Graphical Excellence—Edward Tufte
Graphical Excellence—Edward Tufte

Excellence in statistical graphics consists of complex ideas communicated with clarity, precision, and efficiency.
Excellence in statistical graphics consists of complex ideas communicated with clarity, precision, and efficiency.

- Graphical displays should:
  - show the data
  - induce the viewer to think about the substance
  - avoid distorting what the data says
  - present many numbers in small space
  - make large data sets coherent
  - encourage comparison between data
  - reveal the data at several levels of detail
  - clear purpose: description, exploration, tabulation or decoration
Graphics reveal data.
Graphics reveal data.

They were constructed in 1973 by the statistician Francis Anscombe to demonstrate both the importance of graphing.

All four sets are identical when examined using simple summary statistics, but vary considerably when graphed.
Statistical graphics are only as good as what goes into them.
Statistical graphics are only as good as what goes into them. An ill-specified model cannot be rescued by a graphic. No matter how clever or fancy they are.

A- New York Stock prices
B- Solar Radiation inverted
C- London Stock prices
Graphical Excellence =

efficient communication of complex quantitative ideas
• Fundamental Graphical Designs:
  – Data Maps
  – Time-Series
  – Space-time narrative designs
  – Relational Graphics
• Fundamental Graphical Designs:
  – Data Maps
  – Time-Series
  – Space-time narrative designs
  – Relational Graphics
Data Maps

- Picture - a thousand words
- Only a picture can carry such a volume of data in such a small space
Data Maps

- Picture - a thousand words
- Only a picture can carry such a volume of data in such a small space
Data Maps

- Edmond Halley, 1686
Data Maps

- Dr. John Shaw, 1854
Data Maps

- “New Reduction of the Lick Catalog of Galaxies” - Seldner, Siebers, Groth and Peebles
• Fundamental Graphical Designs:
  – Data Maps
  – Time-Series
  – Space-time narrative designs
  – Relational Graphics
Time-Series

• “A Note on a Tenth Century Graph” - H. Gray Funkhouser
Time-Series

- “Plasma Wave Observation Near Jupiter” - Gurnett, Kurth and Scarf
Time-Series

- New York Weather 1980
• Fundamental Graphical Designs:
  – Data Maps
  – Time-Series
  – Space-time narrative designs
  – Relational Graphics
Narrative Graphics of Space and Time

Charles Joseph Minard

Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813. Dessinée par M. Minard, Inspecteur Général des Ponts et Chaussées en exil.

Paris, le 20 Novembre 1869.

Les nombres d'hommes présents sont représentés par la largeur des zones colorées à raison d'un millième pour dix mille hommes; ils sont de plus écrits en têtes des zones. Le rouge désigne les hommes qui restèrent en Russie; le noir ceux qui en revinrent. Les chiffres en italique qui encadrent la carte indiquent les endroits où se trouvaient les unités de l'Armée depuis le 23 Octobre.

L'œuvre est simple à lire; la diminution de l'armée, j'ai supposé que la valeur de la ligne de vie de cinq Millions qui se trouvaient à Moscou n'était que 10,000; lorsqu'ils arrivèrent à Moscou, ils virent toujours marcher avec l'armée.

TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.
Narrative Graphics of Space and Time

Charles Joseph Minard
Narrative Graphics of Space and Time

Charles Joseph Minard
Narrative Graphics of Space and Time

Charles Joseph Minard
Narrative Graphics of Space and Time

Charles Joseph Minard
Narrative Graphics of Space and Time

“Man and Insects”- I. Hugh Newman
• Fundamental Graphical Designs:
  
  – Data Maps
  – Time-Series
  – Space-time narrative designs
  – Relational Graphics
Relational Graphics

“The Statistical Breviary” - Playfair
Relational Graphics

Comparing sizes represented with similar form.
Relational Graphics

“Evaporation rate of water” - J.H. Lambert
Relational Graphics

“Evaporation rate of water” - J.H. Lambert
Relational Graphics

“Evaporation rate of water” - J.H. Lambert
Relational Graphics

“Evaporation rate of water” - J.H. Lambert
**Graphical Excellence** is the well-designed presentation of interesting data- a matter of *substance*, *statistics* and *design*. 
Graphical Excellence is the well-designed presentation of interesting data- a matter of *substance*, *statistics* and *design*.

Graphical excellence *consists* of complex ideas communicated with clarity, precision, and efficiency.

Graphical excellence *is* that which gives to the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space.

Graphical excellence *requires telling the truth* about data.
Graphical excellence requires telling the truth about data.
Graphical excellence requires telling the truth about data.
Graphical Integrity—Edward Tufte

Misleading graphics
Graphical Integrity—Edward Tufte

Misleading graphics

[Bar chart showing a comparison between the current top tax rate and the rate after the Bush tax cuts expire, with the rate significantly higher after the expiration date.]
Graphical Integrity—Edward Tufte

Misleading graphics
Graphical Integrity—Edward Tufte

Misleading graphics
Graphical Integrity—Edward Tufte

Misleading graphics

Data extracted on: December 12, 2011 (9:50:59 AM)


Series Id: LNS14000000
Seasonally Adjusted
Series title: (Seas) Unemployment Rate
Labor force status: Unemployment rate
Type of data: Percent or rate
Age: 16 years and over

Graph showing unemployment rate over time.
What is Distortion in a Data Graphic?
What is Distortion in a Data Graphic?

A graphic does not distort if the visual representation of data is consistent with the numerical representation.

