, Windows für Excel, http://www.archaeoinfo.dk/) mit Übungsblättern der UFG Kiel (ftp://ftp.rz.uni-kiel.de/pub/ufg/dateien_studium/Uebungsblaetter_Kneisel/)
-R-package seriation (Windows/Linux/OS X, http://cran.r-project.org/web/packages/seriation/index.html)

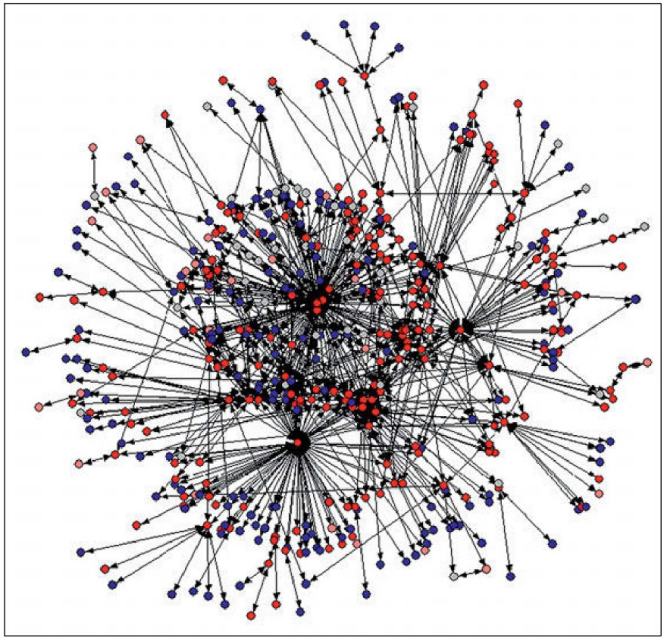
# 2. NETWORK ANALYSIS



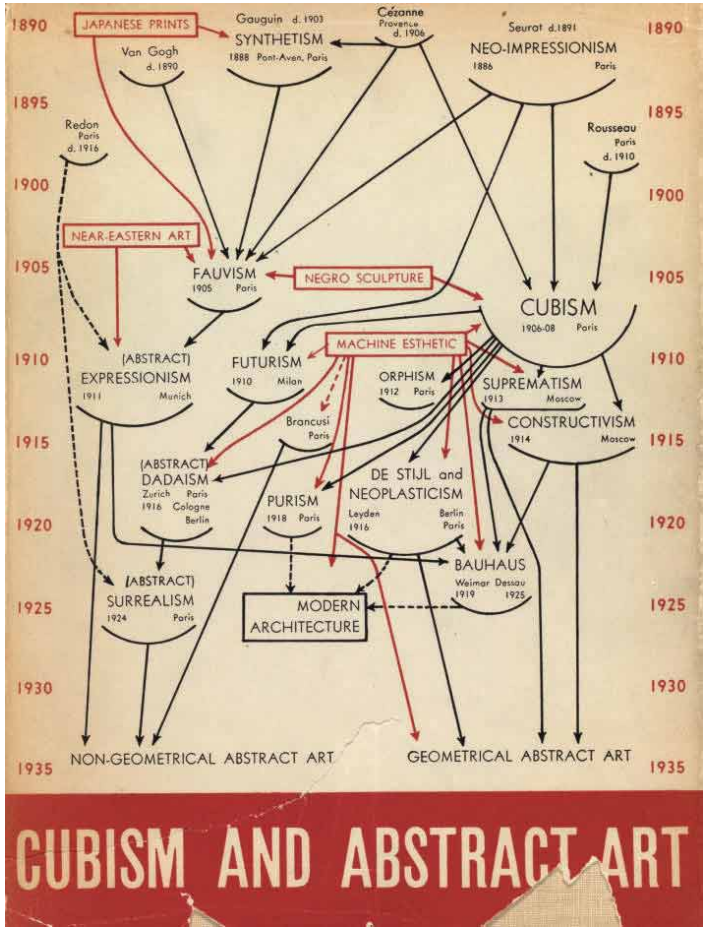
# NETWORK ANALYSIS

Archaeological or historical network analysis has evolved from quantitative network analysis in the social sciences, where it is widely used. Its aim is to capture and analyse complex social structures by diagramming and assessing social actors (i.e. individuals as well as groups and societies) and their relationships to each other.

*Abbildung 1: Hauptkomponente des erhobenen spätrepublikanischen Elitennetzwerkes (cutpoints blau markiert)*



Christian Nitschke – Christian Rollinger, “Network Analysis is performed”. Die Analyse sozialer Netzwerke in den Altertumswissenschaften: Rückschau und aktuelle Forschungen, in: Markus Gamper – Linda Reschke – Marten Düring (Hrsg.), Knoten und Kanten III. Soziale Netzwerkanalyse in Geschichts- und Politikforschung (Bielefeld 2015) 213–260.




https://www.christies.com/en/lot/lot-5388669

# Historical processes and relationships as a network

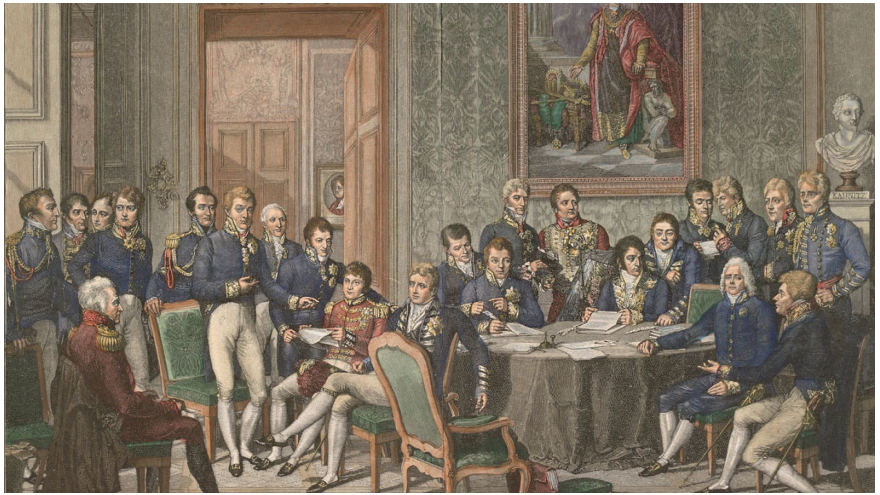
that shows patterns of relationships (edges) between a set of actors (nodes). We can describe these patterns mathematically by calculating, for example, the density of social networks, the number and relationship between individual components (path distances) or the position of key points.

Alfred H Barr, Cubism and Abstract Art (New York: The Museum of Modern Art, 1936)

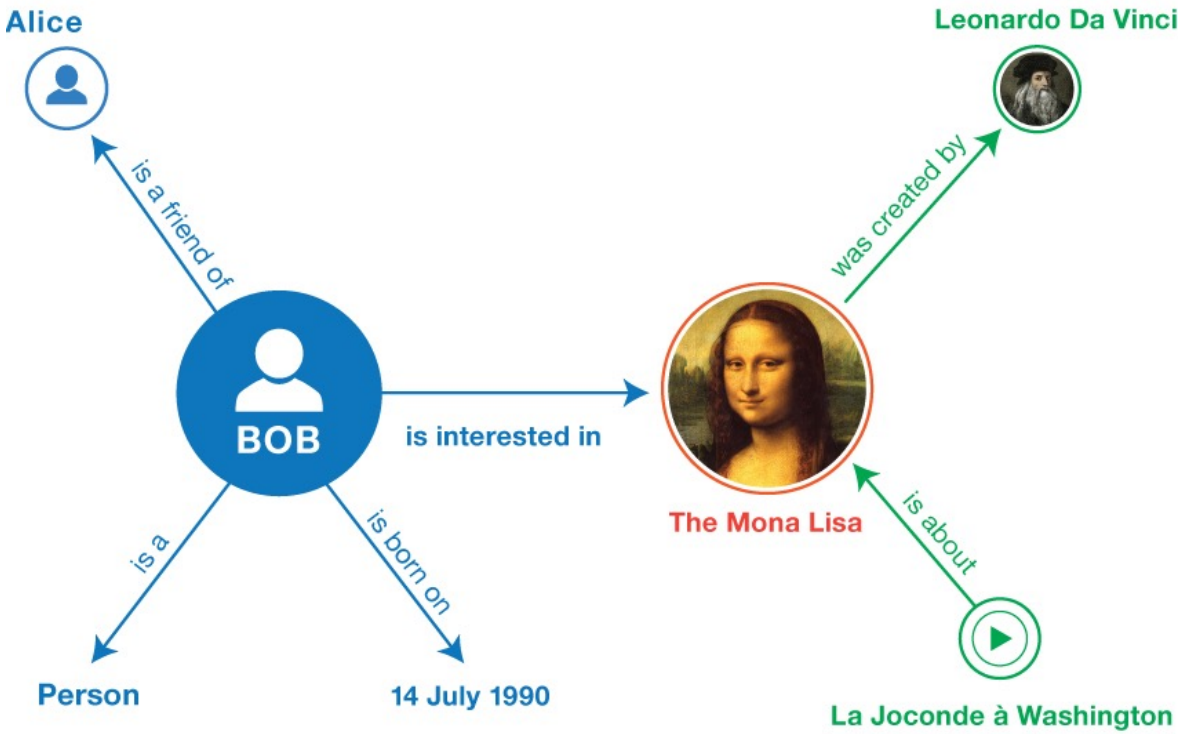
Network analysis defines culture as a (regular) **network of relationships**. All other aspects (such as individuals, resources or norms) are subordinate to the relations between entities.

Accordingly, the individual is defined by his or her position in the network and not by gender, ethnos, age, education, wealth, ideology or behaviour.

Network analysis is therefore particularly suitable for a macroscopic view of complex networks of relationships with a multitude of actors and relationships.

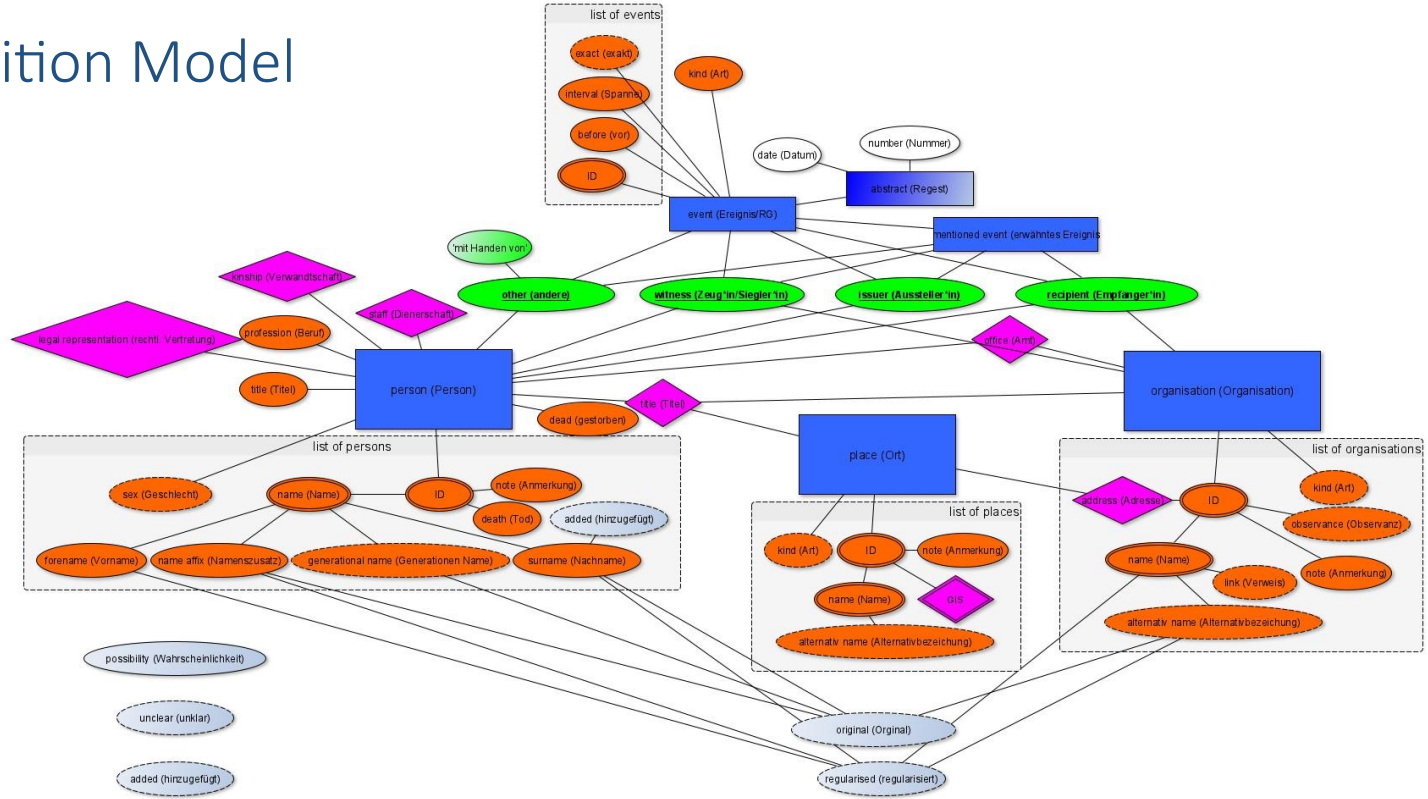


# Semantic Networks and RDF Triple




https://www.w3.org/TR/rdf11-primer/

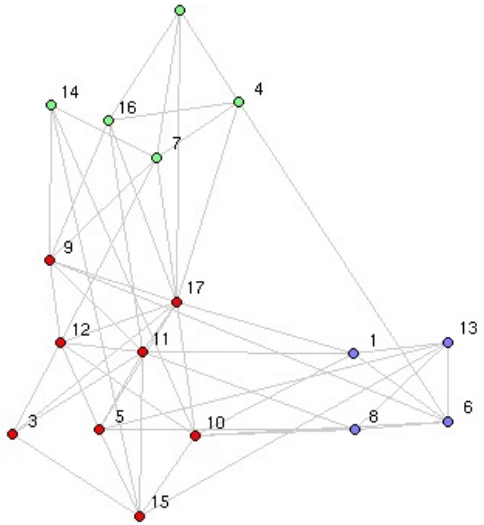
# Data Acquisition Model



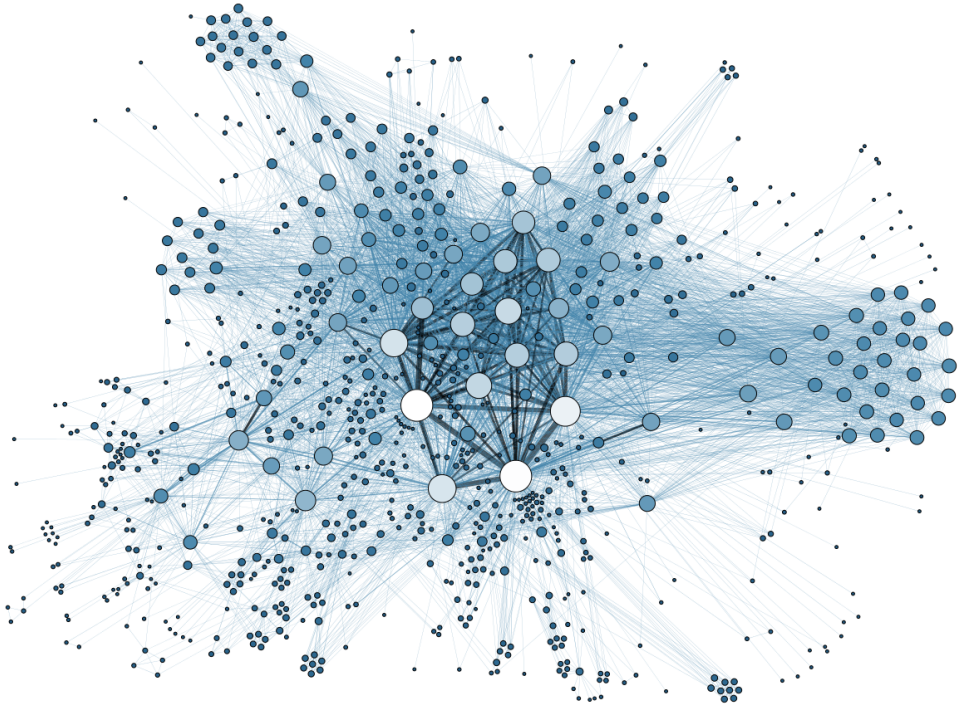

https://memo.imareal.sbg.ac.at/wp-content/uploads/2021/03/Lutter_etAl_MEMO_quer_2021_Abb_2_model_of_entities_Theory.jpg

