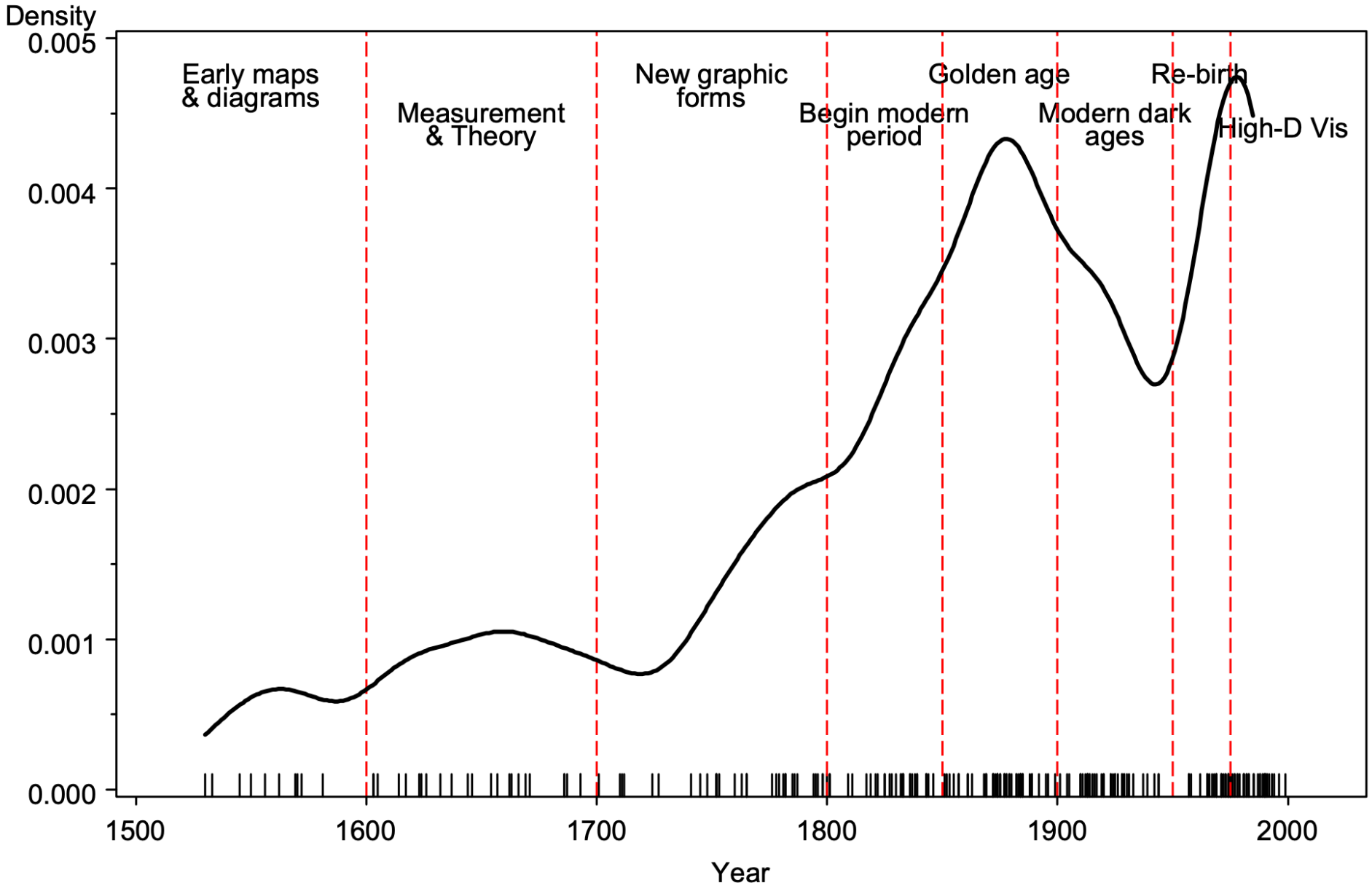
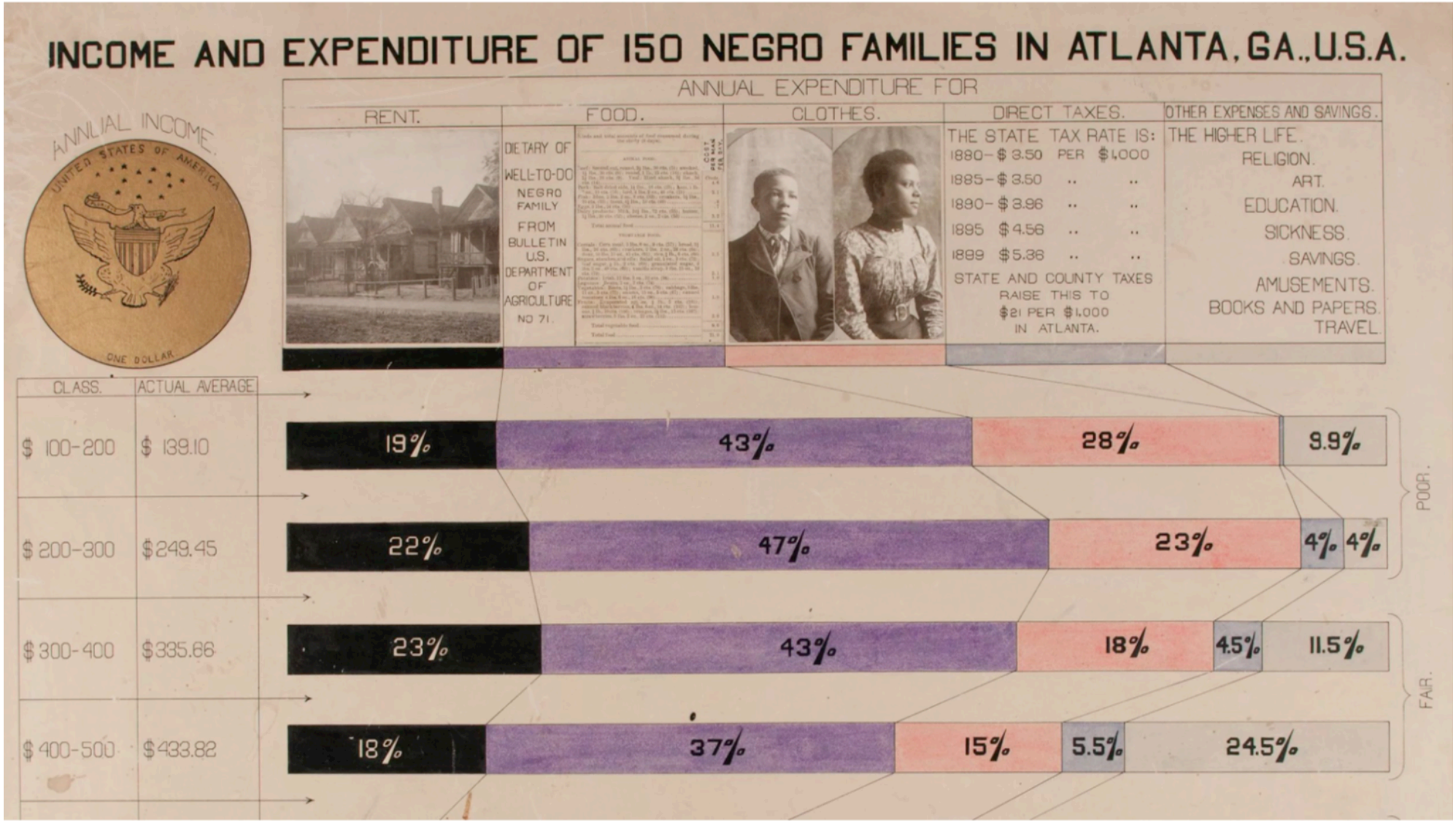

Milestones: Time course of developments
Density
0.005
0.004
0.003
0.002
0.001
0.000
Early maps & diagrams
Measurement & Theory
New graphic forms
Begin modern period
Golden age
Modern dark ages
Re-birth
High-D Vis
1500
1600
1700
1800
1900
2000
Year
friendly, 2006

1900-1950

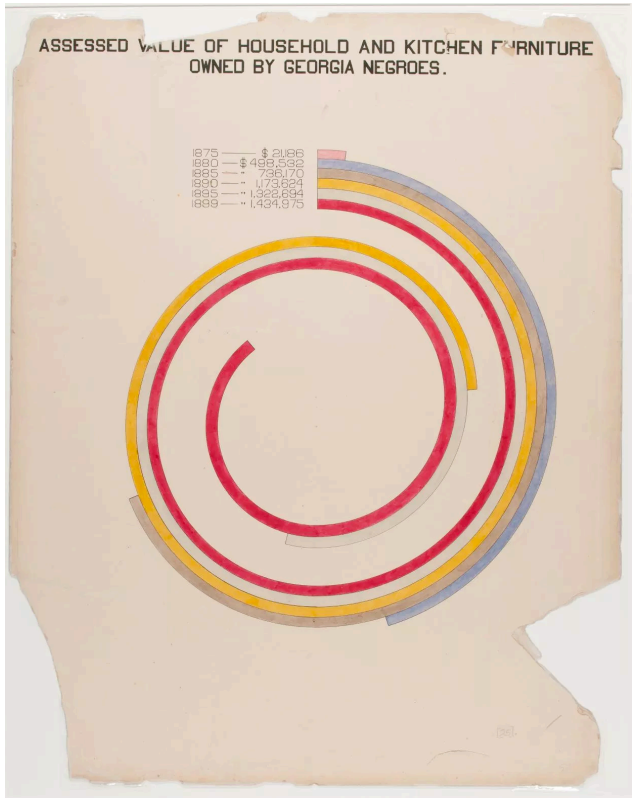
- the “dark age of data visualization”
- few graphical innovations
- time of necessary dormancy, application, and popularization, rather than one of innovation
- experimental comparisons of the efficacy of various graphics forms were begun
- new ideas and methods for multi-dimensional data in statistics and psychology

graphs for social sciences (w.e.b. du bois, 1900)



A compendium of new graphs, handmade, for the 1900's world fair

graphs for social sciences (w.e.b. du bois, 1900)



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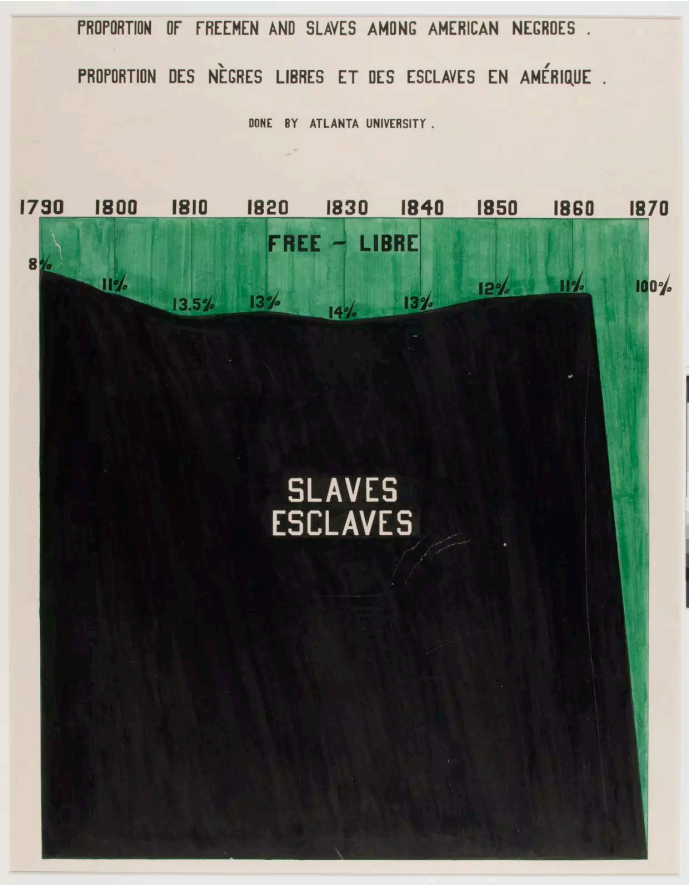

