Visualization

info-20002: foundations of informatics

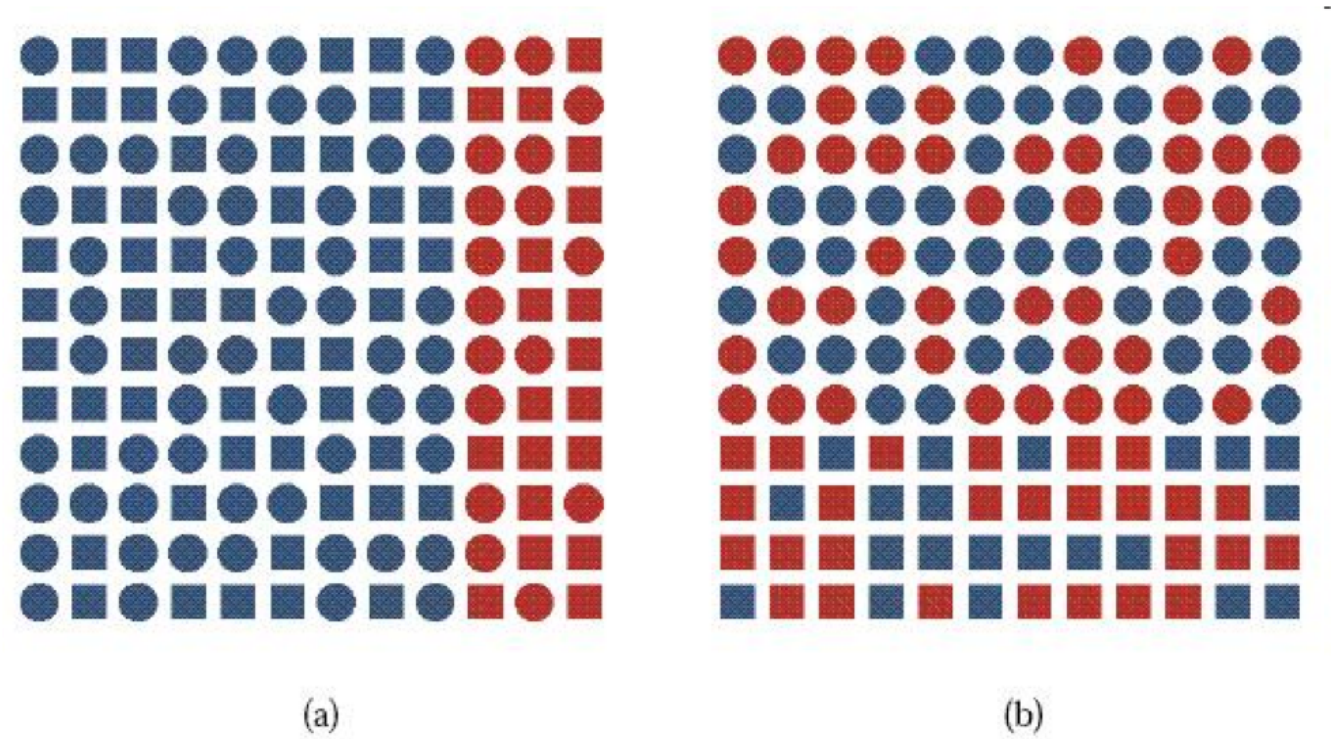
Why Visualisation

Pre-attentive Attention

Preattentive processing of visual information is performed automatically on the entire visual field detecting basic features of objects in the display. Such basic features include colors, closure, line ends, contrast, tilt, curvature and size. These simple features are extracted from the visual display in the preattentive system and later joined in the focused attention system into coherent objects. Preattentive processing is done quickly, effortlessly and in parallel without any attention being focused on the display. [Treisman, 1985; Treisman, 1986]

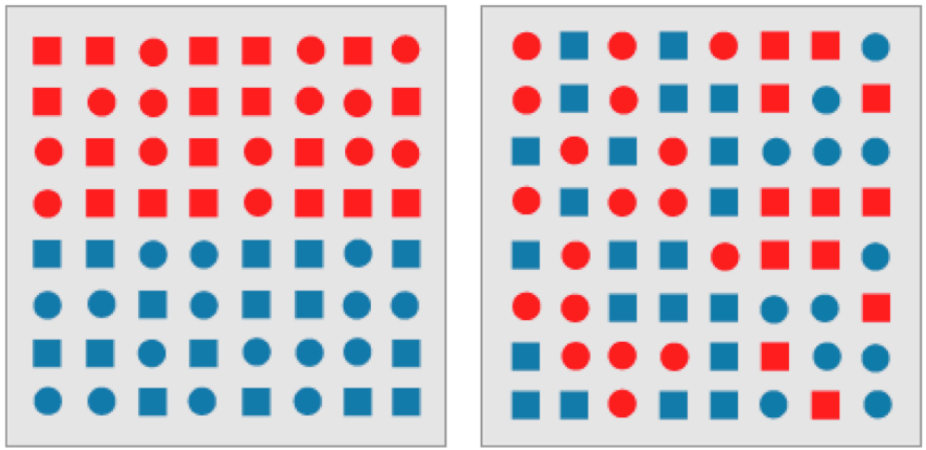
Treisman, A. (1985). **Preattentive Processing in Vision**. Computer Vision, Graphics, and Image Processing (31):2, pp. 157–177

