

My Life in Pictures

Tales of a Graphic Developer and Amateur Historian of #datavis

Michael Friendly

 @datavisFriendly || <http://datavis.ca>



York University

Uncharted Software, April 12, 2022

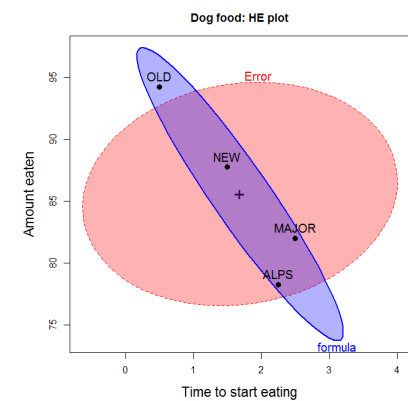
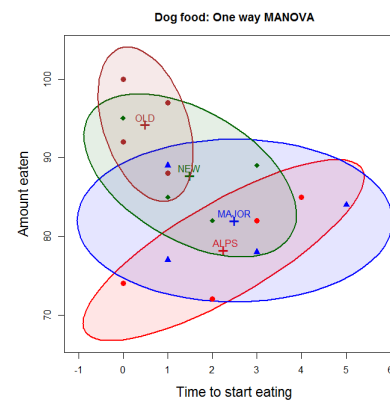
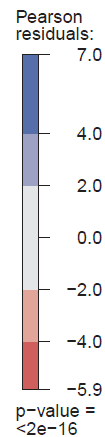
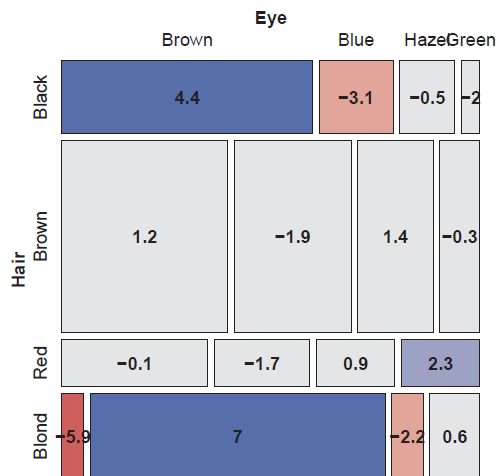
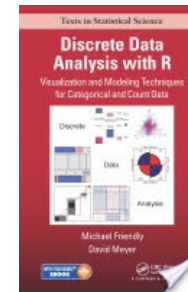
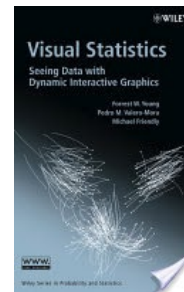
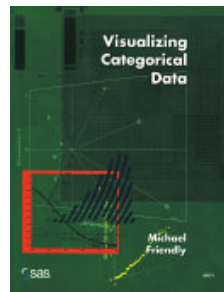
Introducing: me

I wear two hats, both reflected on my license plate:

Statistical graphics developer (categorical & multivariate data analysis)



Yours to discover!



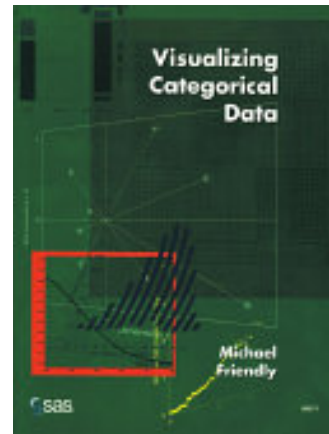
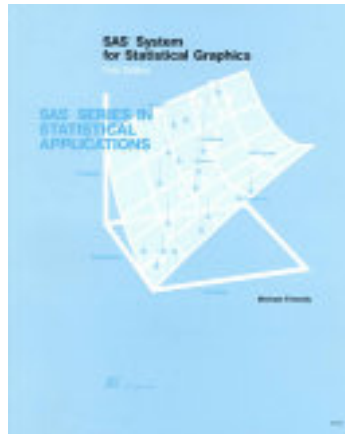
mosaic plots for frequency tables

HE plots for MANOVA

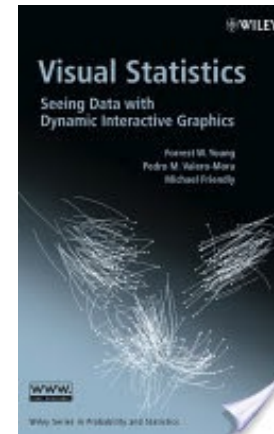
Books: Theory → Practice

Tukey's maxim (Tukey, 1959):

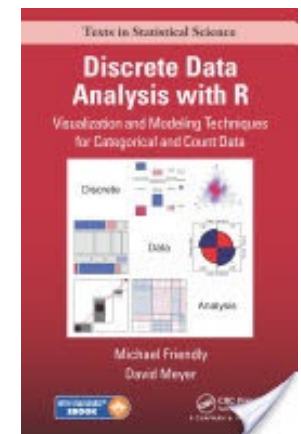
*The **practical power** of any statistical method =
Statistical power × Probability anyone will use it*



<https://www.datavis.ca/books/vcd/>



<https://bit.ly/3L7uPOC>

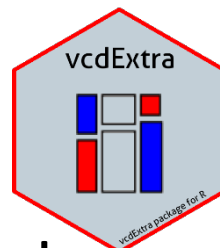


<http://ddar.datavis.ca>

Software: Some R packages

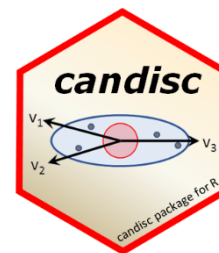
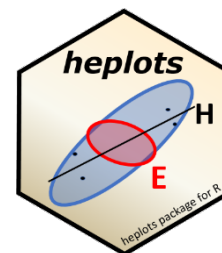
- Categorical data

- vcd & vcdExtra



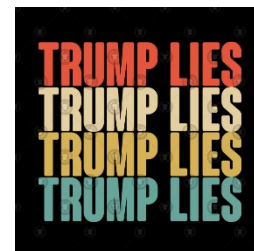
- Linear & multivariate models

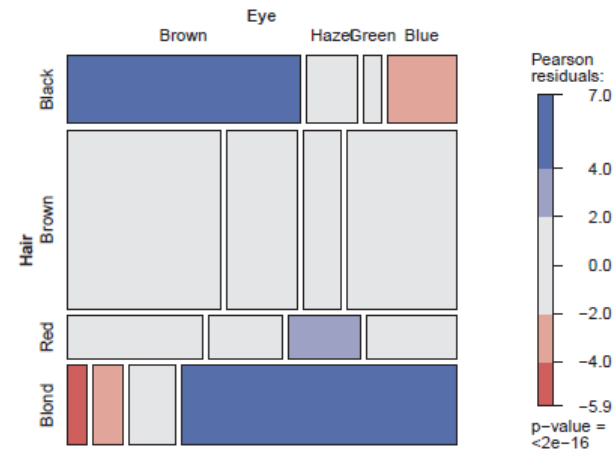
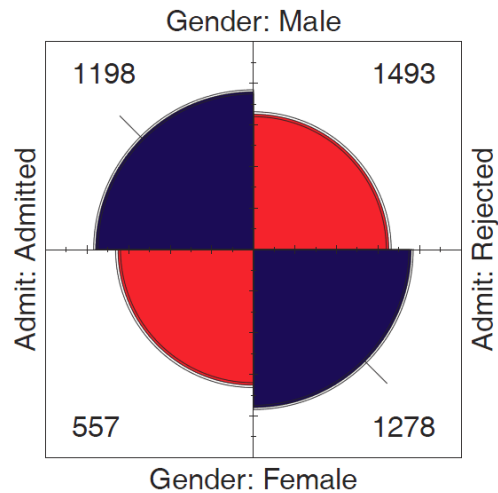
- car: extend graphical methods (John Fox)
- heplots: HE plots & related methods
- candisc: Analyze/view MLMs in low-D space



- Largely data

- Lahman: everything baseball
- HistData: history of statistics & data vis
- TrumpLies: Toronto Star database





Graphical Methods for Complex Problems

- Categorical Data Analysis: Fourfold displays, mosaic plots
- Multivariate Visualization ✘

Gender Bias at UC Berkeley?

Science, 1975, **187**: 398--403

Sex Bias in Graduate Admissions: Data from Berkeley

Measuring bias is harder than is usually assumed,
and the evidence is sometimes contrary to expectation.

P. J. Bickel, E. A. Hammel, J. W. O'Connell

Determining whether discrimination because of sex or ethnic identity is being practiced against persons seeking passage from one social status or locus to another is an important problem in our society today. It is legally impor-

decession to admit or to deny admission.

The question we wish to pursue is whether the decision to admit or to deny was influenced by the sex of the applicant.

We cannot know with any certainty the influences on the evaluators in the

by using a
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2 × 2 Frequency Tables: Fourfold displays

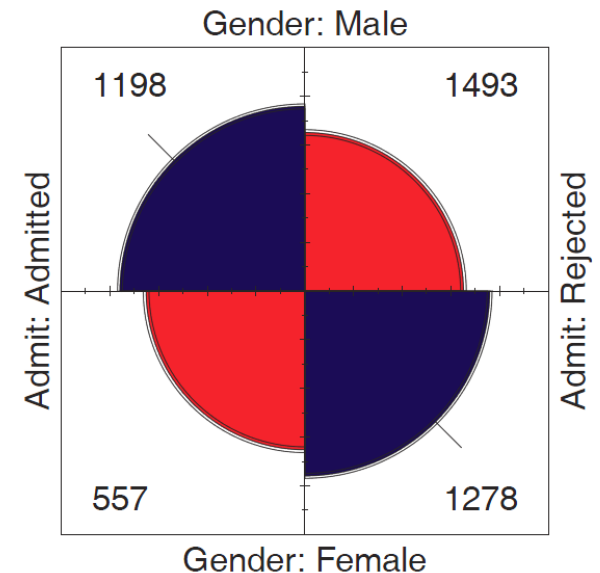
Table: Admissions to Berkeley graduate programs

	Admitted	Rejected	Total	% Admit	Odds(Admit)
Males	1198	1493	2691	44.52	0.802
Females	557	1278	1835	30.35	0.437
Total	1755	2771	4526	38.78	0.633

odds ratio (θ) = 1.84

Males nearly **twice** as likely to be admitted

- Is this a “significant” association?
- Is it evidence for gender bias?
- How to measure strength of association?
- How to visualize?



Fourfold display:

- quarter circles, area \sim frequency
- ratio of areas: odds ratio (θ)
- confidence bands: overlap iff $\theta \approx 1$

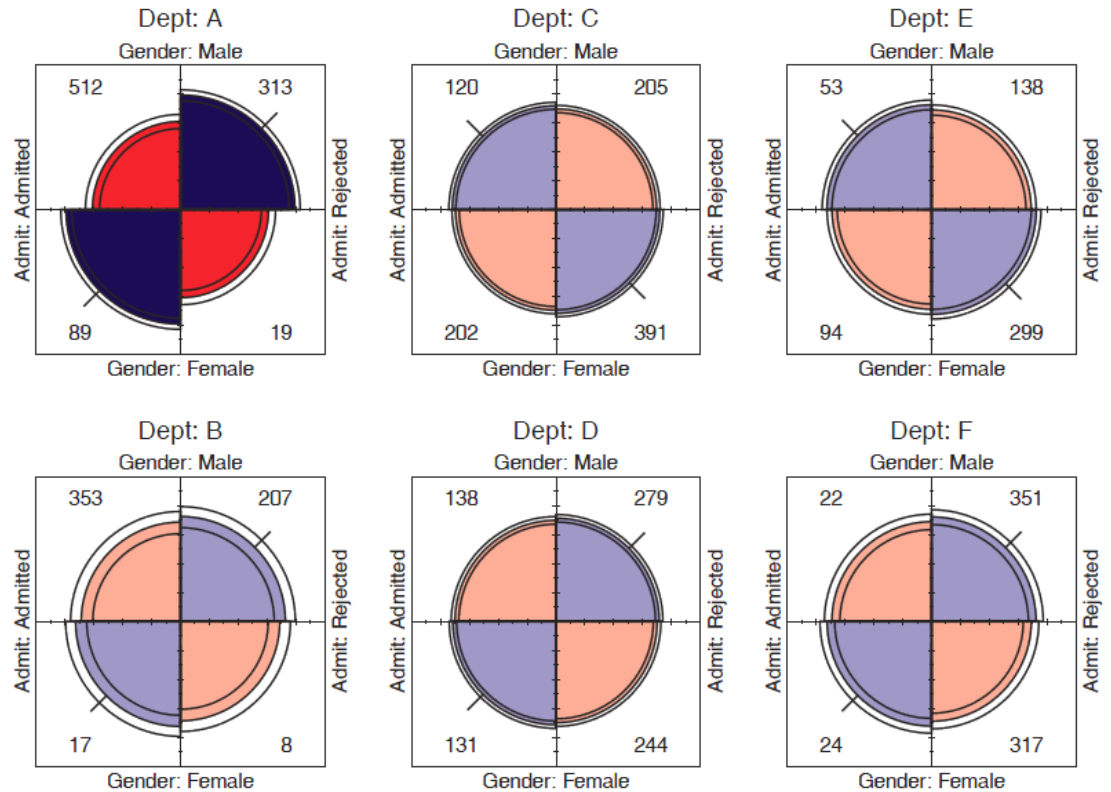
2 × 2 × k Stratified tables

The data arose from 6 graduate departments

No difference between males & females, except in Dept A where women more likely to be admitted!

Design:

- small multiples
- encode direction by color
- encode signif. by shading

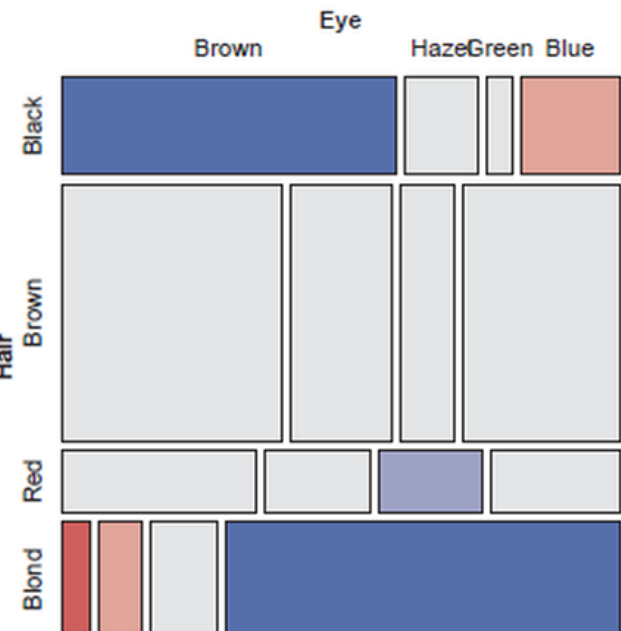


$r \times c$ Tables: Mosaic plots

Table: Hair-color eye-color data

Eye Color	Hair Color				Total
	Black	Brown	Red	Blond	
Brown	68	119	26	7	220
Blue	20	84	17	94	215
Hazel	15	54	14	10	93
Green	5	29	14	16	64
Total	108	286	71	127	592

Students in a large statistics class were categorized by hair color and eye color



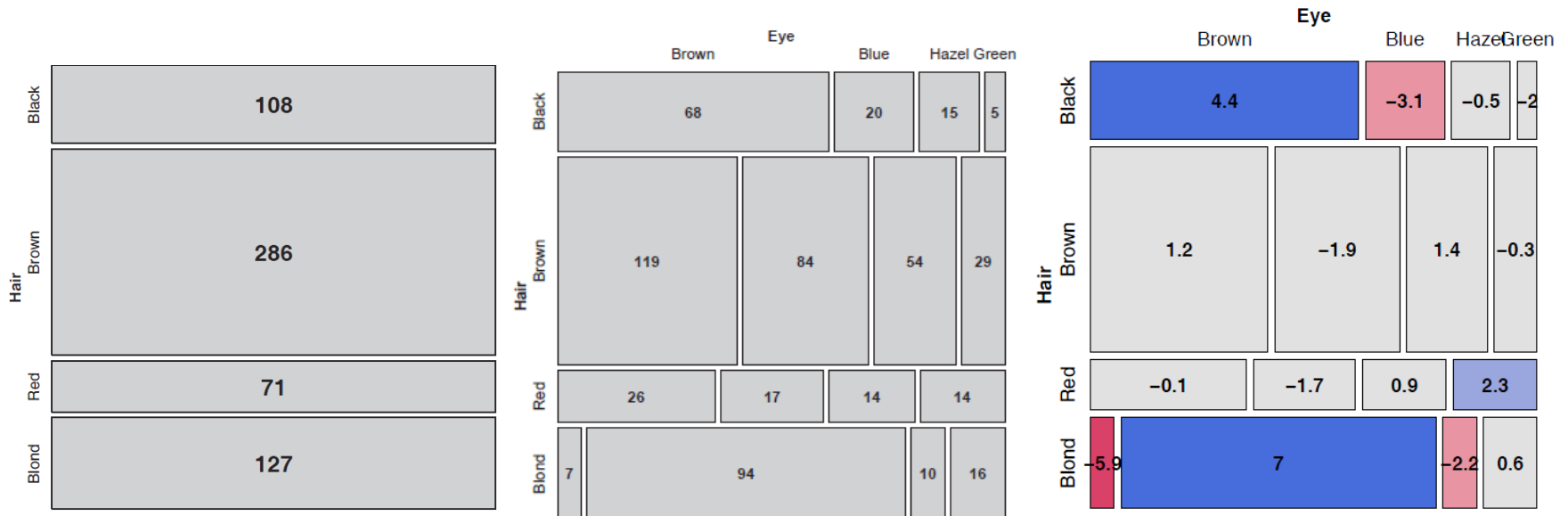
Are hair color and eye color associated?