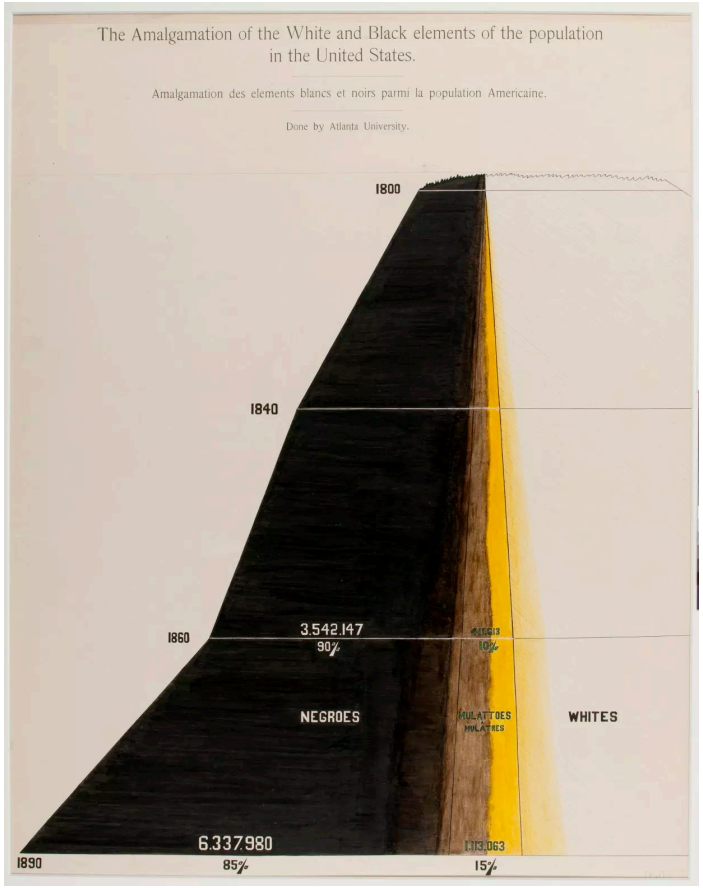

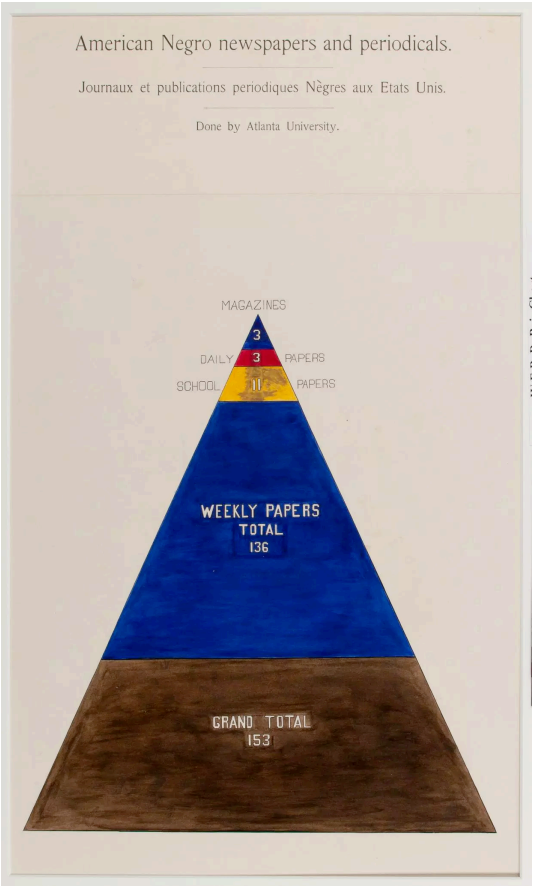

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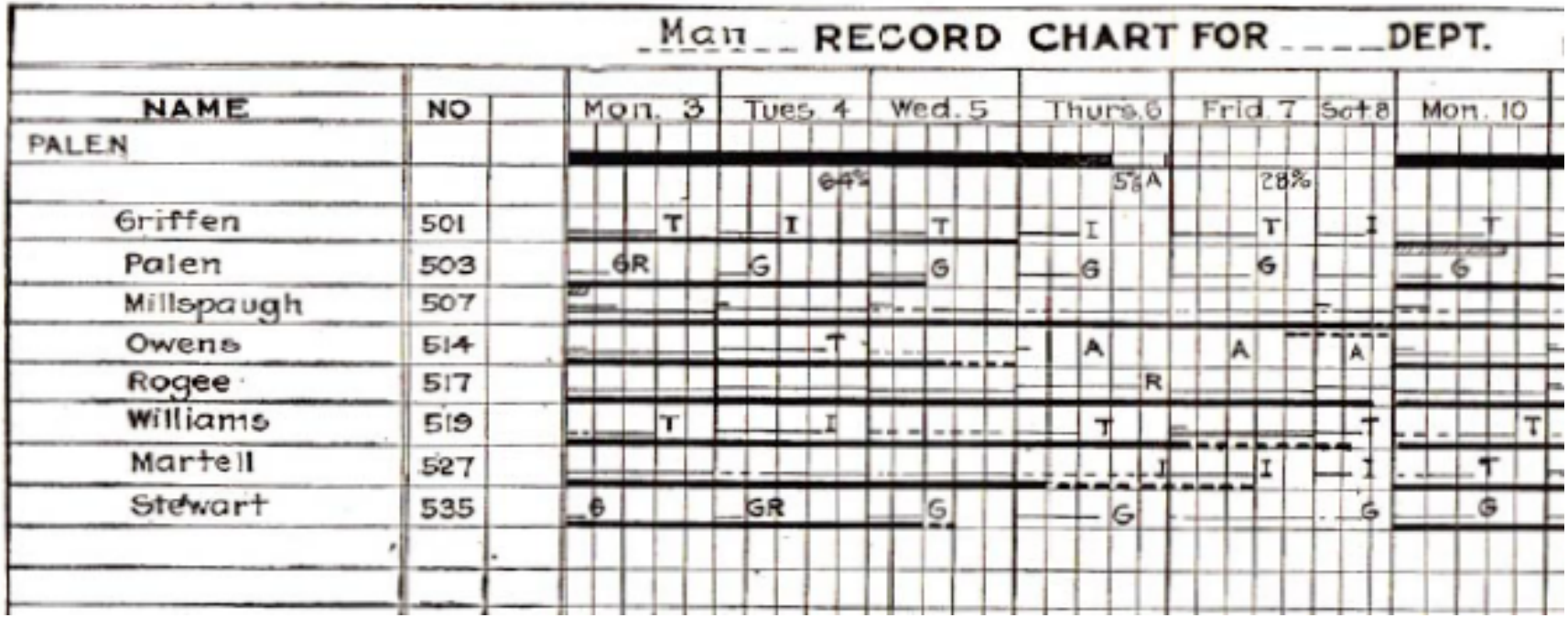
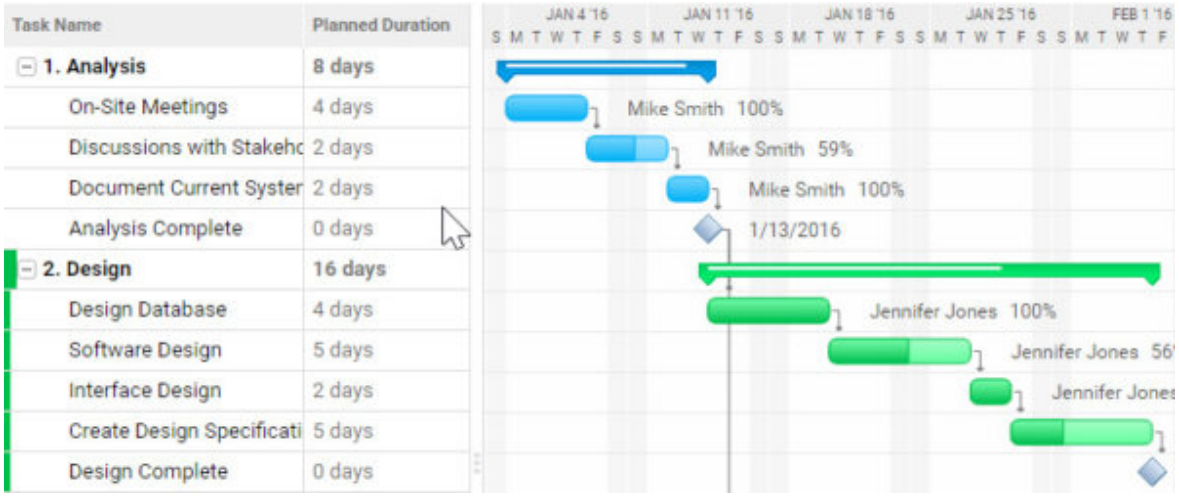
gantt chart (h.l. gantt, 1917)



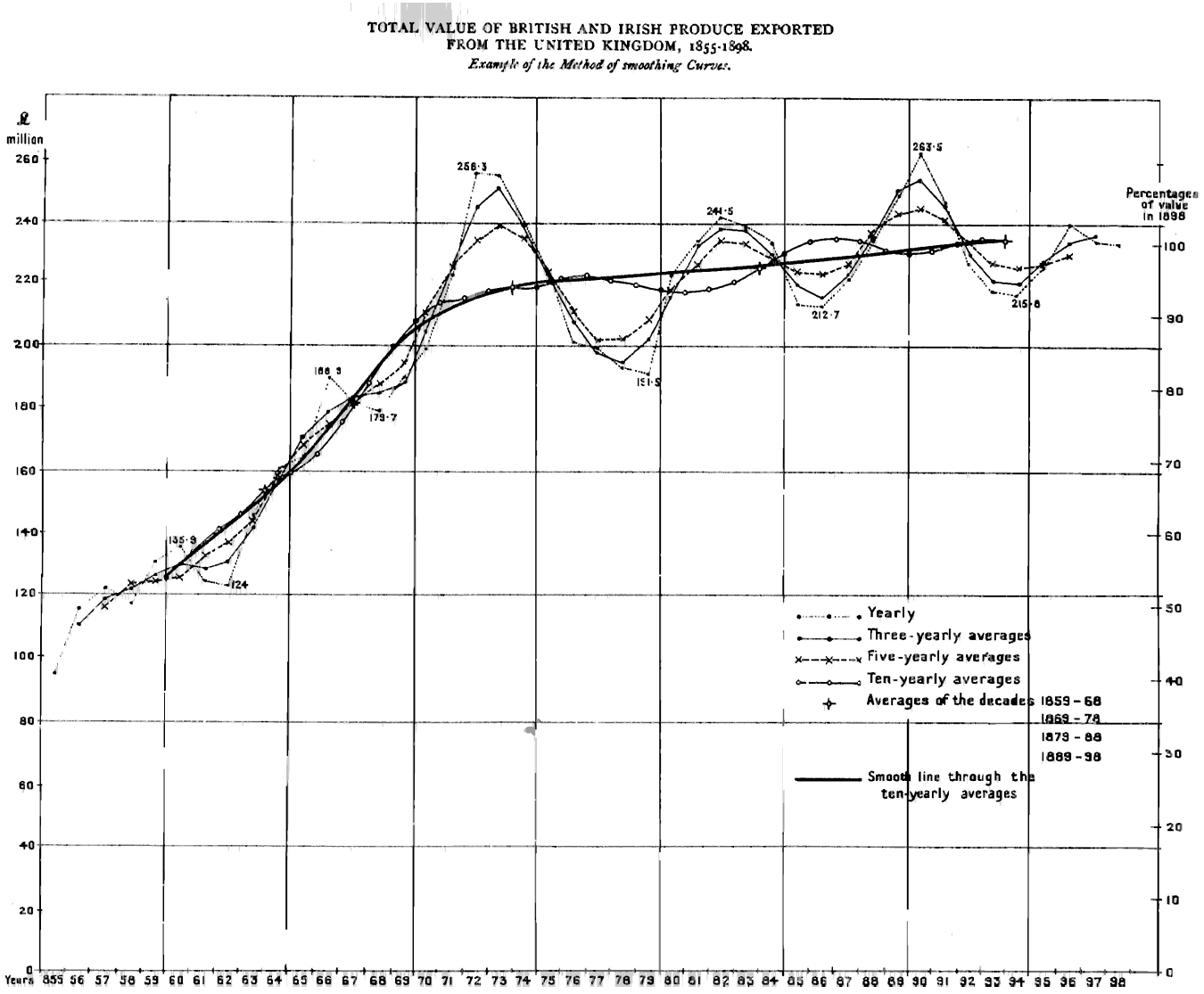
modern gantt chart



london underground map (h.c. beck, 1933)

- inspired to electrical circuit board, w/ only vertical, horizontal and 45 degree angled lines
- stations located according to available space
- geographically inaccurate, but easier to use to determine how to get from point a to b.

smoothing time series (a.l. bowley, 1901)



british and *irish* exports from 1855-1899: line graph of the time-series data, supplemented by overlaid line graphs of 3-, 5- and 10-year moving averages

butterfly plots (e.w. maunder, 1904)

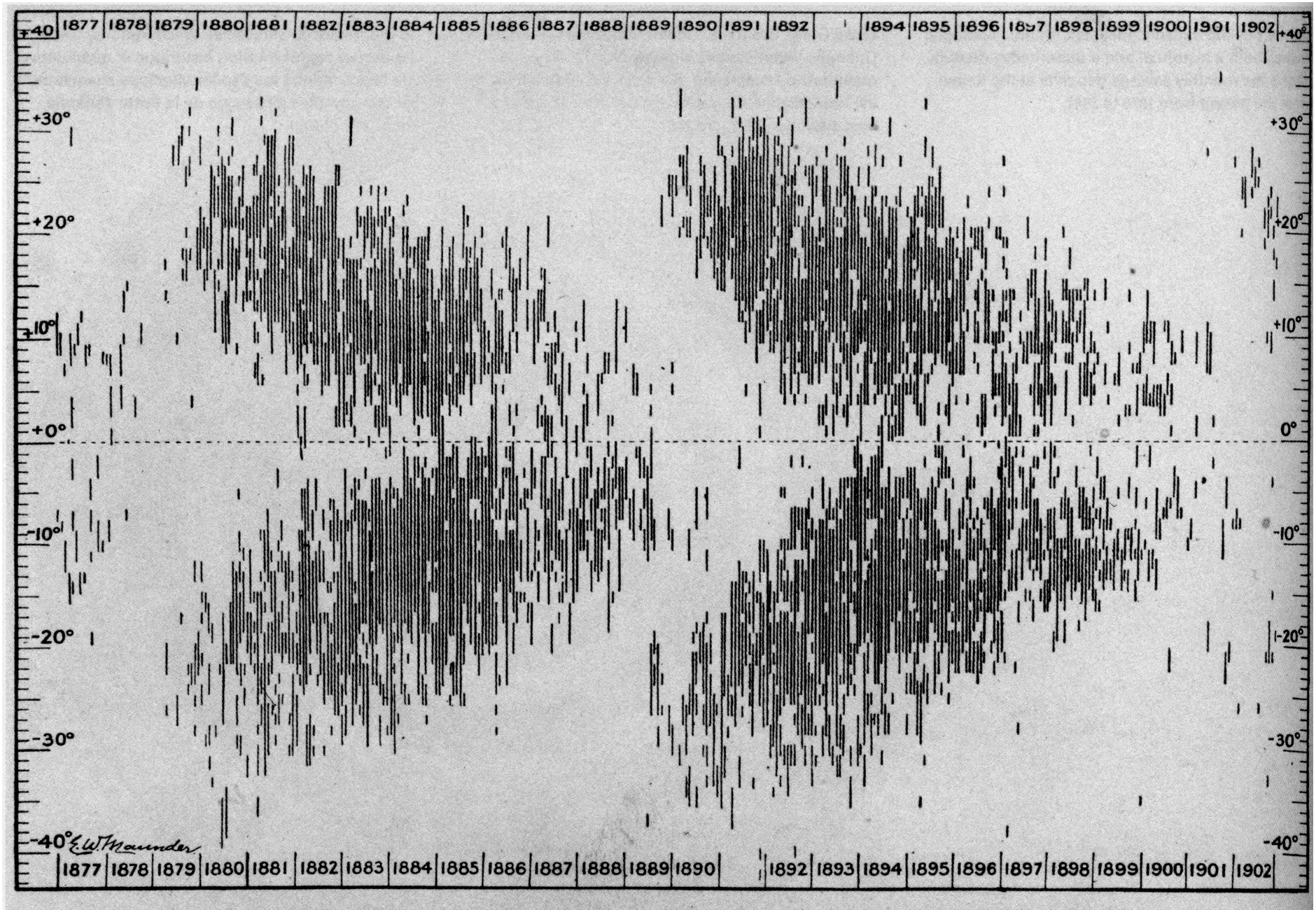
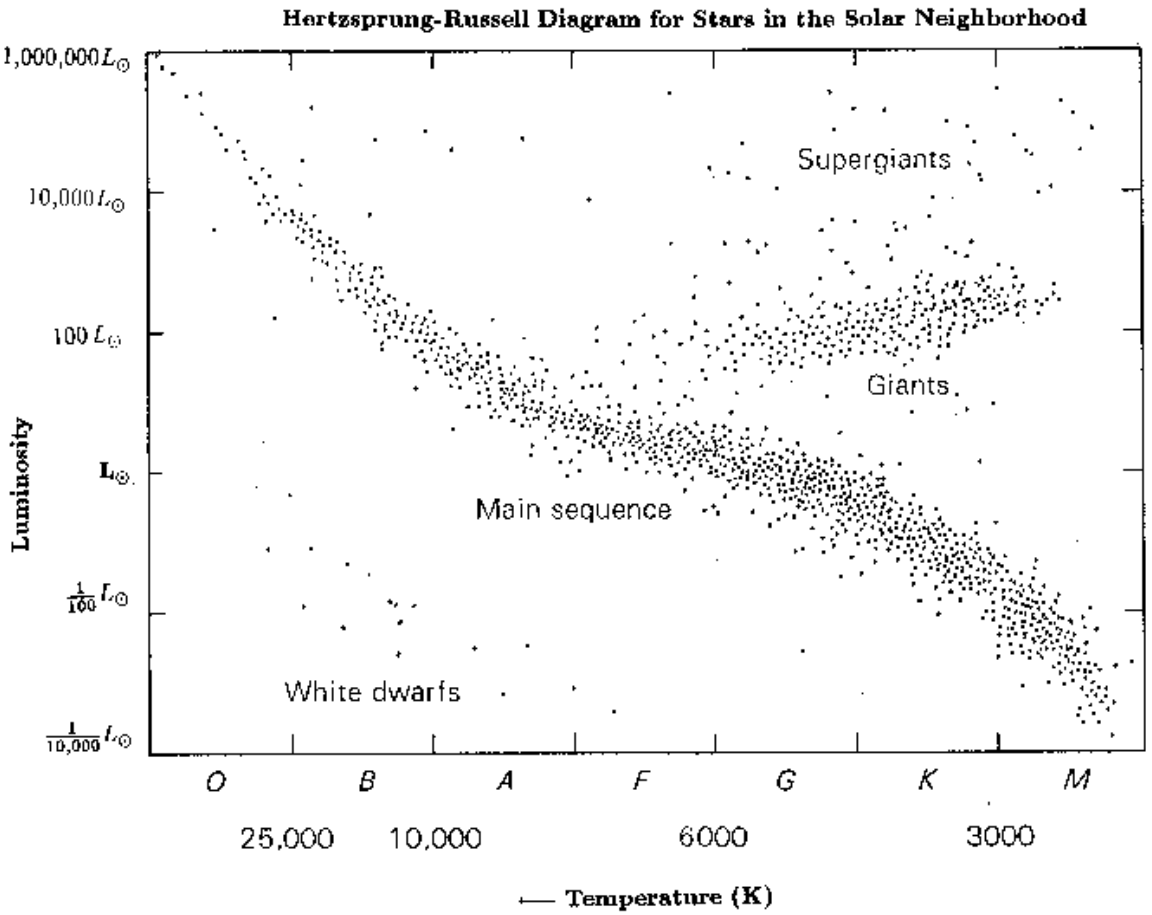
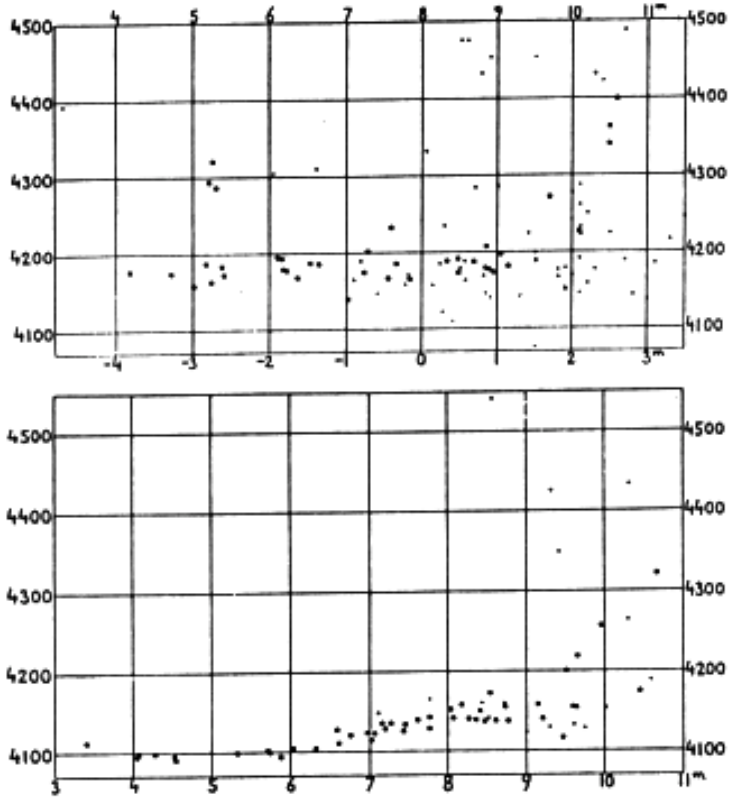


FIG. 8.—DISTRIBUTION OF SPOT-CENTRES IN LATITUDE, ROTATION BY ROTATION, 1877–1902.

