InfoVis

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PG1, 18.10.2020

Motivation

- Visual Thinking & Understanding

- Orientation,position,identification,
- direction/navigation [Roam]
- Coordinate systems, 6W
- 30 000 things… [Biederman87]
- Psychological Review 1917, Vol. M, No. 2, 115-147, 1987
- Recognition-by-Components: Theory
- of Human Image Understanding

- Managing Time and Memory
- Enhance Understanding
- **Picture, Polya, Altshuller, TRIZ**

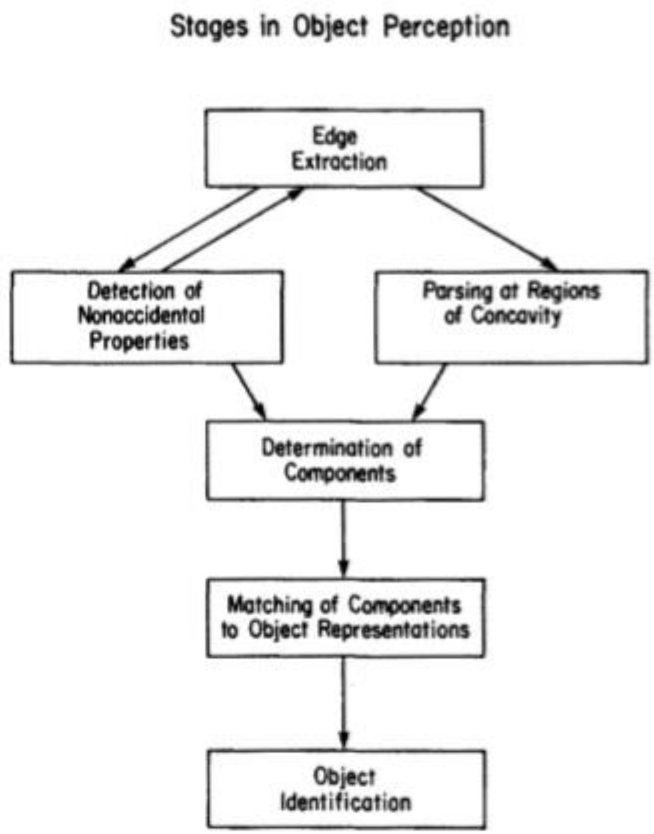


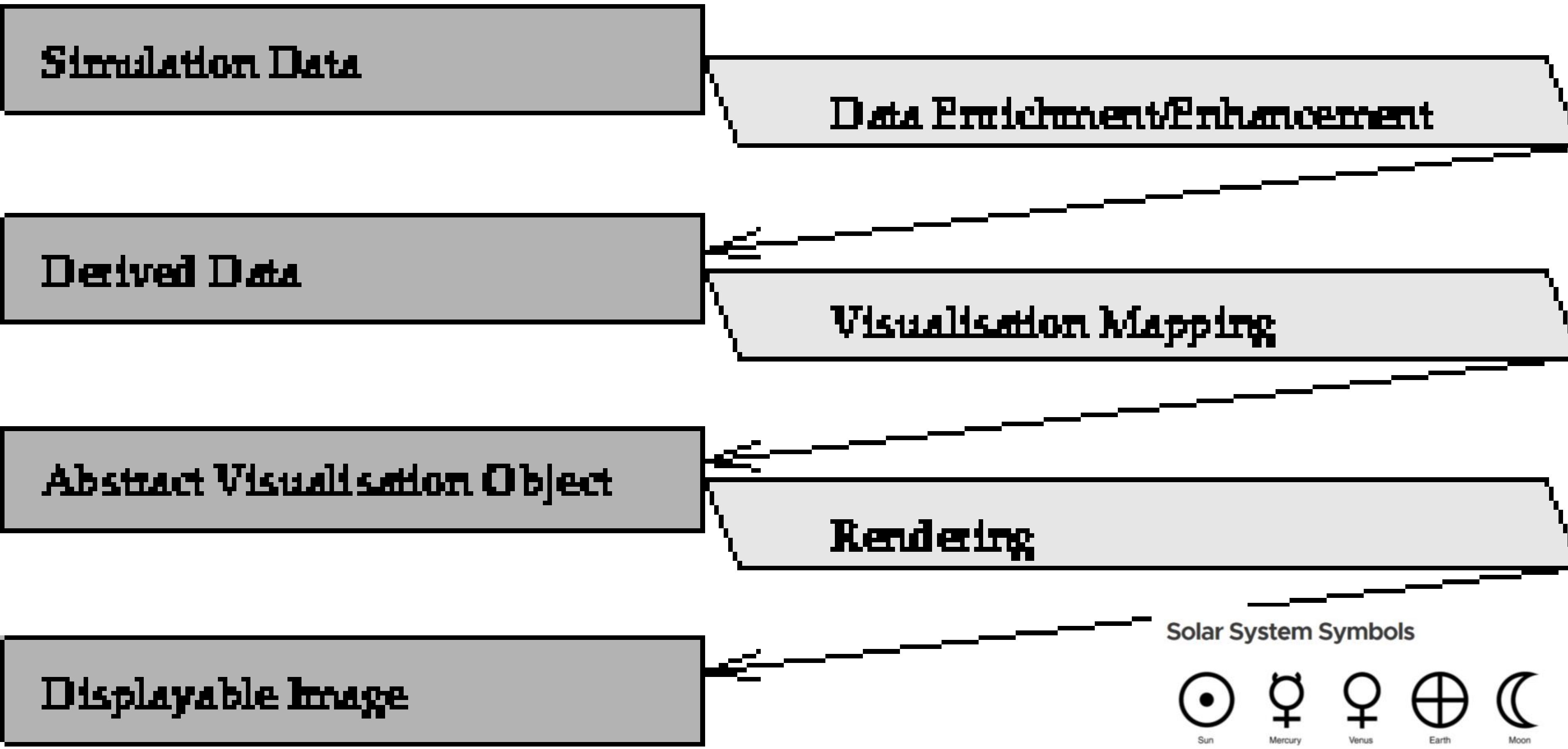
Figure 2. Presumed processing stages in object recognition.

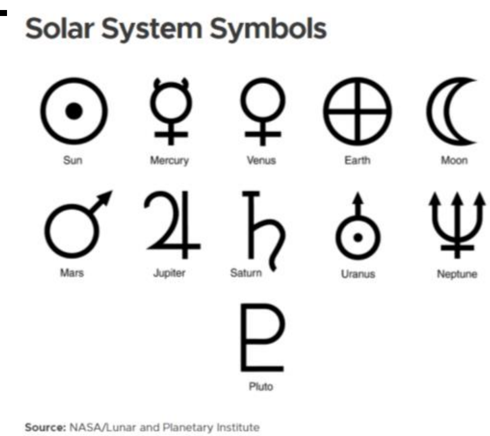
Viz. Course Contents

- 1. Introduction, motivation
  reference model, scenarios, graphics and visualization difference
- 2. Data
  data types, coordinate representations, data connectivity
- 3. Mathematical models and languages
- 4. Representation
  scalar, vector, tensor, multivariate, using color, glyphs
- 5. Visualization software
- 6. Information Visualization
  graph drawing, algorithm animation, …
- 7. Recent Directions
  data sonification, visualizing relativity, NPR in scientific visualization...
- (NPR >> Expressive Rendering, factorization, schematization, less details)

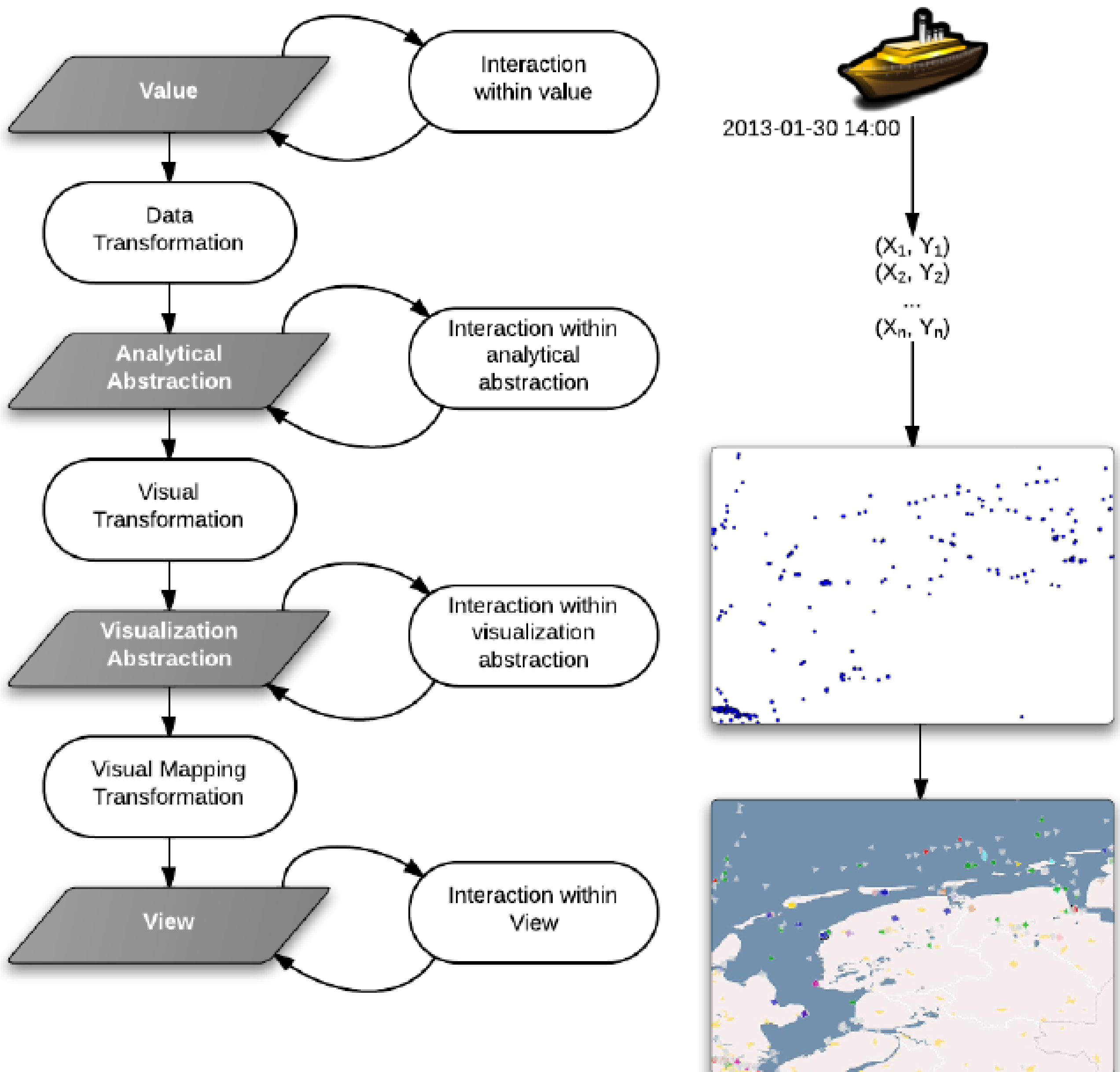
- **Prof. Gitta DOMIK, Visualization Courses 36+17+…**
- **https://web.cs.upb.de/archive/domik/curriculum-for-visualization/visualization-courses-worldwide.html**

Visualization Pipeline





Data State Ref. Model [Chi]



