

# Graphical Excellence—Edward Tufte

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

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■ Graphical displays should:

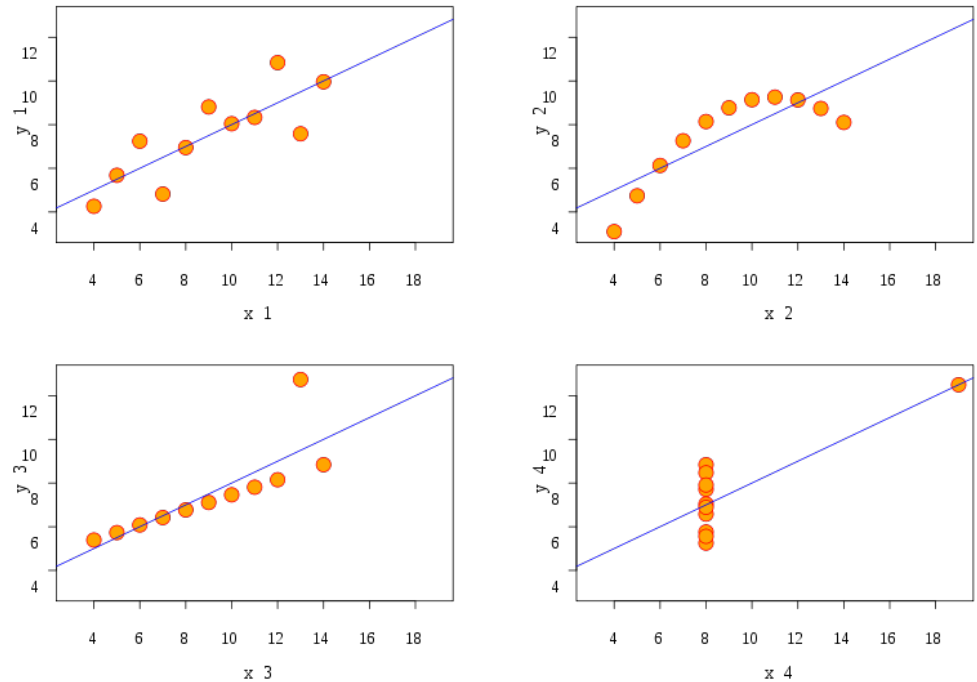
- show the data
- induce the viewer to think about the substance
- avoid distorting what the data says
- present many numbers in small space
- make large data sets coherent
- encourage comparison between data
- reveal the data at several levels of detail
- clear purpose: description, exploration, tabulation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

Graphics **reveal** data.

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I		II		III		IV	
x	y	x	y	x	y	x	y
10,00	8,04	10,00	9,14	10,00	7,46	8,00	6,58
8,00	6,95	8,00	8,14	8,00	6,77	8,00	5,76
13,00	7,58	13,00	8,74	13,00	12,74	8,00	7,71
9,00	8,81	9,00	8,77	9,00	7,11	8,00	8,84
11,00	8,33	11,00	9,26	11,00	7,81	8,00	8,47
14,00	9,96	14,00	8,10	14,00	8,84	8,00	7,04
6,00	7,24	6,00	6,13	6,00	6,08	8,00	5,25
4,00	4,26	4,00	3,10	4,00	5,39	19,00	12,50
12,00	10,84	12,00	9,13	12,00	8,15	8,00	5,56
7,00	4,82	7,00	7,26	7,00	6,42	8,00	7,91
5,00	5,68	5,00	4,74	5,00	5,73	8,00	6,89

### Anscombe's quartet



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.

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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



**SOLAR RADIATION AND STOCK PRICES**

A. New York stock prices (Barron's average). B. Solar Radiation, inverted, and C. London stock prices, all by months, 1929 (after Garcia-Mata and Shaffner).

**Graphical Excellence** =

efficient communication of complex quantitative ideas



- Fundamental Graphical Designs:
  - Data Maps
  - Time-Series
  - Space-time narrative designs
  - Relational Graphics

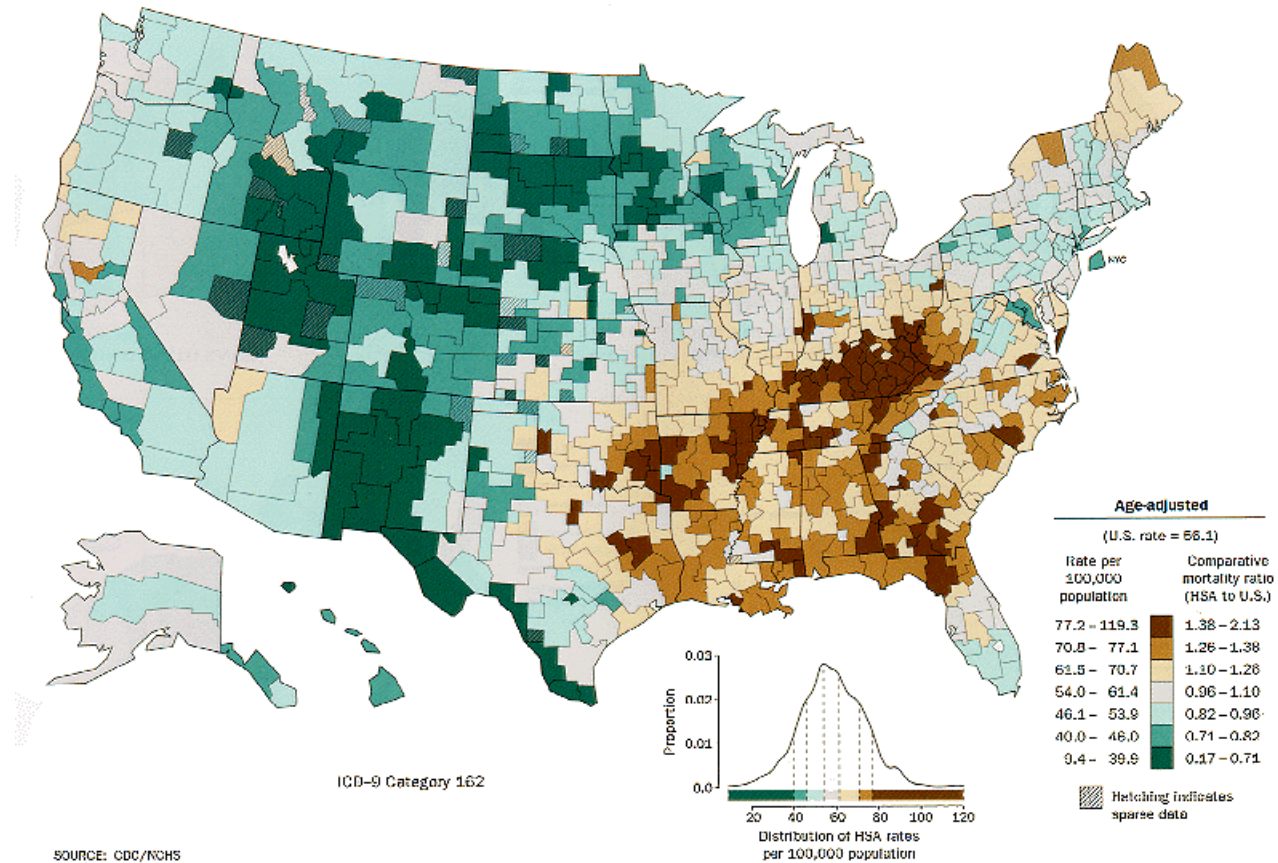
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# Data Maps

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

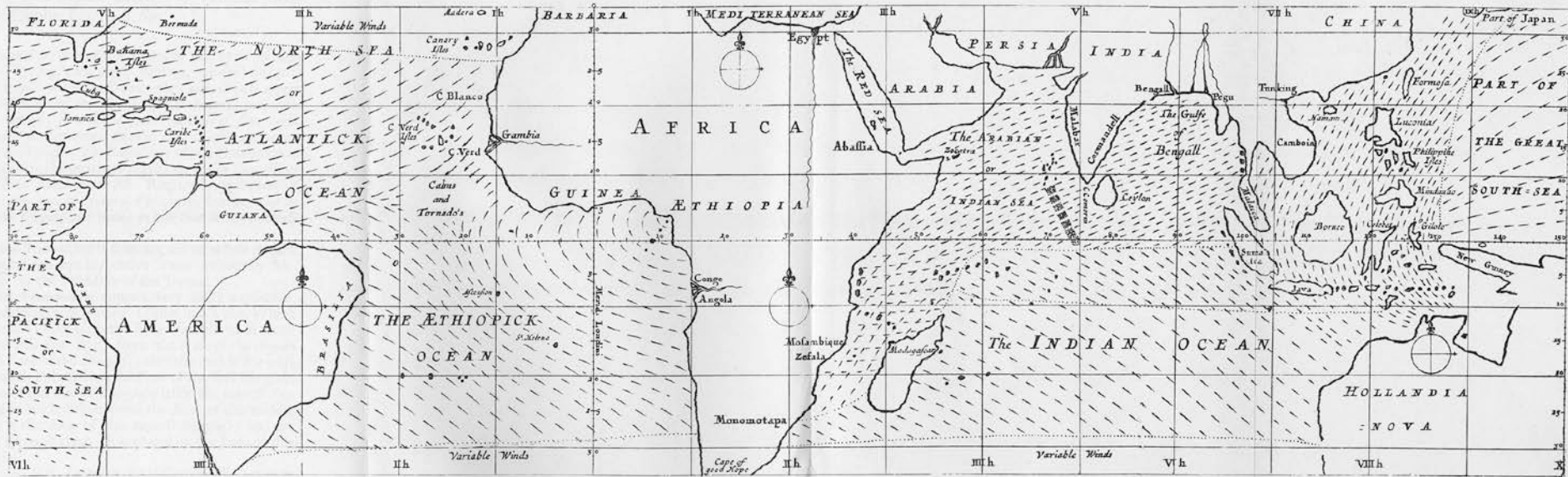
# Data Maps

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# Data Maps

- Edmond Halley, 1686



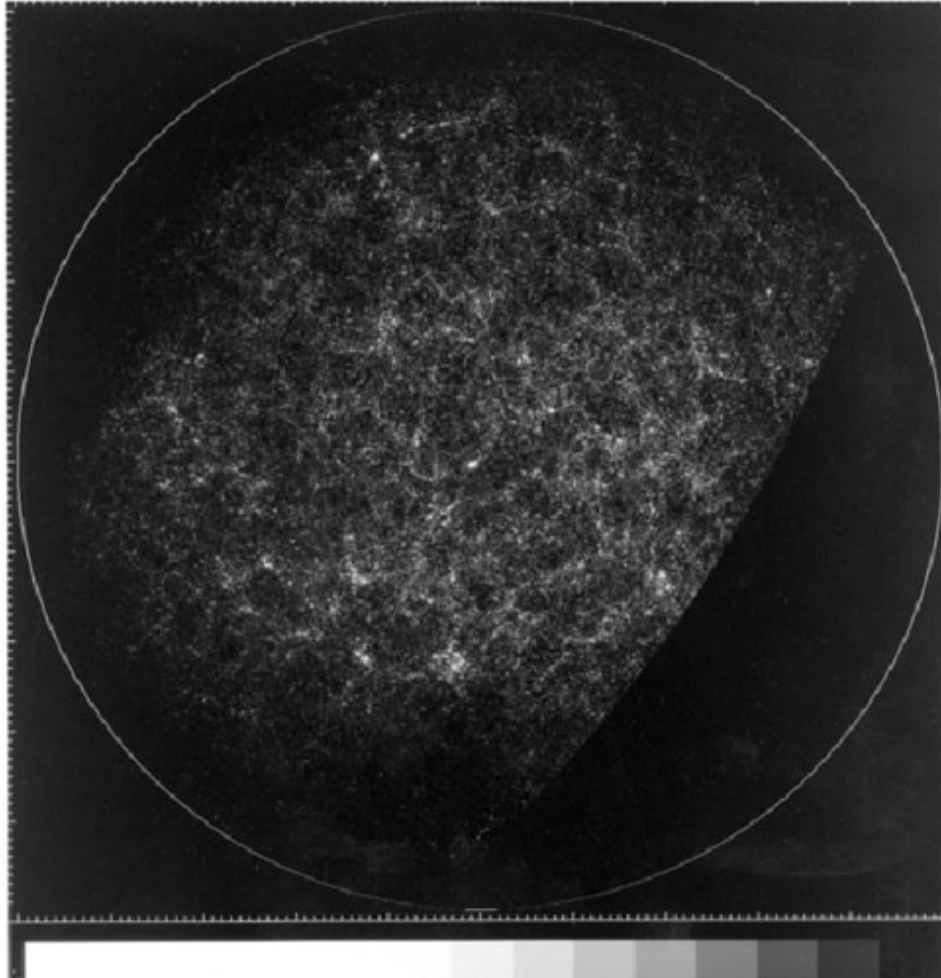
# Data Maps

- Dr. John Shaw, 1854



# Data Maps

- “New Reduction of the Lick Catalog of Galaxies” - Seldner, Siebers, Groth and Peebles

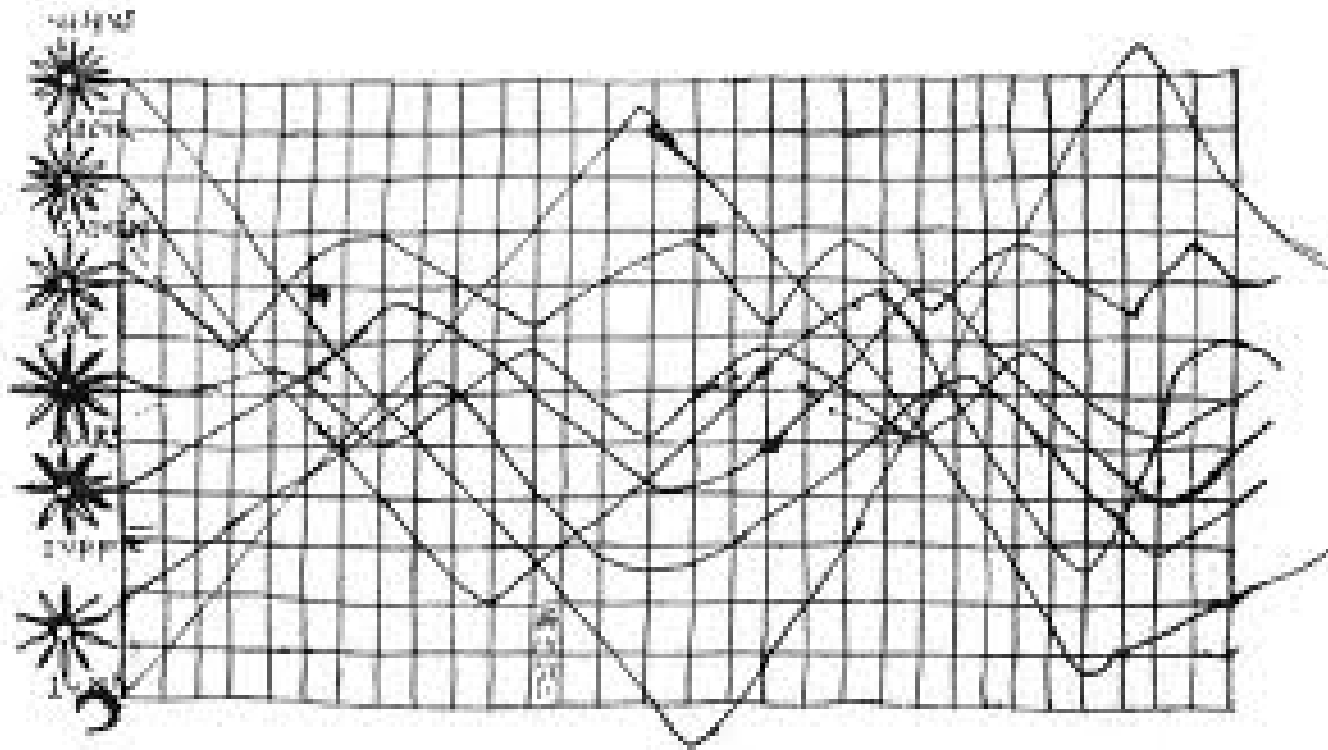


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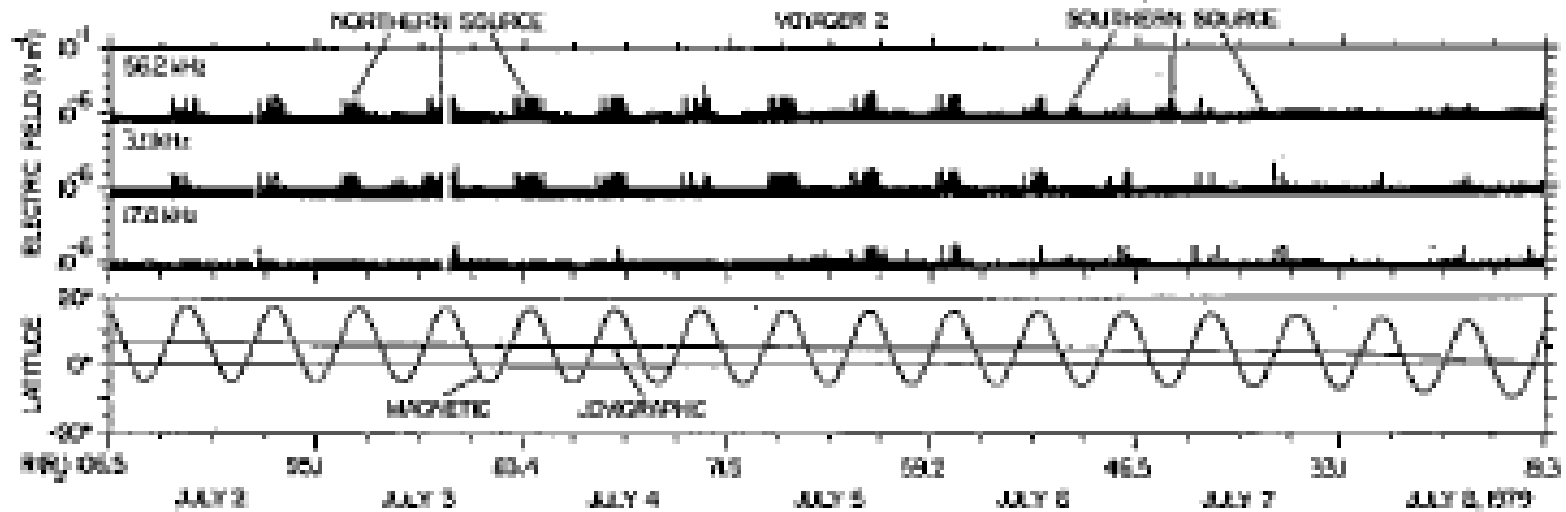
# Time-Series