Why Visualisation



Treisman, A. (1985). **Preattentive Processing in Vision**. Computer Vision, Graphics, and Image Processing 31(2): 157–177

Why Visualisation



An example of a boundary detection from Treisman's experiments: (a) a boundary defined by a unique feature hue (red circles and red squares on the top, blue circles and blue squares on the bottom) is preattentively classified as horizontal; (b) a boundary defined by a conjunction of features (red circles and blue squares on the left, blue circles and red squares on the right) cannot be preattentively classified as vertical.

Treisman, A. (1985). **Preattentive Processing in Vision**. Computer Vision, Graphics, and Image Processing (31):2, pp. 157–177

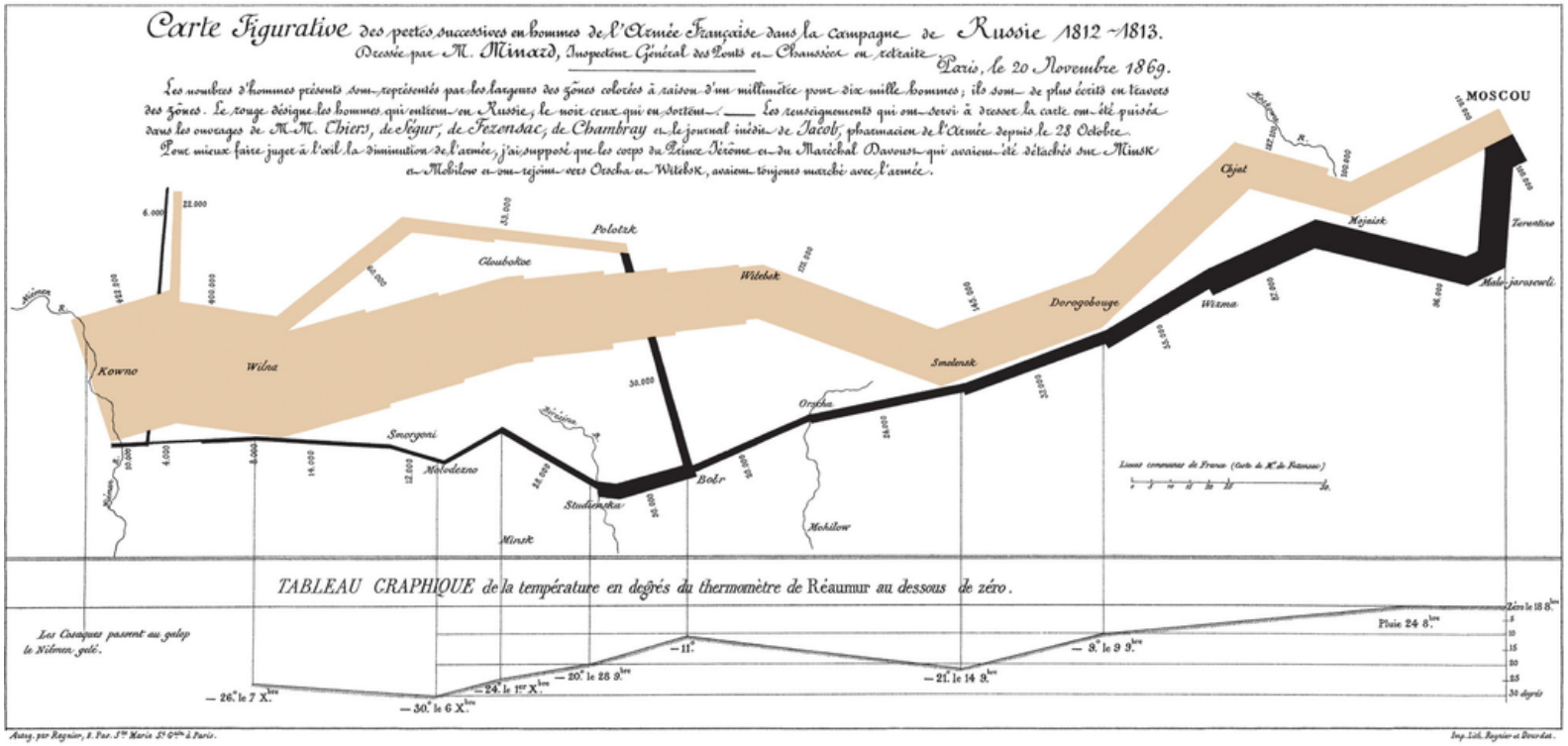
Visualization is

- Way of seeing meaning/relationships in data – prosthetic to our mental models
- Visualisations amplify cognition
- Visualisations provide a space for exploring data
- **Exploratory and explanatory**
  - “discover the unexpected; describe & explain the expected” (National Visualization and Analytics Center, Pacific Northwest Laboratory)