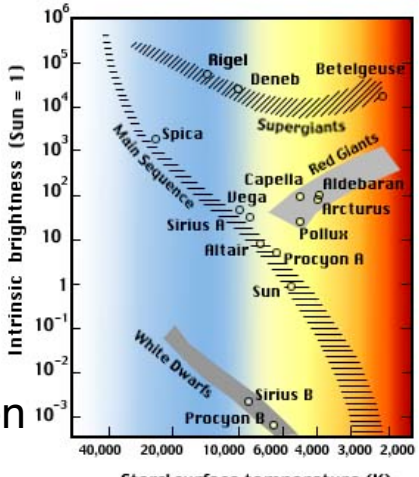
hertzsprung-russell diagram (e. hertzsprung & h.n. russell, 1911-1913)



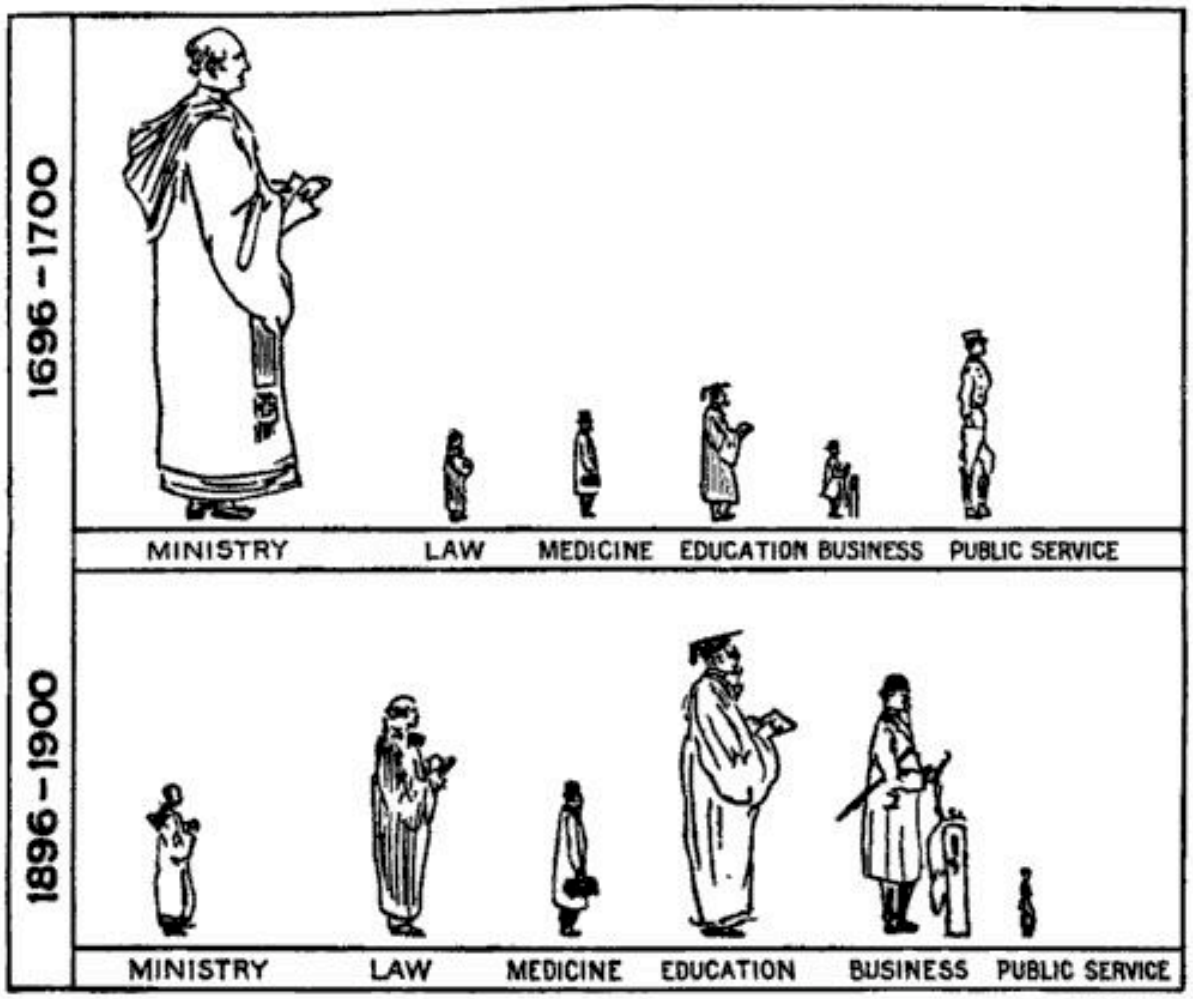
log-log plot of luminosity as a function of temperature for stars, used to explain the changes as a star evolves.



modern version



varying pictograms (w.c. brinton, 1914)



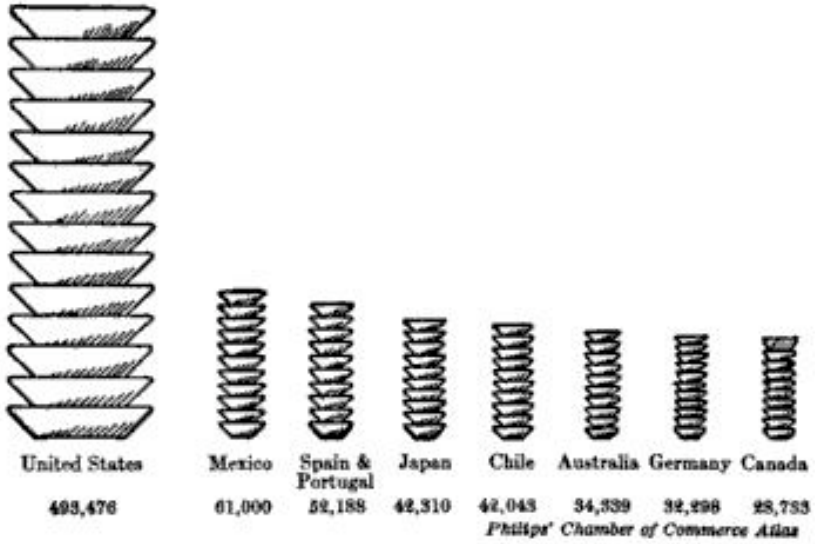
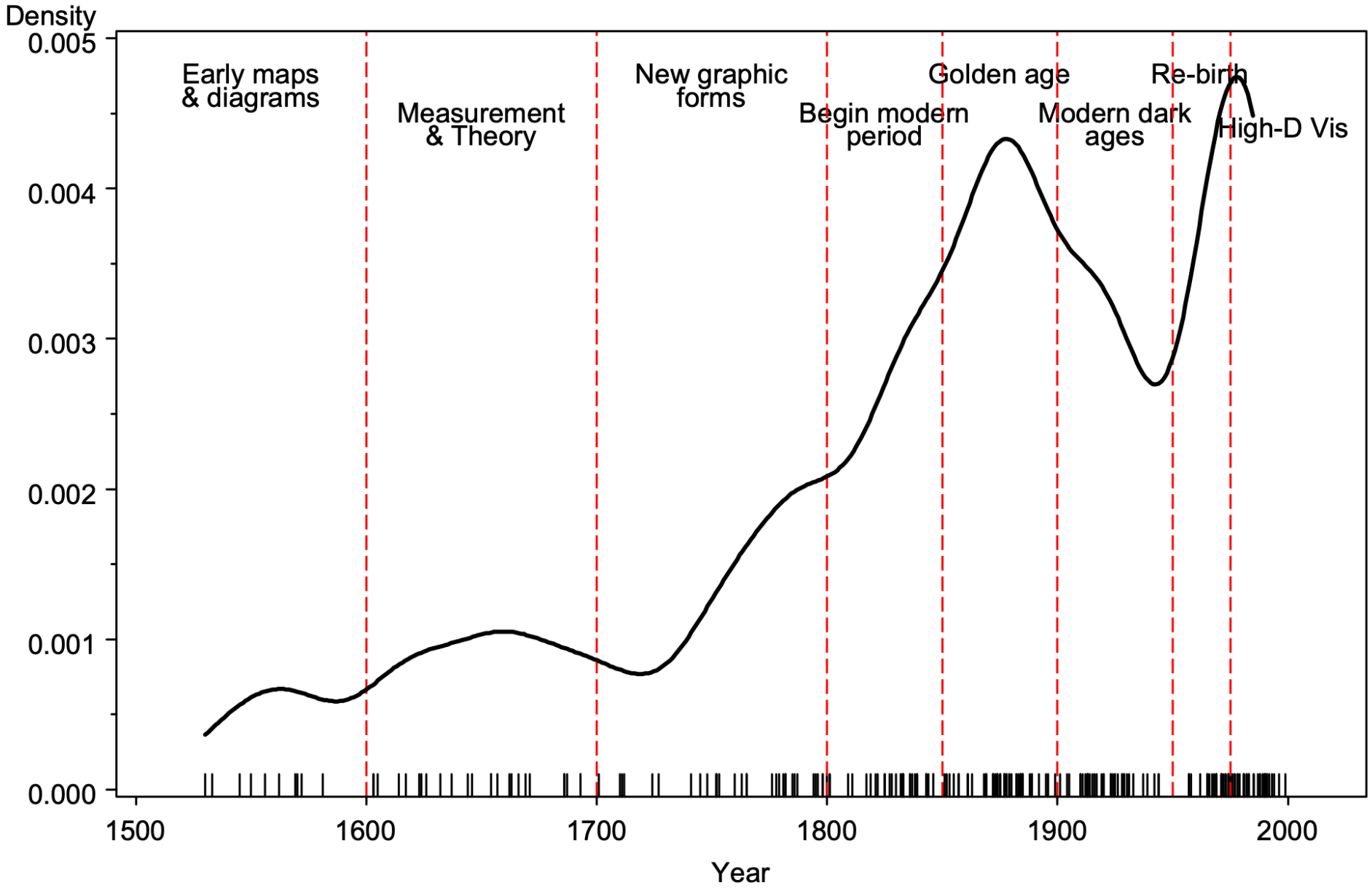


Fig. 25. A Year's Production of Copper in Tons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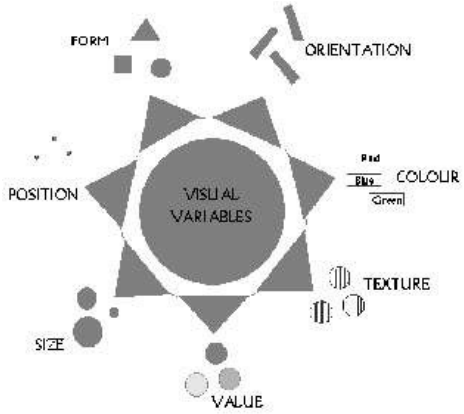
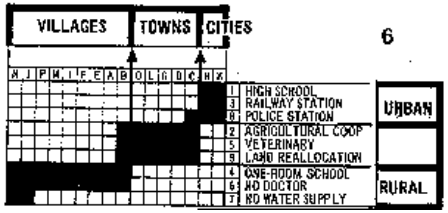
1950-1975

- the “re-birth of data visualization”
- organization of the visual and perceptual elements (*j. bertin*)

Visual variables (bertin, 1967)





VISUAL VARIABLES	*VISUAL LEVELS*			
	ASSOCIATION	SELECTION	ORDER	QUANTITY
SIZE	⬢	⬢	⬢	⬢
VALUE (ACHROMATIC)	⬢	⬢	⬢	⬡
TEXTURE	⬢	⬢	⬢	⬡
COLOUR (HUES ONLY)	⬢	⬢	⬡	⬡
ORIENTATION	⬢	⬢	⬡	⬡
SHAPE	⬢	⬡	⬡	⬡

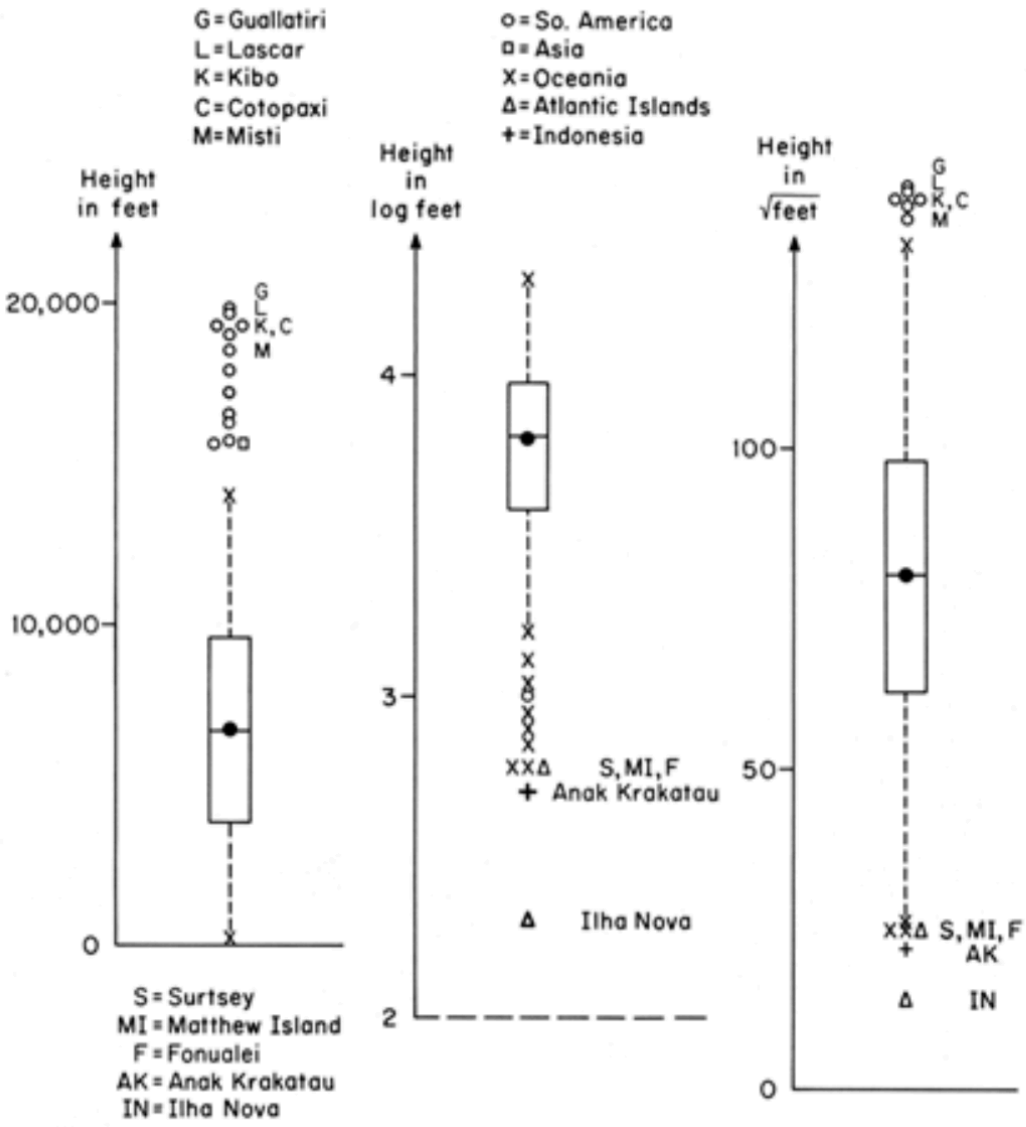
⬢ Available ⬡ Not Available

Figure 2 Bertin's visual variables with their visual levels

1950-1975

- the “re-birth of data visualization”
- organization of the visual and perceptual elements (*j. bertin*)
- wide variety of new, simple, effective graphics (*j.w. tukey*)

box-and-whiskers plot (j.w. tukey, 1969)



18

Some Graphic and Semigraphic Displays

JOHN W. TUKEY

1. Introduction

GRAPHS and semigraphic displays are made for purposes. Different purposes usually call for different graphs (or displays), although they do not always get them. In order of increasing importance come three broad classes:

- Graphs from which numbers are to be read off—substitutes for tables.
- Graphs intended to show the reader what has already been learned (by some other technique)—these we shall sometimes impolitely call propaganda graphs.
- Graphs intended to let us see what may be happening over and above what we have already described—these are the analytical graphs that are our main topic.

Five directions of innovation concern us:

1. Displays that lie between the conventional graph and the conventional table offer real opportunities. The thought that numbers should participate in an exhibit that is at least partly graphical has been too

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This paper has been prepared in part in connection with research at Princeton sponsored by the Army Research Office, Durham, and is based on a paper presented at the annual meetings of the American Statistical Association, Institute of Mathematical Statistics, and ENAR of the Biometric Society, August 1969.