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



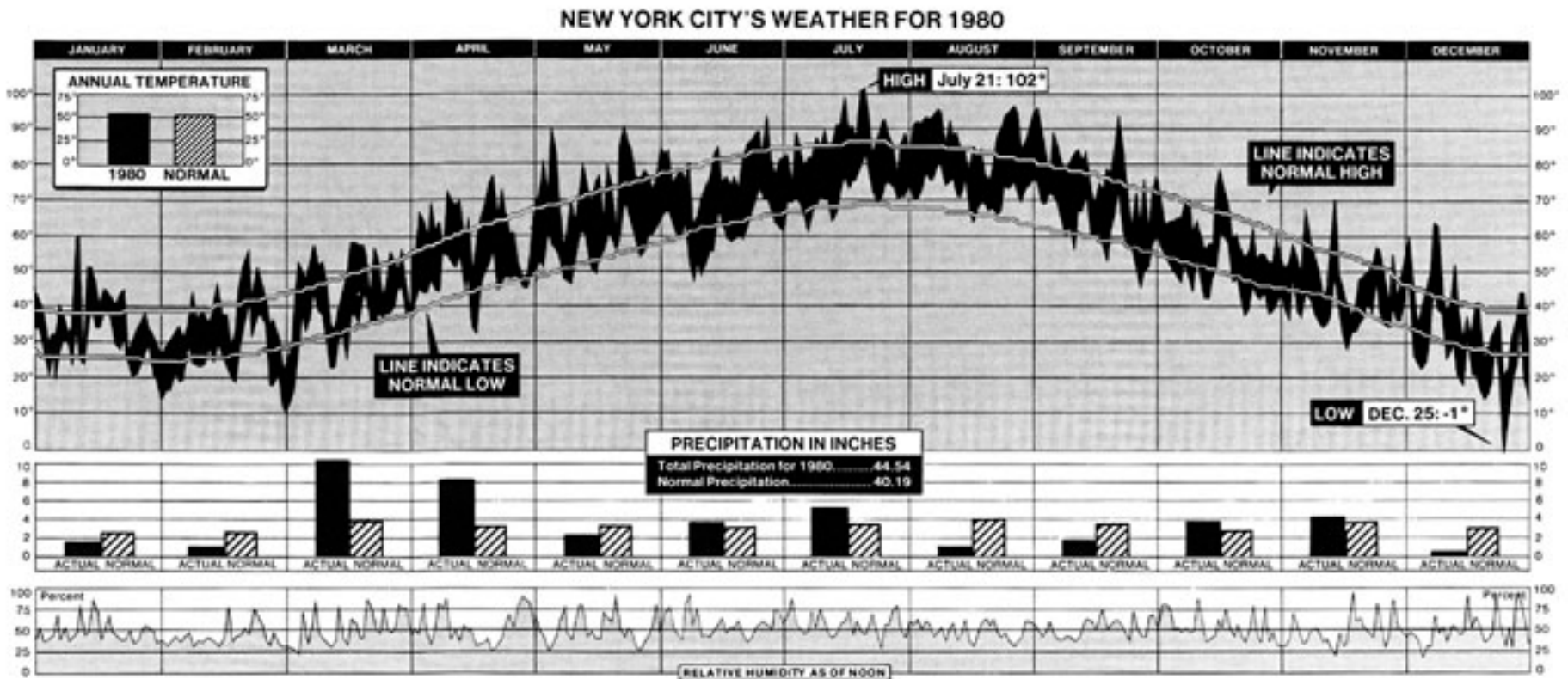
# Time-Series

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

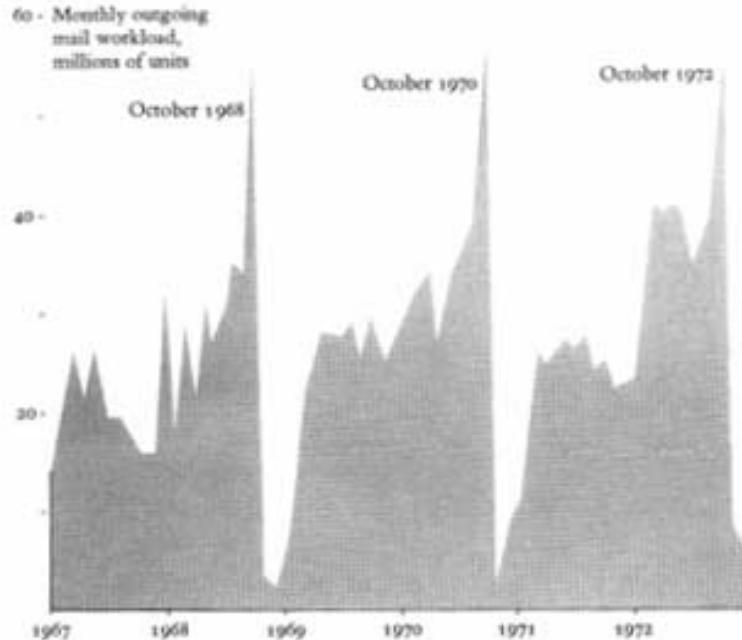


# Time-Series

- New York Weather 1980



# Time-Series



## FRANKED MAIL TIE TO VOTING SHOWN

Testimony Finds the Volume Rose Before Elections

WASHINGTON, June 1 (AP)—New court testimony and documents show that much of the mail Congress sends at taxpayer expense is tied directly to the re-election campaigns of Senate and House members. According to material filed in a lawsuit in Federal Court, closely Republican and two Democratic senators and two House members testified in court to admit that at least in one their free mailing privileges to get votes.

The election material prepared for Senate Democrats when re-elected as a "free frank," and into up a lawsuit

the writing firm as an integral part of a mailed re-election campaign.

Senator John G. Tower, Republican of Texas, mailed more than \$60,000 worth of re-election letters at taxpayer expense as part of his 1970 re-election effort and received campaign committee offices and thousands in support.

Witness Jack R. Jarvis, Republican of New York, gave written approval in 1972 for a "franked mail" program intended to better his image and get off at the polls. He framed his mail to some extent by mailed material.

"The volume of 'franked' Congressional mail rises in election years and peaks in between the general election.

Most of this activity comes early whether by law or regulation, since Congress has wide discretion in the use of taxpayer mail. Congress gave itself the right to send official mail by government expense at the

building of the specific, and only Congress, private citizens may not use the free frank privilege of political use of the free-mailing privilege, under the franking privilege, are used every election year. However, because the volume and cost of franked mail has risen, a 1974 federal law will limit what constituting challenges can spend in such situations.

In 1975, Congress passed a law prohibiting more franked mailings within 30 days before an election. The sponsor of that legislation, Representative Thomas B. (Tex.), Democrat of Arizona, said in an interview that further changes were needed to correct "planned abuse of the frank."

Mr. Clark urged a study procedure "not" for more mailings and said he favored closing a loophole that recently allowed a committee that recently chaired by Representative John Frank W. Clark, Democrat of Pennsylvania, to send a

franked newsletter to its 600 constituents after he had left office. Mr. Clark is seeking to regain the old post.

**Franking Expanded**

Senators use the political use of franked mail, but it was not distributed so to many constituents and Democrats. That is a Federal Court in District of Columbia, the letter states, which is suing for its mail to help a lawsuit filed last month by California Sen. George J. Brown.

For example, Sen. P. Baker, a former mail recipient, said in a 1973 job program, that the word to let an election mail program for Republican voters using franked mail.

"The purpose of such a program is to help an incumbent Senator get re-elected," she said.

The case put on the Senate floor in 1974 and 1975 and settled last during the time she elected Republican Senator Robert J.

John of Kansas, Peter H. Dinkens of Colorado, Charles W. McNichols Jr. of Maryland. Another political mail recipient, Sen. W. Hollings, wrote a program for the use of franked mail by his staff, several years in 1974.

"The general objective of the franked mail program was to get the recipients of the mail to identify themselves with a particular political program and to a full year have considered the kind of distribution that can be requested into a vote in the polls on election day," Mr. Hollings said.

Mr. Jarvis was not of the country and would not be franked letters since they had to be 100 copies before November 1974. Congress sent 121.2 million franked pieces of mail, but in the next 11 months, sending the dollar amount of 1974, Congress sent 228.2 million, a jump of 87 percent since what's happening," Mr. Jarvis said.

Senator Tower's use of franked mail in the 1970 was largely unregulated by such legislation.

Two letters a high-ranking campaign aide wrote to a constituent about Oct. 21, 1970 that during the campaign Senator Tower had sent "20 special letters before sending approximately \$60,000 franked mailings."

Mr. Tower was not available for comment. His administrative assistant, David Gilling, said the Senator's use of franked mail in 1970 was within the law, and he defended the free-mailing privileges.

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# 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.  
Dressée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite. Paris, le 20 Novembre 1869.

Les nombres d'hommes présents sont représentés par les largeurs des zones colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en travers des zones. Le rouge désigne les hommes qui entrent en Russie, le noir ceux qui en sortent. Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de M. M. Chiers, de Légar, de Fezensac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre.

Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davout qui avoient été détachés sur Minsk et Mohilow et ont rejoint vers Orscha et Witebsk, avoient toujours marché avec l'armée.

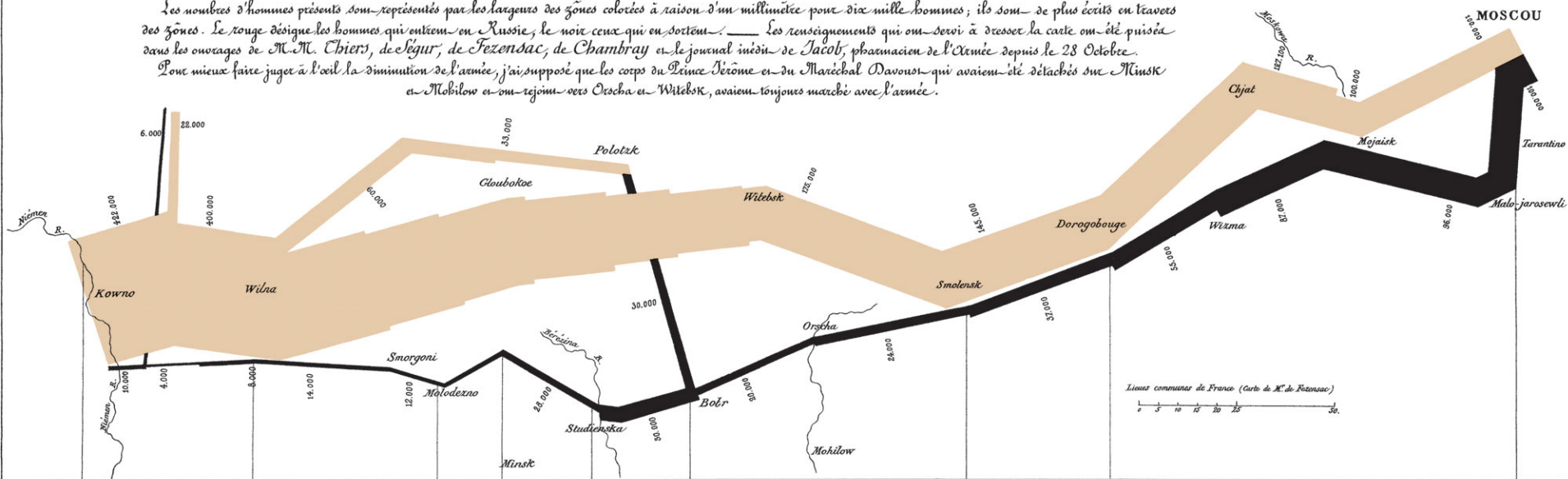
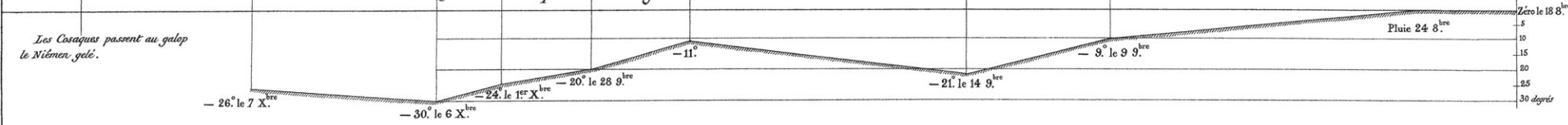


TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.



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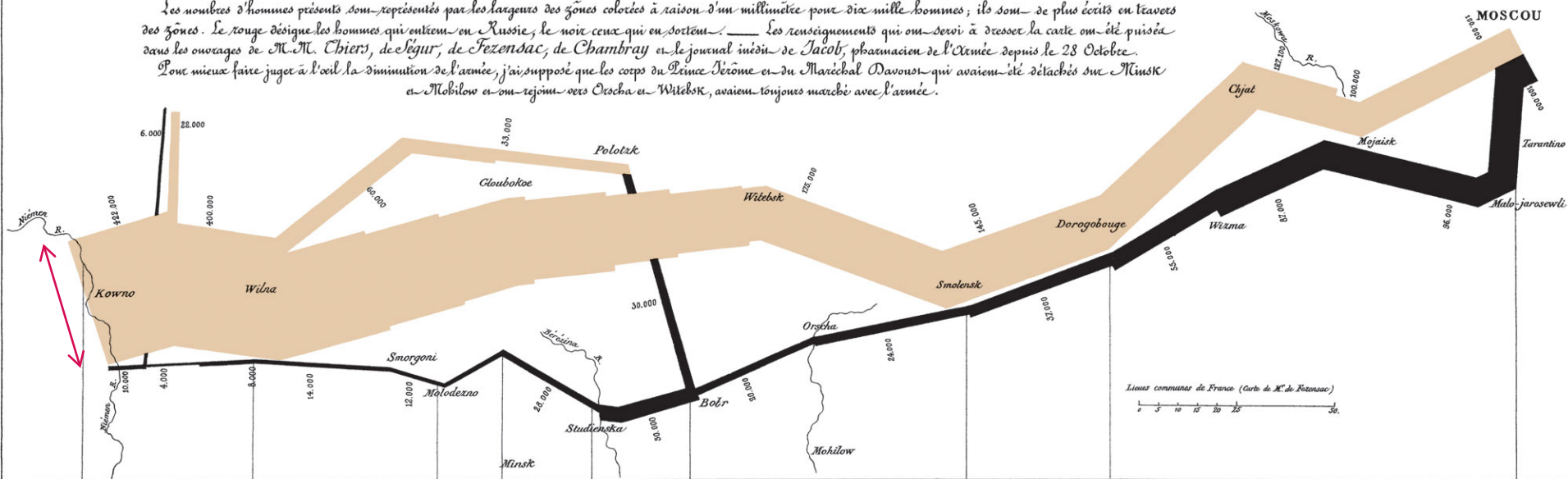
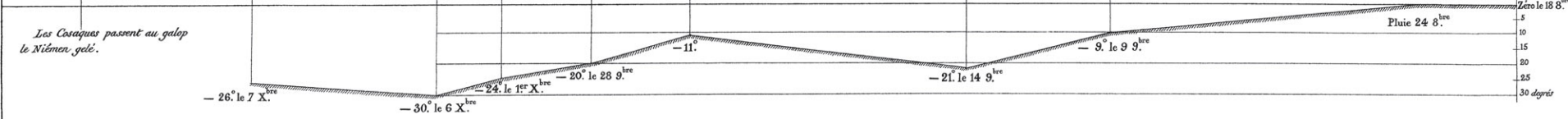


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Les Cosaques passent au galop le Niémen gelé.





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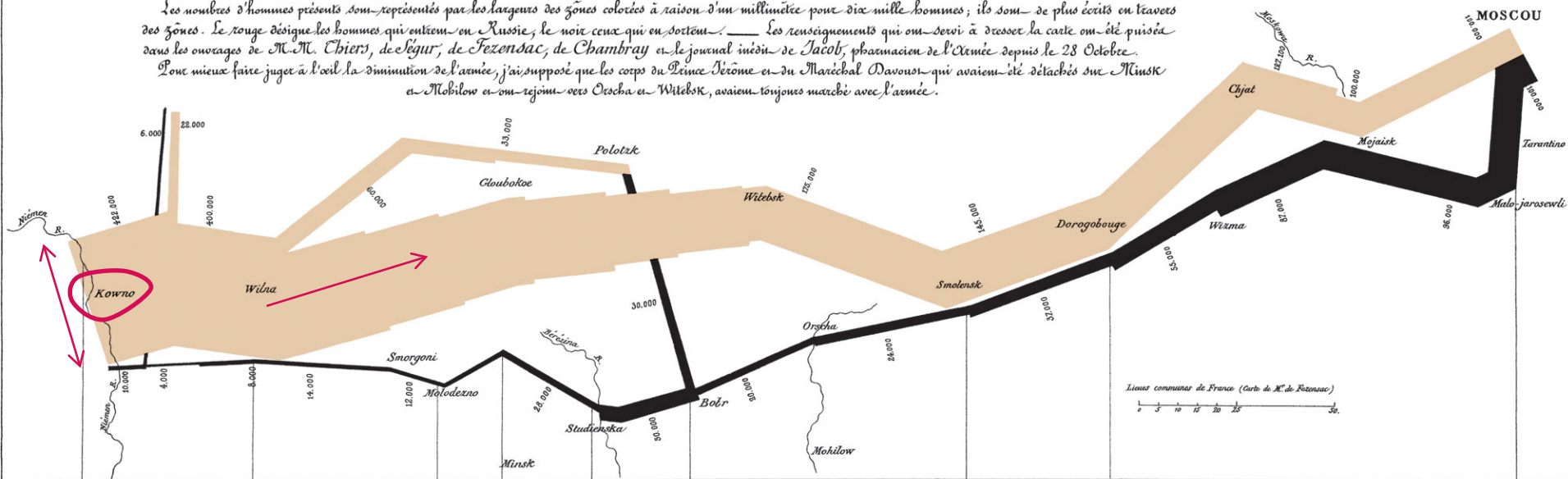
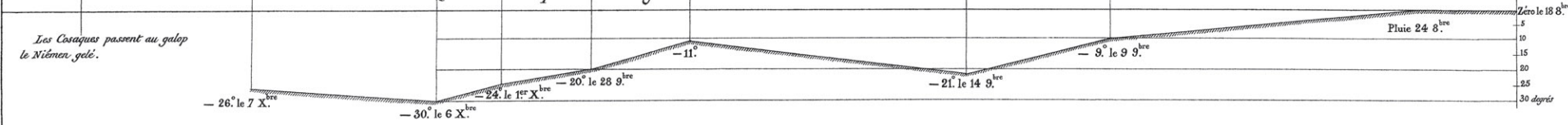


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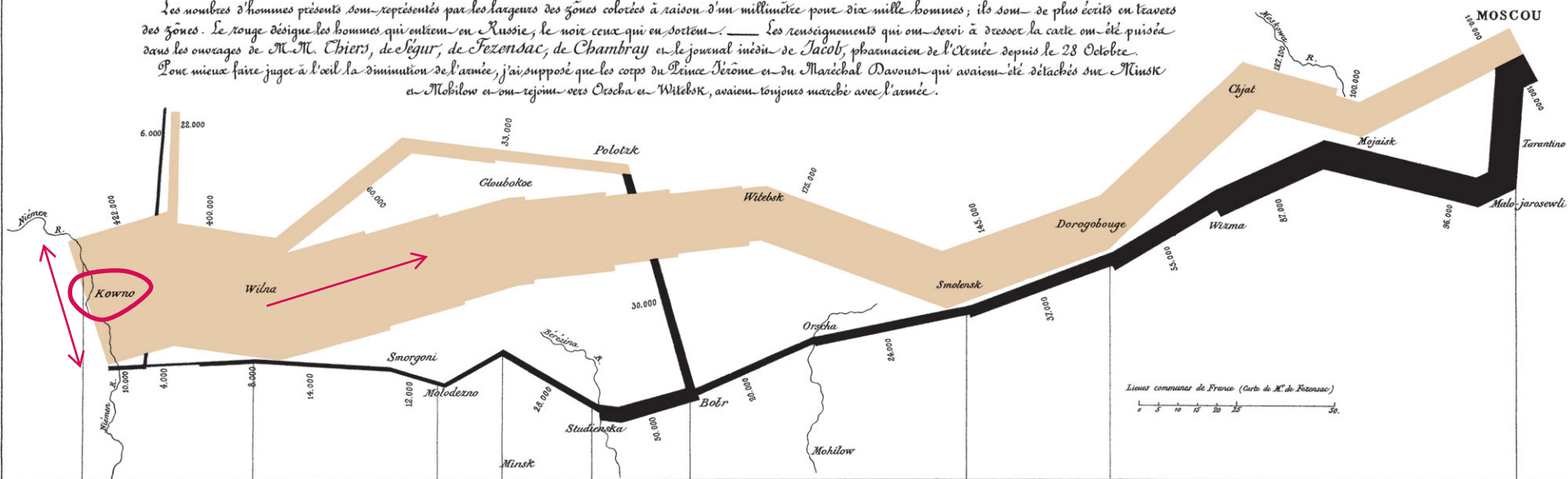
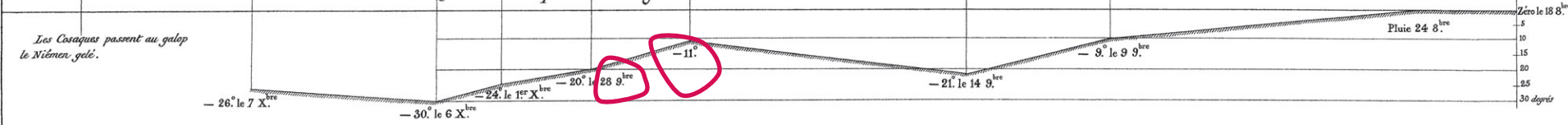