How to visualize?

How to understand the pattern of association?

Mosaic plots

Area proportional display of frequencies in n-way table
Shaded according to deviation from independence



Divide unit square ~ V1
marginal frequencies

Subdivide each ~ V2 | V1
conditional frequencies

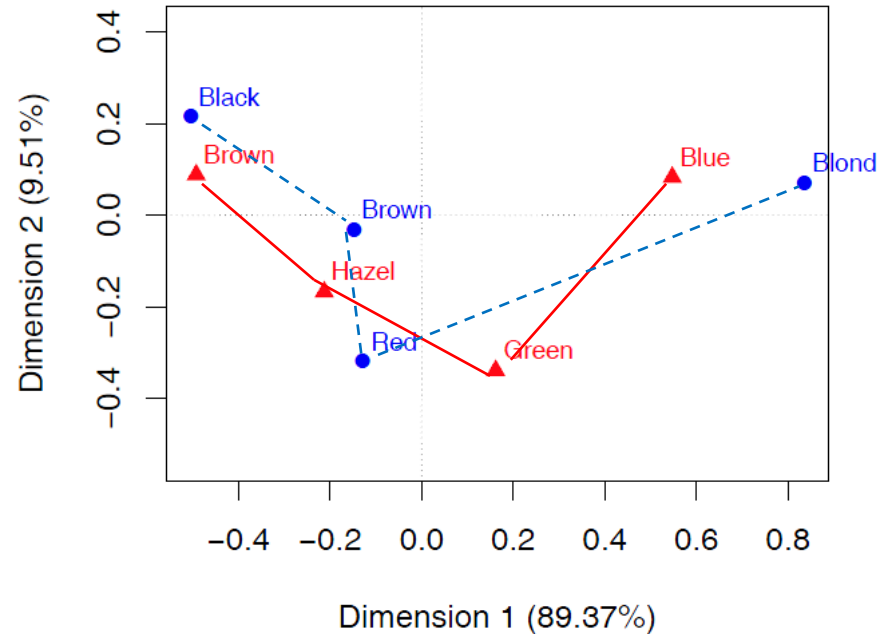
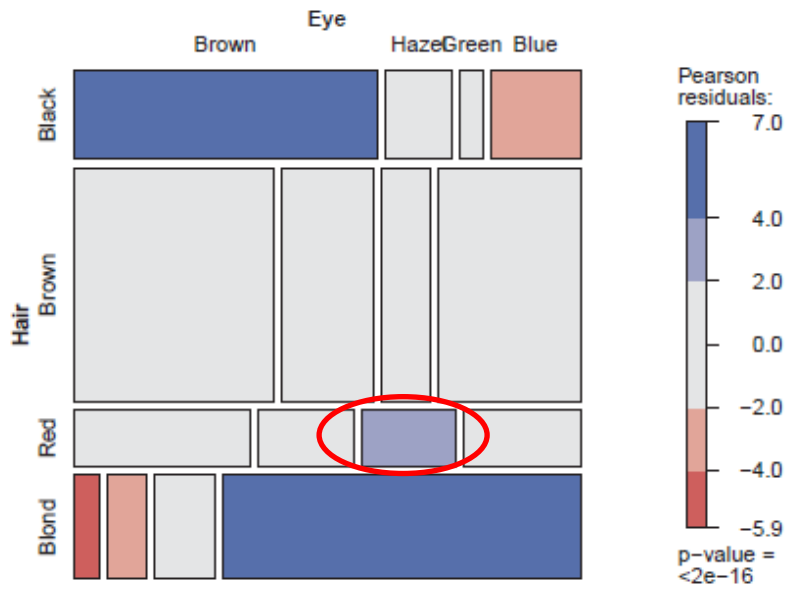
Shade ~ residual (d_{ij})

positive: $O > E$

negative: $O < E$

$$d_{ij} = \frac{(O_{ij} - E_{ij})}{\sqrt{E_{ij}}} \quad \chi^2 = \sum d_{ij}^2$$

Mosaic plots & other methods



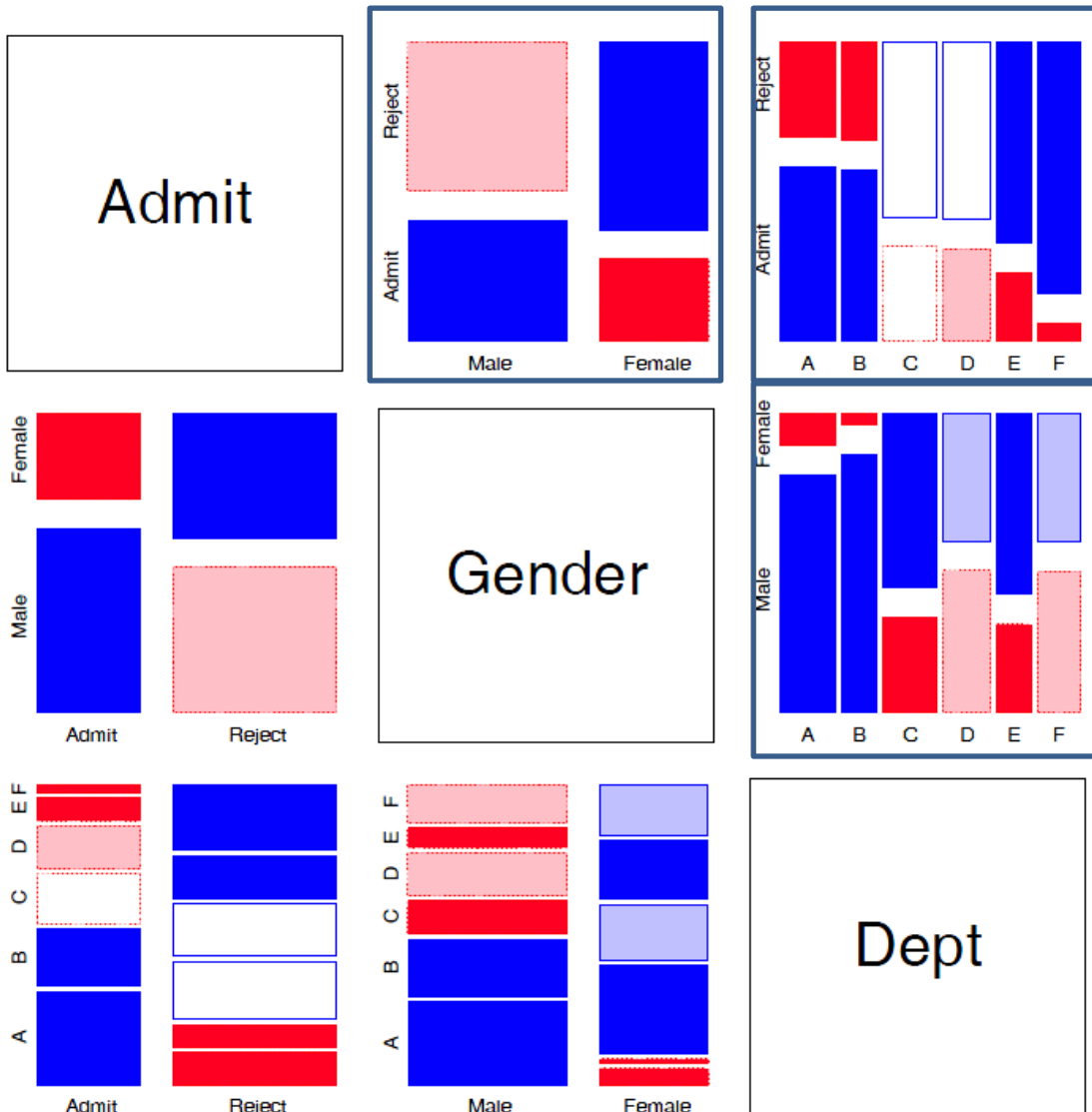
Opposite corner pattern of shading:

- dark hair associated with dark eyes
- (red hair, hazel eyes) unusual

Correspondence analysis:

- like PCA for frequency data.
- The association is 90% 1-D

Mosaic matrices



Scatterplot matrix analog for categorical data

All pairwise views

The answer: Simpson's Paradox

- Depts A, B were easiest
- Applicants to A, B mostly male
- \therefore Males more likely to be admitted overall

Race & Crime

Toronto Star investigation of racial disparities in treatment by Toronto Police Services

FOI request → ½ M arrests, 1997—2002

Evidence for racial profiling?

Only look at discretionary charges:

Simple marijuana possession
Non-moving auto infractions



The photo that never was
GARTH WOOLSEY, C3

Also inside . . .

- **Waterfront:** Dreams of what could be, B1, B4-5
- **Hydro woes:** Insulating against price spikes, E1
- **Wheels:** The Bug goes rootless, G1
- **Paul Martin:** The man who would be king, H1
- **Carol Shields:** Her last novel? Unless . . . J1

Periods of rain; windy. High 14 C

October 19, 2002

thestar.com ONTARIO EDITION

AN INVESTIGATION INTO RACE AND CRIME



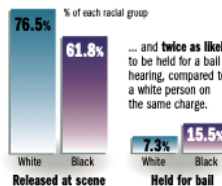
SUING POLICE: Jason Burke, falsely accused of dealing drugs during Caribana two years ago, says he was a victim of racial profiling.

Singled out

Star analysis of police crime data shows justice is different for blacks and whites

Telling numbers

Police records show that a black person in Toronto arrested on a single drug possession charge was **less likely** to be released at the scene.



... and twice as likely to be held for a bail hearing, compared to a white person on the same charge.

Blacks arrested by Toronto police are treated more harshly than whites, a Toronto Star analysis of crime data shows.

Black people, charged with simple drug possession, are taken to police stations more often than whites facing the same charge.

Once at the station, accused blacks are held overnight, for a bail hearing, at twice the rate of whites.

The Toronto crime data also shows a disproportionate number of black motorists are ticketed for violations that only surface following a traffic stop. This difference, say civil libertarians, community

Managing Editor's notebook, A2

leaders and criminologists, suggests police use racial profiling in deciding whom to pull over.

The evidence is contained in a massive police database recording more than 480,000 incidents in which an individual was arrested or ticketed, for an offence dating back to 1996. It included almost 800,000 criminal and other charges.

The Star obtained that data through a freedom of information request, marking the first time access to these numbers was granted to anyone outside the police

community.

Police are forbidden, by their governing board, from analyzing this data in terms of race, but The Star has no such restriction. The findings provide hard evidence of what blacks have long suspected — race matters in Canadian society especially when dealing with police.

Chief Julian Fantino disputed the findings, saying the colour of a person's skin has nothing to do with how they're treated by his officers.

"We don't treat people different-

Chrétien expected to keep cabinet minister

Ethics report has 'wiggle room' to save MacAulay

BY TIM HARPER AND LES WHITTINGTON
OTTAWA BUREAU

OTTAWA — Jean Chrétien receives a report from his ethics counsellor today that is expected to give him enough "wiggle room" to keep his solicitor-general, Lawrence MacAulay, in the federal cabinet.

Ethics counsellor Howard Wilson completed his report and delivered it to the Prime Minister's Office last night, where it was received by Chrétien's chief of staff, Percy Downie.

It was then to be relayed to Chrétien by secure fax to Beirut, where the Prime Minister is attending a summit of French-speaking nations. It was 1:30 a.m. in Beirut when the fax arrived so Chrétien would likely be reading it this morning.

Senior sources said last night that unless there is a surprise in Wilson's report, the Prince Edward Island minister will remain, Chrétien will return to Ottawa and weather the inevitable storm of opposition and media protest and forge ahead with an ethics package by mid-week.

Wilson has been investigating whether MacAulay broke ethics guidelines for cabinet ministers in the awarding of a contract and extension worth \$100,000 to Everett Roche, a Charlottetown political friend of the solicitor-general's.

Chrétien will not fire MacAulay unless he is given incontrovertible evidence of wrongdoing for two key reasons, source-

■ Please see MacAulay, A8

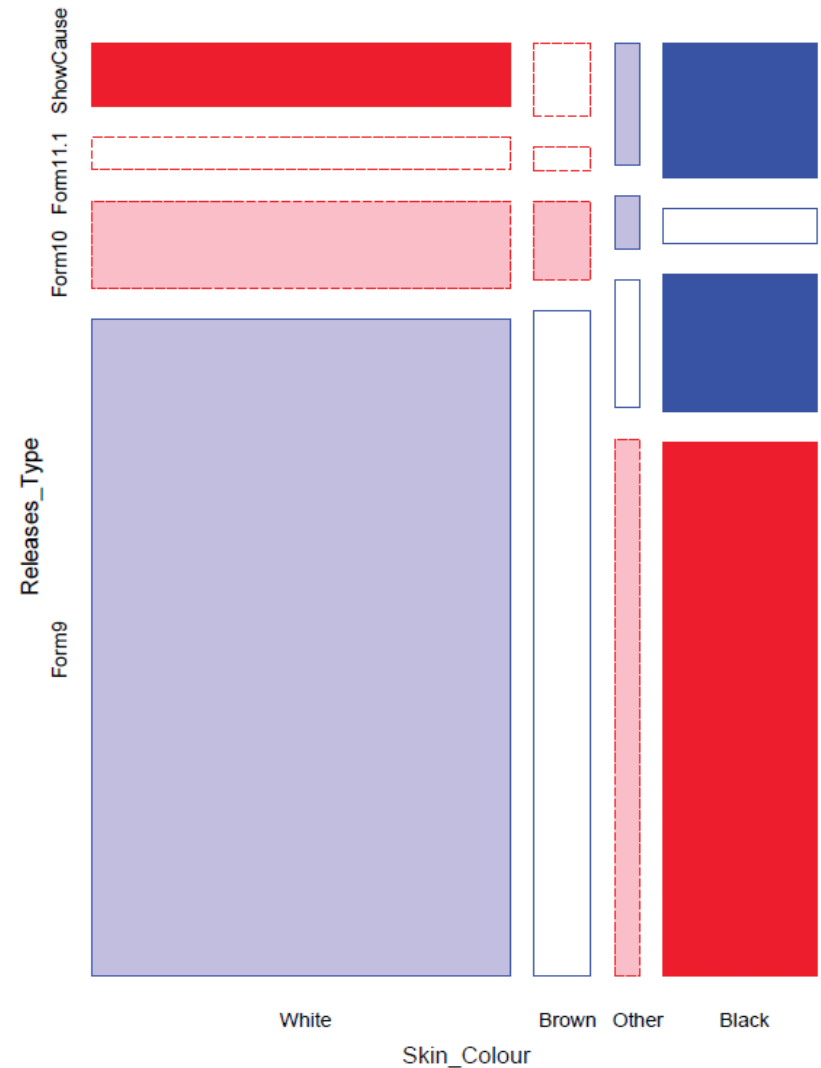
INSIDE

Barclay L2
Birtbis B7
Ellie Teshler L2
James Travers L2

■ Please see Toronto, A12

Racial profiling: Analysis graph

- Police actions on a charge of simple possession of marijuana
 - release with a summons (Form 9) vs. hold for bail (Show cause)
 - Evidence for racial bias?
- First graph: mosaic display
 - area \sim frequency
 - shading: \sim residual
 - Obs > Expected in blue
 - Obs < Expected in red



Racial profiling: The process

How to communicate these results most effectively?

- What is the message? What features are directly comprehensible to the audience?

B SECTION > TORONTO STAR < WEDNESDAY, DECEMBER 11, 2002 ★ thestar.com

Race and Crime

Graphic designer's
early attempts



My early
attempts

York University professor Michael Friendly's expert statistical analysis provided confirmation for the Toronto Star's series on racial profiling by city police.

Man behind the numbers

Racial profiling: Presentation graphic

Together, we created this (nearly) **self-explaining** infographic

Title gives the main conclusion

Text description gives details

Bar width ~ charges
Divided by % release

numbers shown in the cells

Legend gives a layman's description of shading levels

Same charge, different treatment

Statistical analysis of single drug possession charges shows that blacks are much less likely to be released at the scene and much more likely to be held in custody for a bail hearing. Darker colours represent a stronger statistical link between skin colour and police treatment.

