

Tufte's Design Principles

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Based on slides from John Stasko, GTECH



Graphical Excellence

Principles

Graphical excellence is the well-designed presentation of interesting data---a matter of *substance, of statistics, and of design.*

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

Graphical Excellence

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 is nearly always multivariate.

And graphical excellence requires telling the truth about
the data.

Summary of Tuft's Principles

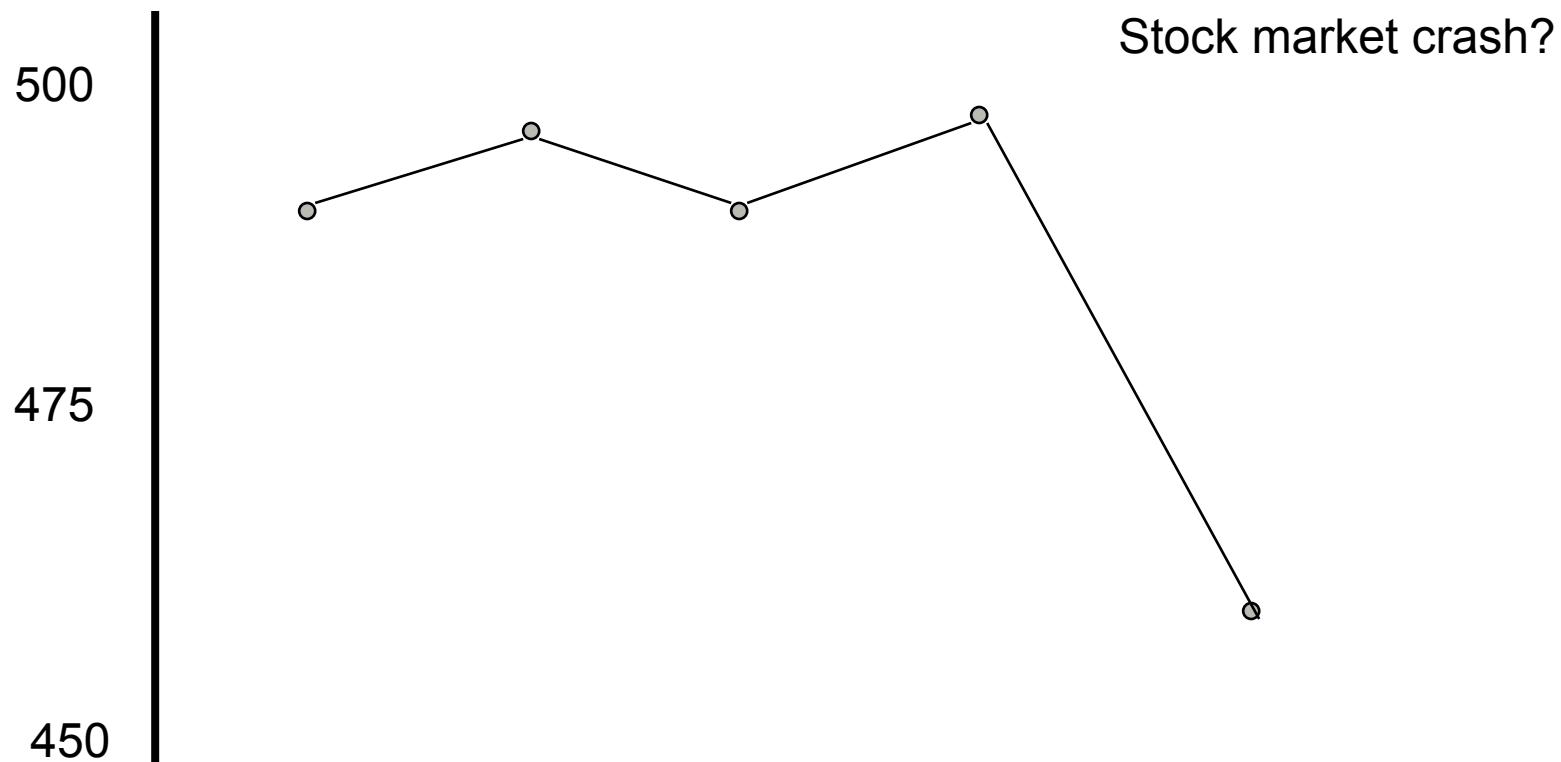
1. Tell the truth

Graphical integrity

2. Do it effectively with clarity, precision...

Design aesthetics

Graphical Integrity



Stock market crash?

Graphical Integrity: Show Entire Scale

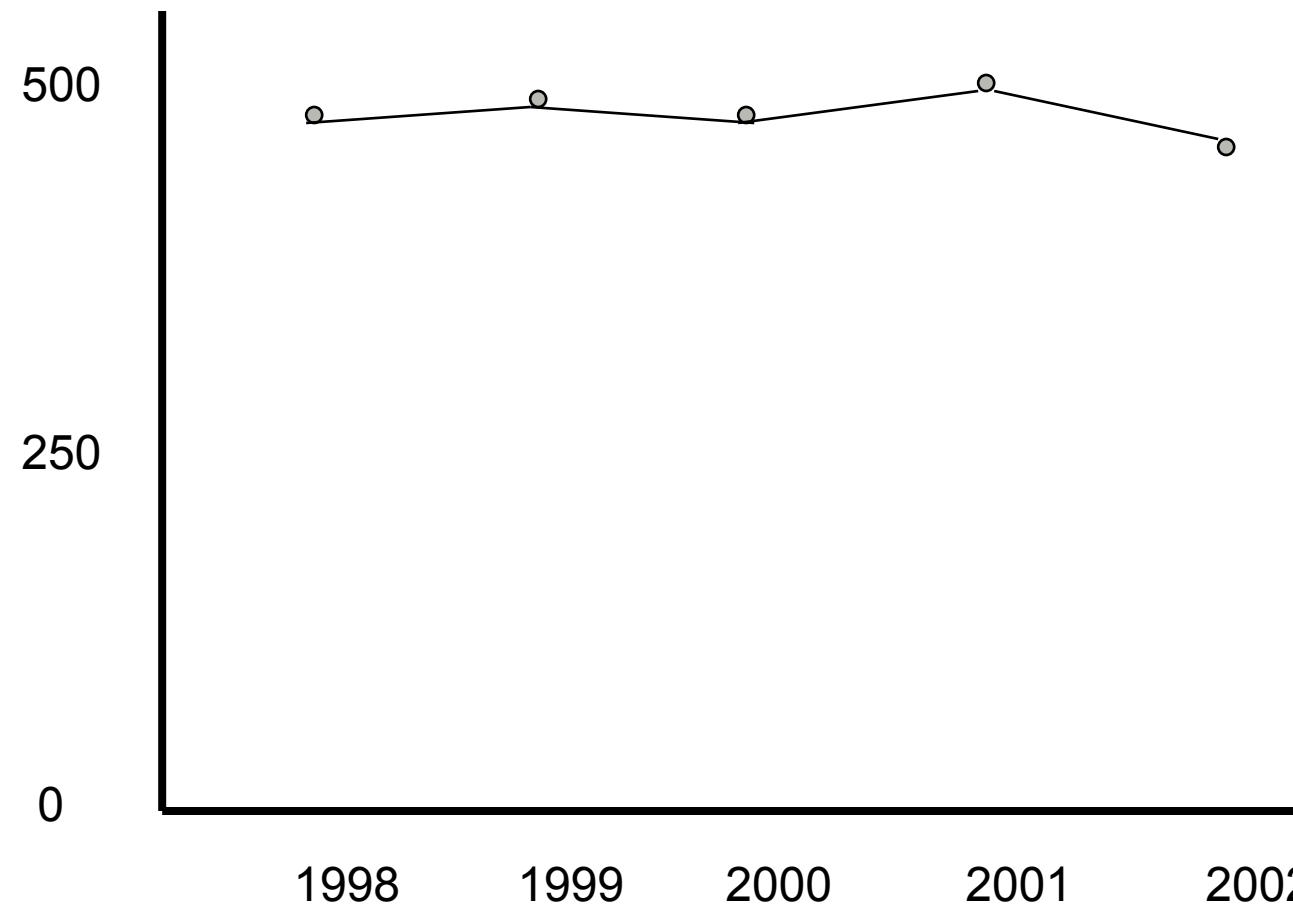
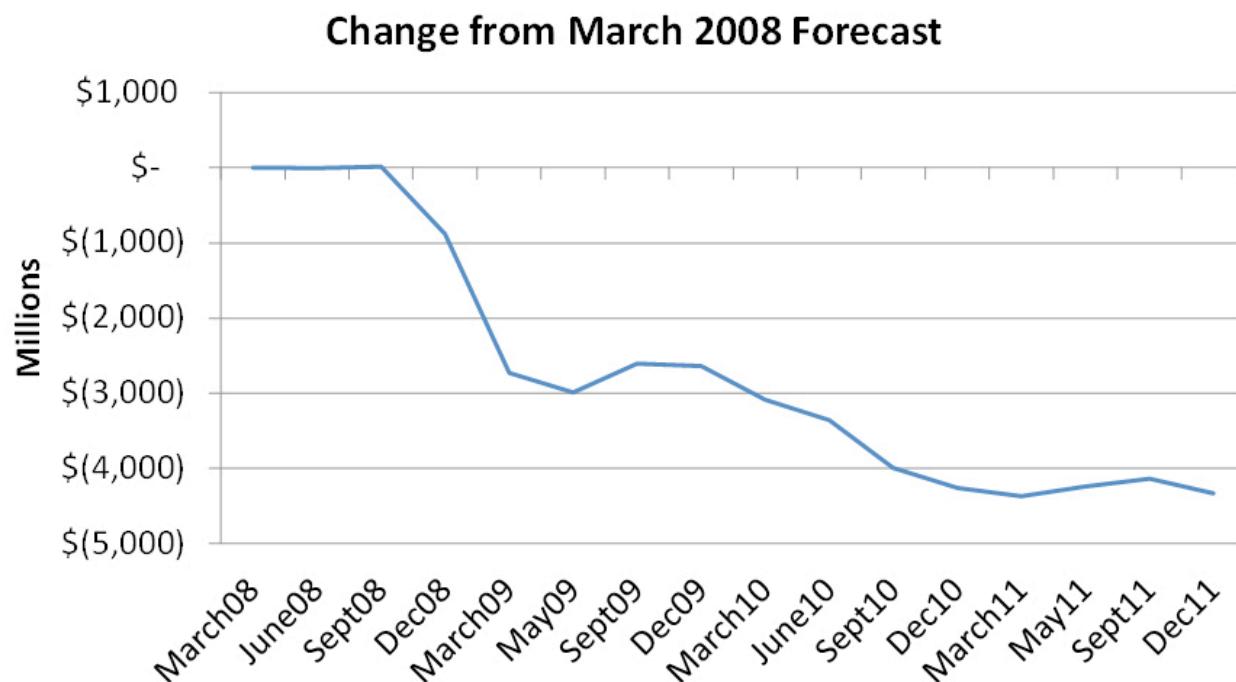