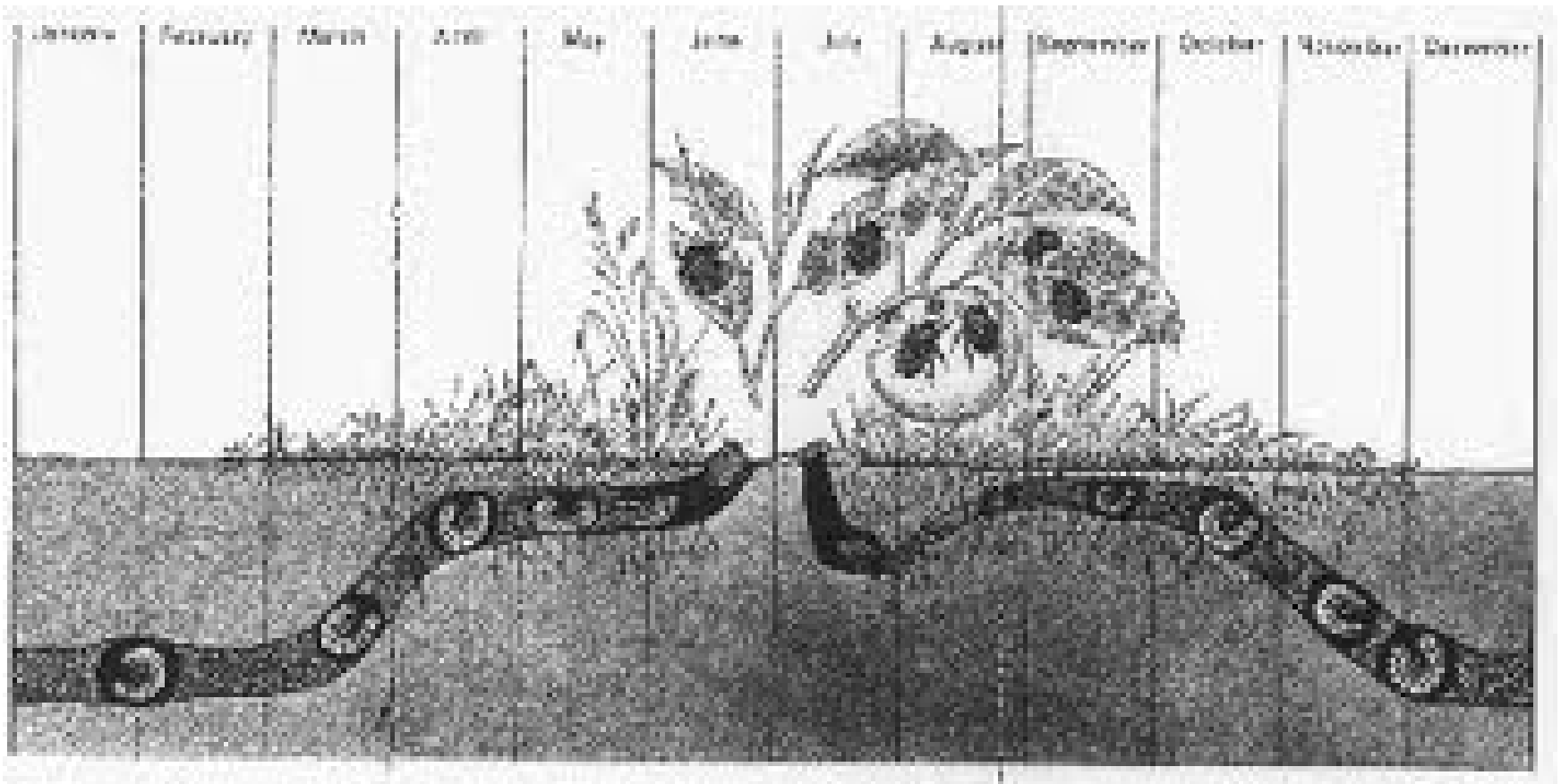
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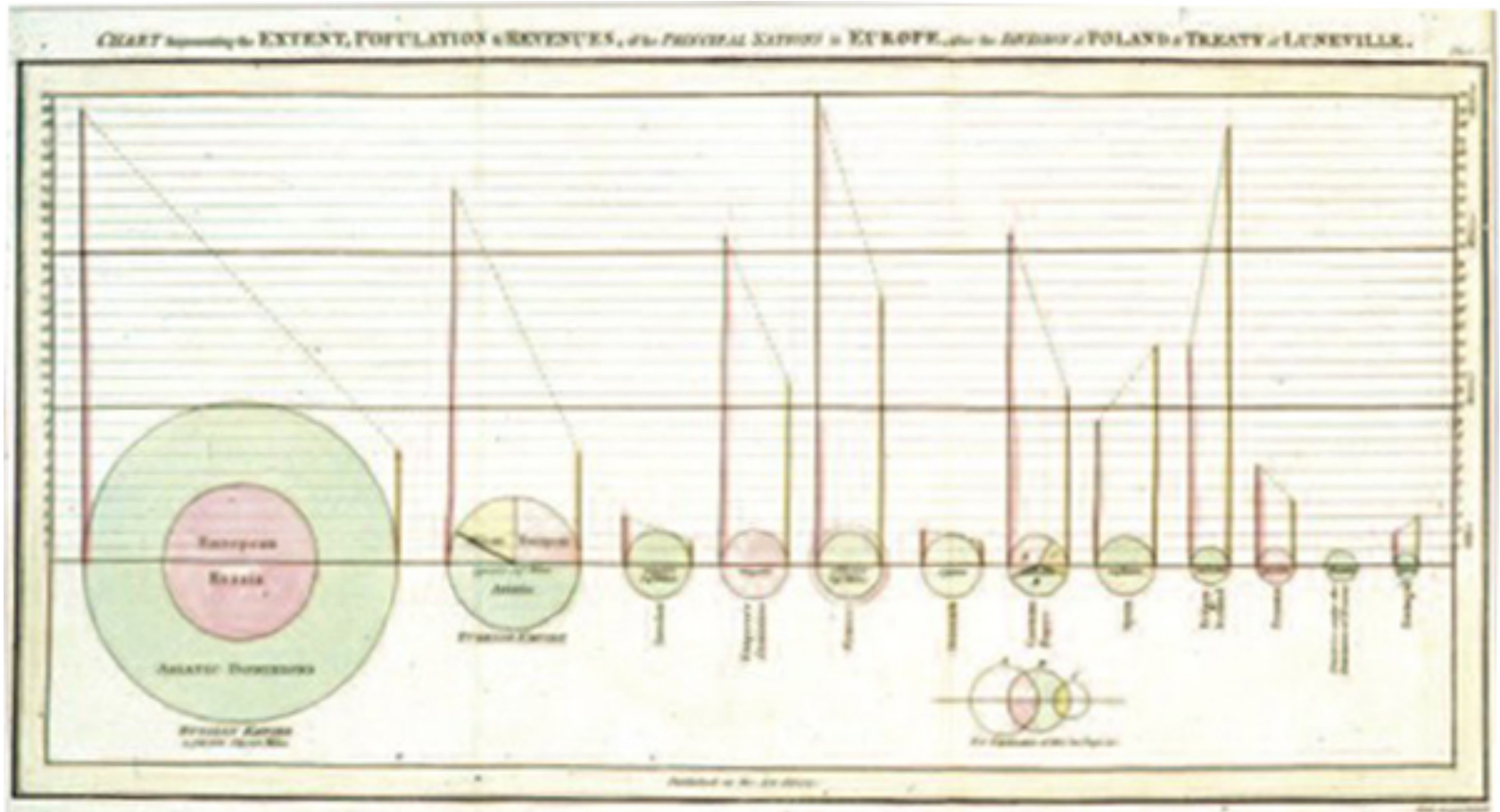
“Man and Insects”- I. Hugh Newman



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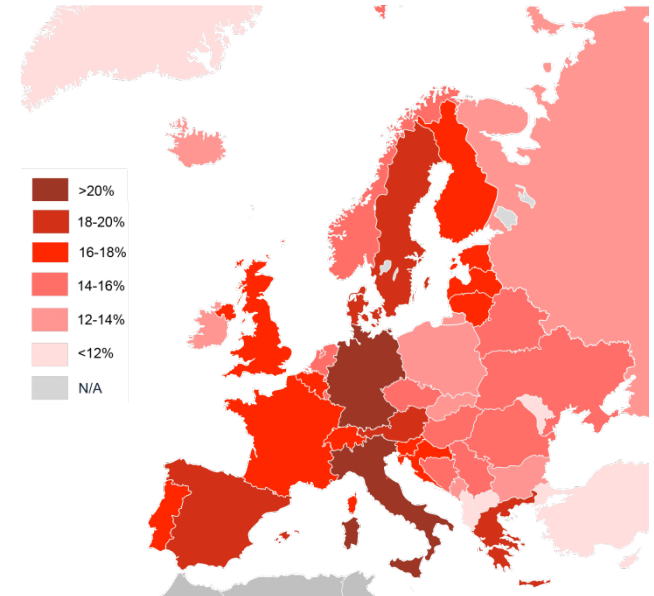
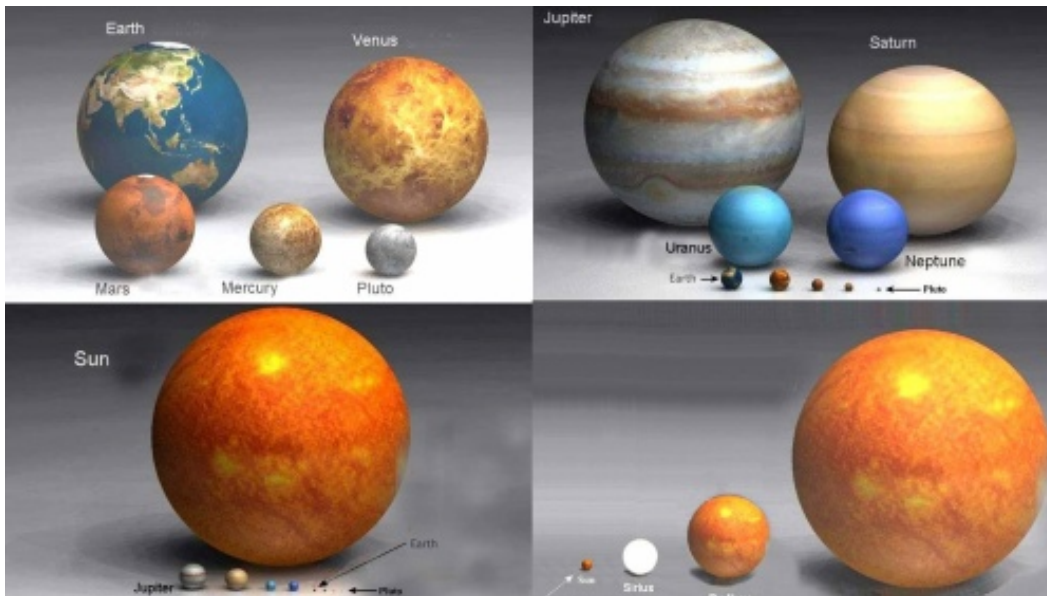
# Relational Graphics

“The Statistical Breviary”- Playfair



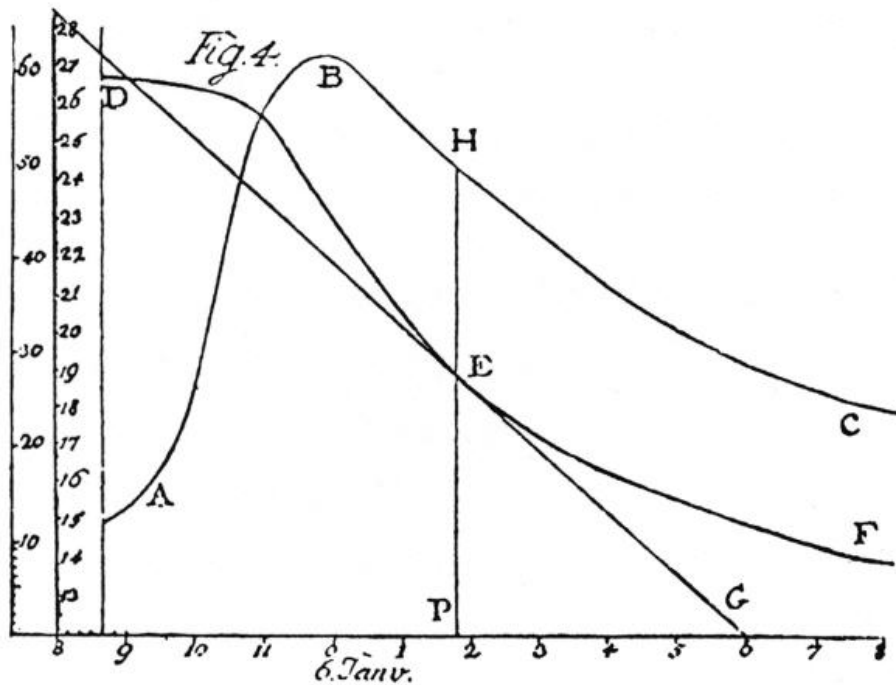
# Relational Graphics

Comparing sizes represented with similar form.



# Relational Graphics

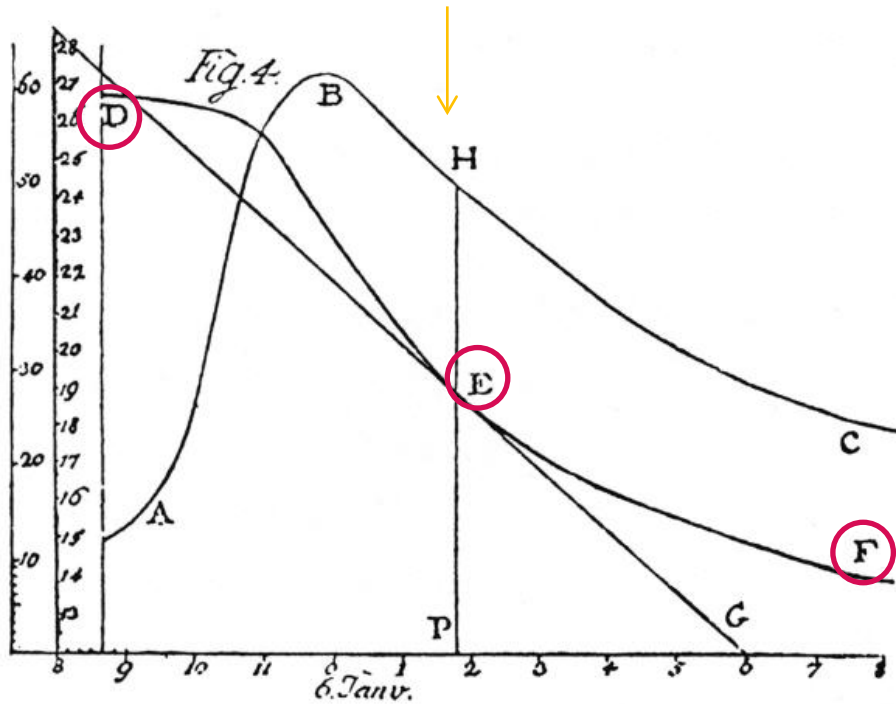
“Evaporation rate of water”- J.H. Lambert





# Relational Graphics

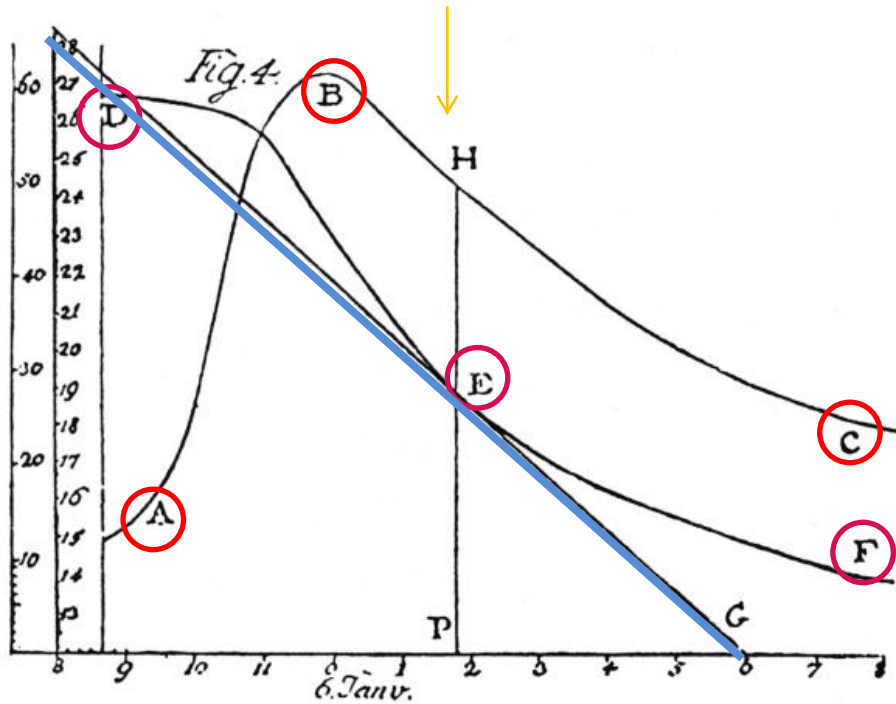
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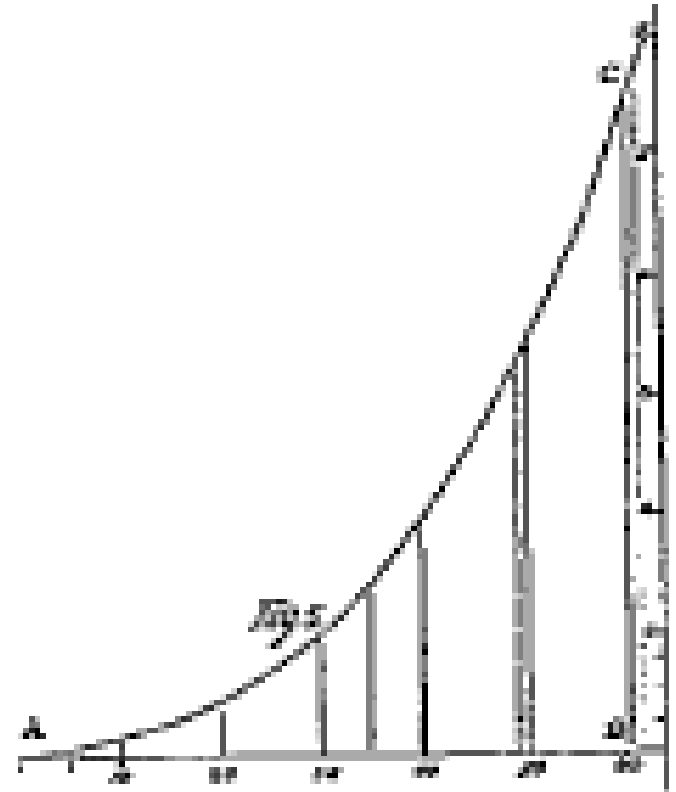
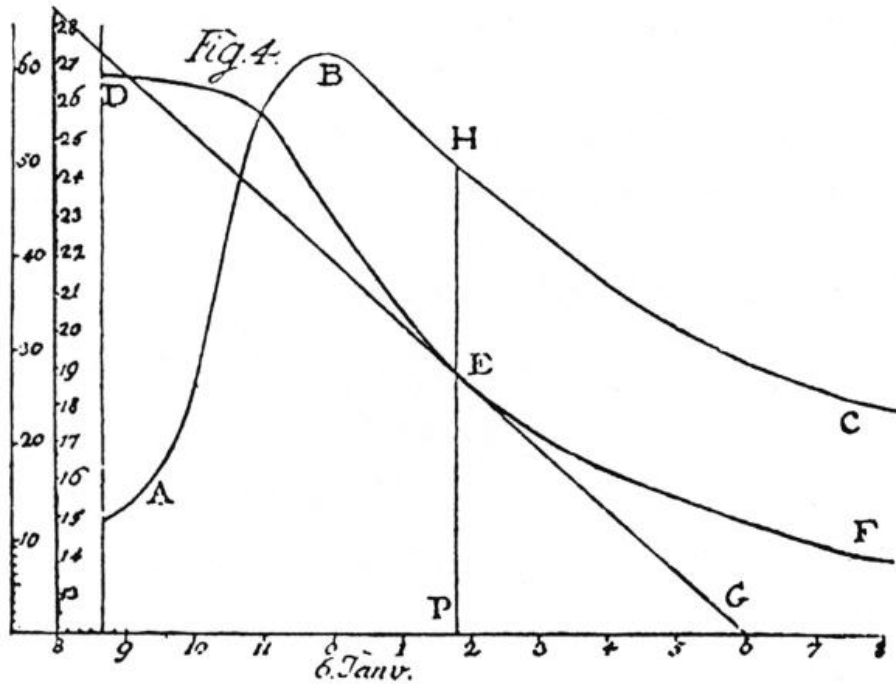
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# Relational Graphics

“Evaporation rate of water”- J.H. Lambert<sup>†</sup>



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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.