1950-1975

- the “re-birth of data visualization”
- organization of the visual and perceptual elements (*j. bertin*)
- wide variety of new, simple, effective graphics (*j.w. tukey*)
- computer processing of data begins
- true high-resolution graphics are developed
- new paradigms, languages and software packages for expressing and implementing statistical and data graphics

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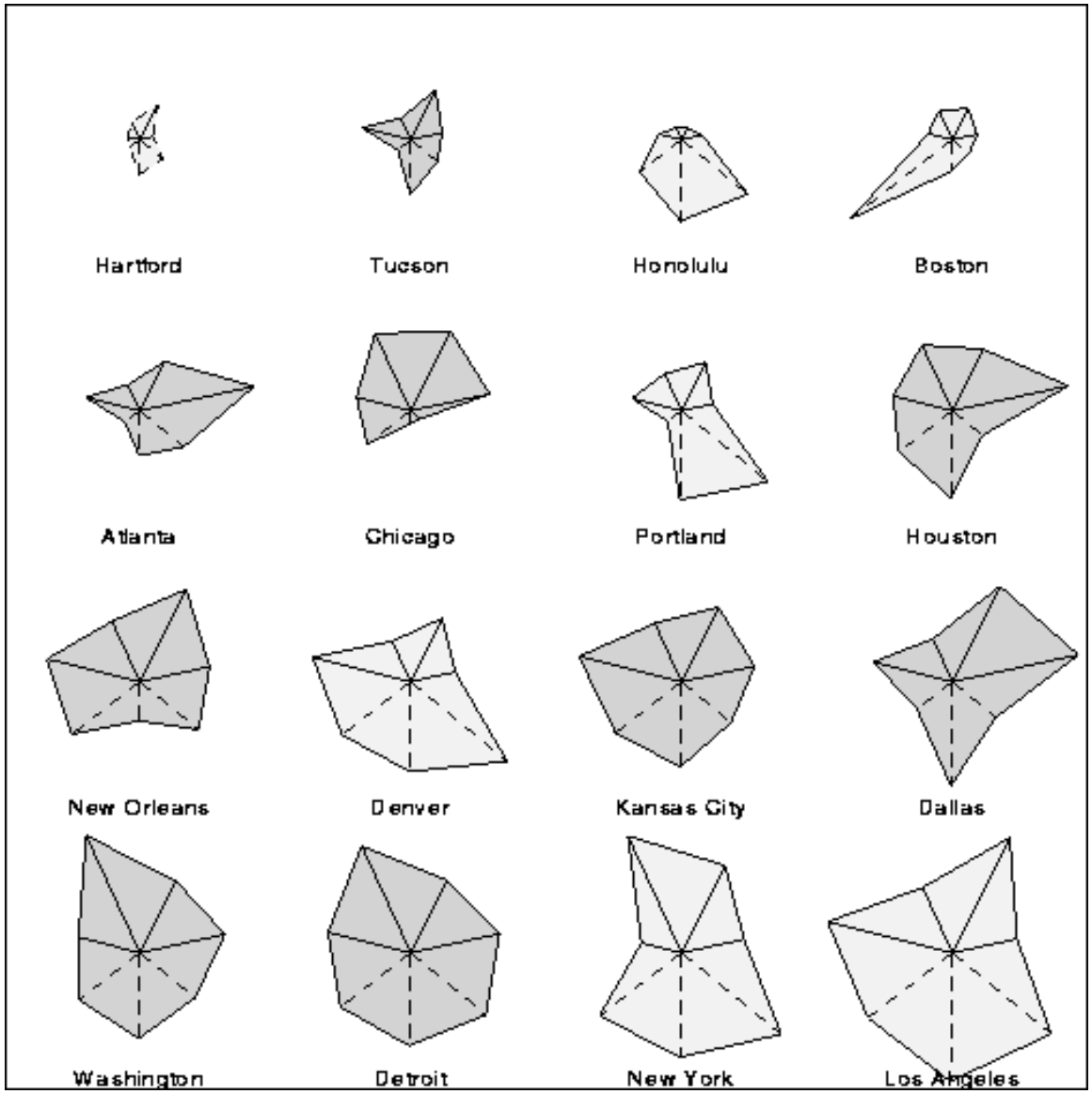
- true high-resolution graphics are developed
- new paradigms, languages and software packages for expressing and implementing statistical and data graphics
- visual representations of multivariate data

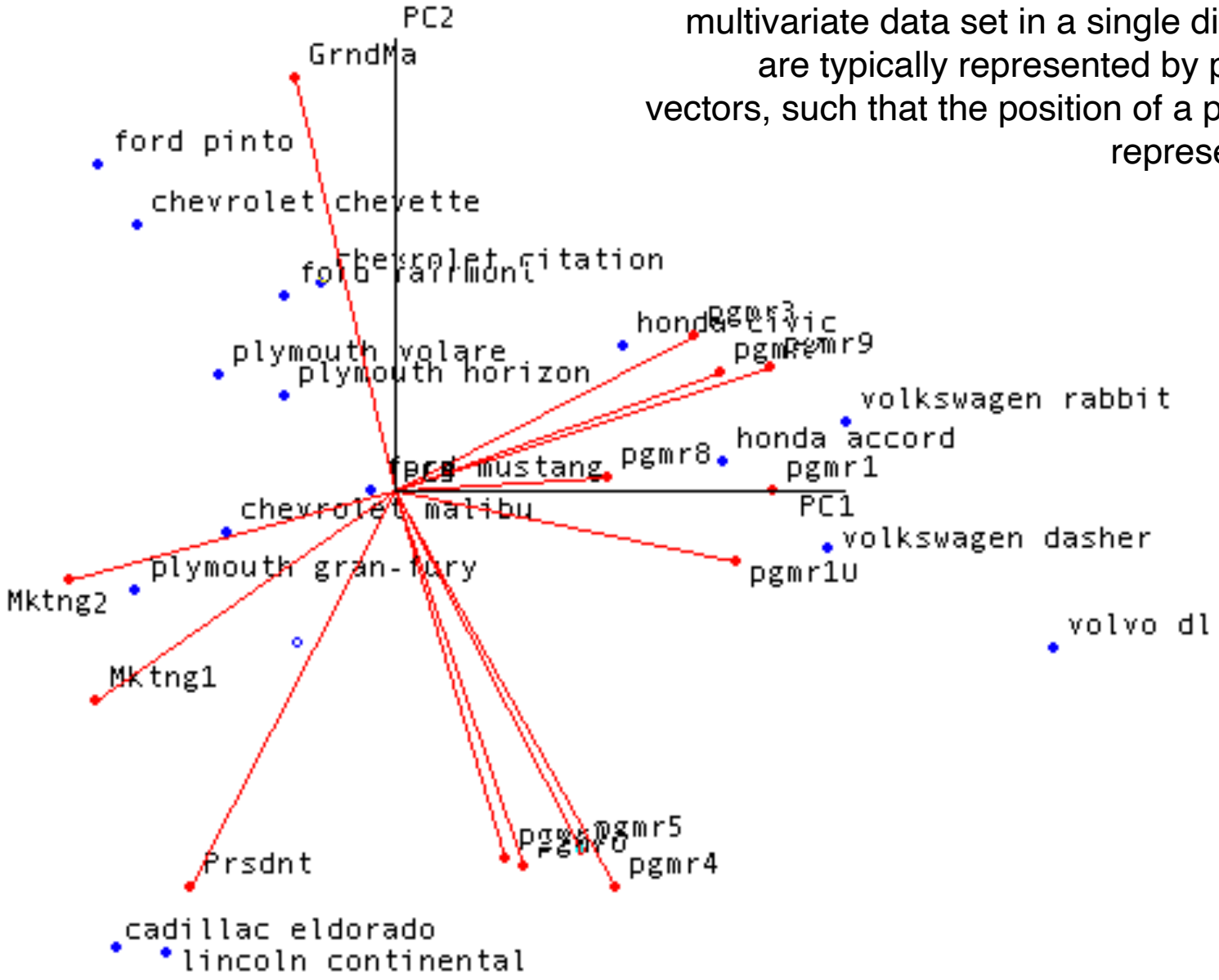
star plot (h.p. friedman, r.m. goldwyn, j.h. siegel, 1971)



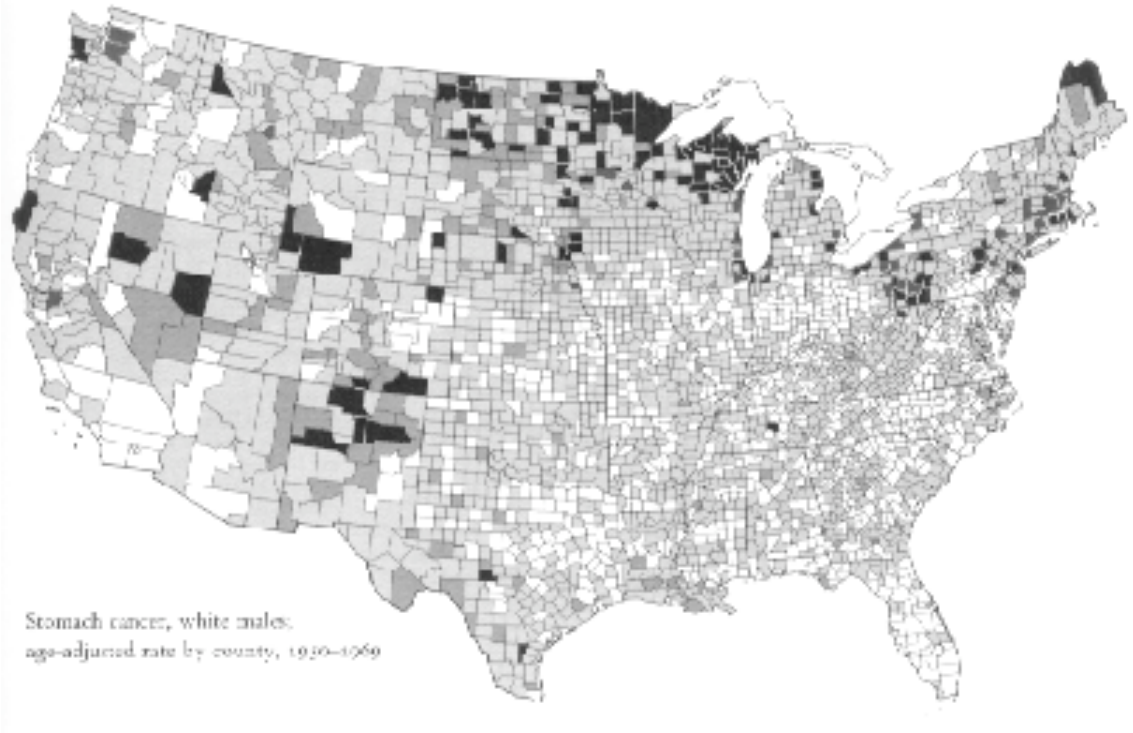
vertices at equally spaced intervals, distance from center proportional to the value of a variable

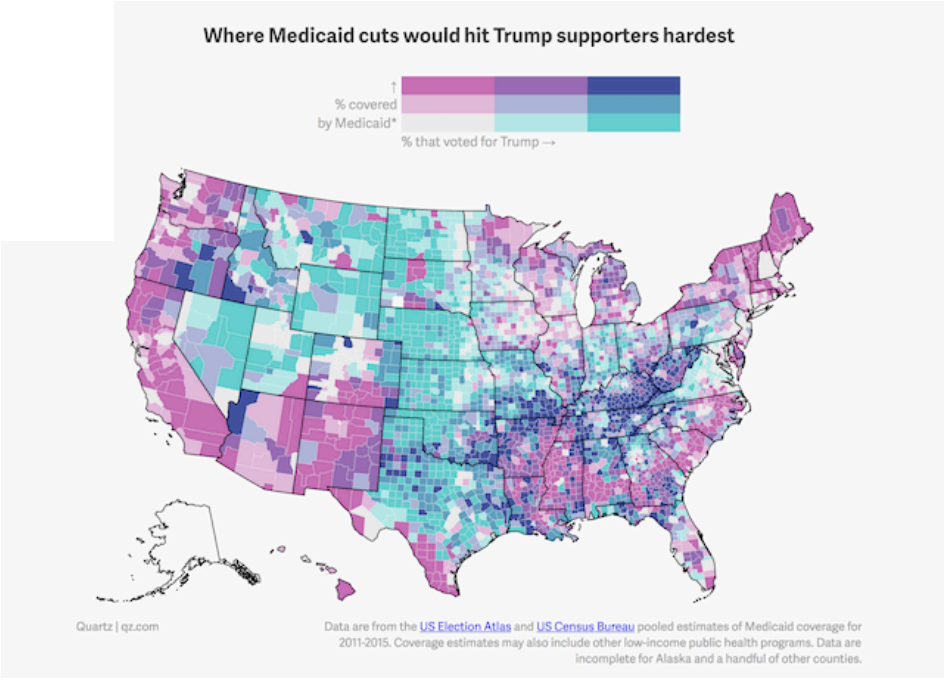
biplot (k.r. gabriel, 1971)

visualizing both the observations and variables in a multivariate data set in a single display observations are typically represented by points, variables by vectors, such that the position of a point along a vector represents the data value



bivariate matrix (u.s. bureau of census, 1974)





color-coded bivariate matrix to represent two intervally measured variables in a single map

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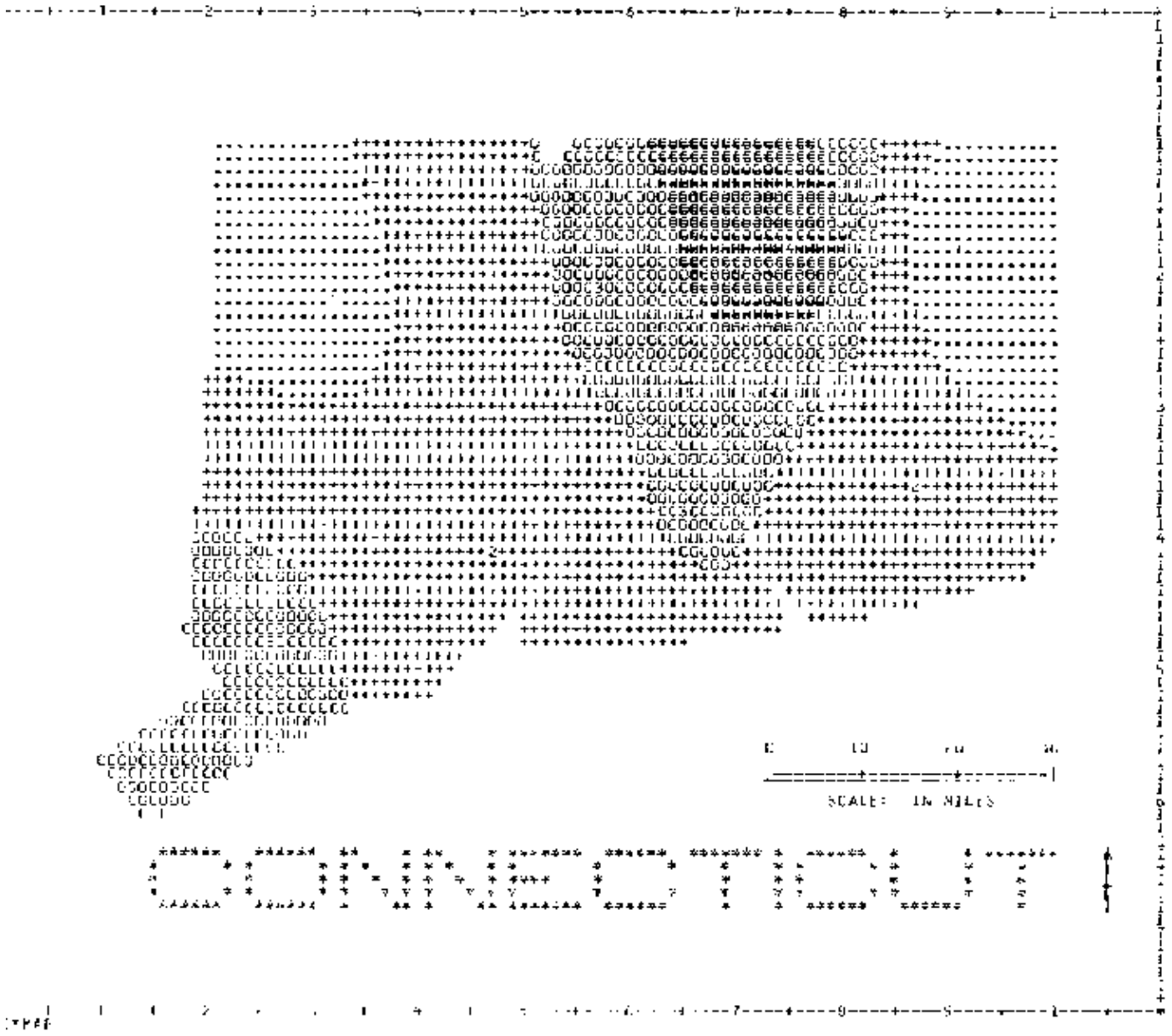
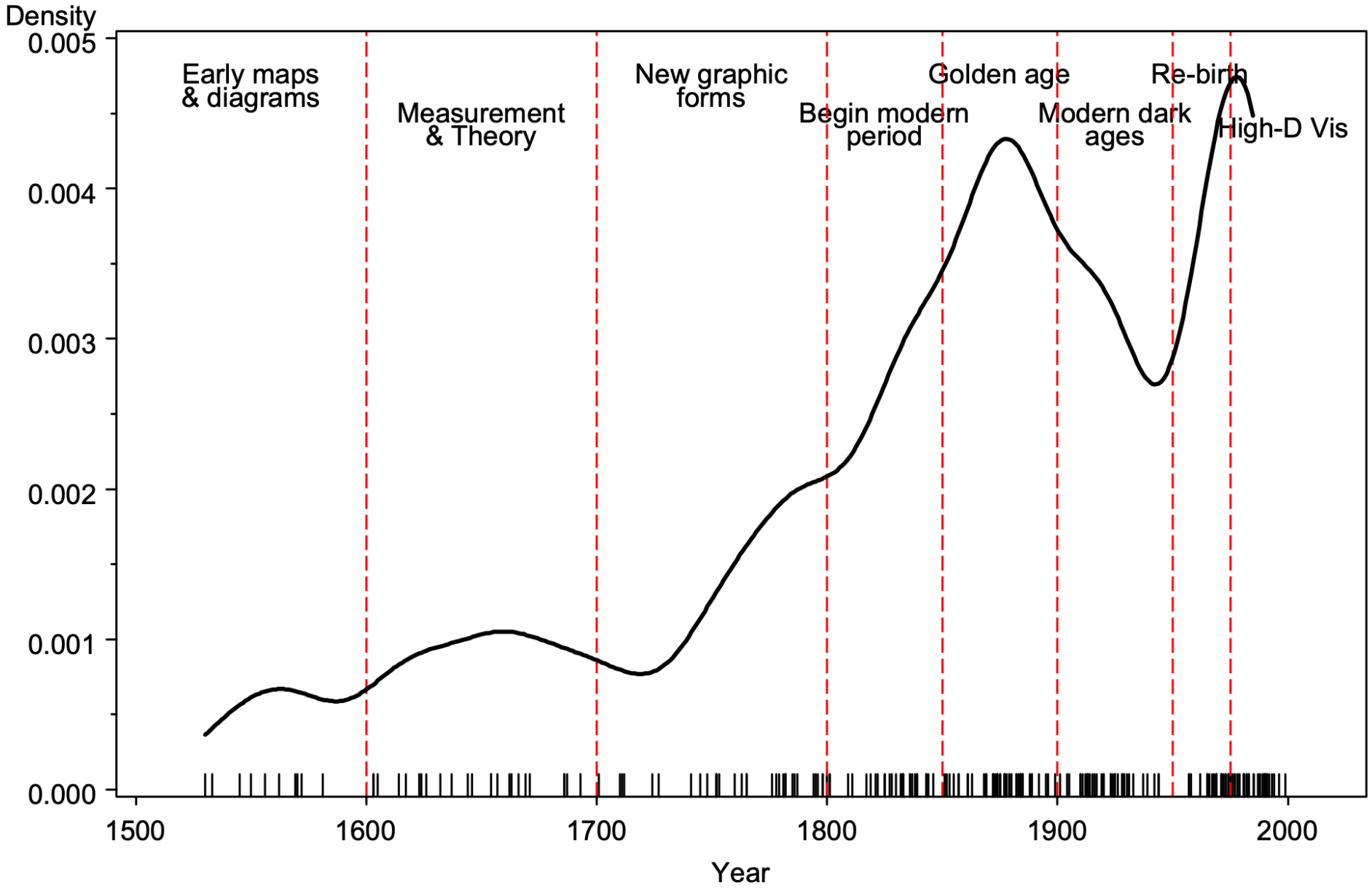
- computer processing of data begins
- true high-resolution graphics are developed
- new paradigms, languages and software packages for expressing and implementing statistical and data graphics
- visual representations of multivariate data
- animations of a statistical process
- perceptually-based theory