Visualization of Data

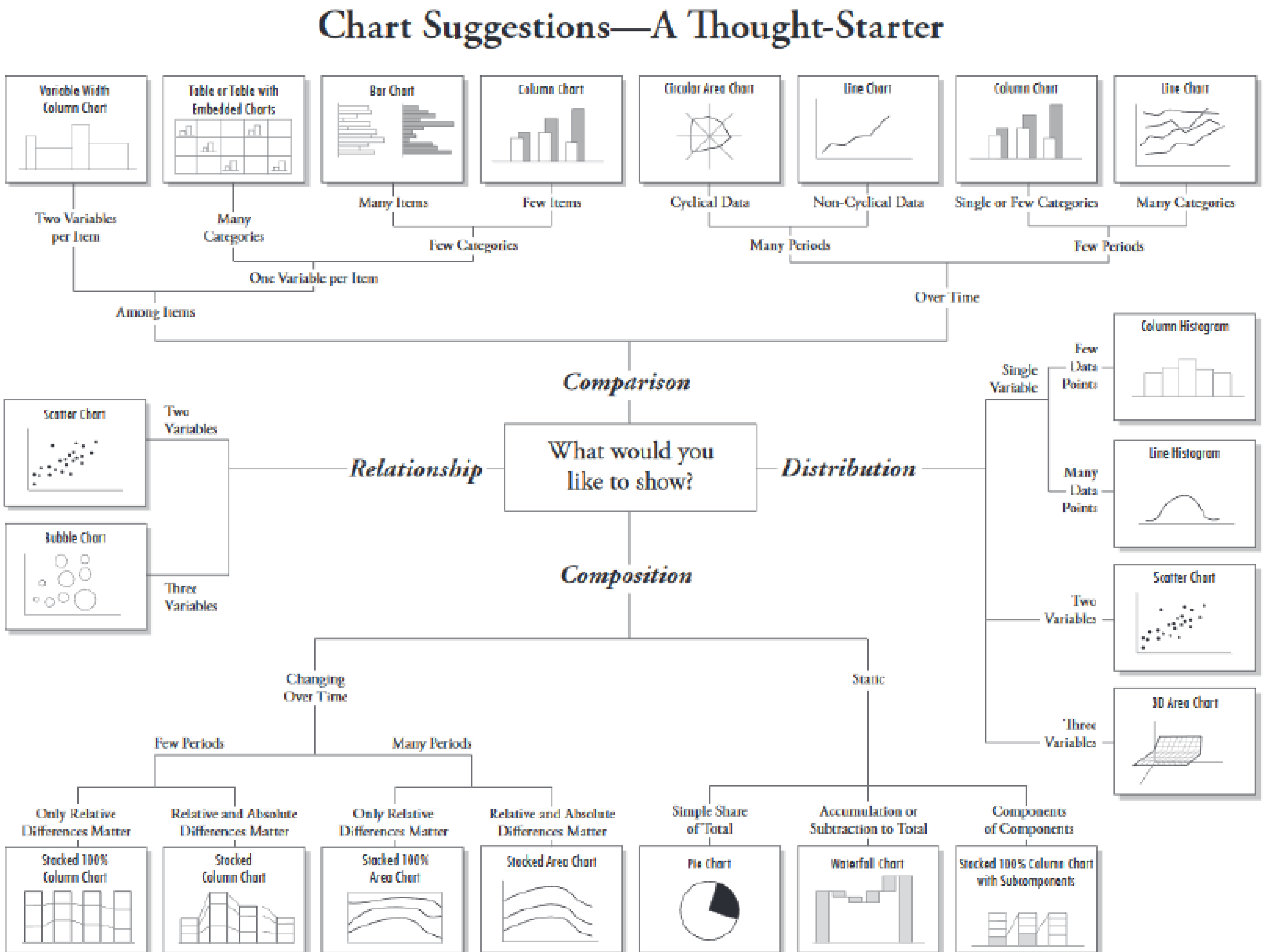
- 1D
- 2D
- 3D
- 4D
- nD, par. coord.

"to visualize":
form a mental vision, image, or picture of (something not visible or present to sight, or of an abstraction); to make visible to the mind or imagination

V. Zajceva, 2019

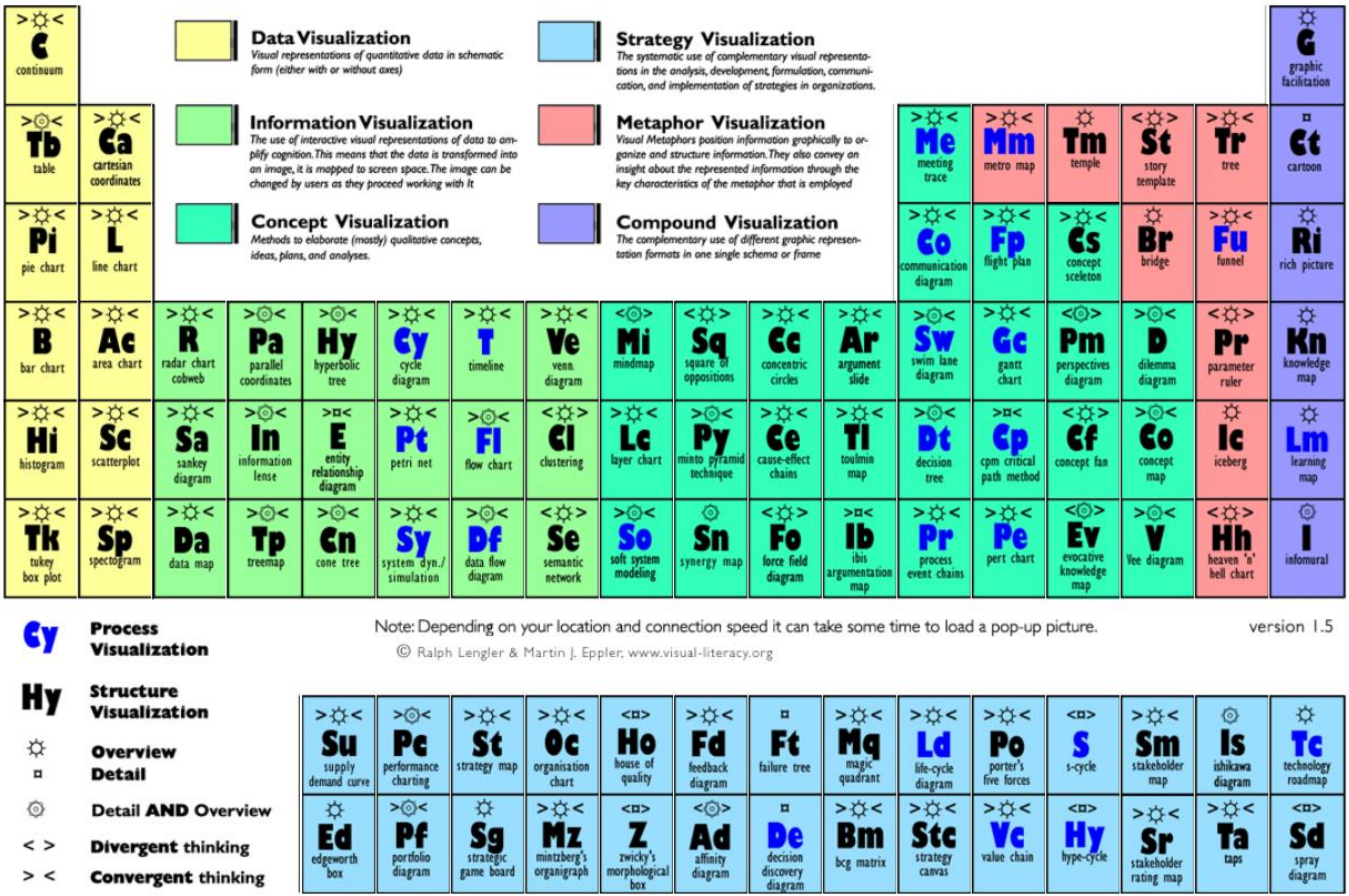
The Oxford English Dictionary, 1989

SCHMIDT, J. 2018. **Visualisation in Data Science**. TU Wien.



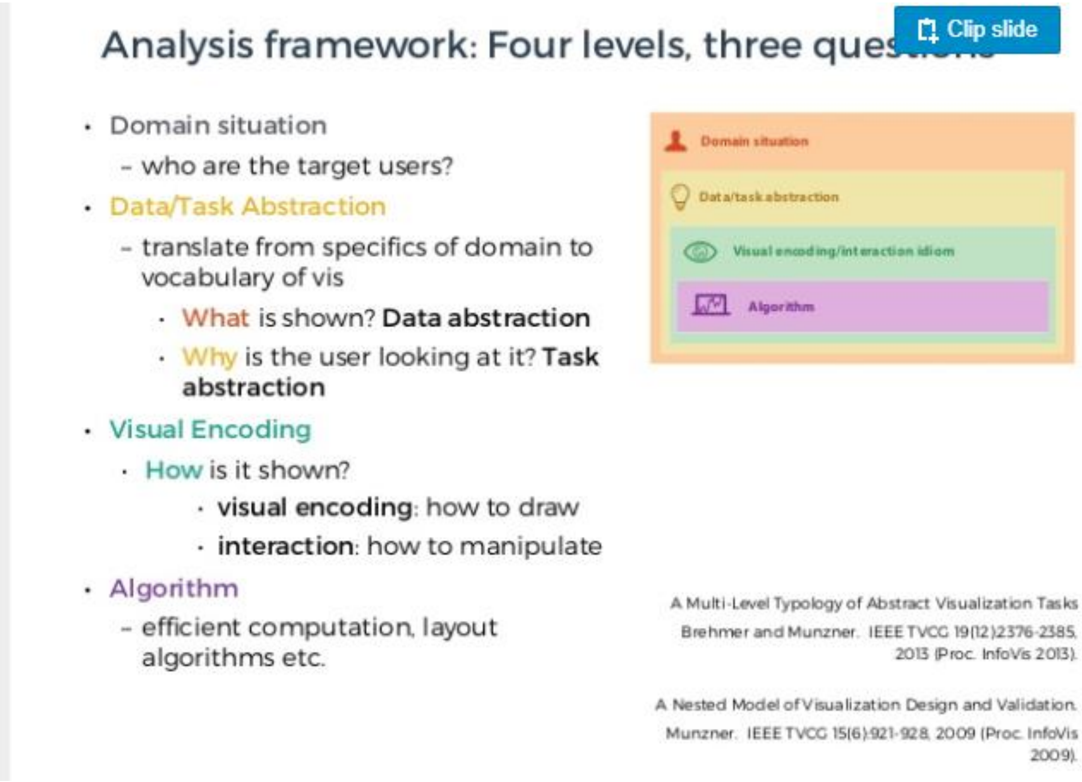
[3]

A PERIODIC TABLE OF VISUALIZATION METHODS

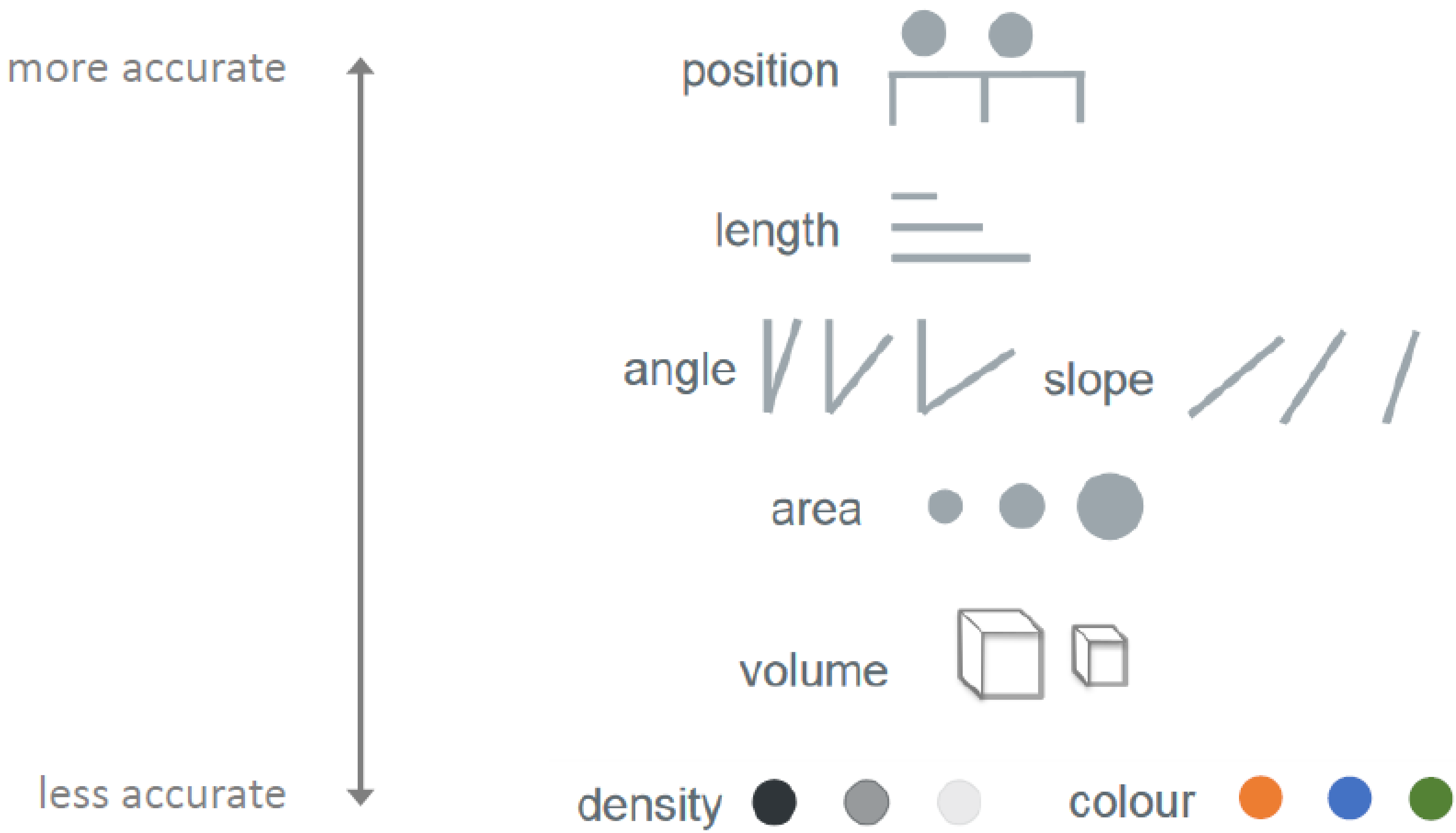


Gestalt Laws [Sch [2]]

- Proximity
- Similarity
- Connectedness
- Good continuati
- Common fate
- Symmetry