Degree of likelihood

- *Much less* likely to occur
- *Much more* likely to occur
- *More* likely to occur

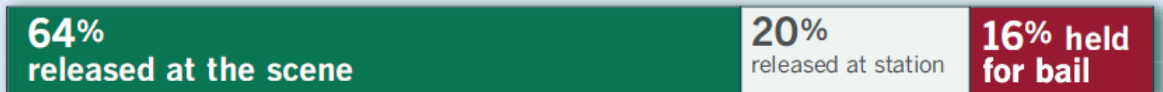
Whites are more likely to be released at the scene

6,662 charges laid

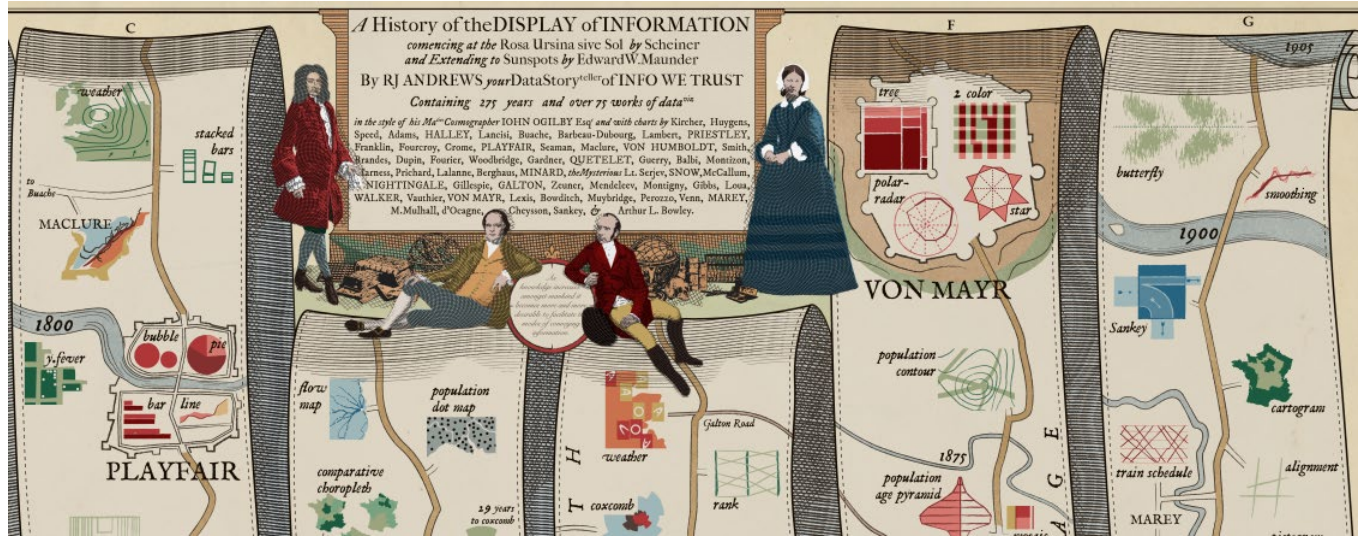


Blacks are much more likely to be held for bail hearings

2,446 charges laid



SOURCE: Toronto police arrest records 1996-2002



A whirlwind tour of the history of Data Visualization

- The *Milestones Project*
- Moral statistics: the birth of modern social science
- Galton: the birth of modern statistical methods
- Graphical excellence: Album de Statistique Graphique

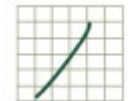
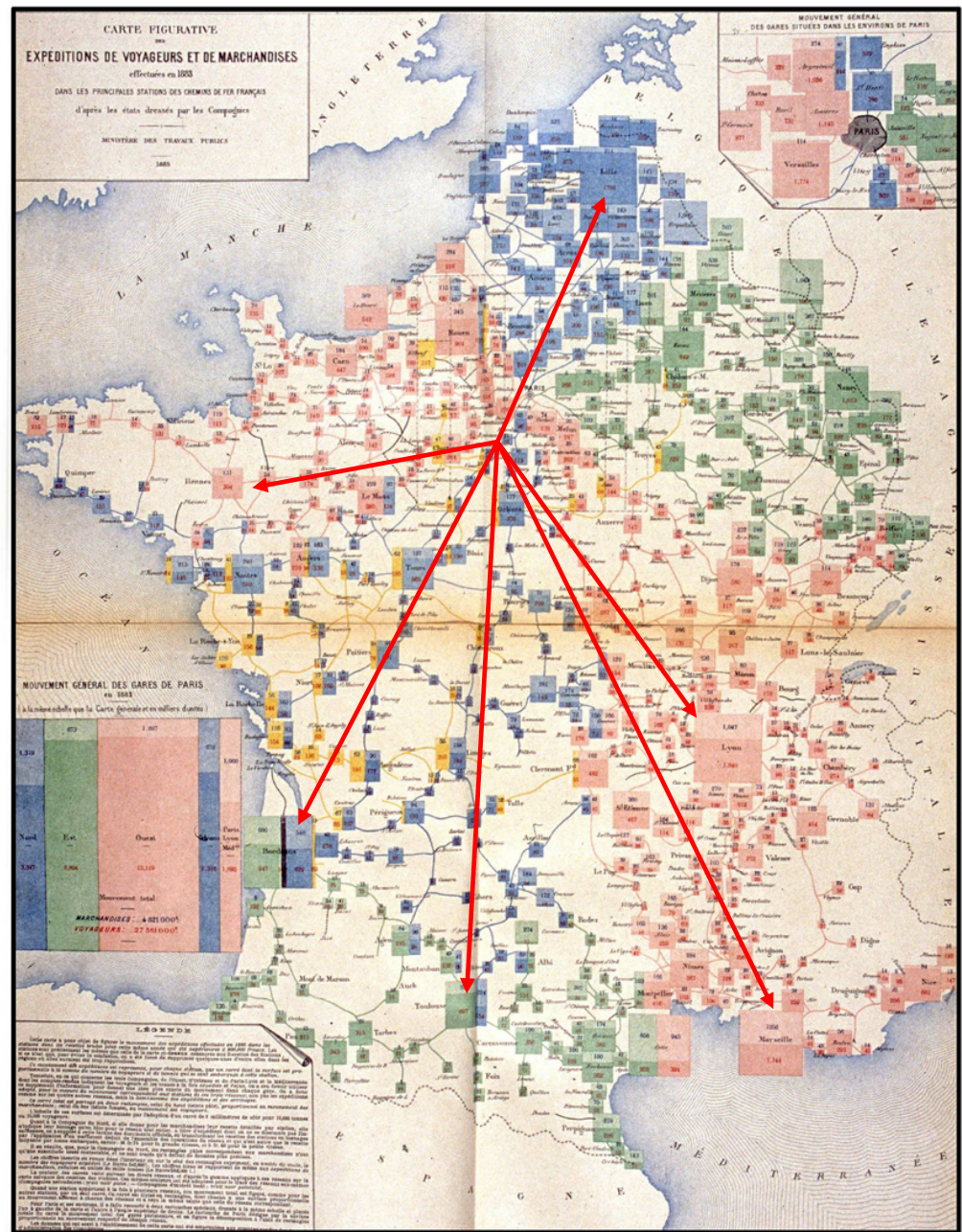
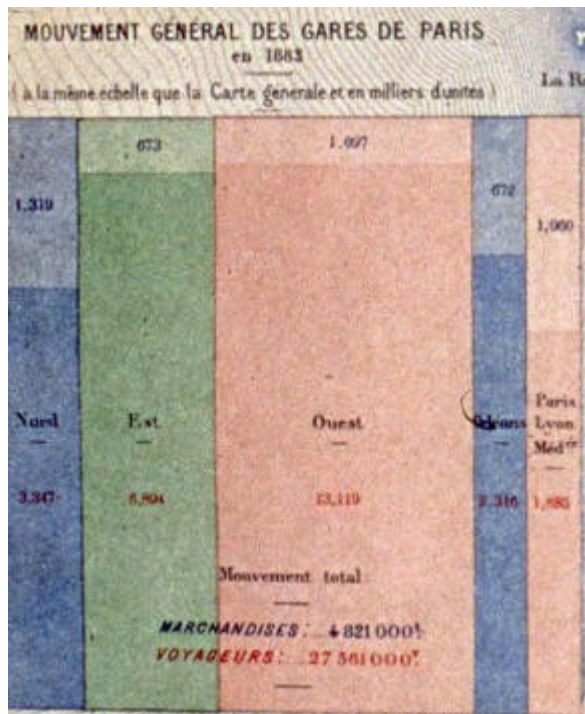


Image: RJ Andrews, <http://infowetrust.com/history/>

Why study history of #datavis?

Those who don't know history are doomed to plagiarize it.

Recursive mosaic: Distribution of passengers and goods from the Paris railways to the rest of France
[Album, 1884, pl. 11]



The Milestones Project

<https://datavis.ca/milestones/>

Milestones in the History of Thematic Cartography, Statistical Graphics, and Data Visualization

An illustrated chronology of innovations by **Michael Friendly** and **Daniel J. Denis**

Home | Introduction | Milestones Project | Varieties of Data Visualization | Related | References | Keyword Index

Search

Pre-1600

1600s

1700s

1800+

1850+

1900+

1950+

1975+

Timeline

This page provides a graphic overview of the events in the history of data visualization that we call "milestones." These milestones are shown below in the form of an *interactive timeline*. The timeline is divided into *two vertical sections*. You can *drag each section left or right* to see milestones of different time periods. You can also click one of the links at the bottom of the timeline to jump to a particular epoch.

Each of the milestone's in the timeline can be clicked to reveal its summary that includes both a link to its category page and a link to its detail page. The category can also be clicked to initiate a search of other milestone's based on that category.

Item categories: ● Cartography ● Statistics and graphics ● Tech



1st data graph

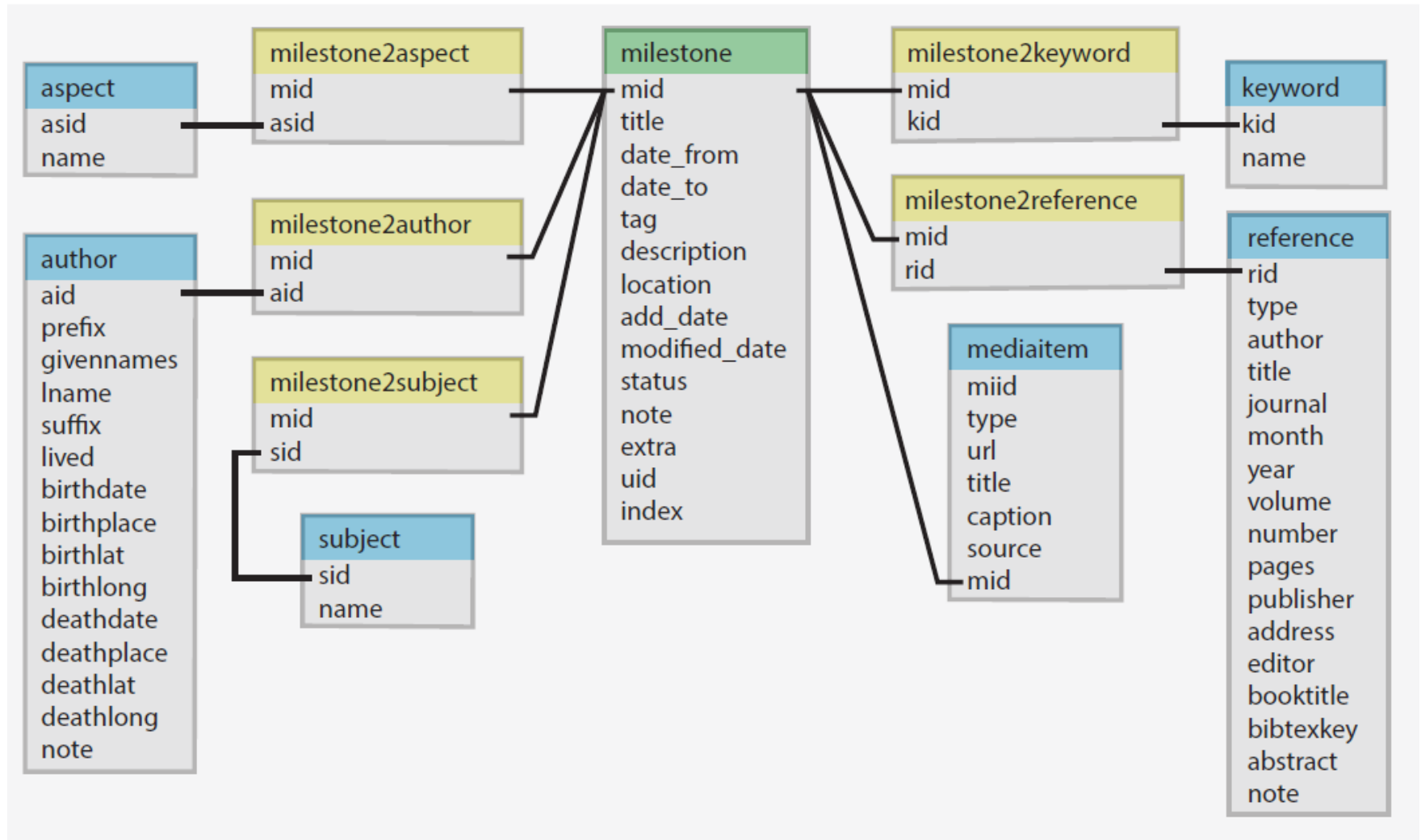
1644 (Spain) [Statistics & Graphics](#)

Michael F. van Langren (1598-1675)
First visual representation of statistical data: variations in determination of longitude between Toledo and Rome.

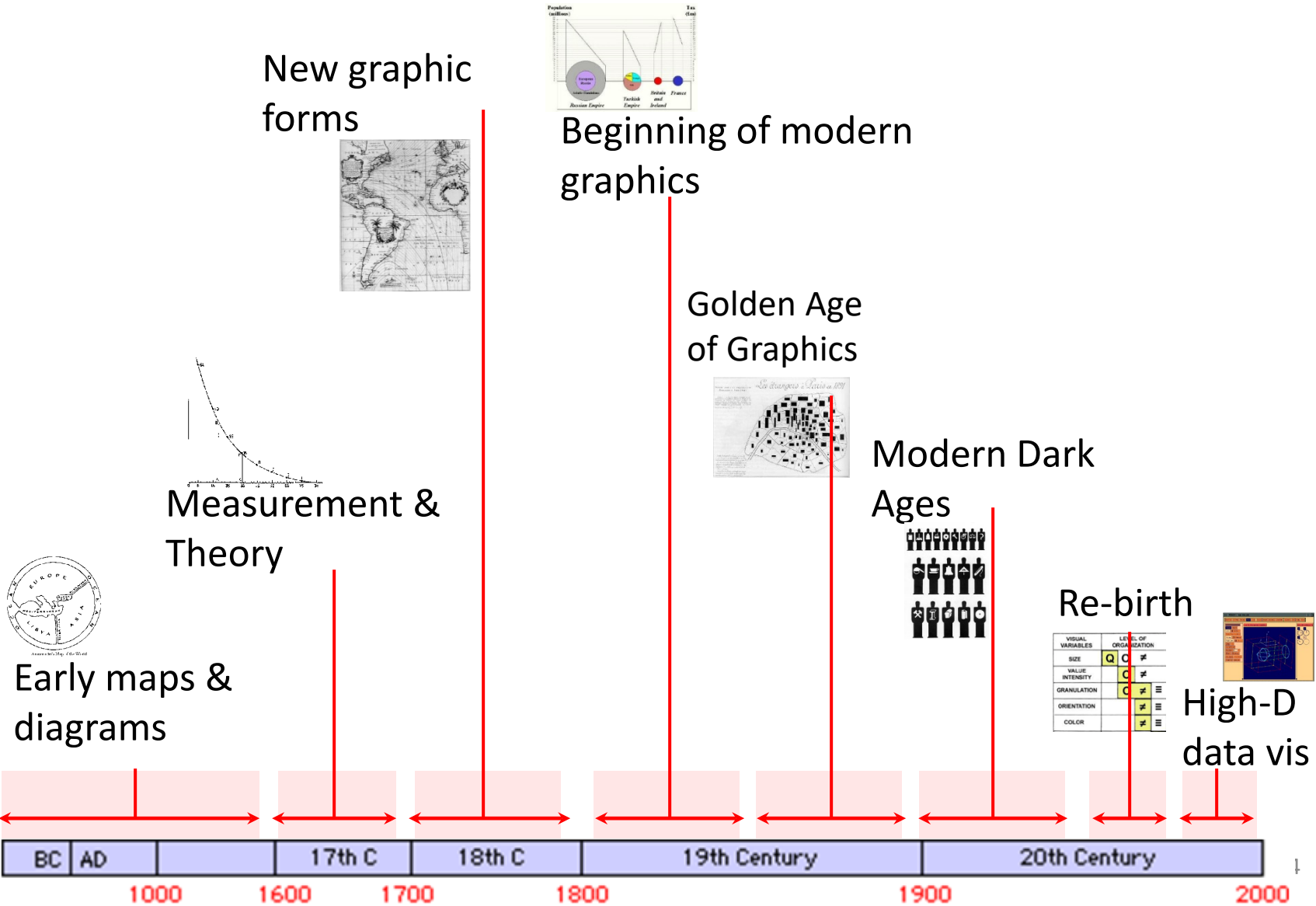
[Milestone Detail](#)

The web site: <http://datavis.ca/milestones> has an interactive timeline, allowing different kinds of search