first geographical information systems (gis) (h.t. fisher, 1960)



isoline, choropleth and proximal maps on a line printer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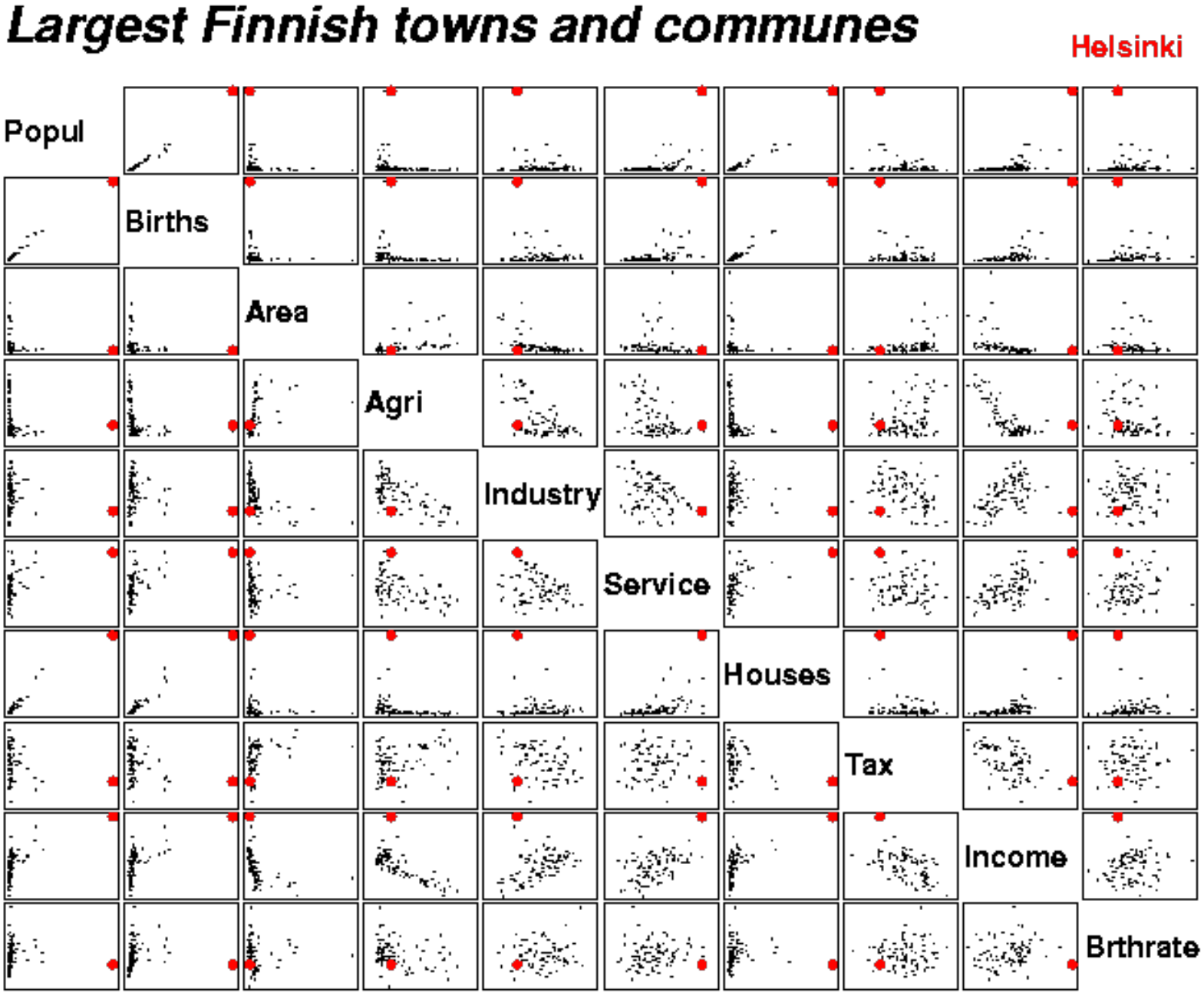
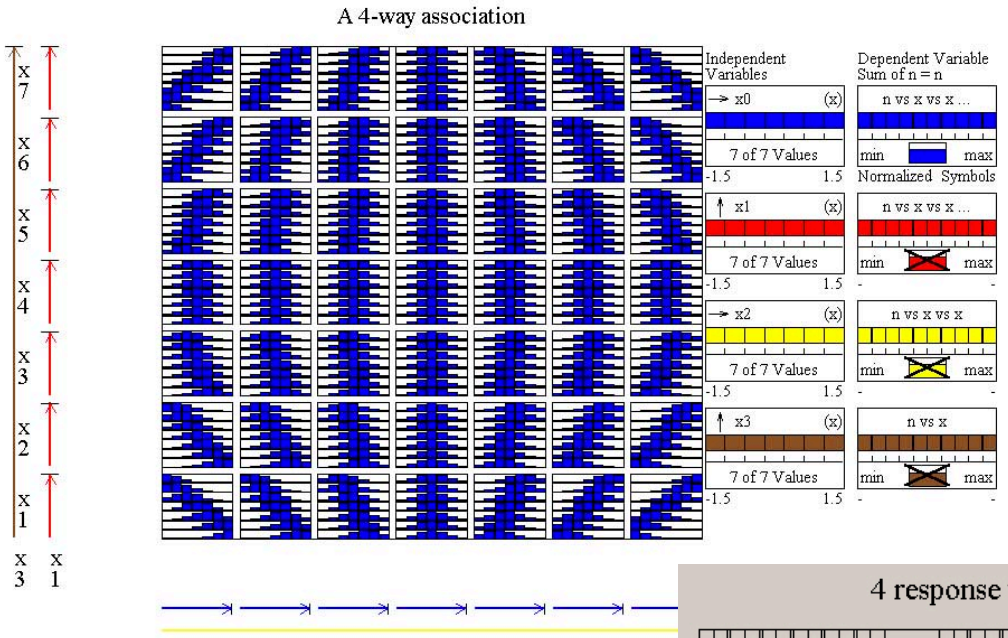
1975-now

- highly interactive computer systems
- new methods for visualizing high-dimensional data (grand tour, scatterplot matrix, parallel coordinates plot, etc.)

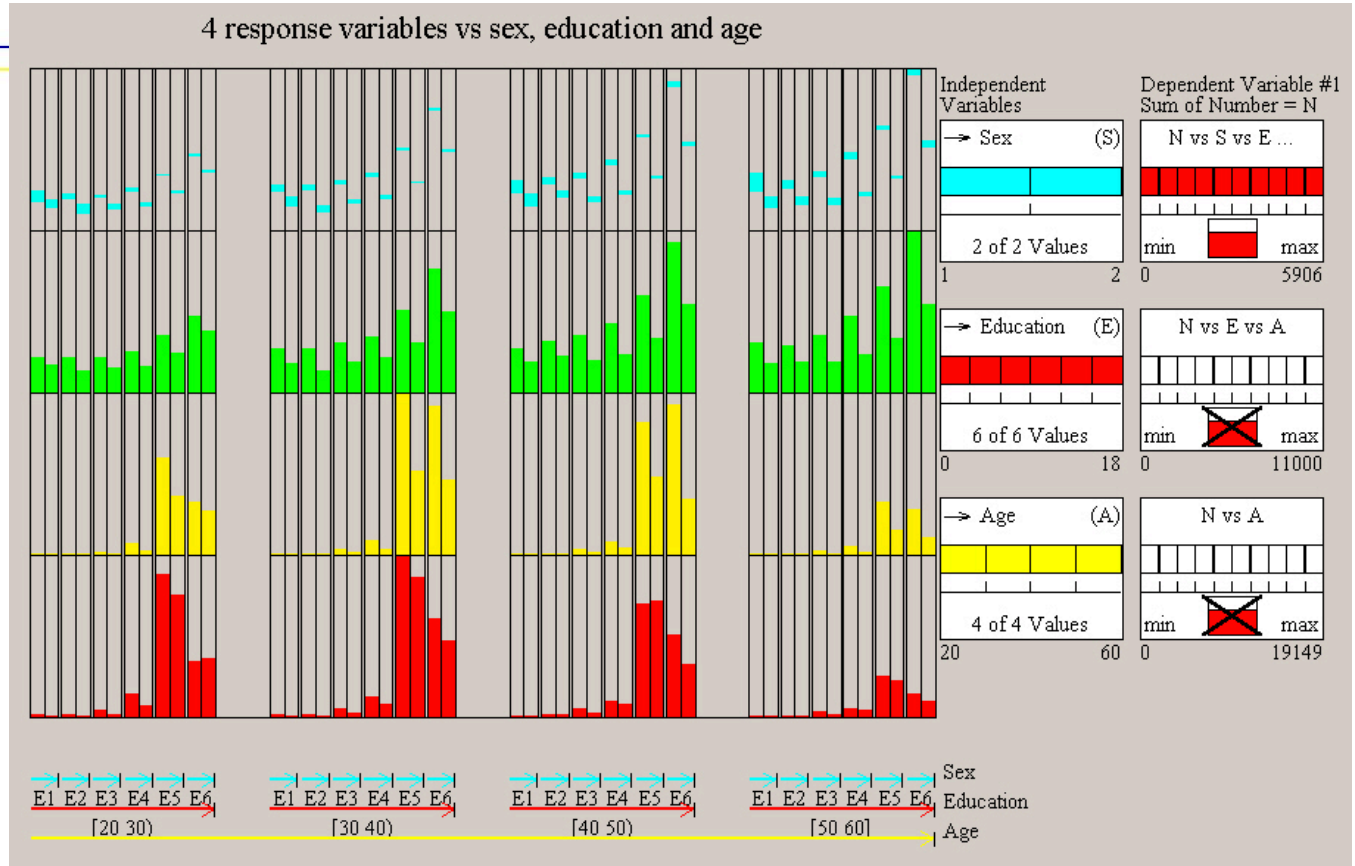
draftsman display (j.w. tukey, p.a. tukey 1981)



nested dimensions (t. mihalisin 1989)



visualization of multidimensional data. continuous variables are binned, and variables are allocated to the horizontal and vertical dimensions in a nested fashion



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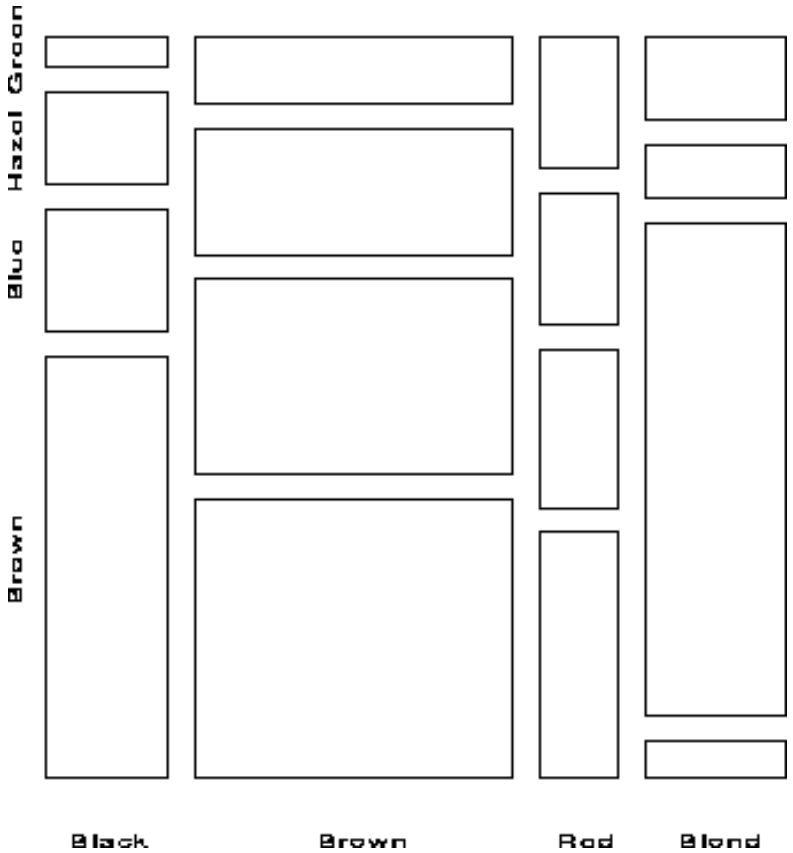
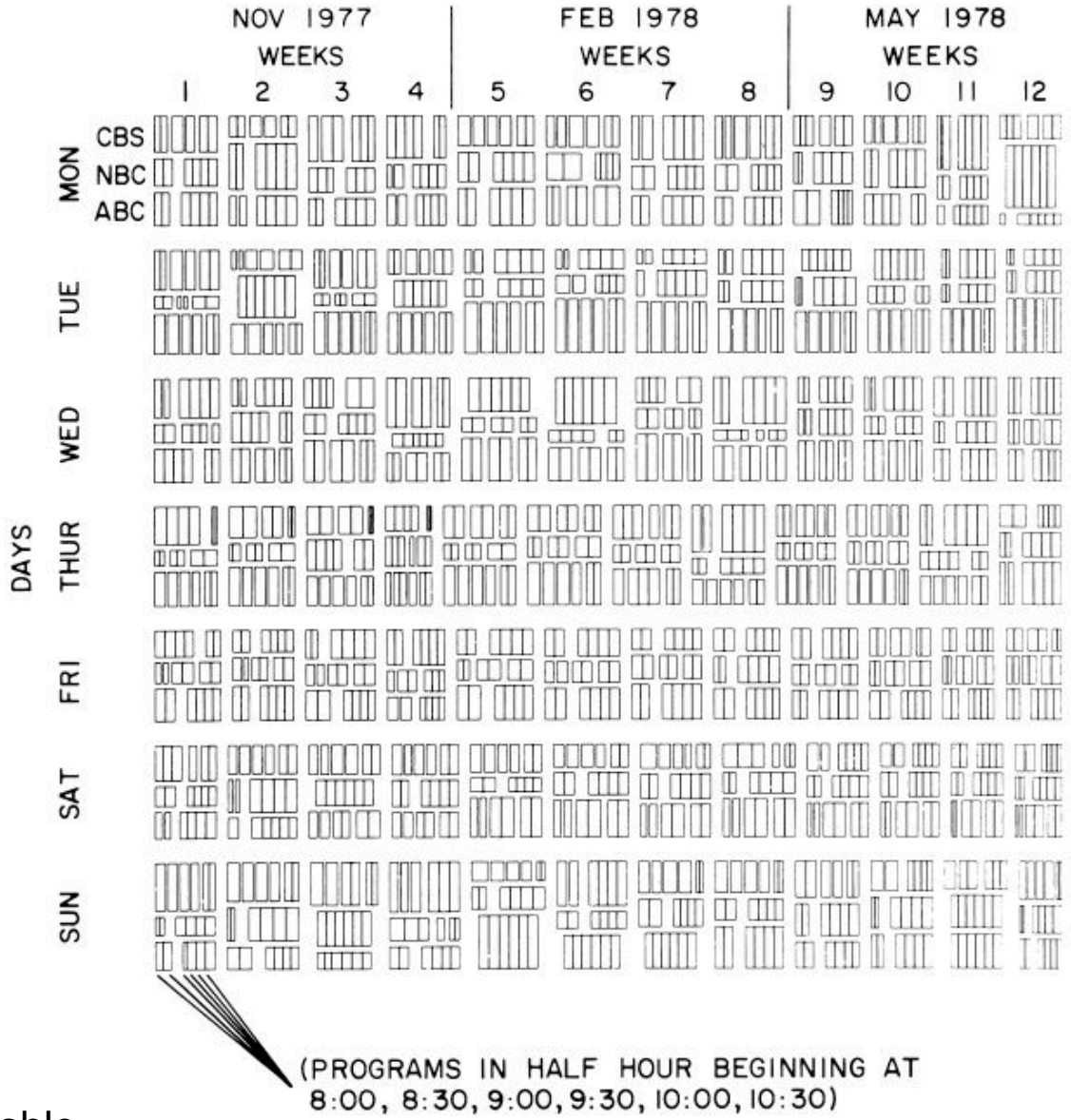
- new graphical techniques for discrete and categorical data (fourfold display, sieve diagram, mosaic plot, etc.)