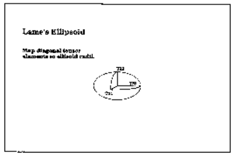


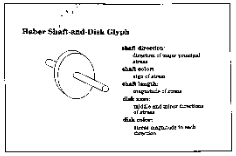
Visual Mappings [Sch]

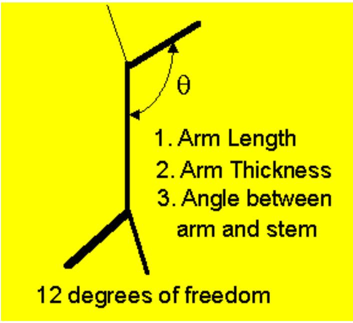


Glyphs

- **UNICODE glyphs: A, @, 7, α, β, γ, δ, Σ, θ, ω… ?, *, §, … symbolic information**
- **Visualization glyphs**







ASCII Convention

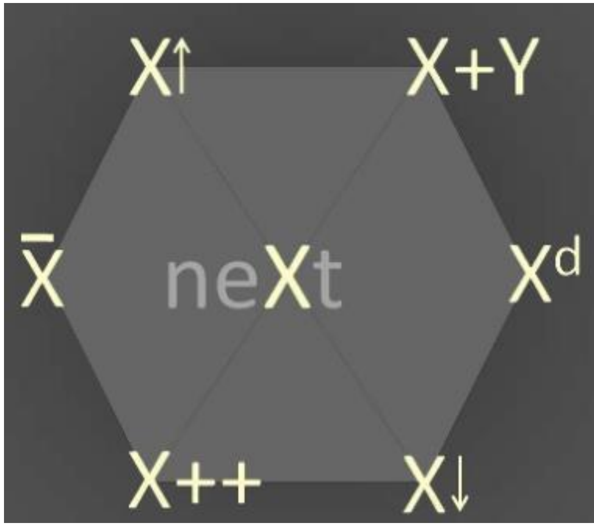
- **Bits >> Images (Rosetta)**

USASCII code chart

b_7 b_6 b_5 →					0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
Bits b_4	b_3	b_2	b_1	Column → / Row ↓	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	|
1	1	0	1	13	CR	GS	−	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	—	o	DEL

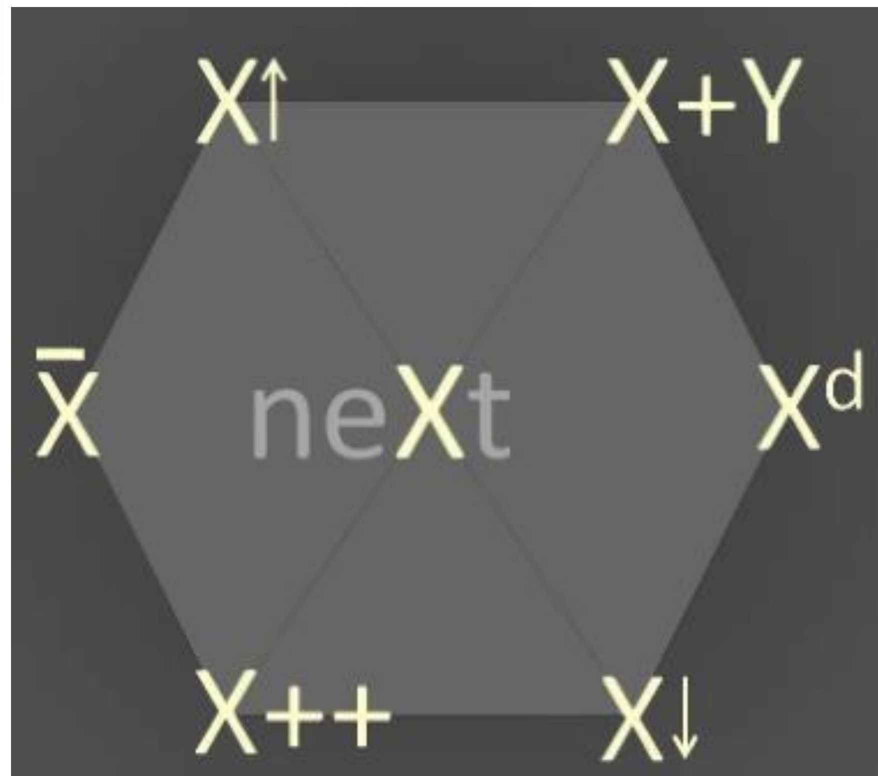
Curse of Dimensionality

- 3D tetrahedron >> 2D distortion
- nD >> lognD distortion (Dimensions 1)
- BUT 2D + Symbols, 3D visual >> 2D V+S
- Idea Hexagon by Raskar
- Time 1D >> (t1,t2,t3)
- X+Y visual+symbolic, Polya
- Ferwerda, 3D pipe Magritte



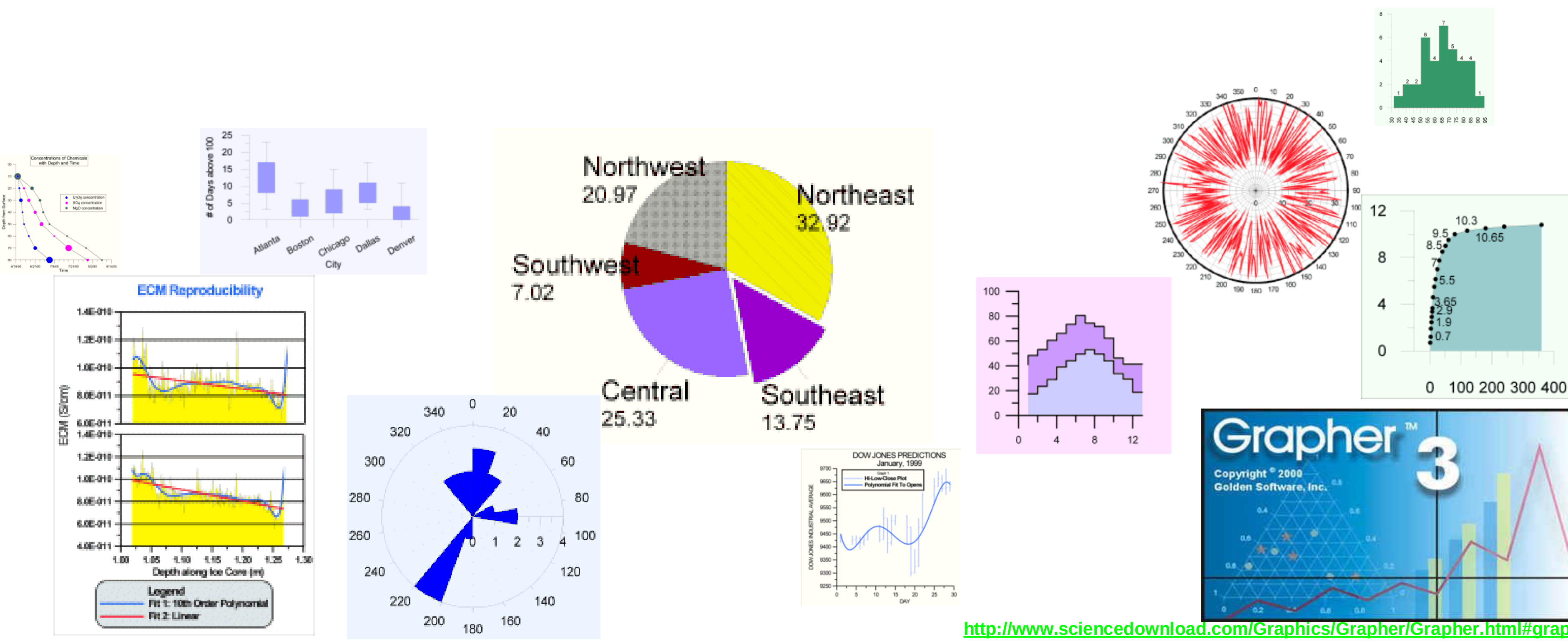
- CoD: ”available data become sparse”


Ceci n'est pas une pipe.


X↑
X+Y
X̄
neXt
X^d
X++
X↓

Visualization Areas

- Scientific Visualization
- Bussines Visualization: no new knowledge
- Language: VEGA/Lite

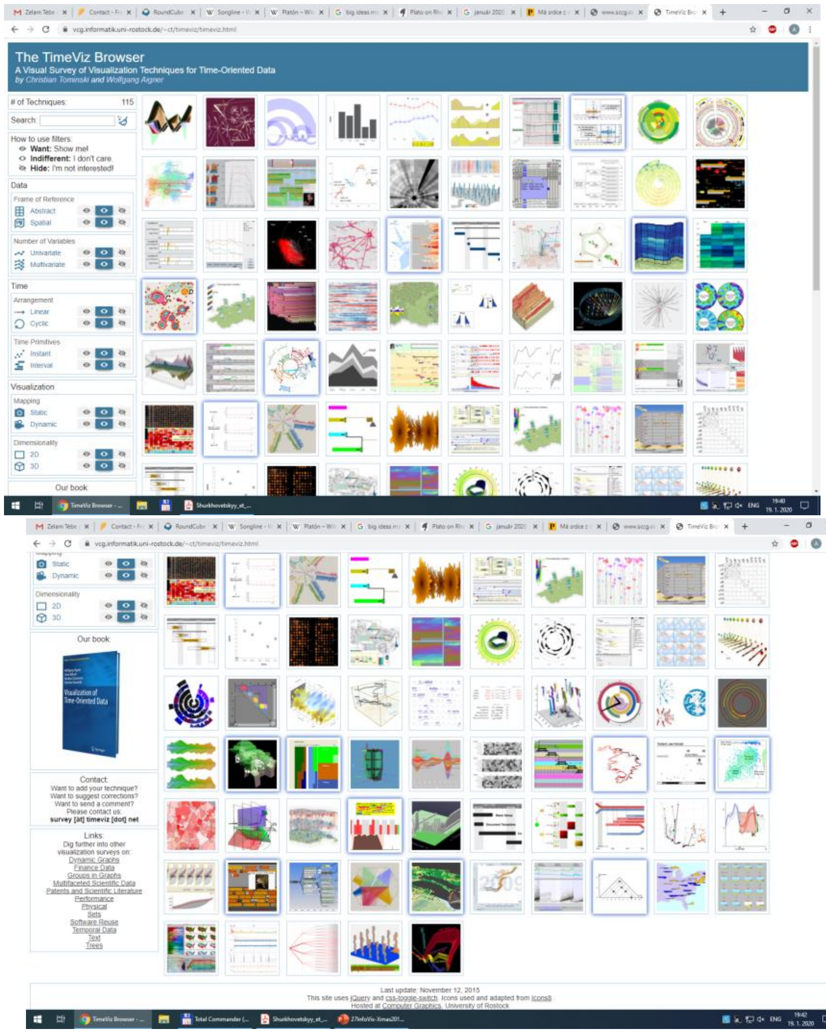


http://www.sciencedownload.com/Graphics/Grapher/Grapher.html#graphtypes

10 Visualizations

Every Data Scientist Should Know

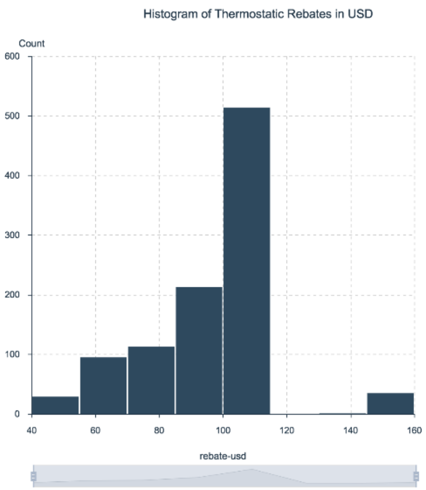
1. Histograms
2. Bar/Pie charts
3. Scatter/Line plots
4. <u>Time series</u>
5. Relationship maps
6. Heat maps
7. Geo Maps
8. 3-D Plots
9. Higher-Dimensional Plots
10. Word clouds

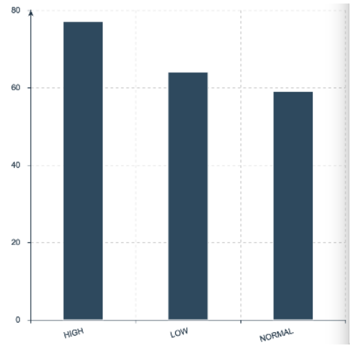


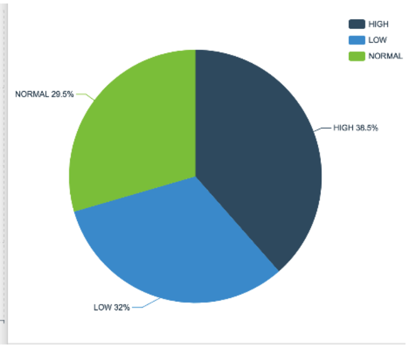
https://towardsdatascience.com/10-viz-every-ds-should-know-4e4118f26fc3