Grau = Register (List of events, persons, organisations, places); Blau = Entitäten; Grün = Rolle/Funktion im Rechtsgeschäft; Violett = Relationen; Orange = Attribute; Blaugrau = zusätzliche Auszeichnungsoptionen

# Complex systems and flexible networks



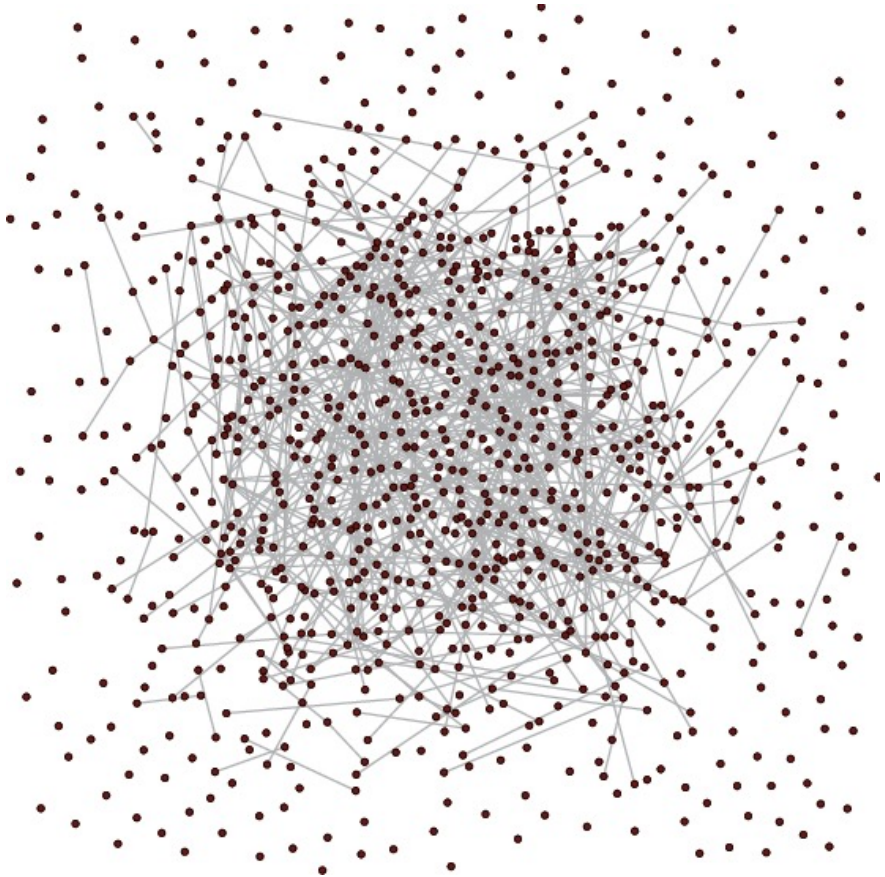

https://i.gifer.com/Bx3t.gif



Graph, der die Metadaten von Tausenden von Archivdokumenten darstellt und das soziale Netzwerk von Hunderten von Mitgliedern im Völkerbund dokumentiert: Martin Grandjean, La connaissance est un réseau, Les Cahiers du Numérique 10.3 (2014), 37–54

# Network analysis based on graph theory

The number of edges grows quadratically with the number of nodes



https://www.stochastik.mathematik.uni-mainz.de/files/2019/09/Grafik_WP-1.jpg

# The Rise of the Medici in Florence at the Beginning of the 15th Century

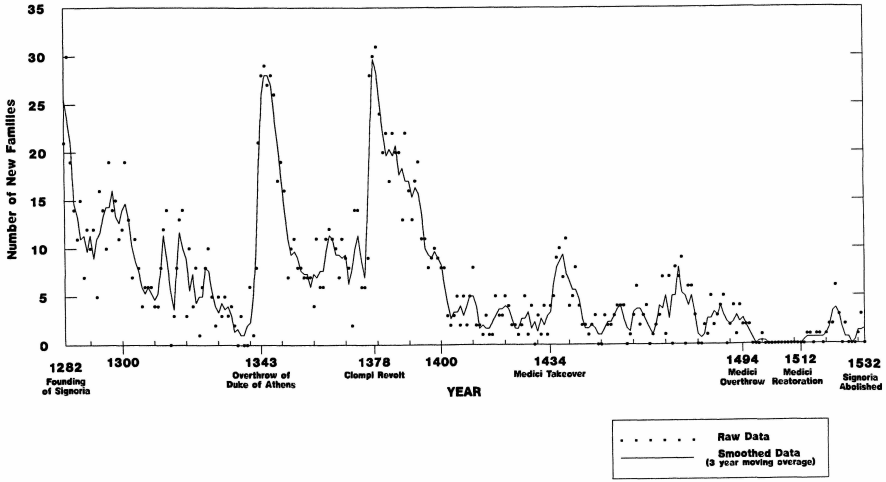
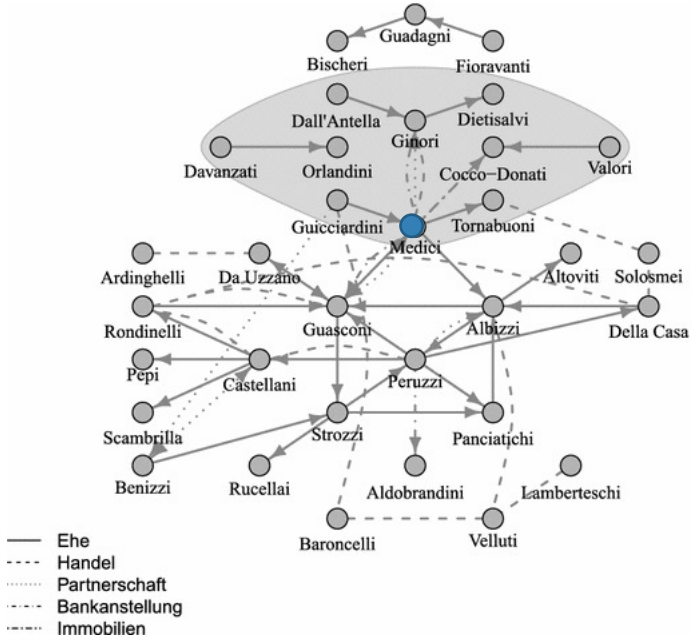


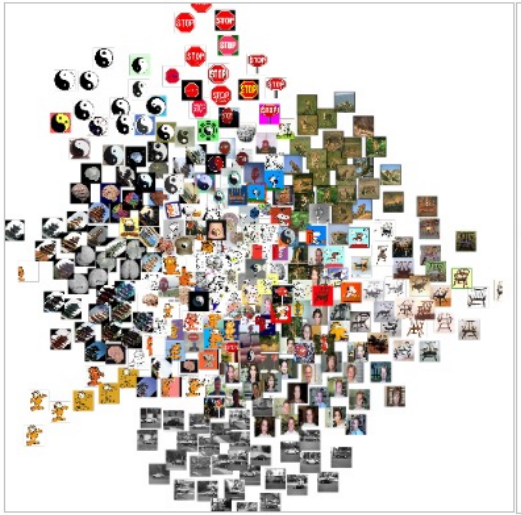

FIG. 1.—New families admitted to the Signoria, 1282–1532 (Source: Najemy 1982, pp. 320–22).

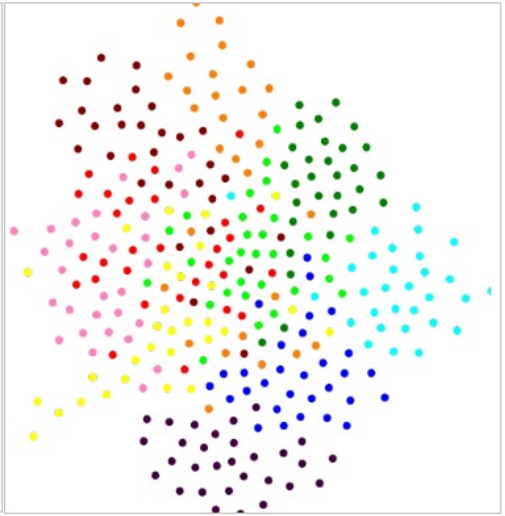



John Padgett, Christopher Ansell, Robust Action and the Rise of the Medici, 1400-1434, The American Journal of Sociology 98, 1993, 1276 Abb. 2a (http://www.stats.ox.ac.uk/~snijders/PadgettAnsell1993.pdf)

Der Datensatz ist zu finden unter: http://www.casos.cs.cmu.edu/computational_tools/datasets/sets/padgett/

# Visual Networks





https://varlab.iti.gr/content/research/visualization

| Clique | Siedlungen der älteren Bandkeramik | | | | |
|---|---|---|---|---|---|
| 1 | Kück | LB 7 | LW 2 | LW 8 | LW 16 |
| 2 | Kück | LB 7 | LW 8 | LW 9 | LW 16 |
| 3 | Kück | LB 7 | LM 2 | LW 8 | LW 16 |
| 4 | LN 3 | LW 8 | LW 16 | | |
| 5 | LB 8 | LN 3 | LW 8 | | |

| Clique | Siedlungen der mittleren Bandkeramik | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | HA 21 | Kö 12 | Kö 14 | Kück | LB 7 | LM 2 | LW 2 | LW 8 | LW 9 |
| 2 | HA 21 | Kö 14 | Kück | LB 7 | LM 2 | LW 2 | LW 8 | LW 9 | LW 16 |
| 3 | ALD 3 | Kö 12 | Kö 14 | Kück | LB 7 | LM 2 | LW 2 | LW 8 | LW 9 |
| 4 | ALD 3 | Kö 14 | Kück | LB 7 | LM 2 | LW 2 | LW 8 | LW 9 | LW 16 |
| 5 | LB 7 | LM 2 | LN 3 | LW 2 | LW 8 | | | | |
| 6 | LB 7 | LM 2 | LW 2 | LW 8 | WW 17 | | | | |
| 7 | HA 21 | Kö 9 | Kö 14 | Kück | LB 7 | LM 2 | LW 8 | | |

| Clique | Siedlungen der jüngeren Bandkeramik | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ALD 3 | HA 21 | Kö 14 | Kück | LB 7 | LM 2 | LW 2 | LW 8 | LW 9 | NM 4 | WW 17 |
| 2 | HA 8 | HA 21 | Kö 14 | Kück | LB 7 | LM 2 | LW 2 | LW 8 | LW 9 | NM 4 | |
| 3 | ALD 3 | HA 21 | Kück | LB 7 | LM 2 | LW 2 | LW 3 | LW 8 | LW 9 | NM 4 | |
| 4 | HA 8 | HA 21 | Kück | LB 7 | LM 2 | LW 2 | LW 3 | LW 8 | LW 9 | NM 4 | |
| 5 | Kö 7 | Kück | LB 7 | LM 2 | LW 2 | LW 8 | LW 9 | | | | |
| 6 | Kück | LB 7 | LM 2 | LW 3 | LW 8 | LW 9 | NM 4 | WW 29 | | | |
| 7 | Kö 14 | Kück | LB 7 | LM 2 | LW 8 | LW 9 | NM 4 | WW 29 | | | |
| 8 | ALD 3 | HA 21 | Kö 13 | Kück | LB 7 | LM 2 | LW 8 | WW 17 | | | |
| 9 | ALD 3 | Kö 14 | LB 7 | LW 2 | LW 8 | LW 9 | NM 4 | WW 6 | WW 17 | | |
| 10 | Kö 1 | Kö 14 | LW 8 | | | | | | | | |

Thus, similarities in the form and decoration of artefacts are seen as indicators of communication processes between workshops and described as a network.

Erich Claßen, Verfahren der ‘Sozialen Netzwerkanalyse’ und ihre Anwendung in der Archäologie, Archäologische Informationen 27 Nr. 2, 2004, 219–226: http://journals.ub.uni-heidelberg.de/index.php/arch-inf/article/view/12683/6515

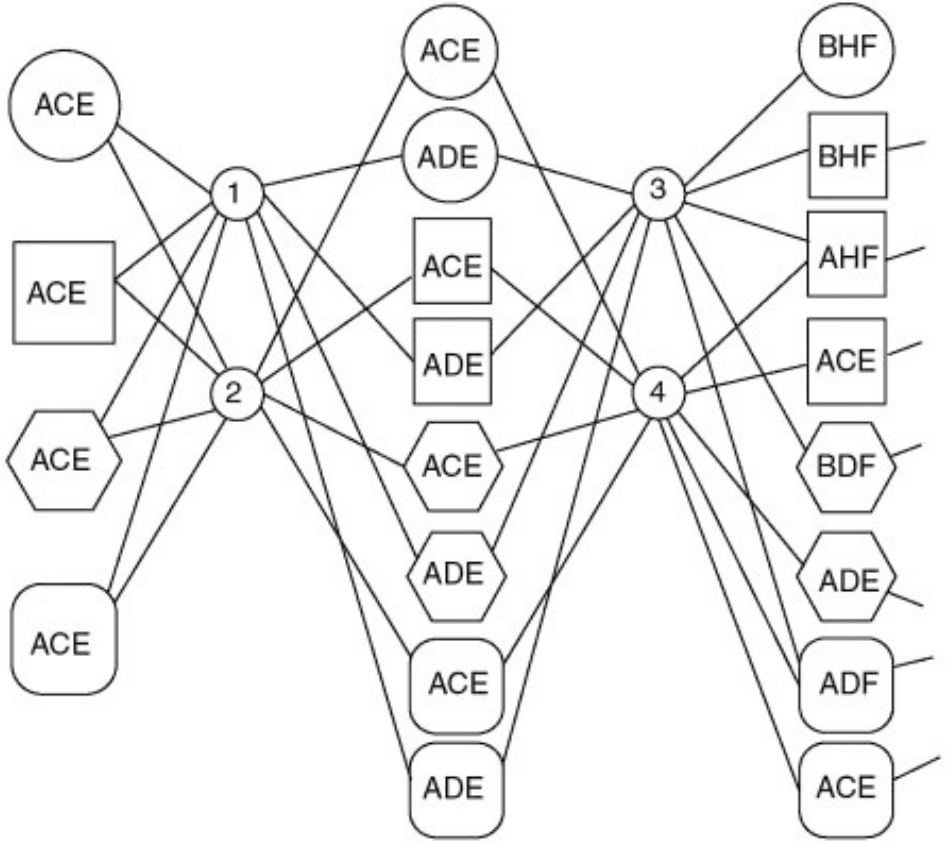



Figure 4.14. Imagined consumption network

*Micro-networks: Proximate Interactions*

| | | |
|---|---|---|
| Material | A | Clay |
| Material | B | Metal |
| Quality | C | Low |
| Quality | D | High |
| Locale | E | Household |
| Locale | F | Palace |

Carl Knappett, An archaeology of interaction. Network perspectives on material culture and society (Oxford 2011).


Other examples are trade relations, dissemination of social or technical innovations, transfer of resources, but also interpersonal relations and role patterns.

Anna C. F. Collar, Religious networks in the Roman Empire. The spread of new ideas (Cambridge 2013).

The possibilities and problems of historical analysis that can arise from the network models are discussed intensively, since network analysis does not provide a uniform interpretation of the results.

s.a. wikipedia s.v. Soziale Netzwerkanalyse

s.a. wikipedia s.v. Graph.

Ulrike Baumöl – Henrik Ickler, Soziale Netzwerkanalyse, Enzyklopädie der Wirtschaftsinformatik. Online-Lexikon: http://www.enzyklopaedie-der-wirtschaftsinformatik.de/lexikon/daten-wissen/Wissensmanagement/Soziales-Netzwerk/Soziale-Netzwerkanalyse/index.html

Gabriel Wurzer, Kerstin Kowarik, Hans Reschreiter (Hrsg.), Agent-based Modeling and Simulation in Archaeology, Advances in Geographic Information Science (Heidelberg / New York 2014).