mosaic plot (j. hartigan, b. kleiner 1981)





frequencies in a multiway contingency table

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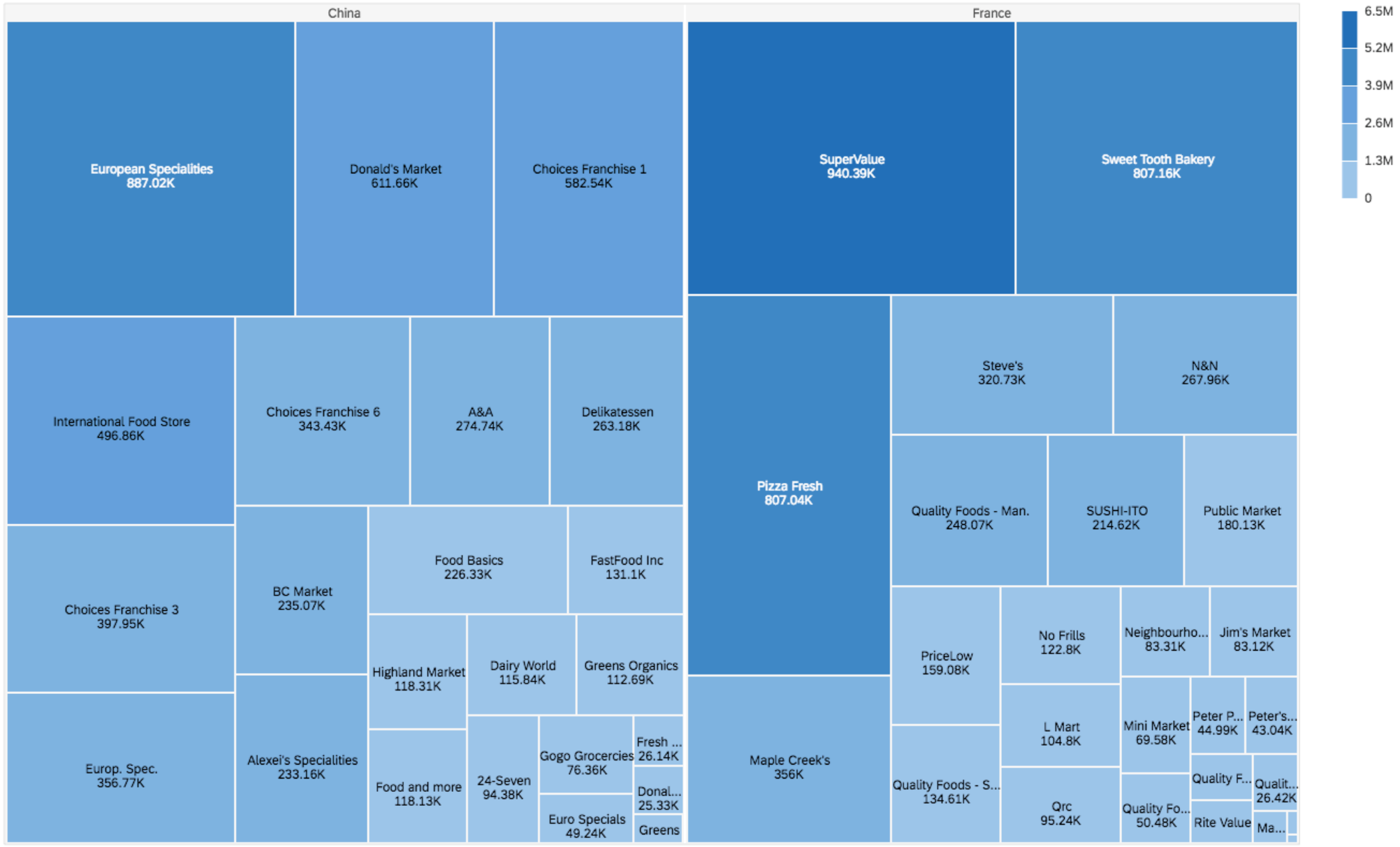
- extensions of older ones (diagnostic plots for generalized linear models, mosaic matrices, etc.)

enhanced mosaic plot (m. friendly 1991)

Marimekko treetop plot (m. shneiderman 1992)



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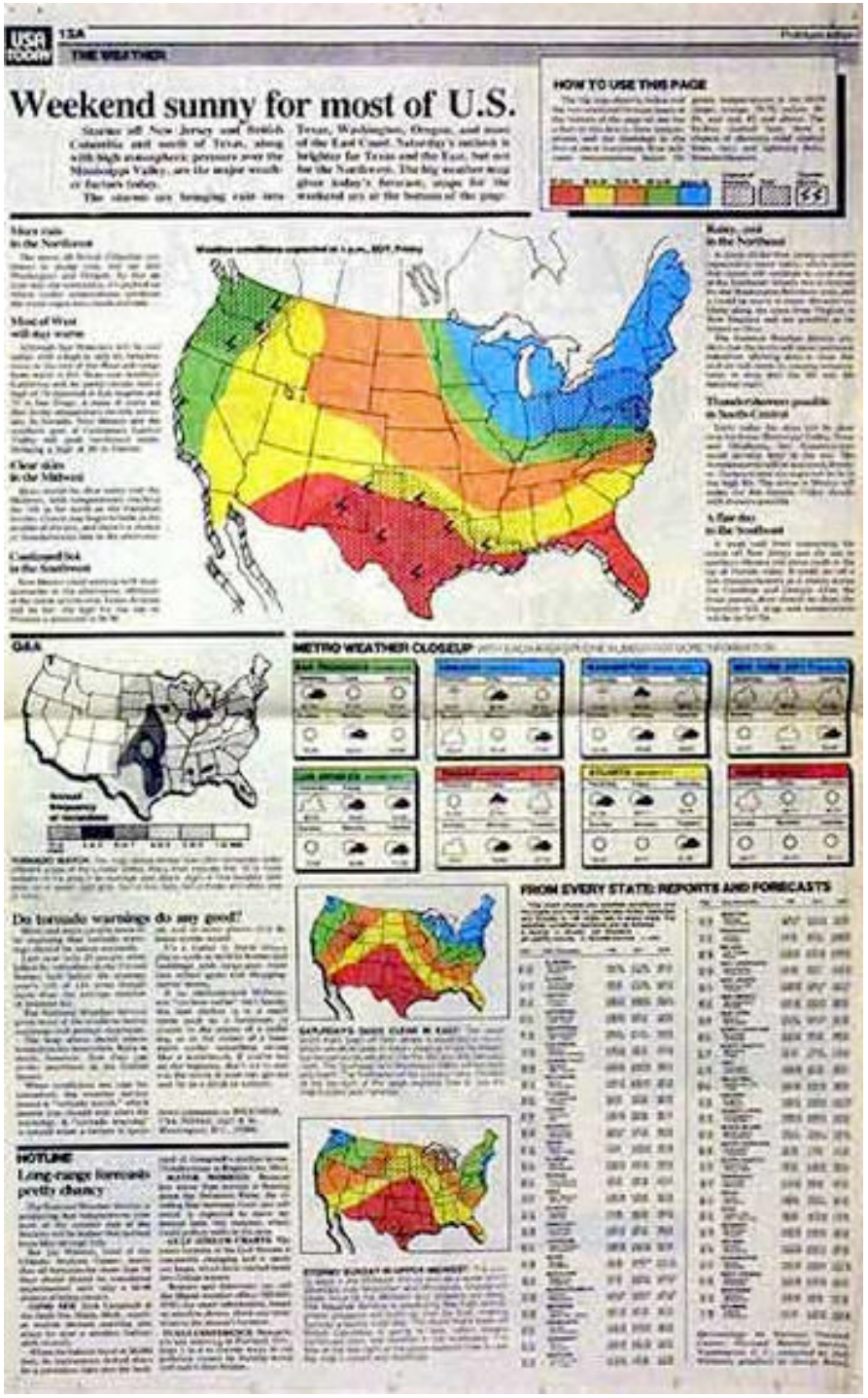

usa today weather maps (g. rorick 1982)

the *usa today* color weather map begins an era of color information graphics in newspapers.

shortly, colorful visual graphics become widespread: the infographics

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- new paradigms of direct manipulation for visual data analysis (linking, brushing, selection, focusing, etc.)

interactive graphics (r.a. becker, w.s. cleveland 1987)

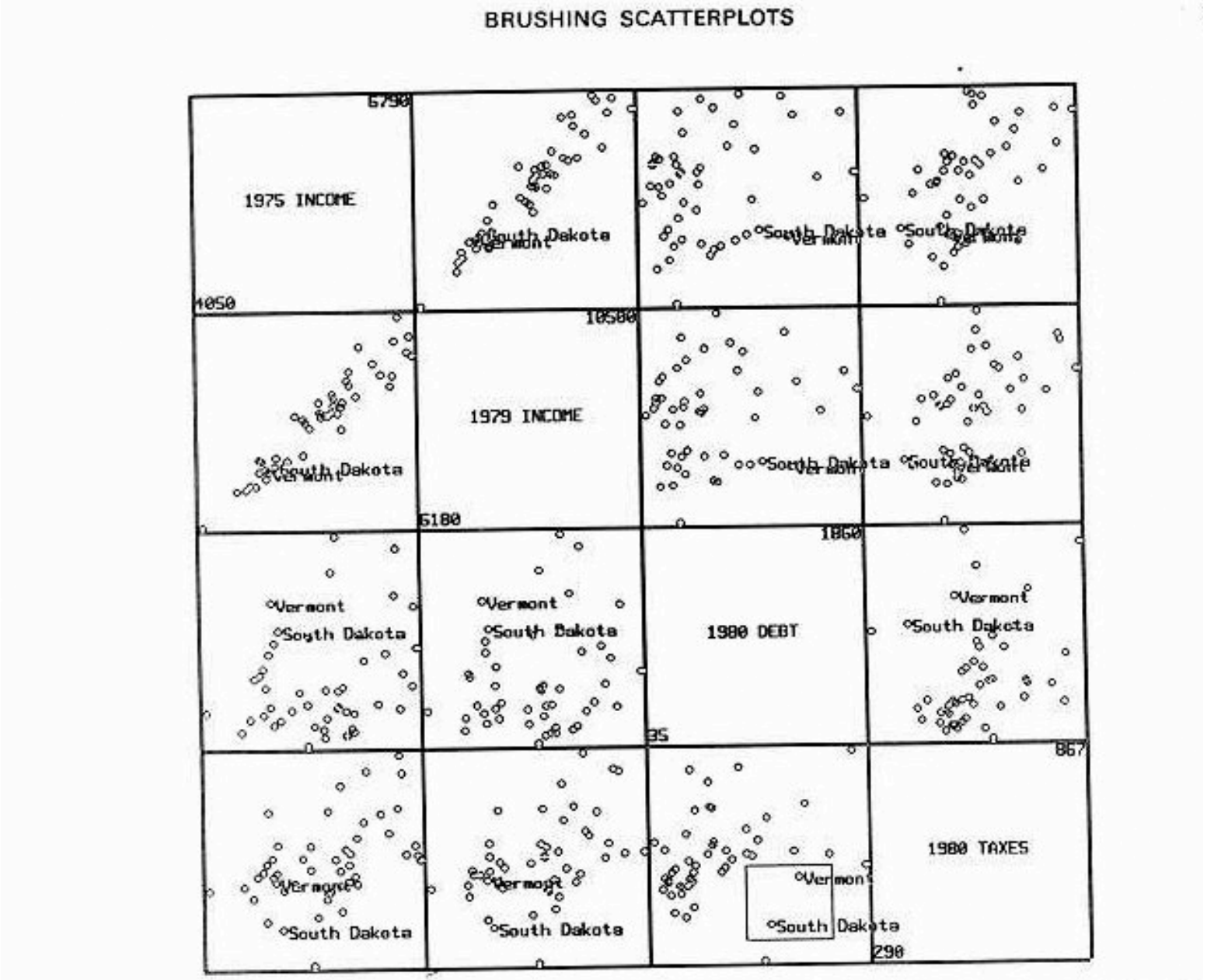

Figure 14. State Data. The label operation is being used. The two points inside the brush on the active panel have their displayed as well as corresponding points on other panels.

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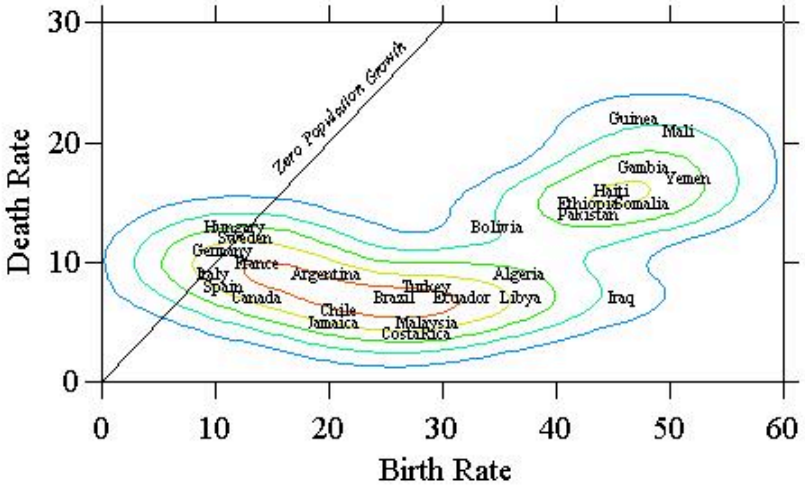
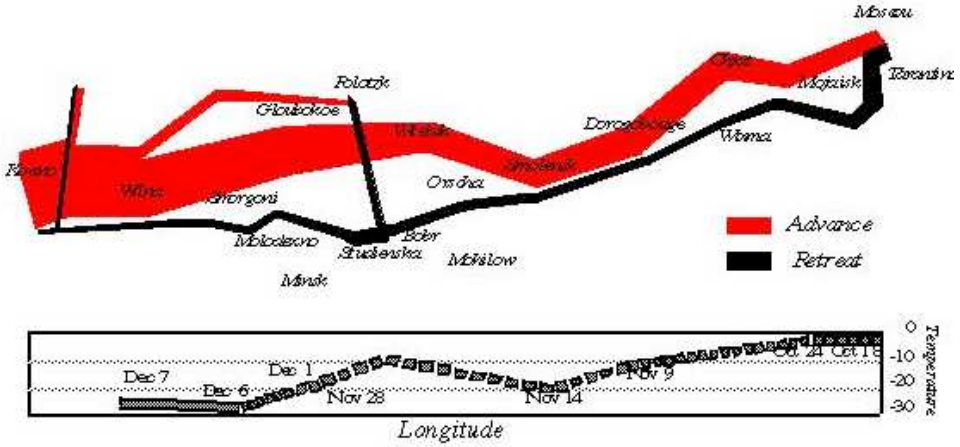
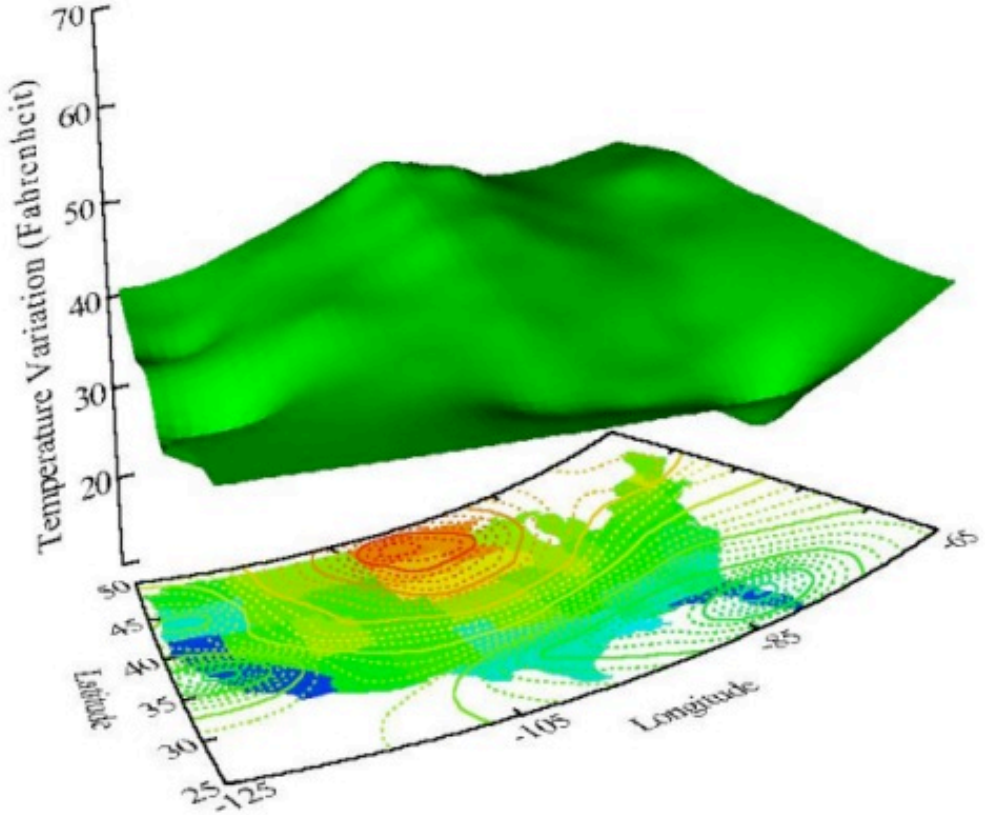
- extensions of older ones (diagnostic plots for generalized linear models, mosaic matrices, etc.)
- application of visualization methods to an ever-expanding array of substantive problems and data structures
- increased computer processing capacity, allowing computationally intensive methods + big data problems

grammar of graphics (I. wilkinson 1999)