Chart Integrity: Maintain Proper Scale

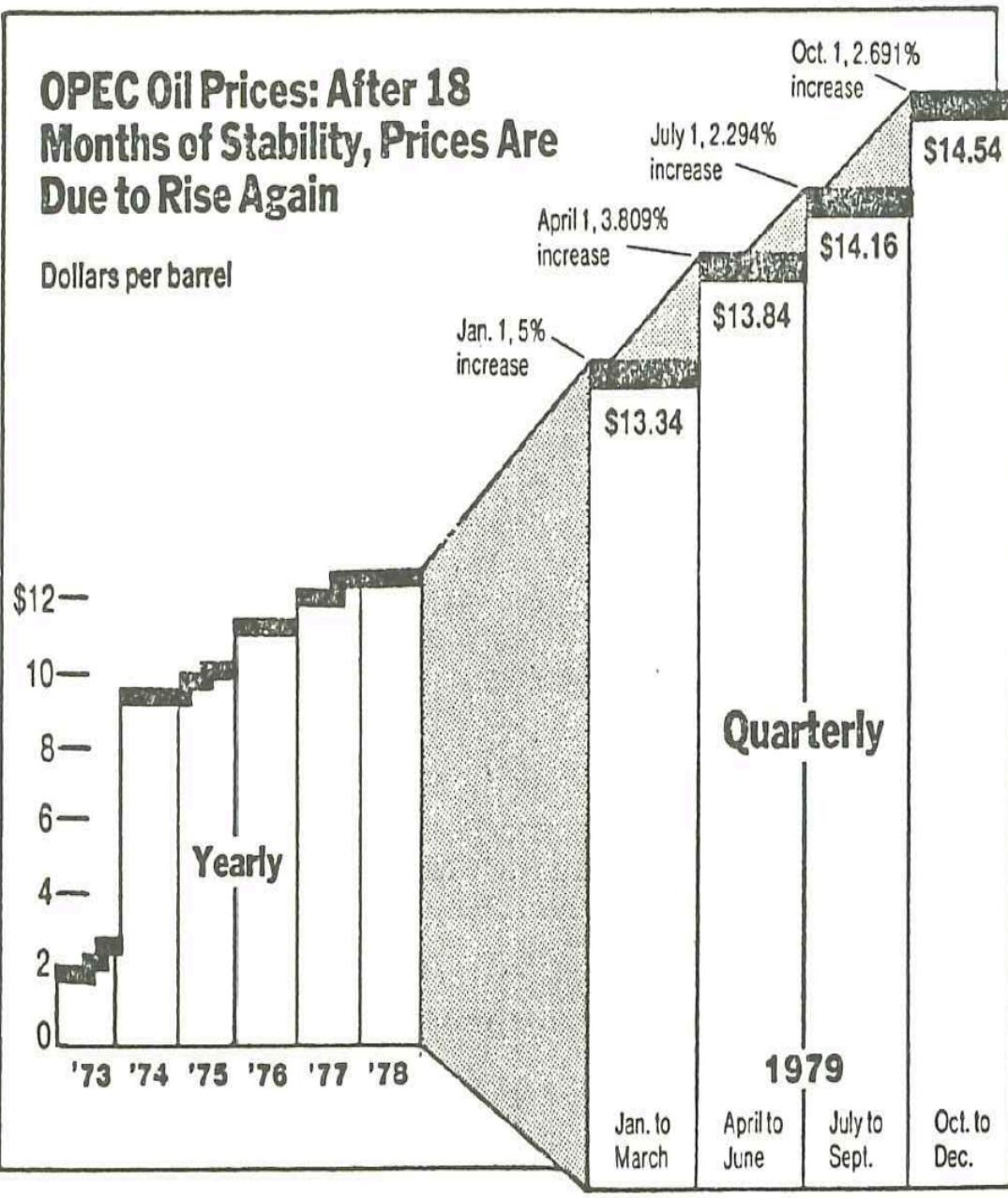
The Changing General Fund/Lottery Revenue Outlook
(Quarterly Revenue Forecast Changes)



Rep. Dennis Richardson

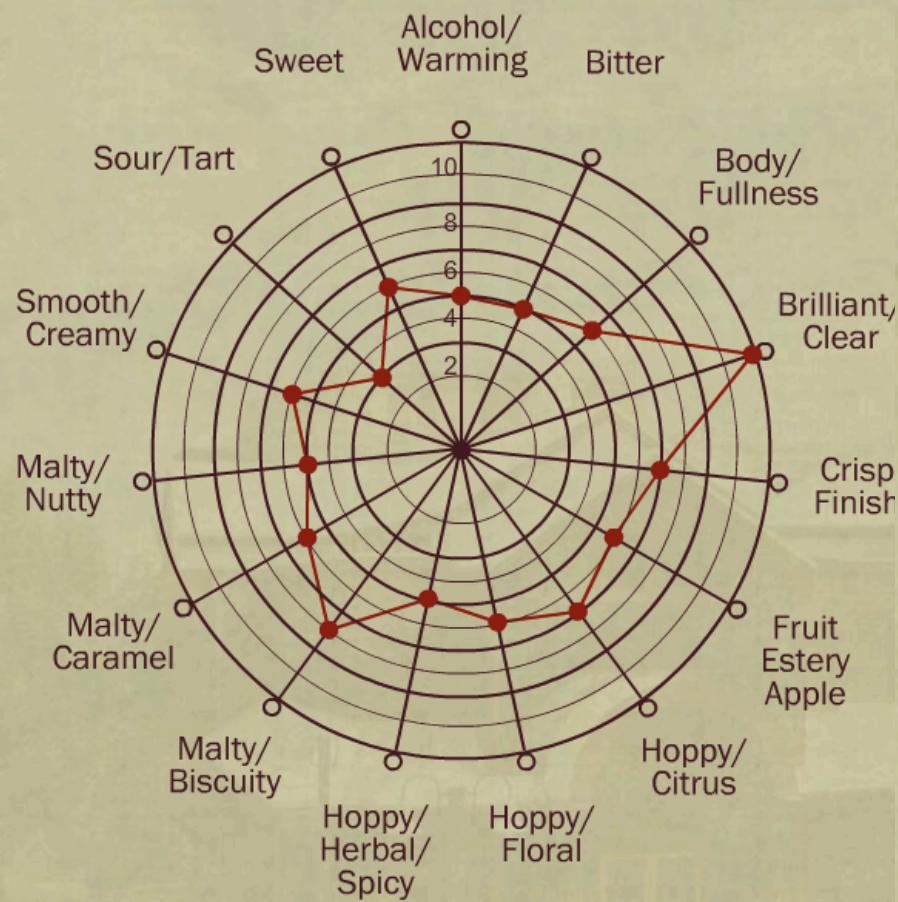
OPEC Oil Prices: After 18 Months of Stability, Prices Are Due to Rise Again

Dollars per barrel

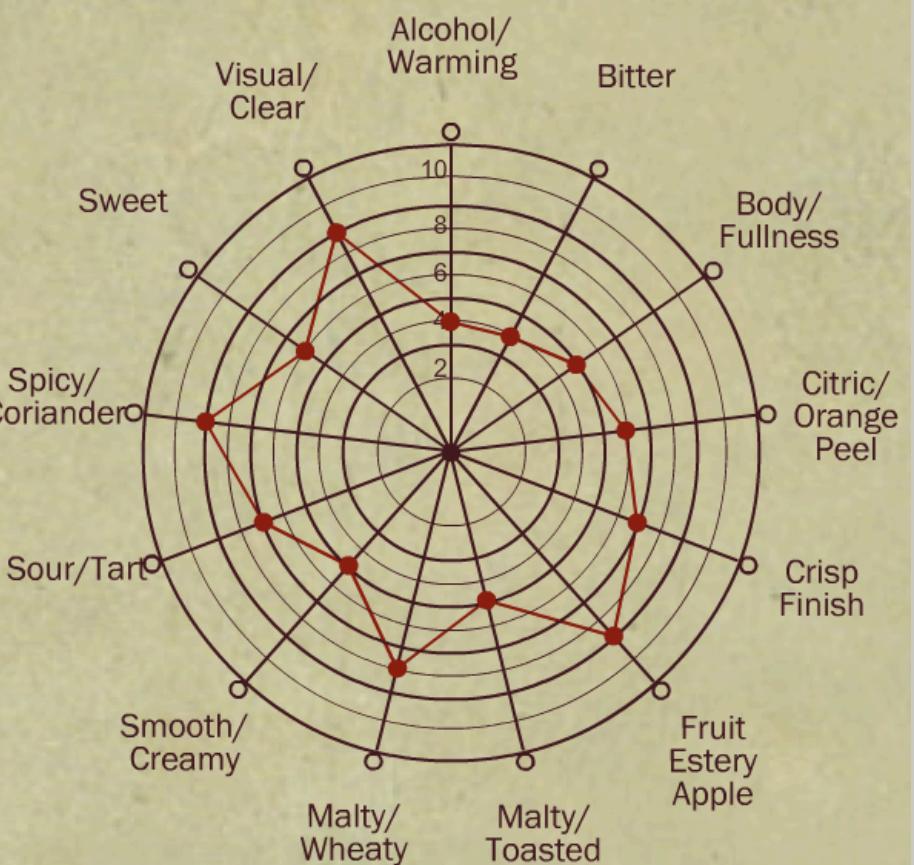


- 5 different vertical scales to show price
- 2 different horizontal scales to show time
(based on comparison of image space units to value changes)

Flavor Attribute Flower



Flavor Attribute Flower

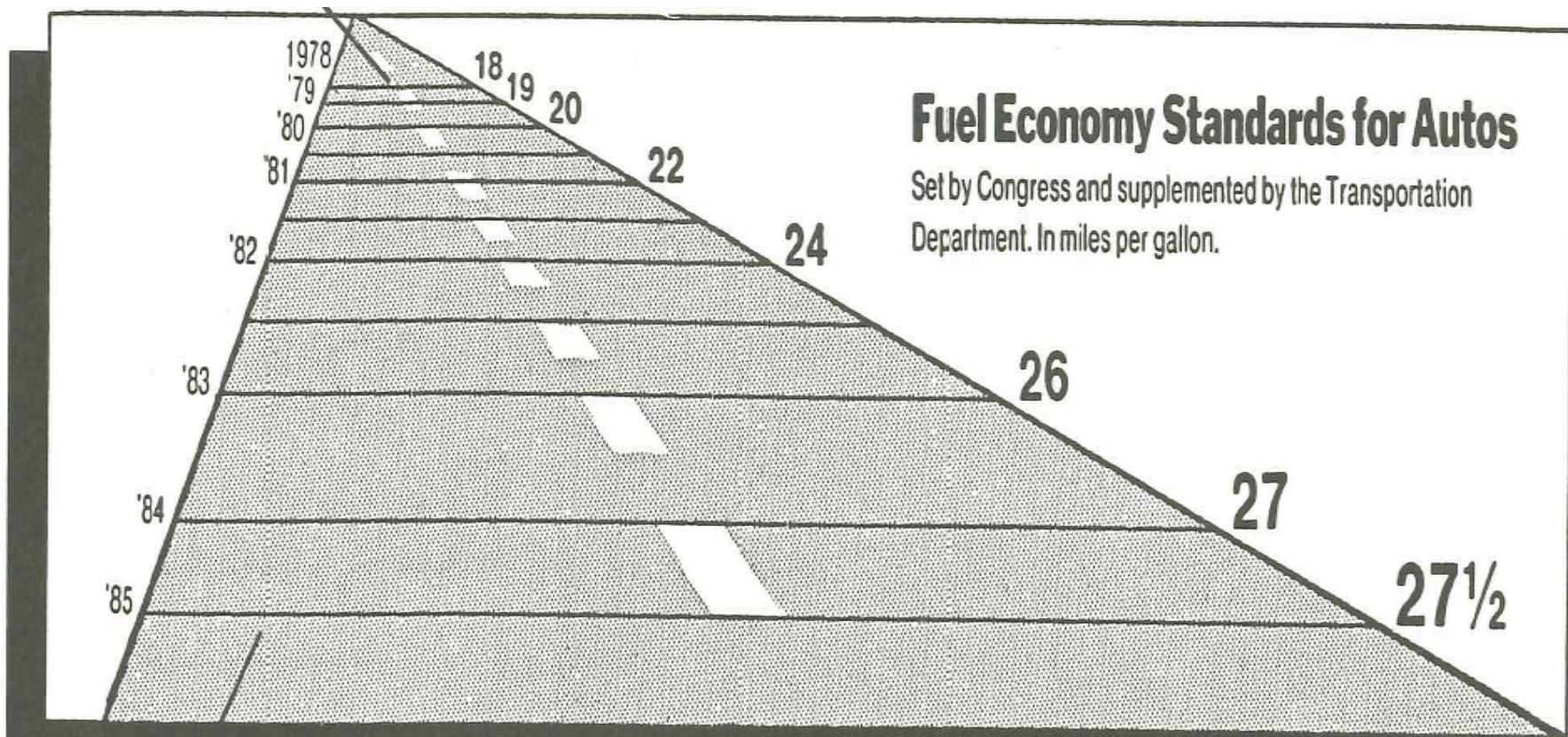


Fat Tire vs. Sunshine Wheat

www.newbelgium.com (2010)