Visualization in story telling

Napoleon's 1812 Russian Campagin

Minard's map of Napoleon's 1812 Russian Campagin



Visualization is

a mapping from *data variables* to *visual variables*

Examples:

- Temperature → brightness of colour
- City → hue of colour
- City → location (x coordinate)

Data variables

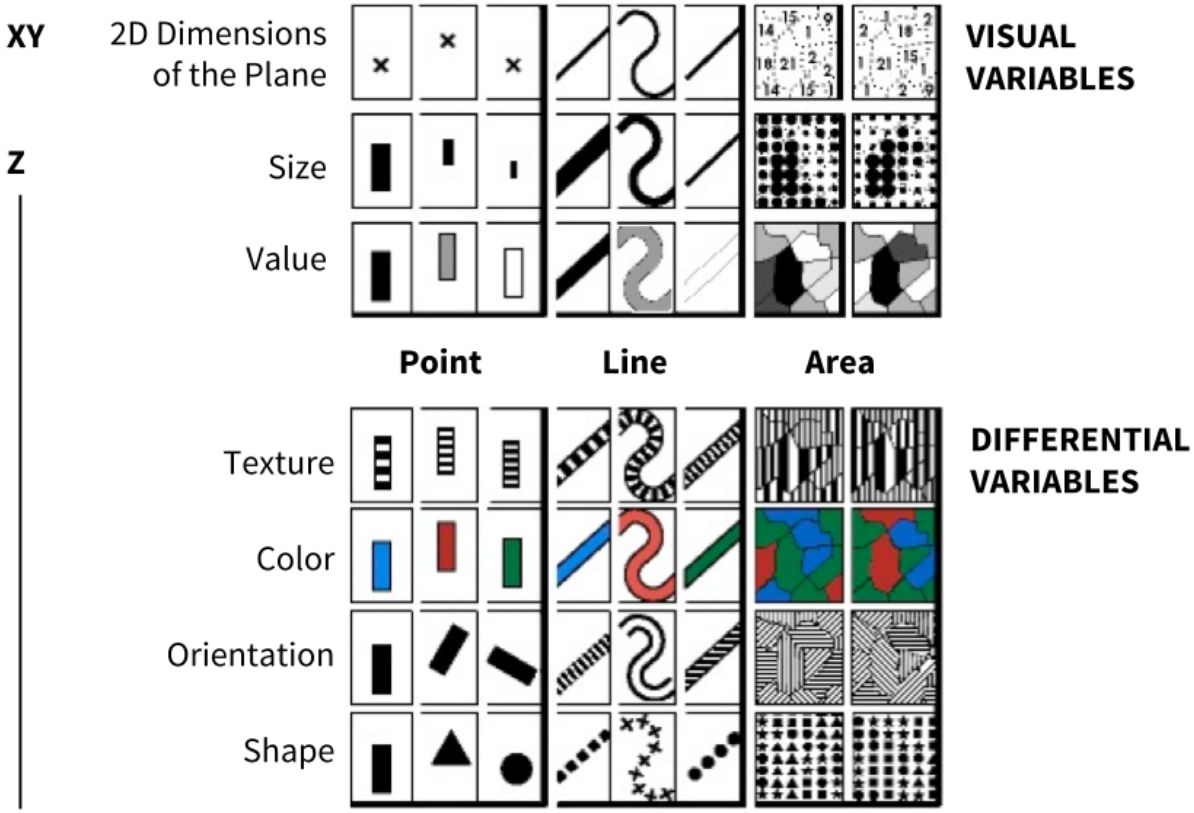
- Continuous and discrete variables
  - **Continuous**
    Numerical or quantitative (Mackinlay, 2086)
    Numbers or anything that can have a range
  - **Discrete**
    Anything else
- Discrete/categorical
  - **Ordinal**
    Ordered/ranked set
    Example: (N, P, H3, H2B, H2A, H1)
  - **Nominal**
    Unordered set
    Examples: (sydney,melbourne,perth,...) and (male,female)

Data variables - Steven's Types (Scales)

- **Nominal scale**
- **Ordinal scale**
- **Interval scale**
  - Has no meaningful zero point (no origin)
  - Express difference (interval) between two measurements
  - Examples: dates (AD), latitude
  - Celcius temperature scale
  - To say that "2°C temperature is twice as hot as 1°C" is NOT meaningful
- **Ratio scale**
  - Has a meaningful, unique and non-arbitrary zero point.
  - Examples: mass, length, duration, angle.
  - Kelvin temperature scale contains absolute zero point.
  - It is meaningful to say that "a 2-metre object has "twice the length" of a 1-metre object"

Stevens, S. S. (1946). **"On the Theory of Scales of Measurement"**. Science 103 (2684): 677–680.