Milestones database

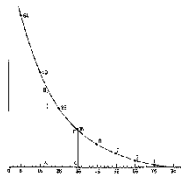


Milestones Tour: Epochs

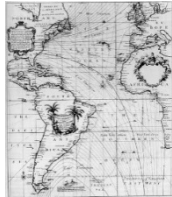


Early maps & diagrams

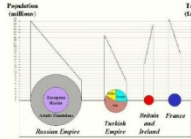
Measurement & Theory



New graphic forms



Beginning of modern graphics



Golden Age of Graphics



Modern Dark Ages



Re-birth

VISUAL VARIABLES	LEV. OF ORGANIZATION
SIZE	q c #
VALUE INTENSITY	c q #
GRANULATION	c q #
ORIENTATION	# q c
COLOR	# q c

High-D data vis

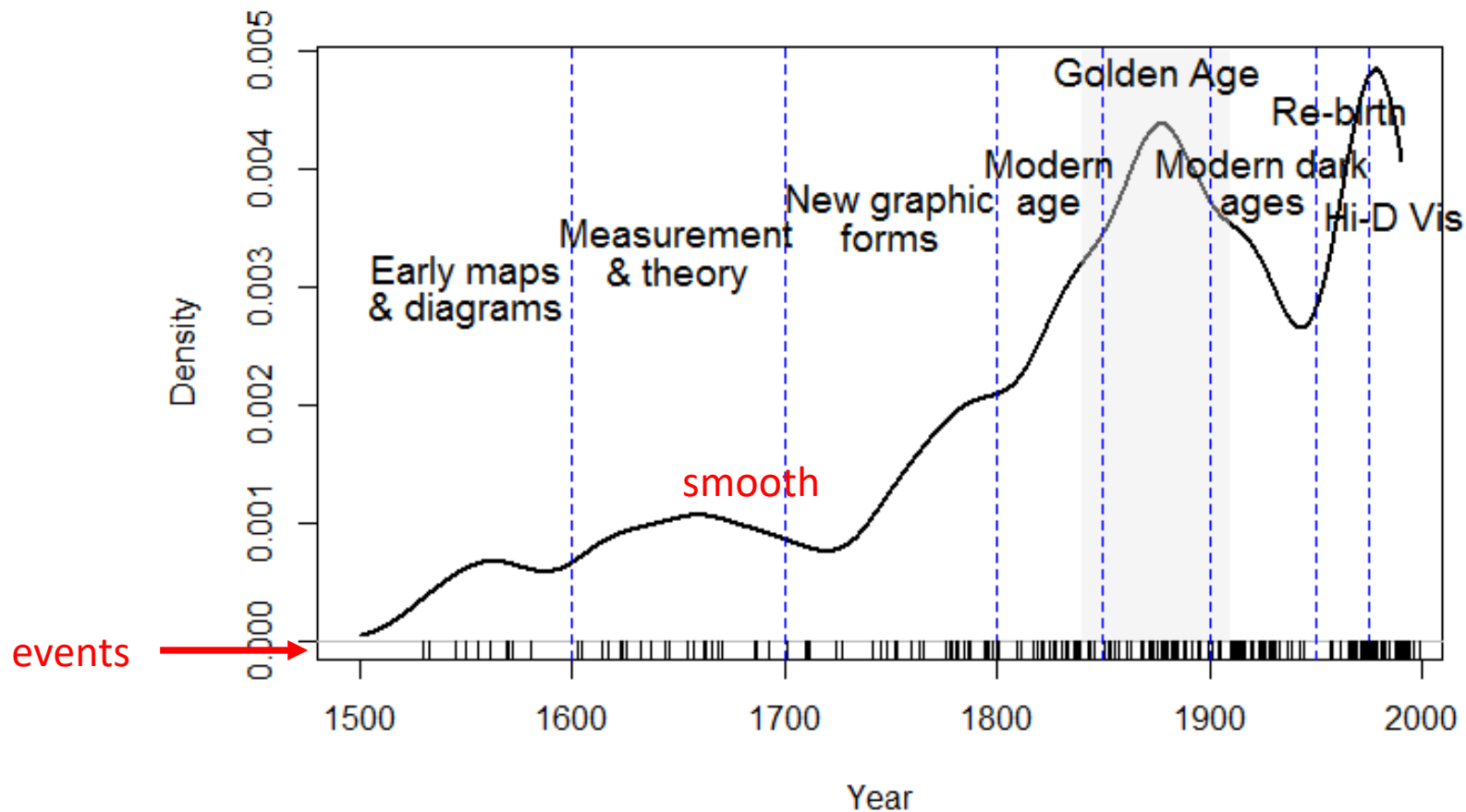


BC AD 1000 1600 17th C 1700 18th C 1800 19th Century 1900 20th Century 2000

Statistical historiography

Historical information, suitably organized can be treated as data, and analyzed. This plot shows a smoothed frequency distribution of 248 milestones items over time, in relation to the named time periods.

Milestones: Time course of development

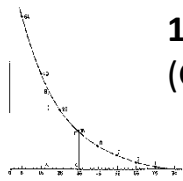


Milestones: Content Overview

Every picture has a story – Rod Stewart

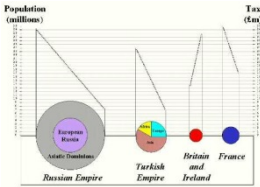
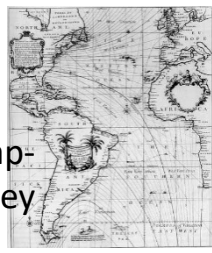


c. 550 BC: The first world map? (Anaximander of Miletus)



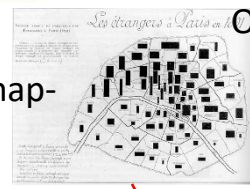
1669: First graph of a continuous distribution function (Gaunt's life table)– Christiaan Huygens.

1701: First contour map– Edmund Halley



1801: Pie chart, circle graph - William Playfair

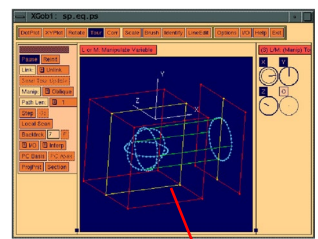
1896: Bivariate map– Jacques Bertillon



1924: ISOTYPE– Otto Neurath

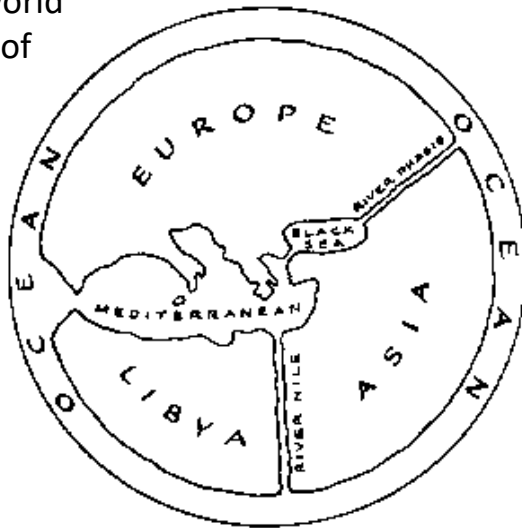


1991-1996: Interactive data visualization systems (Xgobi, ViSta)



Pre 17th C.: Early maps & diagrams

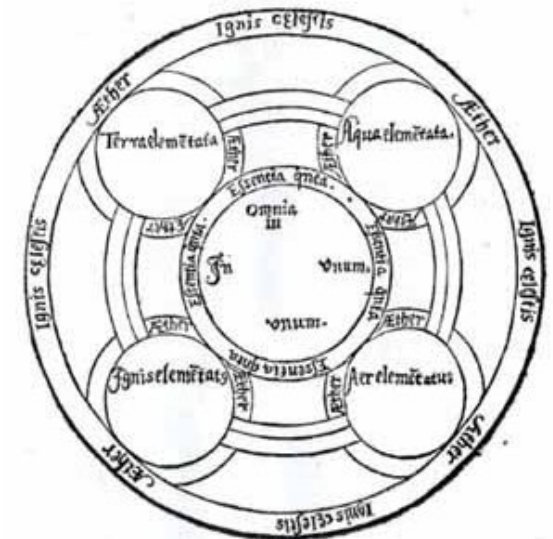
c. 550 BC: The first world map? (Anaximander of Miletus)



1350: Bar graph of theoretical function N. Oresme, France



1305: Mechanical diagram of knowledge- Ramon Llull, Spain



the World

1375: Catalan Atlas, an exquisitely beautiful visual cosmography, perpetual calendar, and thematic representation of the known world- Abraham Cresques, Spain



1375: Catalan Atlas, an exquisitely beautiful visual cosmography, perpetual calendar, and thematic representation of the known world- Abraham Cresques, Majorca, Spain [BNF: ESP 30]

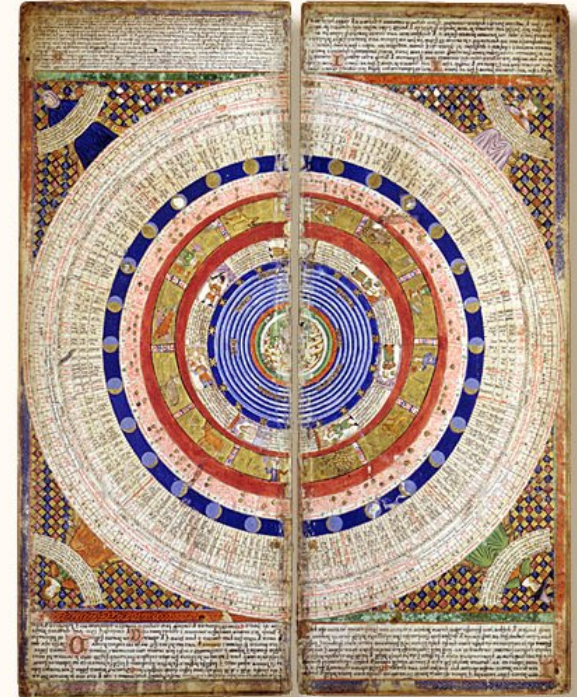
Western world



Eastern world (Marco Polo)



Perpetual calendar



1000

1600

1700

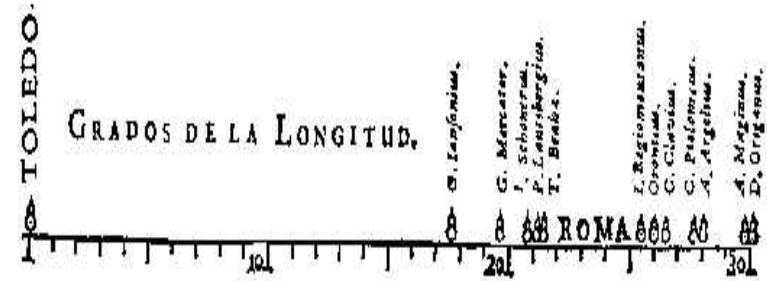
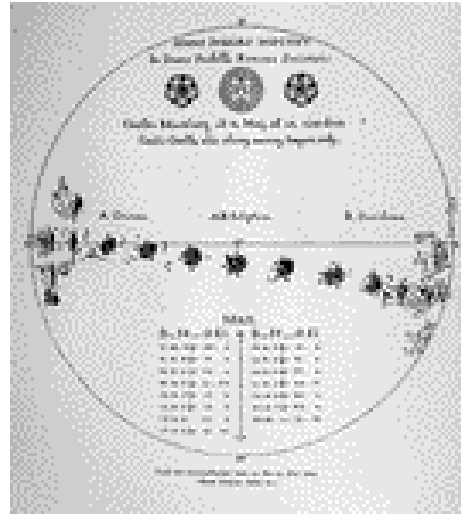
1800

1900

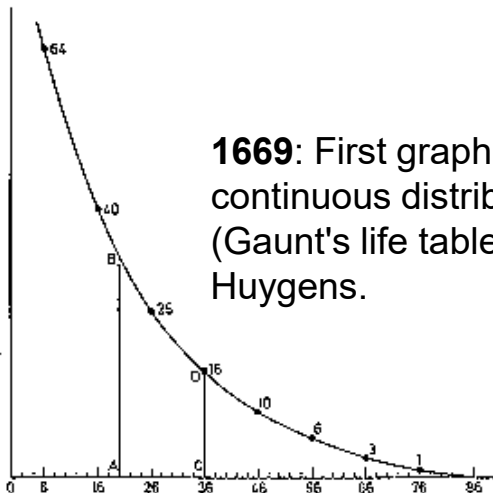
2000

1600-1699: Measurement and Theory

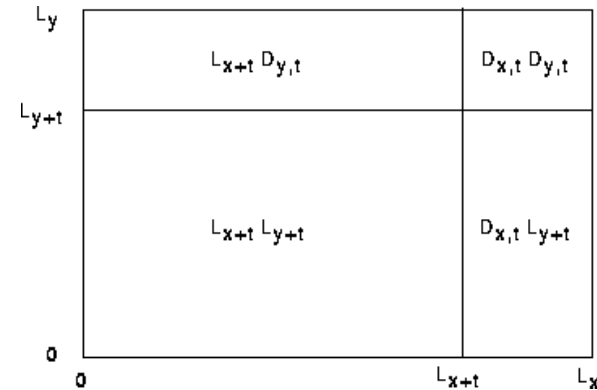
1626: Visual representations used to chart the changes in sunspots over time- Christopher Scheiner



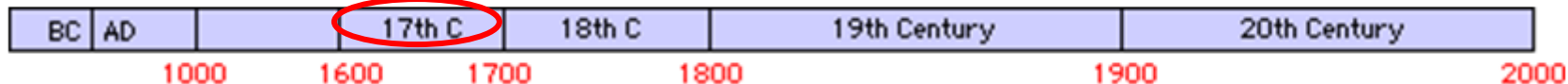
1644: First visual representation of statistical data- M.F. van Langren, Spain



1669: First graph of a continuous distribution function (Gaunt's life table)- Christiaan Huygens.



1693: First use of areas of rectangles to display probabilities of independent binary events- Edmund Halley, England



Sunspots: Galileo



1608: telescope (Hans Lippershey, NL)

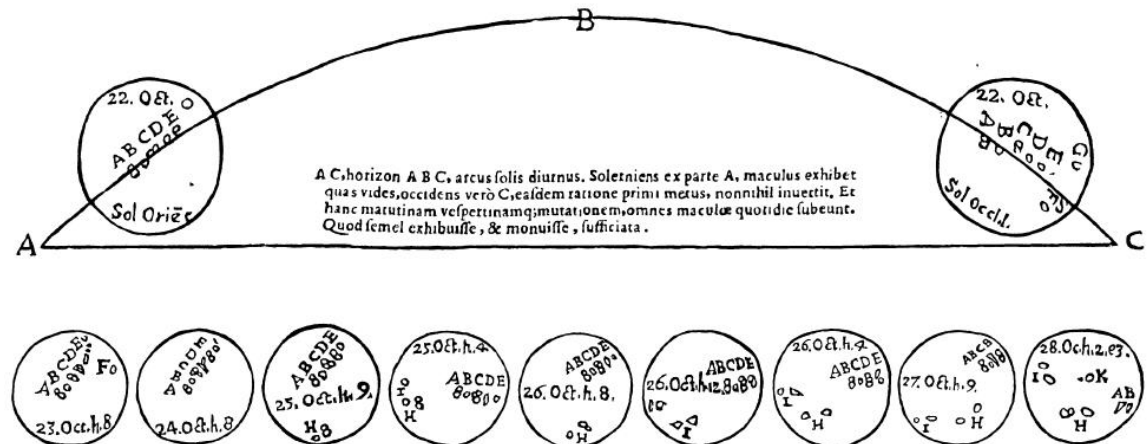


1610: Galileo (*Sidereus Nuncius*)

1611: Galileo records **movement** of sunspots over time (*Three letters on sunspots, 1613*)

Visual ideas:

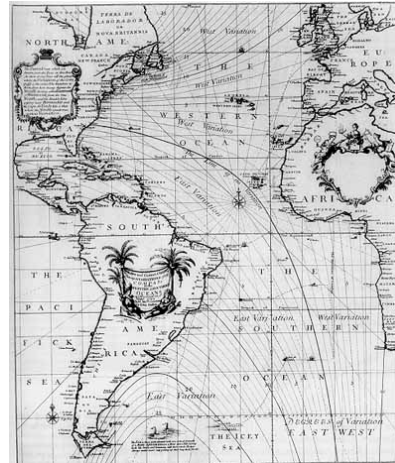
- Animated graphic
- “Small multiples”
- Allows comparison
- Self-explaining diagram



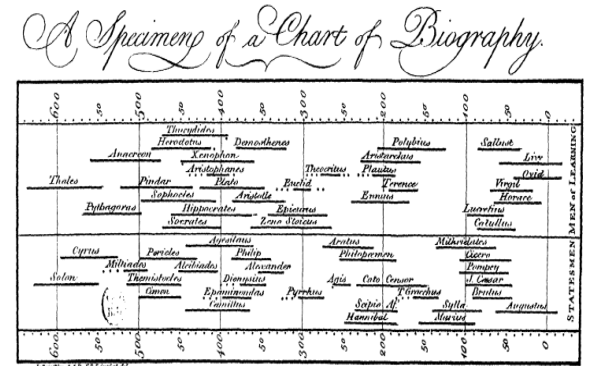
A+ for info design!