Avoid Distortion

18mpg in 1978, 0.6 inch line



27.5 mpg in 1985, 5.3 inch line

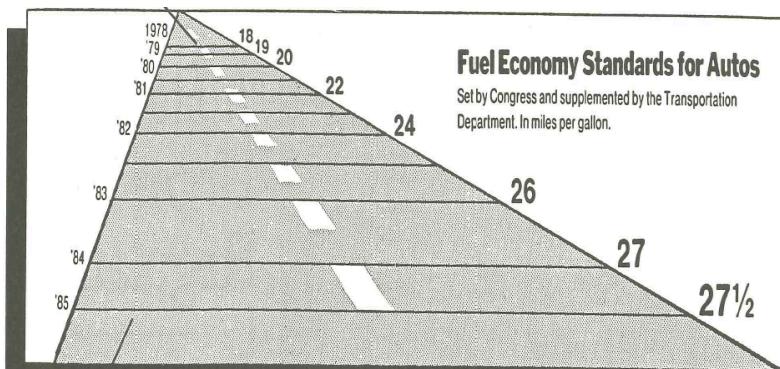
Measuring Misrepresentation

Visual attribute value should be directly proportional to data attribute value

Size of effect shown in graphic

Lie factor = _____

Size of effect in data



Effect in data: $27.5 - 18.0 / 18.0 = 53\% \text{ increase}$

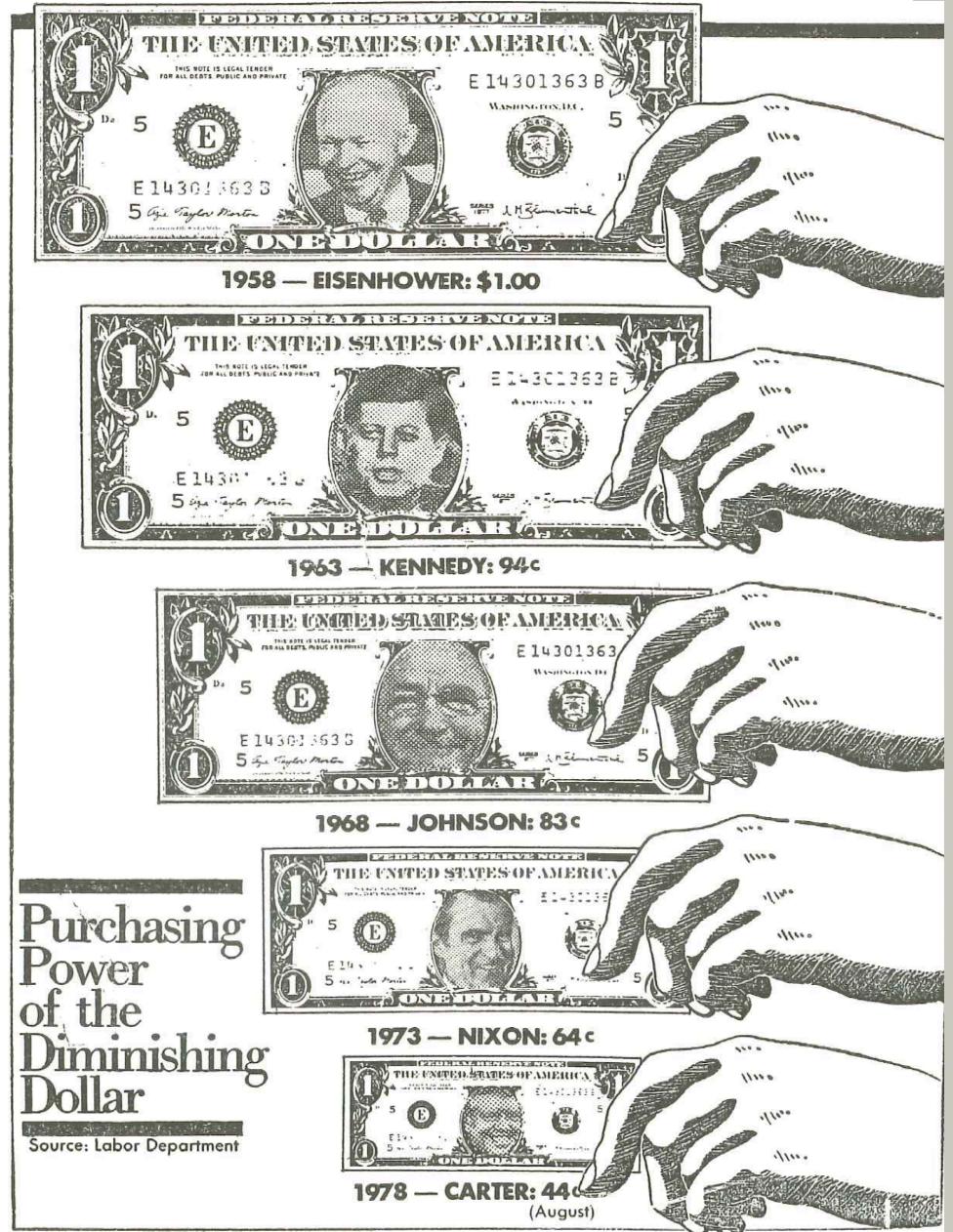
Effect in Image: $5.3 - 0.6 / 0.6 \text{ inches} = 783\%$

Lie = $783 / 53 = 14.8$

Size Encoding

Don't use areas (or volume) to show one dimensional data

More generally, the number of information carrying dimensions \leq number of data dimensions



Graphical Integrity

Additional Principles

1. Clear, detailed labels to defeat distortion and ambiguity
2. Show data variation, not design variation (avoid fancy chart tricks!)
3. Account for inflation (time & money)

Tufte's Design Principles Graphical Excellence

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2. Design Aesthetics

Set of principles to help guide designers in arriving at a visually pleasing result that properly conveys the data

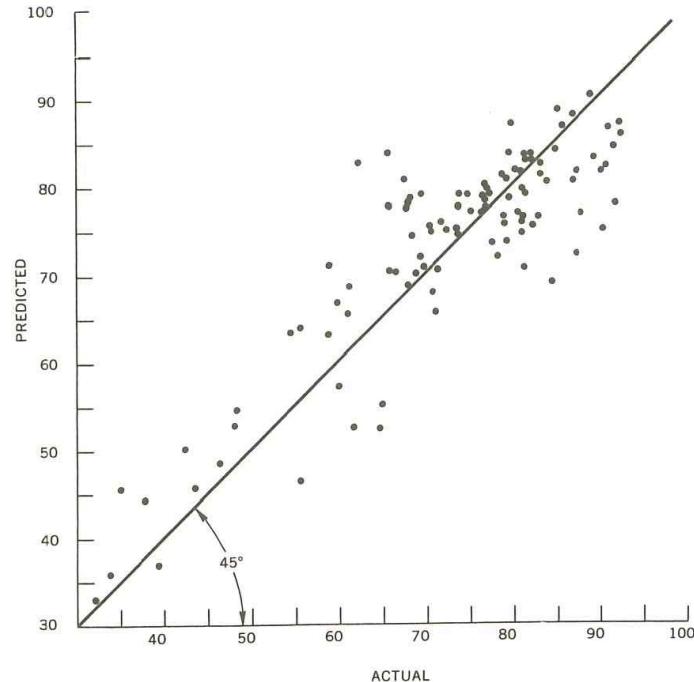
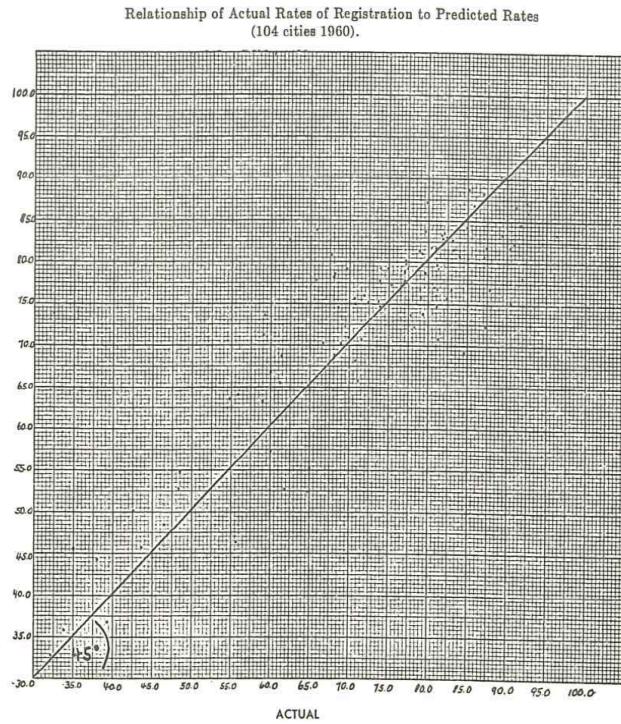
Design Principles

Maximize data-ink ratio

$$\text{Data ink ratio} = \frac{\text{Data ink}}{\text{Total ink used in graphic}}$$

= proportion of graphic's ink devoted
to the ***non-redundant*** display of
data-information

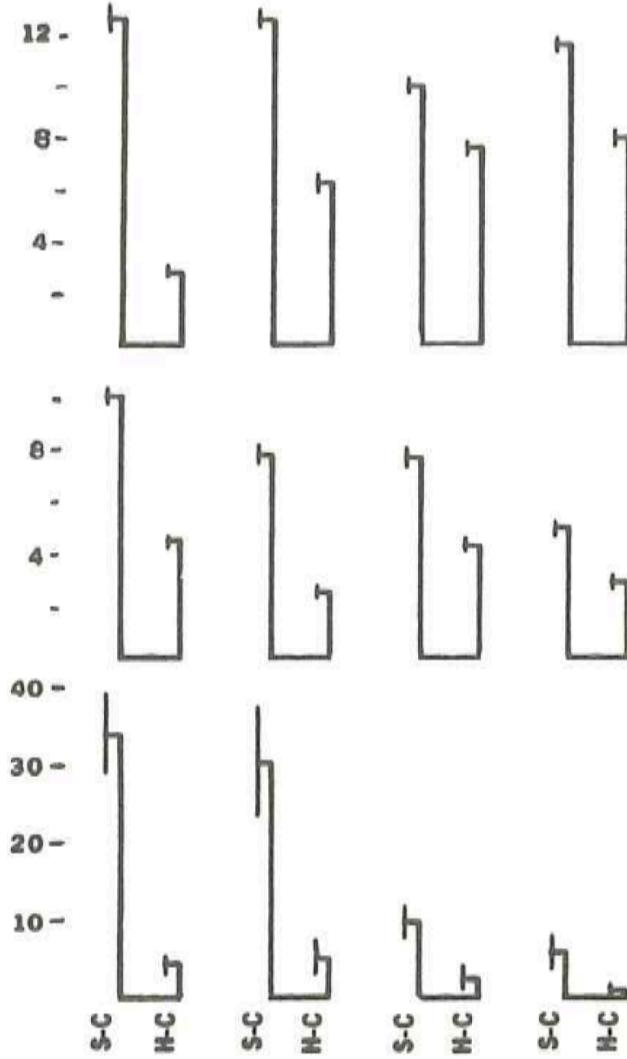
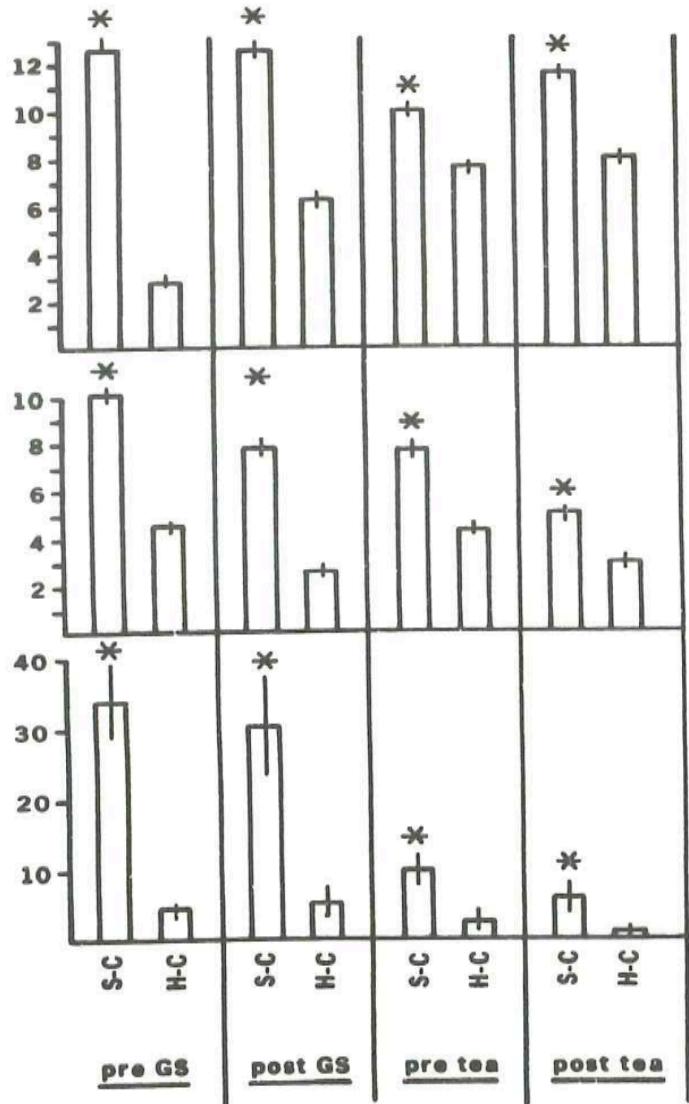
Example