A comprehensive systematization of grammatical rules for data and graphs and graph algebras within an object-oriented, computational framework

tag/word cloud (j. flanagan 2002)

perl exceptions · tilings · compund device usb ·
authenticating user similar to exchange server · 'ting ting jahe' · python weblogs.com
changes.xml · package exception · prepared pessimist book · poems on everything ·
waggish geegaw · price of nonconformance · monday nothing
tuesday nothing fugs · photo ans art of very holy people · seattle

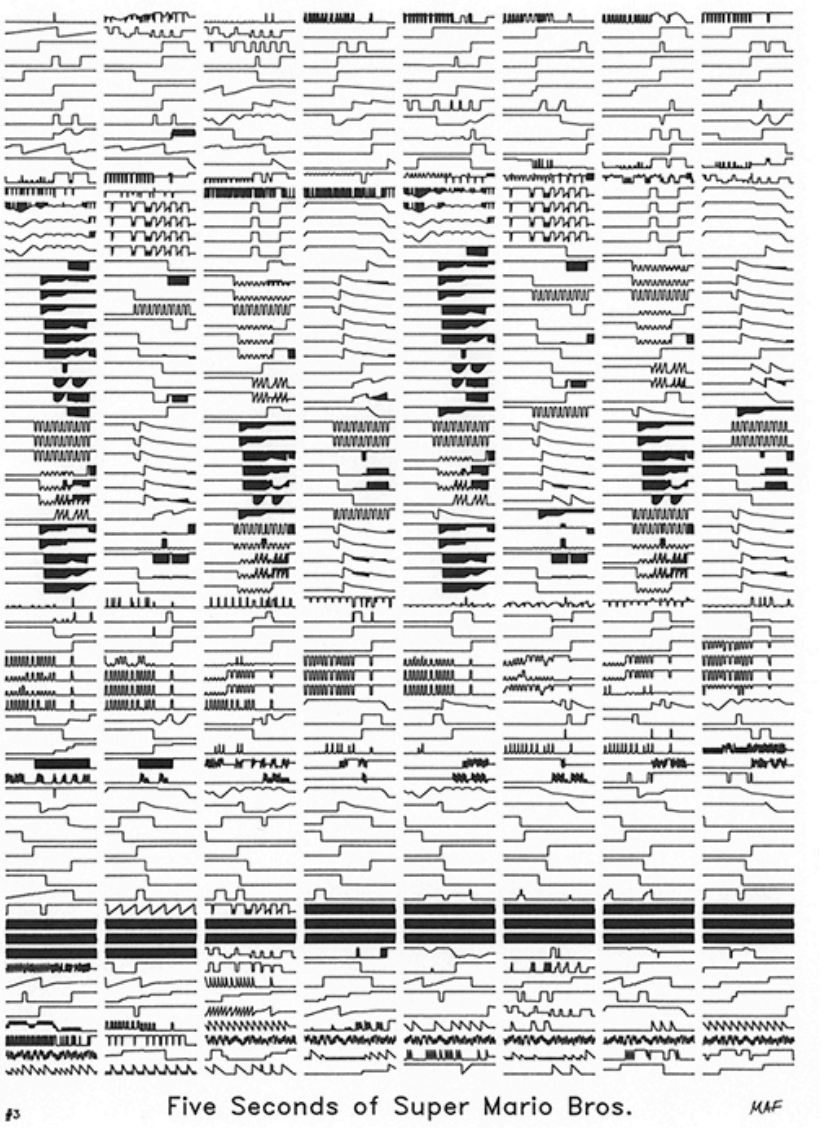
the *search referral zeitgeist*

visually display the frequency of the most commonly used words within a document.

sparklines (e. tufte 2004)

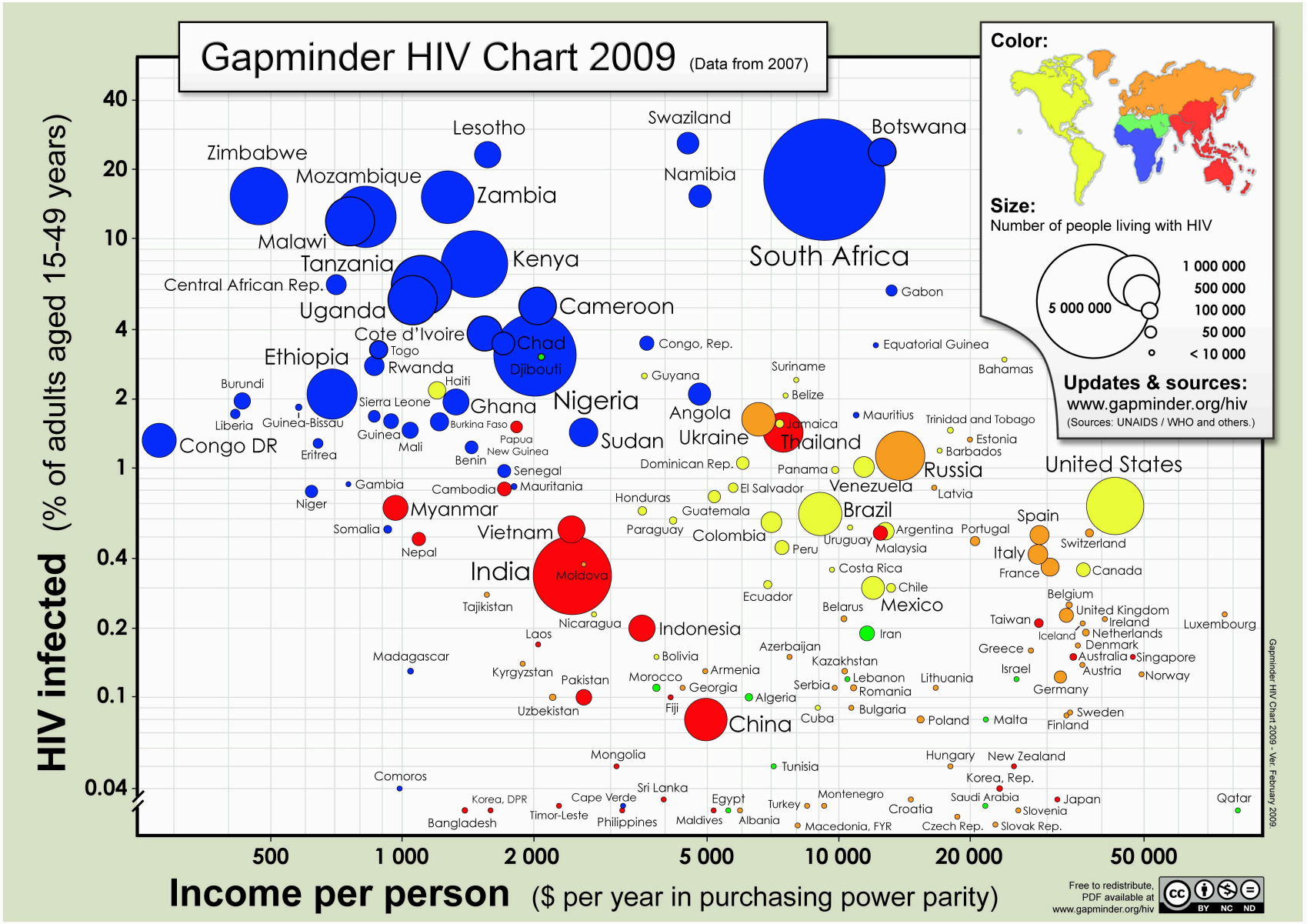
Using d3.js, we can fairly easily draw SVG-based sparklines. This is 2013 historical stock prices for **Google**  **$1084.75**. And this is for **Facebook** 

$55.57. And this is for **Apple**  **$550.77**. Each sparkline has 244 data points, but it's condensed very nicely.



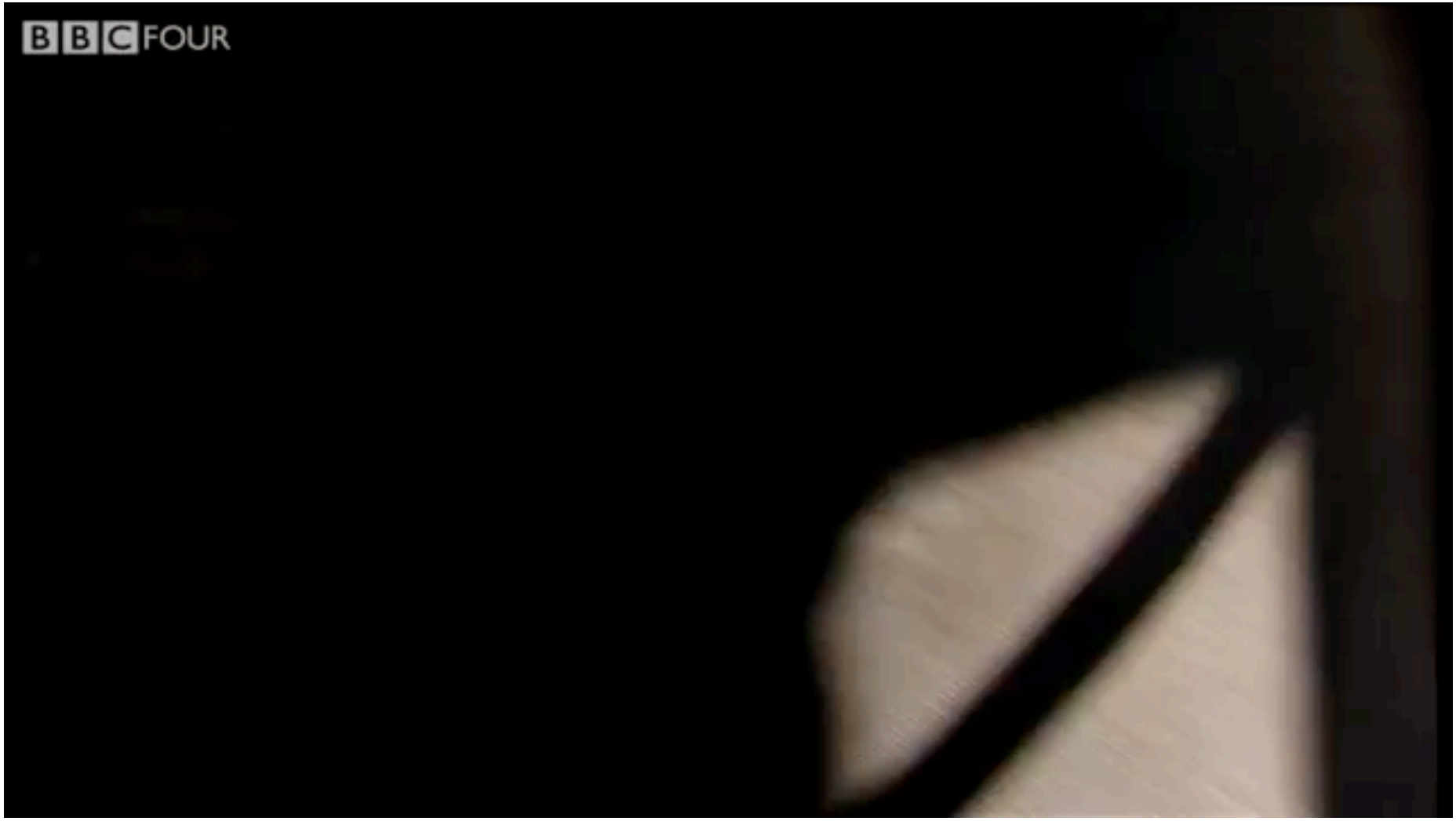
"data-intense, design-simple, word-sized graphics," designed to show graphic information inline with text and tables

maximising the data/ink ratio



GAPMINDER

www.gapminder.org



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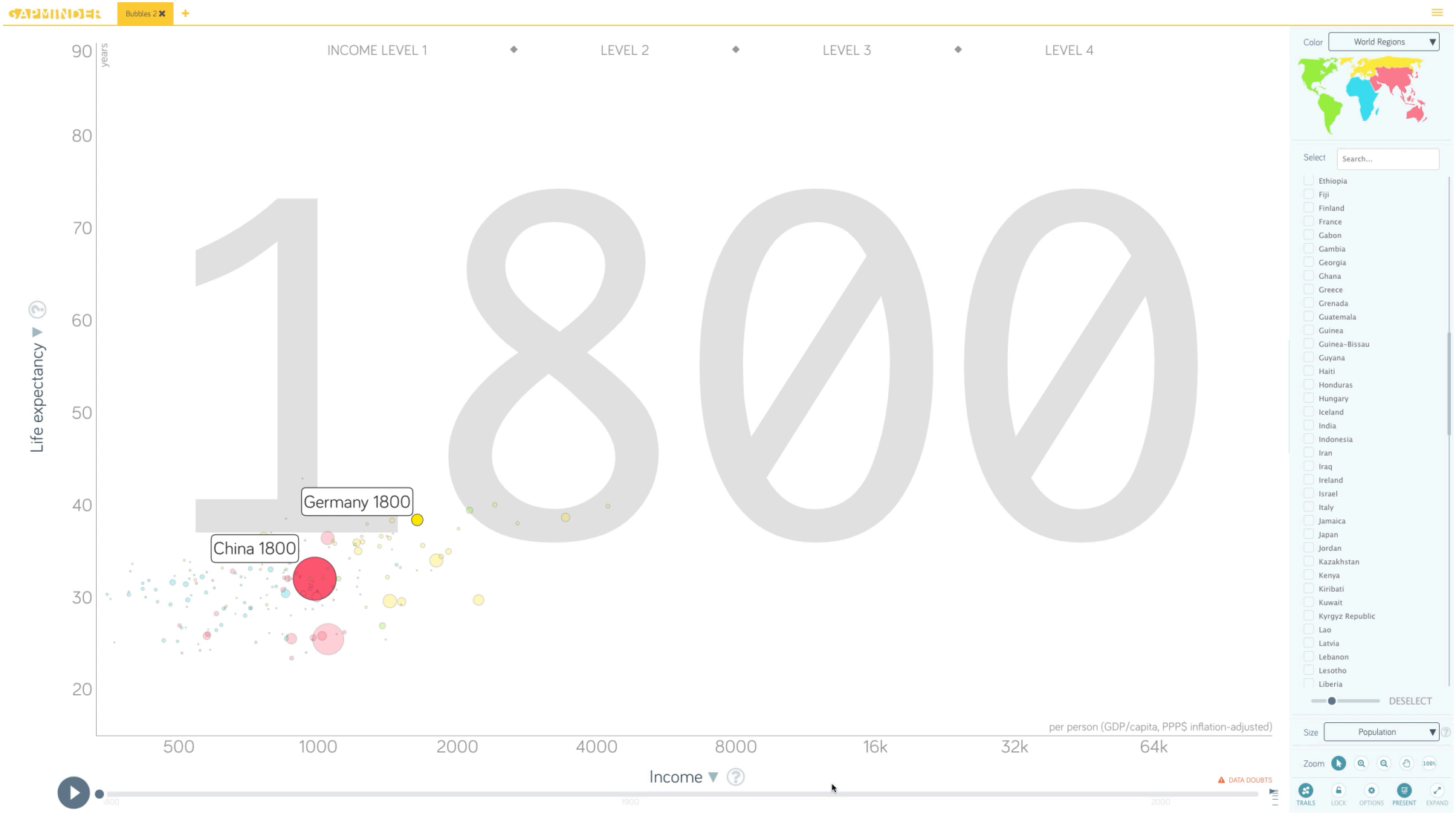


http://www.gapminder.org

GAPMINDER

non-profit foundation founded in 2005 with a goal of '… increase use and understanding of statistics and other information about social, economic and environmental development at local, national and global levels."