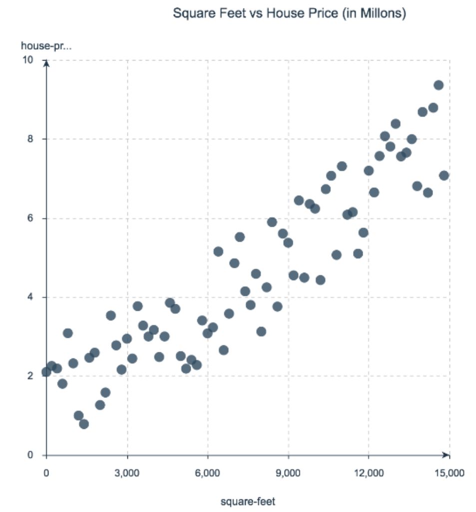
https://vcg.informatik.uni-rostock.de/~ct/timeviz/timeviz.html

Top Ten

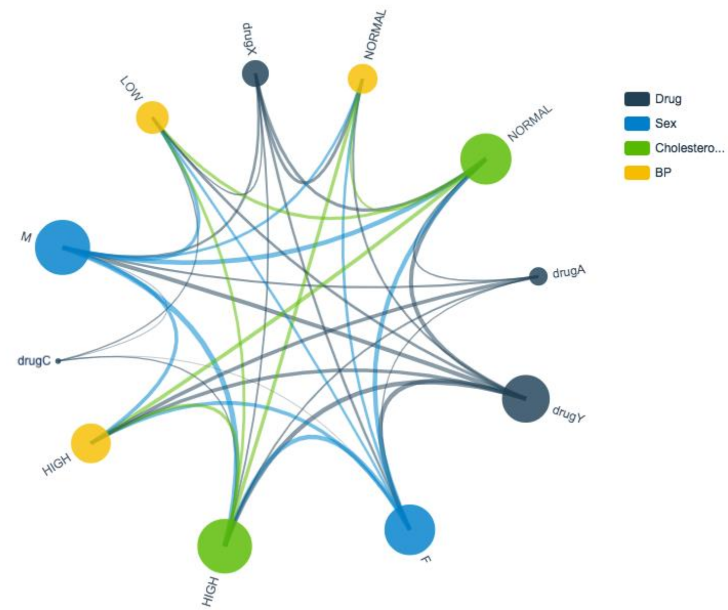

Histogram of Thermostatic Rebates in USD
Count
600
500
400
300
200
100
0
40
60
80
100
120
140
160
rebate-usd


80
60
40
20
0
HIGH
LOW
NORMAL

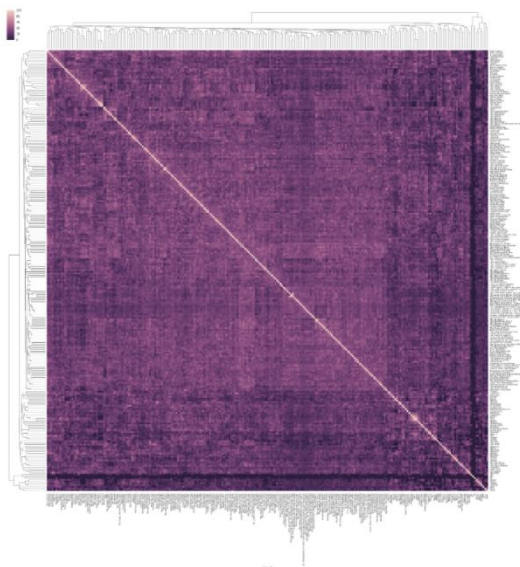

HIGH
LOW
NORMAL
NORMAL 29.5%
HIGH 38.5%
LOW 32%


Square Feet vs House Price (in Millons)
house-pr...
10
8
6
4
2
0
0
3,000
6,000
9,000
12,000
15,000
square-feet


Tesla Stock Close Price in USD
Close
400
350
300
250
200
150
100
01-02 2015
06-30 2015
03-04 2016
11-07 2016
07-13 2017
12-29 2017
Date


drugX
NORMAL
LOW
NORMAL
M
drugA
drugC
drugY
HIGH
HIGH
F
Drug
Sex
Cholestero...
BP

Top Ten 2



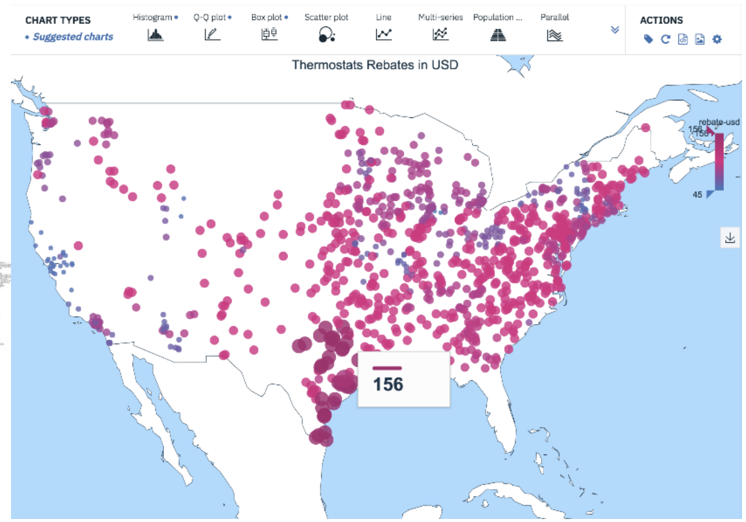
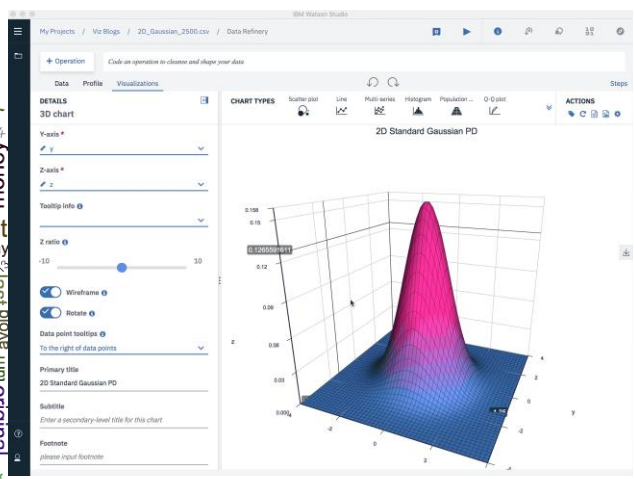
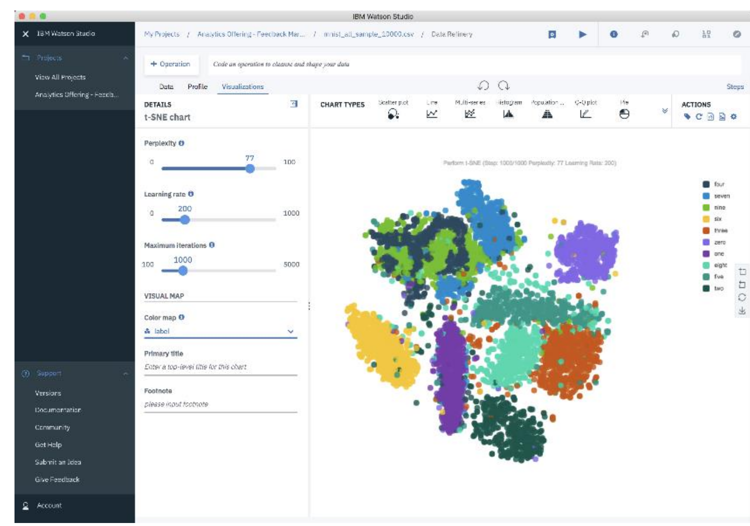
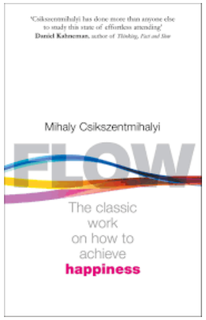


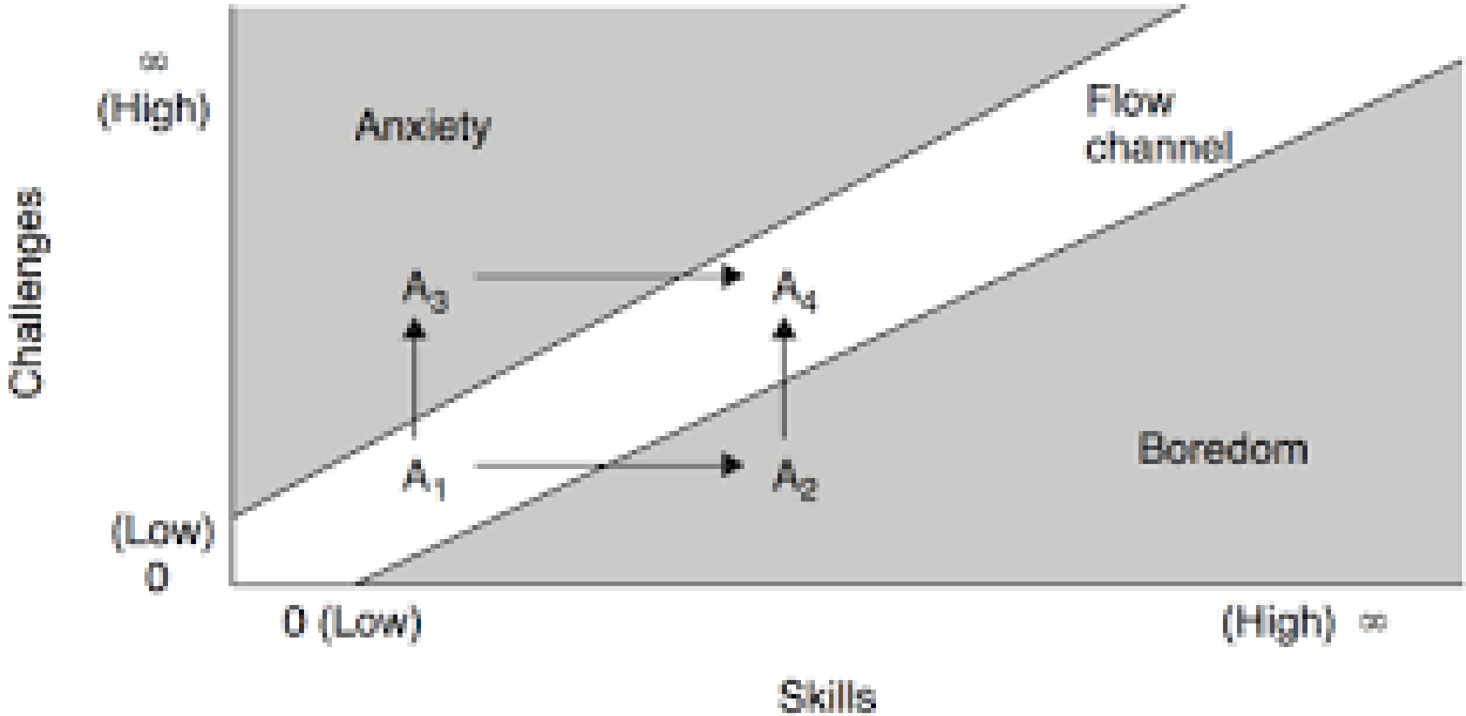
CHART TYPES
Suggested charts
Histogram
Q-Q plot
Box plot
Scatter plot
Line
Multi-series
Population ...
Parallel
ACTIONS
Thermostats Rebates in USD
rebate-usd
45
156

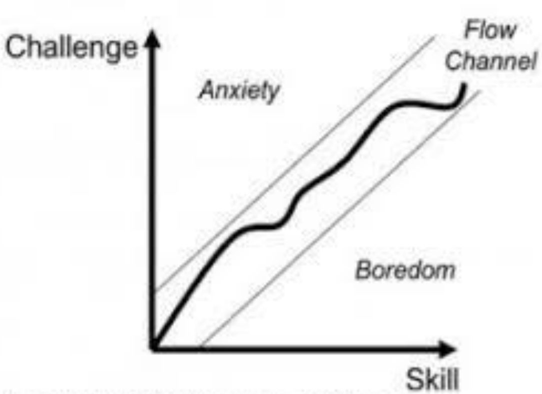

2D Standard Gaussian PD


IBM Watson Studio
t-SNE chart
Perplexity
Learning rate
Maximum iterations

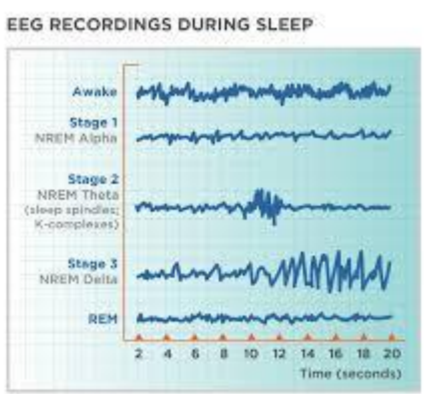


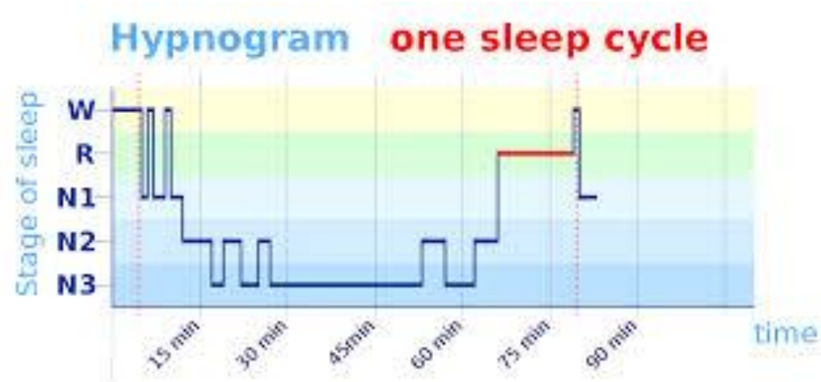
Flow, Sleep, Time





"Flow" concept by Mihaly Csikszentmihalyi. Drawn by Senia Maymin.