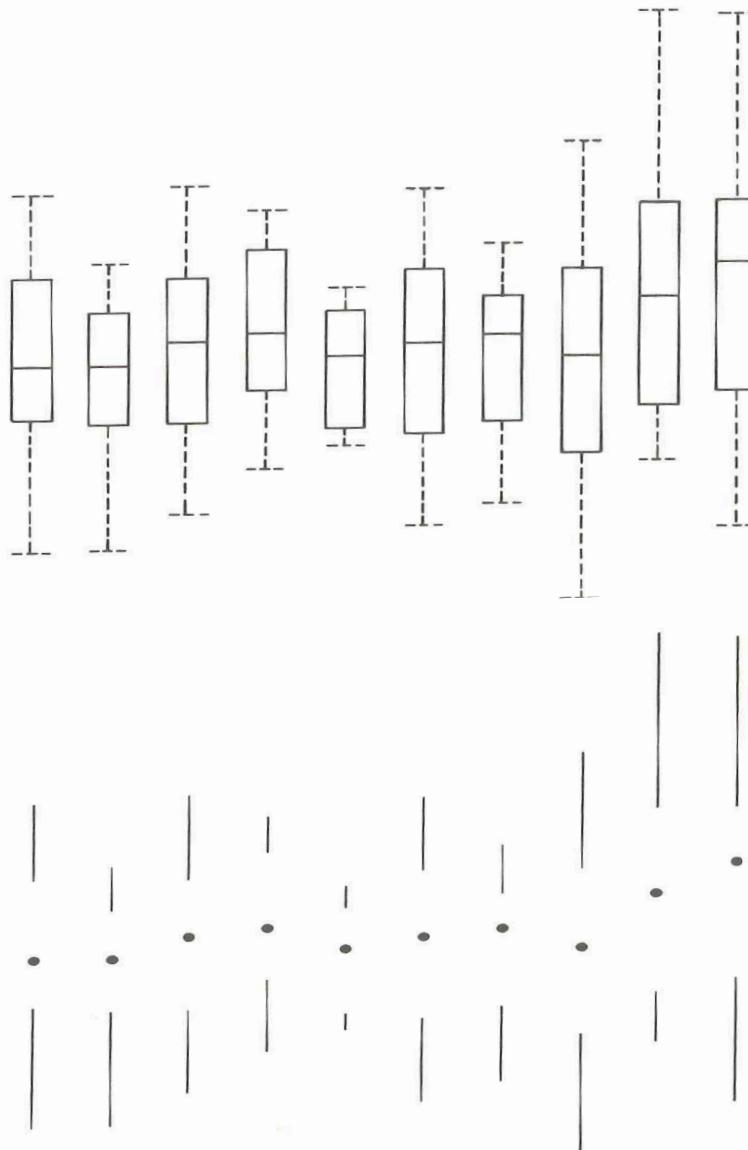
Erase non-data-ink (within reason)

Erase redundant data-ink

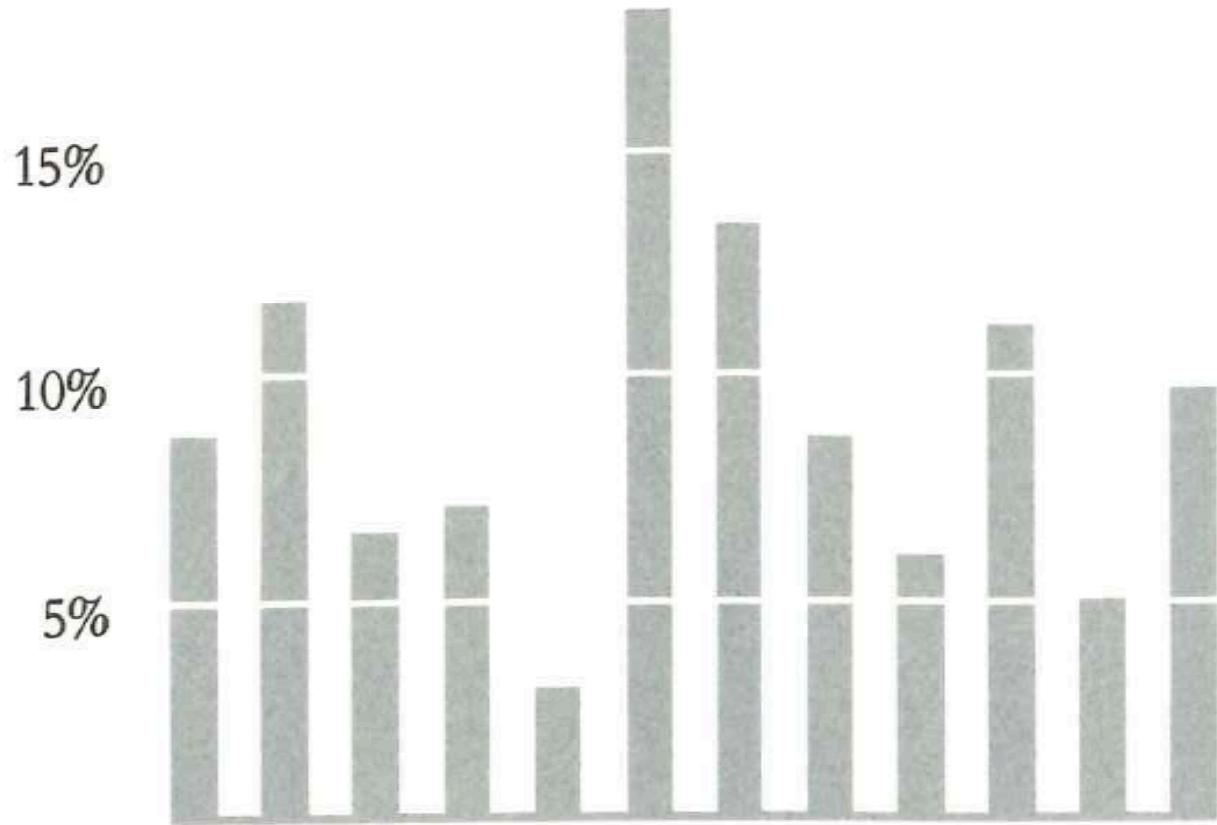
Redesign – Bar Chart



BoxPlot Redesign



Bar Chart Redesign



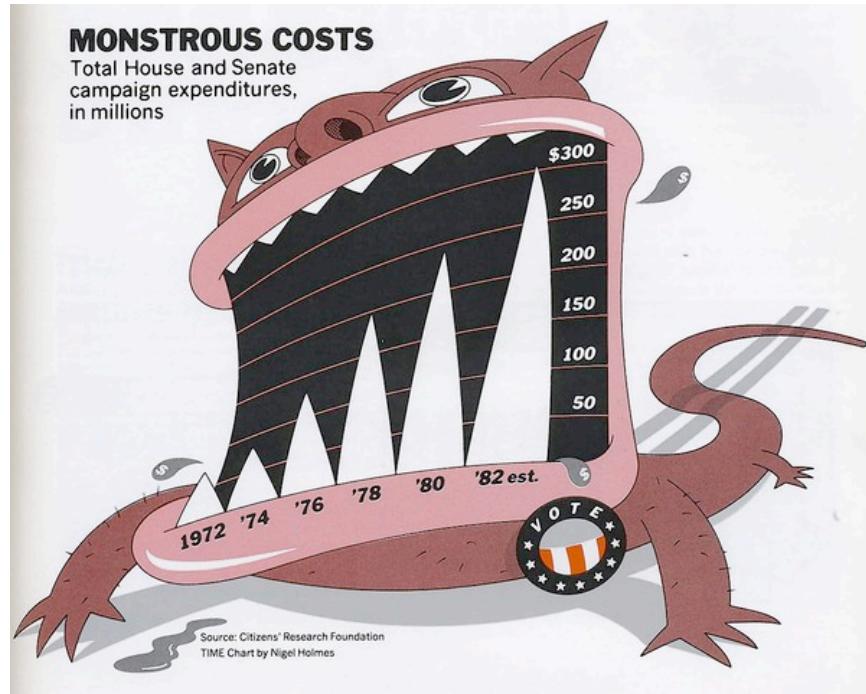
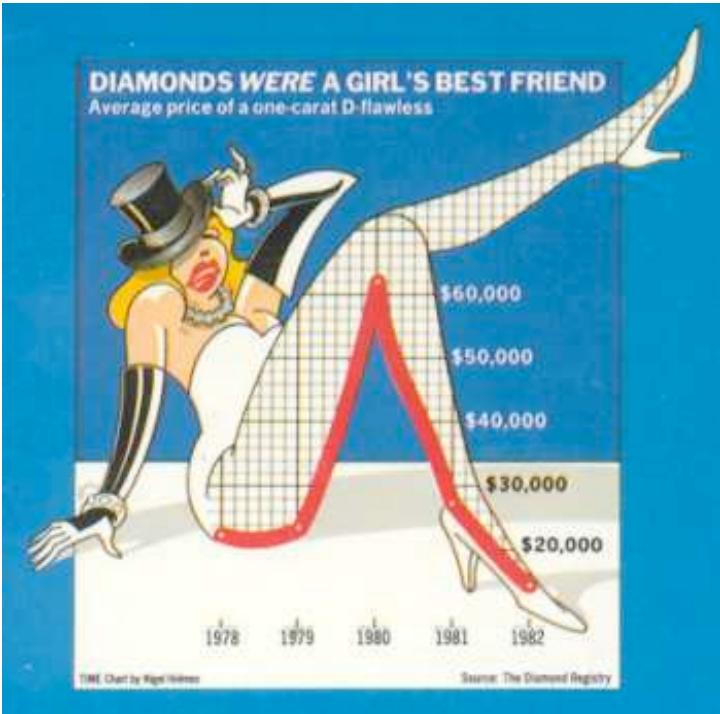
Avoid Chartjunk

Extraneous visual elements that detract from message

“Chartjunk promoters imagine that numbers and details are boring, dull, and tedious, requiring ornament to enliven.

If the numbers are boring...then you've got the wrong numbers”

Chart Junk?



Nigel Holmes Style Graphics

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Multifunctioning Elements

“Mobilize every graphical element, perhaps several times over, to show the data”

Vol1, pg 139

In other words, try to make all present graphical elements data encoding elements.

Stem and Leaf Plots

$0 | 9 = 900 \text{ feet}$

What is the mark?
How is value encoded?

Stem-and-leaf displays:
heights of 218 volcanoes, unit 100 feet.

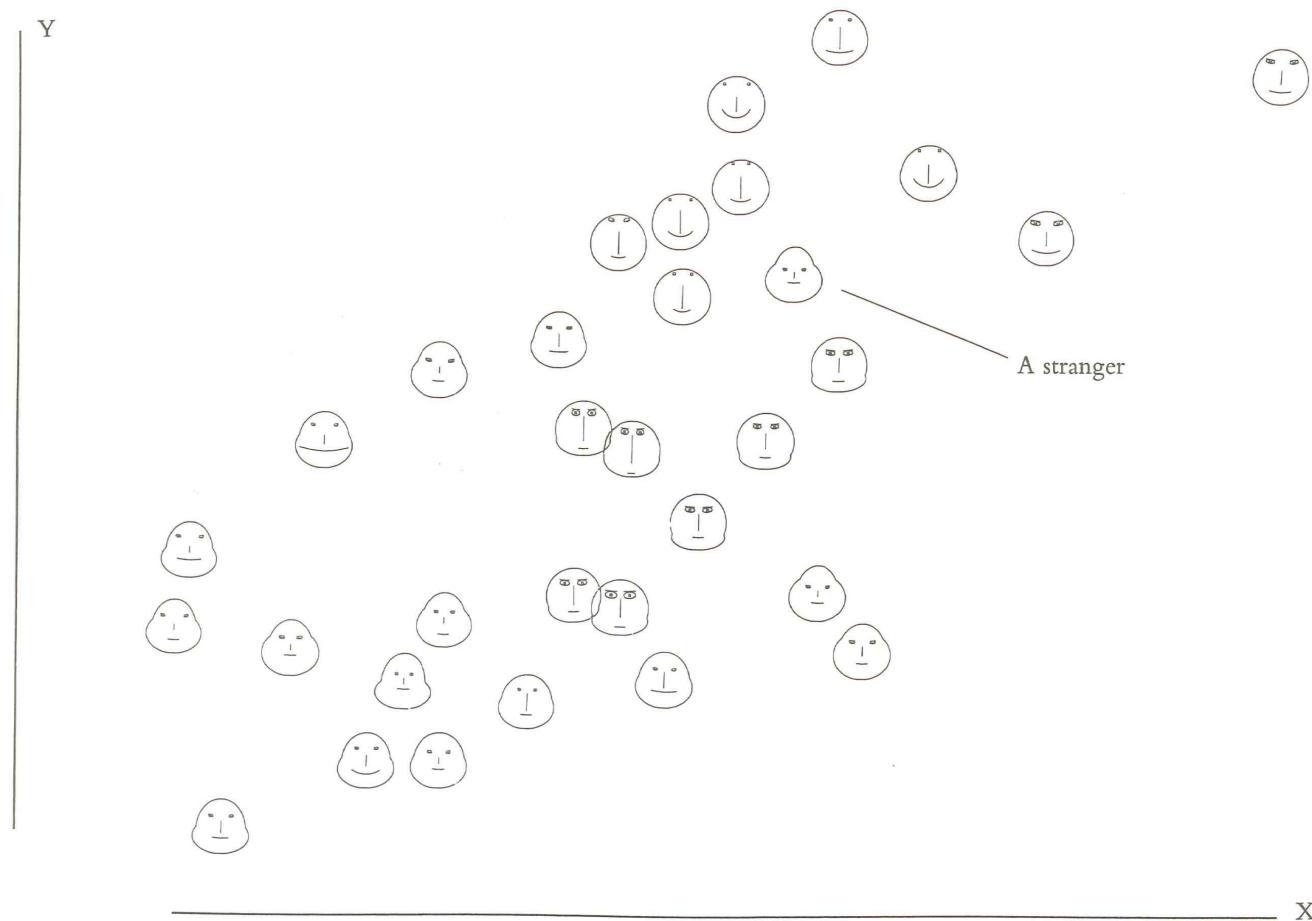
$19 | 3 = 19,300 \text{ feet}$

0	98766562
1	97719630
2	69987766544422211009850
3	876655412099551426
4	9998844331929433361107
5	9766666554422210097731
6	898665441077761065
7	98855431100652108073
8	653322122937
9	377655421000493
10	0984433165212
11	4963201631
12	45421164
13	47830
14	00
15	676
16	52
17	92
18	5
19	39730