Anna Collar, Fiona Coward, Tom Brughmans, Barbara J. Mills, Networks in Archaeology. Phenomena, Abstraction, Representation, Journal of Archaeological Method and Theory 22/1, 2015, 1–32 mit ausführlicher Literaturliste.

# Tools for Network analysis

- **Gephi** (https://gephi.org): free open-source software for analysing and visualizsing networks and complex systems in dynamic or hierarchical graphs. ☛ Windows, Linux and Mac OS X.
- **Sci2 Tool** (https://sci2.cns.iu.edu): The Science of Science Tool is a modular set of applications for time, space, topic, and network analysis and visualization of data on the micro, meso and macro level. ☛ Windows, Linux and Mac OS X manuals and tutorials: https://sci2.cns.iu.edu/user/documentation.php
- **RSiena** (http://www.stats.ox.ac.uk/~snijders/siena): allows the statistical analysis of network data in R with all functions obtained in SIENA. ☛ Windows, Linux and MacOS X.
- **GRASS GIS** (http://grass.osgeo.org): The free open source software is used for data management of spatial data and enables the output of data as a graphic, map or 3D space model. Network analyses of spatial data are also possible to a certain extent.

# Tools for Network analysis

- **Palladio** (http://hdlab.stanford.edu/palladio/)
- **nodegoat** (http://nodegoat.net): web-based data management system that allows you to analyse and visualise any number of records. Tutorials: https://www.youtube.com/channel/UC_bgsLe-CjhyrSC2c_clb7Q
- **Quadrigram** (http://www.quadrigram.com): a "visual programming environment" for the publication of own data as simple charts and graphs, networks, scalable pedigrees with division into multiple branches and geodata.
- **SylvaDB** (http://sylvadb.com): is a graph-oriented database system that creates, manages and analyses data in network structures without prior knowledge of graph theory.
- **Lynks** (http://lynksoft.com): an EU-funded, Leiden University campus (on The Hague campus), easy-to-use tool to create and manage your own networks online or with uploaded data.

# 3. DATA VISUALISATION

# BENEFITS OF VISUALISATION

| | A | B | C |
|---|---|---|---|
| 2 | 1905 | 73 | |
| 3 | 1905 | 99 | |
| 4 | 1905 | 105 | |
| 5 | 1905 | 132 | |
| 6 | 1905,5 | 52 | |
| 7 | 1905,5 | 70 | |
| 8 | 1905,5 | 88 | |
| 9 | 1905,5 | 98 | |
| 10 | 1905,5 | 117 | |
| 11 | 1905,5 | 120 | |
| 12 | 1905,5 | 130 | |
| 13 | 1905,5 | 135 | |
| 14 | 1905,5 | 137 | |
| 15 | 1906 | 91 | |
| 16 | 1906 | 108 | |
| 17 | 1906,5 | 72 | |
| 18 | 1906,5 | 83 | |
| 19 | 1906,5 | 85 | |
| 20 | 1906,5 | 100 | |
| 21 | 1906,5 | 104 | |
| 22 | 1906,5 | 107 | |
| 23 | 1906,5 | 116 | |
| 24 | 1906,5 | 140 | |
| 25 | 1906,5 | 157 | |
| 26 | 1907 | 70 | |
| 27 | 1907 | 88 | |
| 28 | 1907 | 93 | |
| 29 | 1907 | 105 | |
| 30 | 1907 | 119 | |
| 31 | 1907 | 122 | |
| 32 | 1907 | 135 | |
| 33 | 1907 | 138 | |
| 34 | 1907 | 158 | |
| 35 | 1907,5 | 72 | |
| 36 | 1907,5 | 75 | |
| 37 | 1907,5 | 90 | |
| 38 | 1907,5 | 96 | |
| 39 | 1907,5 | 105 | |
| 40 | 1907,5 | 106 | |

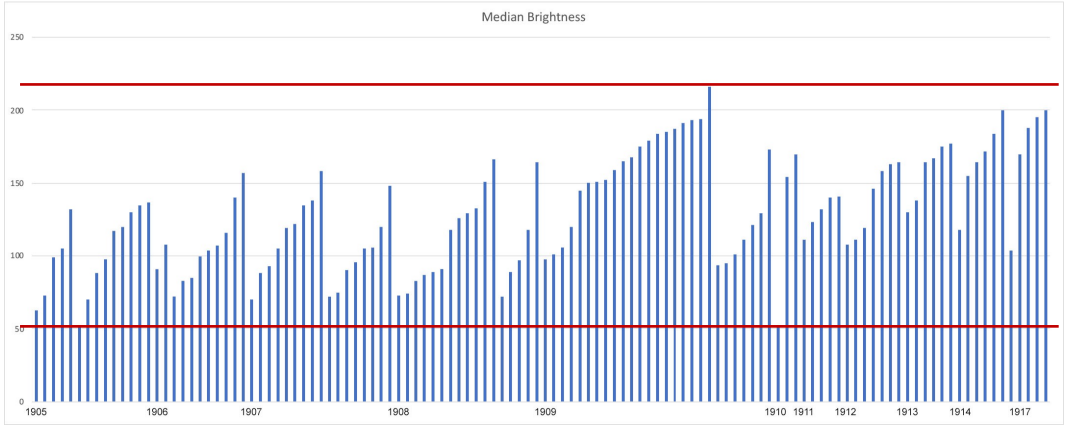
Mondian_Brightness

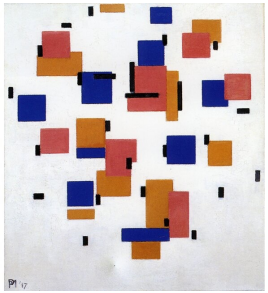
| | A | B | C |
|---|---|---|---|
| 41 | 1907,5 | 120 | |
| 42 | 1907,5 | 148 | |
| 43 | 1908 | 73 | |
| 44 | 1908 | 74 | |
| 45 | 1908 | 83 | |
| 46 | 1908 | 87 | |
| 47 | 1908 | 89 | |
| 48 | 1908 | 91 | |
| 49 | 1908 | 118 | |
| 50 | 1908 | 126 | |
| 51 | 1908 | 129 | |
| 52 | 1908 | 133 | |
| 53 | 1908 | 151 | |
| 54 | 1908 | 166 | |
| 55 | 1908,5 | 72 | |
| 56 | 1908,5 | 89 | |
| 57 | 1908,5 | 97 | |
| 58 | 1908,5 | 118 | |
| 59 | 1908,5 | 164 | |
| 60 | 1909 | 98 | |
| 61 | 1909 | 101 | |
| 62 | 1909 | 106 | |
| 63 | 1909 | 120 | |
| 64 | 1909 | 145 | |
| 65 | 1909 | 150 | |
| 66 | 1909 | 151 | |
| 67 | 1909 | 152 | |
| 68 | 1909 | 159 | |
| 69 | 1909 | 165 | |
| 70 | 1909 | 168 | |
| 71 | 1909 | 175 | |
| 72 | 1909 | 179 | |
| 73 | 1909 | 184 | |
| 74 | 1909 | 185 | |
| 75 | 1909 | 187 | |
| 76 | 1909 | 191 | |
| 77 | 1909 | 193 | |
| 78 | 1909 | 194 | |
| 79 | 1909 | 216 | |

Mondian_Brightness

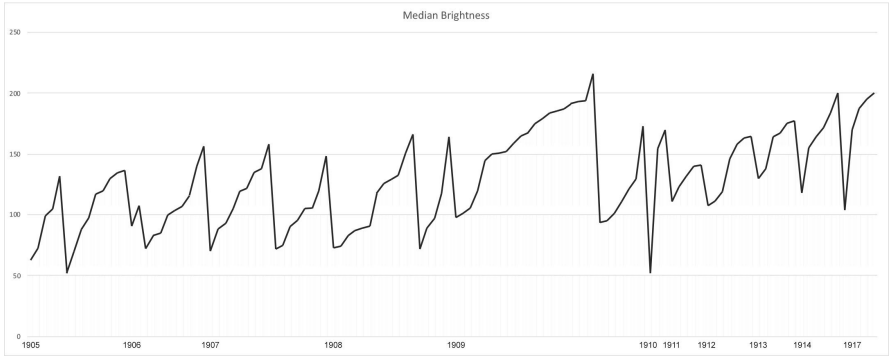
| | A | B | C |
|---|---|---|---|
| 80 | 1909,5 | 94 | |
| 81 | 1909,5 | 95 | |
| 82 | 1909,5 | 101 | |
| 83 | 1909,5 | 111 | |
| 84 | 1909,5 | 121 | |
| 85 | 1909,5 | 129 | |
| 86 | 1909,5 | 173 | |
| 87 | 1910 | 52 | |
| 88 | 1910 | 154 | |
| 89 | 1910 | 170 | |
| 90 | 1911 | 111 | |
| 91 | 1911 | 123 | |
| 92 | 1911 | 132 | |
| 93 | 1911 | 140 | |
| 94 | 1911 | 141 | |
| 95 | 1912 | 108 | |
| 96 | 1912 | 111 | |
| 97 | 1912 | 119 | |
| 98 | 1912 | 146 | |
| 99 | 1912 | 158 | |
| 100 | 1912 | 163 | |
| 101 | 1912 | 164 | |
| 102 | 1913 | 130 | |
| 103 | 1913 | 138 | |
| 104 | 1913 | 164 | |
| 105 | 1913 | 167 | |
| 106 | 1913 | 175 | |
| 107 | 1913 | 177 | |
| 108 | 1914 | 118 | |
| 109 | 1914 | 155 | |
| 110 | 1914 | 164 | |
| 111 | 1914 | 172 | |
| 112 | 1914 | 184 | |
| 113 | 1914 | 200 | |
| 114 | 1916 | 104 | |
| 115 | 1917 | 170 | |
| 116 | 1917 | 188 | |
| 117 | 1917 | 195 | |
| 118 | 1917 | 200 | |

