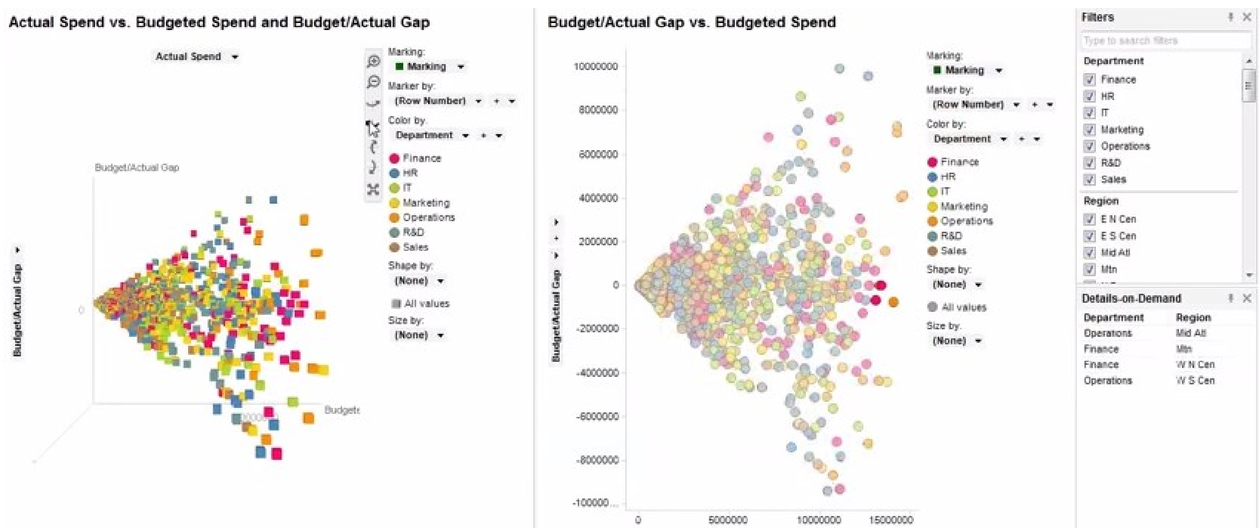
Universidade de Aveiro
Departamento de Electrónica,
Telecomunicações e Informática

universidade de aveiro
1973 . 2018

Issues in InfoVis



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Interesting questions:

Why have a human in the decision-making loop?

Why have a computer in the loop?

Why use an external representation?

Why depend on vision?

Why show the data in detail?

Why use interactivity?

What is the design space of visualization idioms?

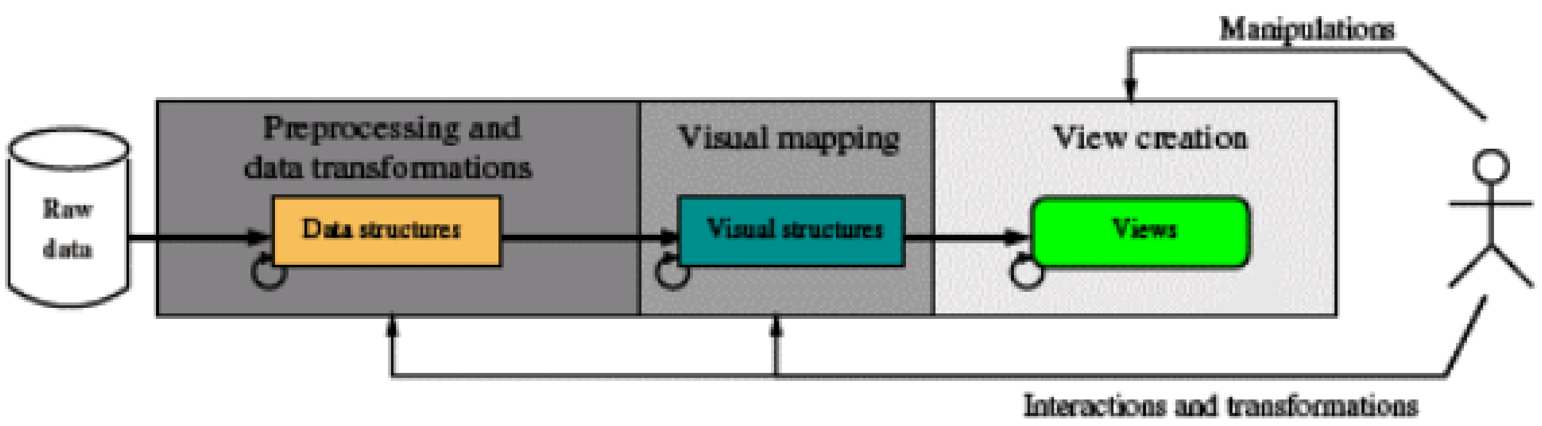
Why focus on tasks?

Why are most designs ineffective?

What resource limitations matter?

How can better be measured? (Munzner, 2014, chap. 1)

The process of creating a Visualization



How can we produce a Visualization?

- There are **many possible** Visualization solutions, but …

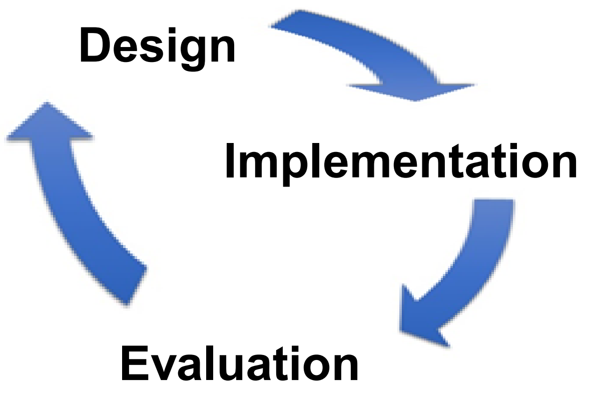
- There are **principles** (derived form human perception and cognition)

  paradigms (examples resulting form past experience)

  and many **methods**

- To obtain **efficacy** it is fundamental:
  - a correct definition of **goal** and **user tasks**
  - apply adequate methods and **evaluate**

  in **several iterations** until the goals are ~satisfied …

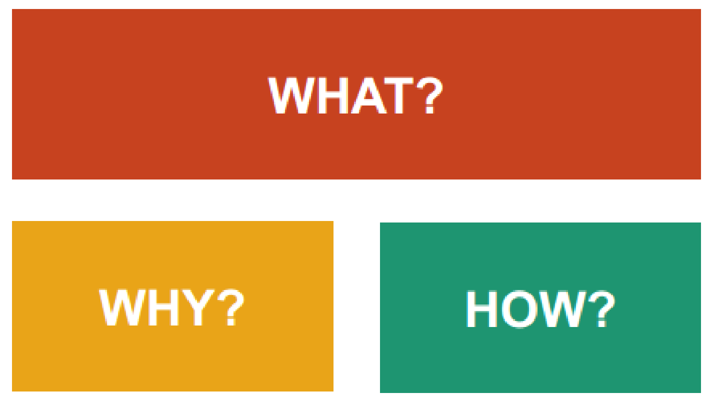


Framework for analyzing Visualization use

- It is a “wicked problem”

https://www.interaction-design.org/literature/article/wicked-problems-5-steps-to-help-you-tackle-wicked-problems-by-combining-systems-thinking-with-agile-methodology

Visualization usage can be analyzed in terms of:
- Why the user needs it
- How the idiom is designed
- What data is shown



Visualization Analysis & Design

(Munzner, 2014)

Framework for analyzing Visualization use

What ? — What data the user sees

Why? — Why the user intends to use a Vis tool (task)

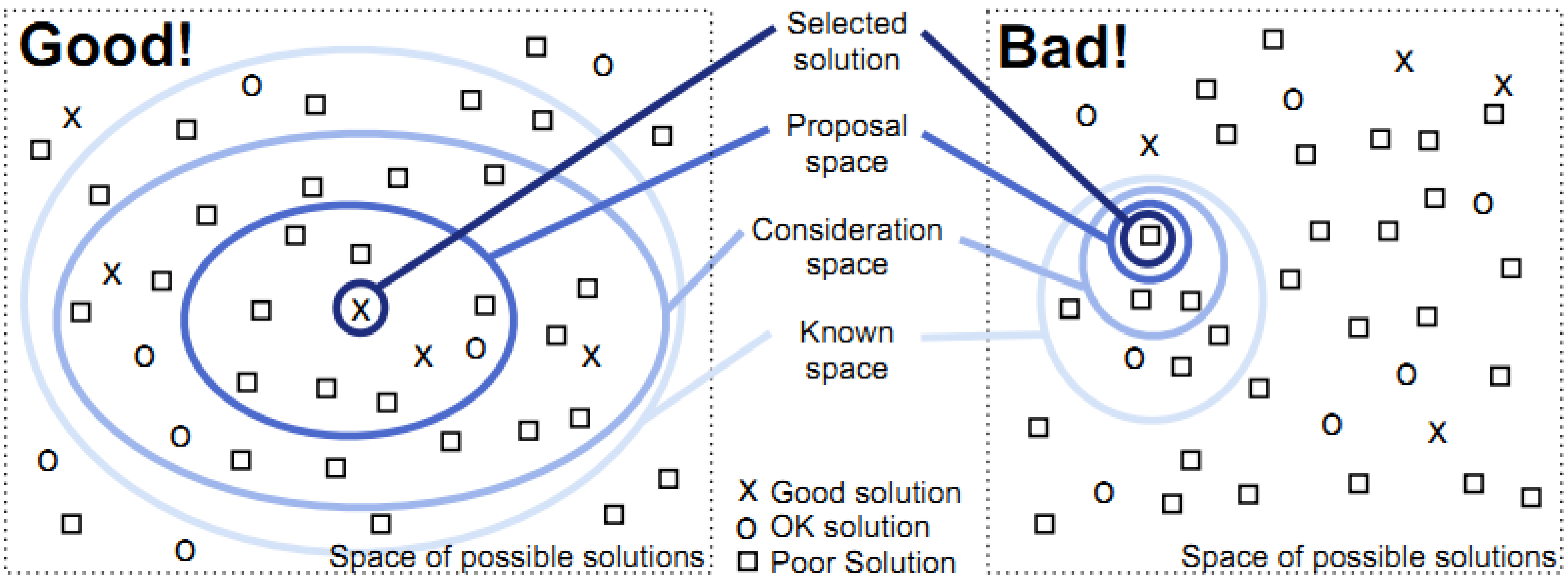
How? — How the visual encoding and interaction idioms are constructed