Tufte, Visual Display of Quantitative Information, pg. 140



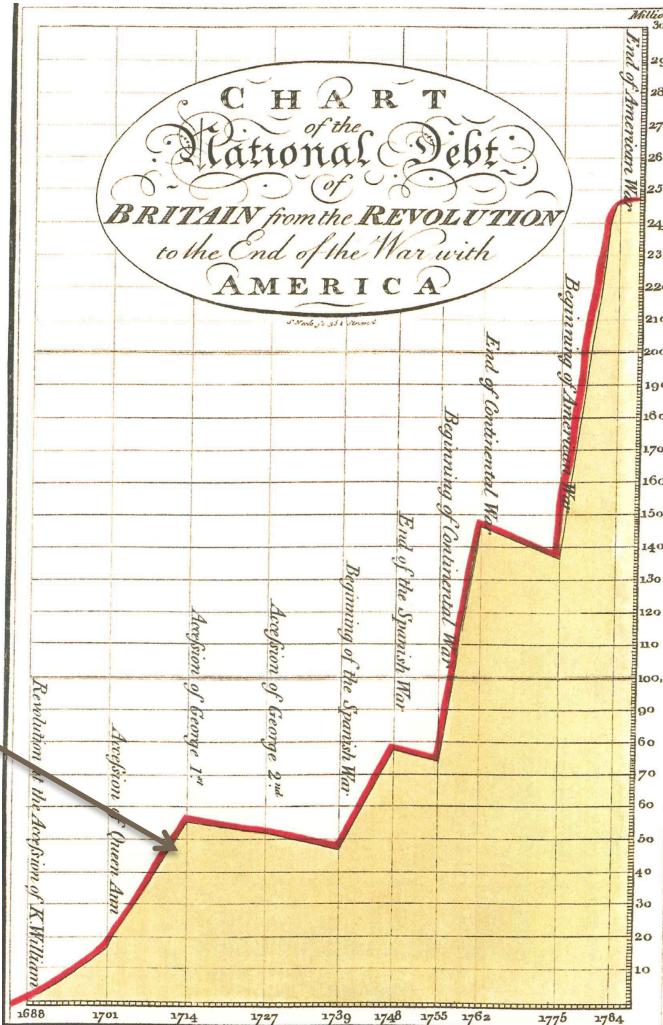
Chernoff Faces



Tufte, Visual Display of Quantitative Information, pg. 142

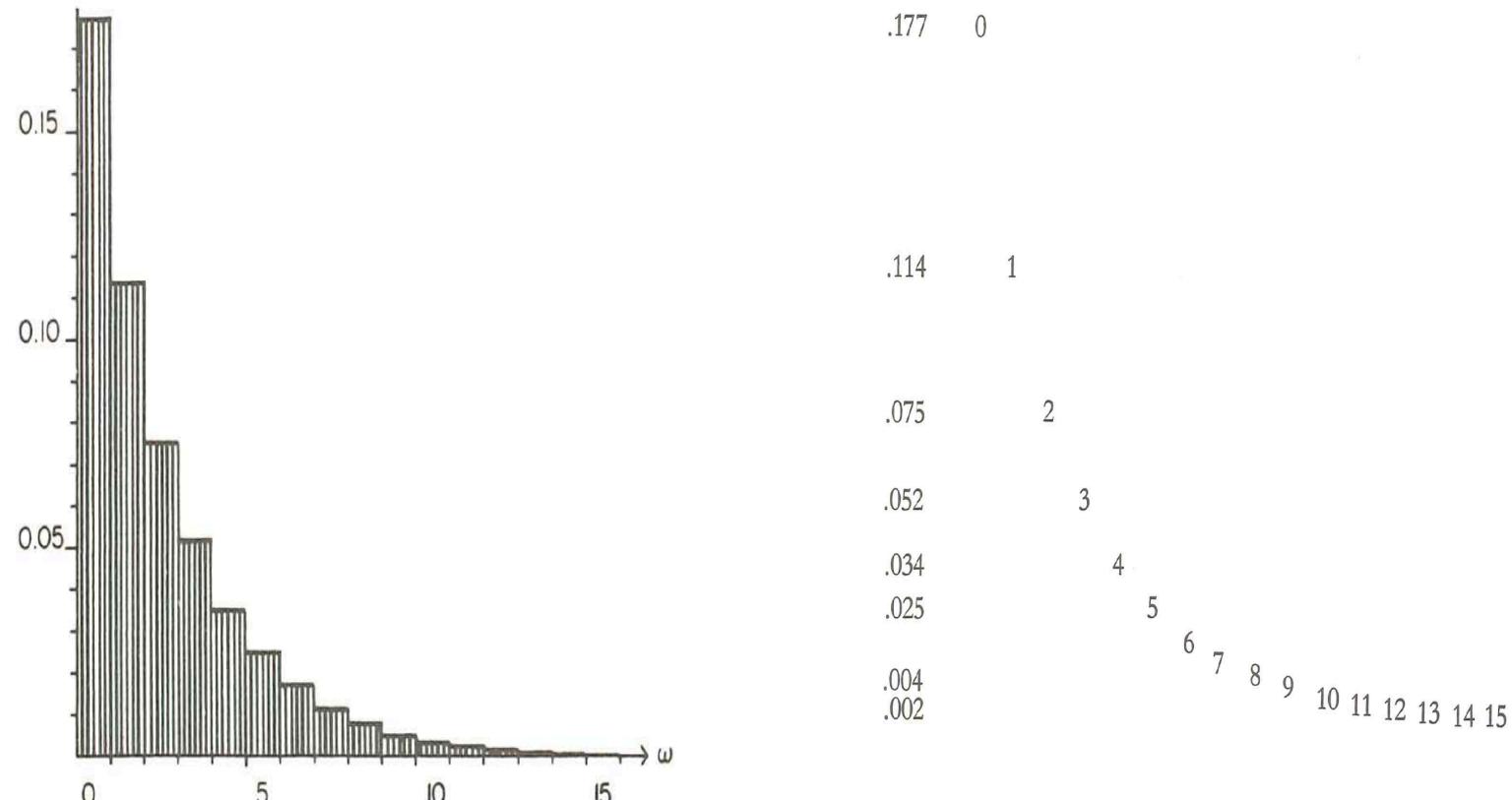
Playfair's Grid

Irregular grid
shows important
events



Tufte, Visual Display of Quantitative Information, pg. 142

Coordinate Labels as Marks



Tufte, Visual Display of Quantitative Information, pg. 140

Maximize Data Density

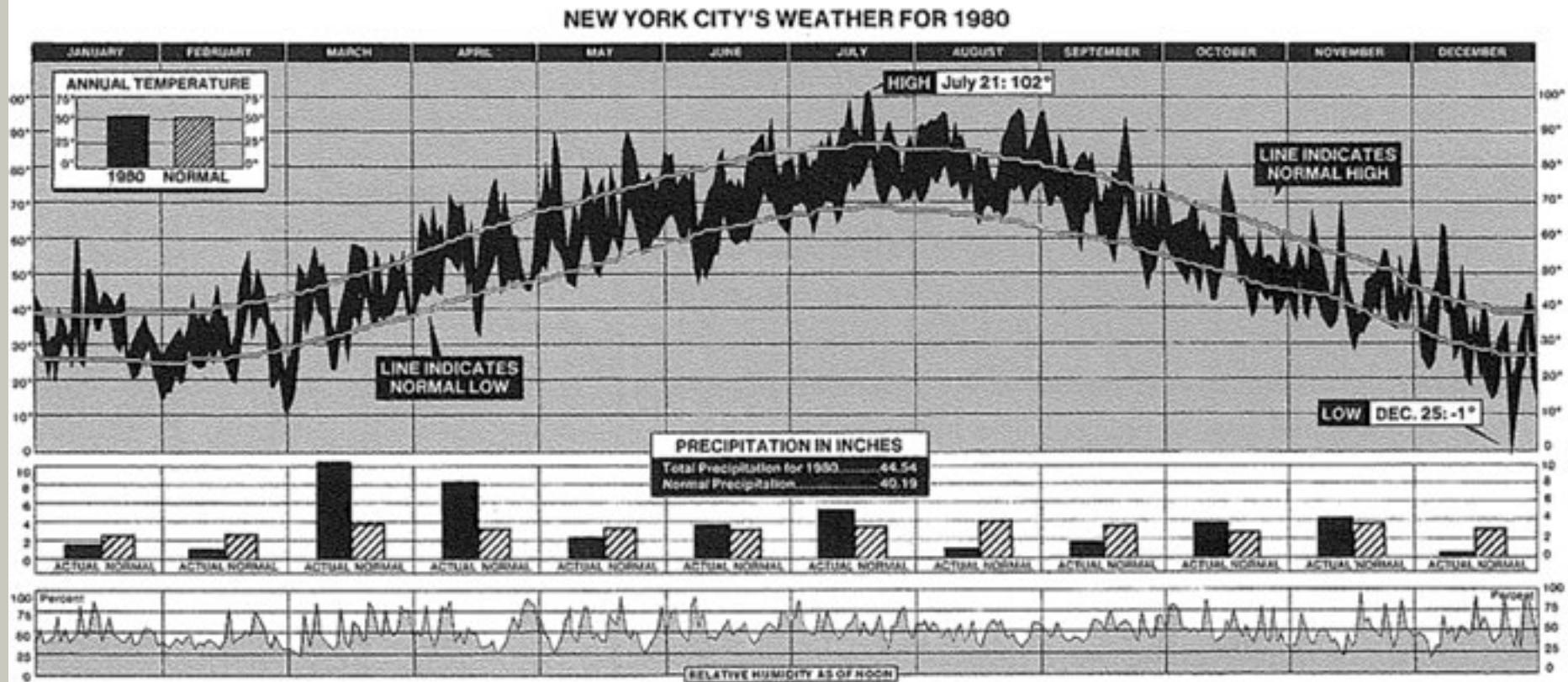
Maximize data density and the size of the data matrix within reason

$$\text{Data Density} = \frac{\text{\# entries in data matrix}}{\text{area of data graphic}}$$

Data Density Examples

Maximize data density and the size of the data matrix within reason

181 numbers / square inch



New York Times, January 11, 1981, p. 32.

Small Multiples

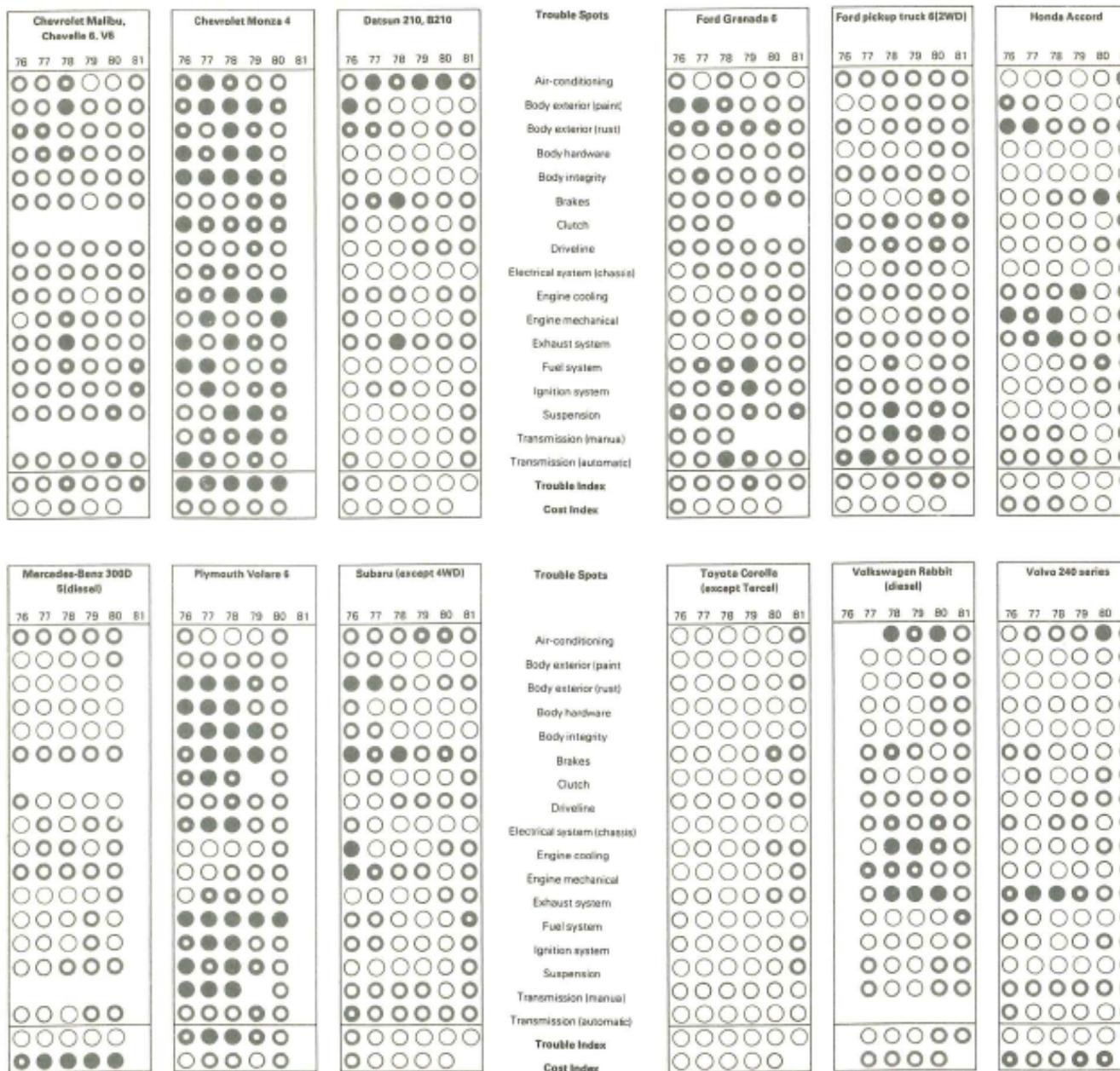
Previous examples improved data density by using a **LARGE** data matrix

$$\text{Data Density} = \frac{\text{\# entries in data matrix}}{\text{area of data graphic}}$$