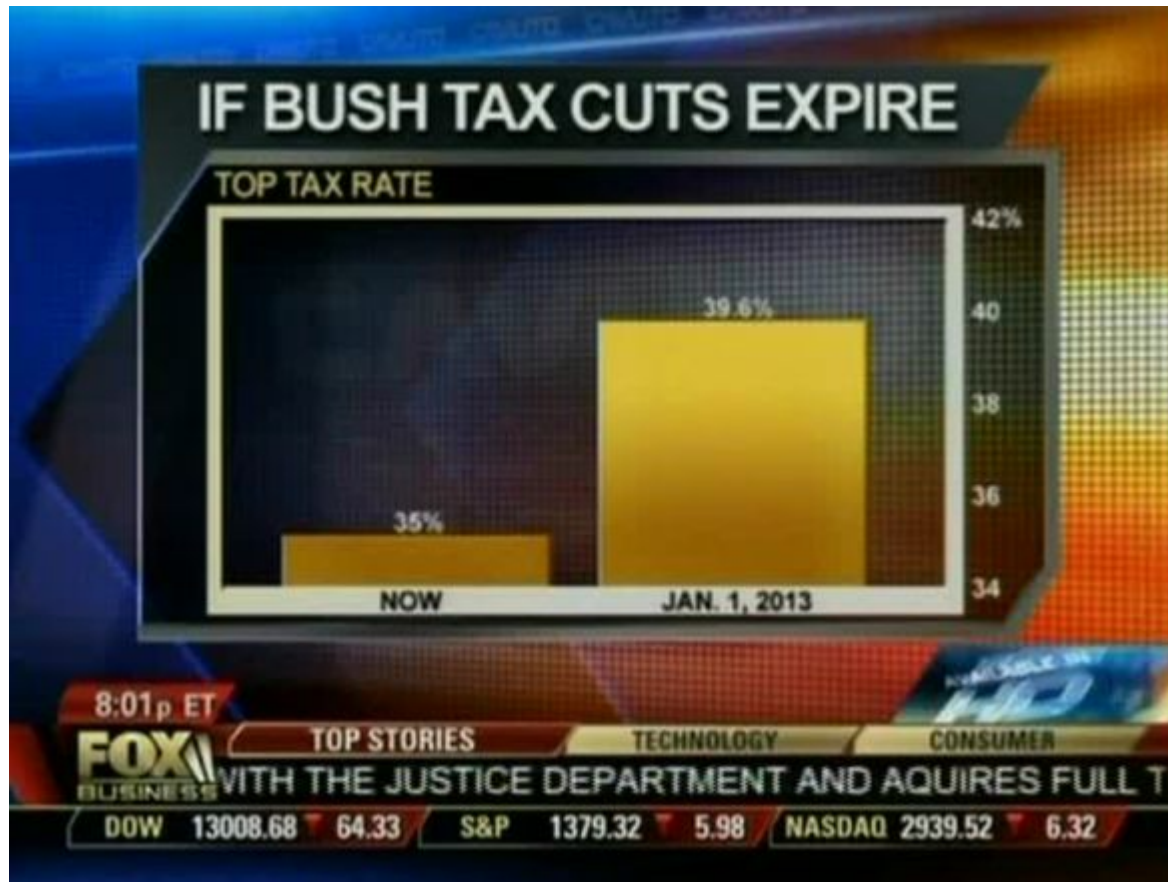
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# Graphical Integrity—Edward Tufte

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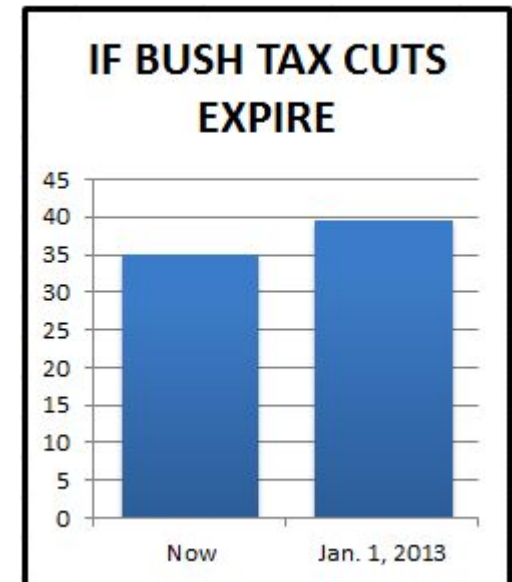
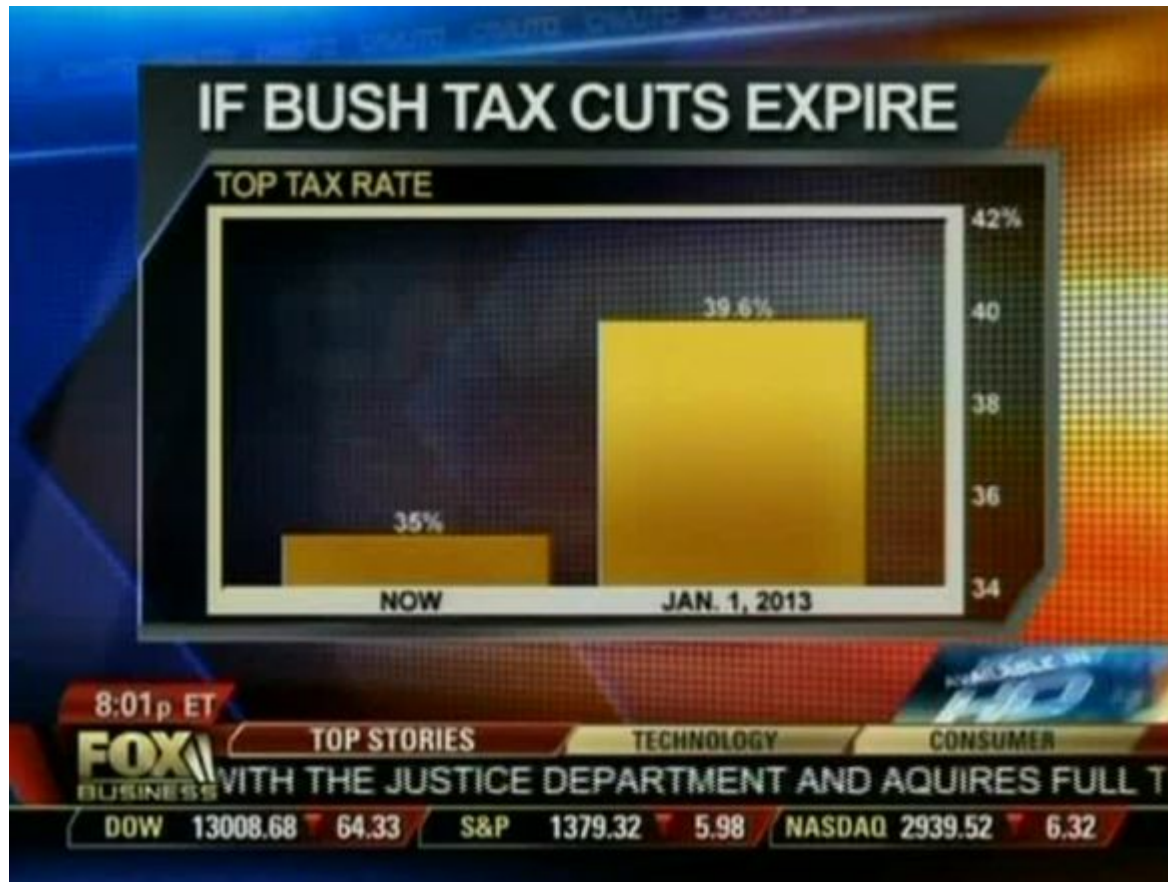
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Misleading graphics



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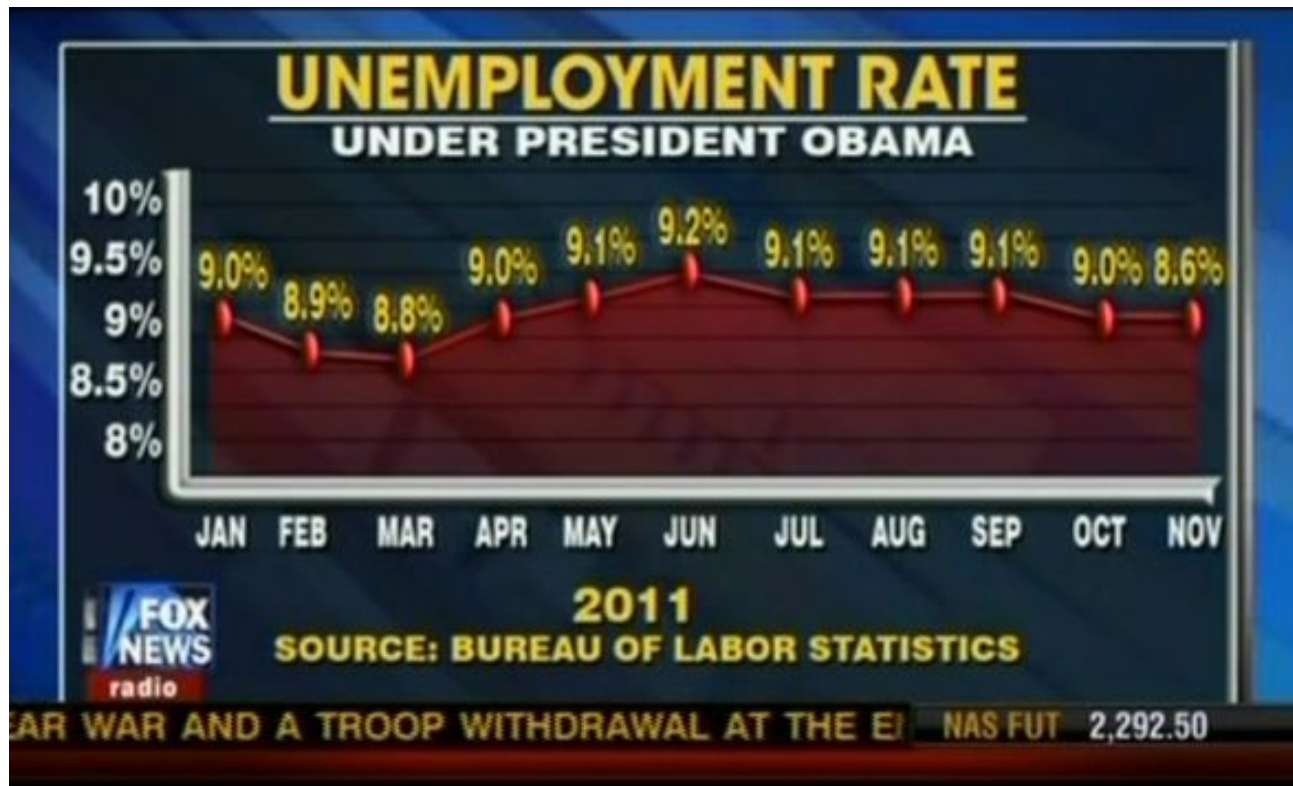
Misleading graphics





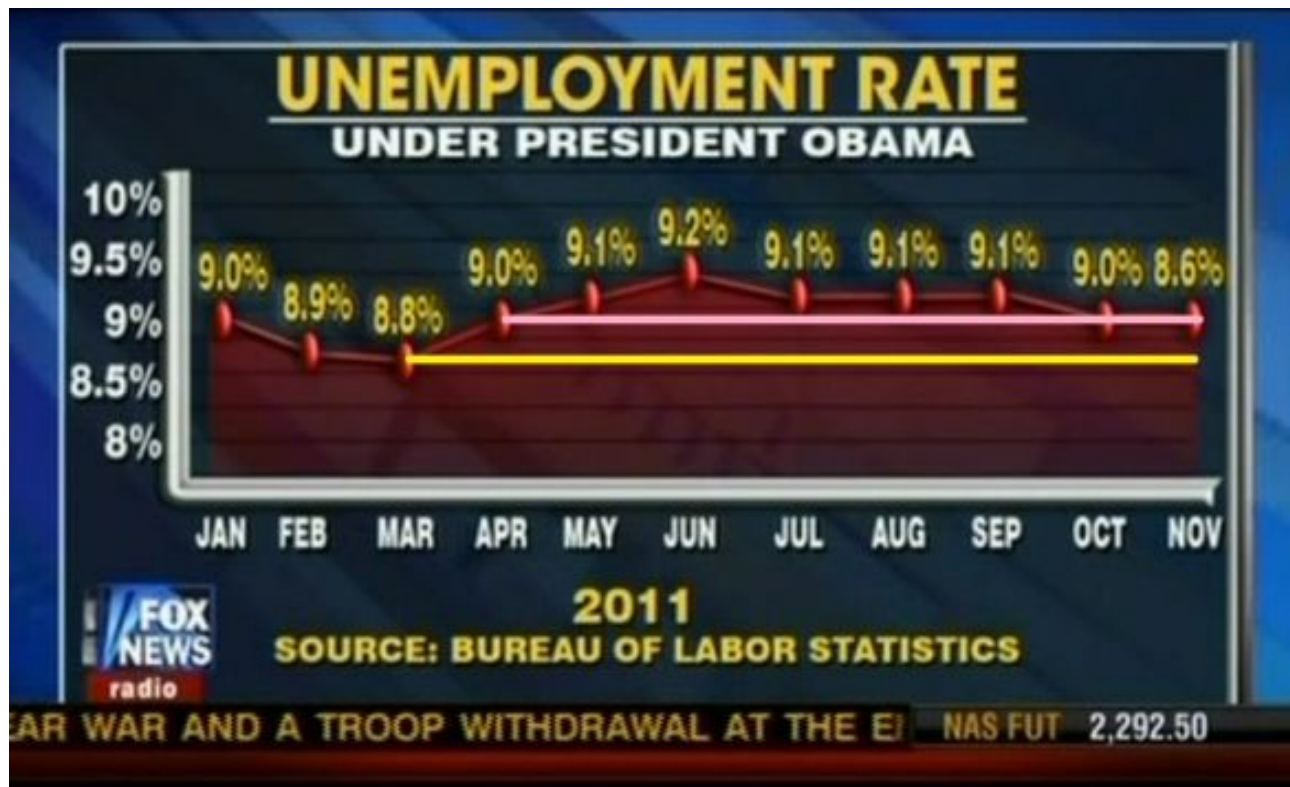
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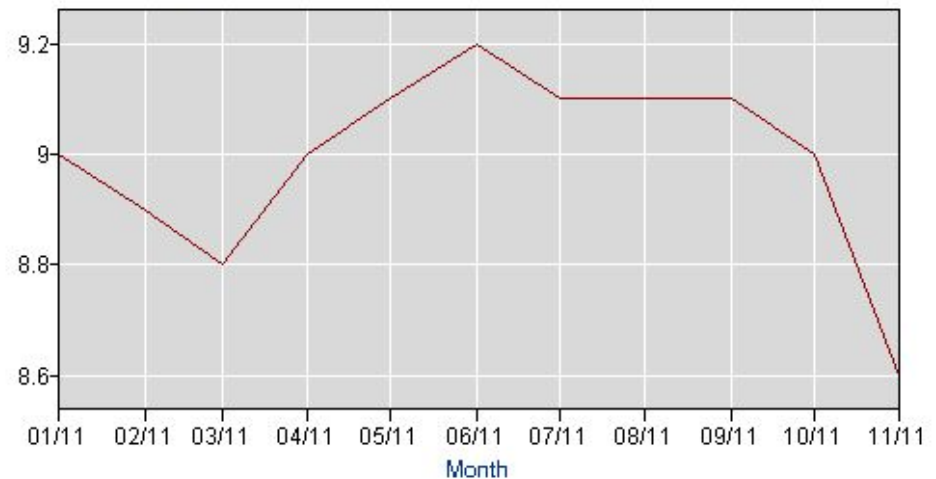
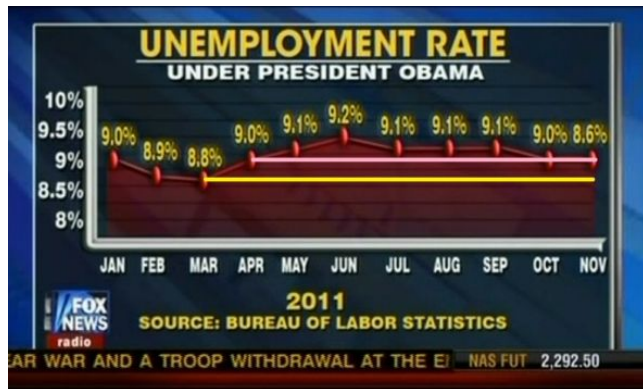
# Graphical Integrity — Edward Tufte

## Misleading graphics

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

### Labor Force Statistics from the Current Population Survey

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



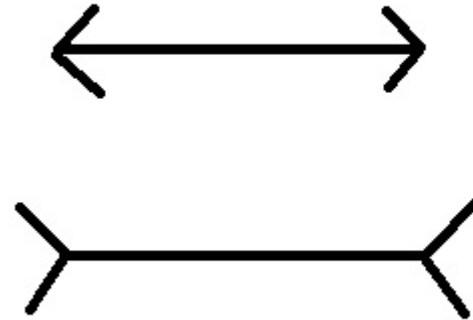
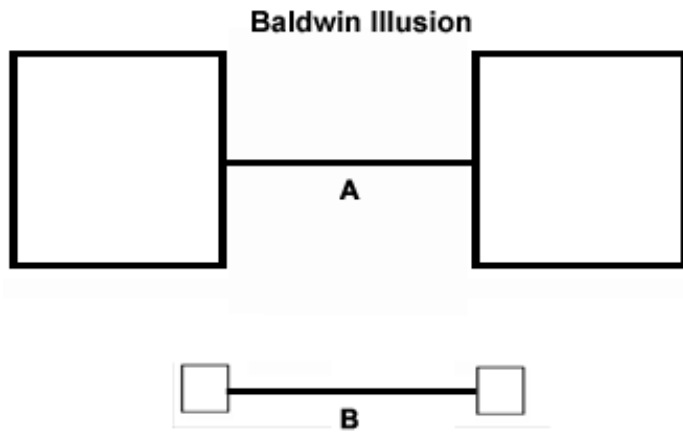
What is Distortion in a Data Graphic?