VEGA-LITE, VUX

Vega-Lite: A Grammar of Interactive Graphics

Arvind Satyanarayan, Dominik Moritz, Kanit Wongsuphasawat, and Jeffrey Heer

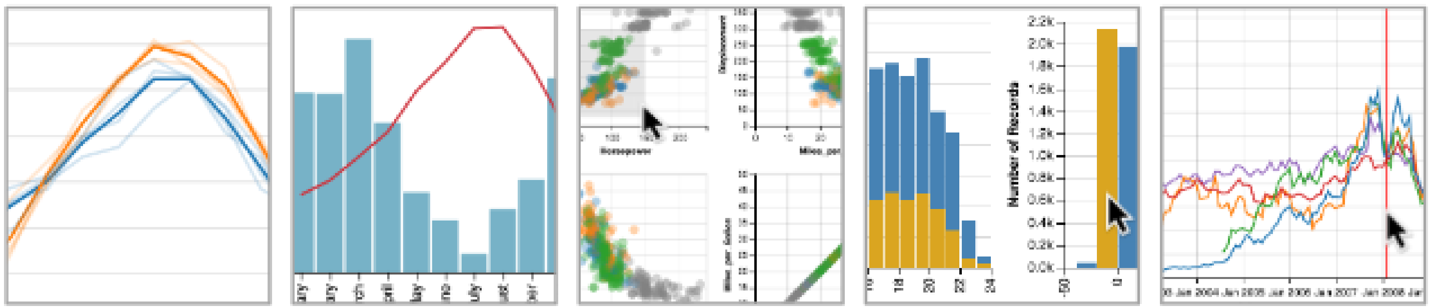
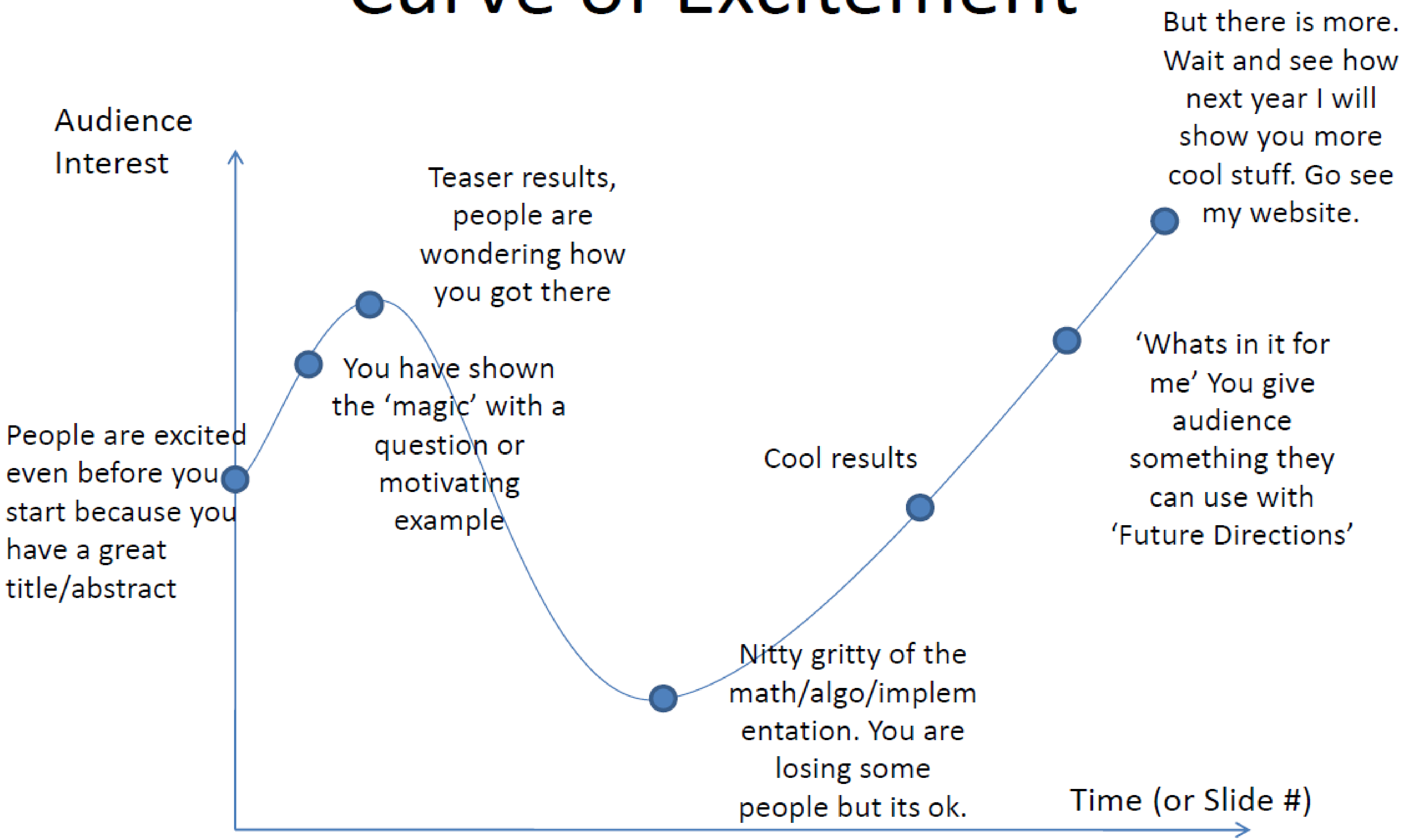


Fig. 1. Example visualizations authored with Vega-Lite. From left-to-right: layered line chart combining raw and average values, dual-axis layered bar and line chart, brushing and linking in a scatterplot matrix, layered cross-filtering, and an interactive index chart.

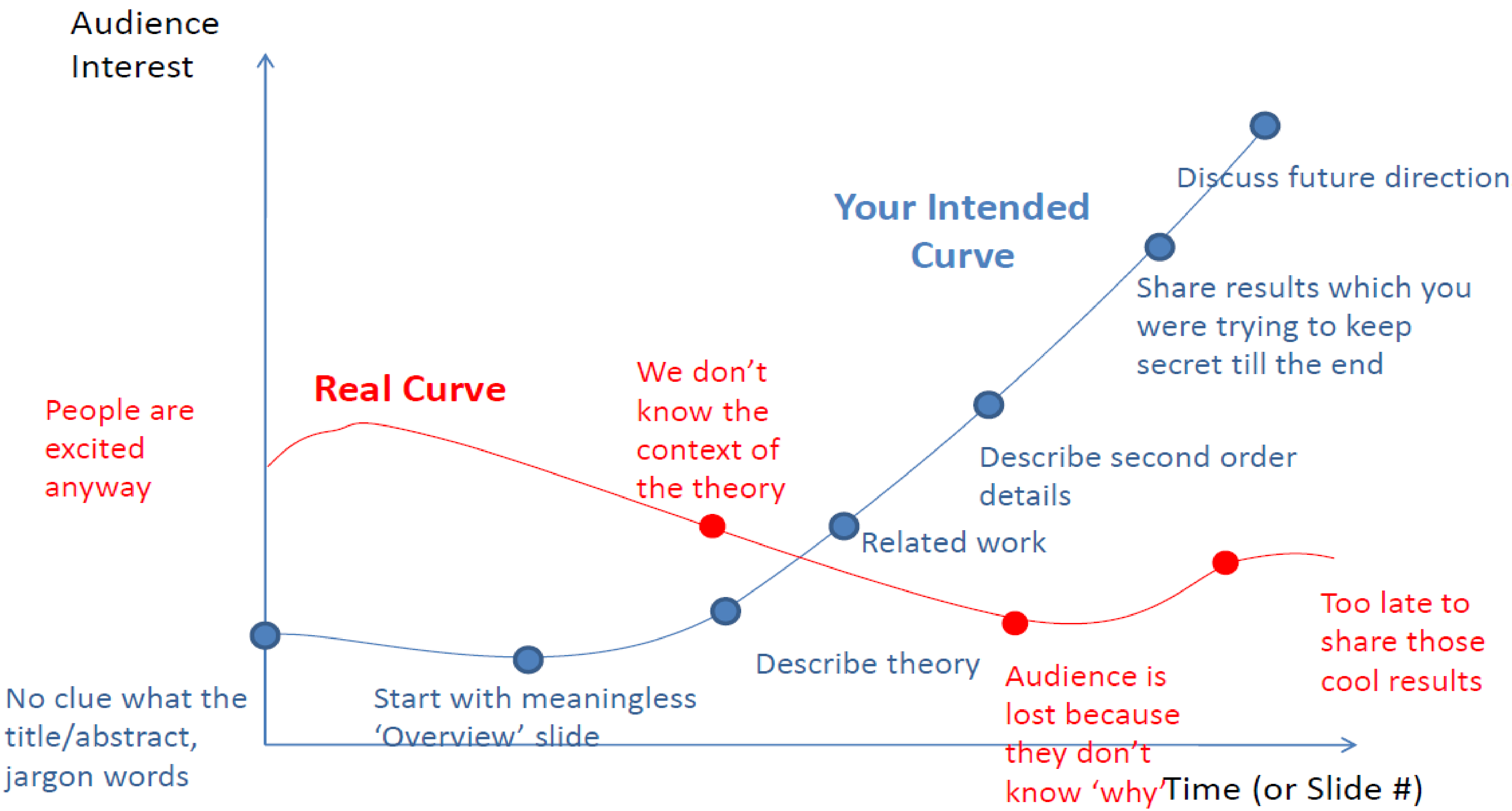
Visual Usability: Principles and Practices for Designing Digital Applications, MK 2013
Tania Schlatter,Deborah Levinson

Curve of Excitement



https://www.slideshare.net/cameraculture/how-to-give-a-good-talk

Curve of Boredome



https://www.slideshare.net/cameraculture/how-to-give-a-good-talk

- Have a photo/figure/sketch on every slide
- The image can be unrelated
- If you run out of ideas for a photo on each slide, just search for the keyword online (here I searched 'unrelated;)

https://www.slideshare.net/cameraculture/how-to-give-a-good-talk

Information	Metaphor	Example
Proportion	Human Body	Le Corbusier, Di Giorgio Martini, Schwaller de Lubicz
Proportion	Music	Stretto House
Sacred Knowledge	Path	Borobudur
Cosmological Order	Gods,Nature,Man	Balinese Architecture
Astronomy	Instrument	Observatory, Jaipur
General Knowledge	Theatre	Memory Theatre
Ethnology	Worldtrip	Museum of Ethnology, Leiden
Advertisement	Screen	Tokyo
Financial Data	Augmented Space	NYSE, Asymptote

Table 1: Overview of Built Information Architectures

STU

Architecture as Information Space [Ferschin Gramelhofer, 2004]

Scientific Visualization

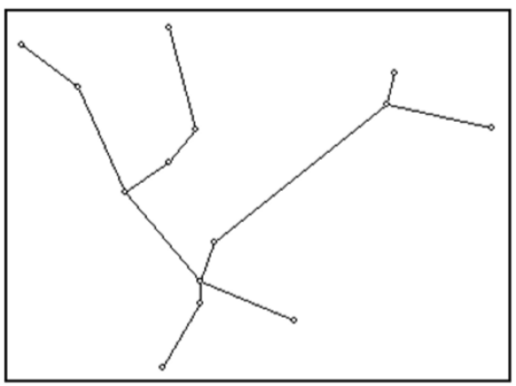
- Visualization of Data Sets
- Information Visualization:
- - graph drawing [Nish04], [DiB99]
- - algorithm animation
- - ...
- ____

- T. Nishizeki and M. S. Rahman, Planar Graph Drawing, World Scientific, Singapore, 2004.
- G. Di Battista, P. Eades, R. Tamassia, I. G. Tollies, Graph Drawing: Algorithms for the visualization of Graphs, Prentice-Hall Inc., 1999.