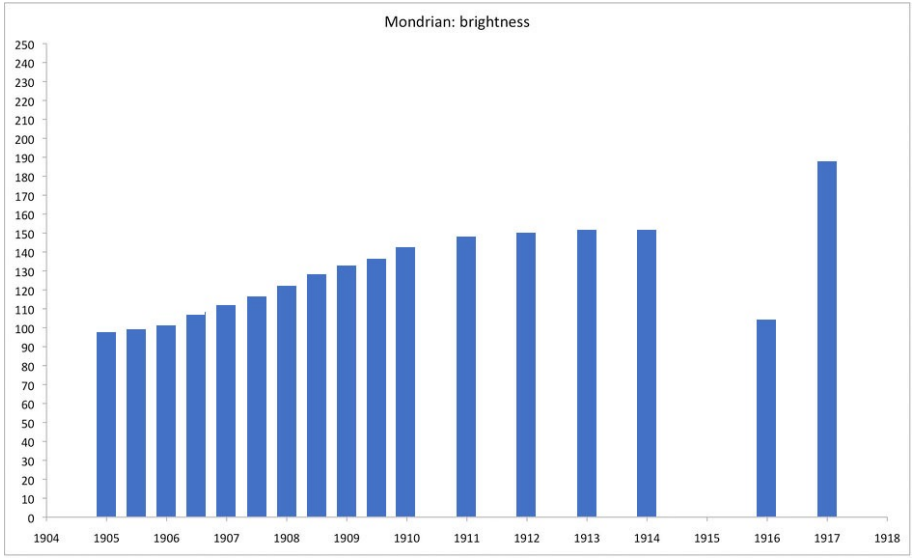
Mondian_Brightness



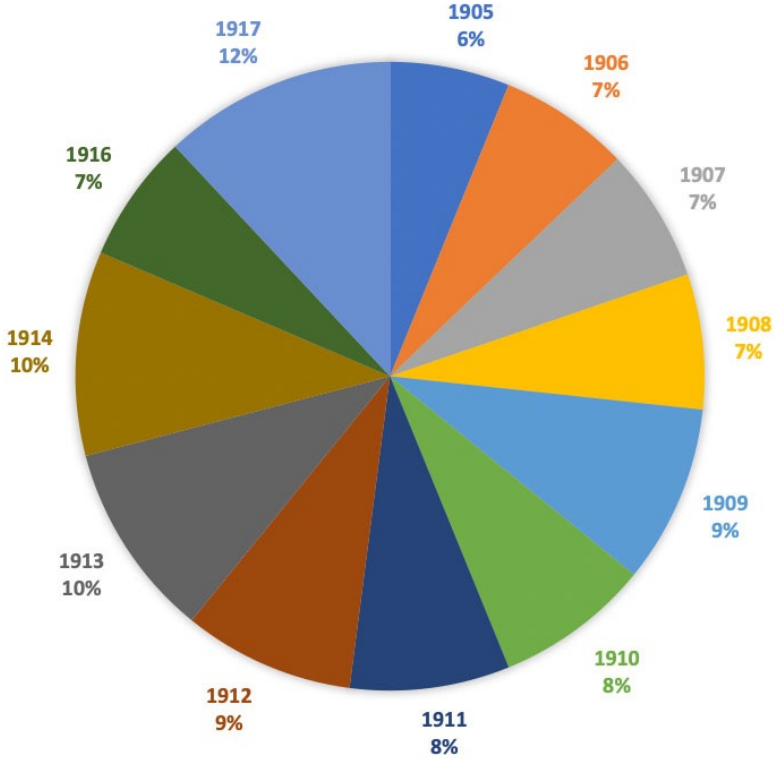



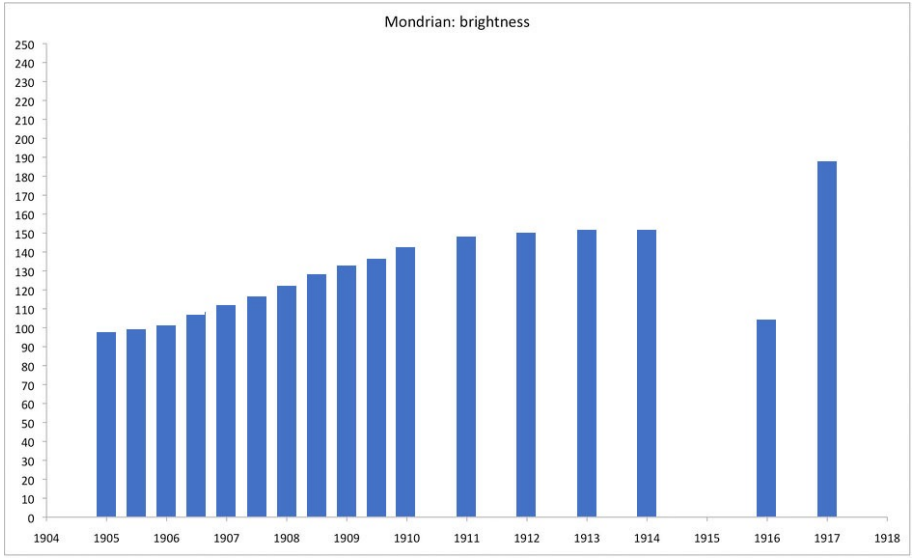
# NEGATIVE EXAMPLES OF VISUALISATION



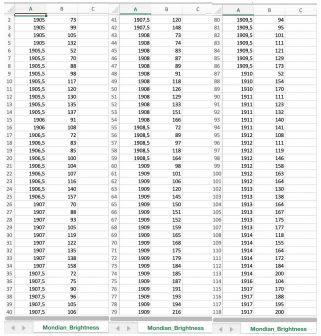



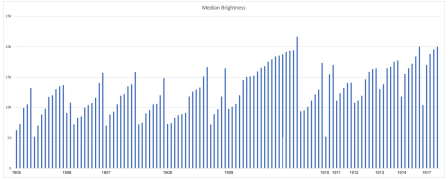
# NEGATIVE EXAMPLES OF VISUALISATION

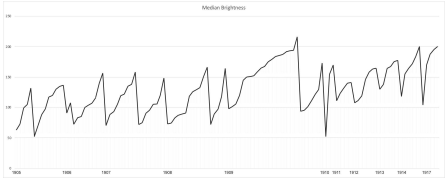


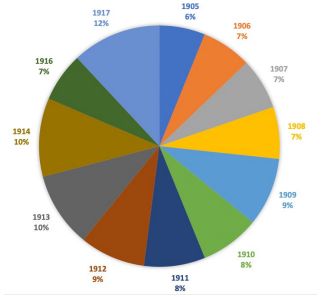



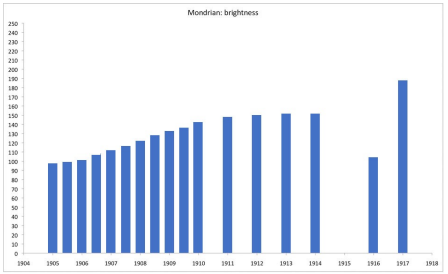
# EXAMPLES OF VISUALISATION

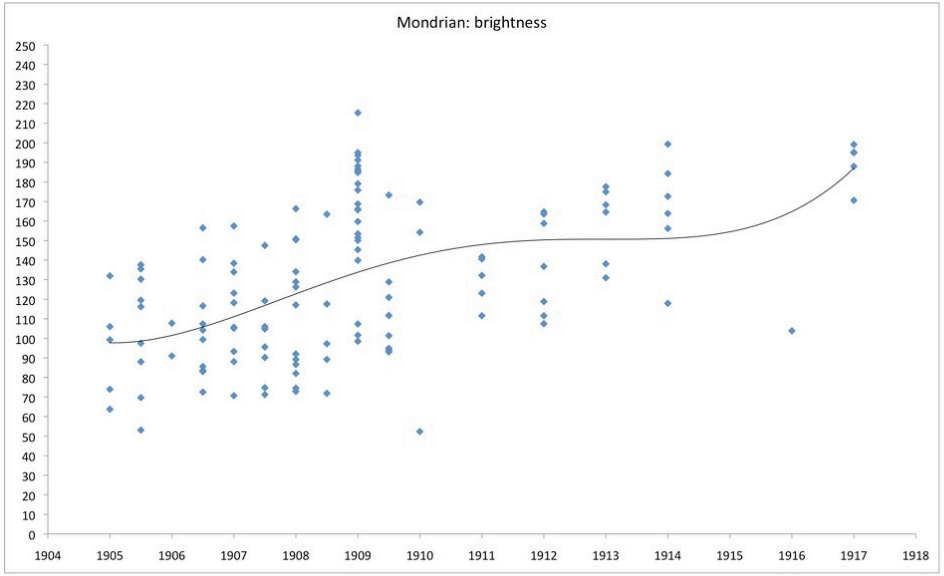




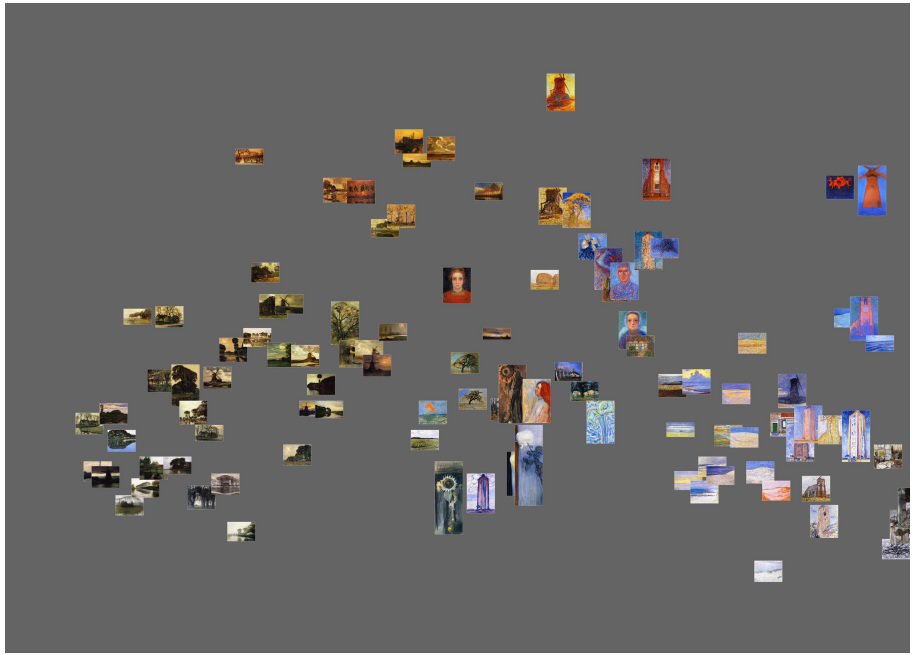



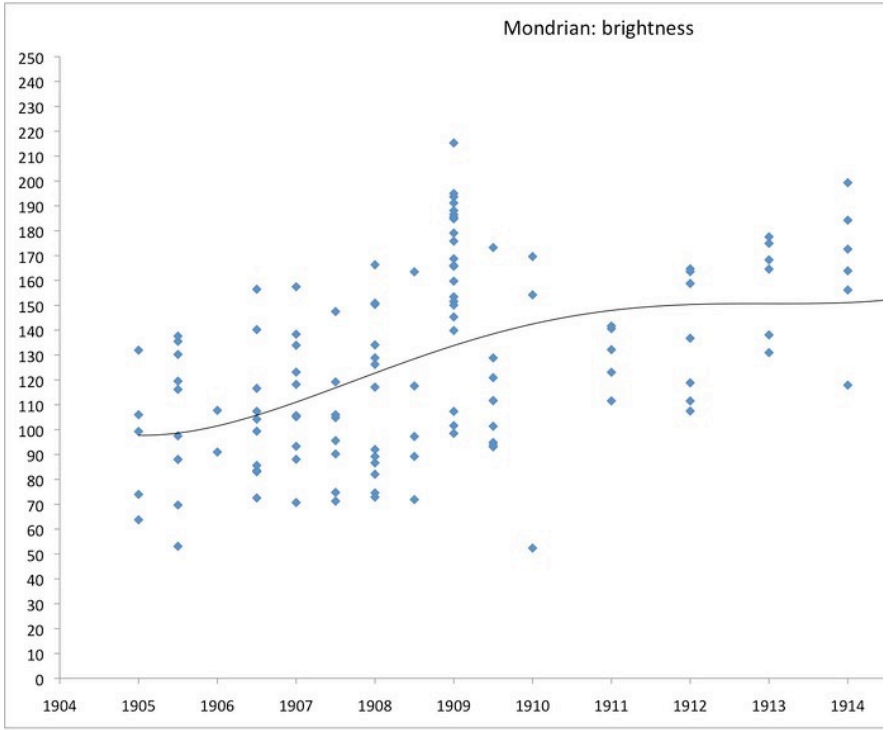




https://live.staticflickr.com/4007/5109314913_8ffa356fd5_k.jpg

Lev Manovich, Style Space: How to compare image sets and follow their evolution (2011): http://manovich.net/index.php/projects/style-space

# EXAMPLES OF VISUALISATION





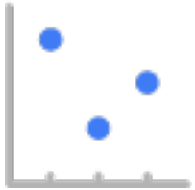

https://live.staticflickr.com/4007/5109314913_8ffa356fd5_k.jpg

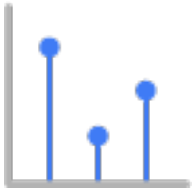
Lev Manovich, Style Space: How to compare image sets and follow their evolution (2011): http://manovich.net/index.php/projects/style-space

# COMPARISONS


Bar Chart

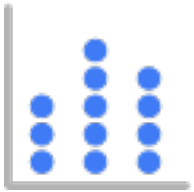

Column Chart

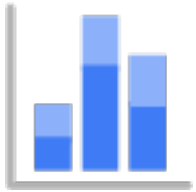

Dot Graph


Lollipop Chart


Grouped Bar Chart

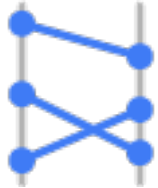

Pictogram Chart


Unit Chart


Stacked Bar Chart


Side by Side Bar Chart

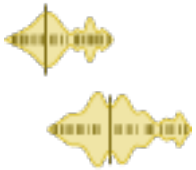

Bullet Graph

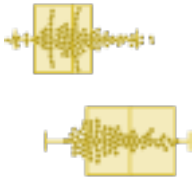

Slopegraph

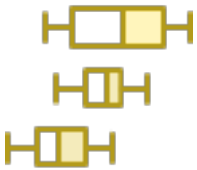

Radial Column Chart

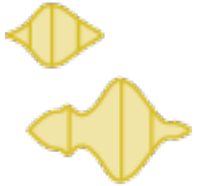
https://www.instagram.com/p/B_Nb2plgUb5/


Barcode Plot

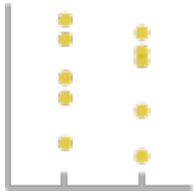

Bean Plot

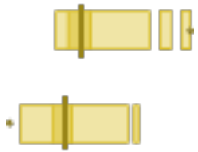

Bee Swarm Box Plot

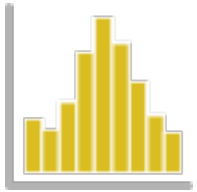

Box Plot

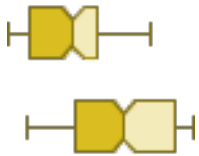

Box-Percentile Plot


Density Plot

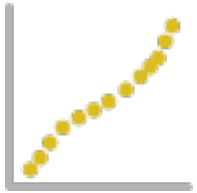

Dot Distribution Plot


HDR Box Plot

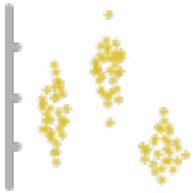

Histogram

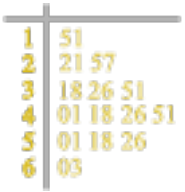

Notched Box Plot


Population Pyramid

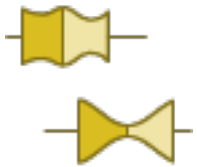

Q-Q Plot

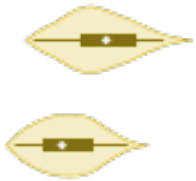

Ridgeline Plot


Sina Plots



Stem & Leaf Plot


Vase Plot


Violin Plot

https://www.instagram.com/p/CANZZzCgQqQ/

# DATA OVER TIME

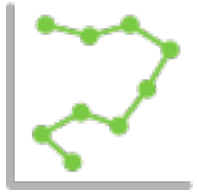

Line Graph


Run Chart

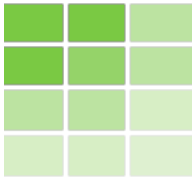

Control Chart

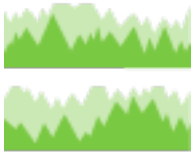

Area Graph


Stacked Area Graph

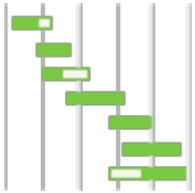

Connected Scatterplot


Streamgraph


Heatmap


Horizon Plot


Spiral Plot


Gantt Chart


Timeline

https://www.instagram.com/p/B_1zsNDAEya/

# PROPORTIONS

Bubble Chart

Bubble Map

Dorling Map

Demers Cartogram

Proportional Area Chart

Unit Chart (Area)

Parallel Sets

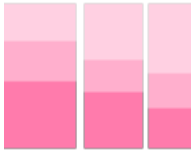
Circle Packing

Sankey Diagram

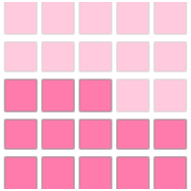
https://www.instagram.com/p/B_SSrdZjy0r/

# PARTS TO A WHOLE

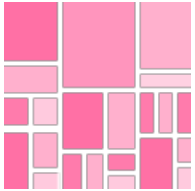
100% Stacked Bar Chart



Marimekko Chart



Waffle Chart



Treemap

Pie Chart

Donut Chart

https://www.instagram.com/p/CAIB1cdgWal/

# GEOGRAPHICAL

Bubble Map

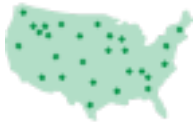
Cartogram

Choropleth Map

Connection Map

Demer Cartogram

Dorling Map



Dot Map

Flow Map

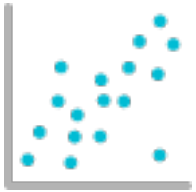
Isochrone Map

Non-contiguous Cartogram

Tile Grid Map

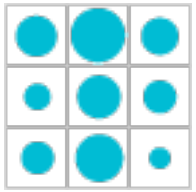
https://www.instagram.com/p/CAfS2qrgYD7/

# CORRELATIONS

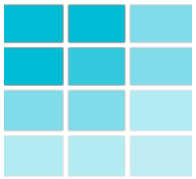


Scatterplot

Bubble Chart



Correlation Matrix



Heatmap

# CONNECTIONS

Arc Diagram

Circular Tree Diagram

Hive Plot

Network Diagram

Non-ribbon Chord Diagram

Connection Map

https://www.instagram.com/p/CA5CLtCAPFm/

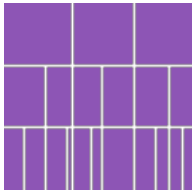
# HIERARCHY

Circular Tree Diagram

Circular Treemap

Tree Diagram

Treemap

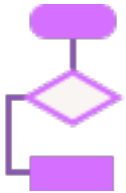


Icicle Chart

Sunburst Diagram

# FLOW

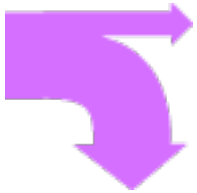
Alluvial Diagram



Flow Diagram

Flow Map

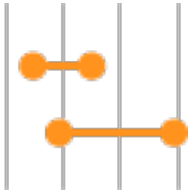
Parallel Sets



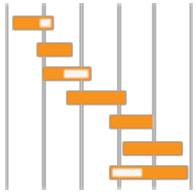
Sankey Diagram

https://www.instagram.com/p/CAxN8M2Awy6/

# RANGES



Barbell Plot



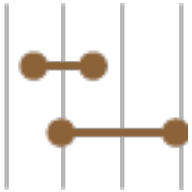
Gantt Chart

Ranged Area Graph

Span Chart

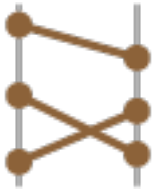
https://www.instagram.com/p/B_cxQ4sAs6y/

# SHOWING CHANGE BETWEEN TWO POINTS



Barbell Plot

Change Bar Chart



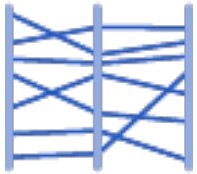
Slopegraph

https://datavizcatalogue.com/index.html

https://www.instagram.com/p/CADFMnrgPDM/

# MULTI-VARIABLE ANALYSIS

Chernoff Faces



Parallel Coordinates

Radar Chart

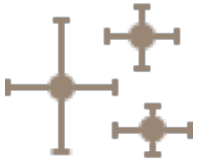
Ternary Graph

https://www.instagram.com/p/CAsFn9CgsDH/

# UNCERTAINTY AND ERROR

Area Bands

Confidence Strips



Error Bars

Graded Error Bars

https://www.instagram.com/p/B_zQ1cnA_ba/

# BASIC PRINCIPLES OF VISUALISATION I (DATA)

- Good graphics are based on good data!


https://suxeedo.de/wp-content/uploads/2018/08/Infigrafik-Hamburg.png

Johanna Drucker, Humanities Approaches to Graphical Display, Digital Humanities Quarterly 5.1, 2011: http://www.digitalhumanities.org/dhq/vol/5/1/000091/000091.html

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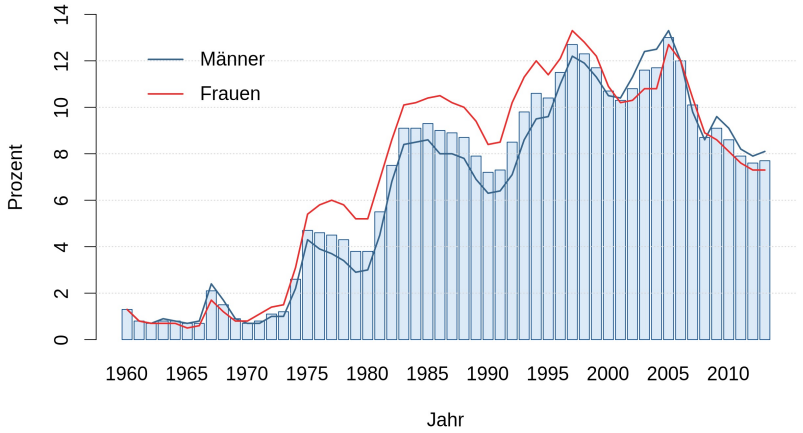
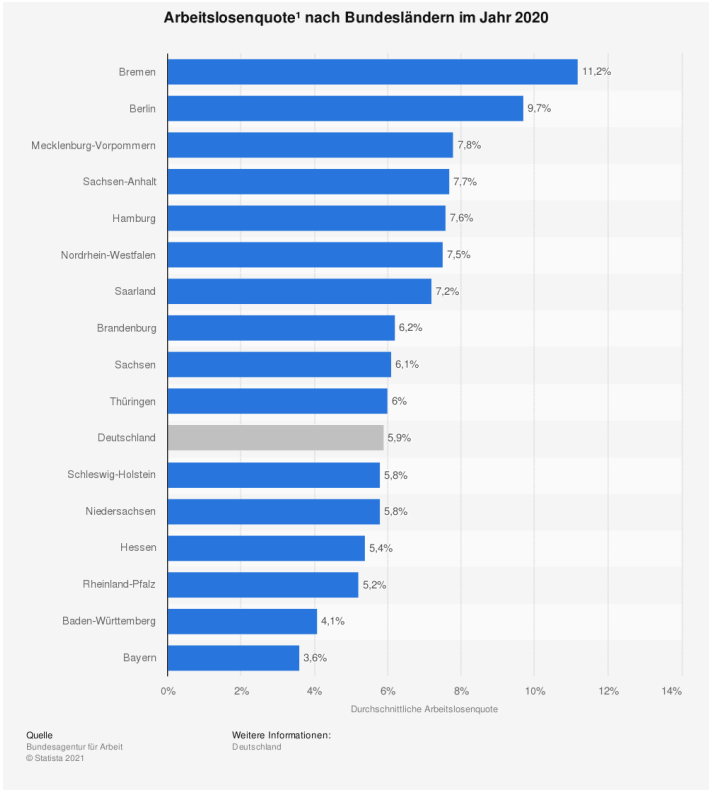
- Good graphics are based on good data!