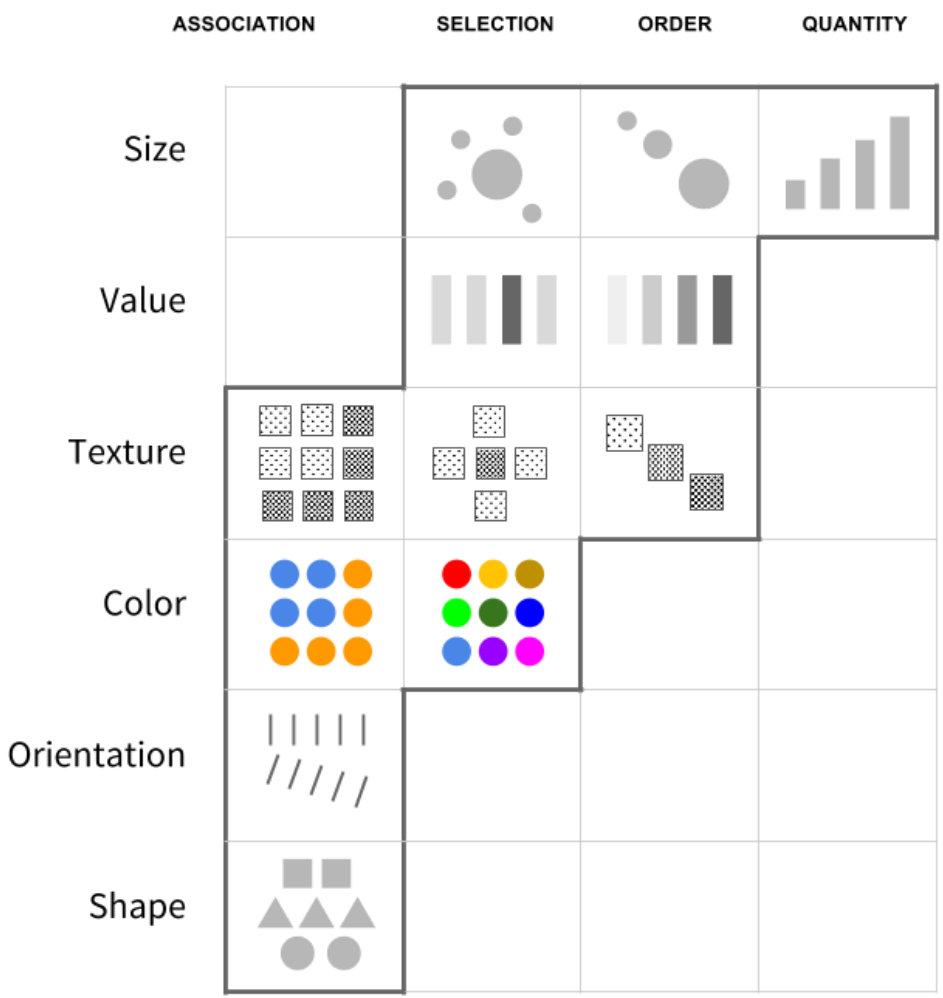
Visual Variables



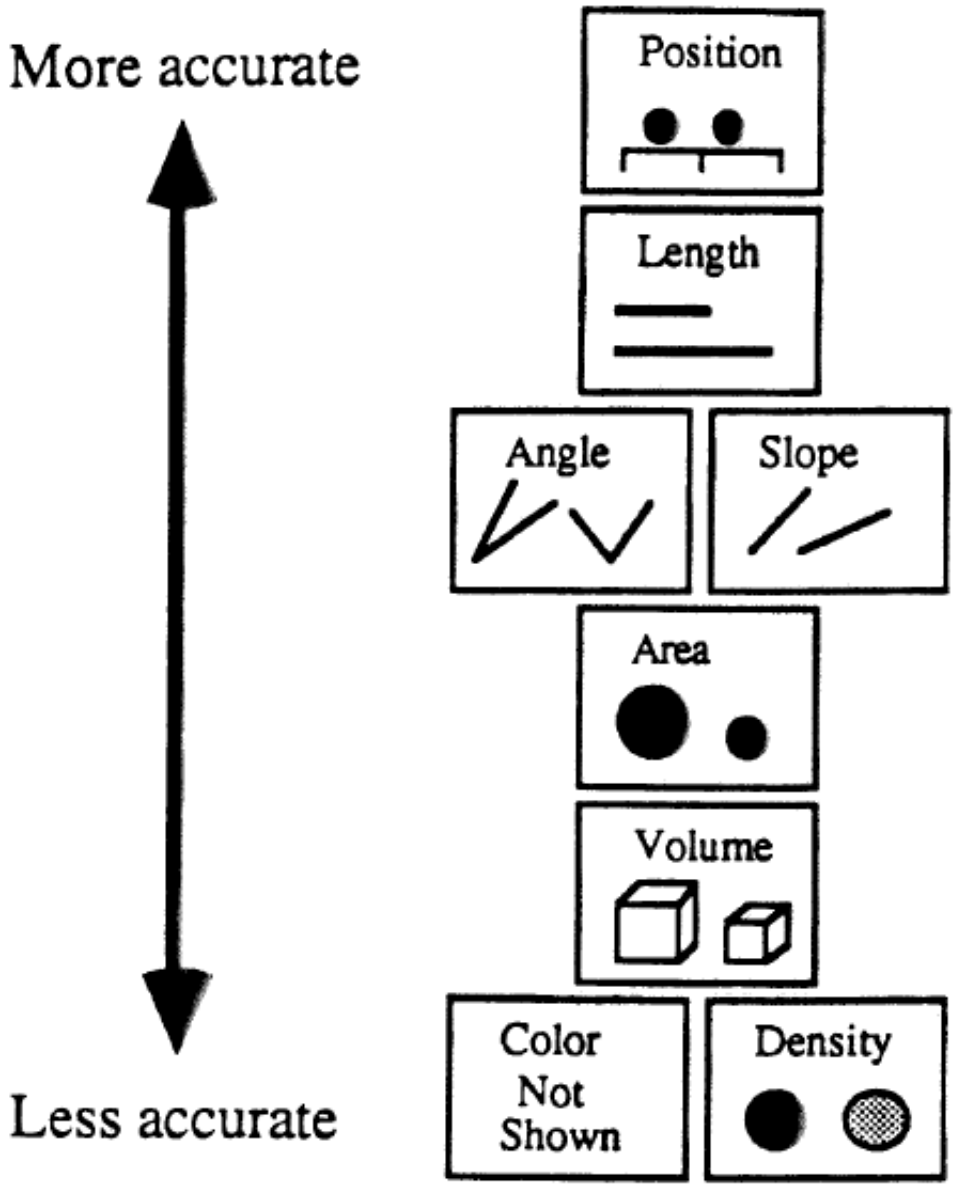
Functions of Visualisation

- **Associative function**
  grouping of all correspondences differentiated by a variable
  perceived as *similar*
- **Selective function**
  isolation of correspondences differentiated by a variable
  perceived as *different*, forming families
- **Ordering function**
  a spontaneous visual perception of rank
  perceived as *ordered*
- **Quantitative function**
  a visual difference between two categories expressed as a numerical ratio
  perceived as *proportional*