1700-1799: New graphic forms

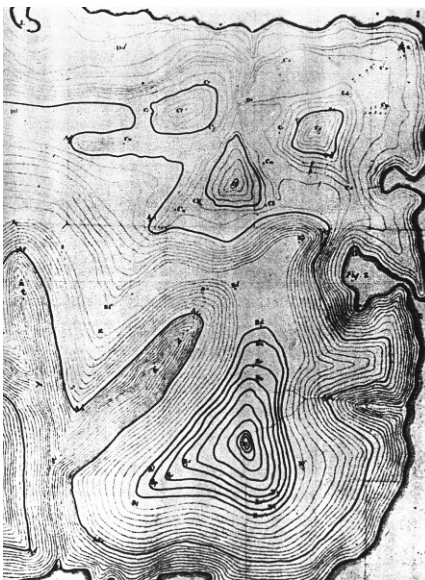
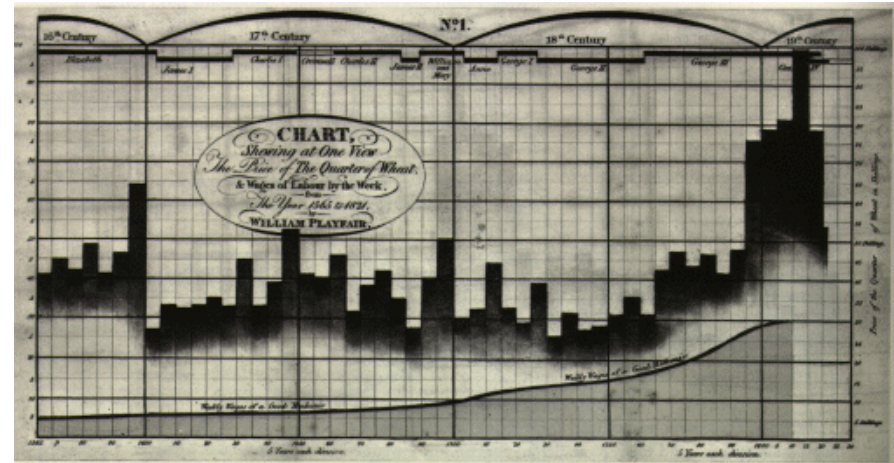
1701: Isobar map, lines of equal magnetic declination – Edmund Halley



1765: Historical time line (life spans of famous people) Joseph Priestley



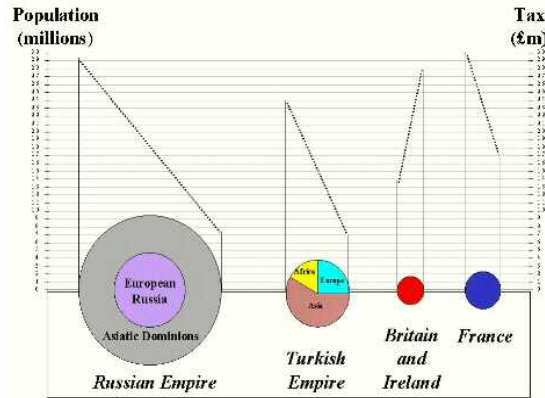
1786: Bar chart, line graphs of economic data- William Playfair



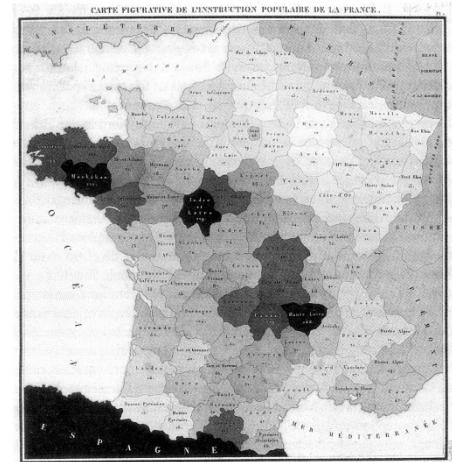
1782: First topographical map- Marcellin du Carla-Boniface

1800-1849: Beginning of modern data graphics

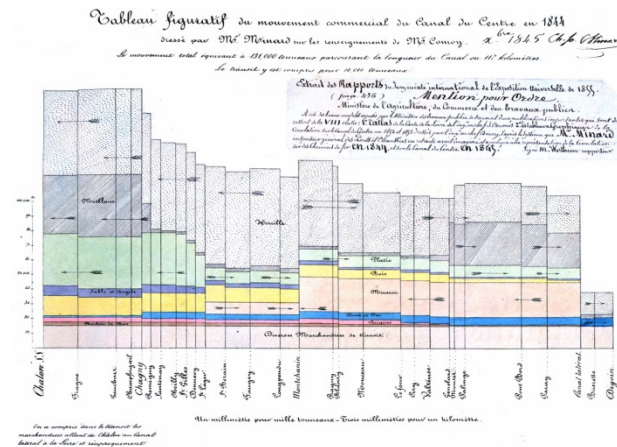
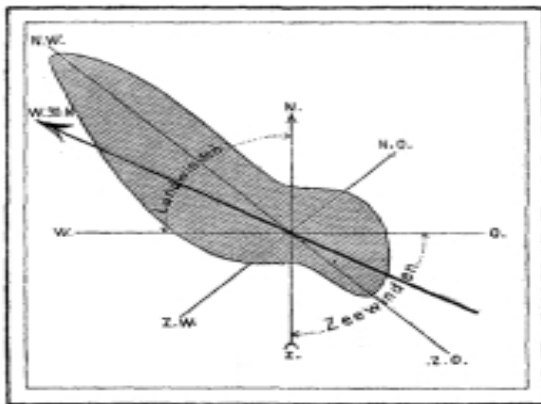
1801: Pie chart, circle graph invented- William Playfair



1826: First modern statistical map (illiteracy in France)- Charles Dupin

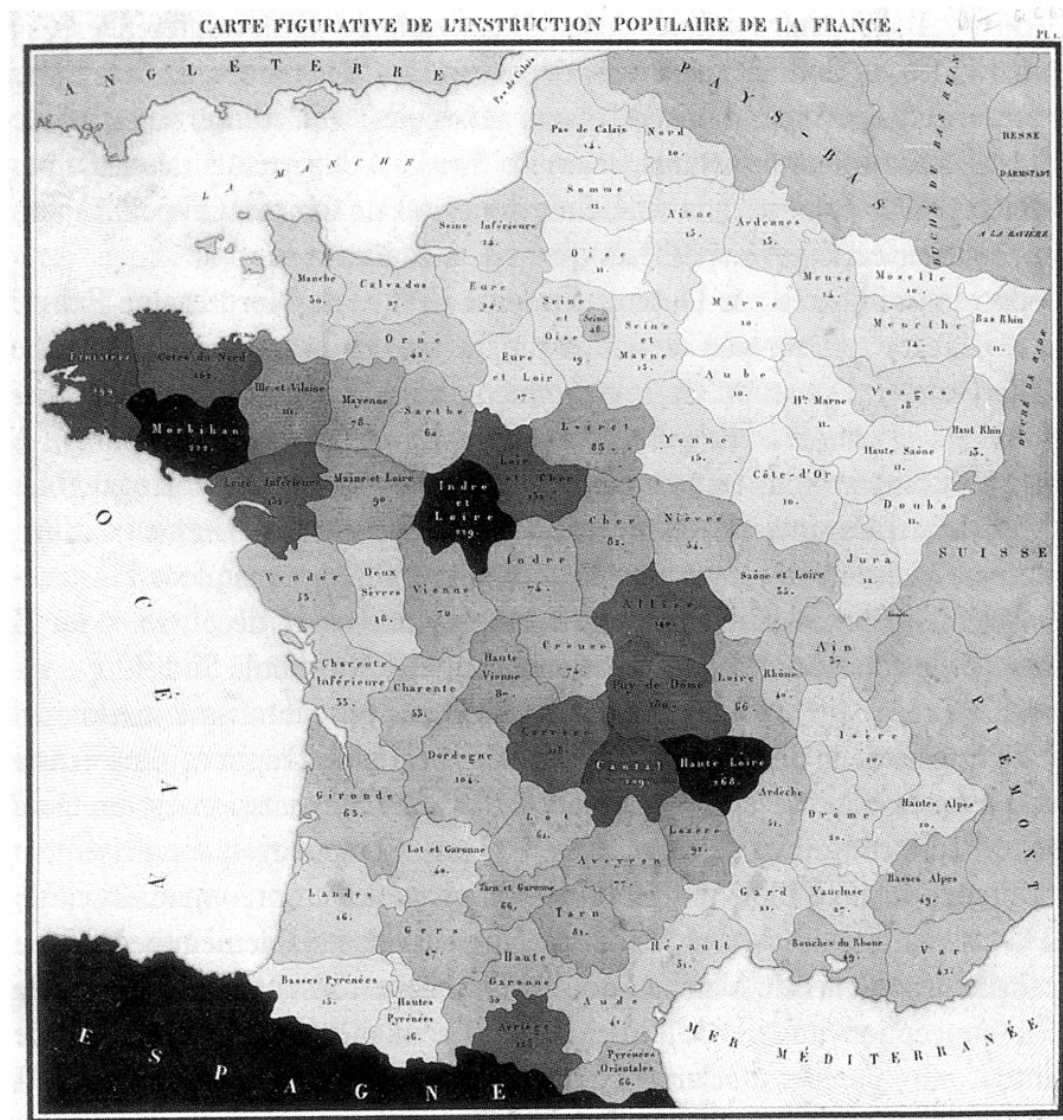


1843: Wind-rose (polar coordinates)- L. Lalanne



1844: variable-width, divided bars, area ~ cost of transport- C. J. Minard

1826: The 1st choropleth map, showing the distribution of literacy in France – Baron Charles Dupin



Social variables became:

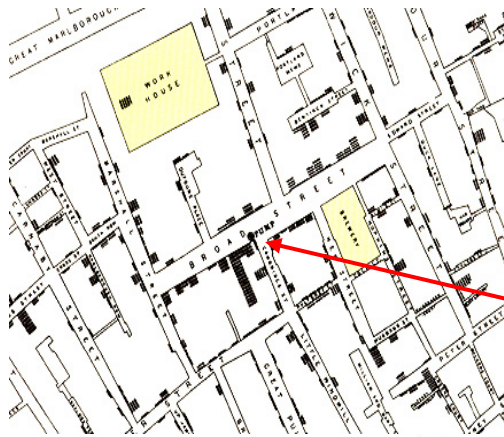
- visual
- subject to scientific discussion

1850-1900: Golden Age

- By the last half of the 19th century the conditions for rapid growth of visualization had been established:
 - widespread data collection for planning, commerce, social theory
 - the beginnings of statistical theory and visual thinking
 - a wide range of graphic forms, reasonably well understood
 - technology:
 - lithography and color printing
 - automatic recording devices
 - calculation: machines & graphical calculators
- The result was a perfect storm-- among the most exquisite graphics ever produced.

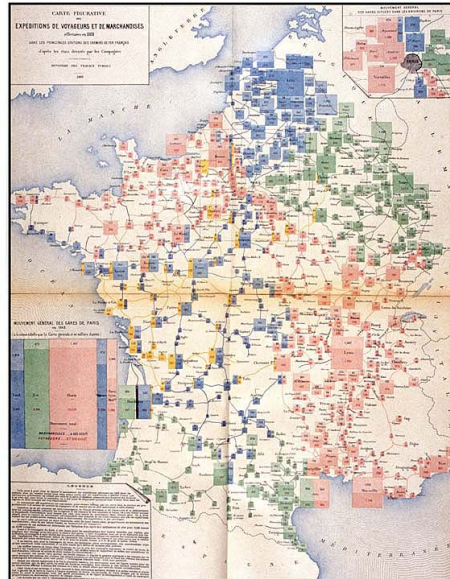


1850-1900: Golden Age



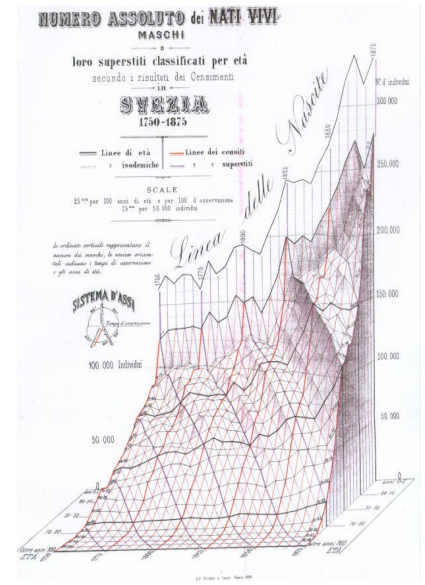
1855: Dot map of disease data (cholera)- John Snow

Broad St. pump

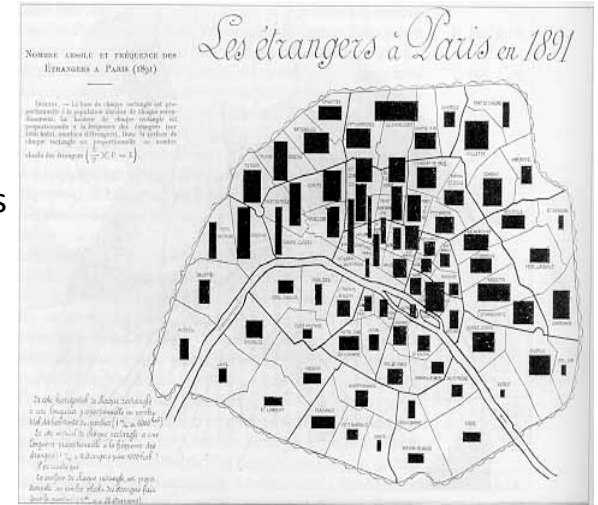


1884: Recursive multi-mosaic on a map- Emile Cheysson

1879: Stereogram (3D population pyramid)- Luigi Perozzo



1896: Area rectangles on a map to display two variables and their product- Jacques Bertillon





Stories from the Golden Age (1850-1900)

Stories:

- A.-M. Guerry & the rise of social science
- Galton's graphical discoveries
- Statistical albums

Themes:

- Statistics: numbers of the state
- Escaping flatland: 2D → 3D
- Visualization → Theory (graphic discovery)
- Data → Theory → Practice
- Graphical excellence

A. M. Guerry and the rise of social science

Essai sur la statistique moral de la France

The launching pad of modern social science

- ▶ Presented to Academie des Sciences Français July 2, 1832
- ▶ First systematic analysis of comprehensive data on crime, suicide, and other social variables.
- ▶ Along with Quetelet (1831, 1835), established the study of “moral statistics”
↳ modern social science, criminology, sociology



Guerry, *La Statistique Morale*

- In France, widespread, national data collection on social issues began ~ 1810—1825
 - literacy: % of army conscripts who could read and write
 - crime: Ministry of Justice launched the *Compte Générale*
 - every criminal charge recorded, with all details: age, sex, occupation, date, court outcome
 - mandated quarterly reports to Paris
- Suddenly, one could attempt to answer important questions using **data** rather than philosophy
 - Is greater literacy related to less crime?
 - Do more priests lead to less crime, suicide or prostitution?
- Moral statistics: the beginning of modern social science
 - Social data could lead to “social laws” à la “physical laws”

The discovery of “social facts”

Stability and Variation

Guerry's results were both compelling and startling:

- ▶ Rates of crime and suicide remained **remarkably invariant** over time, yet **varied systematically** by region, sex of accused, type of crime, etc.
- ▶ In any given French city or department, almost the same number committed suicide, stole, gave birth out of wedlock, etc.

Year	1826	1827	1828	1829	1830	Avg
Sex	All accused (%)					
Male	OMG! ~ constant → 79	79	78	77	78	78
Female	21	21	22	23	22	22
Age	Accused of Theft (%)					
16–25	37	35	38	37	37	37
25–25	OMG! ~ constant → 31	32	30	31	32	31
Crime	Committed in summer (%)					
Indecent assault	.	36	36	35	38	36
Assault & battery	.	28	27	27	27	28

“We are forced to conclude that the *facts of the moral order* are subject, like those of the *physical order* to invariable laws.” (Guerry, 1833, p14)

Guerry (1864): General causes of crime

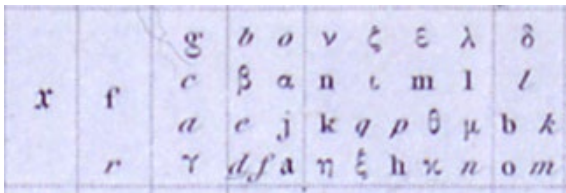
Plate XVII: Guerry's magnum opus

Goal:

- Show **multivariate factors** associated with distribution of crimes of various type
- Before invention of correlation

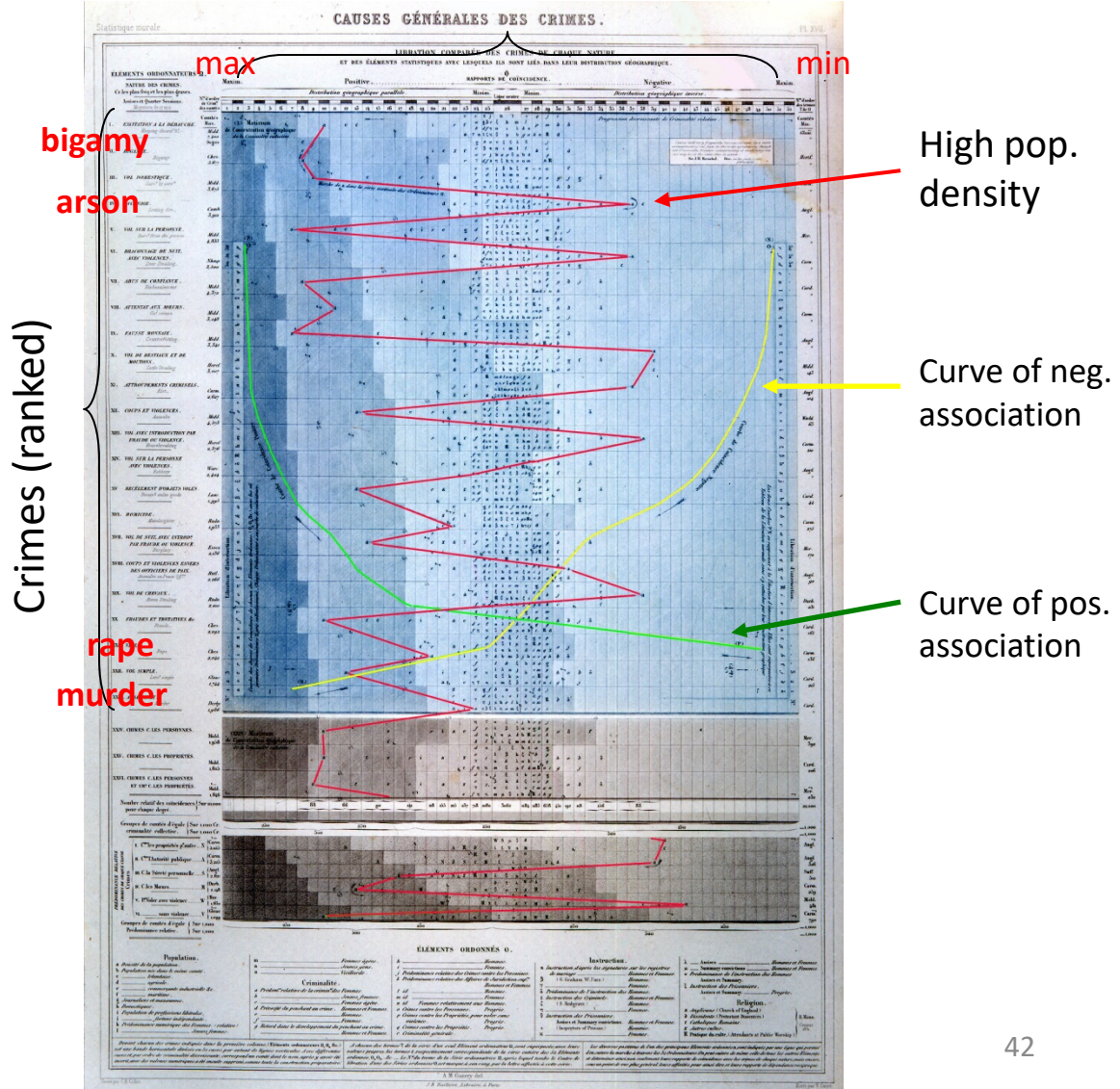
Entries: Codes for factors

- Pop: (% Irish, domestics, ...)
- Criminality: (male, young, ...)
- Religion (Anglicans, dissenters, ...)