- Distinguish between discrete measured values and constantly changing data!



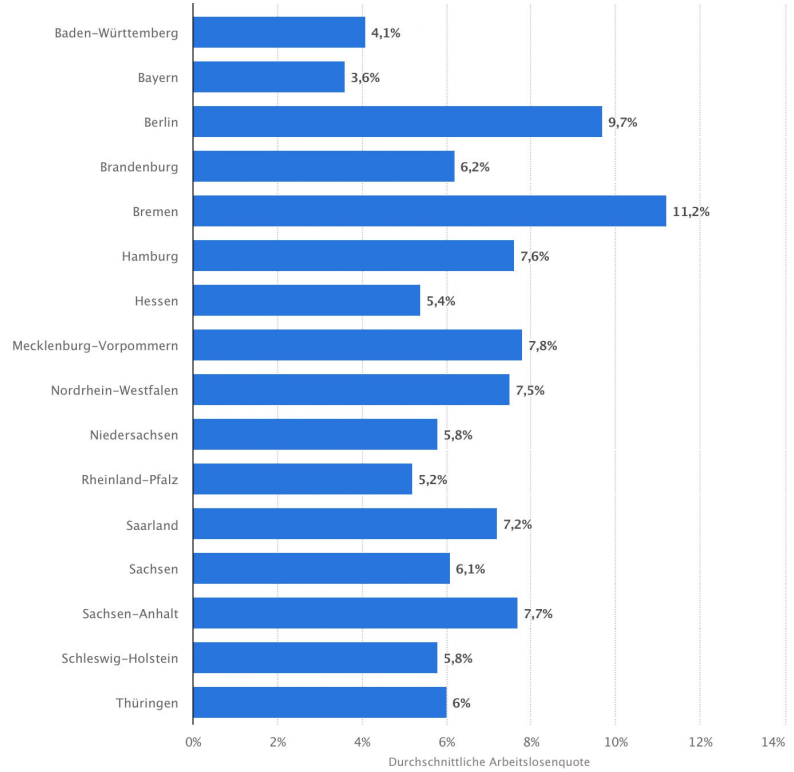

https://upload.wikimedia.org/wikipedia/commons/thumb/9/97/GermanyUnemploymentRate.svg/2560px-GermanyUnemploymentRate.svg.png




https://de.statista.com/graphic/1/2192/durchschnittliche-arbeitslosenquote-nach-bundeslaendern.jpg

# BASIC PRINCIPLES OF VISUALISATION I (DATA)

- Good graphics are based on good data!
- Distinguish between discrete measured values and constantly changing data!
- Arrange the data in a sensible order!



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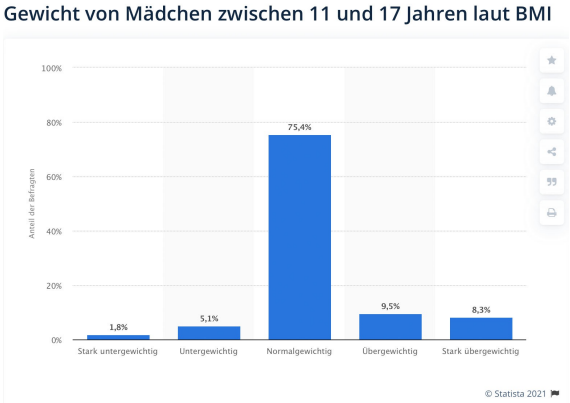
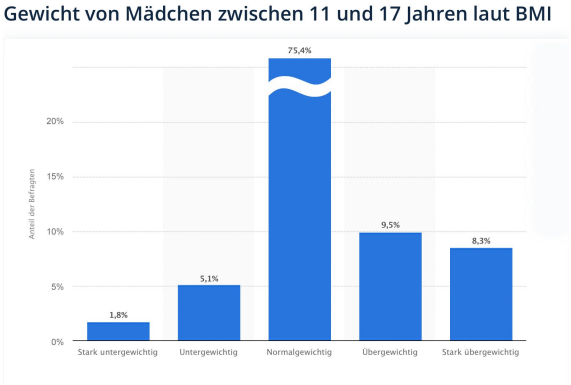
- Arrange the data in a sensible order!
- Choose the right dimensions for the visualisation!




https://de.statista.com/statistik/daten/studie/696



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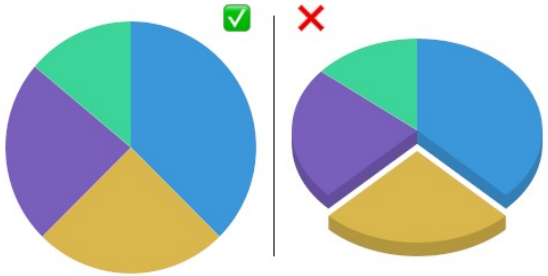
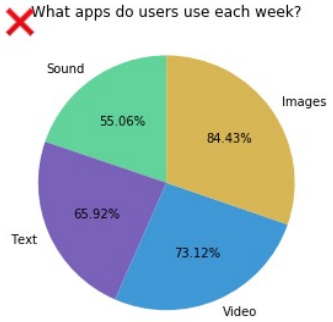
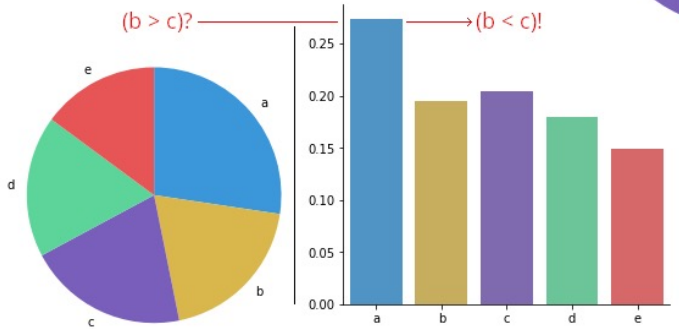
- Good graphics are based on good data!
- Distinguish between discrete measured values and constantly changing data!
- Arrange the data in a sensible order!
- Choose the right dimensions for the visualisation and avoid distortions!






https://chartio.com/learn/charts/pie-chart-complete-guide/

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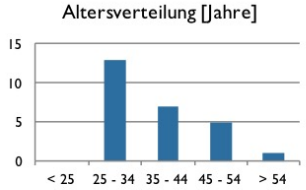
- Good graphics are based on good data!
- Distinguish between discrete measured values and constantly changing data!
- Arrange the data in a sensible order!
- Choose the right dimensions for the visualisation and avoid distortions!
- Always state the size of the sample (n)!


https://assets.trendkraft.io/pressebilder/8113/2020/95-jahre-weltspartag-so-spart-deutschland-2020_0.jpg

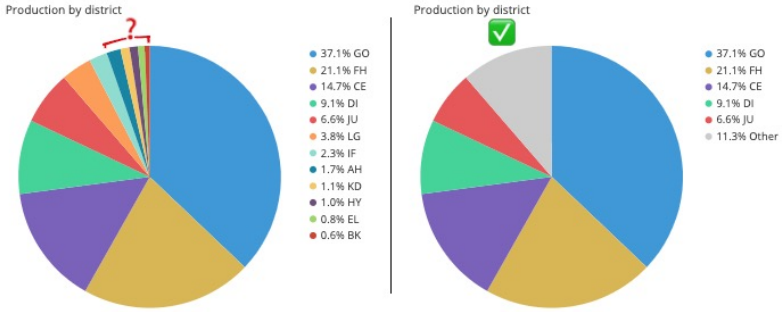
Quelle: Im Oktober 2020 führte Wechselpilot mit Civey eine bundesweite, repräsentative Meinungsumfrage durch. Die Teilnehmer*innen wurden nach ihren Sparmaßnahmen (Stichprobengröße: 2.503), ihrem mtl. Sparbetrag (5.012), ihrer Sparmotivation (2.501) sowie danach gefragt, inwiefern der Satz ‚Ich habe meine Finanzen im Griff' (2.501) auf sie zutrifft.

# BASIC PRINCIPLES OF VISUALISATION II (DESIGN)

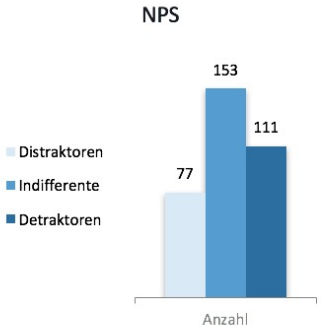
- Make it easy for the viewer to assign information! Increase the readability of your diagrams through information reduction and appropriate labelling!








https://chartio.com/learn/charts/pie-chart-complete-guide/

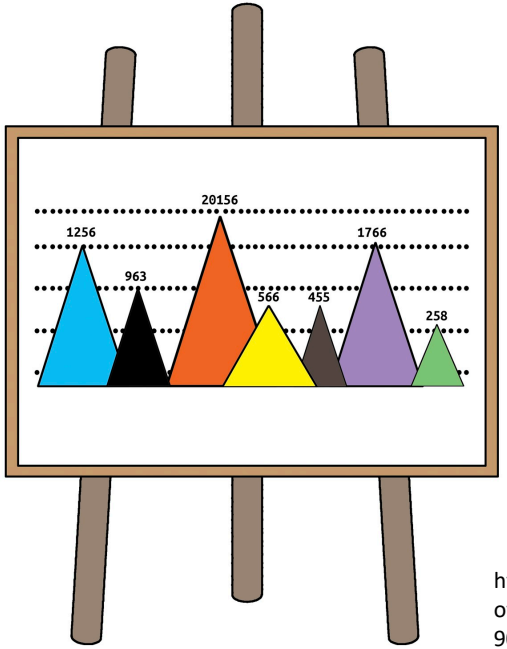




https://www.usabilityblog.de/wp-content/uploads/2017/07/Diagramme-Beispiele.png

# BASIC PRINCIPLES OF VISUALISATION II (DESIGN)

- Make it easy for the viewer to assign information! Increase the readability of your diagrams through information reduction and appropriate labelling!

- Avoid superfluous design elements!





www.flickr.com/photos/laurenmanning/5658951917/

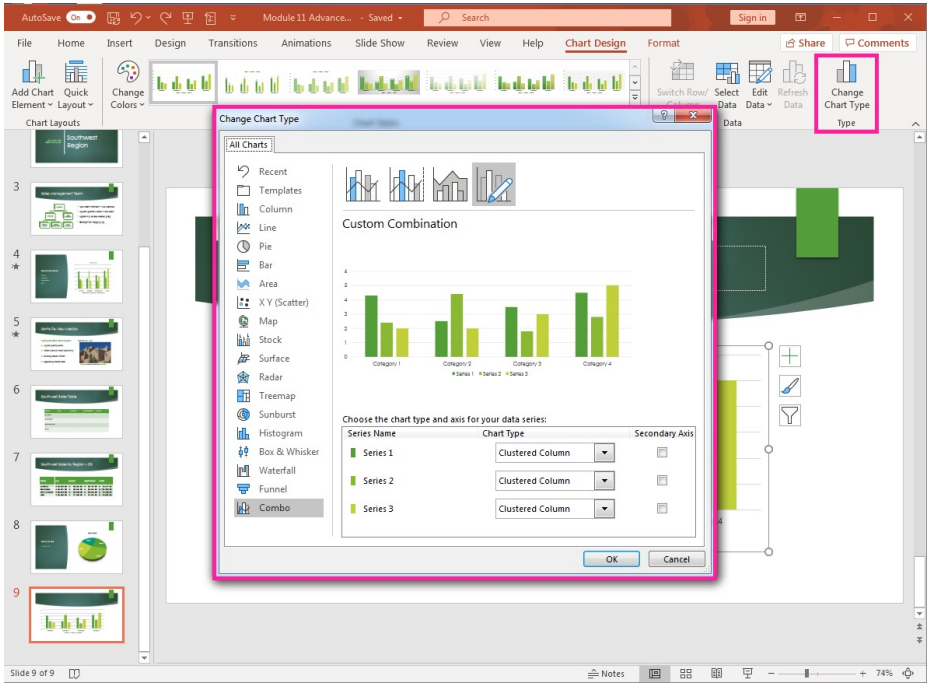
https://www.clipartsfree.de/images/joomgallery/originals/office_clipart_download_77/clip_art_chart_20141221_1879042728.png

# BASIC PRINCIPLES OF VISUALISATION II (DESIGN)

- Make it easy for the viewer to assign information! Increase the readability of your diagrams through information reduction and appropriate labelling!

- Avoid superfluous design elements!