Graph Drawing

- 1736 Euler (stars, Boruvka 1926)

Kruja, E. et al. 2001. A Short Note on the History of Graph Drawing.
GD 2001: pp 272-286. [online]
http://www.merl.com/publications/docs/TR2001-49.pdf



AND – Andromeda

https://en.wikipedia.org/wiki/Bor%C5%AFvka%27s_algorithm

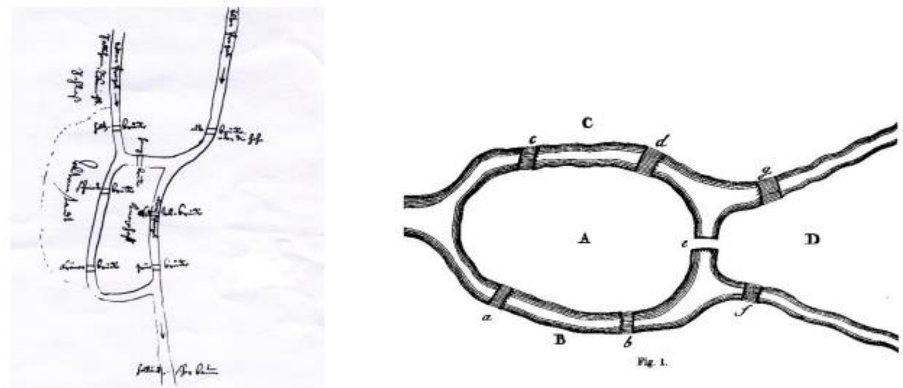


Fig. 9. Ehler's sketched map of Königsberg, 1736 (left), and Euler's more polished version [12]. Euler included one more sketched map (a variant of the first with more bridges included) in his paper, but no abstract graph drawing of the problem. Reproduced with permission.

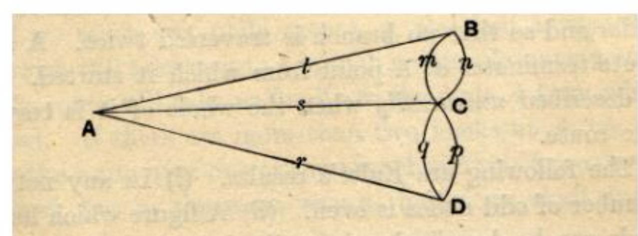


Fig. 10. Ball's 1892 graph-drawing abstraction of the bridges of Königsberg. The nodes represent the land areas and the edges represent the bridges connecting them.

Graph Drawing before Graphs

- Kruja, E. et al. 2001. A Short Note on the History of Graph Drawing. GD 2001: pp 272-286. [online] http://www.merl.com/publications/docs/TR2001-49.pdf

Fig. 1. Depictions of Morris gameboards from the 13th century. The nodes of these graph drawings are the positions that game counters can occupy. The edges indicate how game counters can move between nodes. Reproduced with permission.

Fig. 7. Musical intervals drawn in a square of opposition from the 11th century. The nodes (corners) represent numbers and the edges represent named ratios between them (e.g., "octave" and "fifth"). Reproduced with permission.

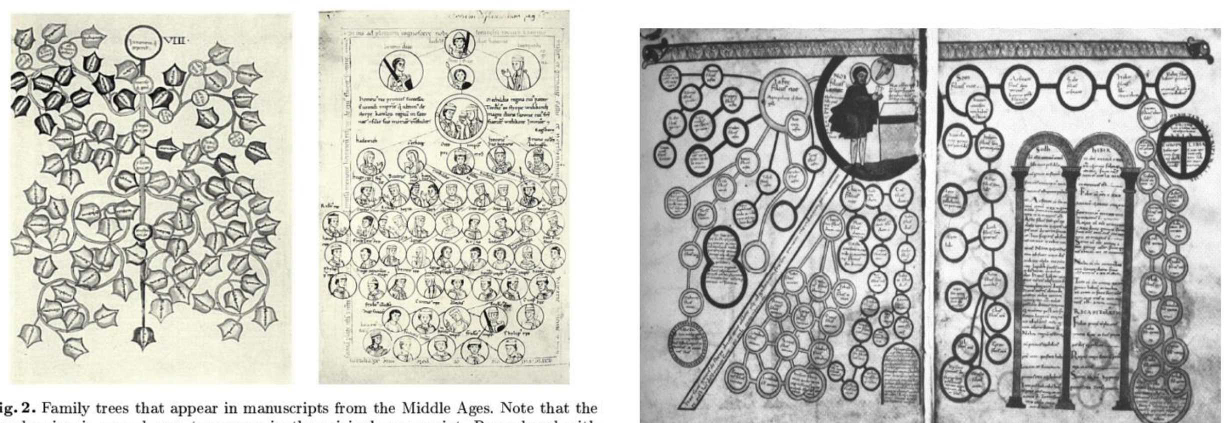


Fig. 2. Family trees that appear in manuscripts from the Middle Ages. Note that the top drawing is spread over two pages in the original manuscript. Reproduced with permission.

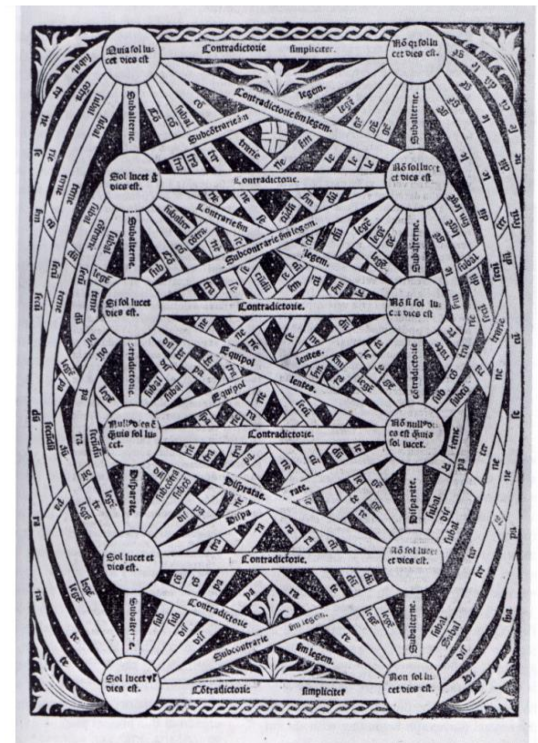


Fig. 6. A more complex square of opposition from the 16th century. It is a symmetric drawing of K_{12} with labeled nodes and edges. Reproduced with permission.

Graph Drawing before Graphs 2

- Kruja, E. et al. 2001. A Short Note on the History of Graph Drawing. GD 2001: pp 272-286. [online] http://www.merl.com/publications/docs/TR2001-49.pdf

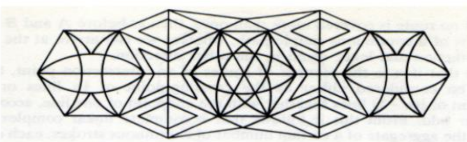


Fig. 12. A graph drawing from 1847 that can be drawn in a single stroke. Reproduced with permission.

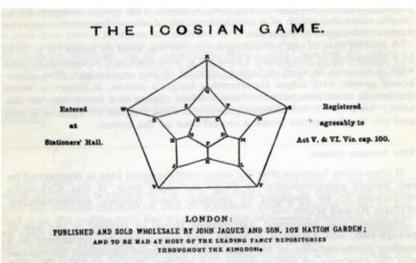


Fig. 13. Hamilton's *Icosian Game* from 1857. Reproduced with permission.

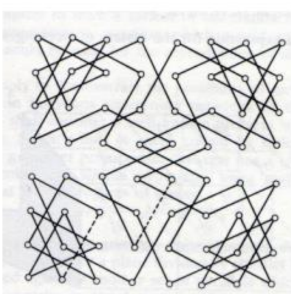


Fig. 11. Vandermonde's 1771 graph drawing of a Knight's Tour. This is actually a drawing of a subgraph of the graph that represents all possible knight moves. In that graph the nodes represent squares on a chessboard and edges represent legal moves. Reproduced with permission.

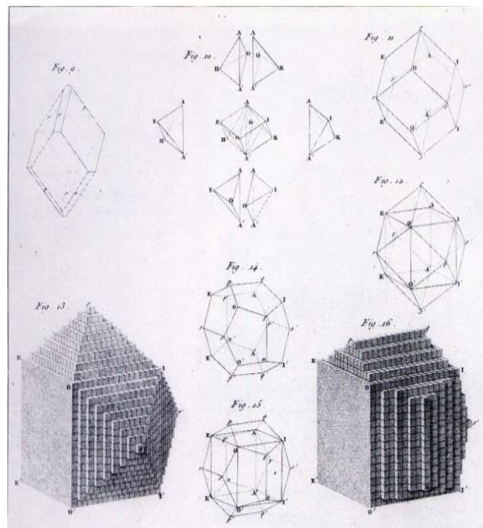
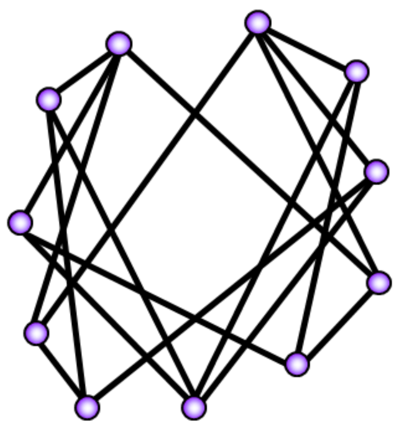


Fig. 15. Drawings from 1784 that depict the geometry of crystal structures but that also foreshadow the use of 3D graph drawing. The graph nodes correspond to corners or apexes of the physical crystal. Edges connect neighboring nodes. Reproduced with permission.

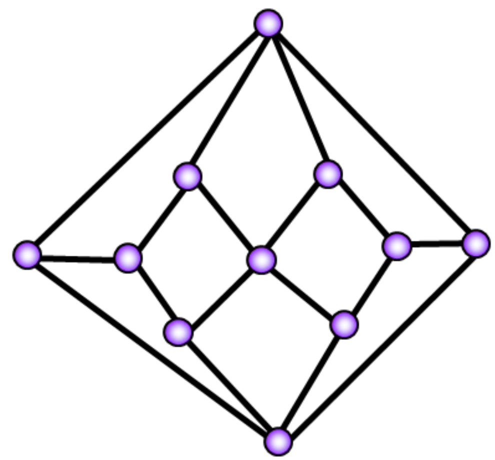
Fig. 8. A quipu in the collection of the Museo National de Anthropologia y Arquelogía, Lima, Peru [4]. Photograph by Marcia and Robert Ascher. Reproduced with permission.

Planar Graph Drawing

- Nishizeki, T. & Rahman, S. 2004. Planar Graph Drawing. World Scientific 2004.



structure of the graph is
difficult to understand



structure of the graph is
easy to understand

Graph Drawing Styles

- Nishizeki, T. & Rahman, S. 2004. Planar Graph Drawing. World Scientific 2004.

- **Planar**
- **Polyline**
- **Straight Line**
- **Convex**
- **Orthogonal**
- **Box-Orthogonal**
- **Rectangular**
- **Box-Rectangular**
- **Grid**

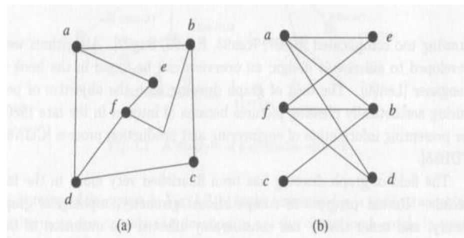
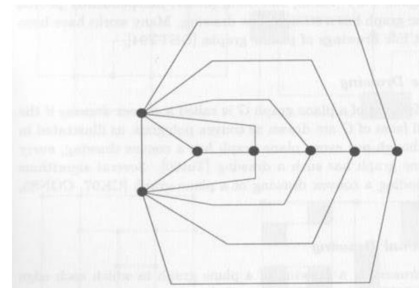


Fig. 1.3 (a) A planar drawing, and (b) a non-planar drawing of the same graph.



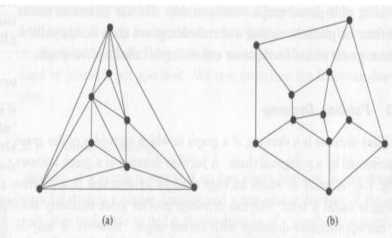
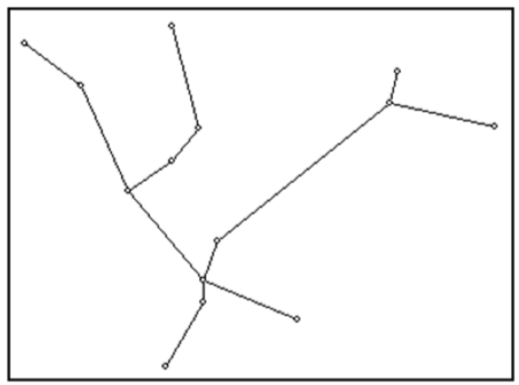


Fig. 1.5 (a) A straight line drawing, and (b) a convex drawing.