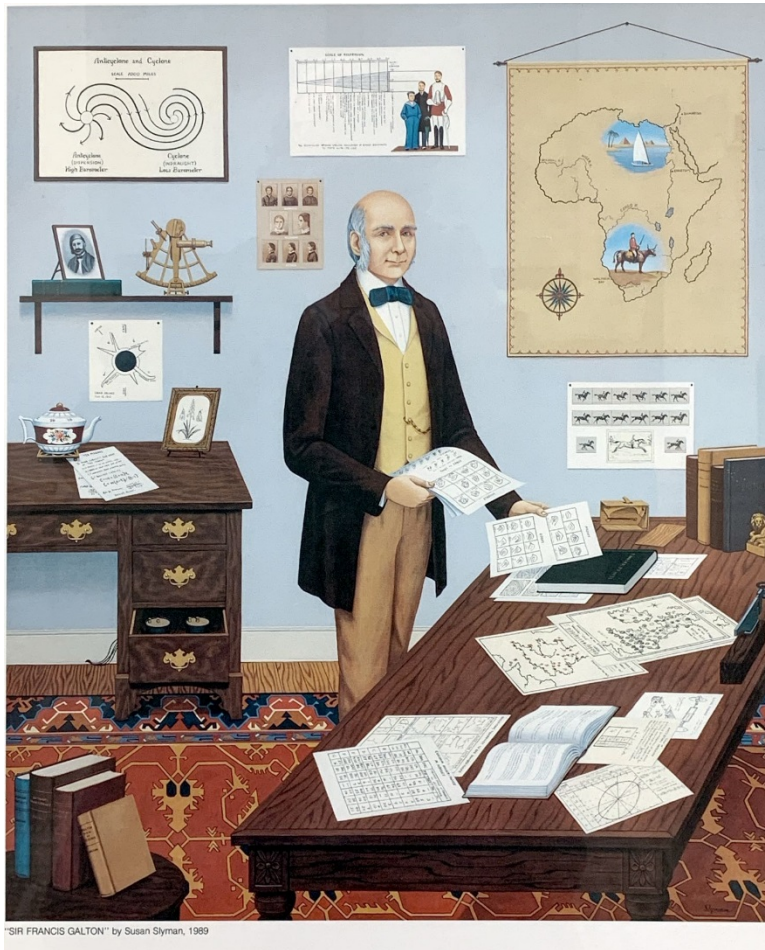


Guerry, A.-M. (1864). *Statistique morale de l'Angleterre comparée avec la statistique morale de la France*

English counties (ranked on each)



Galton: Visual thinking & graphic discovery



Galton's contributions:

- Genetics (inheritance)
- Regression towards mean
- Forensics (fingerprints)
- Travel: Isochronic maps
- Weather maps
- Psychology: Mental imagery & word associations
- Standardized data forms & crowd-sourced collection

Portrait of Galton in his study by Susan Slyman

Galton's discovery of weather patterns-
Perhaps the most notable *purely graphic* discovery ever!

METEOROGRAPHICA,

OR

METHODS OF MAPPING THE WEATHER;

ILLUSTRATED BY UPWARDS OF 600 PRINTED AND LITHOGRAPHED DIAGRAMS

REFERRING TO

THE WEATHER OF A LARGE PART OF EUROPE,

During the Month of December 1861.

By FRANCIS GALTON, F.R.S.

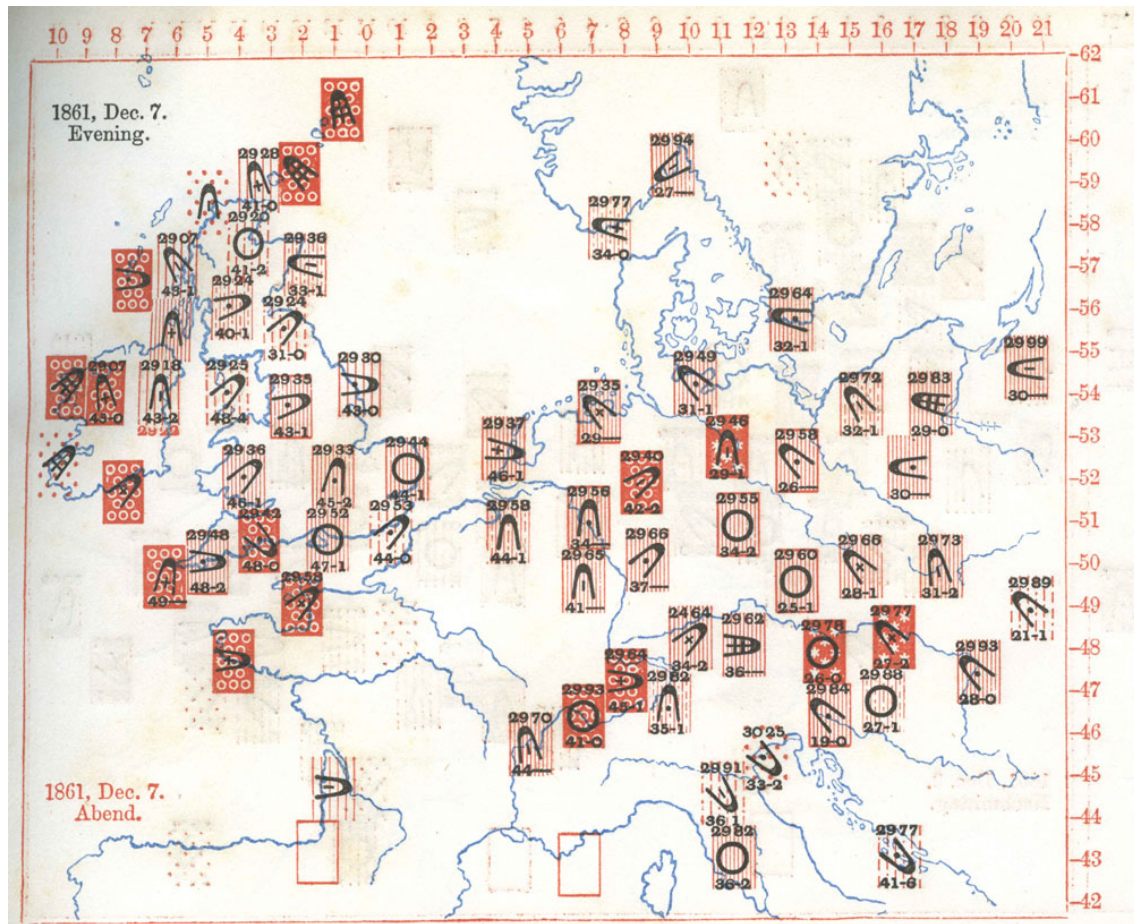
(Galton, 1863)

Images here courtesy of Stephen Stigler. Thx!

Method: All weather stations across Europe asked to record data 3x/day for all of Dec., 1861

Data: recordings of barometric pressure, wind dir/speed, rain, temp., cloud: 3x/day, 50 weather stations in Europe.

Graphic analysis: 3x31=93 maps, each with multivariate glyphs showing all variables



EXPLANATION OF THE SYMBOLS USED IN THE WEATHER CHARTS.

RAIN.				CLOUD.			
Rain.	Snow.	Entirely and heavily clouded.	Entirely clouded.	Mostly clouded.	Half clouded.	A few clouds.	Clear blue sky.
DIRECTION OF WIND.				FORCE OF WIND.			
S.	S.S.W.	S.W.	W.S.W.	Gale.	Strong.	Moderate.	Gentle.
&c.				Almost calm.			
				Calm.			

Visual ideas:

- Iconic symbols
- Multivariate glyphs (stamps!)

Visual abstraction → Patterns

What varies with what, over time and space?

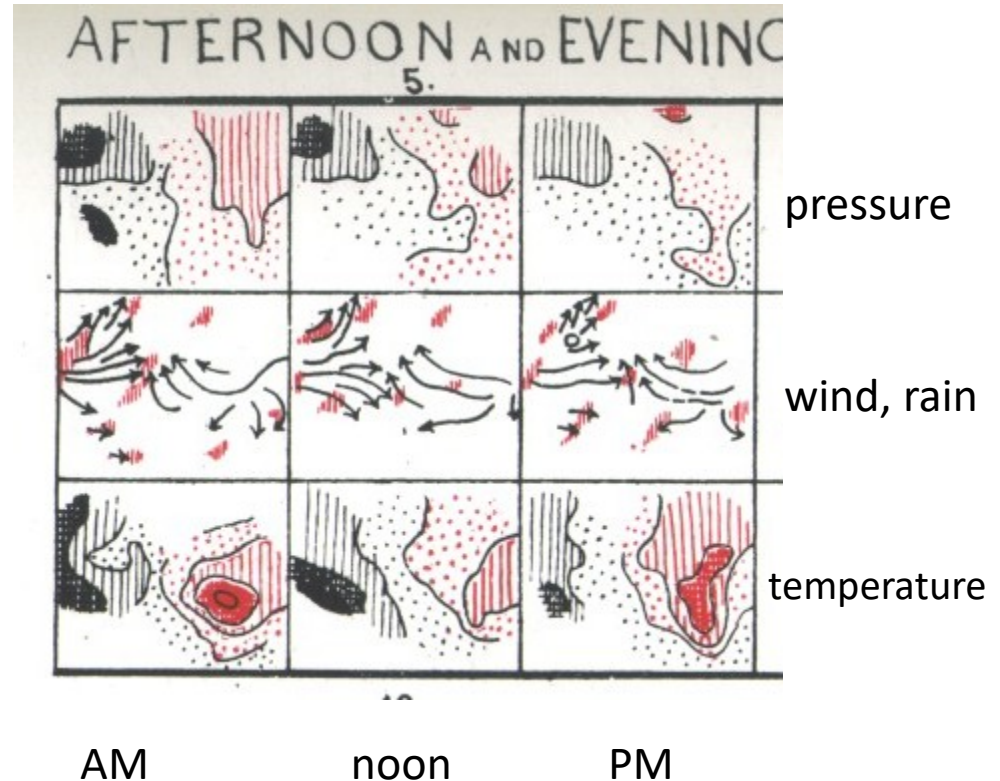
- mini, abstract maps: vars x TOD
- iso-contours, shading to show equivalence
- arrows to show wind direction

EXPLANATION OF SYMBOLS.

Barometer	29.85 - 29.9 In.	29.90 - 29.95 In.	29.95 - 29.97 In.	29.97 In. & below
Barometer	29.95 - 30.0 In.	30.01 - 30.05 In.	30.06 - 30.07 In.	30.07 In. & above
Thermometer	33 - 37° F.	38 - 42° F.	43 - 47° F.	48° & above.
Thermometer	32 - 28° F.	27 - 23° F.	22 - 18° F.	17° & below.

WIND: - from West, from North

RAIN: -



Data for Dec 5, 1861

The large picture → Insight

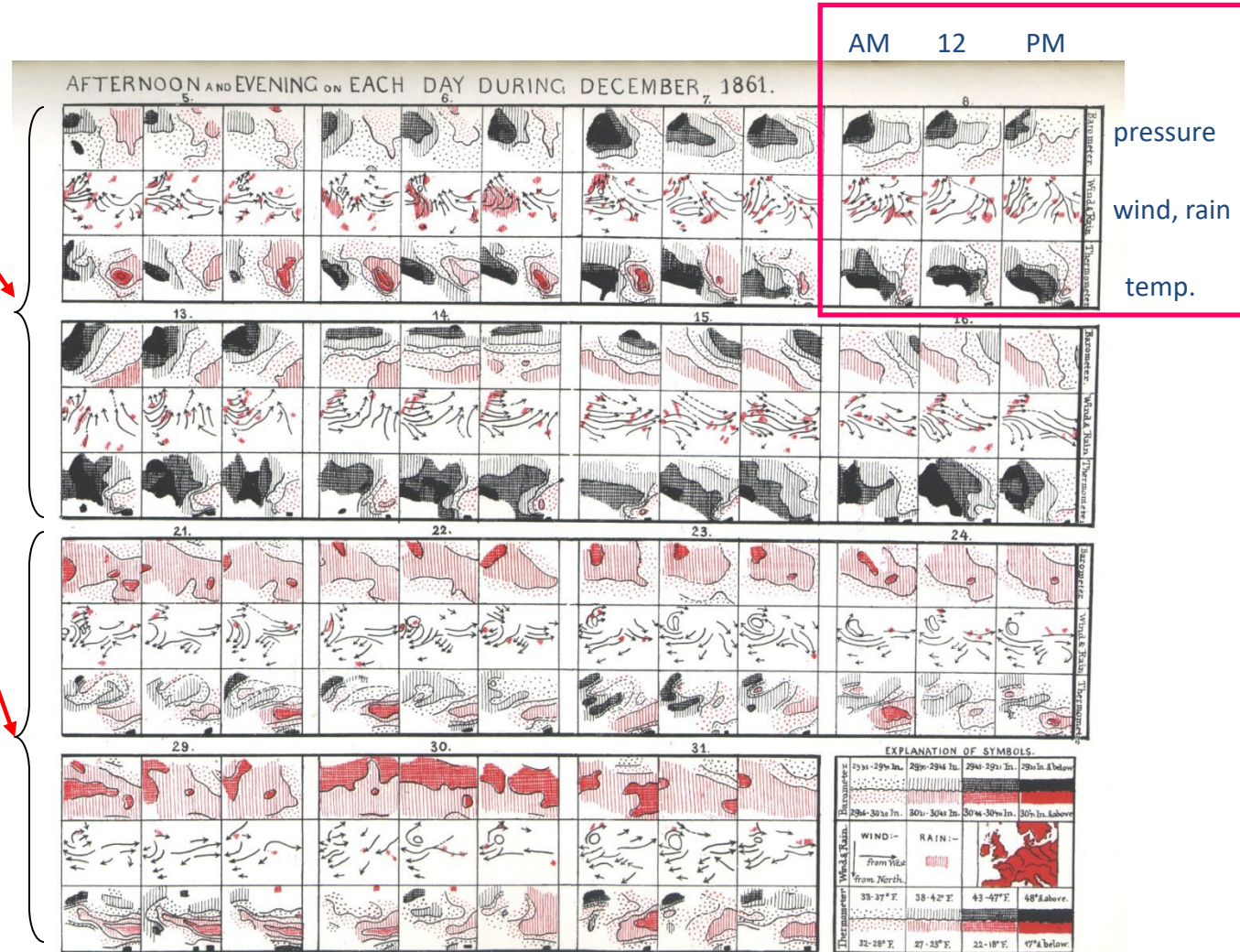
Pattern:

Low pressure (black) in early Dec. → CCW wind

High pressure (red) in late Dec. → CW wind

Graphic: 3x3x31 grid, mapping {pressure, wind/rain, temperature} x {AM, 12, PM} x day {1:31}

(try this with your software!)



A series of weather maps from the *Meteorographica*.