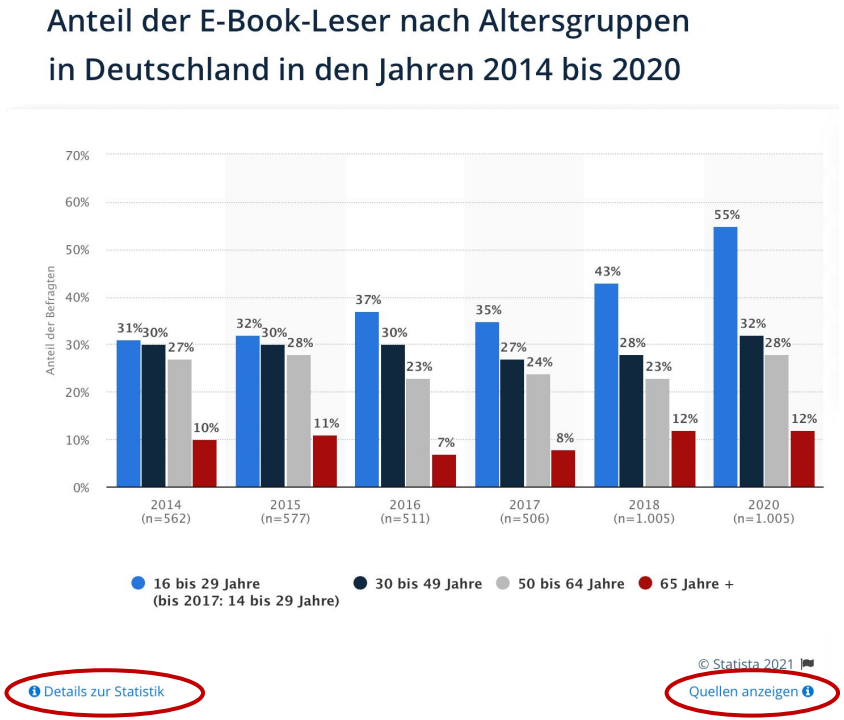
- Revise the presentation to highlight your thesis even better!




https://s3-us-west-2.amazonaws.com/courses-images/wp-content/uploads/sites/3008/2020/01/04013007/Module_11_Chart_Modify_1.11.png

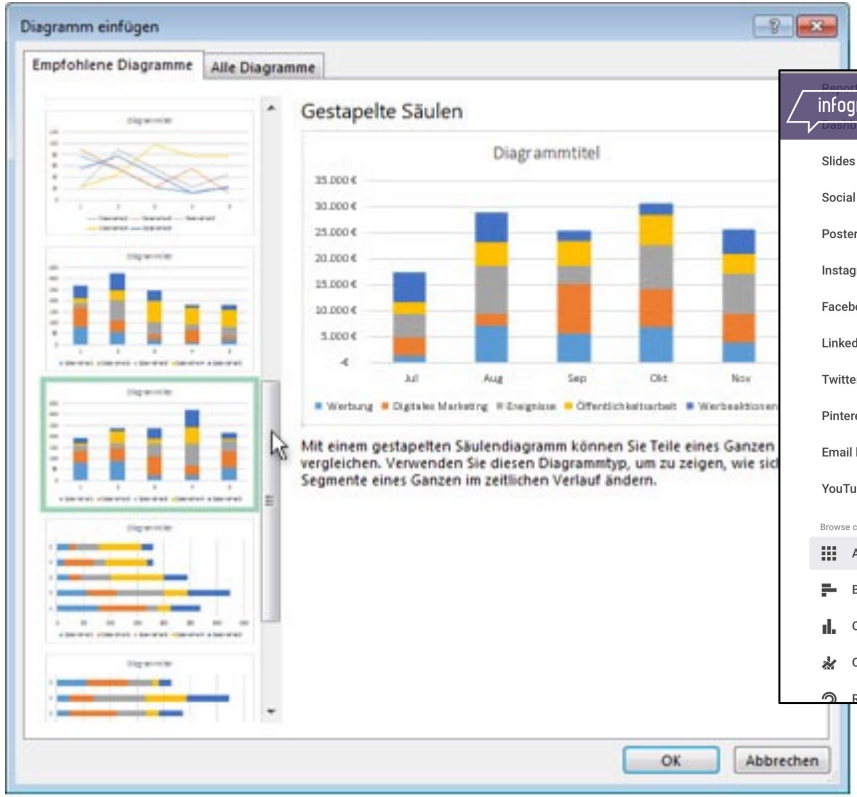
# BASIC PRINCIPLES OF VISUALISATION II (DESIGN)

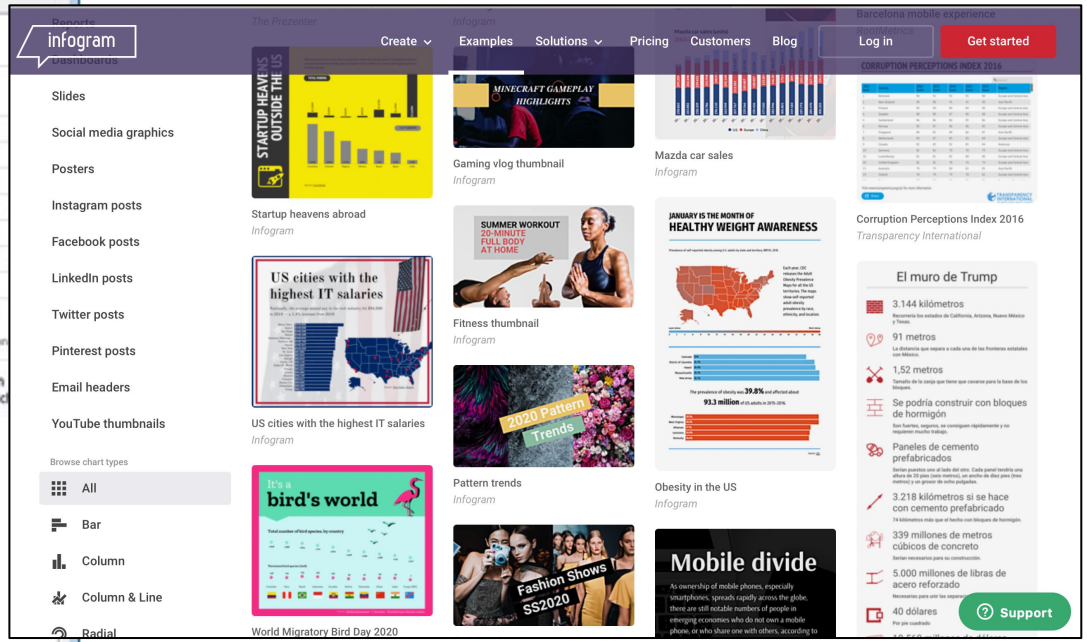
- Make it easy for the viewer to assign information! Increase the readability of your diagrams through information reduction and appropriate labelling!
- Avoid superfluous design elements!
- Revise the presentation to highlight your thesis even better!
- Document your decisions in a study!




https://de.statista.com/statistik/daten/studie/473969

# SPREADSHEET PROGRAMMES ETC.



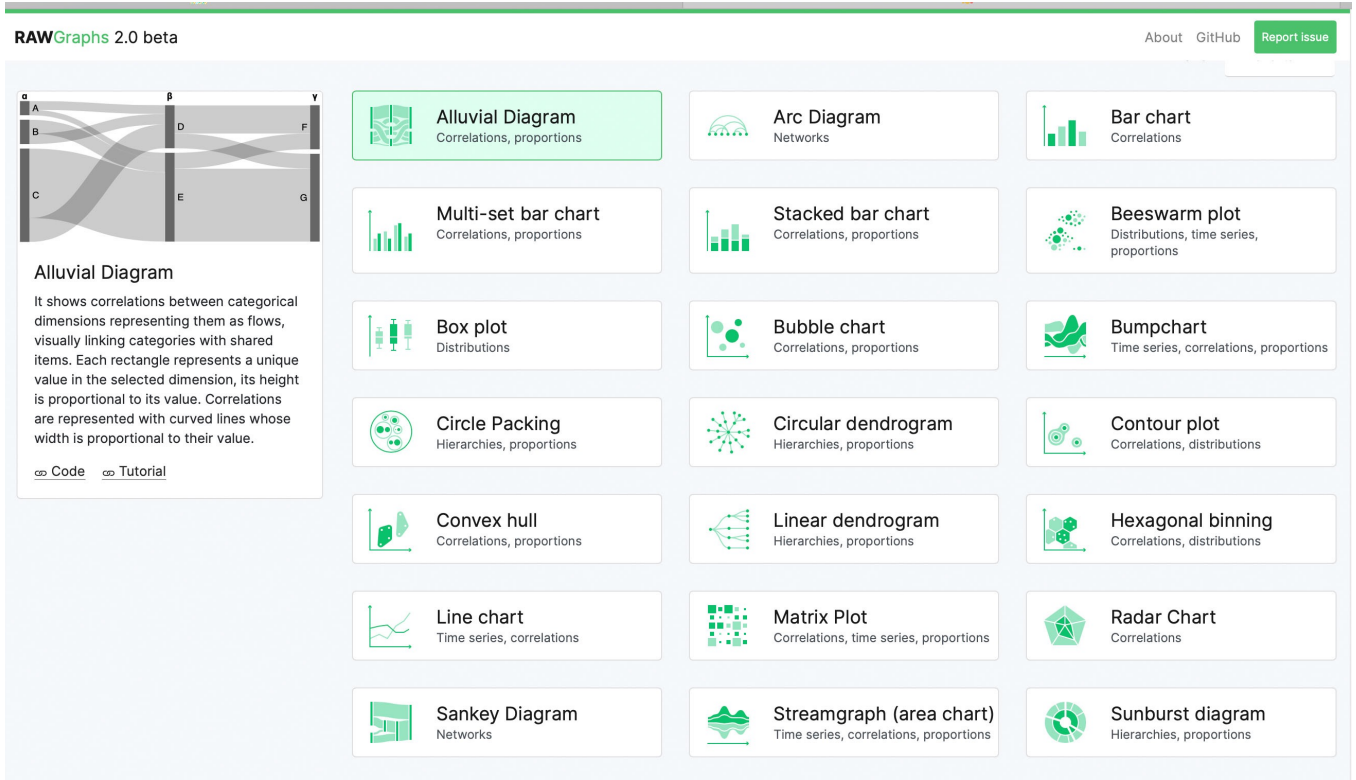




https://infogram.com

https://support.content.office.net/de-de/media/7c57eaf2-ab9a-4301-ae9c-1c183605eed4.jpg