(Munzner, 2014)

Simple Vis tools may be analyzed as an instance;

Complex tools may require analysis in terms of a sequence of instances

The problem of Visualization design



(Munzner, 2014)

- Only a very small number of possibilities are reasonable …
  most are ineffective

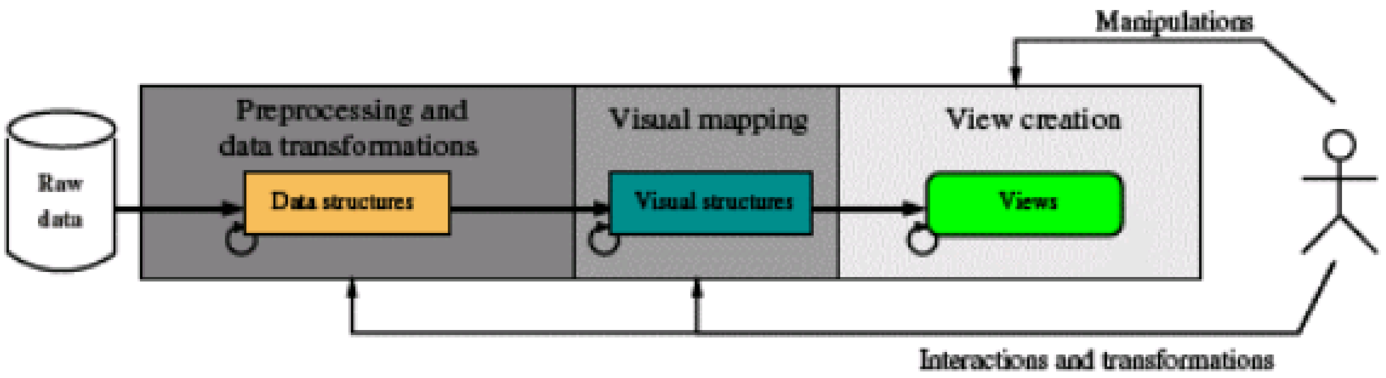
Consider multiple alternatives and then select the best!
(based on evaluation …)

Creating Visualizations

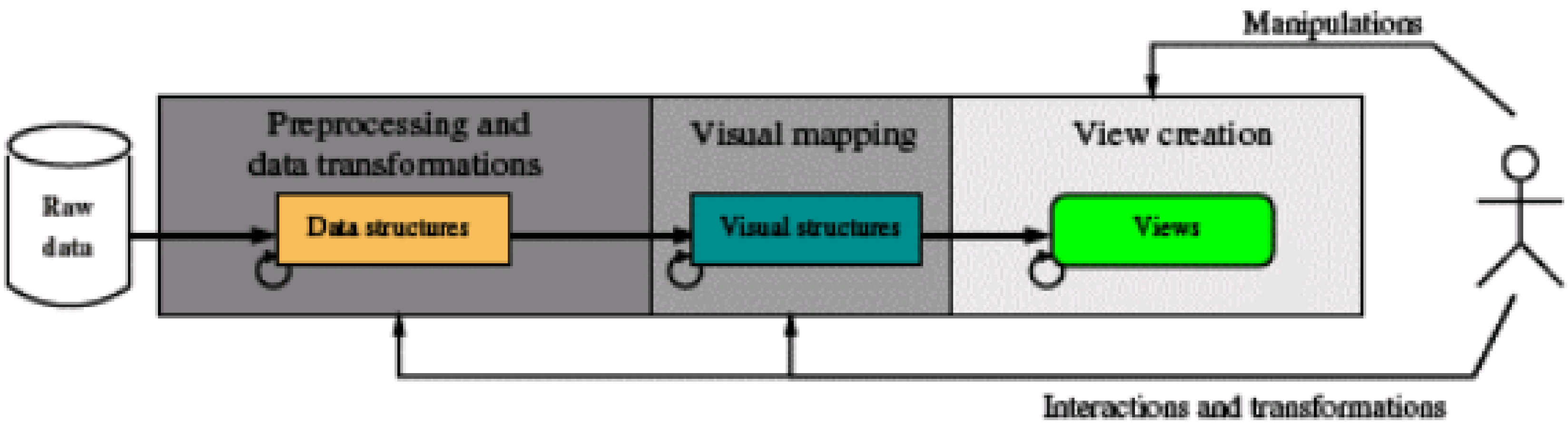
- **Good design and evaluation** is the key to success in producing a Visualization

- Visualization S/W can provide many visual templates;

- In spite of variation, all S/W packages follow the same generation process



(Mazza, 2009)



- Creating a visualization can be modeled as a process including several stages:

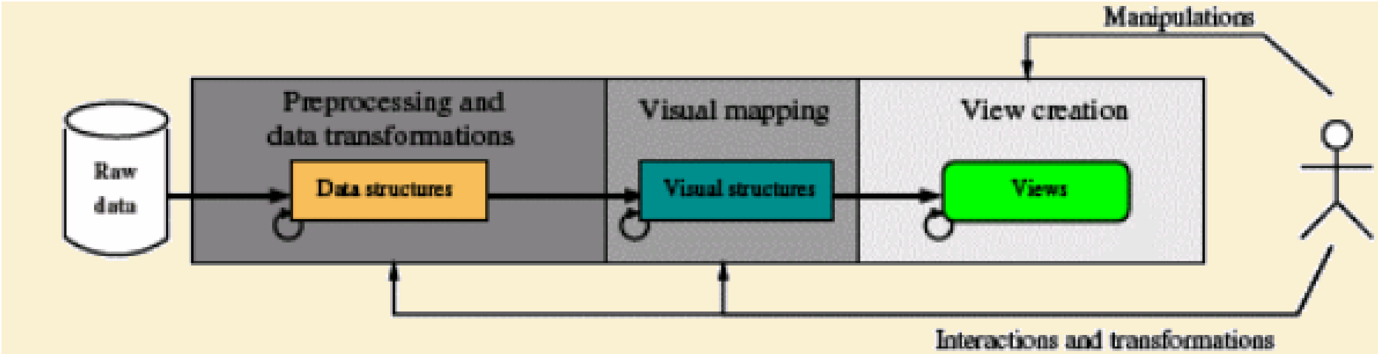
(Mazza, 2009)

- preprocessing and transformation

- visual mapping **not forgetting evaluation in several iterations!**

- creation of views

Note: this is similar to the visualization reference model

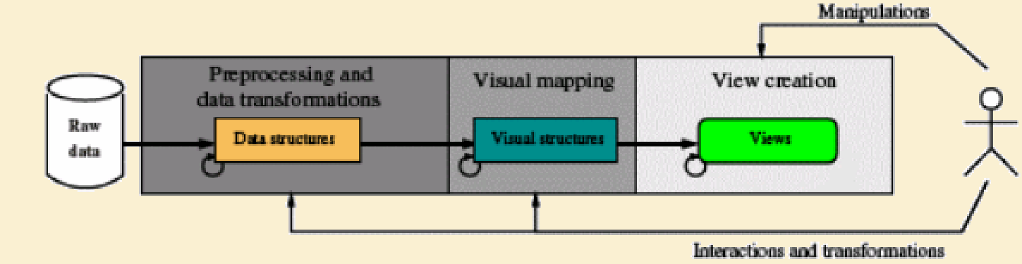


1. Preprocessing (Data transformation):

- Abstract data (which don´t have a specific connection with physical space) are rarely in a suitable format for automatic treatment and visualization

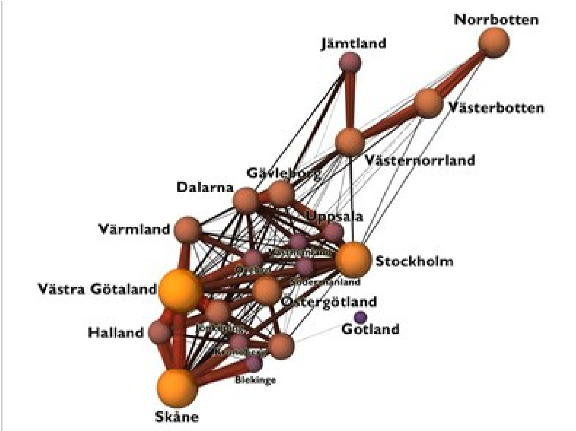
- Raw data (data supplied by the world around us, a.k.a. data sets) have to be given an organized logical structure to be processed by the Visualization S/W

This is a fundamental step; it is assumed to be addressed in another course!