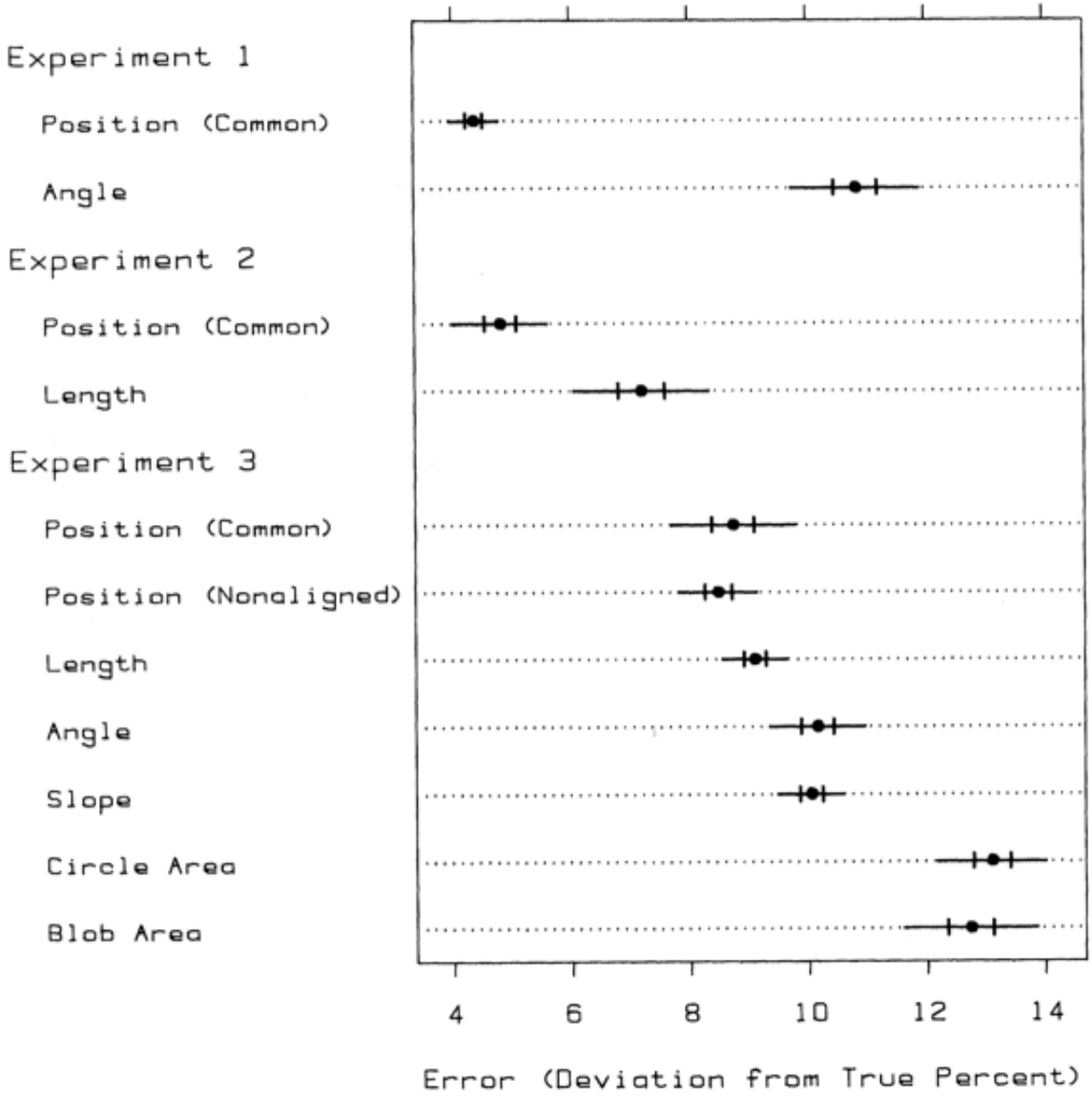
Variables vs Functions



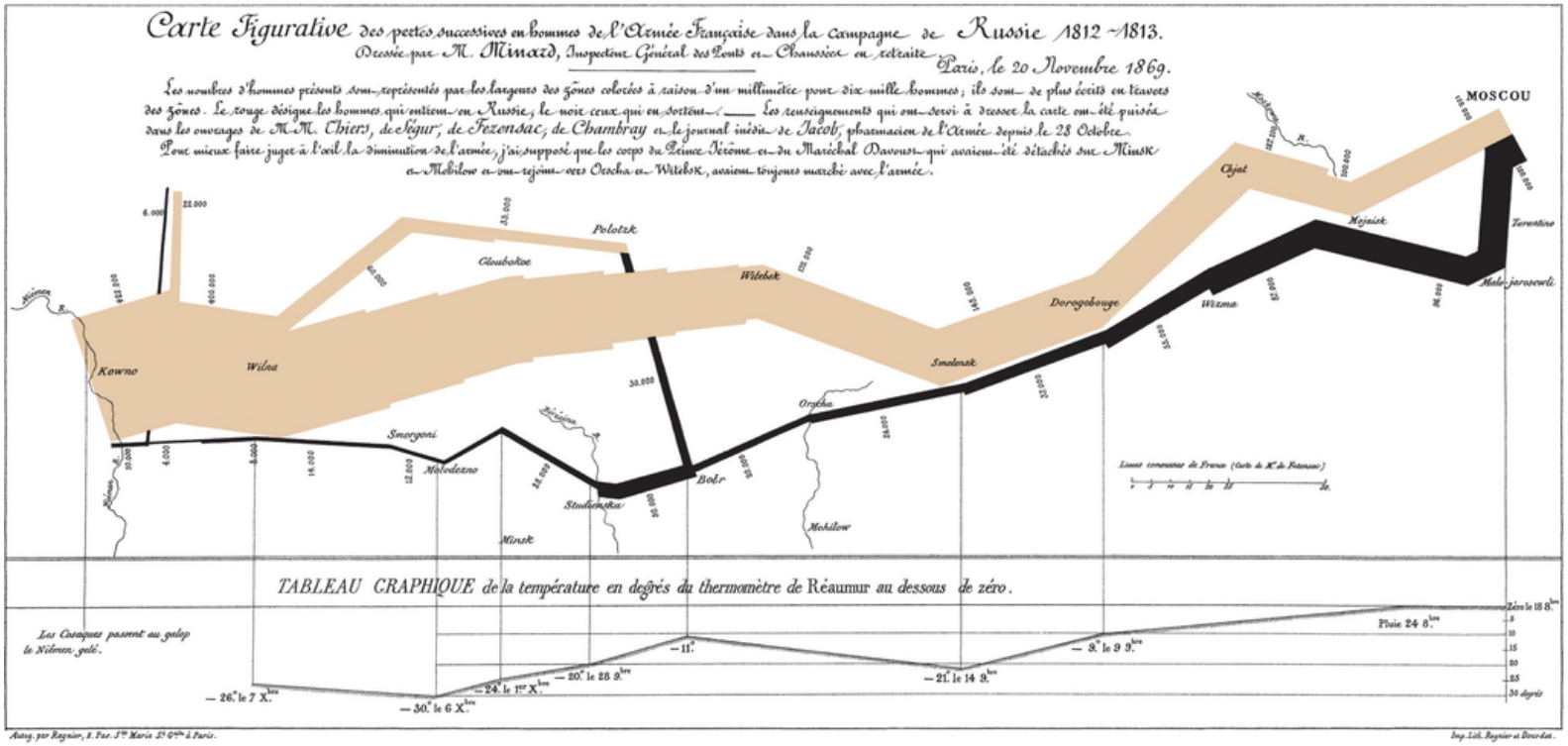
Accuracy of Visual Variables


More accurate
Position
Length
Angle
Slope
Area
Volume
Color
Not
Shown
Density
Less accurate