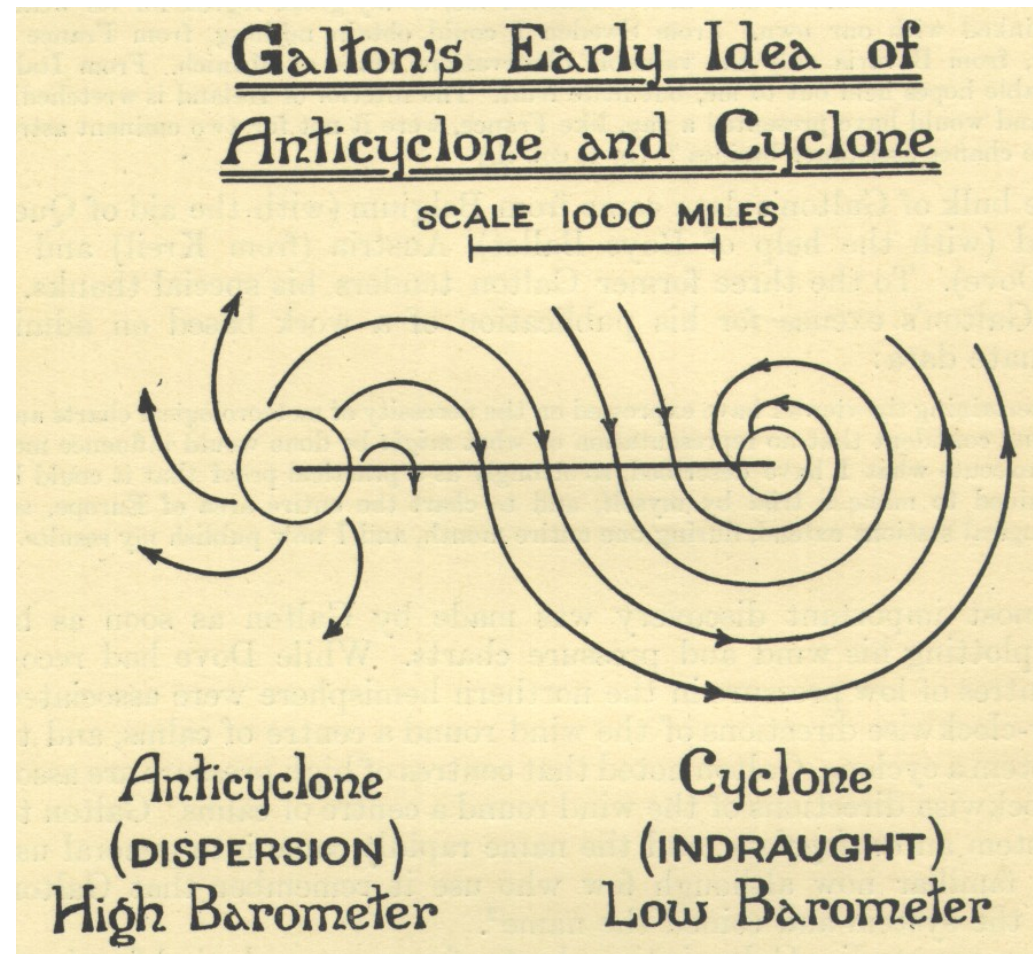
Visual insight → Theory

Visual insight from 93 (3x31) high-D graphs:

- Changes in wind dir w/ pressure over time
- → Winds revolve inwardly (CCW) in low pressure areas– as in a cyclone;
- → revolve outwardly (CW) in high pressure areas– “anti-cyclone”

Theory:

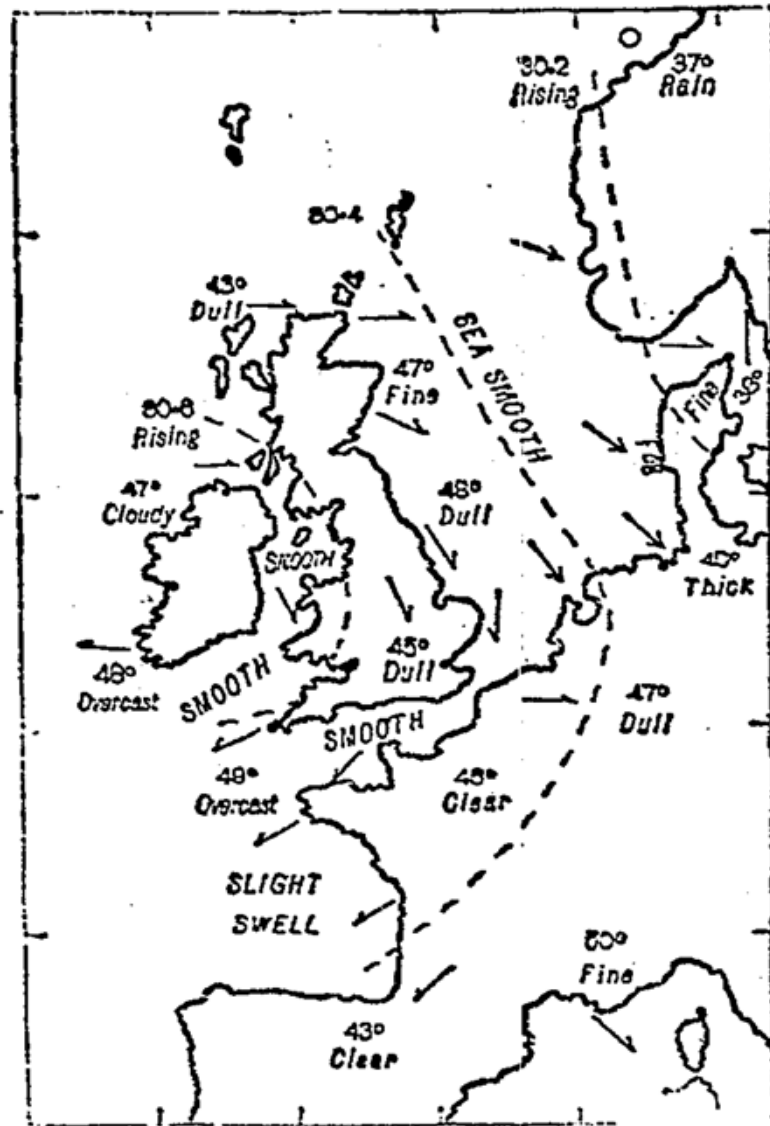
- Explained by Dove’s ‘Law of Gyration’
- Prediction: reversed pattern (CW/CCW) in southern hemisphere – confirmed!




Theory → Practice

The first modern weather map,
London Times, Apr. 1, 1875

Galton did for weathermen what Kepler did for Tycho Brahe. This is no small accomplishment. (Wainer 2005)



The dotted lines indicate the gradations of barometric pressure. The variations of the temperature are marked by figures, the state of the sea and sky by descriptive words, and the direction of the wind by arrows—barbed and feathered according to its force. © denotes calm.

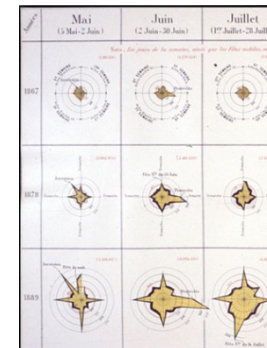
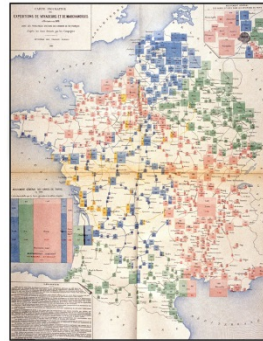


Statistical atlases: Data → practice, national identity & graphical excellence

- Collection of gov't statistics on pop., trade, moral & political issues widespread in Europe & US, starting ~ 1820
- Statistical albums ~ 1870—1910
 - France: *Album de Statistique Graphique*: 1879-1899
 - USA: Census atlases: 1870/80/90
 - Germany: local albums (Berlin, Frankfurt, etc.)
 - Switzerland: *Atlas graphique de la Suisse*: 1897, 1914
 - Others: Latvia, Romania, Bulgaria, etc.

Album de statistique graphique

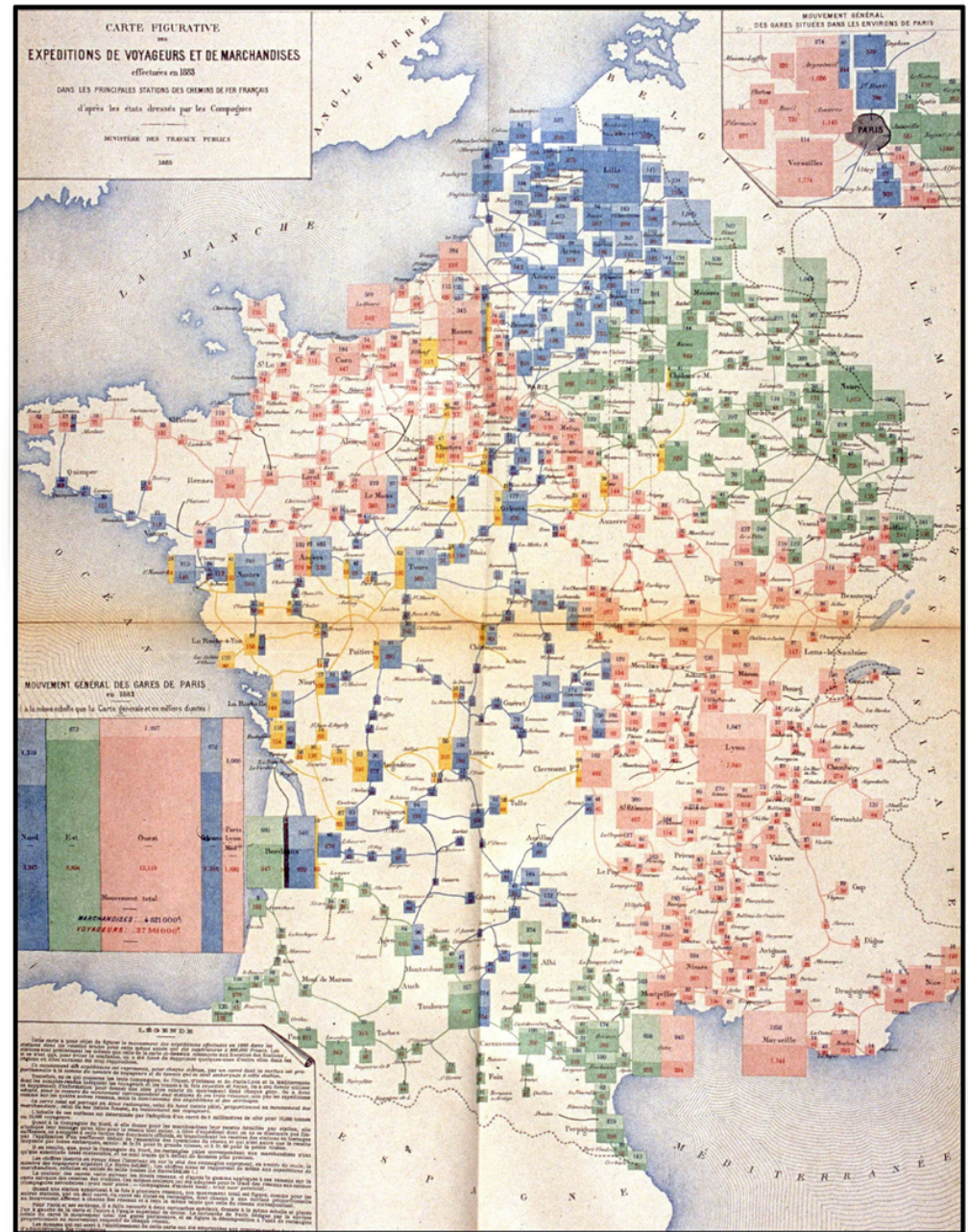
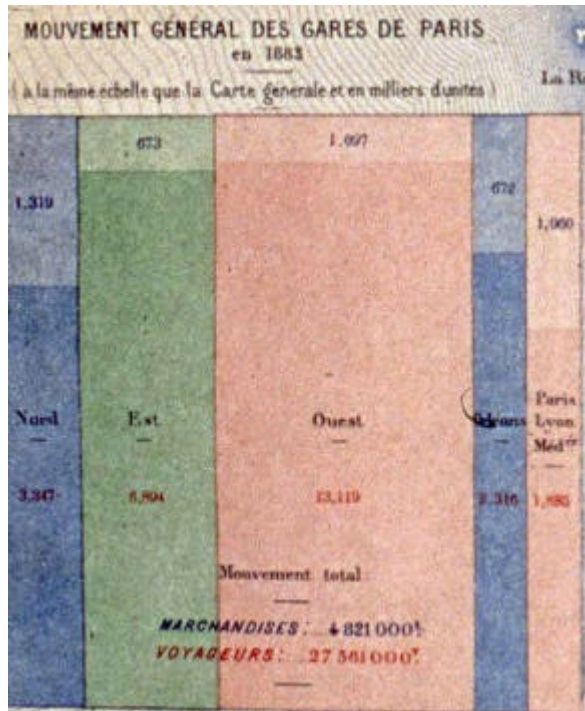
- Published by the *Statistical Graphics Bureau*, Ministry of Public Works, Émile Cheysson, director
- 18 volumes: 1879-1899, 12—34 plates each, ~ 11"x15" pages
- Graphic forms:
 - Flow maps (simple, double, multi)
 - Pie maps, star, radial, polar time-series, proportional circles
 - Mosaic maps, anamorphic maps, planetary diagrams
 - Choropleth, bi-polar scales
 - Charts: line, bar, time-series
- **Pinnacle of the Golden Age:** exquisite sampler of all known graphic forms!



Recursive multi-mosaic map

Distribution of **passengers and goods** from the Paris railways to the rest of France [Album, 1884, pl. 11]

(The image that launched my interest in the history of data vis.)

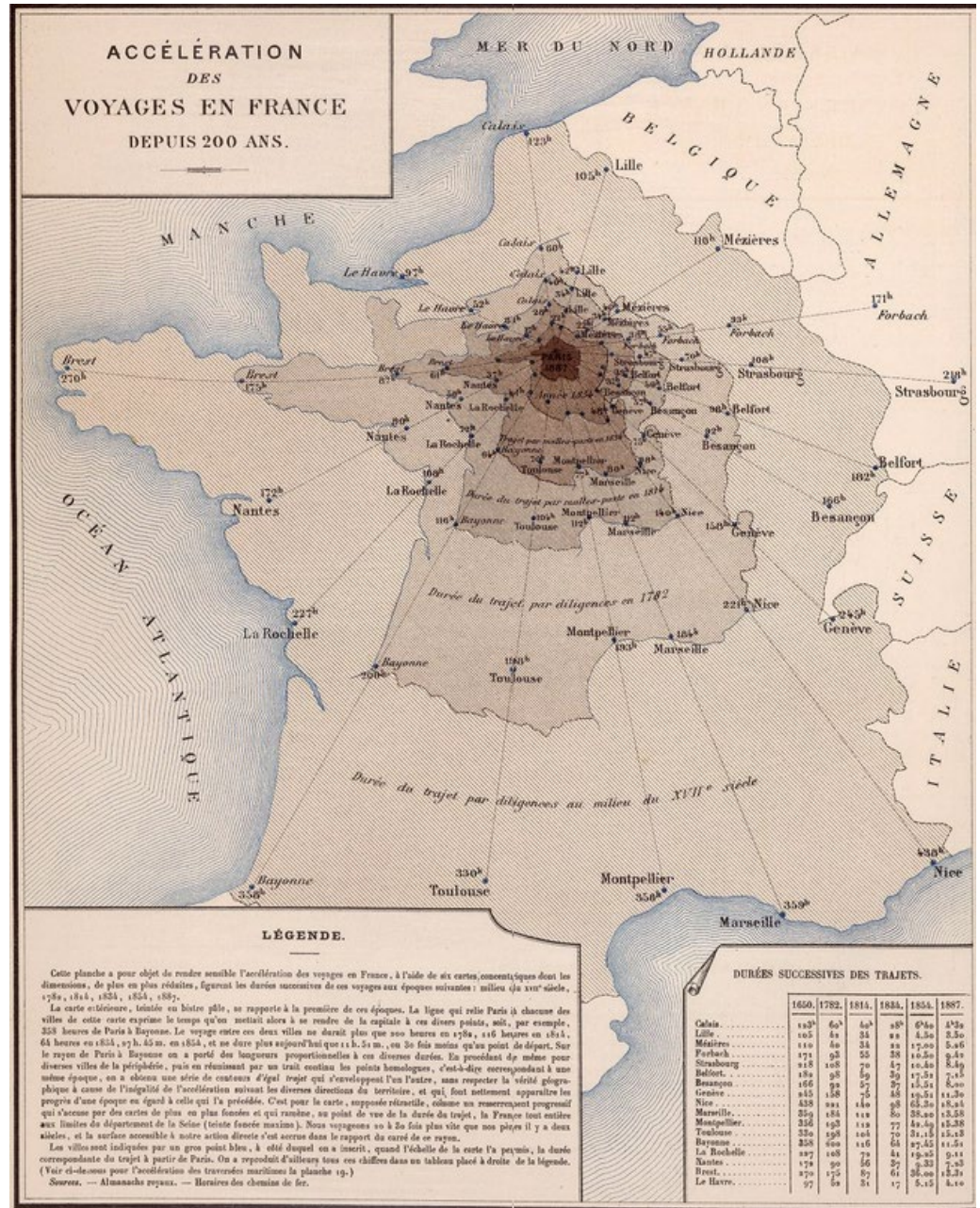


Anamorphic map

Shrinking France to show change in travel time over 200 years
 [Album, 1888, plate 8]

DURÉES SUCCESSIVES DES TRAJETS.