2. Visual mapping:

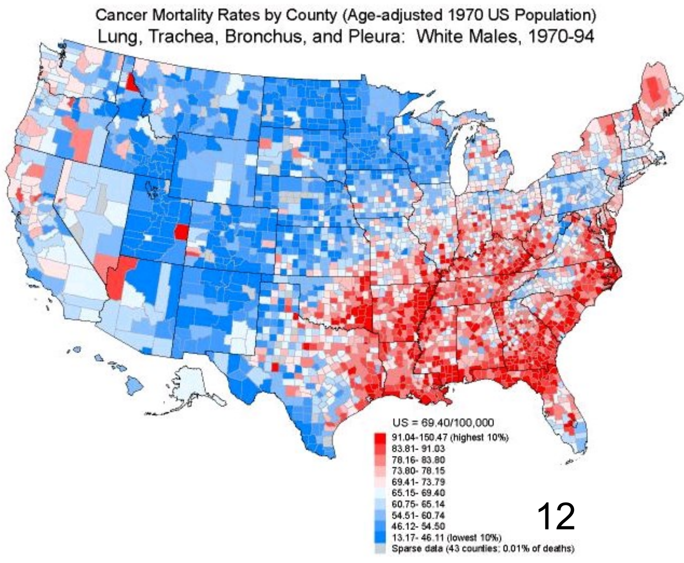
- It is necessary to decide:
  - which visual structures to use to **represent** the data
  - their location in the display



http://www.Visualcomplexity.com

• Some types of abstract data can be easily mapped to a spatial location

• Examples:
. data with a topological or geographical structure



• Many types of data don't have an easy correspondence with the dimensions of the physical space around us

Three **structures** must be defined in the **visual mapping**:

- Spatial substrate

- graphical elements

- graphical properties

- **Spatial substrate** - dimensions in physical space where the visual representation is created (can be defined in terms of axes and type of data)

- **Graphical elements** - anything visible appearing in the space points, lines, surfaces, volumes

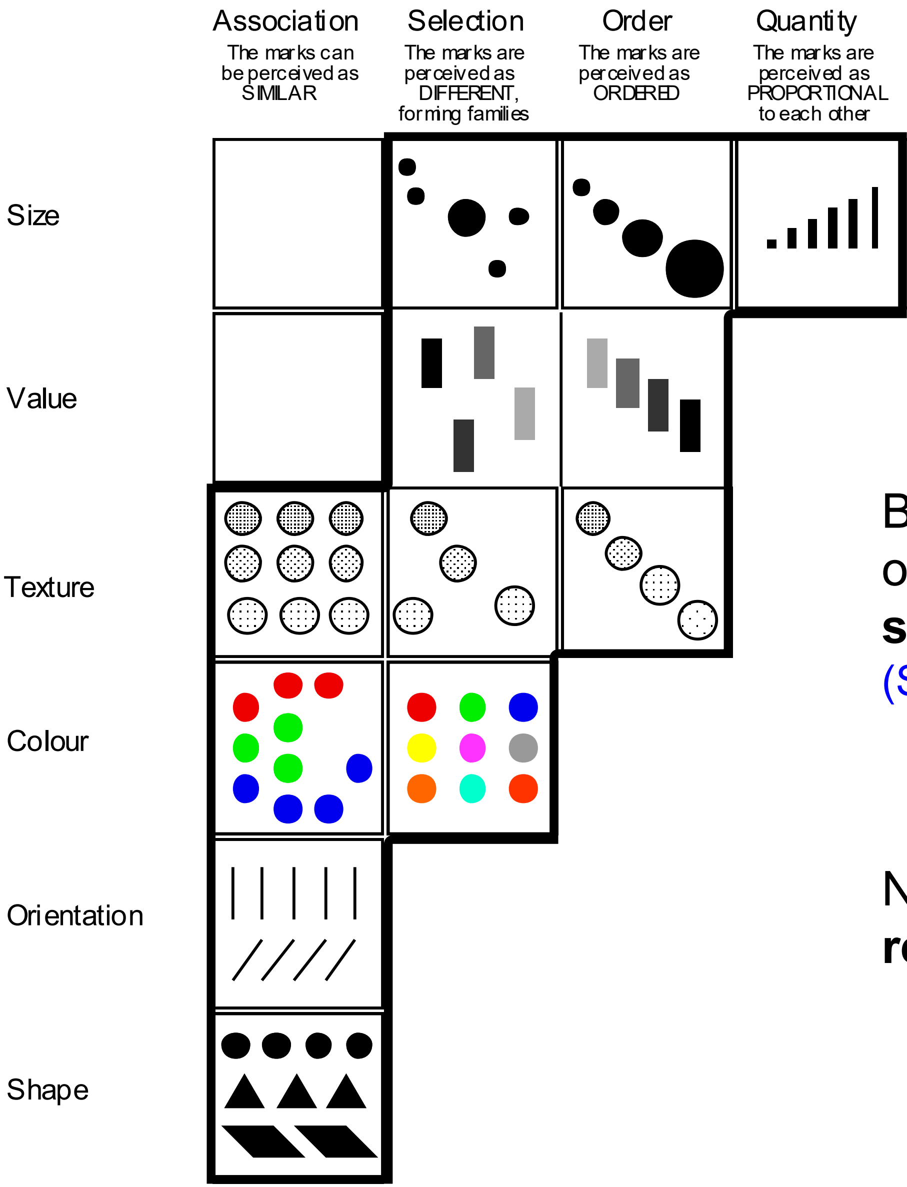
- **Graphical properties** – properties of the graphical elements to which the human retina is very sensitive - **retinal variables:** size, orientation, color, texture, and shape

- **Spatial substrate** axes (x, y, …)
  type of data (quantitative, ordinal, categorical)

- **Graphical elements** points
  lines
  surfaces
  volumes

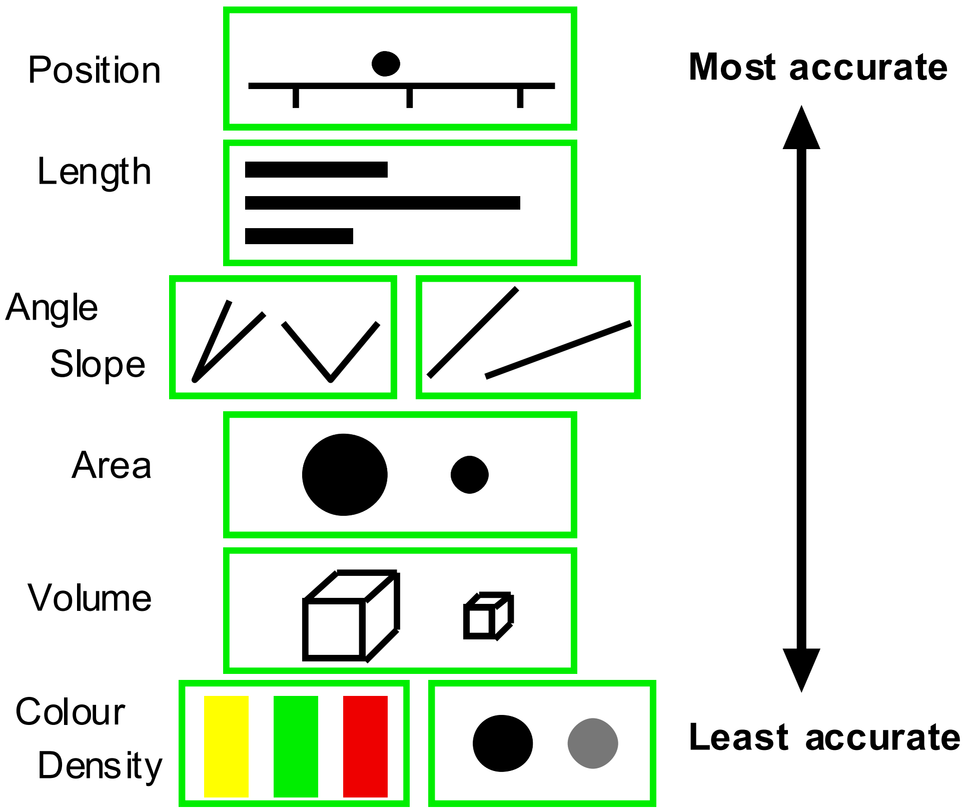
- **Graphical properties** retinal variables:
  size,
  orientation
  color (depends on physiology and culture)
  texture
  shape

•



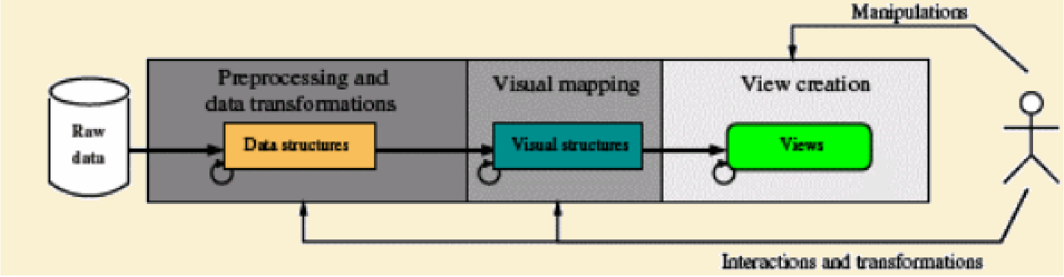
Bertin's guidance regarding the suitability of various visual **encoding methods to support common tasks** (Spence, 2007)

Note that **only size is adequate to represent quantity accurately**



The relative difficulty of **assessing quantitative value** as a function of encoding method, as established by Cleveland and McGill (Spence, 2007)

3. Creation of views:



- Views are the final result of the generation process

- Producing them corresponds to the computer graphics phase:

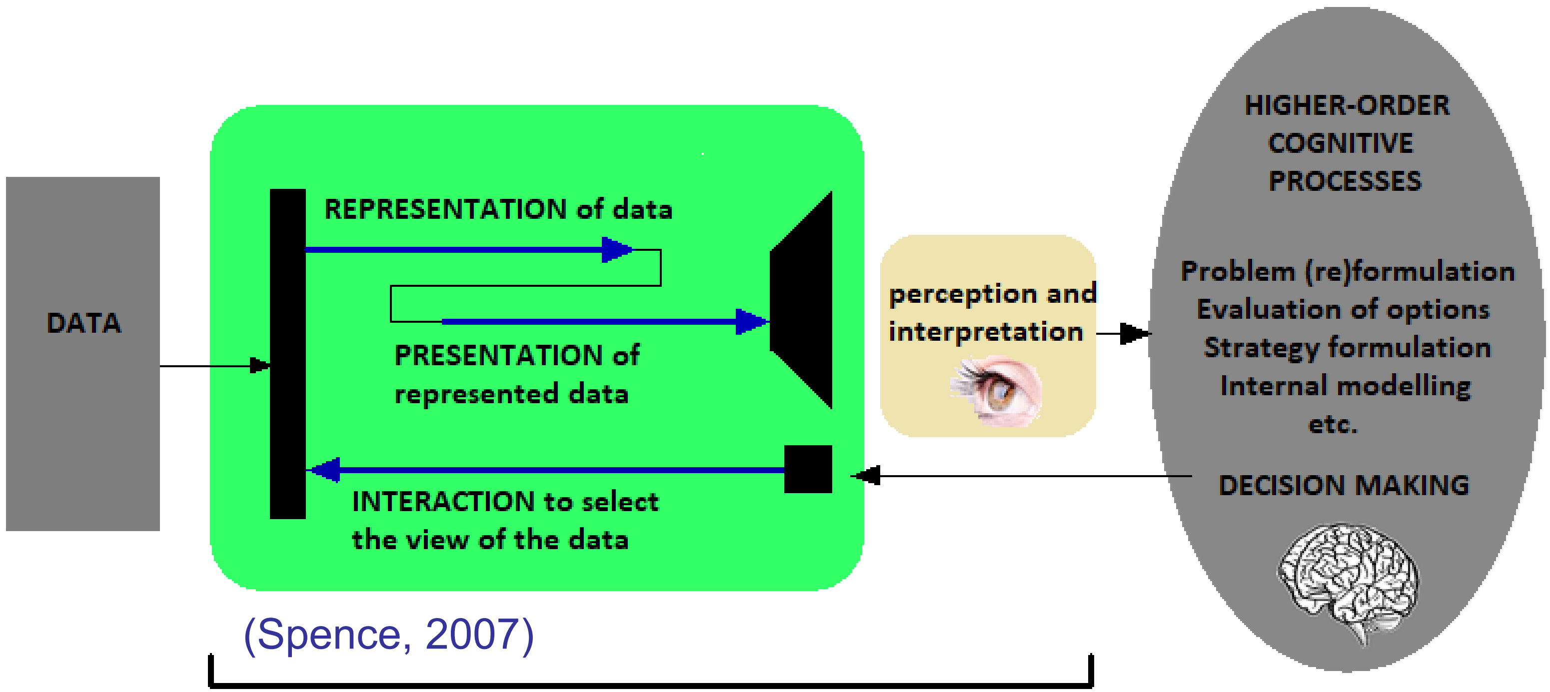
- Often the quantity of data to represent is too large for the available space