Visual representation of data $\neq$ numerical representation
What is Distortion in a Data Graphic?
What is Distortion in a Data Graphic?
Table vs. Graph

Before: **Table**

![Table Image]

**Total grants spend by London Borough**

<table>
<thead>
<tr>
<th>Borough</th>
<th>Trust rank</th>
<th>Index rank</th>
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After: **Grable**

![Graph Image]

**Total grant spend by London Borough**

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The **power of graphics** comes in the display of large data sets.
Two Principles:

- Representation of numbers: the numbers should be directly proportional

- Clear, detailed and thorough labeling: write out explanations and label important events
First Principle:

\[
\text{Lie Factor} = \frac{\text{size of effect shown in graphic}}{\text{size of effect in data}}
\]
First Principle:

\[
\text{Lie Factor} = \frac{\text{size of effect shown in graphic}}{\text{size of effect in data}}
\]
First Principle:

\[ \text{Lie Factor} = \frac{783}{53} = 14.8\% \]
First Principle:
First Principle:
Design and Data Variation:

Nobel Prizes Awarded in Science, for Selected Countries, 1901-1974

(number of Prizes)


United States

Germany

United Kingdom

France

U.S.S.R.
Design and Data Variation:

![Graph showing Nobel Prizes Awarded in Science for Selected Countries, 1901-1974](image-url)
Design and Data Variation:
show data variation, not design variation
Design and Data Variation:

Diagram: OPEC Oil Prices: After 18 Months of Stability, Prices Are Due to Rise Again

- Yearly
- Quarterly

Dollars per barrel

- Jan to March
- Apr to June
- July
- Oct to Dec
Design and Data Variation:

Prices:

‘73-78’

1 inch = $8.00
Design and Data Variation:

Prices:

‘73-78’  
Jan-March

1 inch = $8.00
1 inch = $4.73
Design and Data Variation:

Prices:

‘73-78’
Jan-March 1inch = $4.73
Apr-June 1inch = $4.37
1inch = $8.00
Design and Data Variation:

Prices:

'73-78'  
Jan-March  1 inch = $8.00
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1 inch = $4.16
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OPEC Oil Prices: After 18 Months of Stability, Prices Are Due to Rise Again
Dollars per barrel
Design and Data Variation:

Prices:

‘73-78’ 1inch=$8.00
Jan-March 1inch=$4.73
Apr-June 1inch=$4.37
July-Sept 1inch=$4.16
Oct-Dec 1inch=$3.92

Time:
1973-1978 1inch=3,8yrs
Design and Data Variation:

Prices:

‘73-78’  1 inch = $8.00
Jan-March  1 inch = $4.73
Apr-June  1 inch = $4.37
July-Sept  1 inch = $4.16
Oct-Dec  1 inch = $3.92

Time:
1973-1978  1 inch = 3.8 yrs
1979  1 inch = 0.57 yrs
Design and Data Variation:

Prices:

‘73-78’
- 1 inch = $8.00

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Time:

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The Case of Skyrocketing Government Spending:

- Playfair, 1786
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The Case of Skyrocketing Government Spending:

-New York Times, Feb 1, 1976
The Case of Skyrocketing Government Spending:

-New York Times, Feb 1, 1976
The Case of Skyrocketing Government Spending:

-New York Times, Feb 1, 1976

This claim of type emphasis and stretches out the low value for 1966–1967, encouraging the impression that recent years have shot up from a small, stable base. Horizontal arrows provide similar emphasis.

Total Budget

Total Aid to Localities

*Pumping from a base of 2.1 percent of the total in the 1930s to a high of 21.5 percent in 1973–74*
The Case of Skyrocketing Government Spending:

-New York Times, Feb 1, 1976
The Case of Skyrocketing Government Spending:

-New York Times, Feb 1, 1976

The Principle: In time-series of money, deflated and standardized units of monetary measurement are better than nominal units.
THE SHRINKING FAMILY DOCTOR
In California

Percentage of Doctors Devoted Solely to Family Practice

<table>
<thead>
<tr>
<th>Year</th>
<th>1964</th>
<th>1975</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>27%</td>
<td>16.0%</td>
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</table>

1: 3.167
6.694

1: 4,232
6,212

1: 2,247 RATIO TO POPULATION
6,894

8,023 Doctors
Visual Area and Numerical Measure:

**The Shrinking Family Doctor**

In California

Percentage of Doctors Devoted Solely to Family Practice

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1: 3.167

6.894

1: 4,232

6,212

1: 2,247 Ratio to Population

8,023 Doctors

**Purchasing Power of the Diminishing Dollar**

- 1958 - Eisenhower: $1.00
- 1953 - Kennedy: 94c
- 1968 - Johnson: 83c
- 1973 - Nixon: 64c
- 1978 - Carter: 44c

Sources: Labor Department
Visual Area and Numerical Measure:

THE SHRINKING FAMILY DOCTOR
In California
Percentage of Doctors Devoted Solely to Family Practice

<table>
<thead>
<tr>
<th>Year</th>
<th>1964</th>
<th>1975</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>27%</td>
<td>16.0%</td>
<td>12.0%</td>
<td></td>
</tr>
</tbody>
</table>

1: 3,167
6,894

1: 4,232
6,212

1: 2,247 RATIO TO POPULATION
8,023 Doctors

1958 - Eisenhower: $1.00
1963 - Kennedy: 94c
1968 - Johnson: 83c
1973 - Nixon: 64c
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Purchasing Power of the Diminishing Dollar

Source: Labor Department
Visual Area and Numerical Measure:

**Conclusion:** The use of two or three varying dimensions to show one-dimensional data is a weak and inefficient technique.

The number of information-carrying dimensions **should not exceed** the number of dimensions in the data.
Context is Essential for Graphical Integrity:

Graphics must not quote data out of context.
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1. The representation of numbers should be directly proportional to the numerical quantities represented
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1. The representation of numbers should be directly proportional to the numerical quantities represented
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Thank you for the attention.