Alternatively, we can reduce the size of the graphic = the Shrink Principle

Repeated application of this principle leads to a Small Multiples design

Small Multiples



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Tufte's Design Principles Composition

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Design Principles

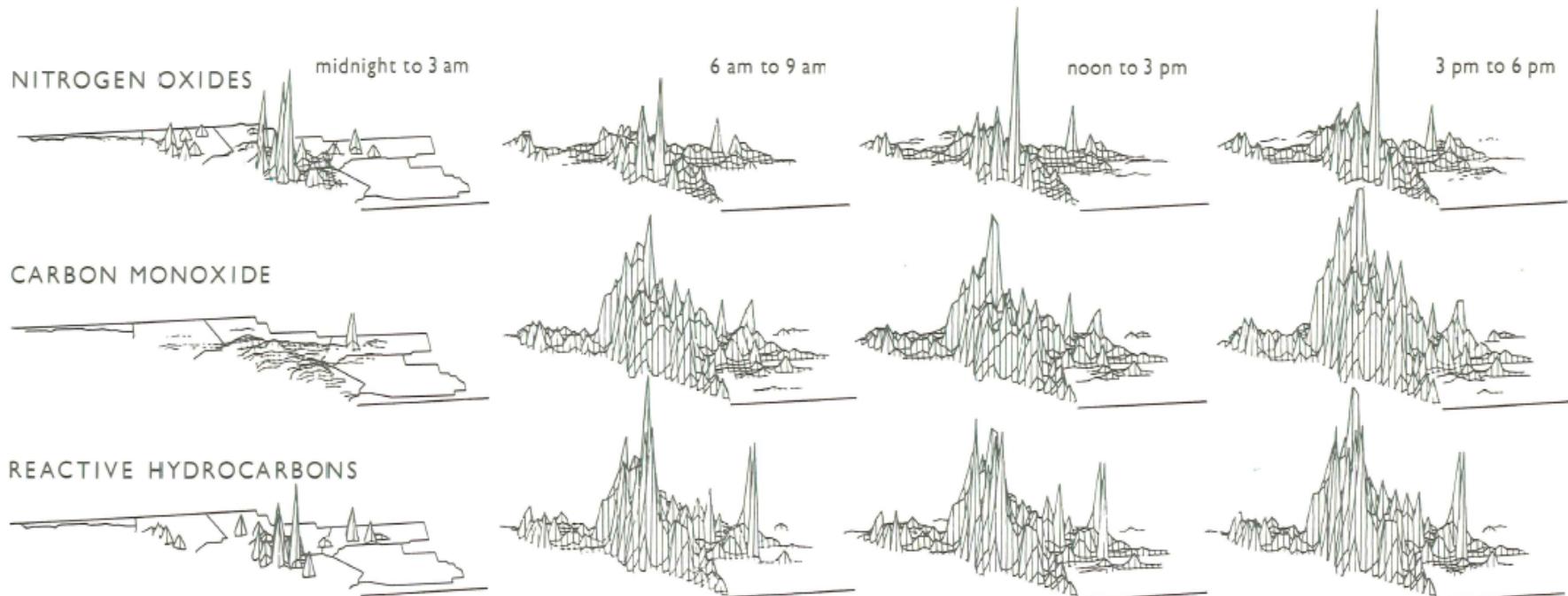
Escape flatland – small multiples, parallel sequencing

Data is multivariate

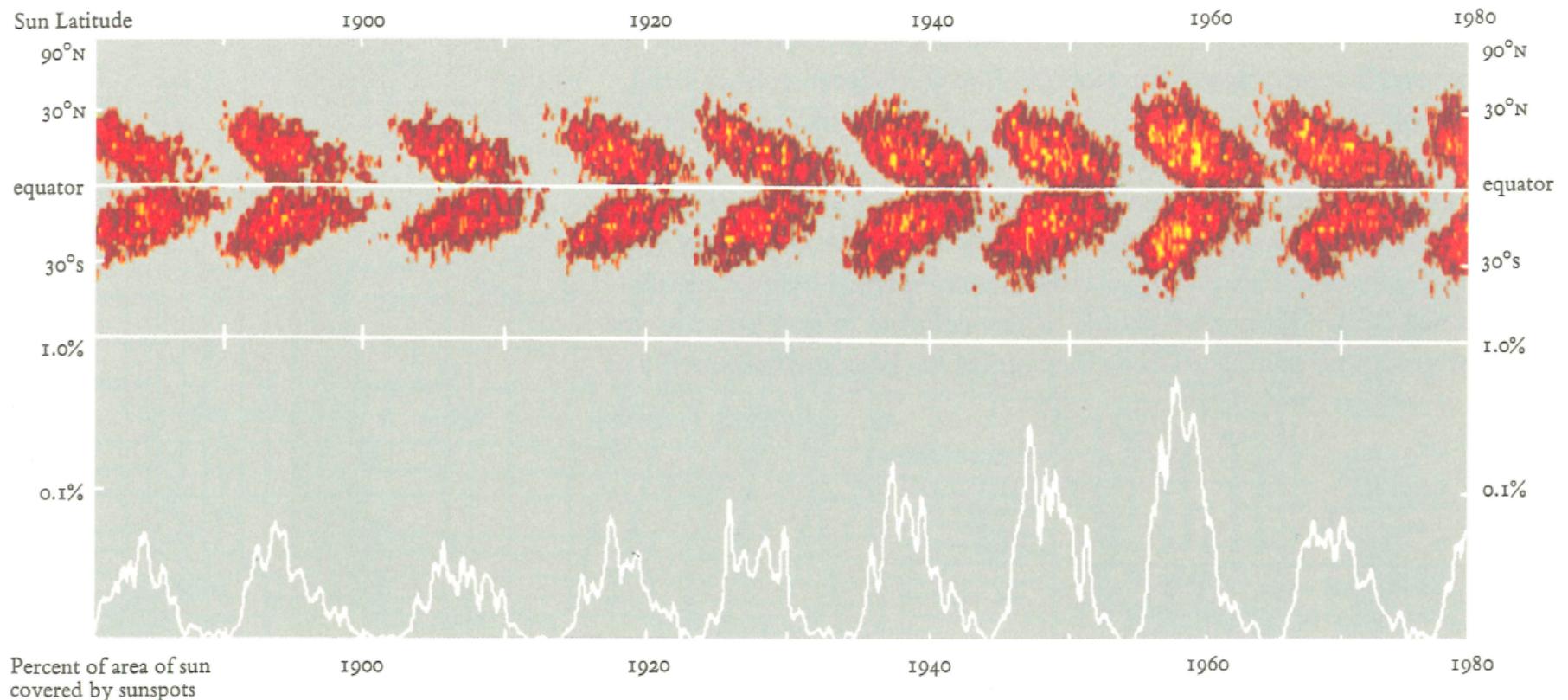
Doesn't necessarily mean 3D projection

How can we enhance multivariate data on inherently 2D surfaces?