# RAWGRAPHS

https://app.rawgraphs.io

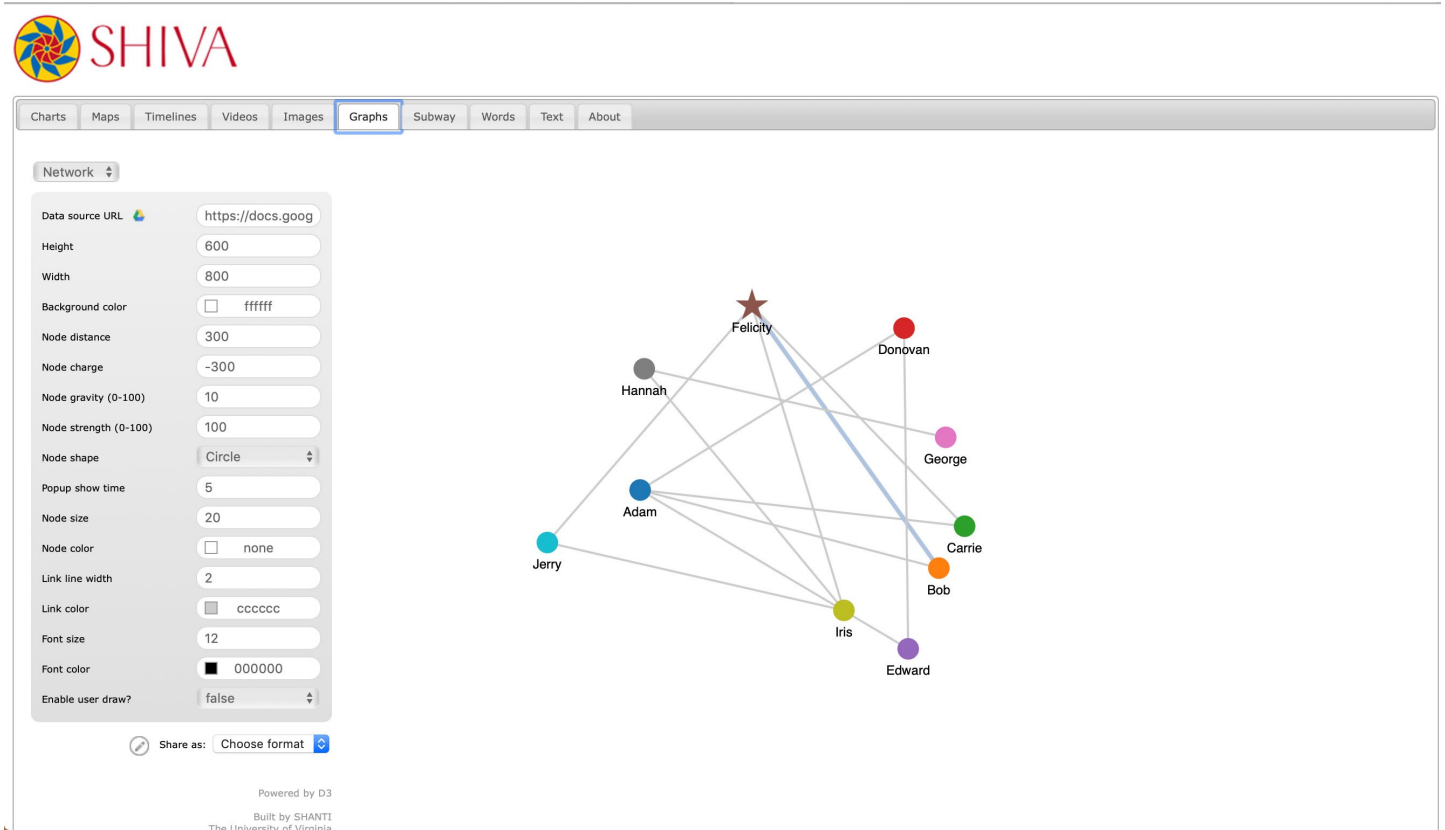


# MAPSCHOLAR

http://viseyes.org/mapscholar/

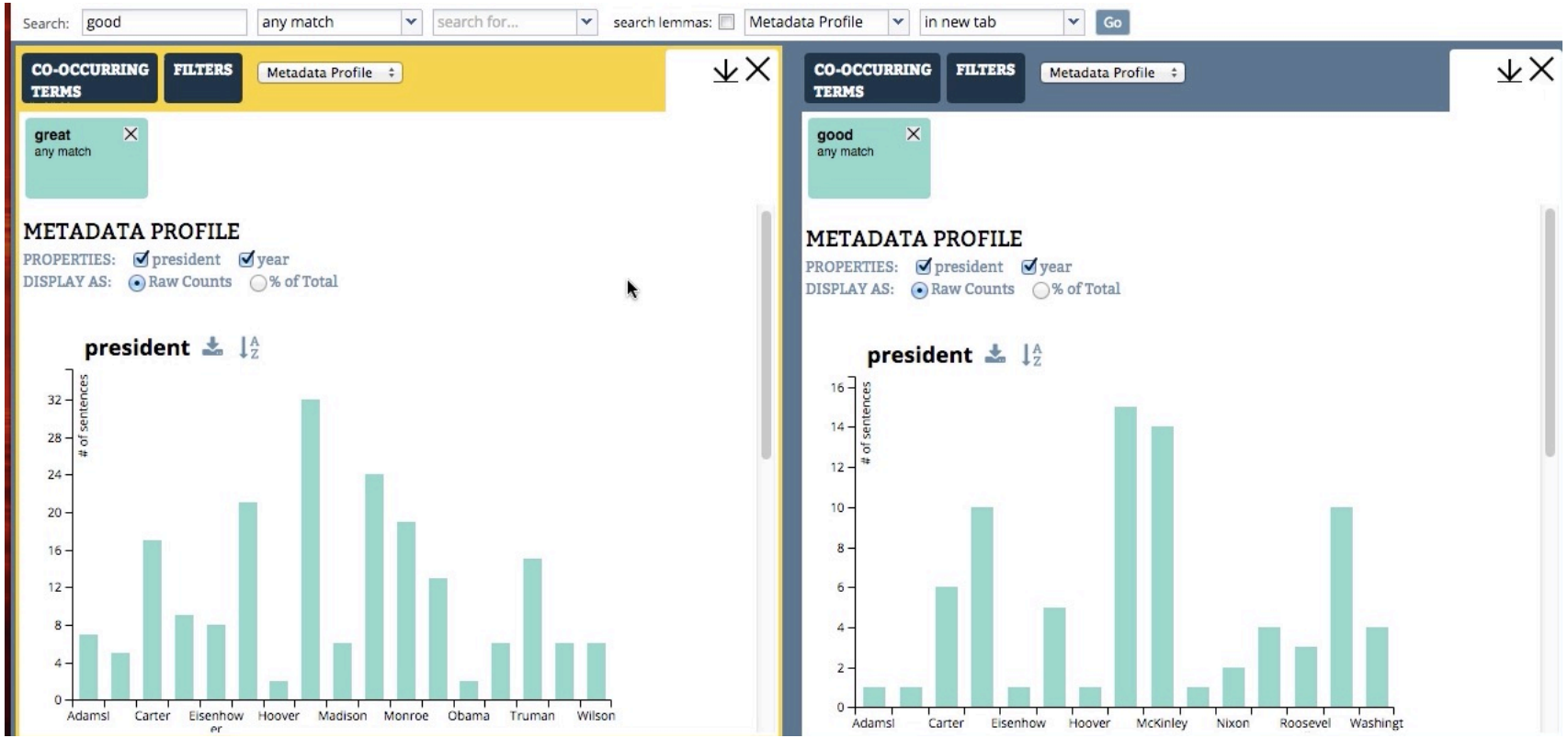
# SHIVA

http://www.viseyes.org/shiva/



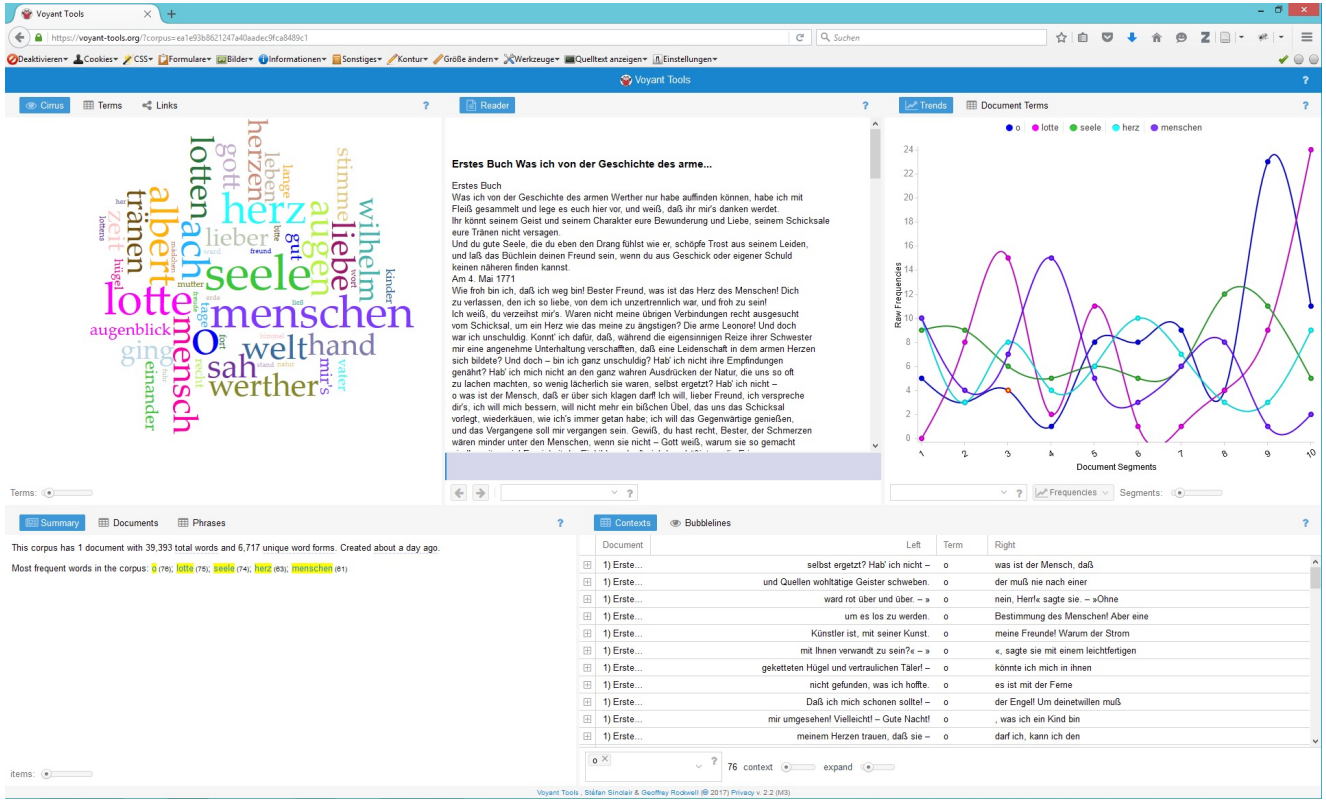
# WORDSEER

https://wordseer.berkeley.edu



# VOYANT

https://voyant-tools.org




https://fortext.net/ressourcen/videos/tutorials/textvisualisierung-und-digitale-literaturanalyse

# TOME: INTERACTIVE TOPIC MODEL AND METADATA VISUALIZATION

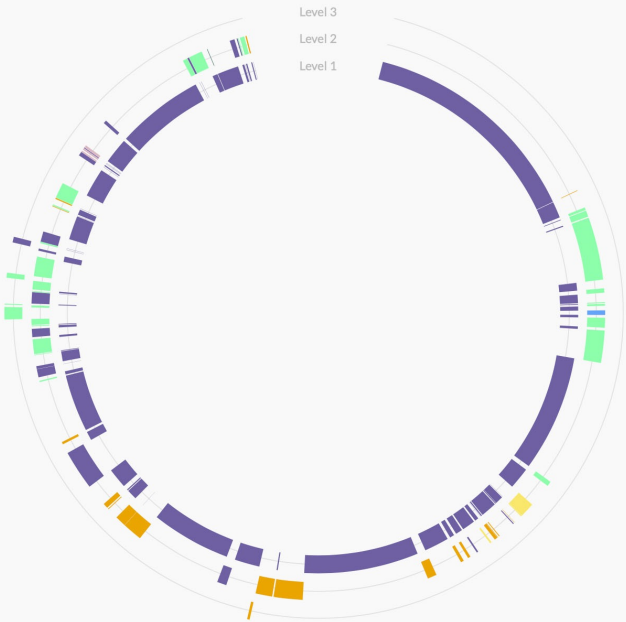
https://dhlab.lmc.gatech.edu/tome/

# NARRELATIONS

https://uclab.fh-potsdam.de/narrelations/

Import Datei auswählen Keine Datei ausgewählt

Lili
Das waren unbeständige Frühlingstage, die ich im Mai des Jahres 1873 in der Heimat antraf. Ich kam aus dem Süden, dem Land der Sonne und der Sorglosigkeit, daheim hiengen Wolken am Himmel, umlagerte die Sorge das Leben. Und doch war es Mai. Aber alle bösen Eigenschaften, welche der Volksmund dem oft so lieblichen April nachsagt, hatte diesmal der vielbelobte Wonnemond entfesselt und dabei herrschte sommerliche Schwüle, die sich dann und wann in Gewitterschauern über der blühenden, kaum zu frohem Dasein erwachten Erde entlud.
Eine Gewitterstimmung fand ich auch in den Kreisen meiner Bekannten und Freunde und bald sollte ich erfahren, daß solche Schwüle auch im Leben der Gesellschaft gar oft Entladungen von vernichtender Wirkung zur Folge hat. Das Gewitter hieß Krisis des Geldmarktes. Das Spekulationsfieber hatte damals Menschen ergriffen, deren Gedanken- und Gesprächskreise sonst weitab von der Welt der Geldgeschäfte gelegen hatten, und mit aufgeregter Spannung verfolgte plötzlich der sonst so bedächtige Rentner das Steigen und Fallen der Course, die Erscheinungen und Bewegungen an der Börse, für die er vorher nur wenig Verständniß gehabt. Und in jenen Tagen war nur vom Sinken der Werthpapiere, nur von erschütternden Katastrophen an der Börse die Rede.
An dem Morgen, der mir heute mit greifbarer Lebendigkeit in der Erinnerung auftaucht, ließ freilich die Sonne und ihr lichtes Spiegelbild auf der Erde nichts von solchen Betrachtungen aufkommen. Wie die Jugend unter dem Gruß des Glücks, schnell und lebensfroh', das momentan durch einen Mißerfolg gebeugte Haupt




NARRATIVE LEVELS

Speakers
- »Ich«
- Erich
- Lili
- Anton
- Portier
- Geschäftsführer
- Kinder

Transgression

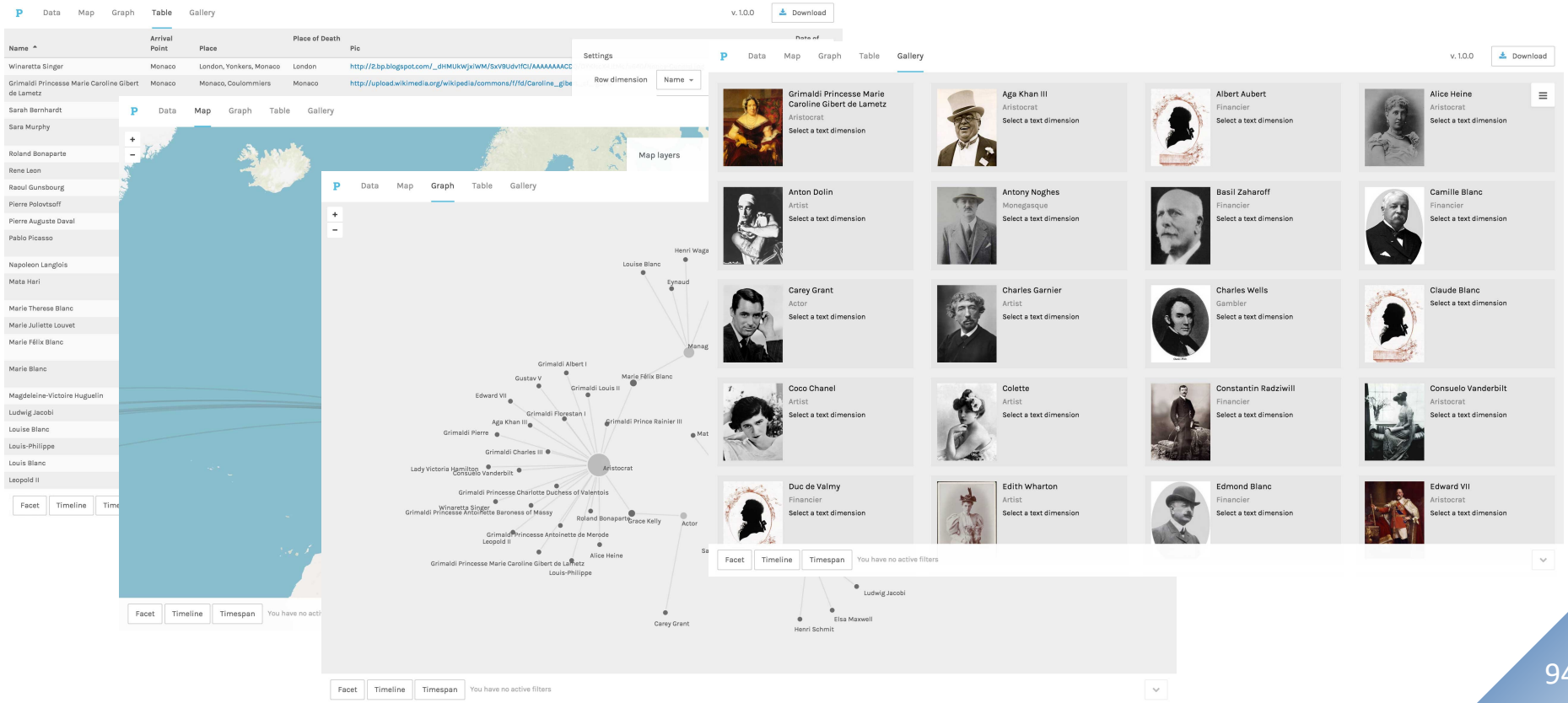
Illocutionary boundary
- Actually crossed
- Not crossed
- Virtually crossed
- Non