AND – Andromeda

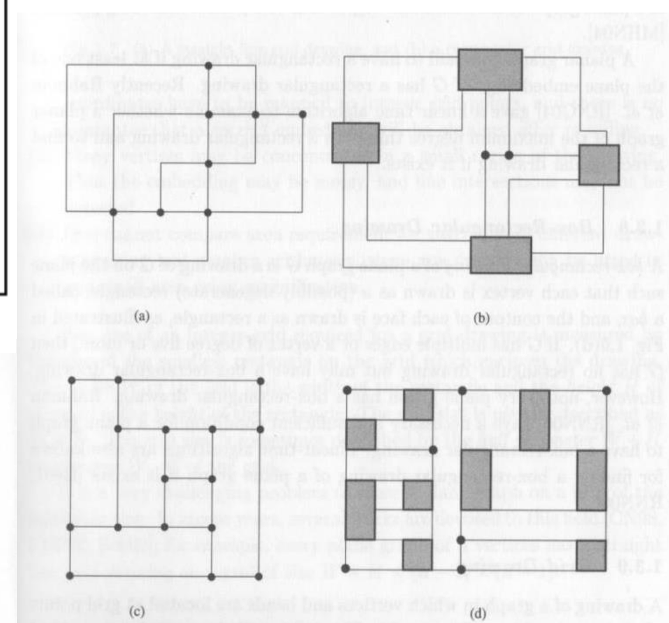


Fig. 1.6 (a) An orthogonal drawing, (b) a box-orthogonal drawing, (c) a rectangular drawing, and (d) a box-rectangular drawing.

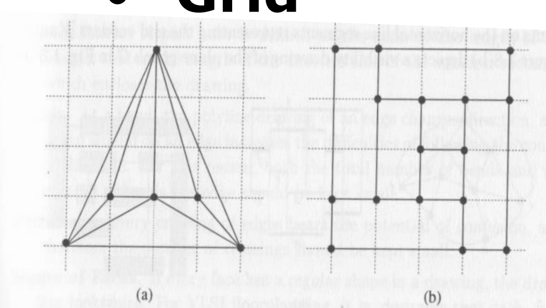


Fig. 1.7 (a) A straight line grid drawing, and (b) a rectangular grid drawing.

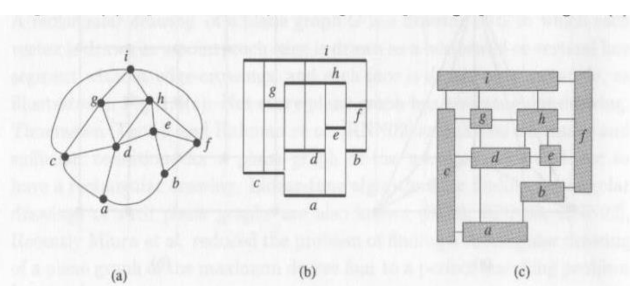
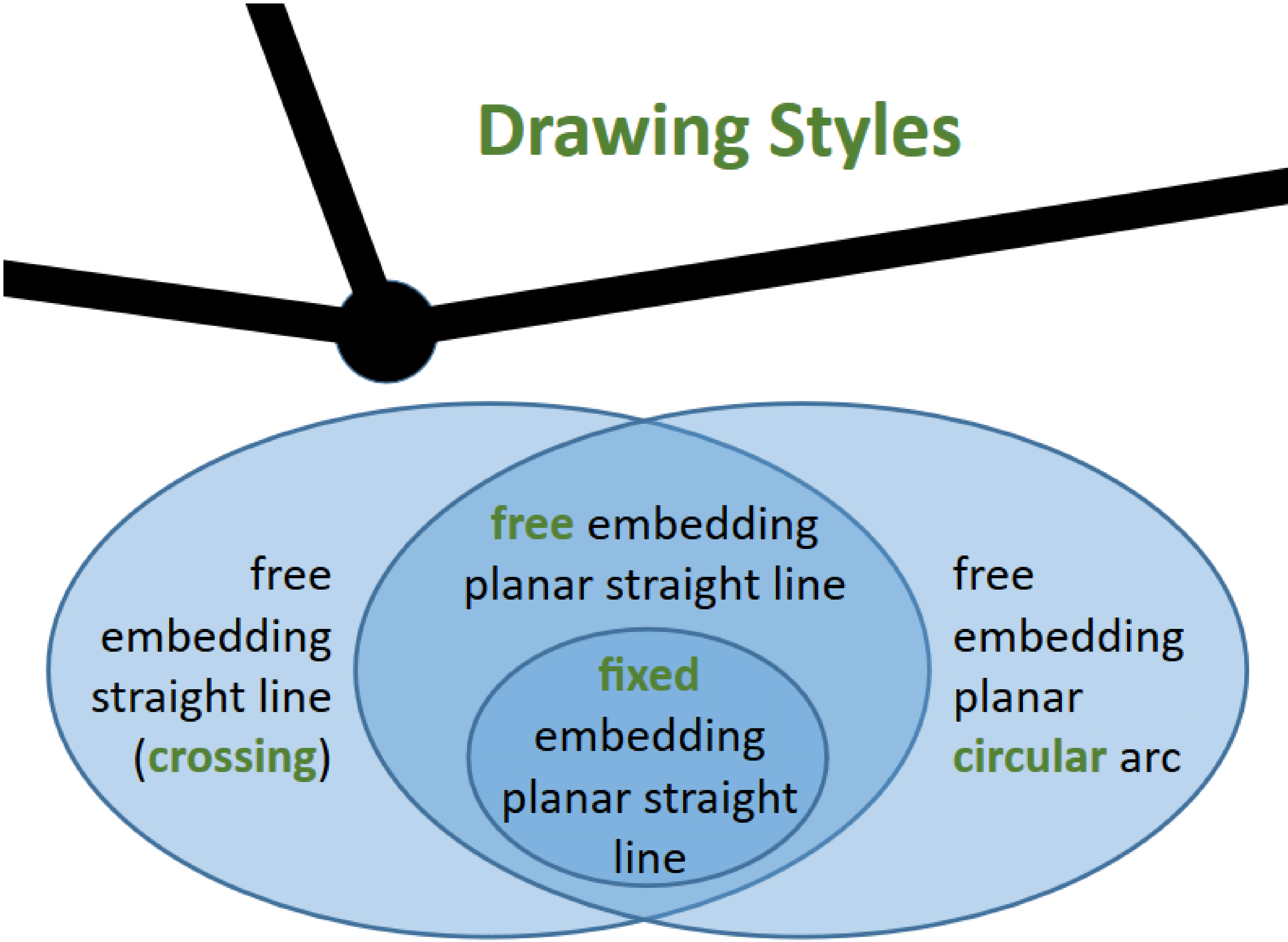


Fig. 1.8 (a) A plane graph G, (b) a visibility drawing of G, and (c) a 2-visibility drawing of G.

Drawing Styles



Properties of graph drawing

Area

A drawing is useless if it is unreadable. If the used area of the drawing is large, then we have to use many pages, or we must decrease resolution, so either way the drawing becomes unreadable. Therefore one major objective is to ensure a small area. Small drawing area is also preferable in application domains like VLSI floorplanning.

Aspect Ratio

Aspect ratiois defined as the ratio of the length of the longest side to the length of the shortest side of the smallest rectangle which encloses the drawing.

Bends

At a bend, the polyline drawing of an edge changes direction, and hence a bend on an edge increases the difficulties of following the course of the edge. For this reason, both the total number of bends and the number of bends per edge should be kept small.

Crossings

Every crossing of edges bears the potential of confusion, and therefore the number of crossings should be kept small.

Shape of Faces

If every face has a regular shape in a drawing, the drawing looks nice. For VLSI floorplanning, it is desirable that each face is drawn as a rectangle.

Symmetry

Symmetry is an important aesthetic criteria in graph drawing. A symmetryof a two-dimensional figure is an isometry of the plane that fixes the figure.

Angular Resolution

Angular resolution is measured by the smallest angle between adjacent edges in a drawing. Higher angular resolution is desirable for displaying a drawing on a raster device.

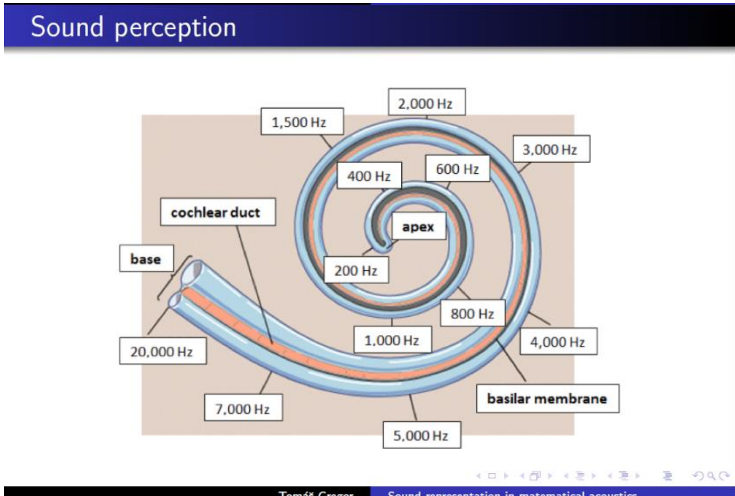
Data Abstraction for Visualizing Large Time Series

Data Abstraction for Visualizing Large Time Series

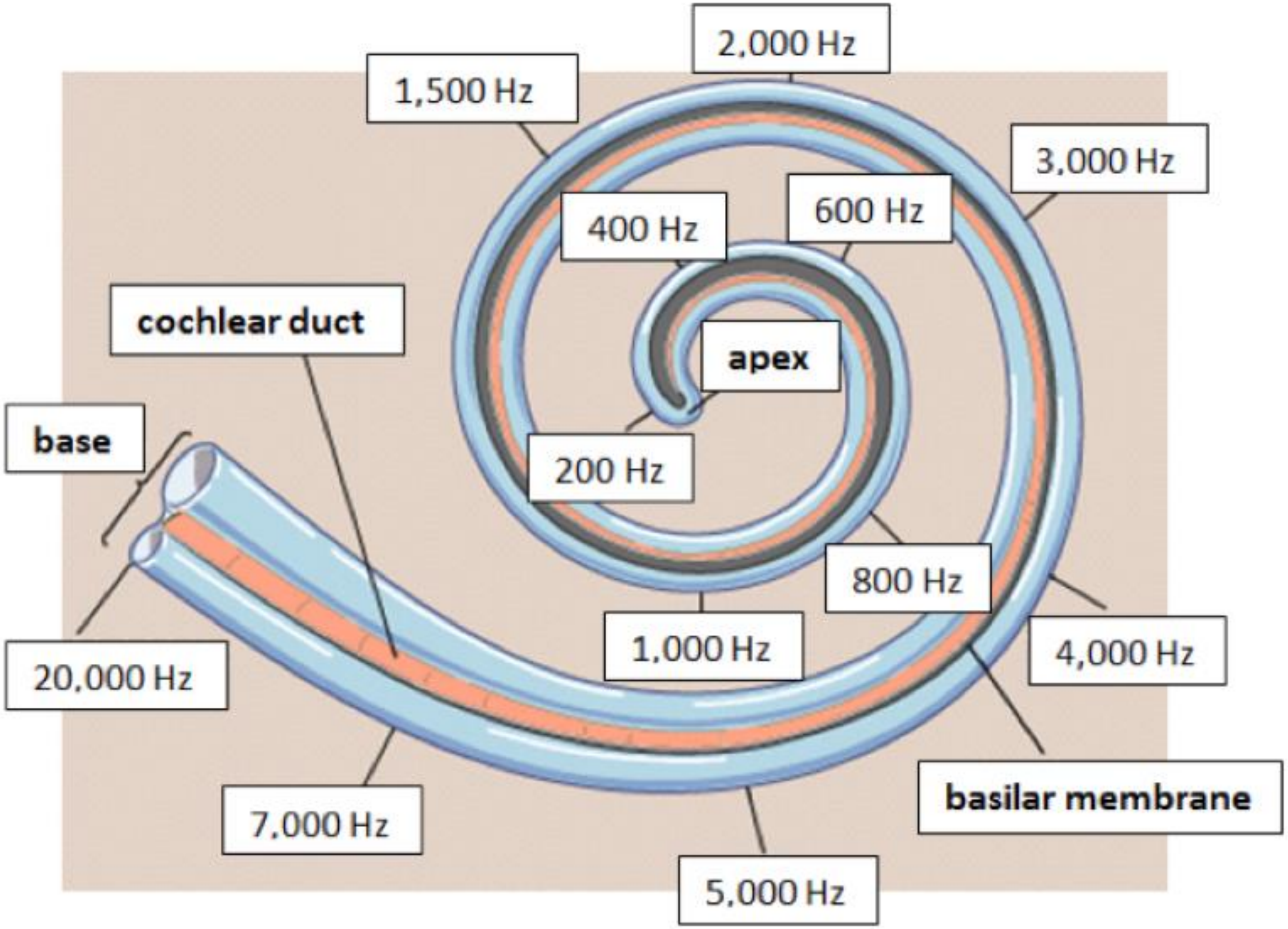
Shurkhovetskyy et al. 2018.
CGF. **https://doi.org/10.1111/cgf.13237**