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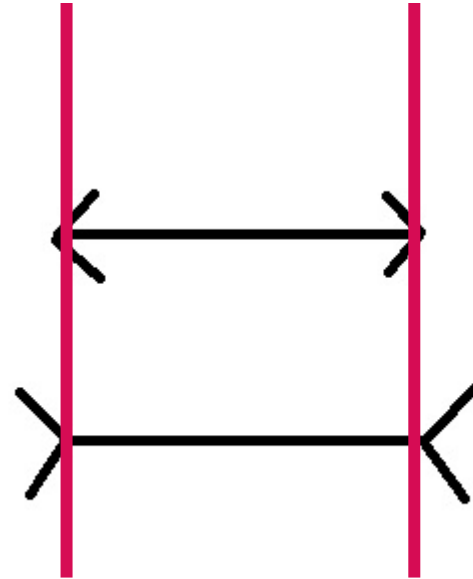
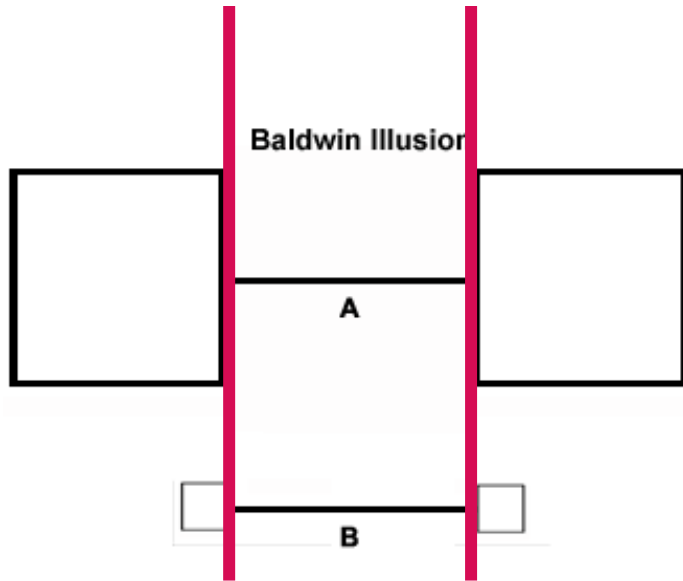
A graphic does not distort if the visual representation of data is consistent with the numerical representation.

Visual representation of data  $\neq$  numerical representation

# What is Distortion in a Data Graphic?



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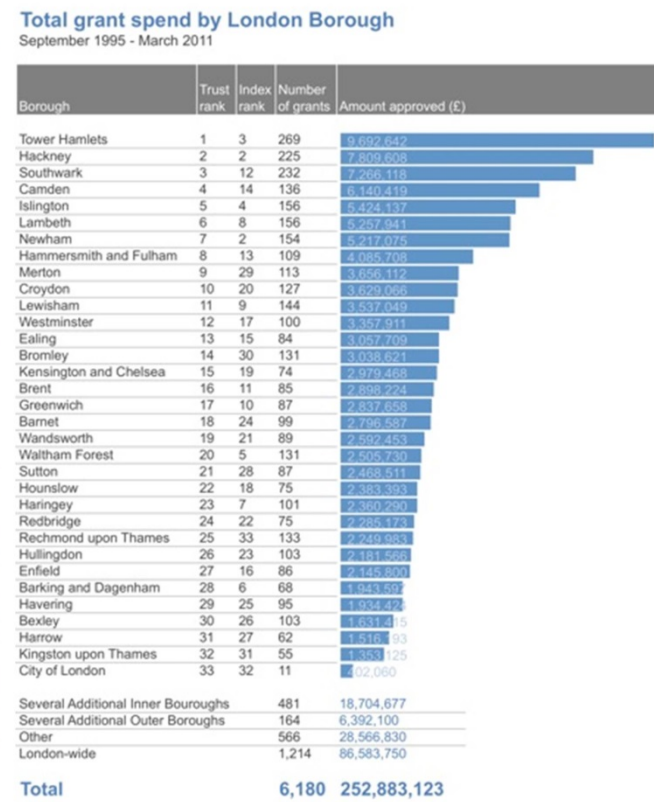
# Table vs. Graph

Before: **Table**

**Total grants spend by London Borough**  
September 1995 to March 2011

Trust rank	Deprivation Index rank	Borough	Amount approved	Number of grants
1	3	Tower Hamlets	£9,692,642	269
2	1	Hackney	£7,809,608	225
3	12	Southwark	£7,266,118	232
4	14	Camden	£6,140,419	136
5	4	Islington	£5,424,137	156
6	8	Lambeth	£5,257,941	158
7	2	Newham	£5,217,075	154
8	13	Hammersmith and Fulham	£4,085,708	109
9	29	Merton	£3,656,112	113
10	20	Croydon	£3,629,066	127
11	9	Lewisham	£3,537,049	144
12	17	Westminster	£3,357,911	100
13	15	Ealing	£3,057,709	84
14	30	Bromley	£3,038,621	131
15	19	Kensington and Chelsea	£2,979,488	74
16	11	Brent	£2,898,224	85
17	10	Greenwich	£2,837,658	87
18	24	Barnet	£2,796,587	99
19	21	Wandsworth	£2,592,453	89
20	5	Waltham Forest	£2,505,730	131
21	28	Sutton	£2,468,511	87
22	18	Hounslow	£2,383,393	76
23	7	Haringey	£2,360,290	101
24	22	Redbridge	£2,285,173	76
25	33	Richmond upon Thames	£2,248,983	133
26	23	Hillingdon	£2,181,596	103
27	16	Enfield	£2,145,800	86
28	6	Barking and Dagenham	£1,943,597	68
29	25	Havering	£1,834,424	95
30	26	Bexley	£1,831,415	103
31	27	Harrow	£1,516,193	62
32	31	Kingston upon Thames	£1,353,125	55
33	32	City of London	£402,060	11
Several Inner Boroughs			£18,704,677	481
Several Outer Boroughs			£8,392,100	164
Other combination			£28,566,830	566
London-wide			£86,583,750	1,214
Total			£252,883,123	6,180

After: **Grable**



The power of graphics comes in the display of large data sets.



## Two Principles:

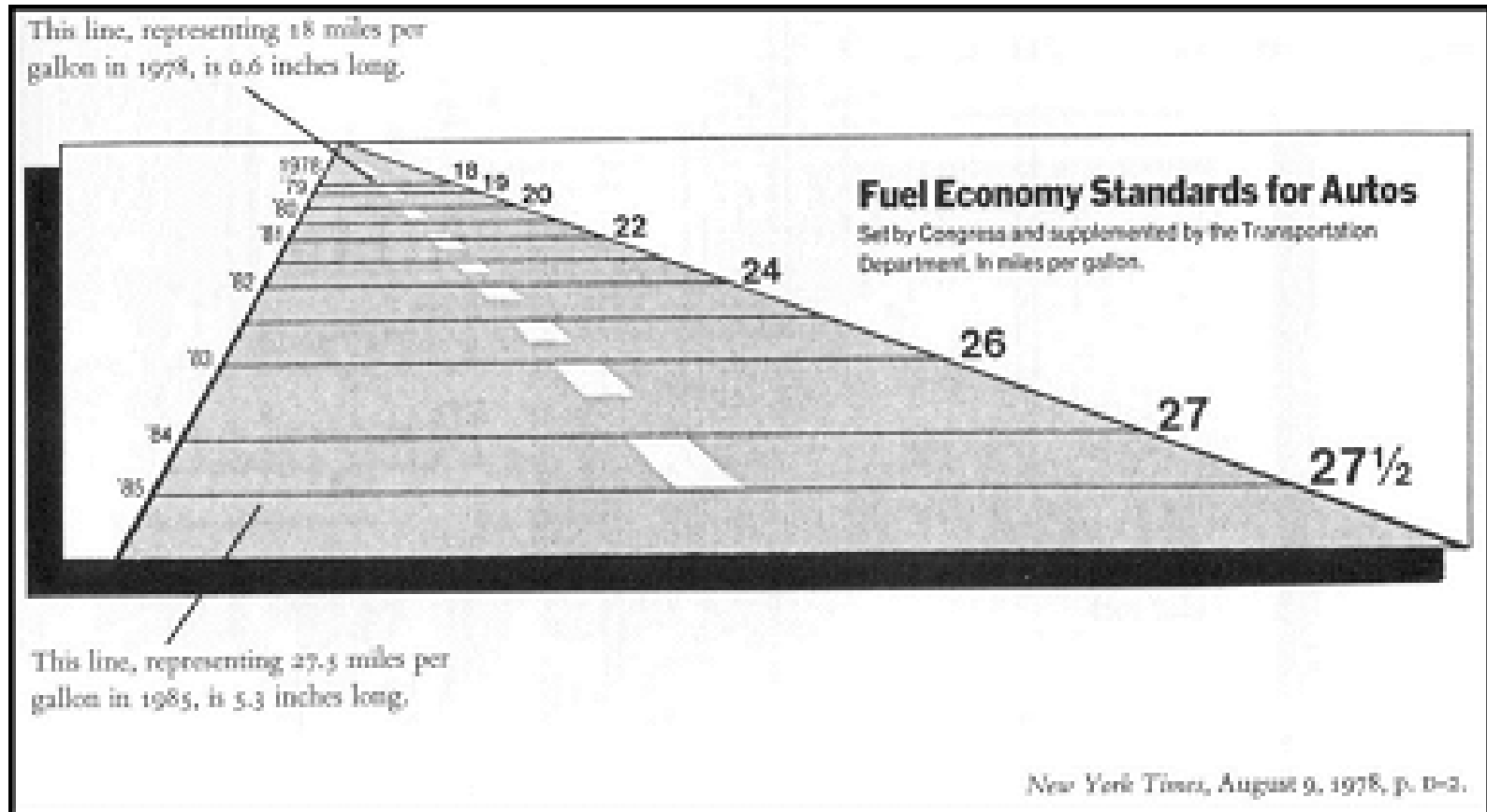
- Representation of numbers: the numbers should be directly proportional
- Clear, detailed and thorough labeling: write out explanations and label important events

First Principle:

$$\textit{Lie Factor} = \frac{\textit{size of effect shown in graphic}}{\textit{size of effect in data}}$$

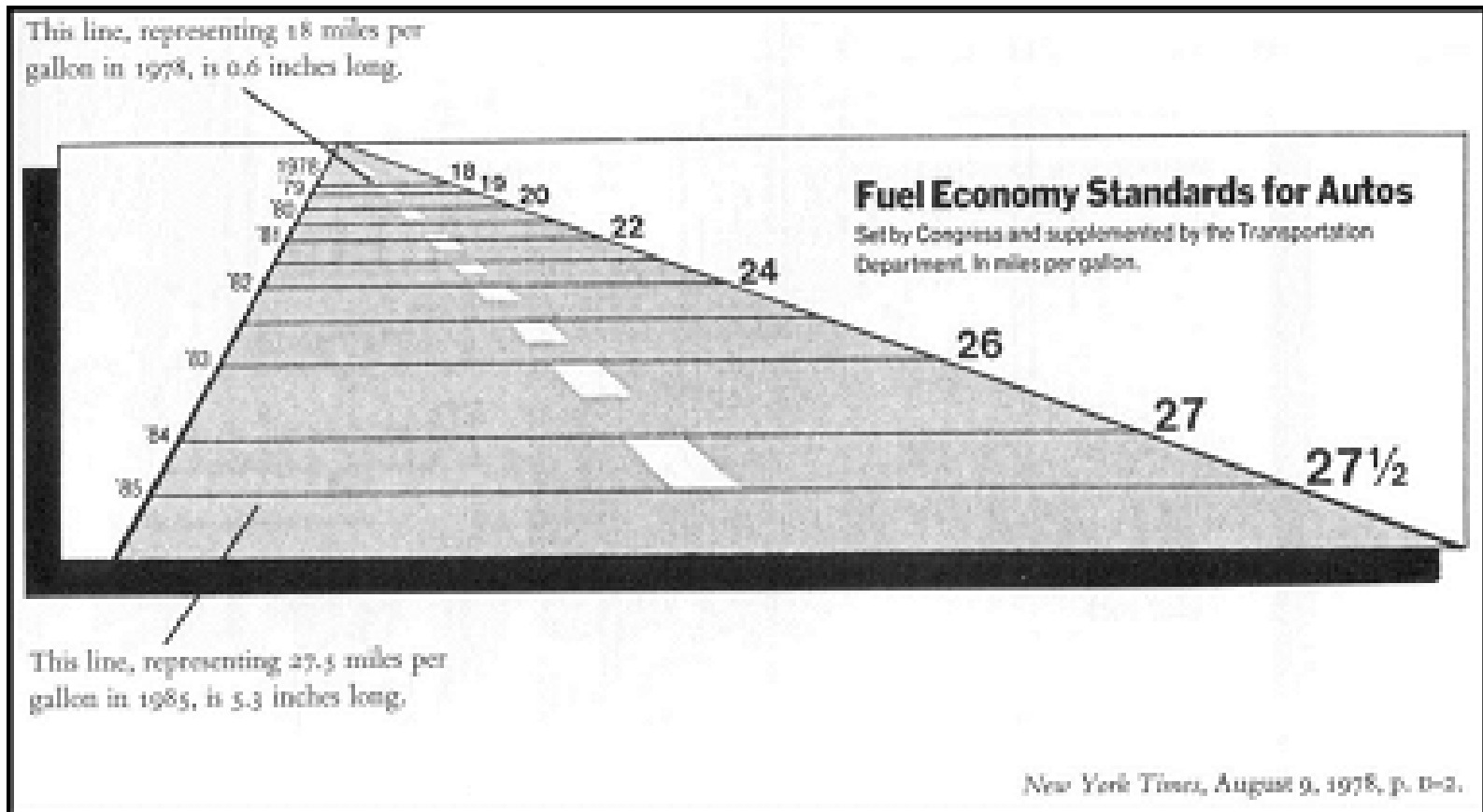
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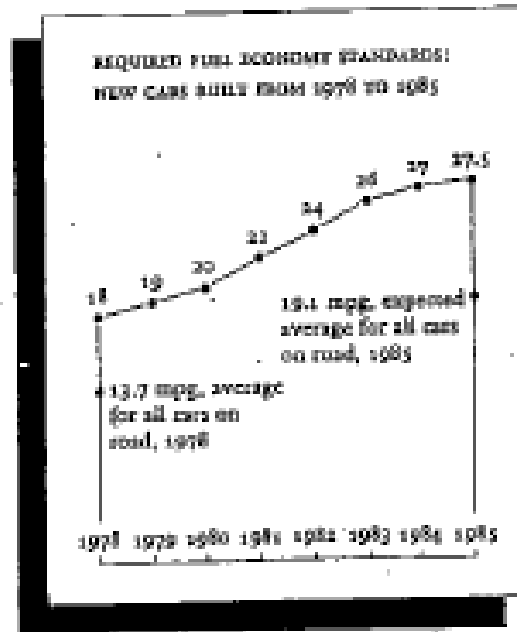


## First Principle:

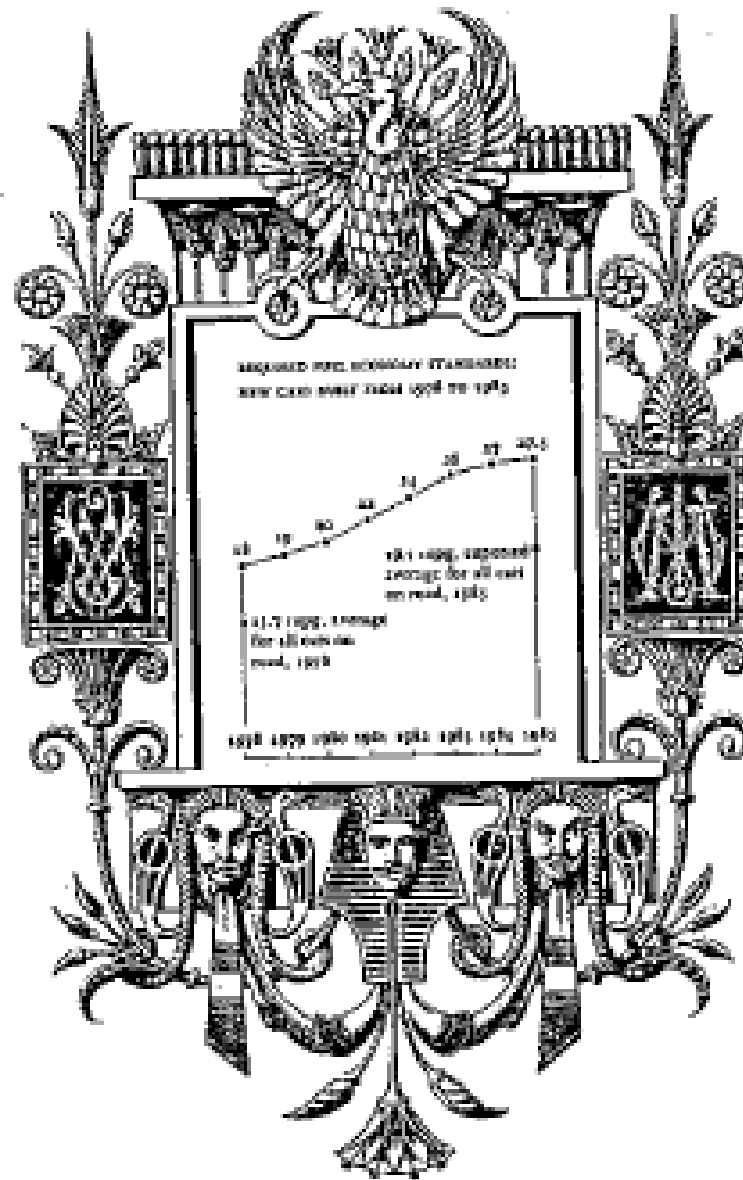
$$\text{Lie Factor} = \frac{783}{53} = 14,8\%$$



# First Principle:

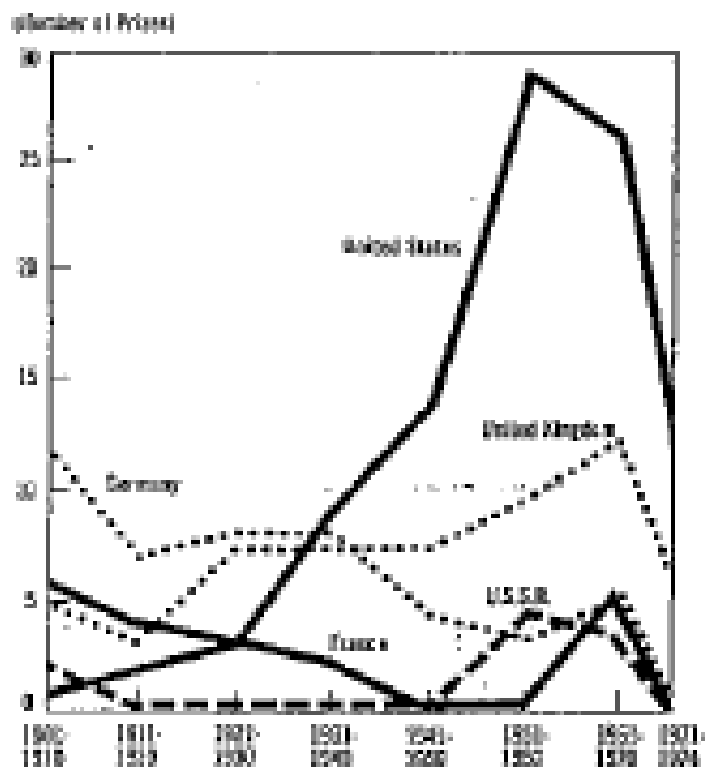


# First Principle:



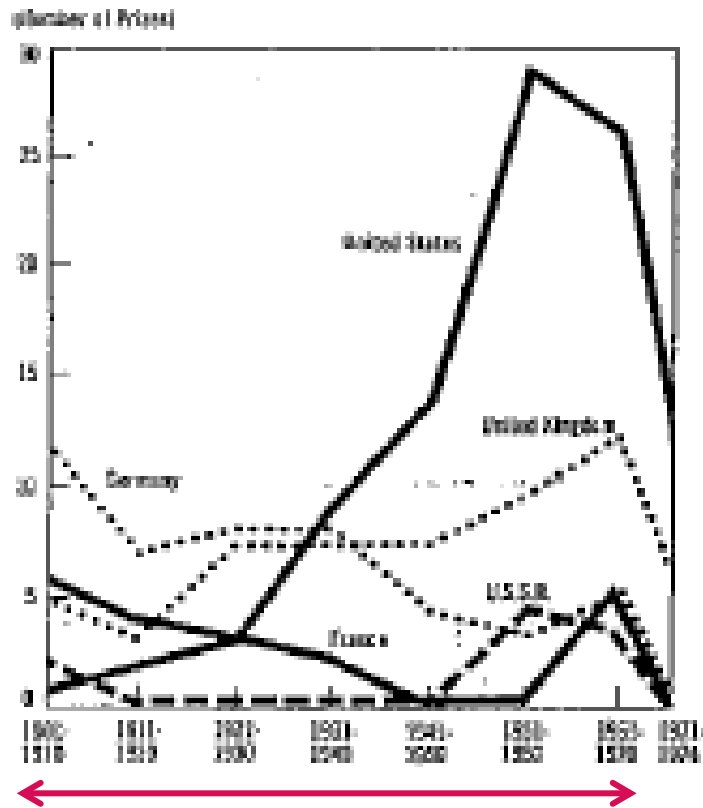
# Design and Data Variation:

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



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**Nobel Prizes Awarded in Science,  
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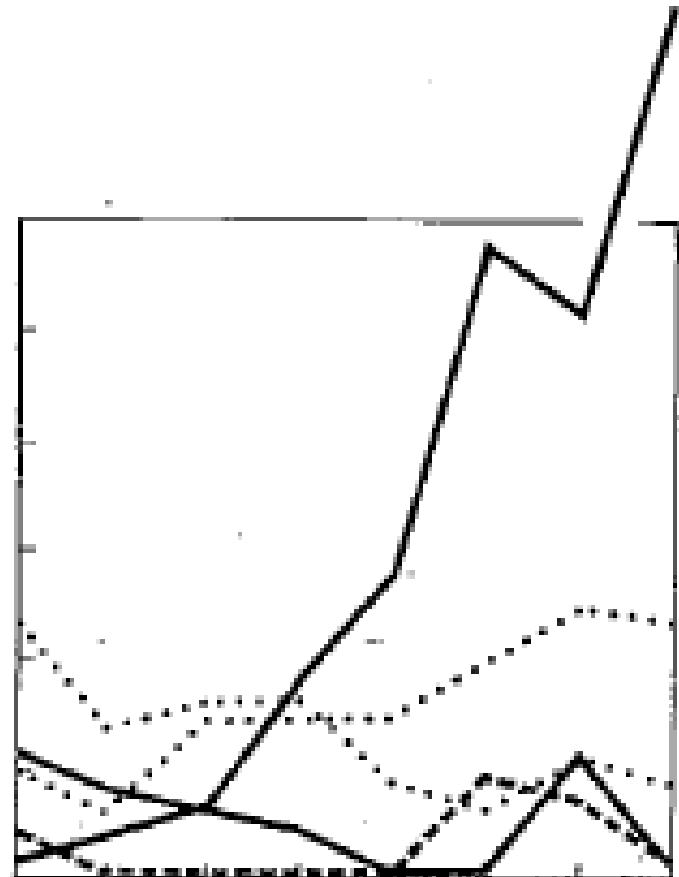
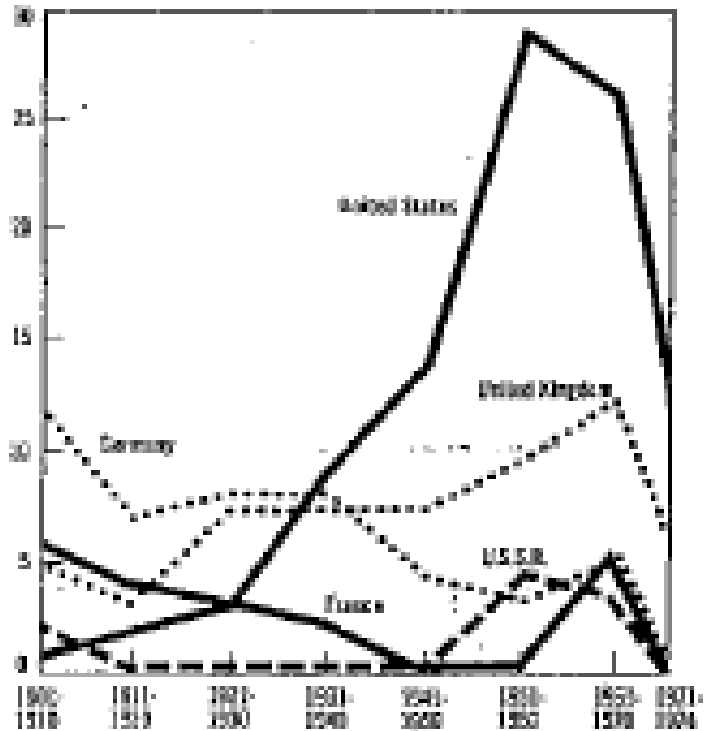


# Design and Data Variation:

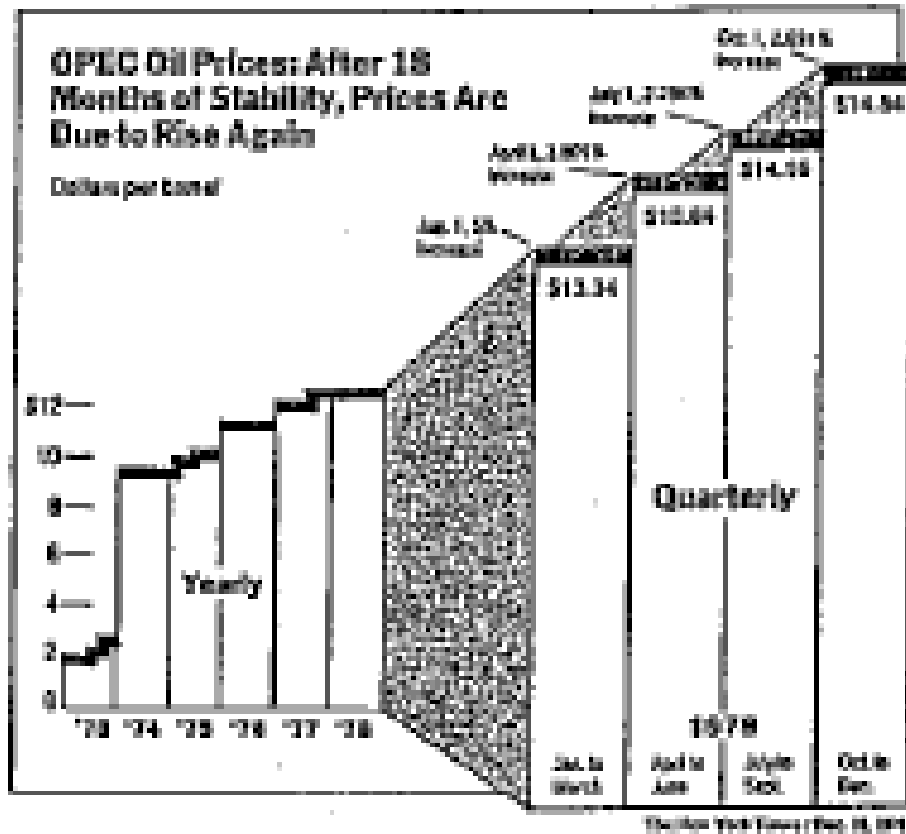
show data variation, not design variation

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

(Number of Prizes)



# Design and Data Variation:

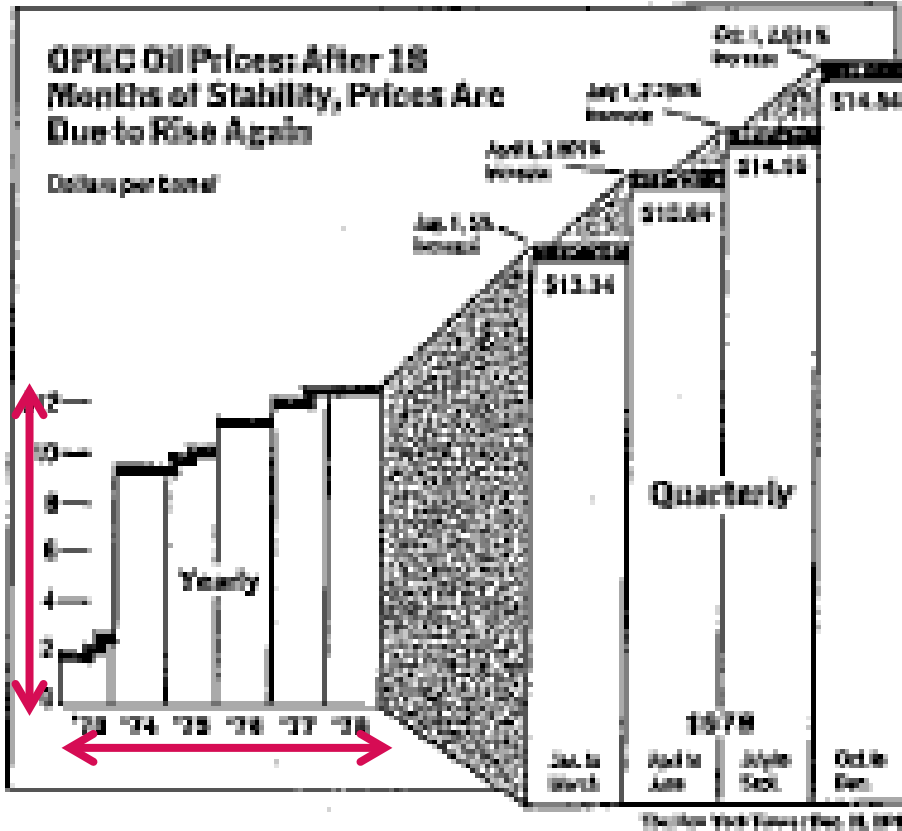


# Design and Data Variation:

Prices:

'73-78'

1 inch = \$8.00

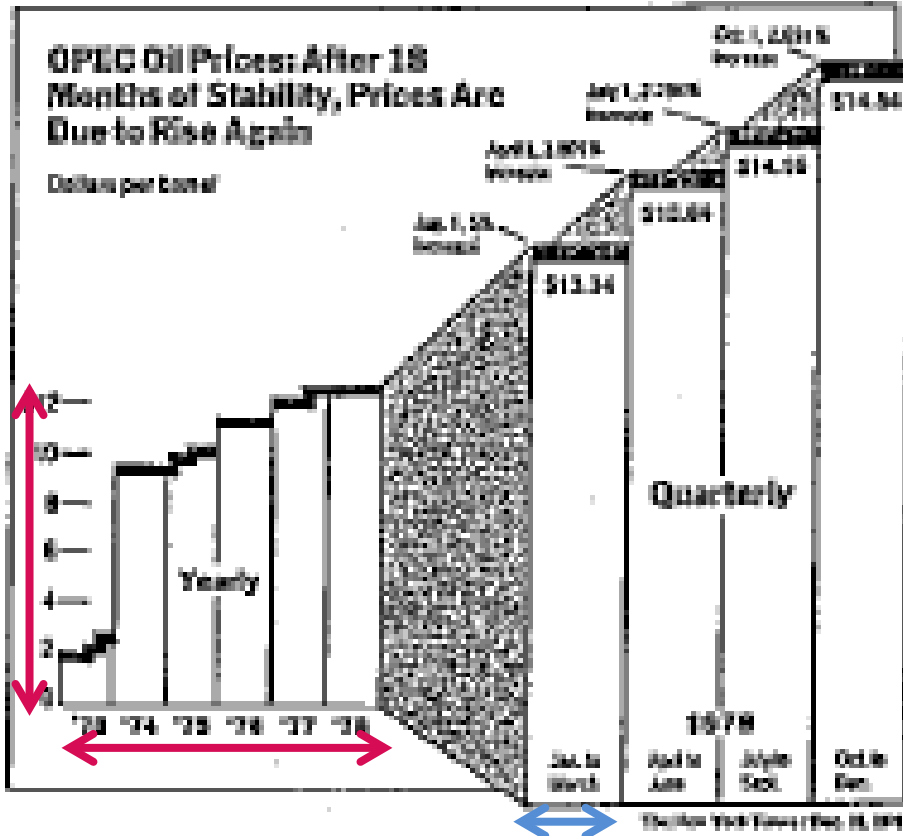


# Design and Data Variation:

Prices:

'73-78'  
Jan-March

1inch=\$8.00  
1inch=\$4.73

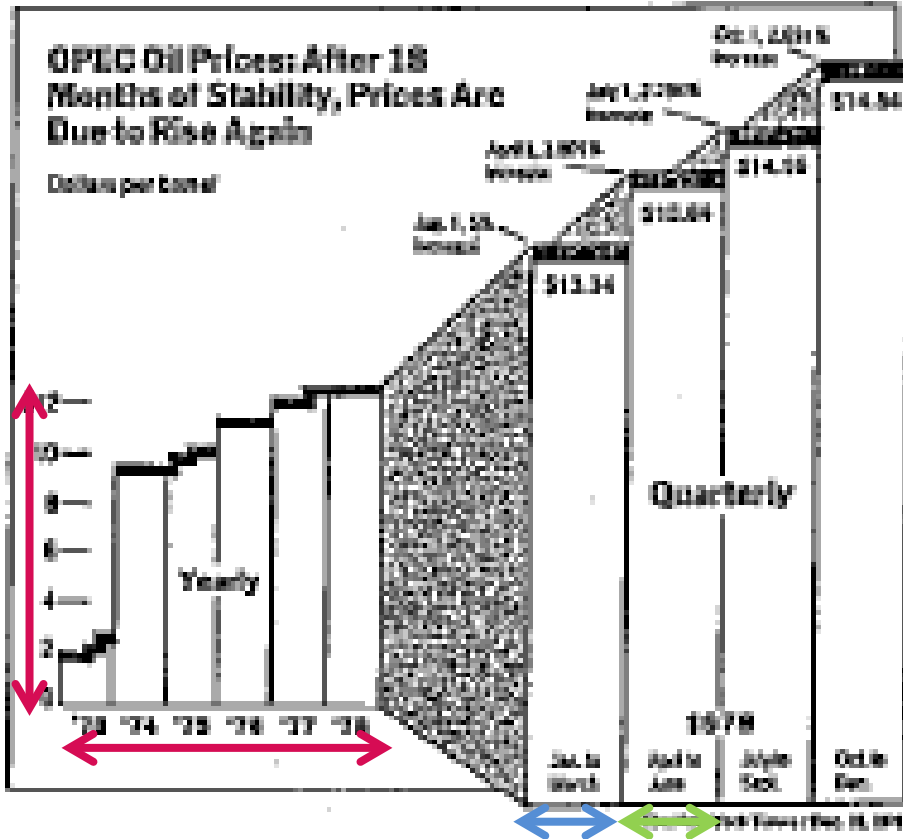


# Design and Data Variation:

Prices:

'73-78  
Jan-March  
Apr-June

1 inch = \$8.00  
1 inch = \$4.73  
1 inch = \$4.37



# Design and Data Variation:

Prices:

'73-78'

Jan-March

Apr-June

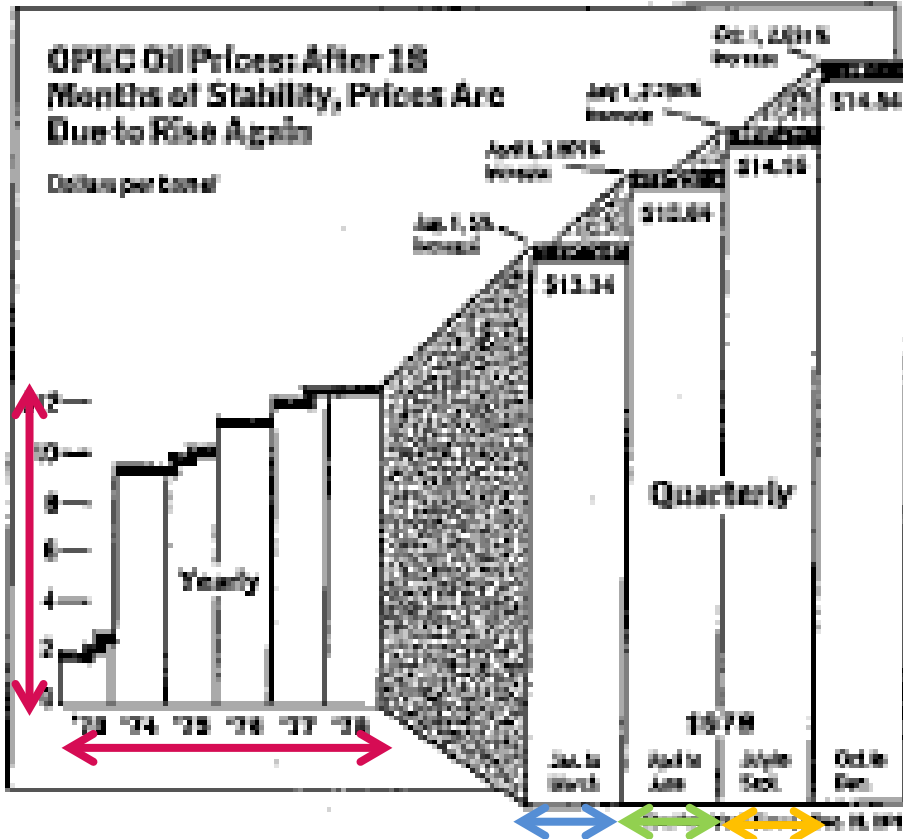
July-Sept

1inch=\$8.00

1inch=\$4.73

1inch=\$4.37

1inch=\$4.16



# Design and Data Variation:

Prices:

'73-78'