Ontological boundary
- Not crossed
- Virtually crossed
- Non

TEMPORAL PHENOMENA
- Order
- Frequency (repetitive)
- Duration

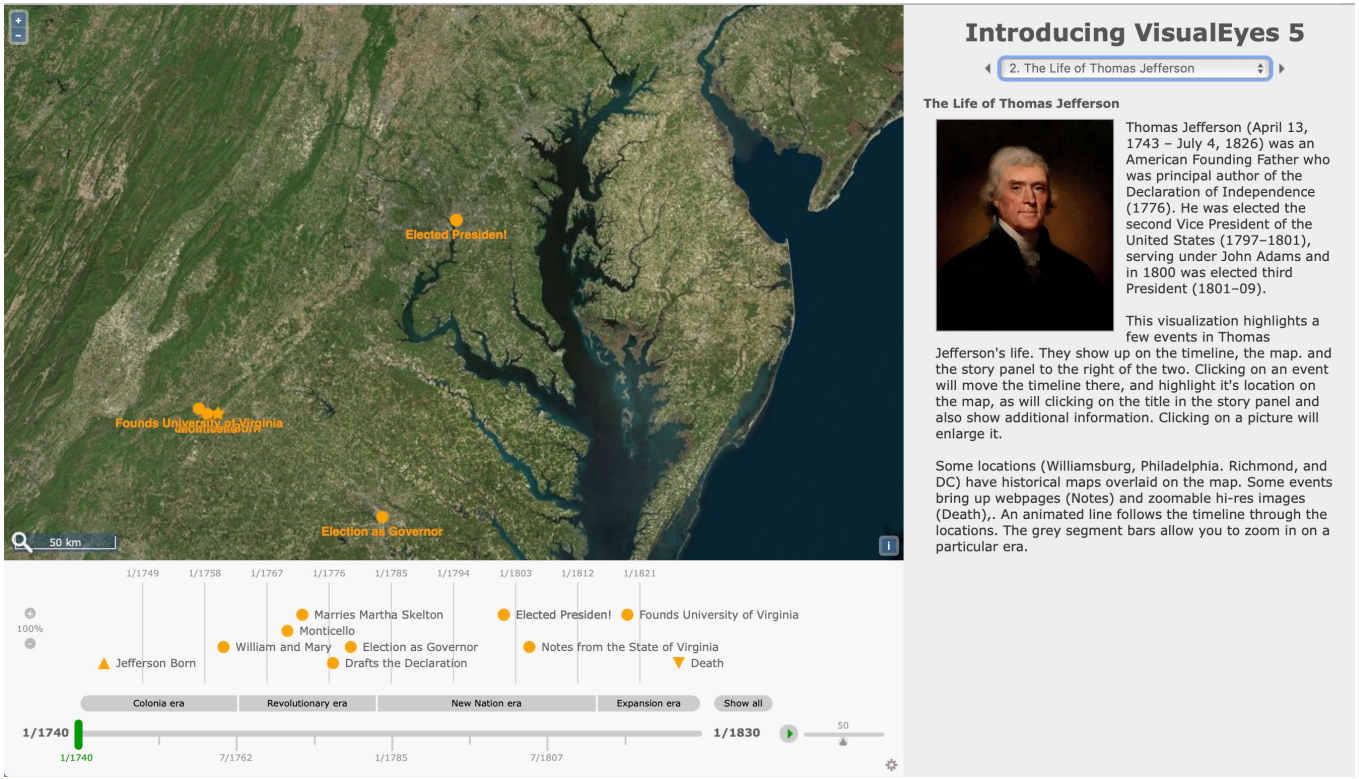
# PALLADIO

https://hdlab.stanford.edu/palladio/



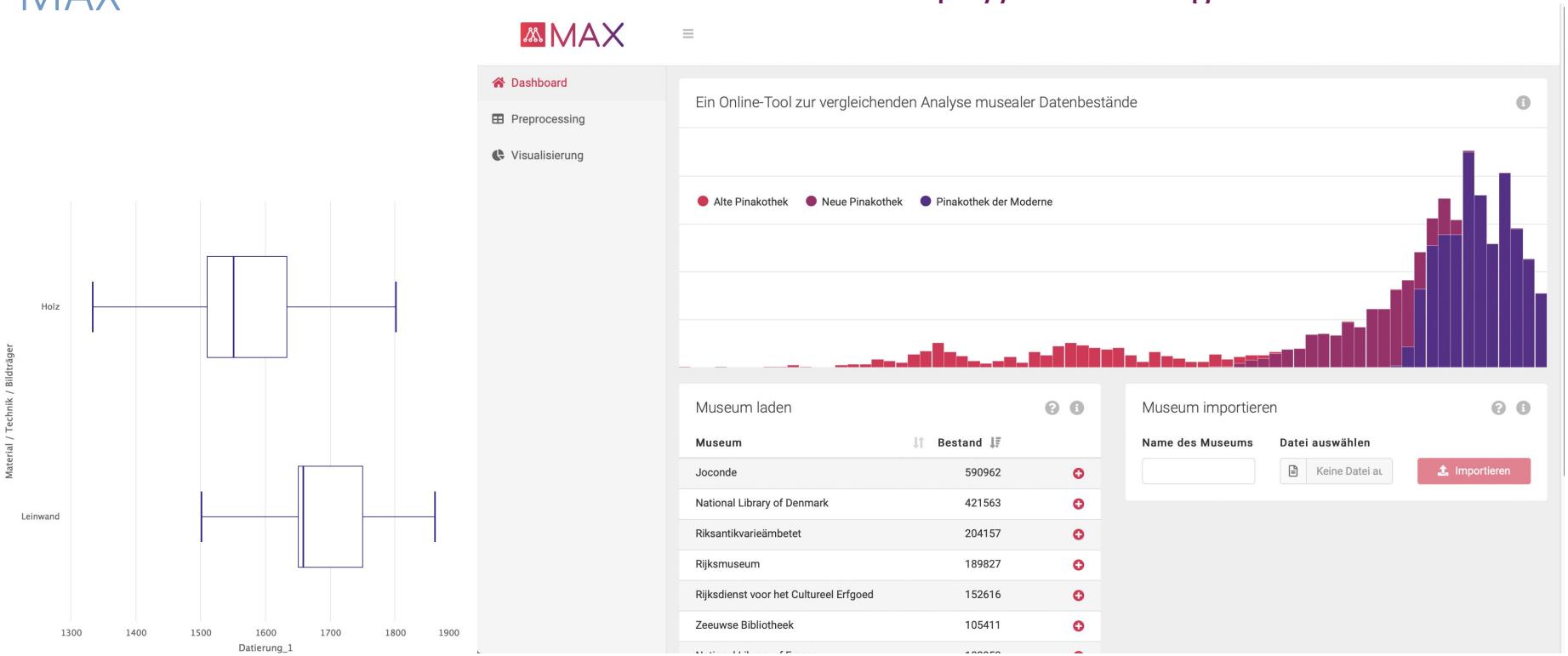
# VISUALEYES

http://www.viseyes.org/visualeyes/

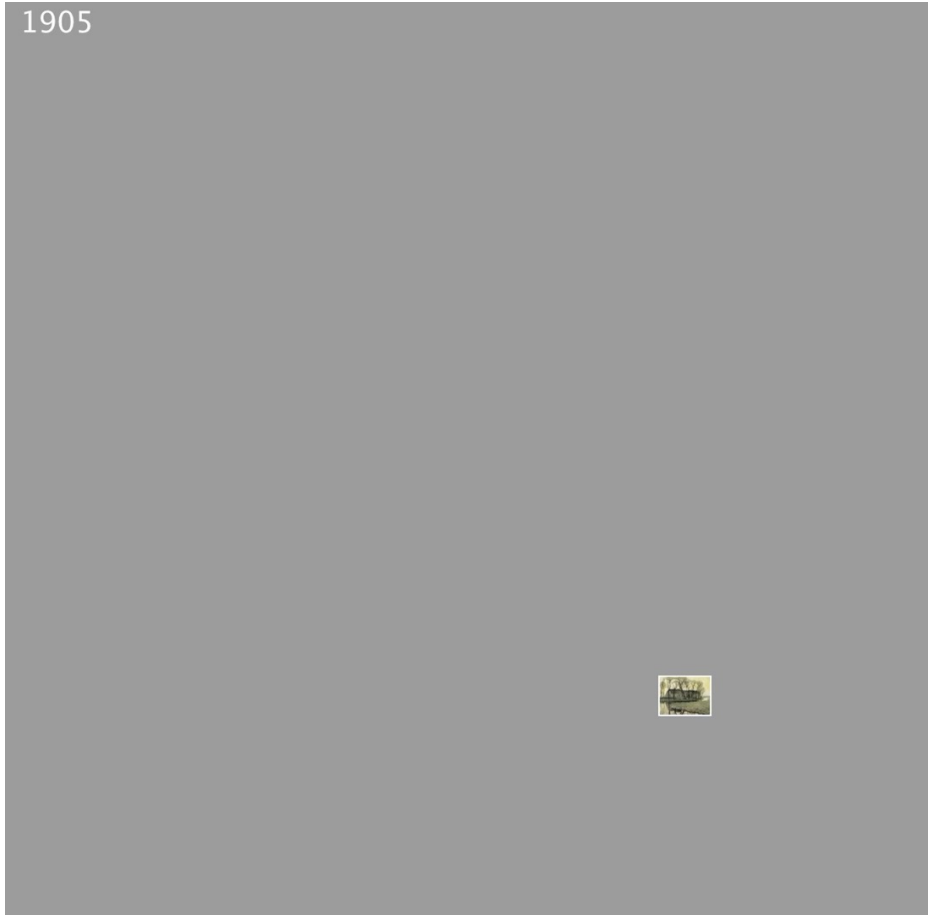


# MAX

https://www.max.gwi.uni-muenchen.de




https://www.max.gwi.uni-muenchen.de/analyse-unterschiedlicher-bildtraeger/




https://www.youtube.com/watch?v=xiWpZ5jhvx4&t=10s

# IMAGEPLOT

http://lab.softwarestudies.com/p/imageplot.html

## Nutrition Facts

8 servings per container
**Serving size** **2/3 cup (55g)**

**Amount per serving**
**Calories** **230**

| | % Daily Value* |
|---|---|
| **Total Fat** 8g | **10%** |
| Saturated Fat 1g | **5%** |
| *Trans* Fat 0g | |
| **Cholesterol** 0mg | **0%** |
| **Sodium** 160mg | **7%** |
| **Total Carbohydrate** 37g | **13%** |
| Dietary Fiber 4g | **14%** |
| Total Sugars 12g | |
| Includes 10g Added Sugars | **20%** |
| **Protein** 3g | |
| Vitamin D 2mcg | 10% |
| Calcium 260mg | 20% |
| Iron 8mg | 45% |
| Potassium 235mg | 6% |

* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

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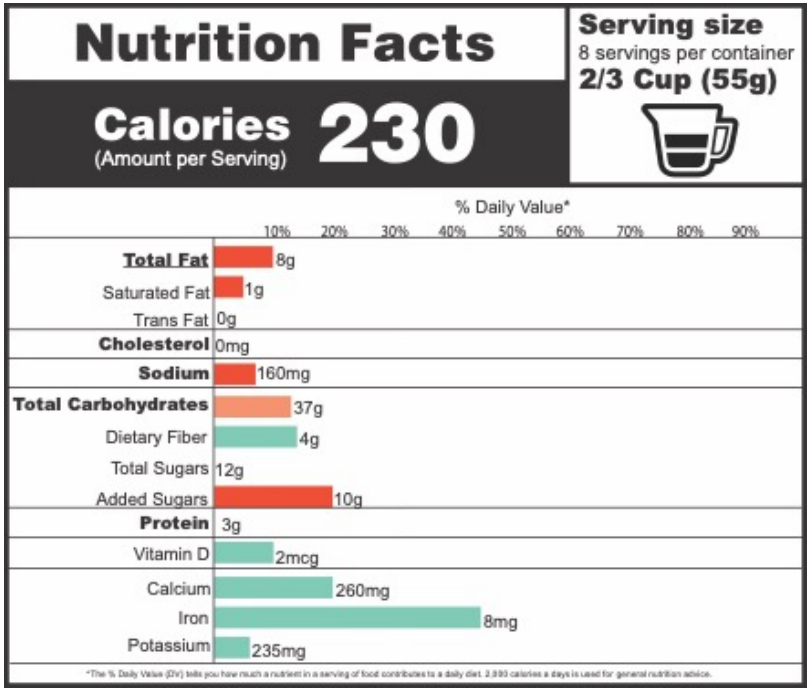
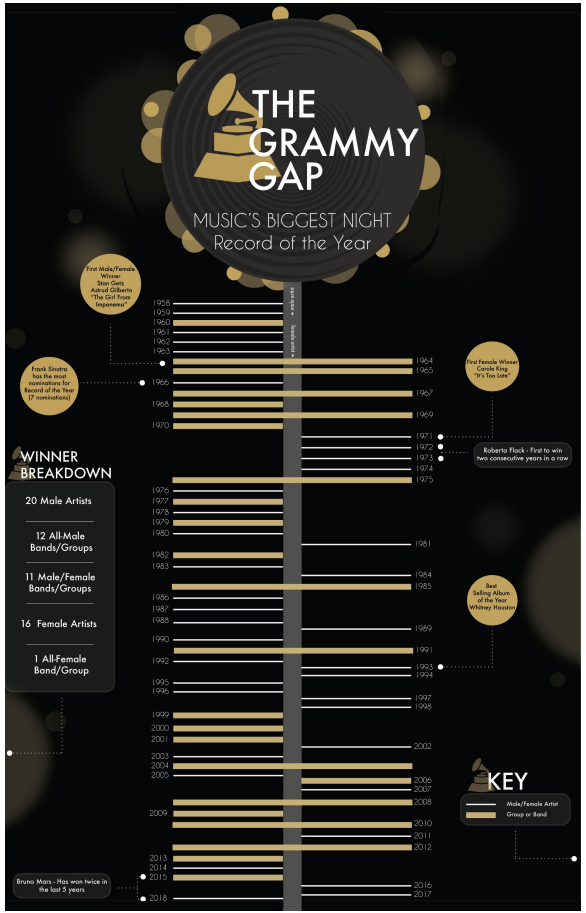
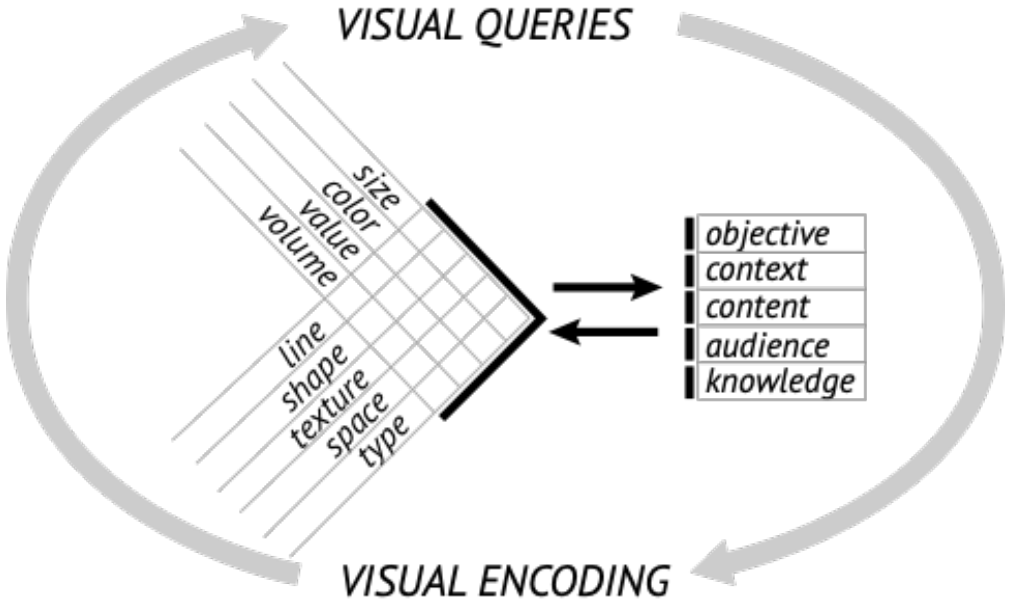



https://www.fda.gov/food/food-labeling-nutrition/nutrition-facts-label-images-download

Redesigning nutrition labels as a typical task for graphic design students to visually present quantifiable information while paying attention to font, space and colour relationships.




Modular approach to address design concerns in visualisation

Yvette Shen, Placing Graphic Design at the Intersection of Information Visualization Fields, DH Quarterly 12.4, 2018: http://www.digitalhumanities.org/dhq/vol/12/4/000406/000406.html

# CHALLENGES

- Reflection on the appropriate form of visualisation in each case
- Developing new forms of scientific discourse in the exploratory analysis of cultural data
- Representation of image-to-image relations and spatial relationships in visual networks and virtual spaces

- Various quantitative methods and multivariate procedures
- Basics of exploratory statistics
- Concepts and theories of network analysis
- Analysis procedures and visualisation methods of common measures and structures
- Basic principles of information visualisation
- Data collections and tools for data analysis and visualisation

- Structural and relational analysis, dealing with relational issues, selecting suitable analysis software (e.g. R, Python, PAST, gephi, Palladio)
- Reproducing / checking diagrams and other forms of visualisation
- Analyse common measures and structures and output the results as a suitable visualisation

How could the results of a multivariate analysis of large image sets be visualised?

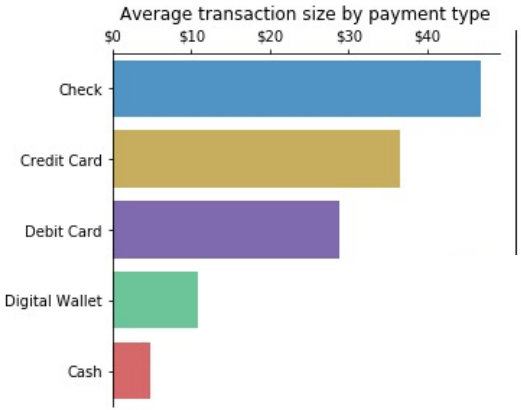
Folie 20–26. 57–61. 97

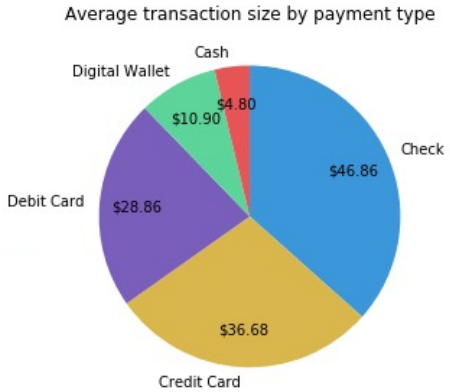
On which mathematical methods is correspondence analysis based? What can it be used for?

Folie 30–39

Give an example of the convincing use of historical network analysis.

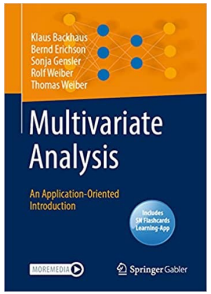
Folie 48–52

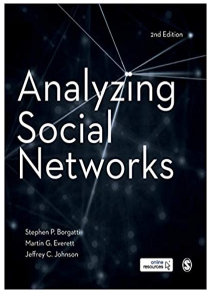


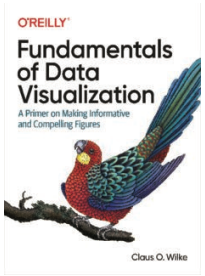



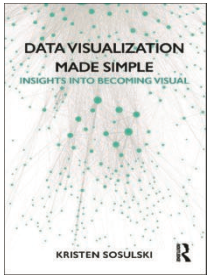

Which of the two visualisations would you choose? Please justify your answer.

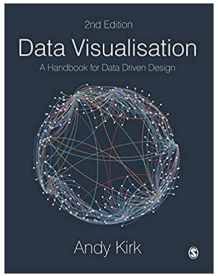
Folie 57–60. 80–82

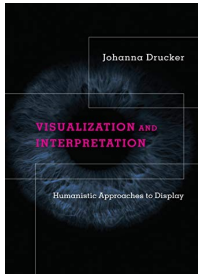
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Royksopp
Remind Me
https://www.youtube.com/watch?v=adYBtNT2CNI

# ABBILDUNGSNACHWEIS

Folie 1:

Folie 2:

Folie 3:

Folie 4:

Folie 5:

Folie 6:

Folie 7:

Folie 8:

Folie 9:

Folie 10:

Folie 11:

Folie 12:

Folie 13:

Folie 14:

Folie 15:

Folie 16:

# IMPRESSUM

**Inhaltlich verantwortlich:**

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