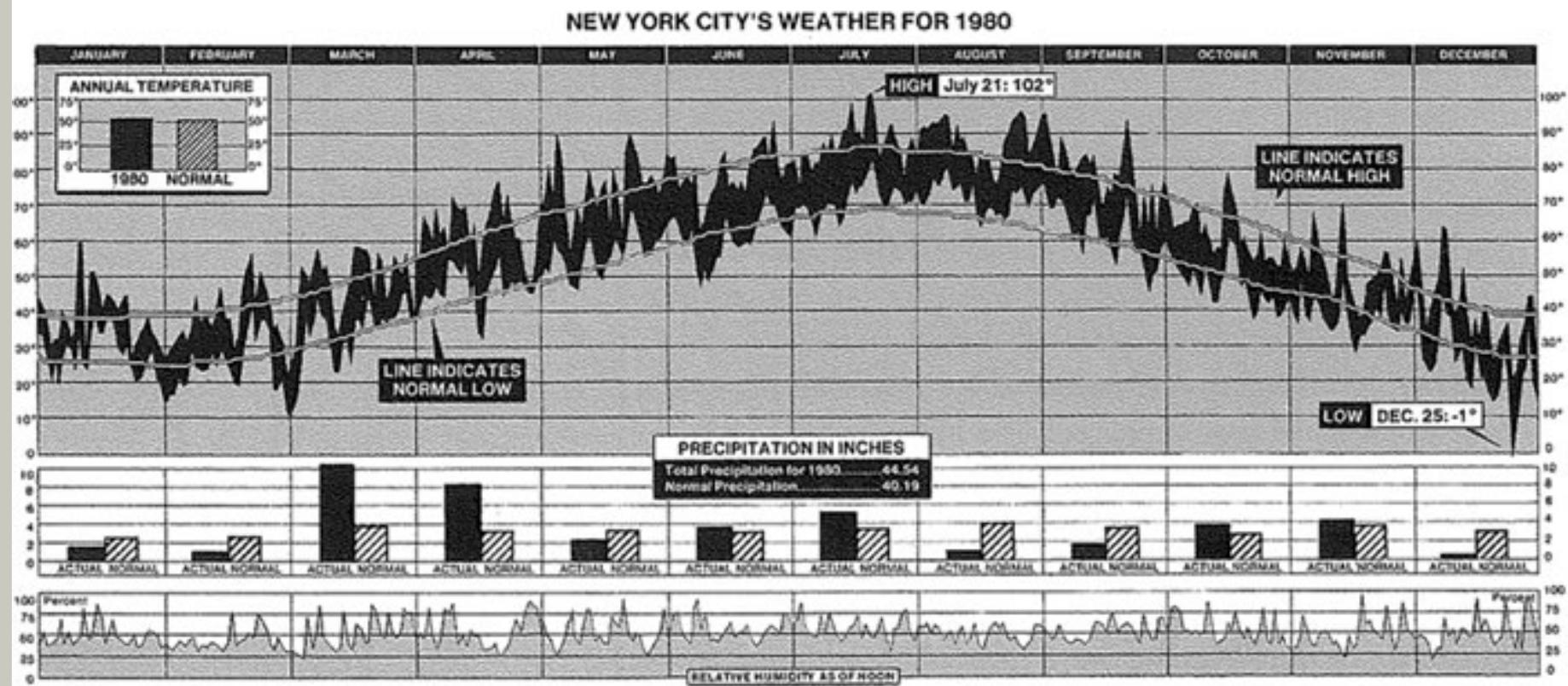
Small Multiples



Parallel Sequencing



Parallel Sequencing



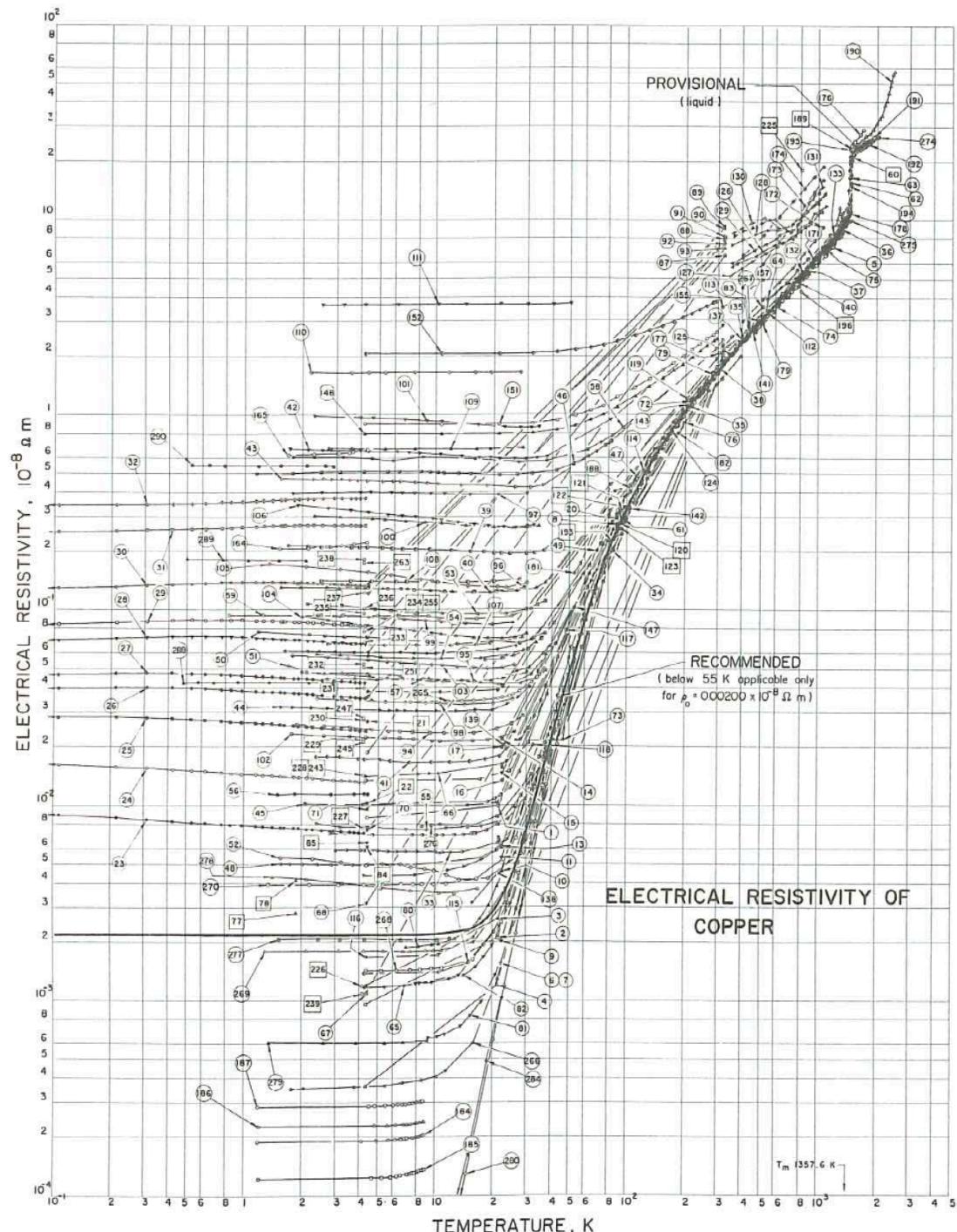
New York Times, January 11, 1981, p. 32.

Tufte- Macro/Micro

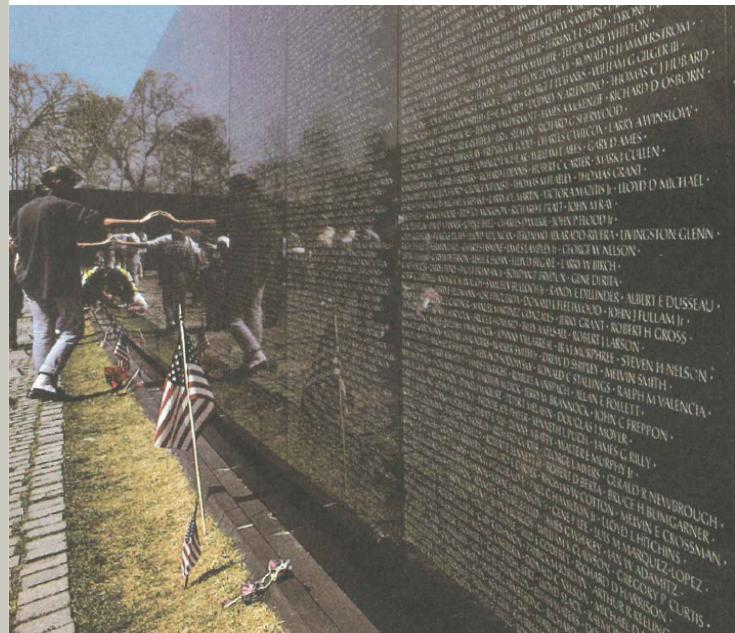
Provide the user with both views (overview + detail)

Carefully designed view can show a macro structure (overview) as well as micro structure (detail) in one space

Tufte, Envisioning Information



Tufte, Envisioning Information



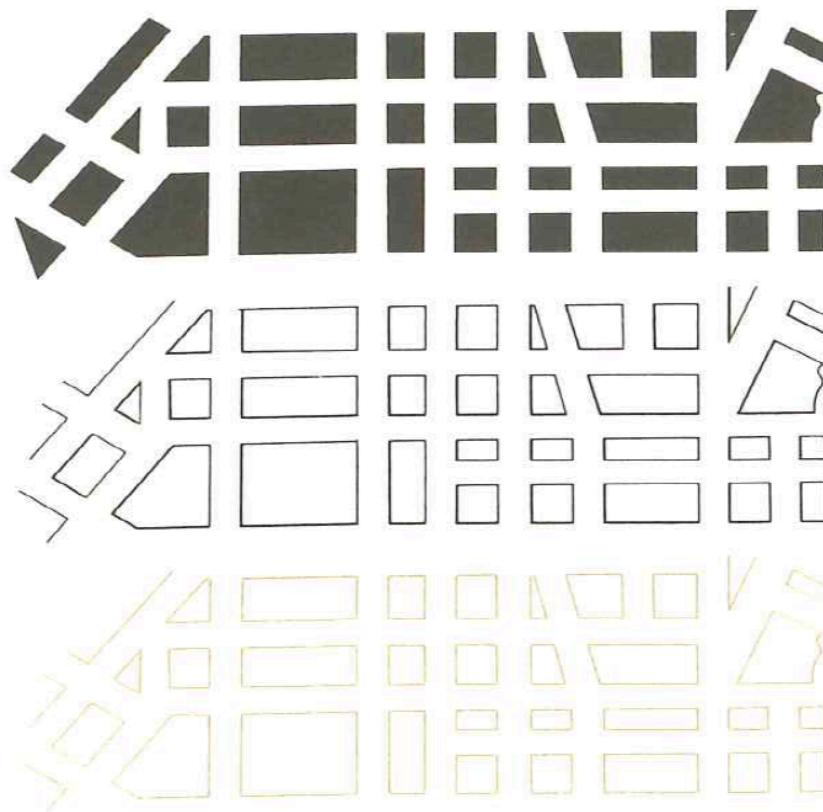
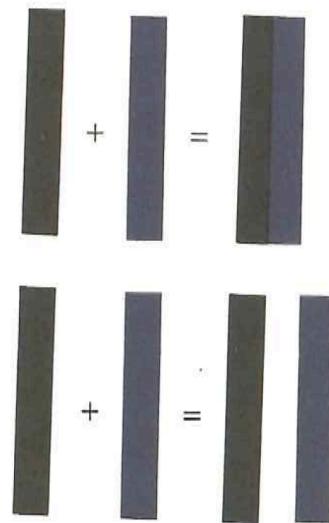
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Tufte- Utilize Layering & Separation

Supported by Gestalt laws

- Grouping with colors
- Using Color to separate
- $1+1 = 3$ (clutter)

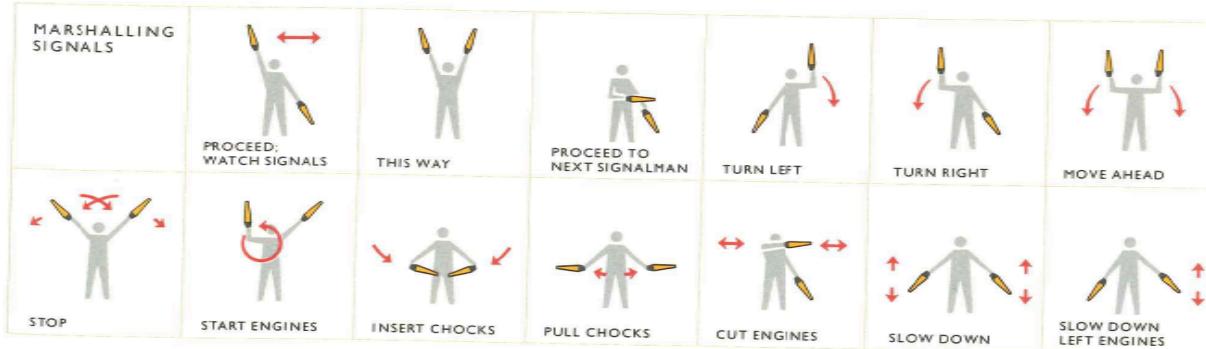
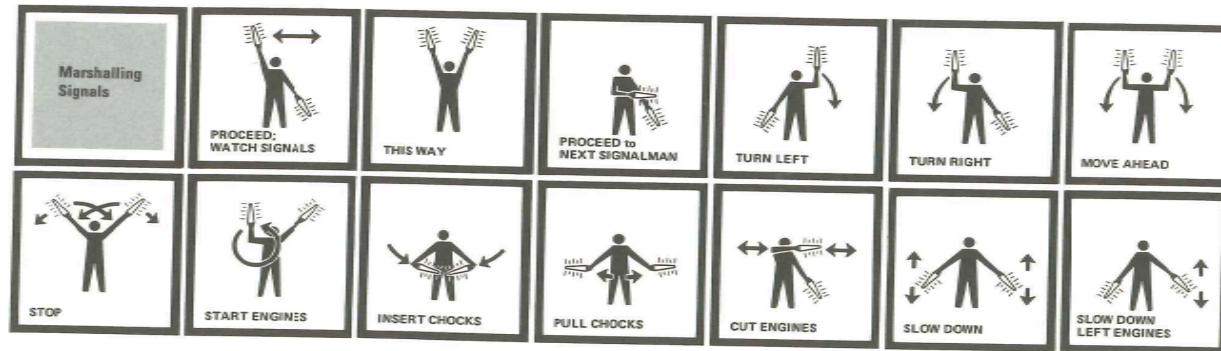
Tufte- Utilize Layering & Separation



Tufte, Envisioning Information

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Tufte- Utilize Layering & Separation



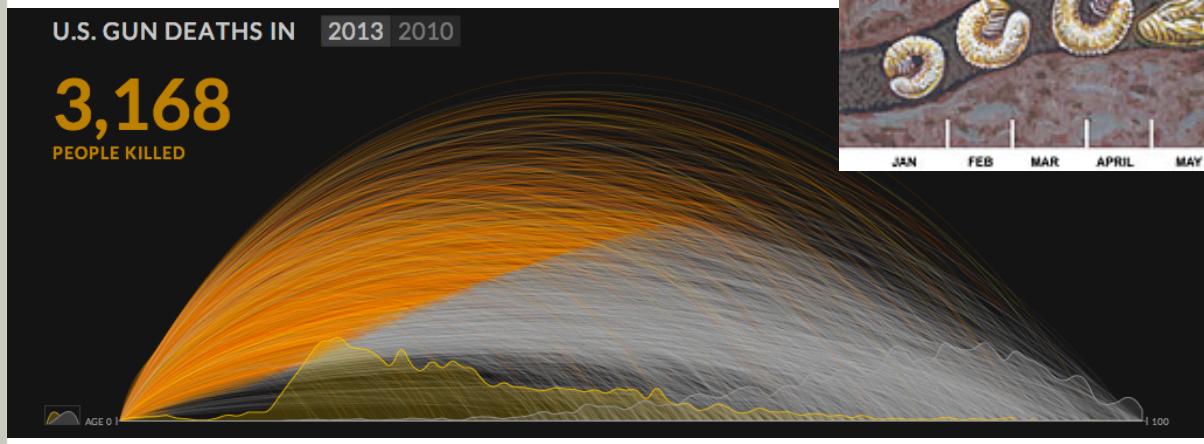
Tufte, Envisioning Information

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Design Principles

Utilize narratives of space and time

Tell a story of position and chronology through visual elements



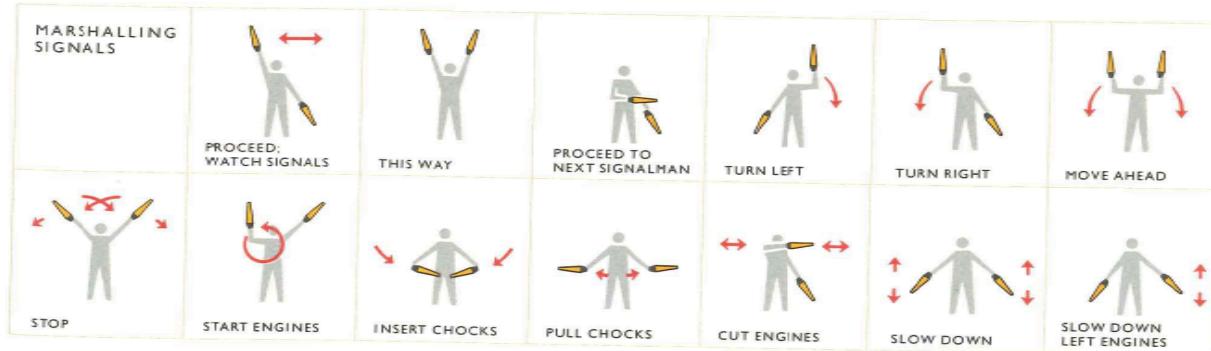
[http://www.arbordoctor.net/
japanesebeetle.html](http://www.arbordoctor.net/japanesebeetle.html)

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Graph and Chart Tips

Avoid separate legends and keys -- Just have that information in the graphic

Make grids, labeling, etc., very faint so that they recede into background



Using Color Effectively

“The often scant benefits derived from coloring data indicate that even putting a good color in a good place is a complex matter. Indeed, so difficult and subtle that avoiding catastrophe becomes the first principle in bringing color to information:
Above all, do no harm.”