Jan-March

Apr-June

July-Sept

Oct-Dec

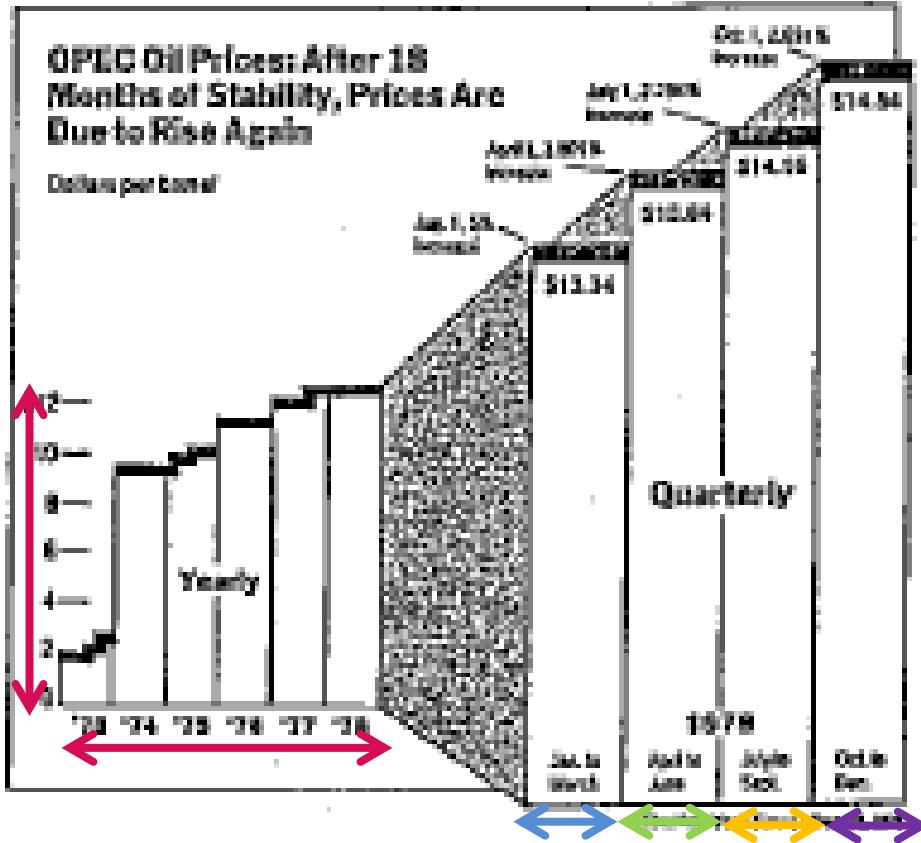
1 inch = \$8.00

1 inch = \$4.73

1 inch = \$4.37

1 inch = \$4.16

1 inch = \$3.92



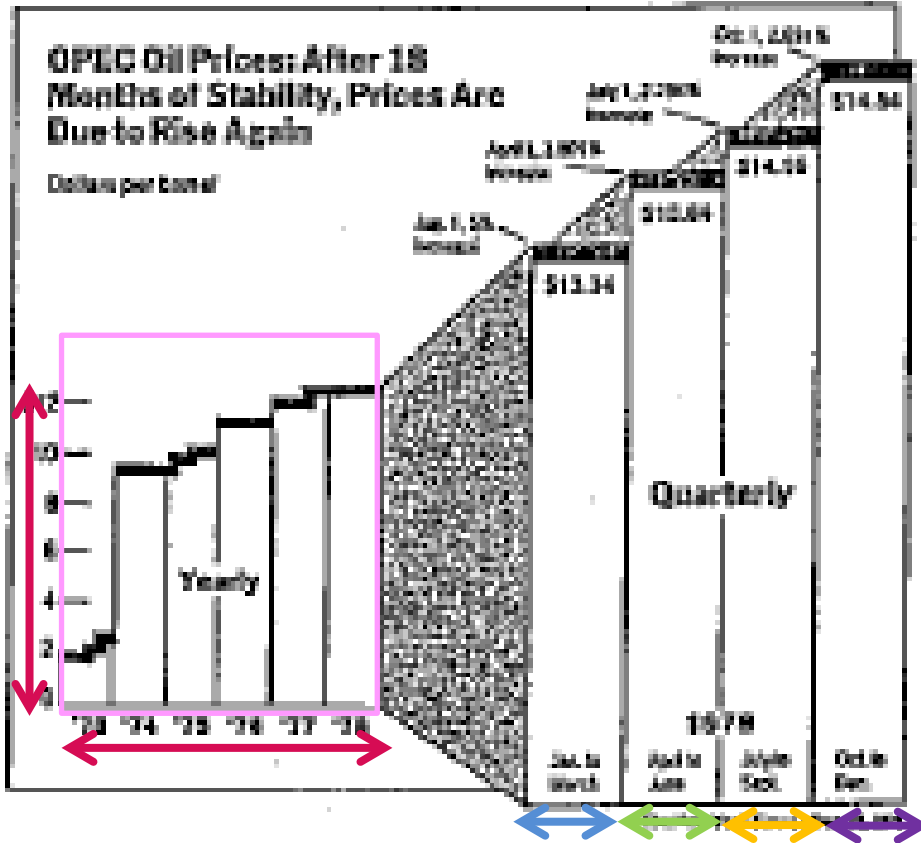
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Prices:

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Apr-June	1 inch = \$4.37
July-Sept	1 inch = \$4.16
Oct-Dec	1 inch = \$3.92

Time:

1973-1978	1 inch = 3,8yrs
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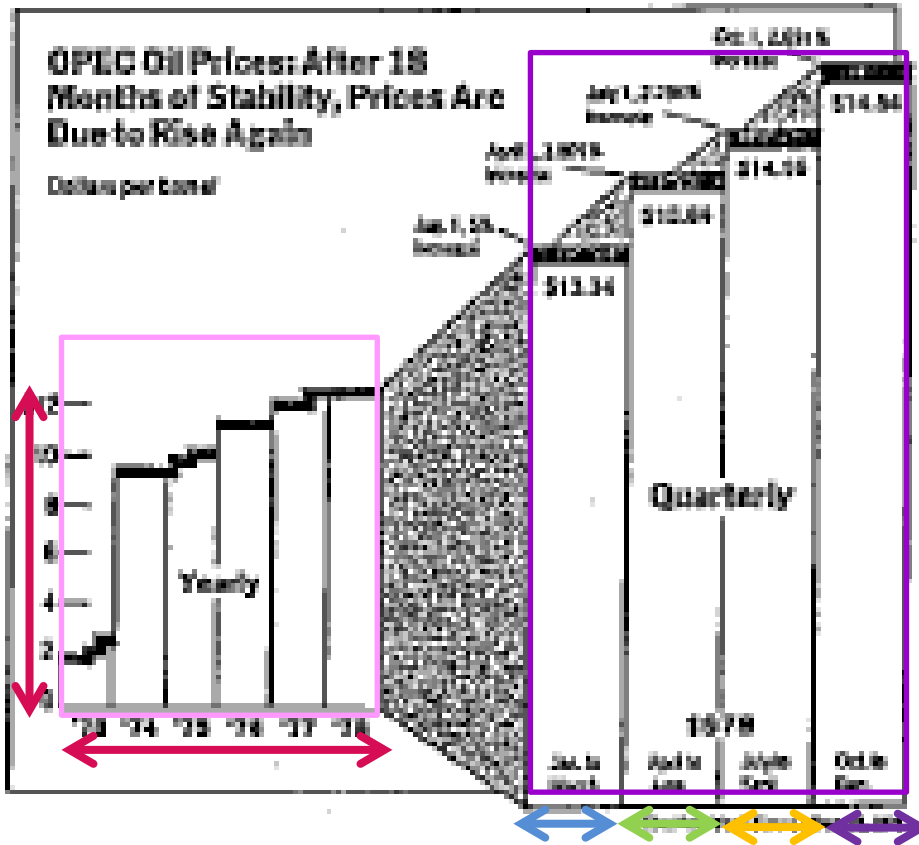
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Time:

1973-1978	1 inch = 3.8yrs
1979	1 inch = 0.57yrs



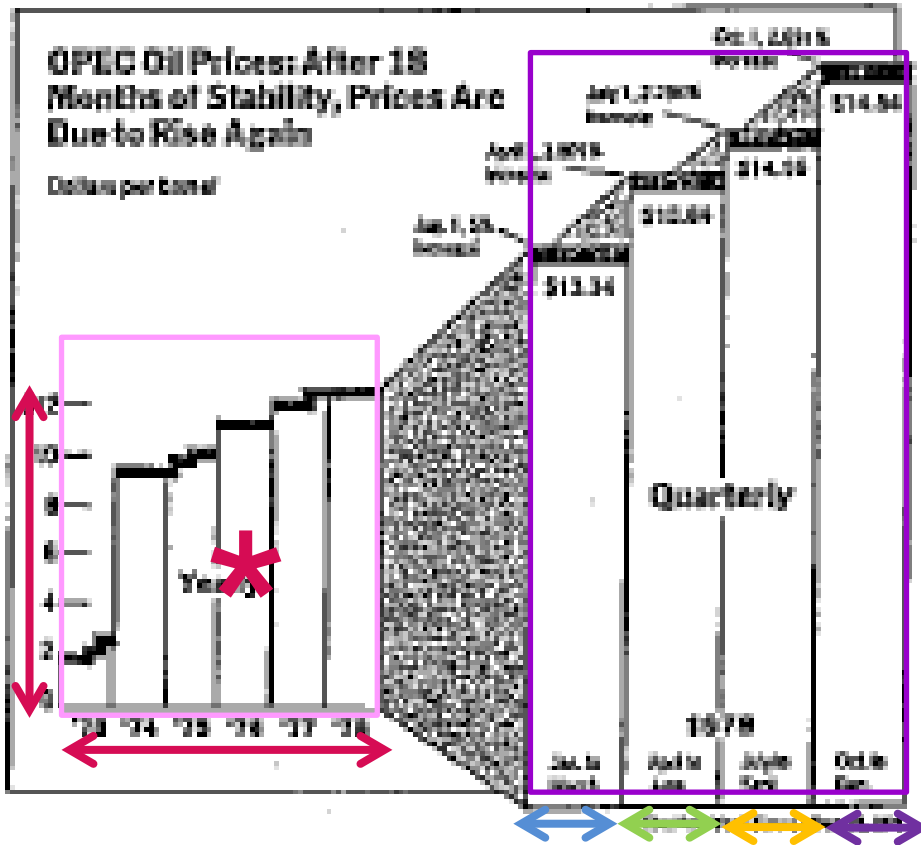
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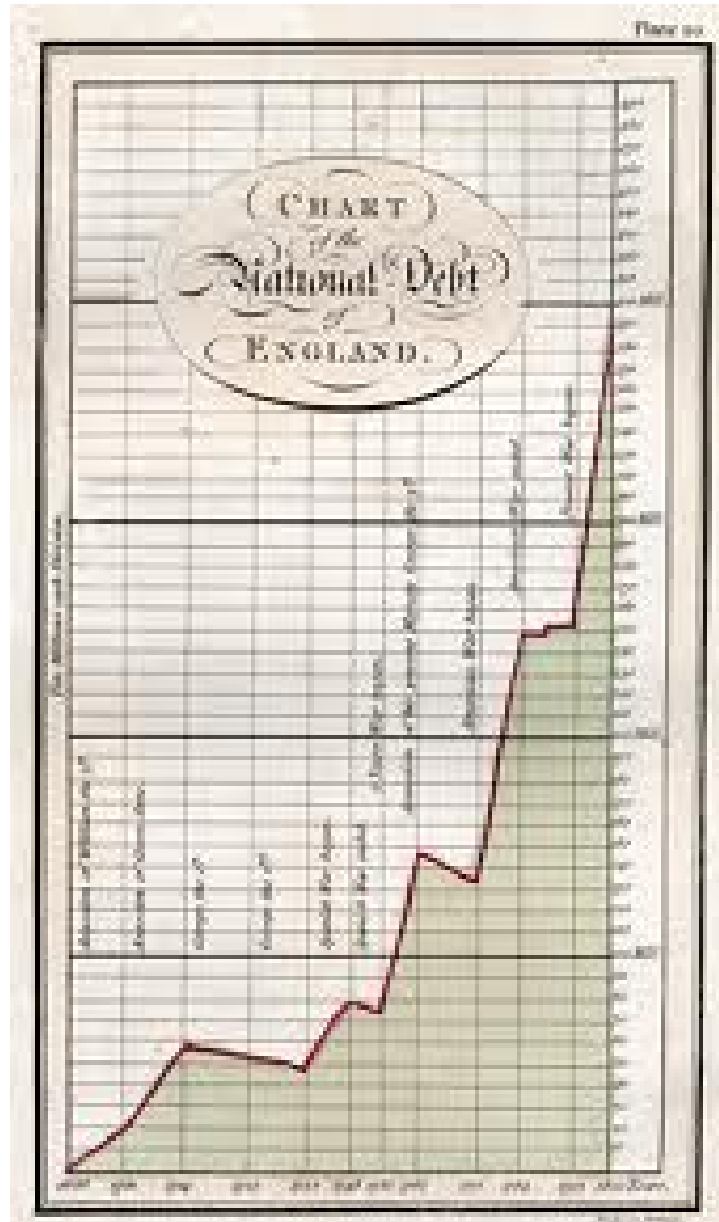
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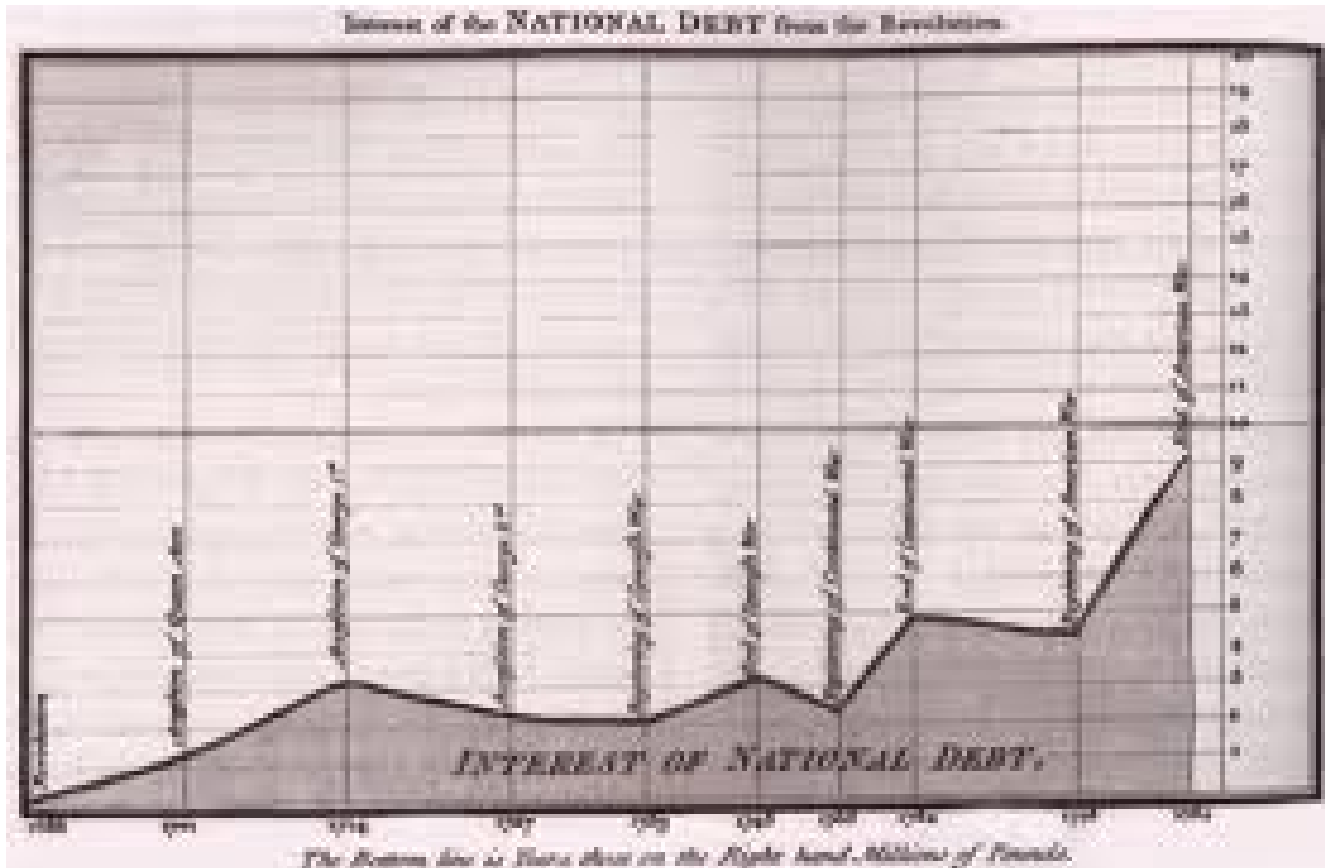
# The Case of Skyrocketing Government Spending:

-Playfair, 1786



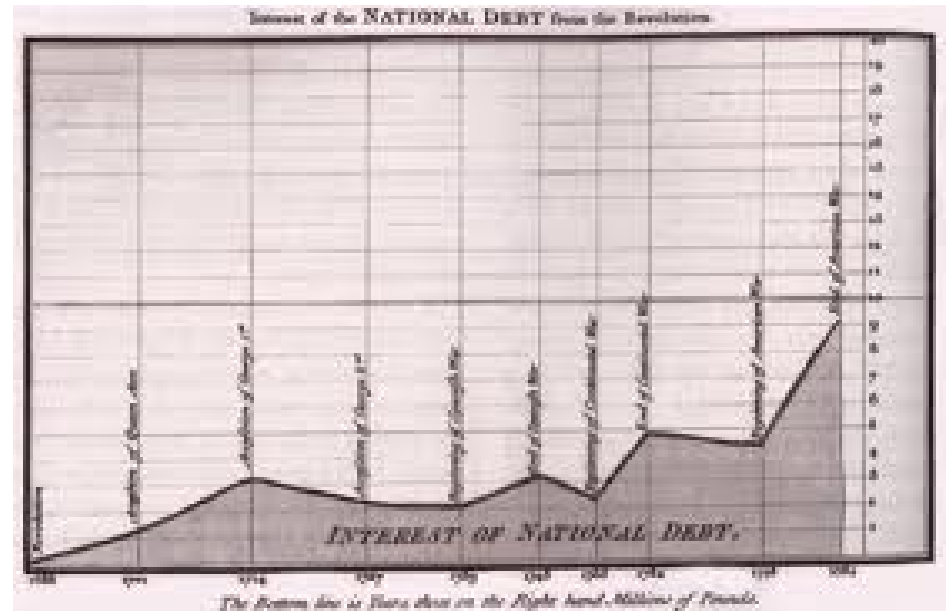
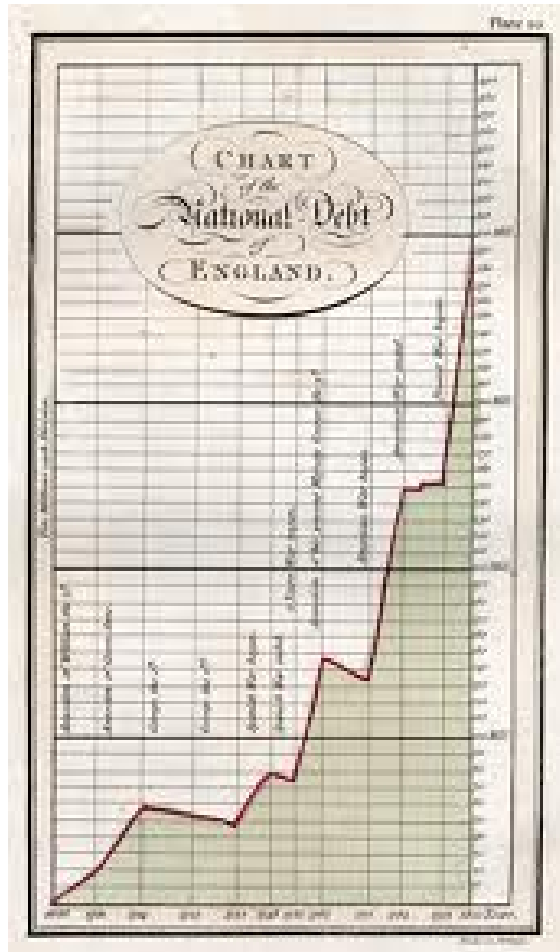
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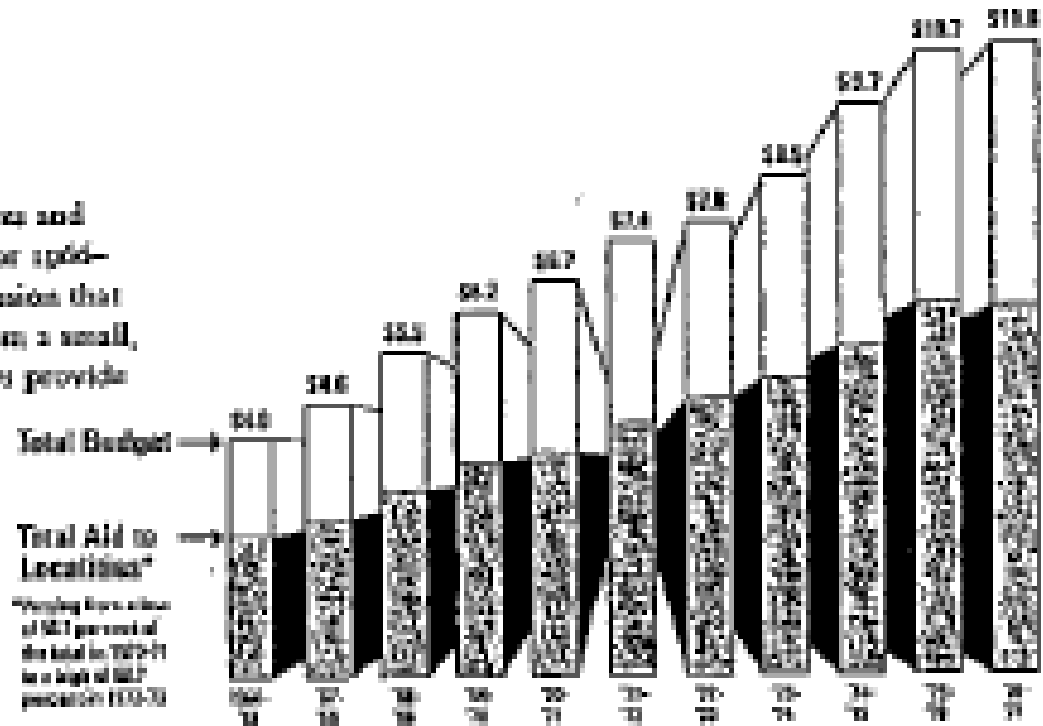
-Playfair, 1786