- To overcome this problem there are **presentation** techniques as:
  - Zooming
  - Panning
  - Scrolling
  - Focus + context
  - Magic lenses
  - ...

https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/bifocal-display

The process of visualization

Let us increase the known solution space organizing the methods!



Interaction with data governed by high-order cognitive processes involves:

- Representation
- Presentation
- Interaction

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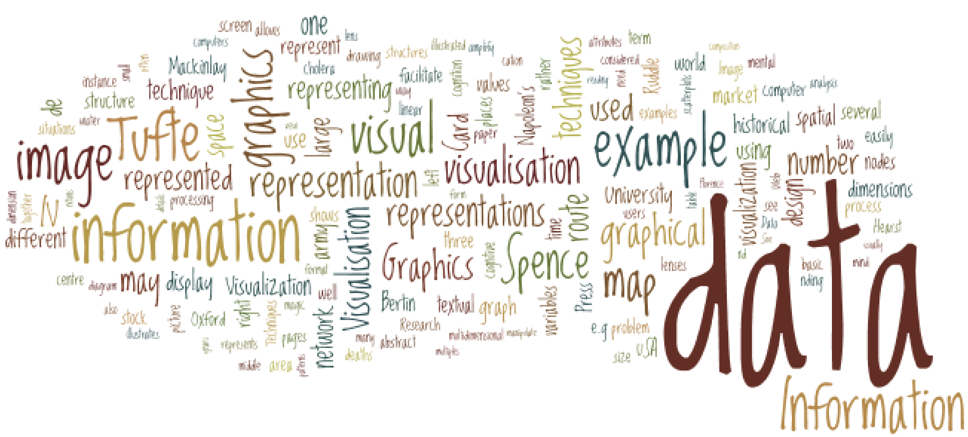
Data Characteristics



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- Data may have a lot of different forms and there are many techniques and systems to visualize them

- A data classification is important to:

  - predict what visualization techniques are adequate

  - make easier the communication about the data

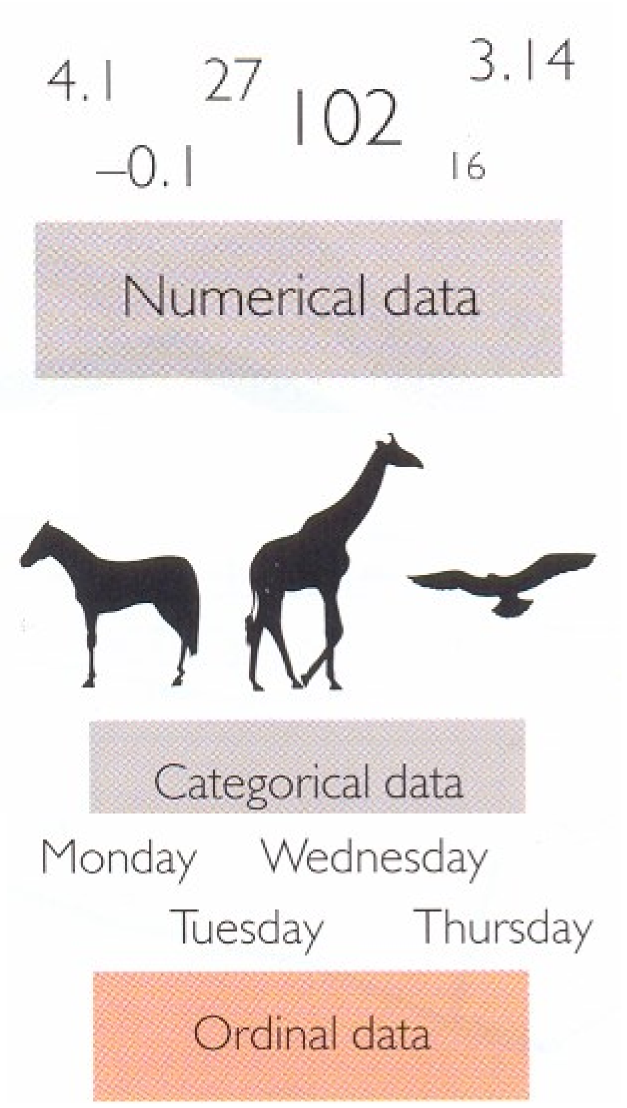
  - allow a more systematic approach to Visualization

  ….

- Data representation level:
  - Qualitative (or categorical)
  - Quantitative (or numeric)

- Data nature:
  - Continuous
  - Discrete

- Measuring scale:
  - Nominal
  - Ordinal
  - Interval
  - Ratio



(Spence, 2007)

- Examples of measuring scales and types of data:
  - nominal --> car brands, gender, animal species…
  - ordinal --> week days, preferences, levels measured in a Likert-type scale
  - Interval --> date, IQ, temperatures in ºC
  - Ratio --> temperatures in ºK, weight, height
- The ratio scale represents the highest level of representation, has a non-arbitrary zero (unlike the interval scale)
- This is a general classification and might be used to select the statistical methods to use with the data

Example: beyond the structure of the data to Visualize

- Consider a data set with three columns:

  latitude *longitude* *d*

- Which is the most adequate way to visualize these data?

- If *d* is depth or altitude?

the selected visualization technique may involve interpolation

(e.g. isocontours, isosurfaces, 3D surface)

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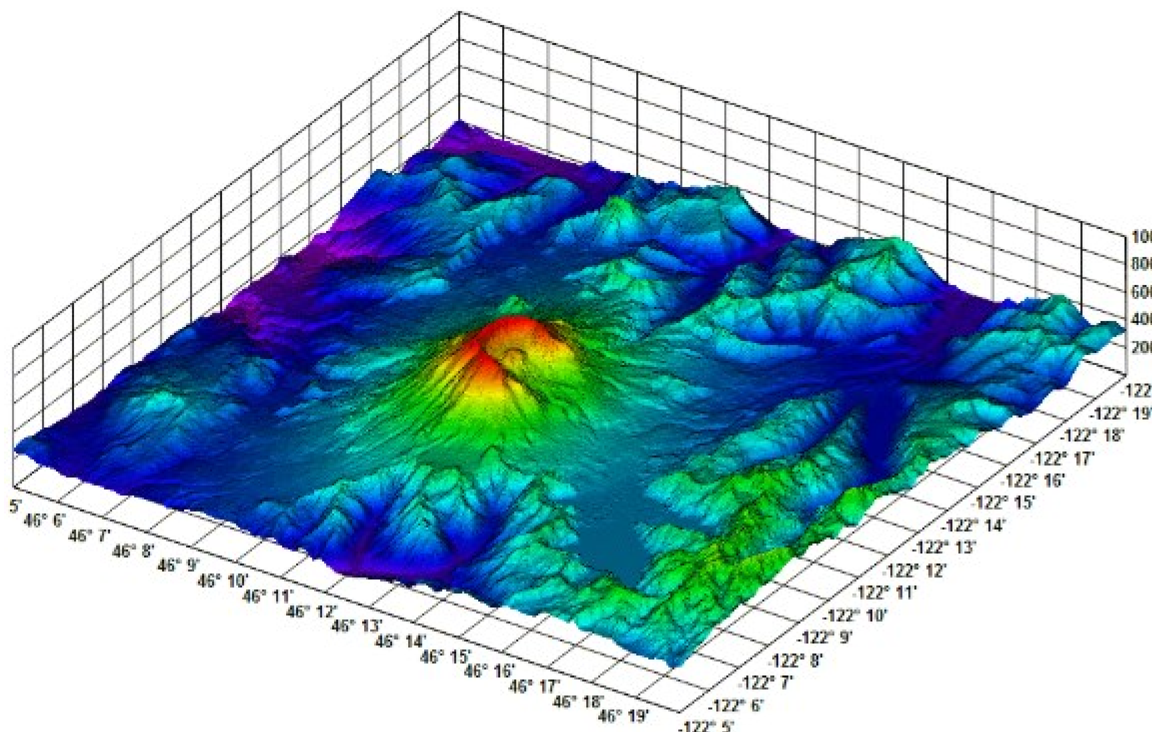
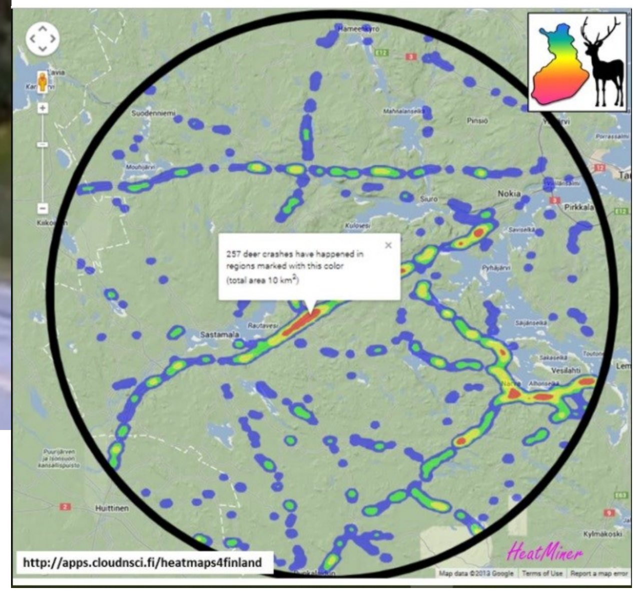
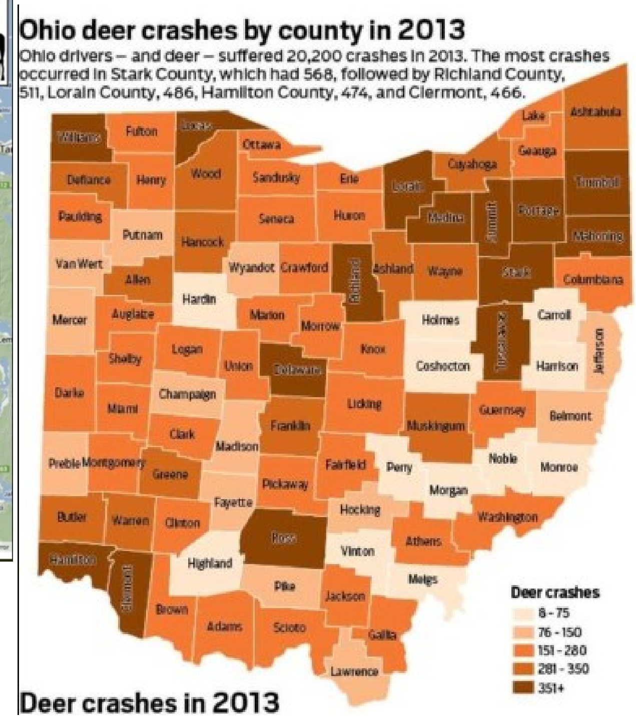