''empower instructors in designing dynamic

presentation of real life data, energizing students''

[*le*, 2013]

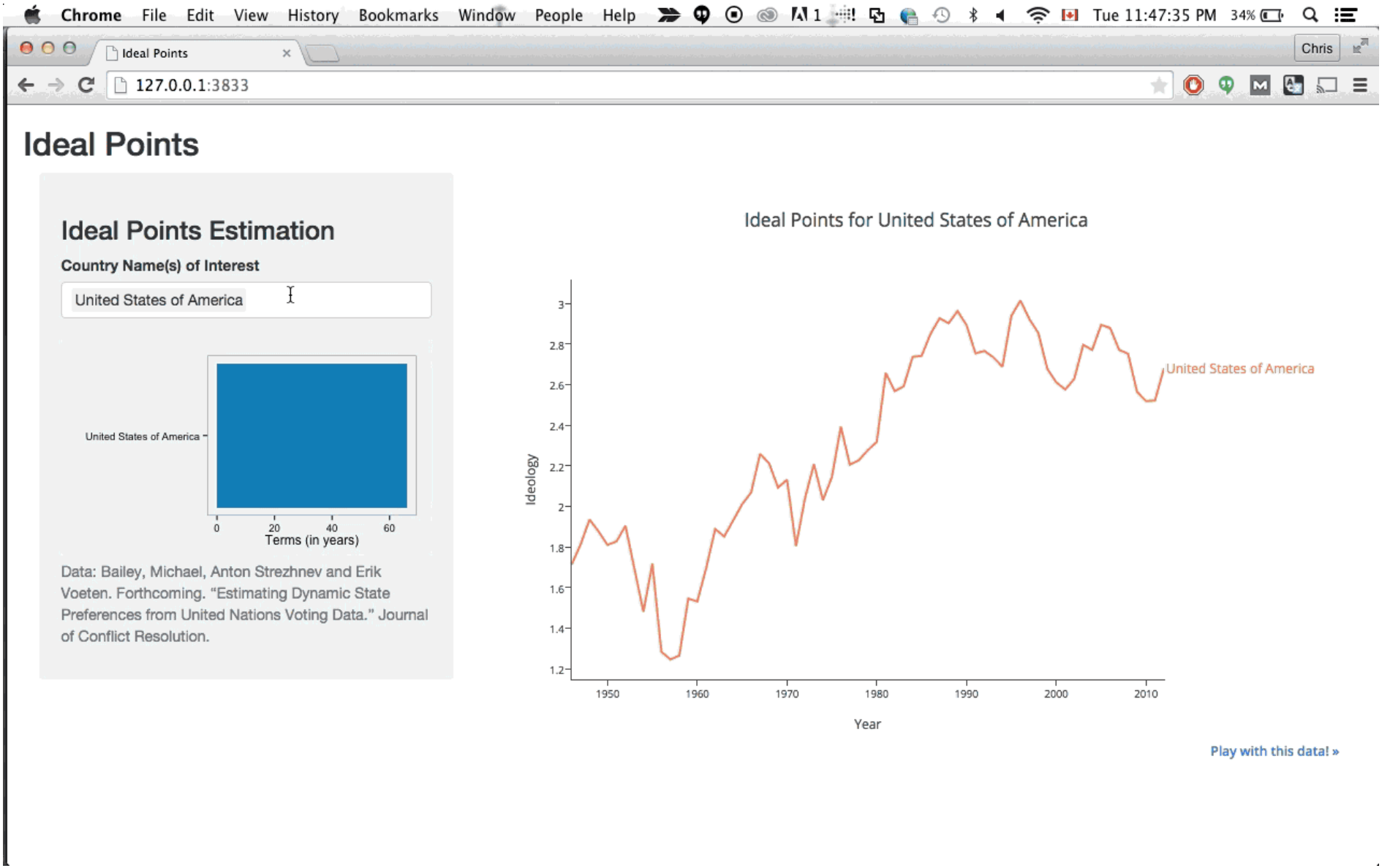
seizes the power of statistics by expressing 5-dimensional data into one place

the 5 dimensions of the gapminder graphs are:

- variable on the horizontal axis,
- variable on the vertical axis,
- time,
- geography (color of the dot),
- population (size of the dot).

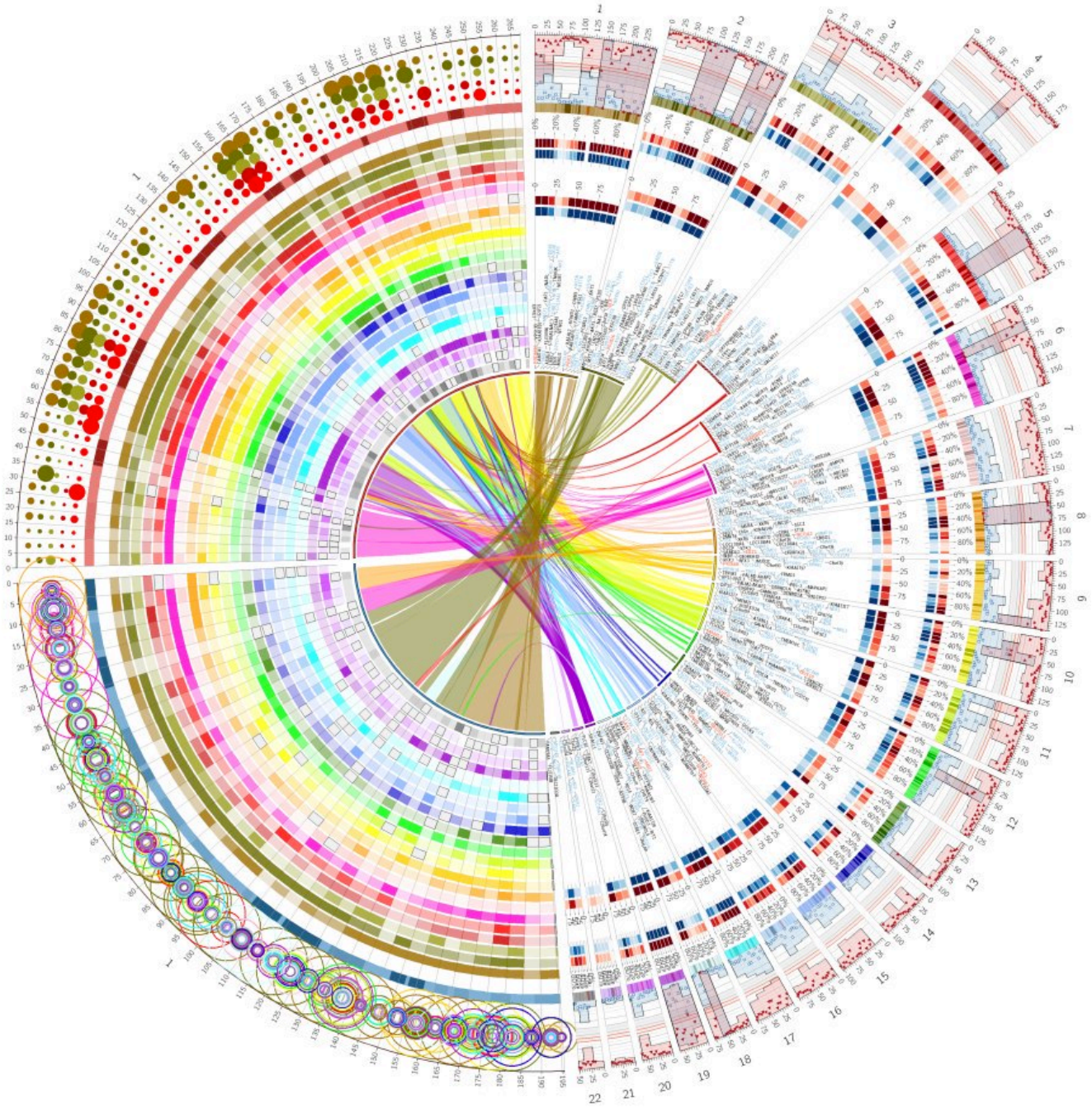
[*smaranda*, 2016]

ggplot2 (h. wickham, 2006)



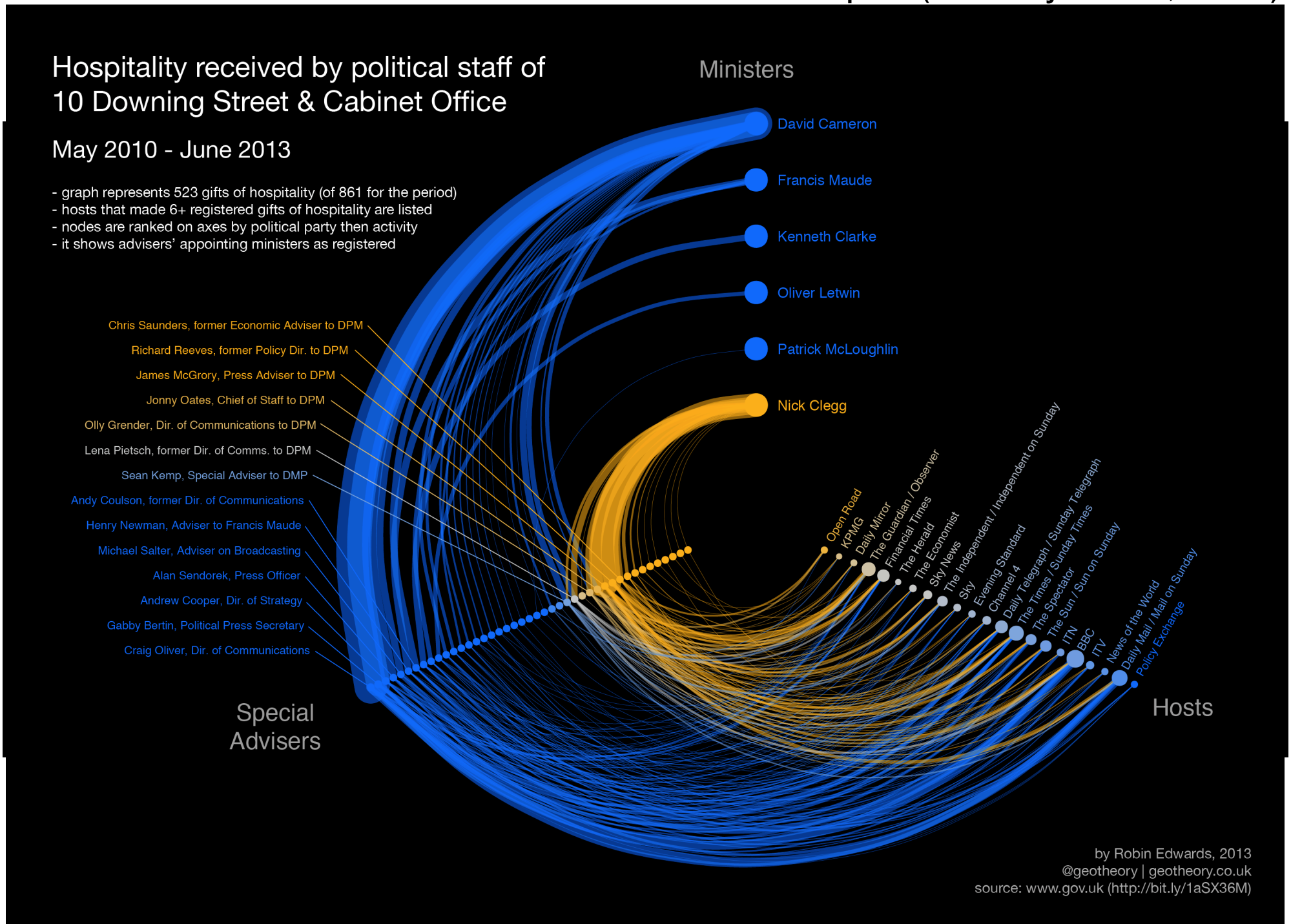
an influential, open source implementation of the grammar of graphics in *r*, together with other computational tools to make it easier to produce beautiful and interactive statistical diagrams

circos plot (m. krzywinski, 2009)



circular diagram designed to facilitate the analysis of relationship among categorical and other variables using chords of a circle with various visual attributes.
the main application is to genomic structure, where the chords can encode various properties of genomic sequences.

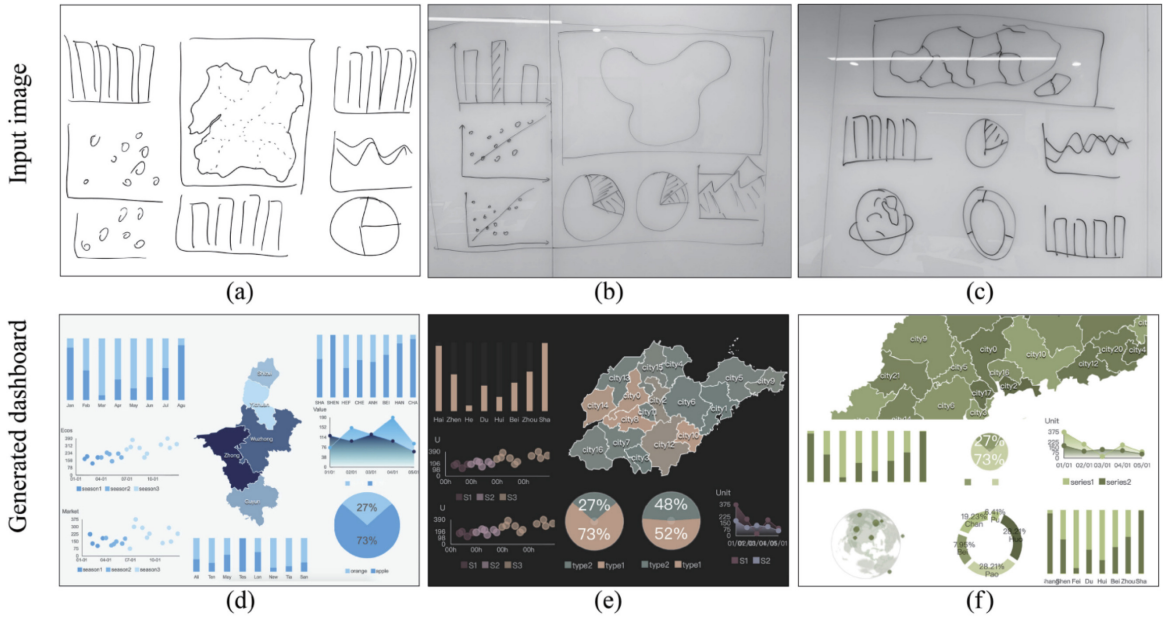
network hive plot (m. krzywinski, 2011)



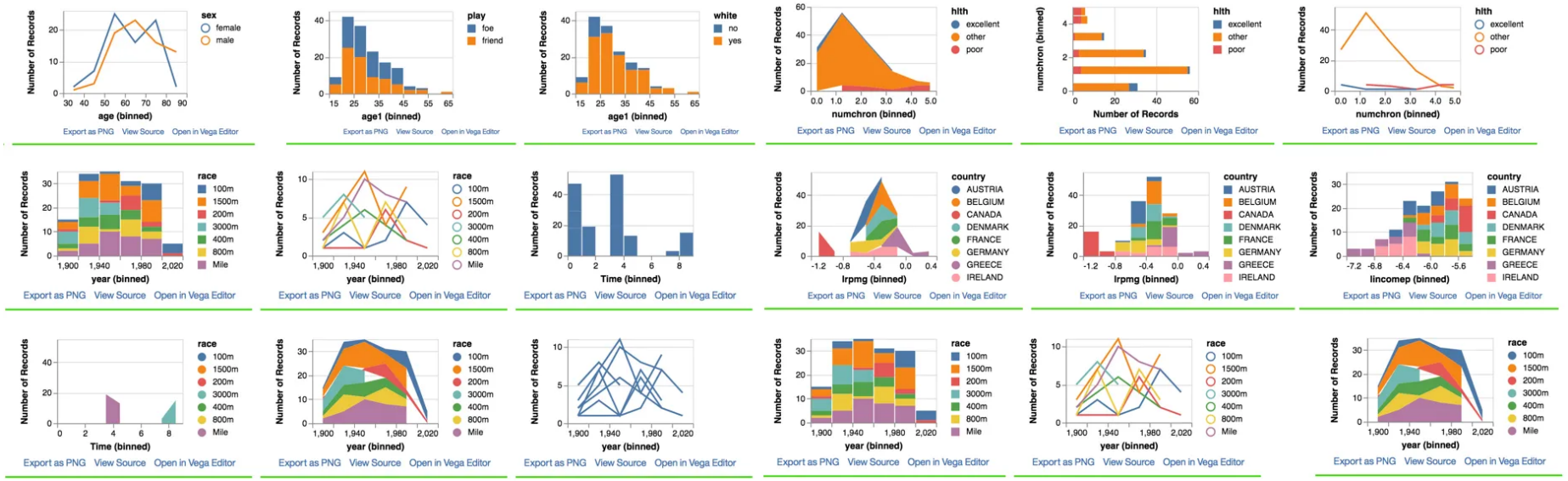
where to now?

[*hololens*, 2018]

where to now?



[*LADV*, 2020]



[*Data2Vis*, 2018]