- Time Series Representations
  - Data Adaptive
    - Sorted Coefficients
    - Piecewise Polynomial
      - Piecewise Linear Approximation
        - Interpolation
        - Regression
      - Adaptive Piecewise Constant Approximation
    - Singular Value Decomposition
    - Symbolic
      - Natural Language
      - Strings
        - Lower Bounding
        - Non-lower Bounding
  - Non-data Adaptive
    - Wavelets
      - Orthonormal
        - Haar
        - Daubechies
      - Bi-orthonormal
        - Coiflets
        - Symlets
    - Random Mappings
    - Spectral
      - Discrete Fourier Transform
      - Discrete Cosine Transform
    - Piecewise Aggregate Approximation

Figure 2: *Classification of time series representations based on Lin et al. [LKLC03]. The leaf nodes are representations and the internal nodes are classes.*

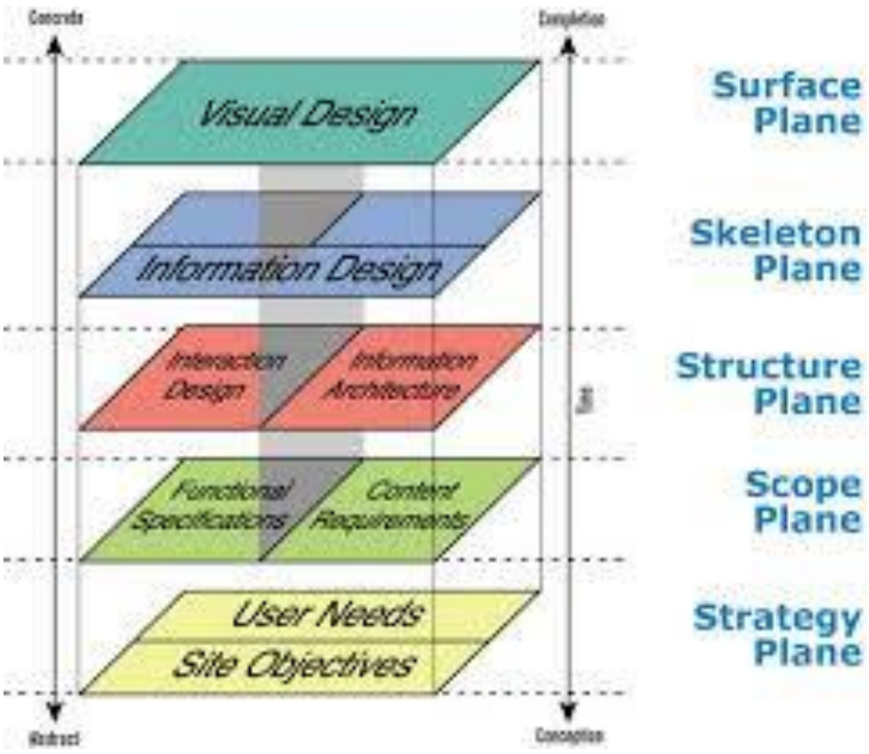


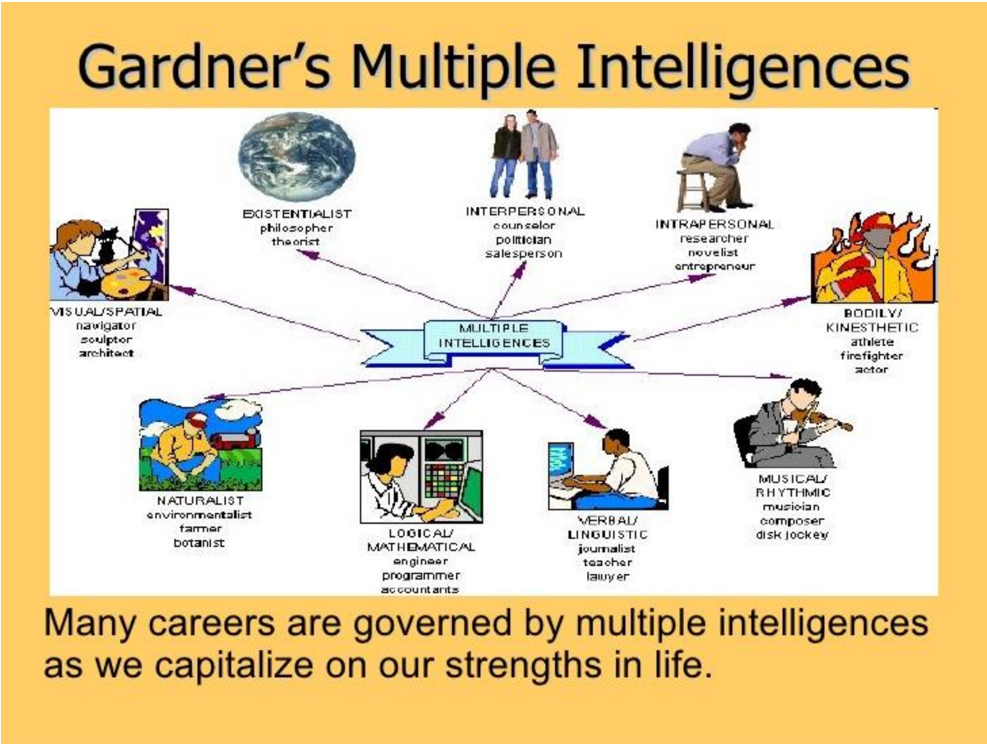
Sound perception



Authoring

- Mental operations?
- Objects, semiotic representations, metaphors…
- Meaning





Sensemaking

- Story

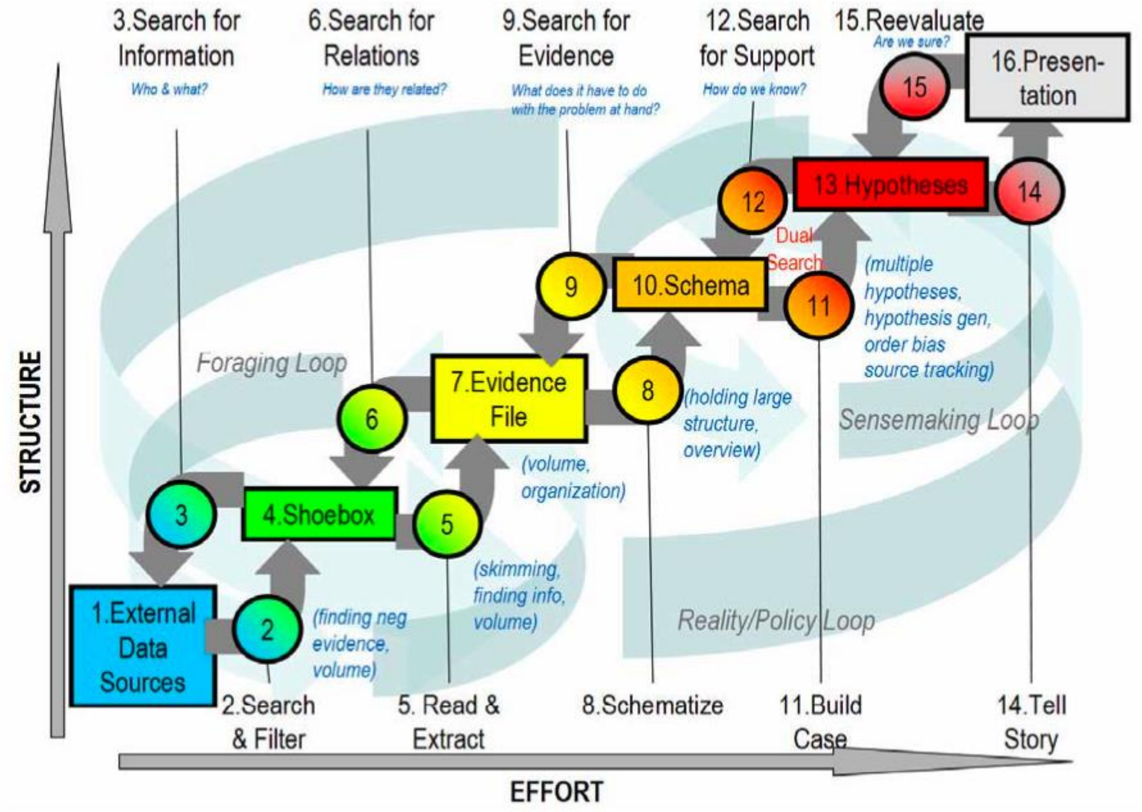
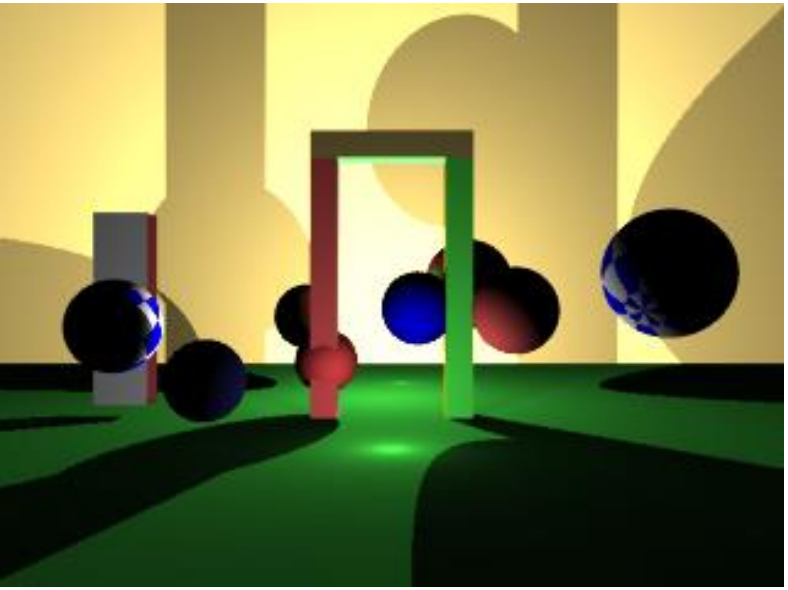
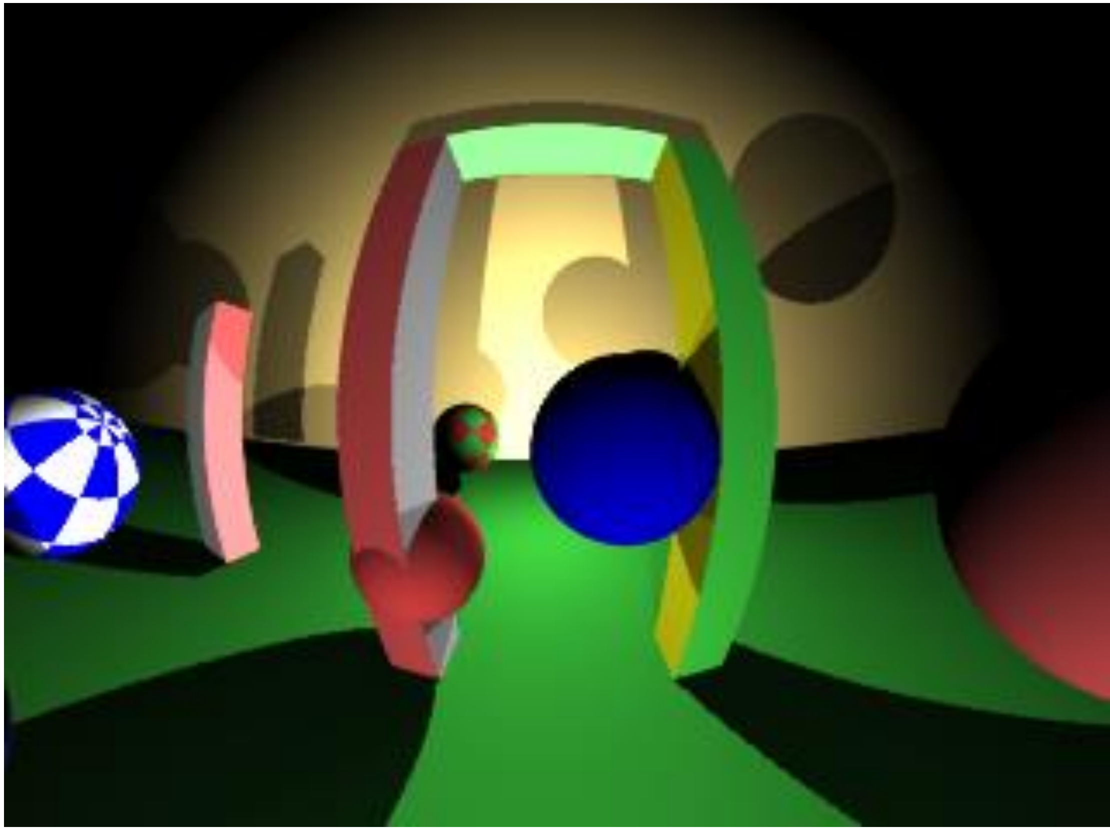


Figure 1.1: *The sensemaking process described by Pirolli & Card [PC05]. The Exploration process within visualization is analogous to the foraging loop, e.g. collecting evidence in a shoebox, while analysis is the consideration of this evidence. Ultimately any hypothesis or evidence found must be presented in one way or another.*

Relativistic Effects

Motionless camera and camera moving towards the scene with 0.9c velocity. Covered sides of objects can be seen.





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