- What if the data represent location and the number of “deer crash” accidents?

http://cloudnsci.fi/wiki/index.php?n=Applications.Heatmaps4Finland



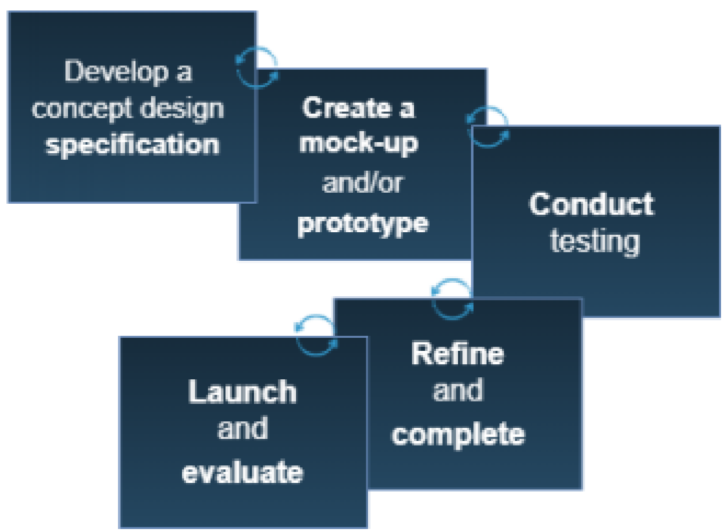


- Interpolation and contours don’t make sense!
  Know the data structure is not enough

  It is necessary to **know the phenomenon behind the data**

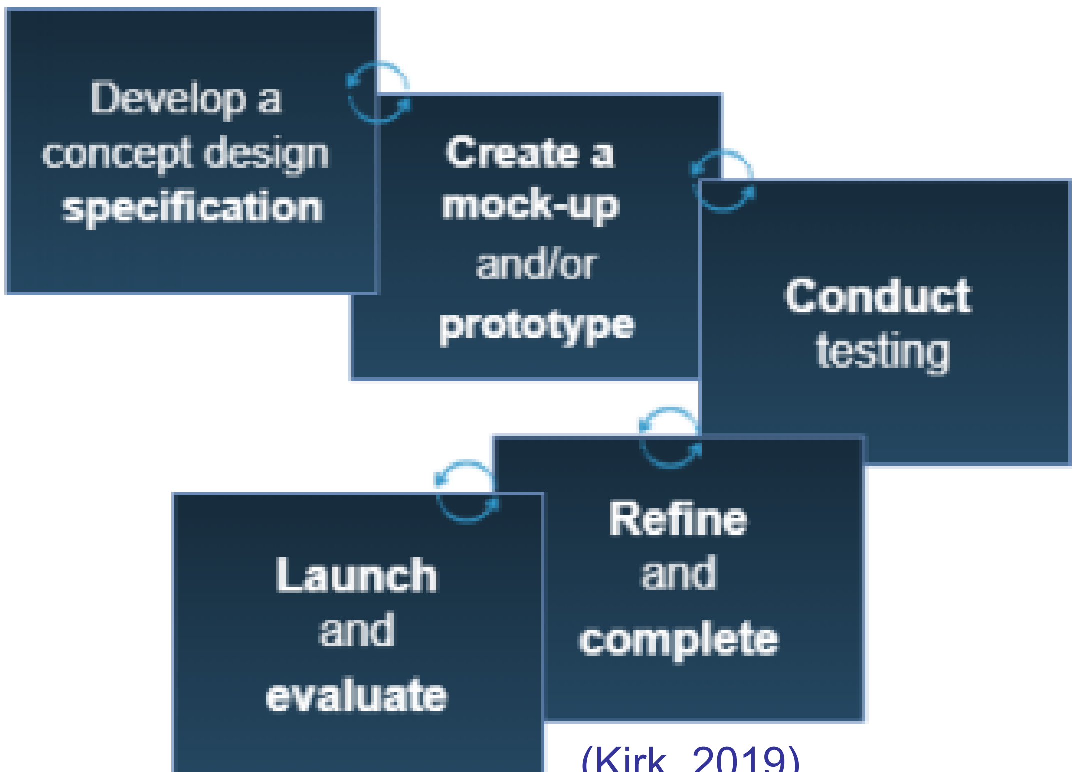
Developing a Visual data exploration application

a very brief introduction



Phases of the development cycle
of a visual data exploration application

(after understanding the users and their questions to elicit requirements, and pre-processing the data)



(Kirk, 2019)

- There are several methods that can be used to help requirement elicitation of an interactive application, e.g.
  - User models (such as Personas)
  - Scenarios
  - Task analysis
  - …

Typical in user-centered design approaches (UCD)

Personas

- Personas are fictional characters based on user research to help understand:
  - users' needs,
  - experiences,
  - behaviors
  - goals.

- Make the design task at hand less complex

- Guide the ideation processes, and help to achieve the goal of creating a good user experience for the target user group

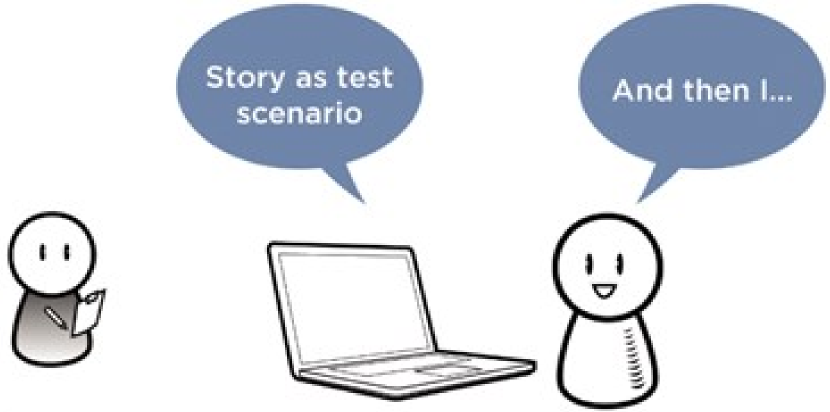
https://www.interaction-design.org/literature/article/personas-why-and-how-you-should-use-them

Scenarios

- Stories and contexts about how the user groups use a future product/service

- Note the goals and questions to be achieved and sometimes define the possibilities of how the user(s) can achieve them on the application

- Scenarios are critical for
  - designing
  - UX testing



(Note: Different from User stories and Use cases)

https://www.usability.gov/how-to-and-tools/methods/scenarios.html

https://www.interaction-design.org/literature/topics/user-scenarios

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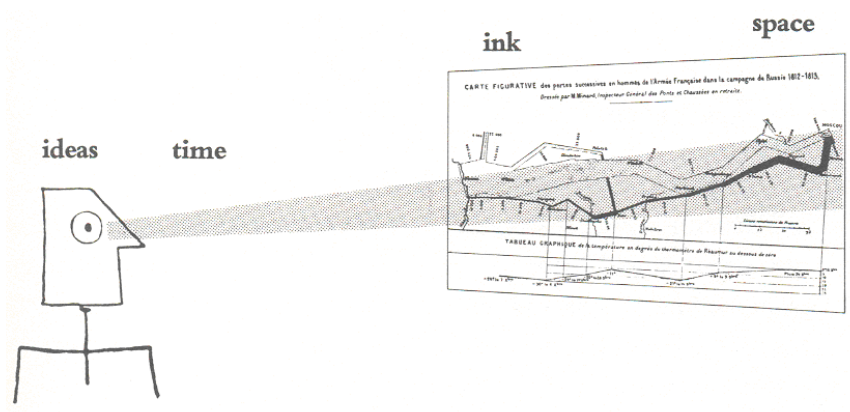
Effective Visualization