	1650.	1782.	1811.	1834.	1854.	1887.
Calais	103 ^h	60 ^h	40 ^h	28 ^h	6 ^h 30	4 ^h 30
Lille	105	42	34	22	4.50	3.50
Mézières	110	60	34	22	17.00	5.06
Forbach	171	93	55	38	10.50	9.42
Strasbourg	218	108	70	47	10.40	8.49
Belfort	182	98	59	39	17.51	7.15
Besançon	166	91	57	37	15.51	8.00
Genève	245	128	75	48	19.51	11.30
Nice	438	221	140	98	65.30	18.24
Marseille	359	184	112	80	38.20	13.58
Montpellier	356	193	112	77	42.49	15.38
Toulouse	330	195	104	70	31.15	15.18
Bayonne	358	190	110	64	27.45	11.51
La Rochelle	227	105	71	41	19.43	9.11
Nantes	179	90	56	37	9.33	7.23
Brest	270	175	87	61	36.00	15.31
Le Havre	97	52	31	17	5.15	4.10

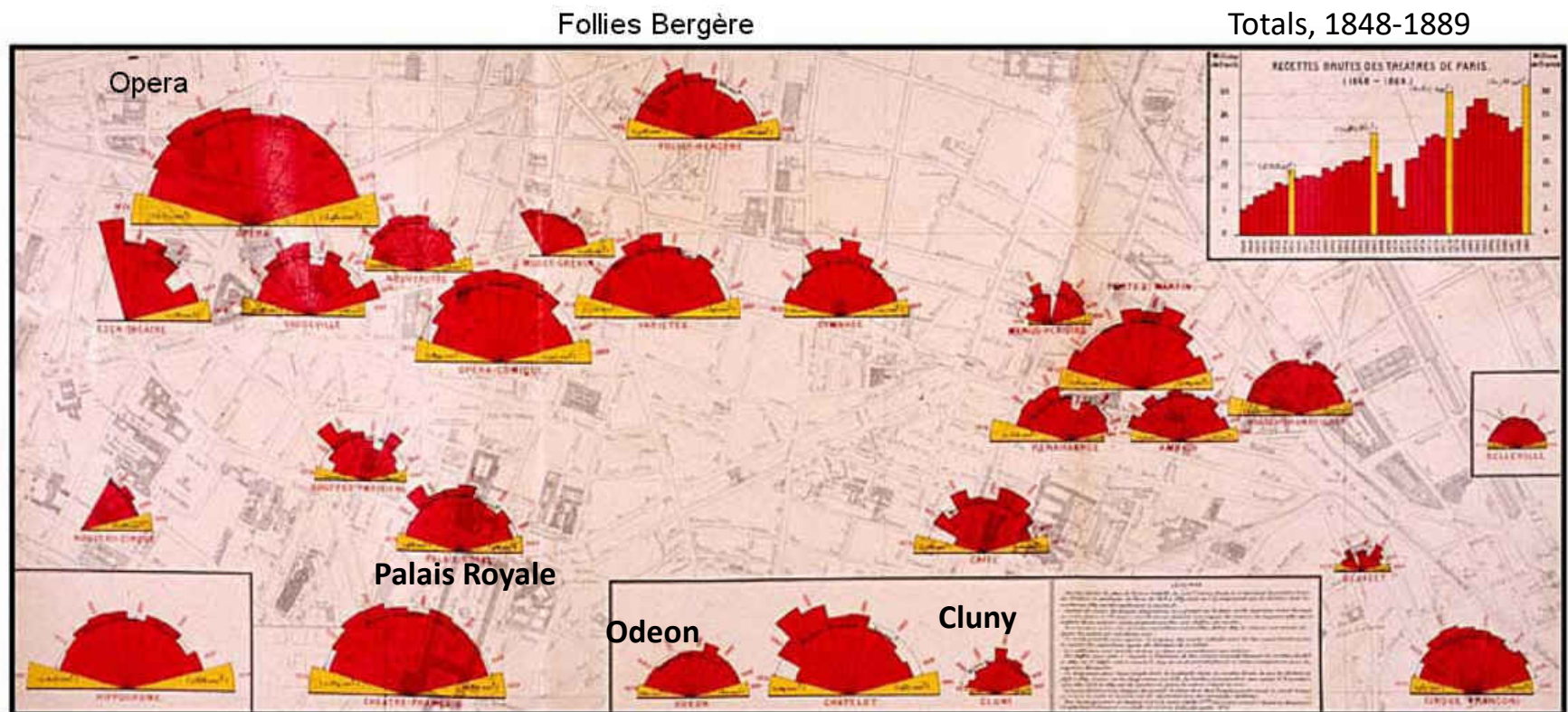


Album de statistique graphique

Q: How did Paris benefit from various int'l expos? How to show this visually?

Polar area diagrams on Paris map

Gross receipts in theaters in Paris, 1878—1889, related to universal expositions
[Album, 1889, plate 26]



Les Chevaliers des Albums

Antony Unwin



Sandra Rendgen



Gilles Palsky



RJ Andrews



Howard Wainer



David Rumsey



Antoine de Falguerolles



Michael Greenacre



Stephen Stigler



Ian Spence



ASG now online: David Rumsey

All 18 volumes, <https://www.davidrumsey.com/luna/servlet/s/nl72bu>



Ministere des Travaux P...
Carte Figurative des Re...
1886
National Atlas
Related (28)



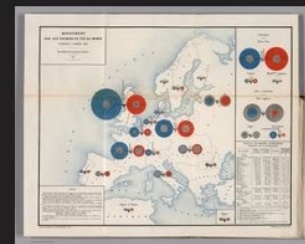
Ministere des Travaux P...
Carte Figurative des Ex...
1886
National Atlas
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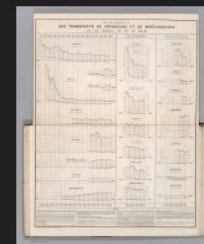
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Nombre de Voyageurs Tra...
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Ministere des Travaux P...
Mouvement Sur les Chemi...
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Statistical Diagram: Ra...
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Situation des Chemins d...
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Resultats D'Exploitiatio...
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D'Epenses de Premier Et...
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Carte Figurative du Ton...
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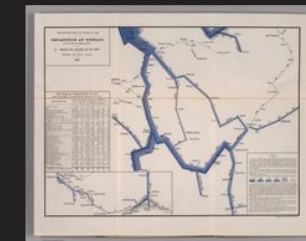
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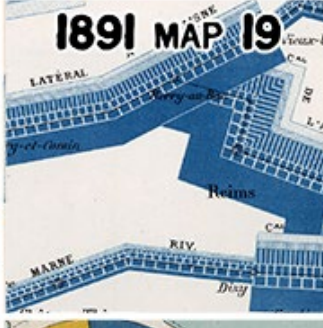
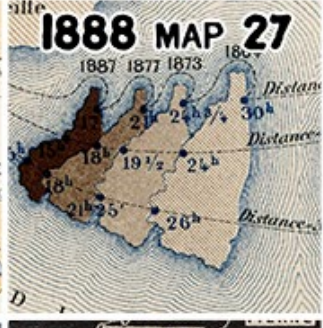
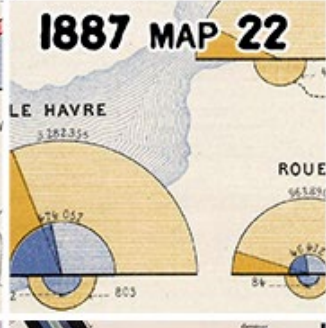
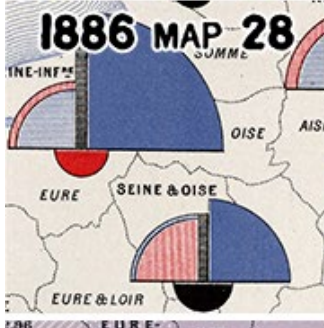
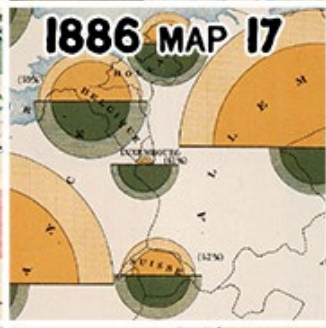
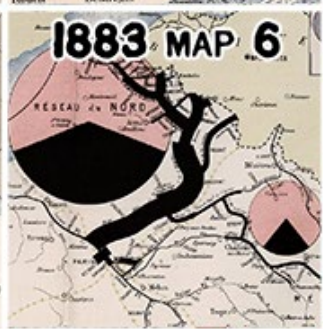
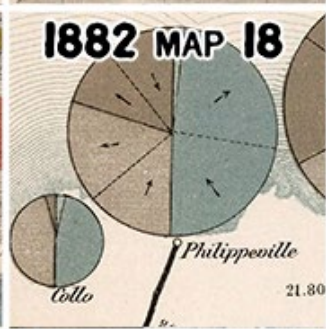
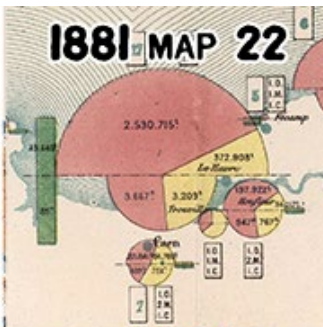
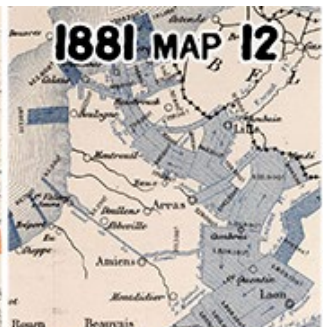
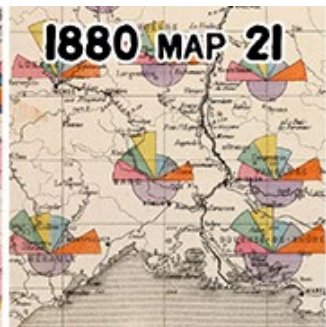
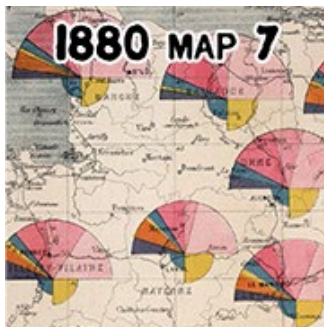
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Tonnage des Voies Navig...
1886
National Atlas
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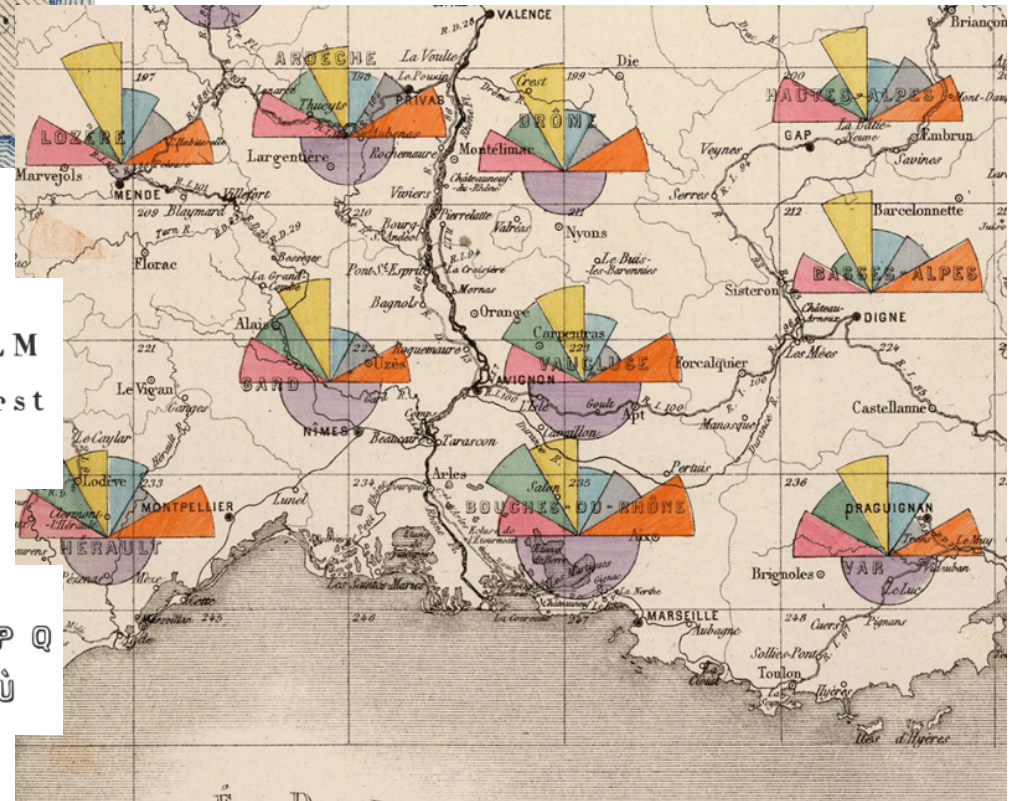
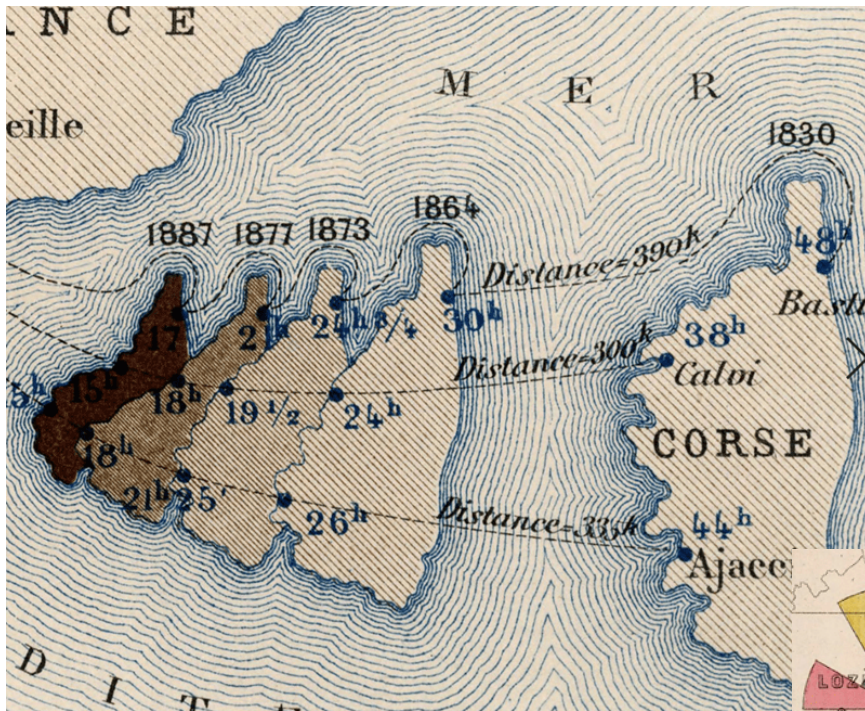


Ministere des Travaux P...
Tonnage des Voies Navig...
1886
National Atlas
Related (28)



Graphic details

“God is in the details” – Ludwig Mies van der Rohe



Cheysson Regular

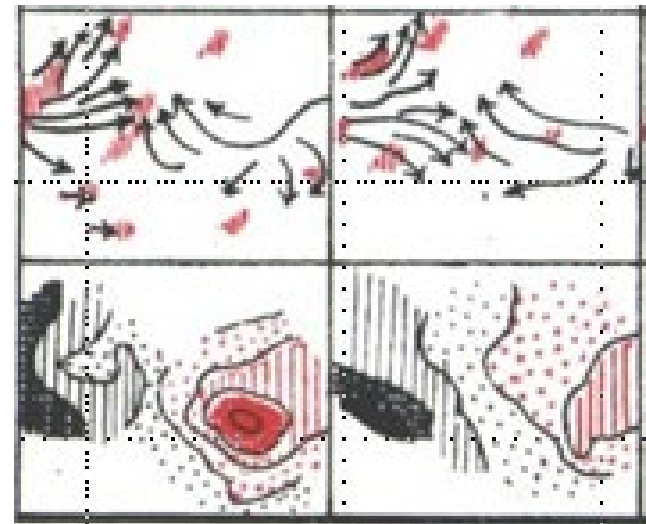
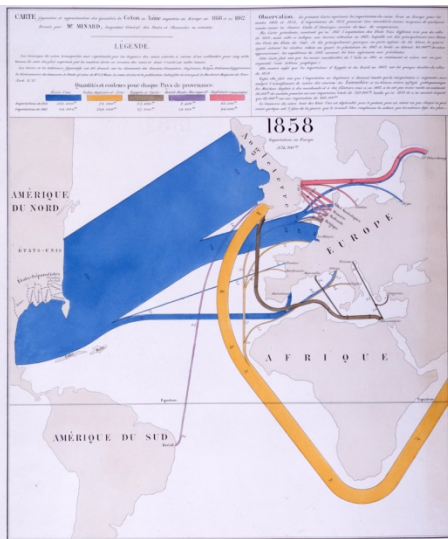
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u v w x y z « » À Â Ç È É Ê Ë Ì Ï Ò Ó Ô Ù à â ç è é ê ë ì ï ò ó ù

CHEYSSON OUTLINE CAPS

“ ” , - . : ; A B C D E F G H I J K L M N O P Q
R S T U V W X Y Z À Â Ç È É Ê Ë Ì Ï Ò Ó Ô Ù

Golden Lessons

- What are the lessons for the future?
- **Phenomena**, not numbers or simply pretty pictures
 - Playfair, Guerry, Minard, Galton, etc. all developed new graphic forms to show **phenomena of deep interest**:
 - balance of trade, rates of crime, patterns in weather data, ...
- **1st lesson**: data visualization today should have a similar focus



Golden Lessons: Graphical Impact

- Impact: Early ideas
 - Playfair, Guerry: data should “speak to the eyes”
 - Minard, Lalanne: allow “calculation by the eyes”
 - Nightingale: graphs should speak to the heart and mind, influence public policy & practice
- Graphical impact (Tukey, 1990)
 - **Interocularity**: the message hits you between the eyes
 - **Immediacy**: it hits you fast
 - **Inescapability**: it is hard to avoid the message
- **2nd lesson**: strive for visual impact in graphs and tables
 - God is in the details

Golden Lessons: Expressive power

- Hand-made graphics were often beautiful but entailed much sweat and hard work.
- Today: software– ease of use vs. expressive power
- Theories of graphics → graphic “languages”
 - Bertin: *Semiology of graphics*
 - Wilkinson: *Grammar of Graphics*
 - Wickham: *ggplot2* R package
 - In all: the devil is in the details!
- **3rd lesson:** continue to reduce the distance between a graphic idea and appearance on screen or paper.



Conclusions

The only new thing... is the history you don't know – Harry Truman

- Data visualization has deep roots:
 - Cartography
 - Statistical theory
 - Data collection
 - Visual thinking
 - Technology

All combine to give insightful views of data

Each area fed from, and nourished the others
- The Golden Age:
 - Qualitatively distinct, deserves recognition
 - Works of unparalleled beauty & scope
 - Statistical graphics had a ***purpose***: tell a story, inform decision
 - Provides lessons for today and tomorrow

Thank you!

Ask me anything

Further info:



<https://datavis.ca>



@datavisFriendly



Photo mosaic of history of datavis