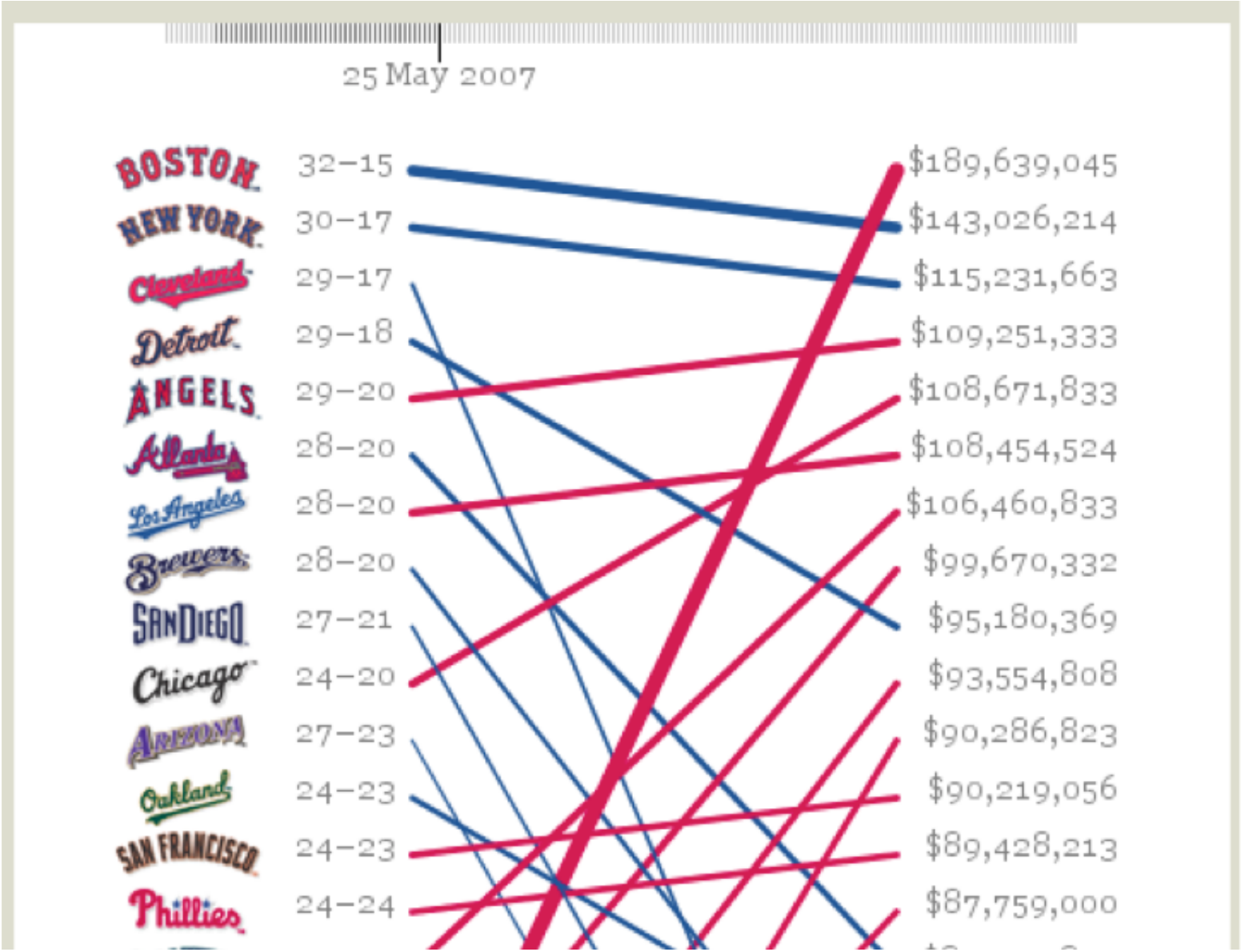
Accuracy of Visual Variables

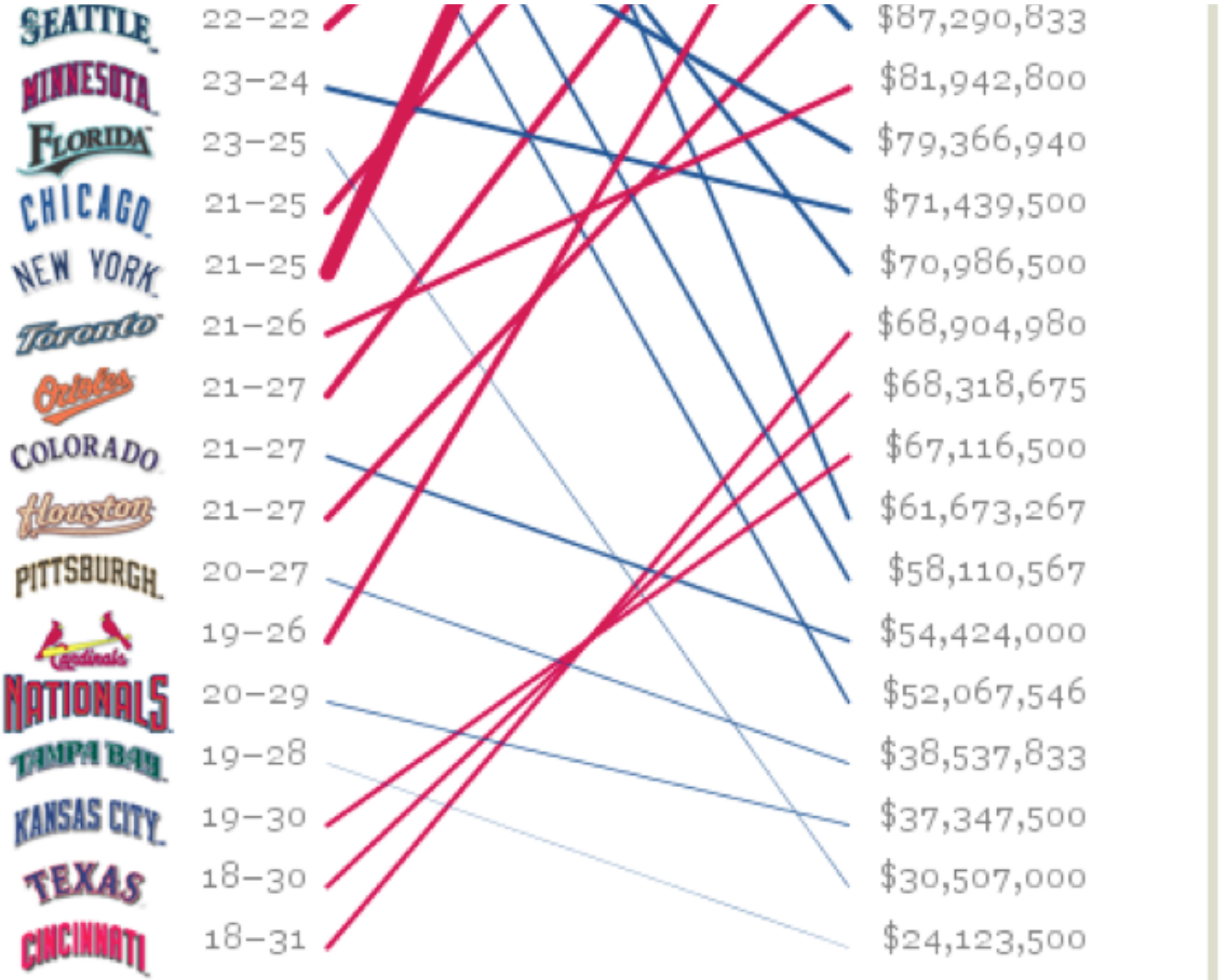

Experiment 1
Position (Common)
Angle
Experiment 2
Position (Common)
Length
Experiment 3
Position (Common)
Position (Nonaligned)
Length
Angle
Slope
Circle Area
Blob Area
4
6
8
10
12
14
Error (Deviation from True Percent)

What are the data/visual variables?



What are the data/visual variables?




SEATTLE
MINNESOTA
FLORIDA
CHICAGO
NEW YORK
Toronto
Orioles
COLORADO
Houston
PITTSBURGH
Cardinals
NATIONALS
TAMPA BAY
KANSAS CITY
TEXAS
CINCINNATI
22–22
23–24
23–25
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19–28
19–30
18–30
18–31
$87,290,833
$81,942,800
$79,366,940
$71,439,500
$70,986,500
$68,904,980
$68,318,675
$67,116,500
$61,673,267
$58,110,567
$54,424,000
$52,067,546
$38,537,833
$37,347,500
$30,507,000
$24,123,500

Visualisation Steps

- **Data Definition**
  Define the visualisation goal and the supporting data variables
- **Visualisation Selection**
  Select appropriate visual structure
- **Data Pre-Processing**
  Preparing raw data to visualisation-ready data
- **Visual Transformation**
  Mapping data variables to visual elements