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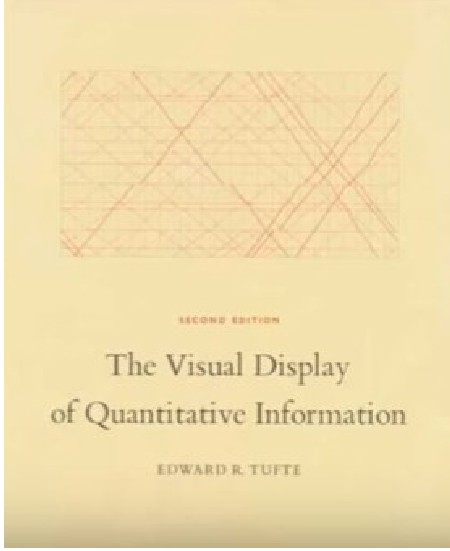
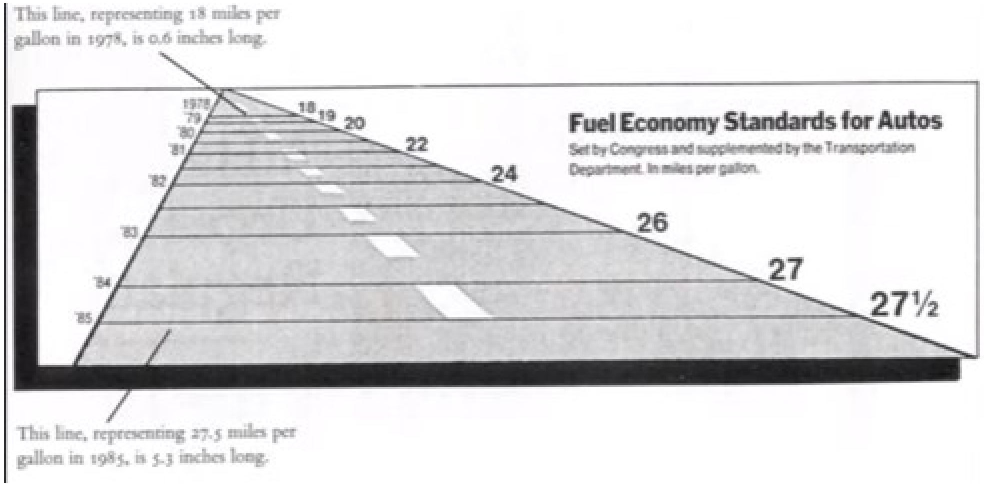
Effective visualization

Implies saying the **truth** about the data

Tufte presents a lot of commented examples in his book:



Tufte, E., *The Visual Display of Quantitative Information*, Graphics Press, 1983

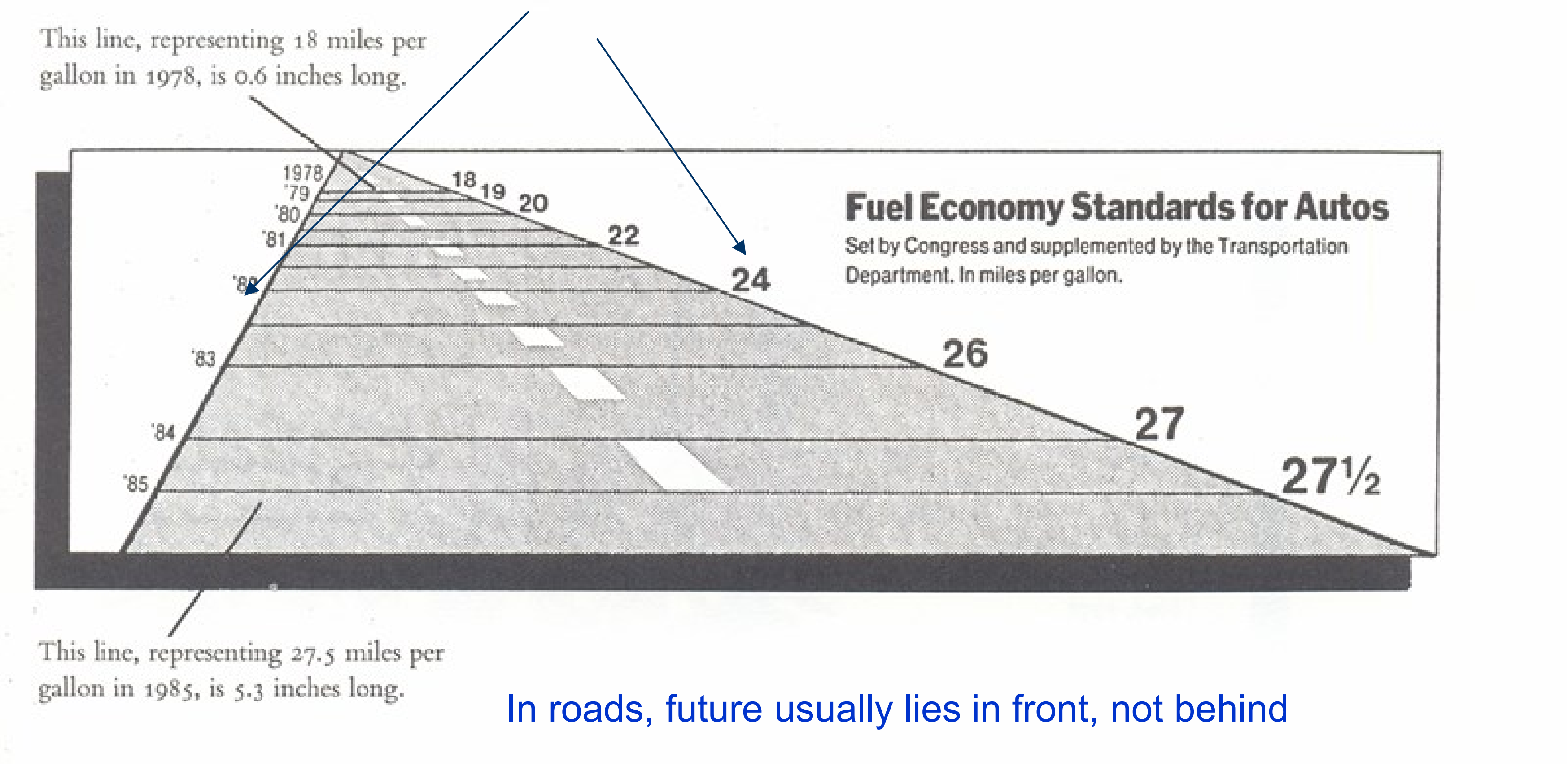


There are methods to evaluate visualizations that should be used along the process of creating a visualization

https://infovis-wiki.net/wiki/Lie_Factor this example has several problems:

Lie Factor = 14.8

Legends have a constant size in one side and variable in the other



In roads, future usually lies in front, not behind

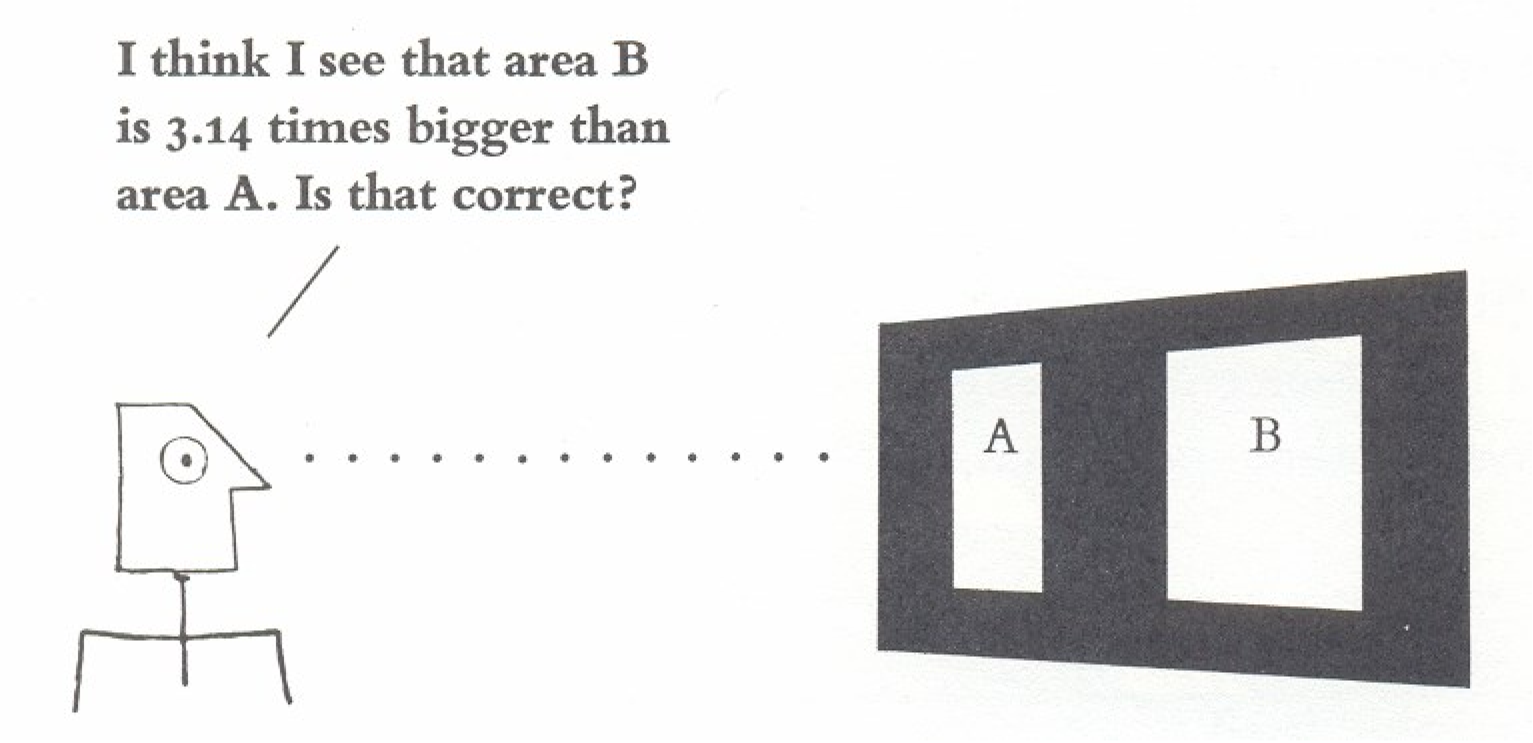
- Perception varies with

    - context

(Tufte, 1983)