# The Case of Skyrocketing Government Spending:

-New York Times, Feb 1, 1976

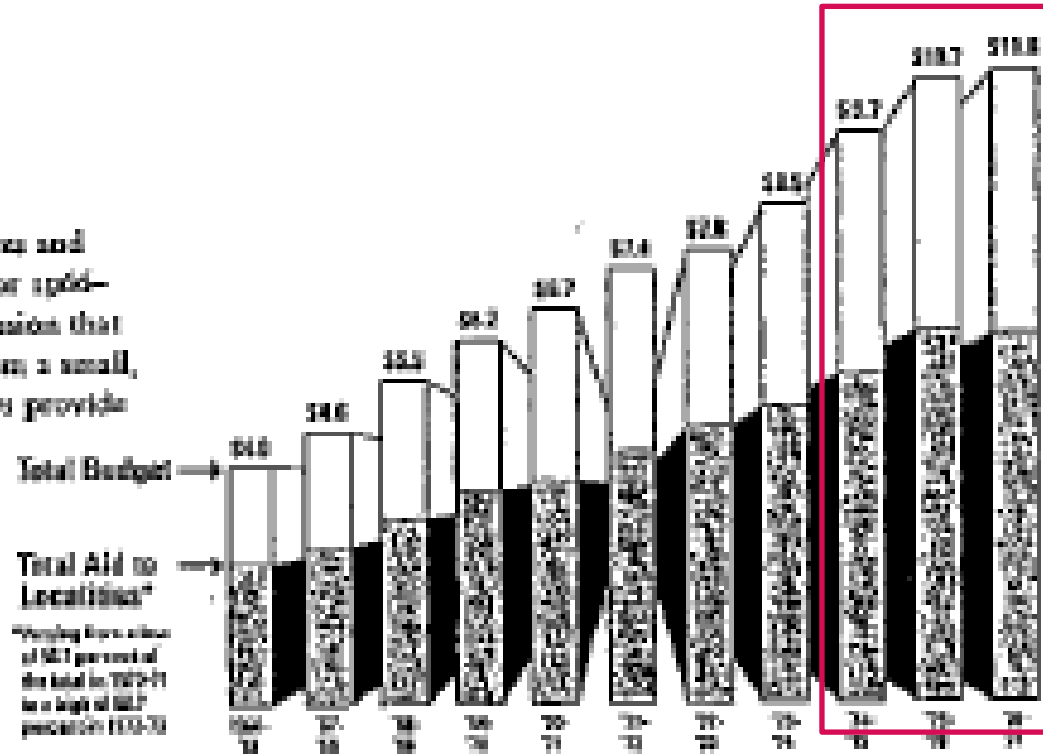
This cluster of type emphasizes and stretches out the low value for 1968-1969, encouraging the impression that recent years have shot up from a small, stable base. Horizontal arrows provide similar emphasis.



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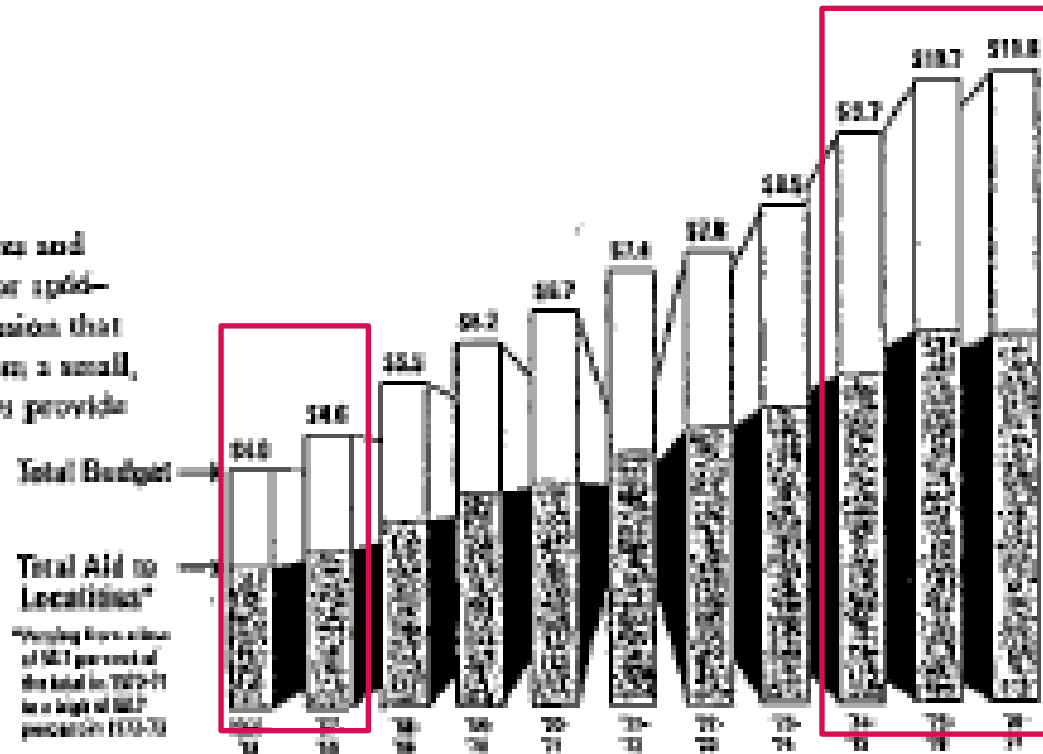
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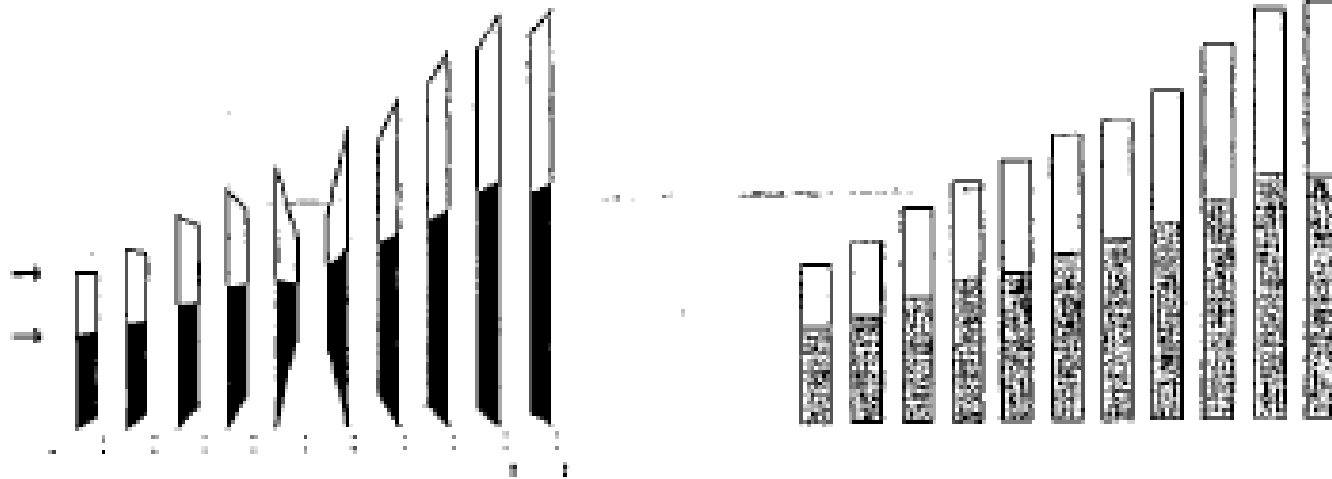
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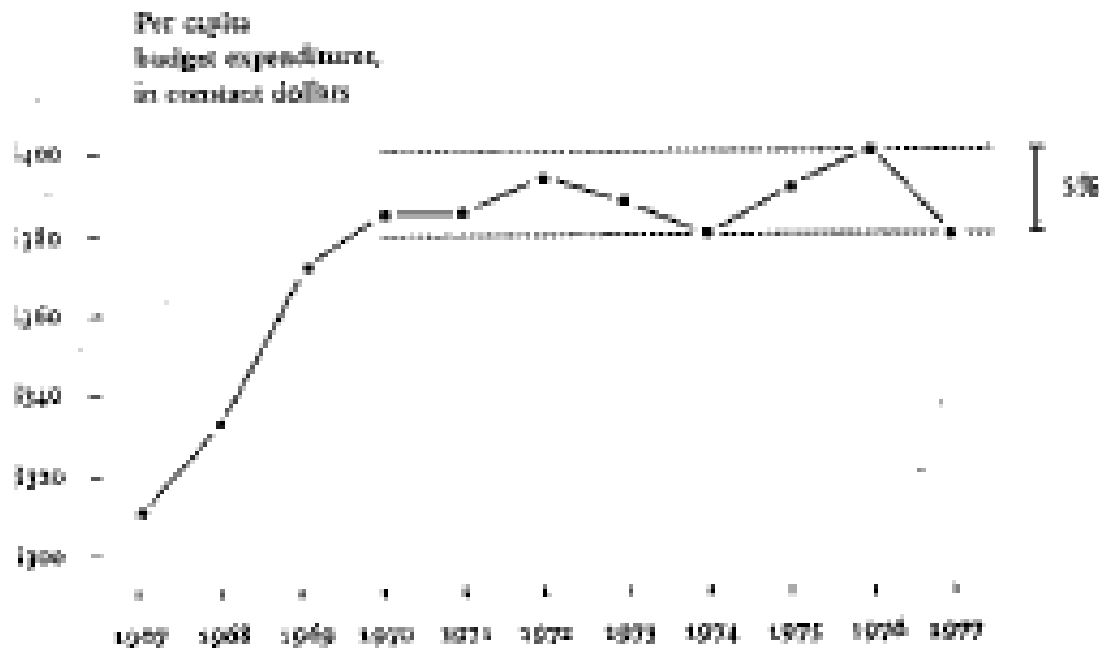
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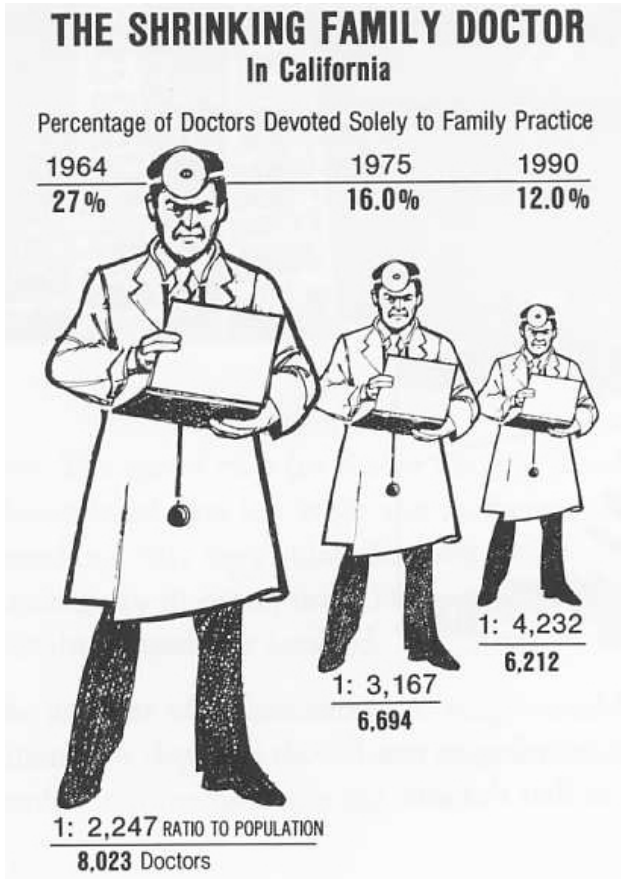
**The Principle:** In **time-series of money**, deflated and standardized units of monetary measurement are better than nominal units.



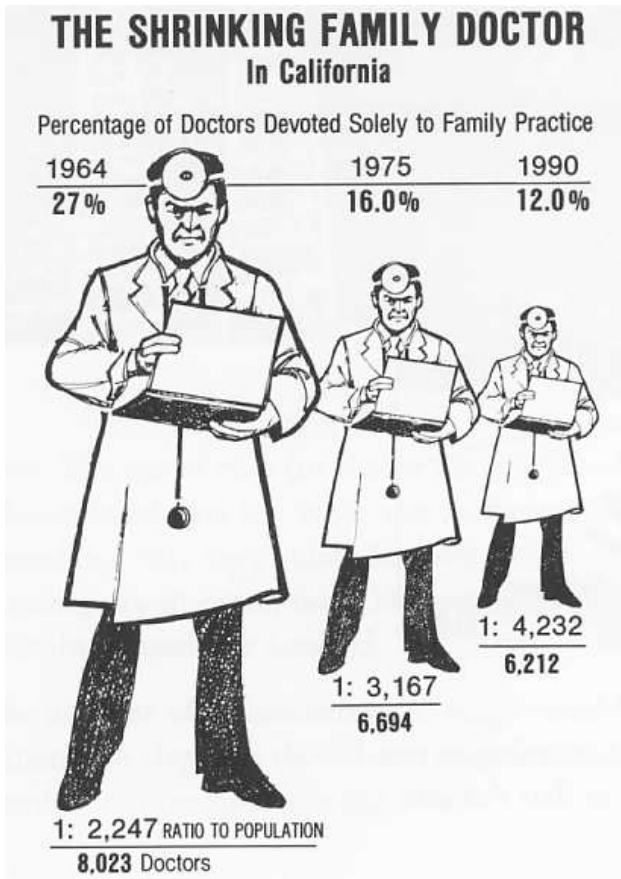
# Visual Area and Numerical Measure:



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## 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.

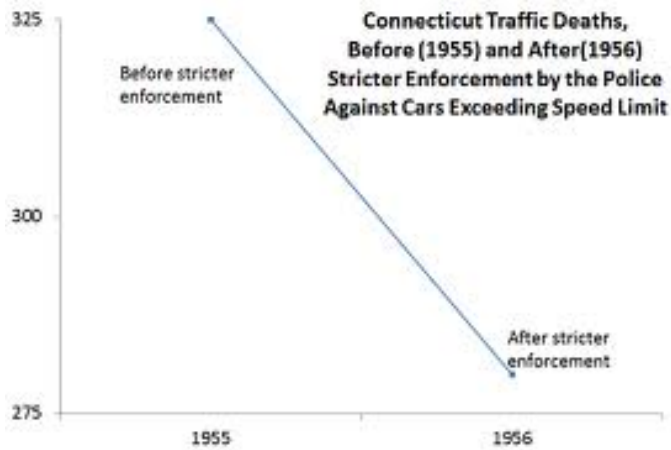
The number of information-carrying dimensions **should not exceed** the number of dimensions in the data.

# Context is Essential for Graphical Integrity:

Graphics **must not** quote **data out of context**.

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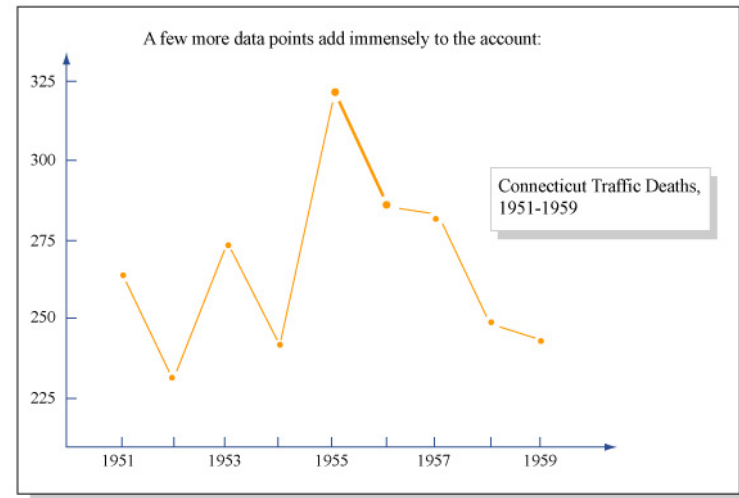
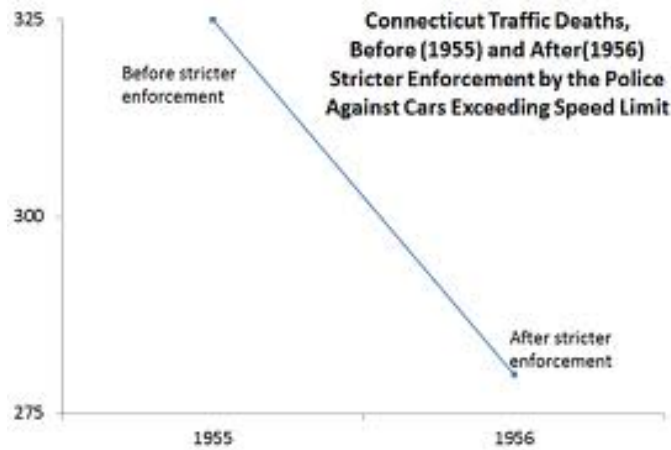
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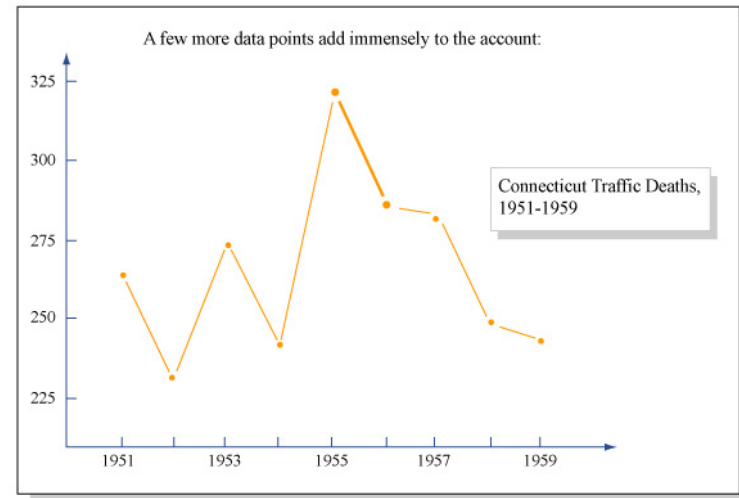
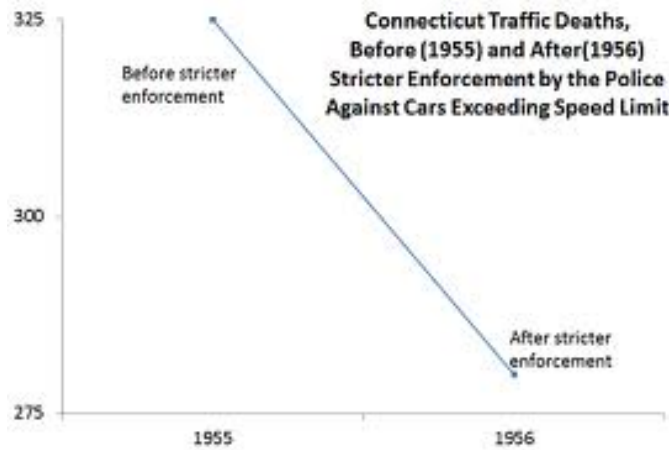
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Lying graphics cheapen the graphical art everywhere.

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Thank you for the attention.