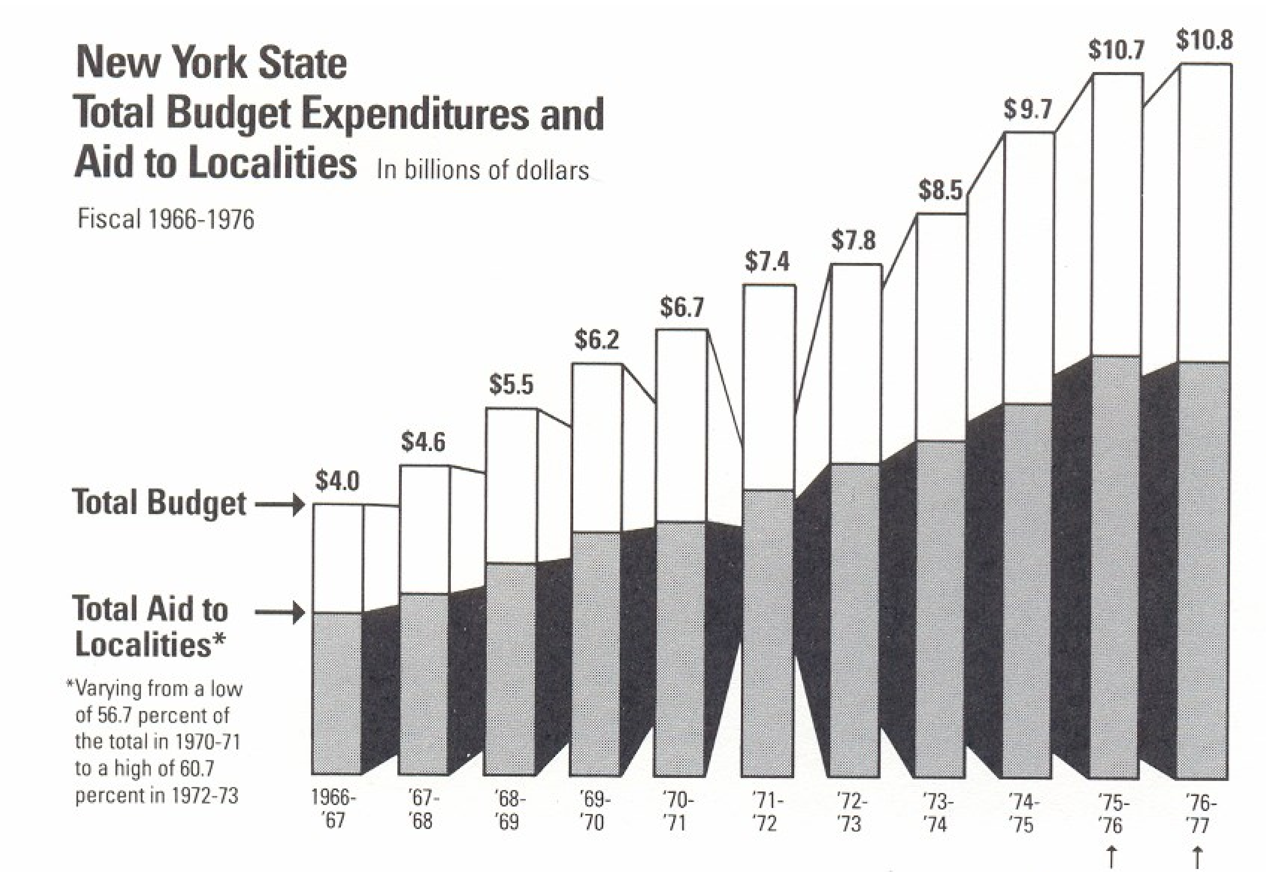
• How do we know that the visual image represents the underlying numbers?

• One way to try to answer these questions is to conduct experiments on the visual perception of graphics



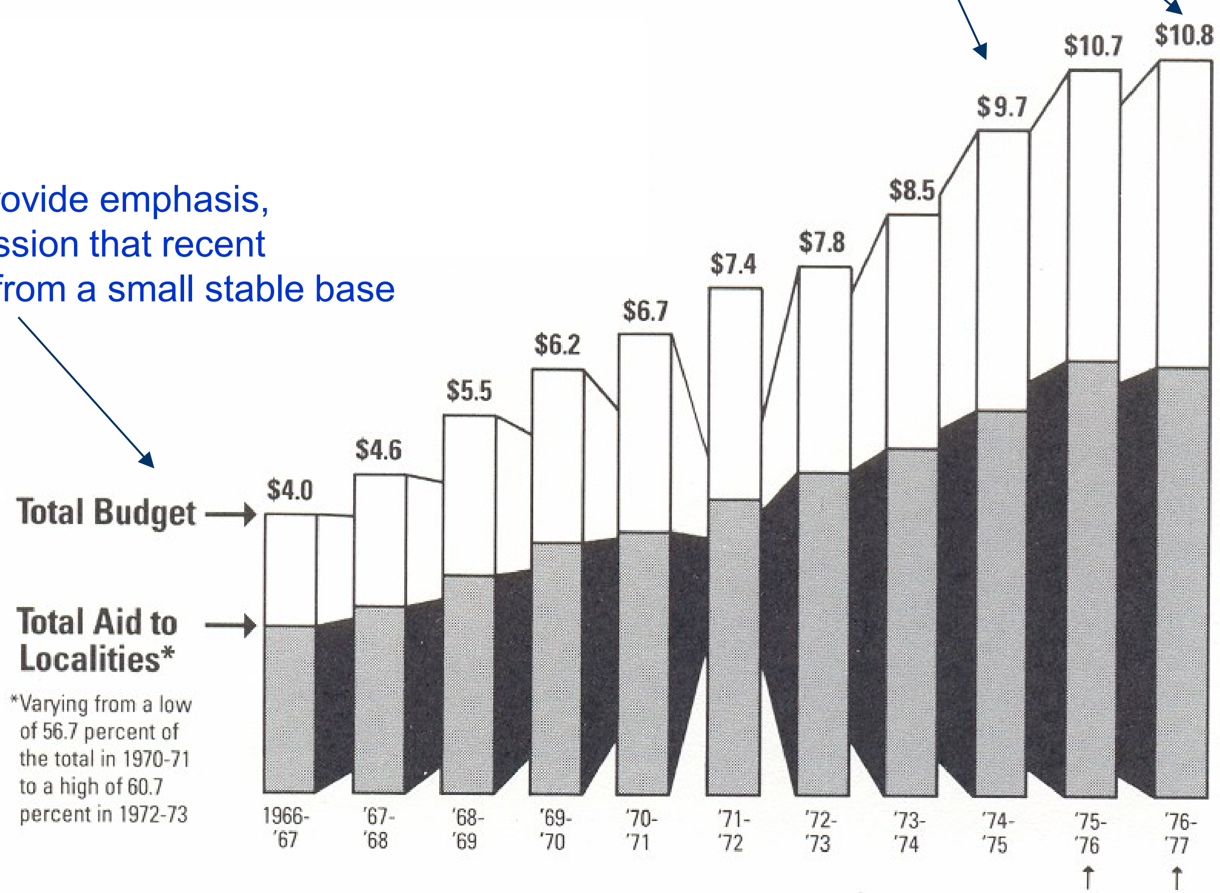
(Tufte, 1983)

Another example:



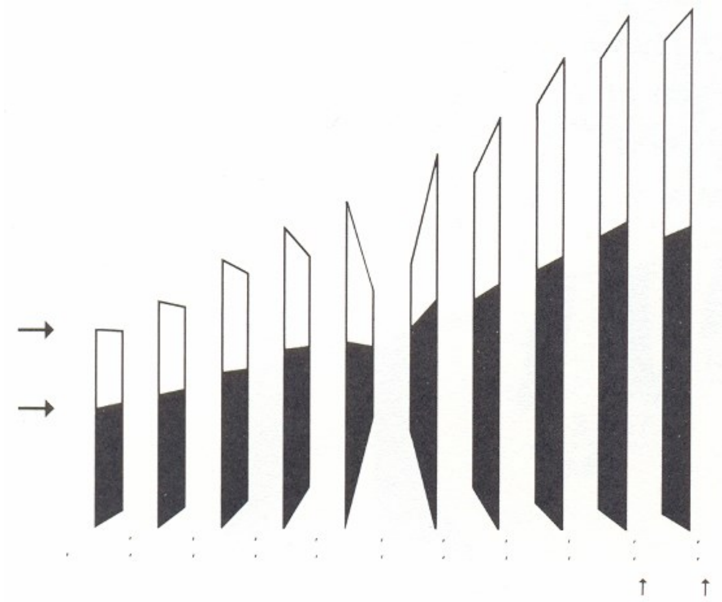
These three parallelipeds have been placed in na optical plane in front of the other eight, creating the image that the newer budgets tower over the older ones

Horizontal arrows provide emphasis, Encorage the impression that recent years have shot up from a small stable base

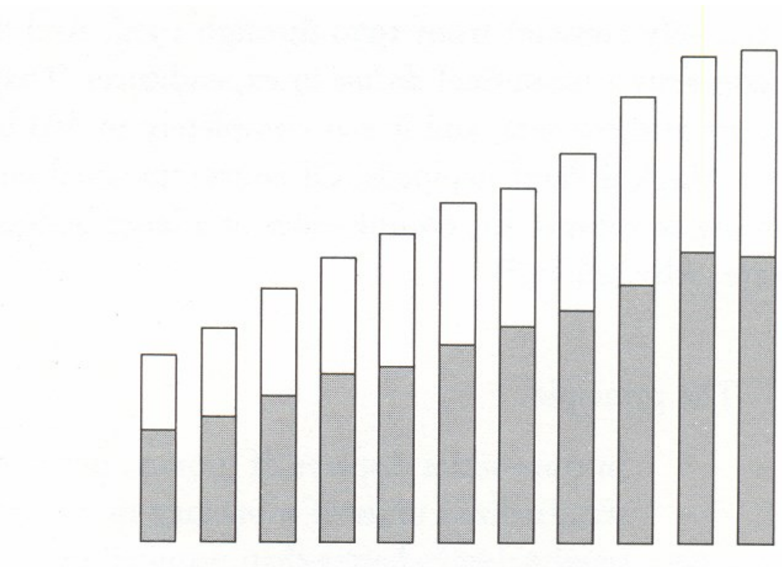


Arrows pointing straight up emphasize recent growth

Leaving behind the distortion



we have a calmer view:

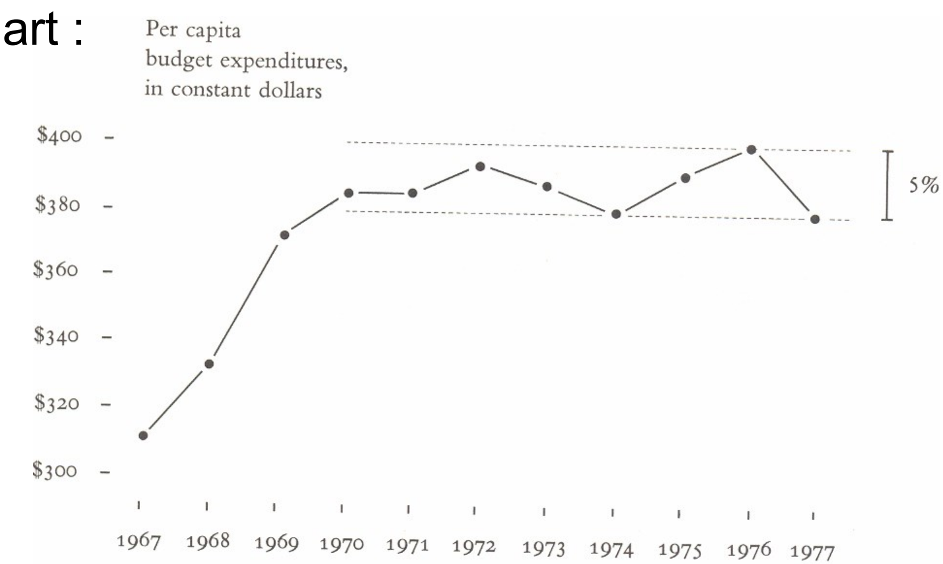


Two statistical lapses also bias the chart :

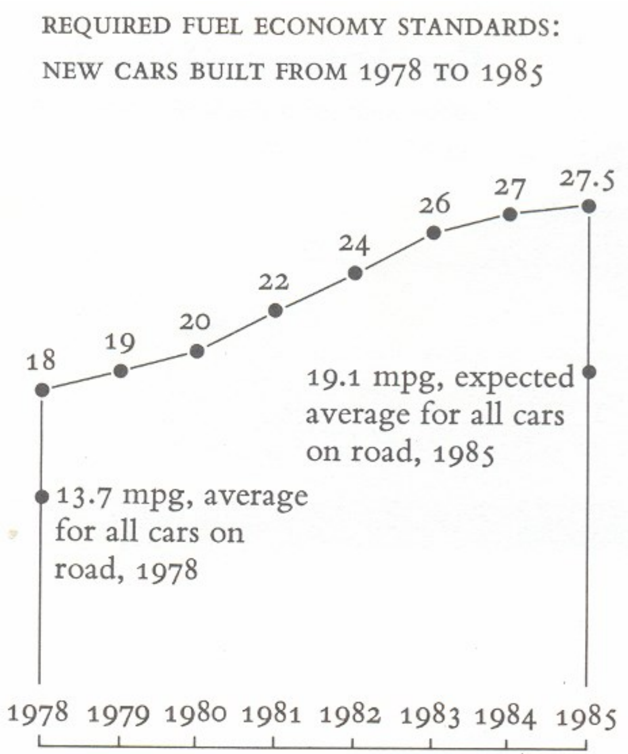
- Population increased10%

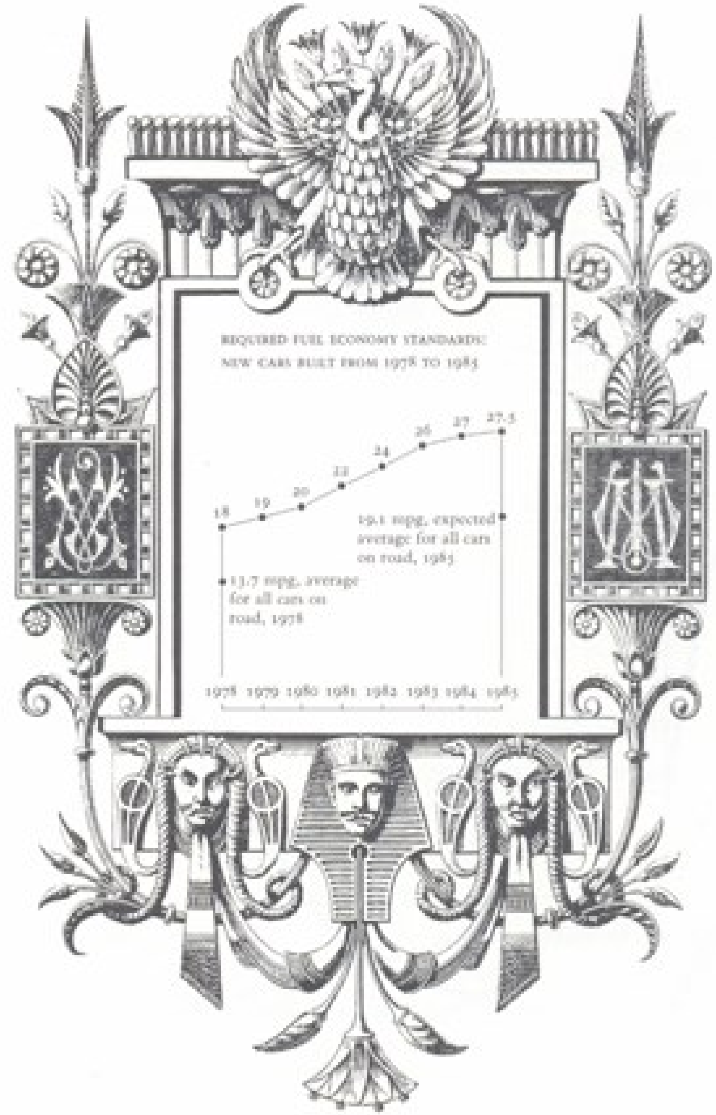
- there was substantial inflation

Final result

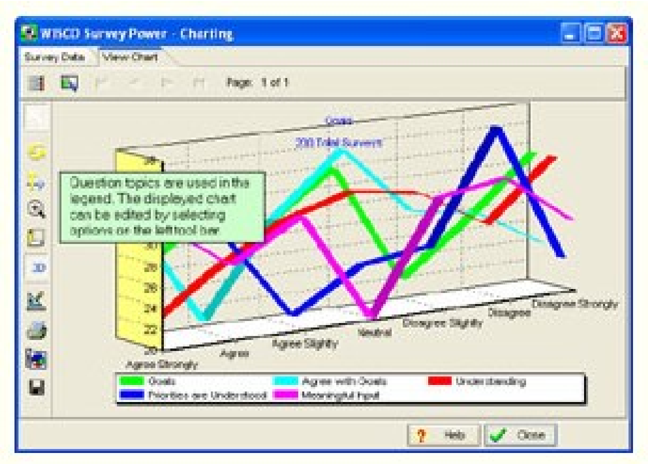


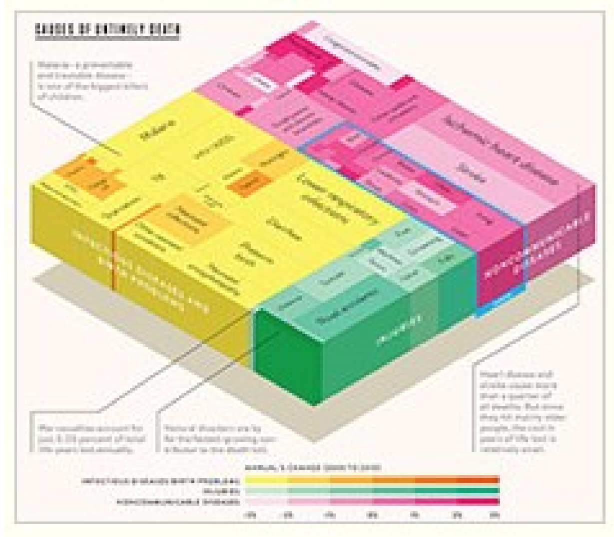
Decorations without lies:

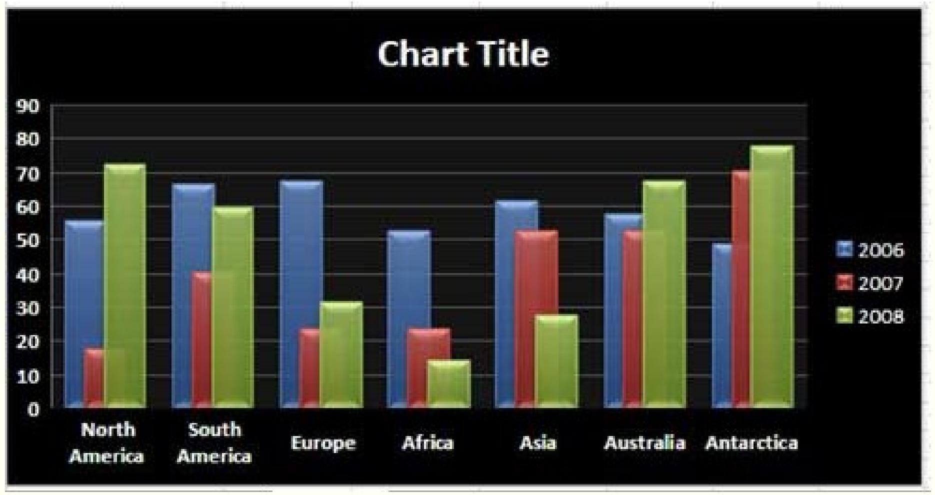




Effective visualization: more poor examples analyzed







There are methods to evaluate visualizations that should be used along the process of creating a visualization

http://www.perceptualedge.com/examples.php

Main bibliography

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