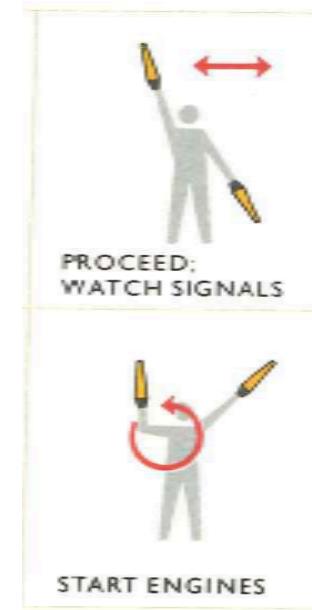
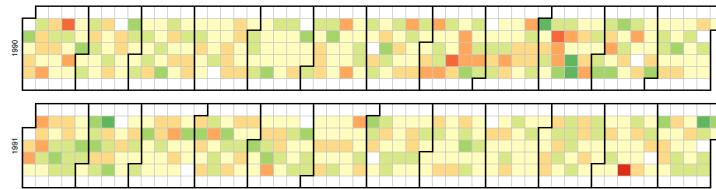
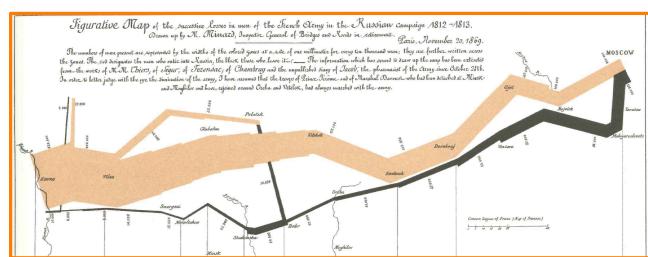
Proper Color Use

To label (nominal)

To measure (quantitative)

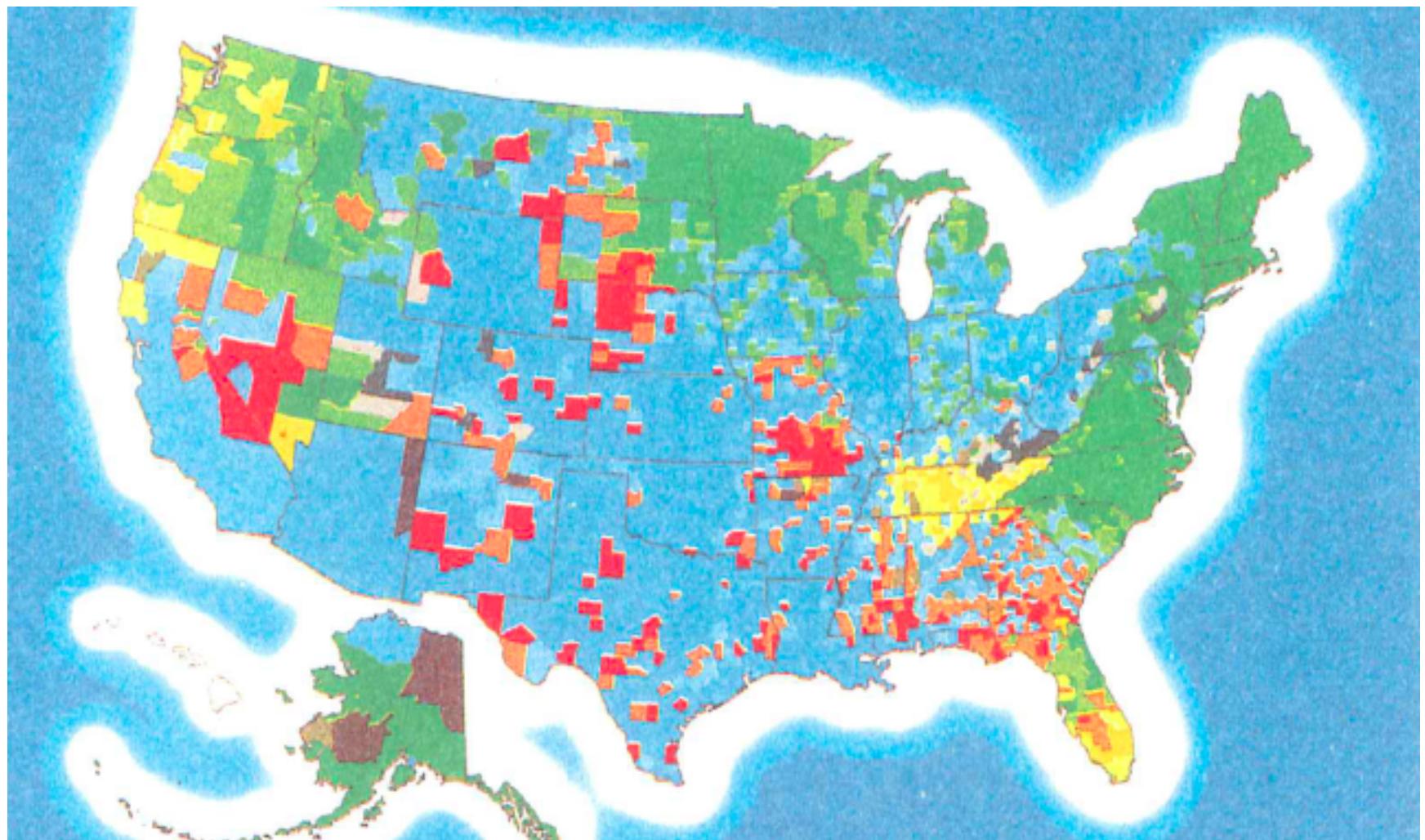
To represent or imitate reality

To enliven or decorate



Color Rules

1. “Bright, strong colors have loud, unbearable effects when they stand unrelieved over large areas adjacent to one another, but extraordinary effects can be achieved when they are used sparingly on or between dull background tones” Vol2, pg. 82
2. “The placing of light bright colors mixed with white next to each other usually produces unpleasant results, especially if the colors are used for large areas” Vol2 pg. 82

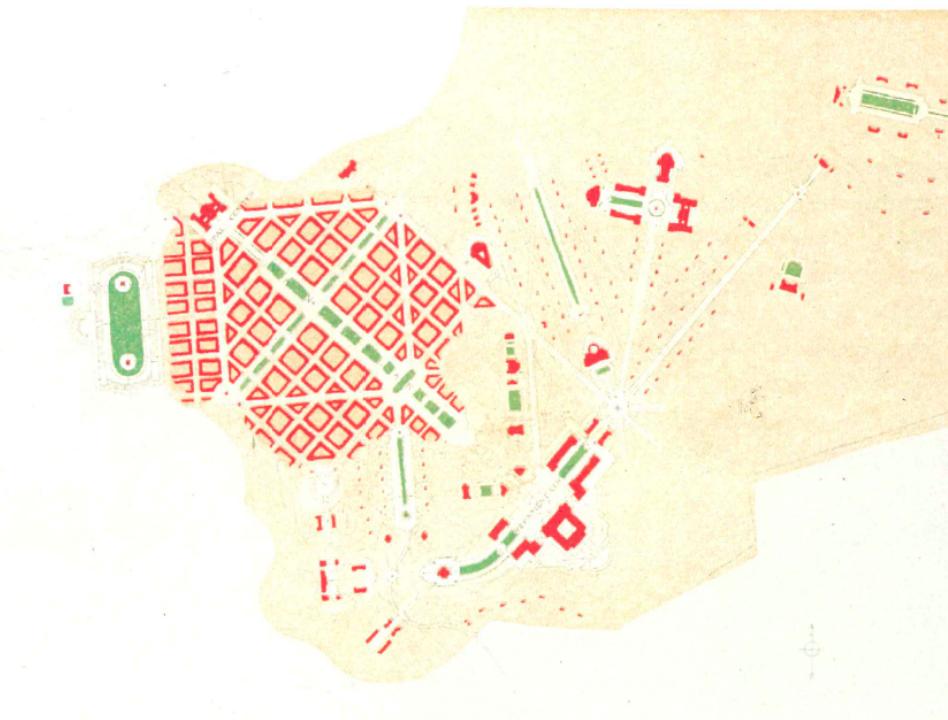


Vol2 , Pg. 82

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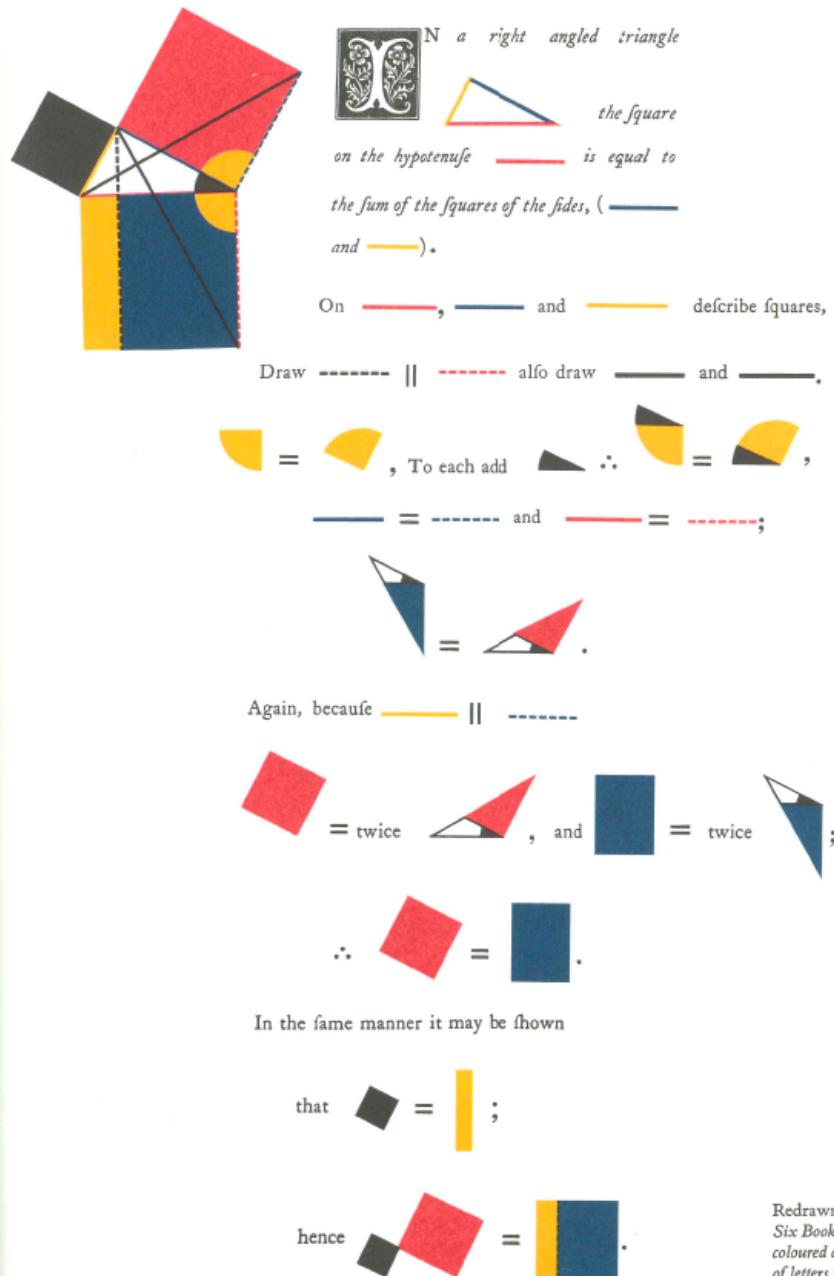
Color Rules

3. Large background colors should be quiet, muted to let brighter colors stand out



Vol2, Pg. 83

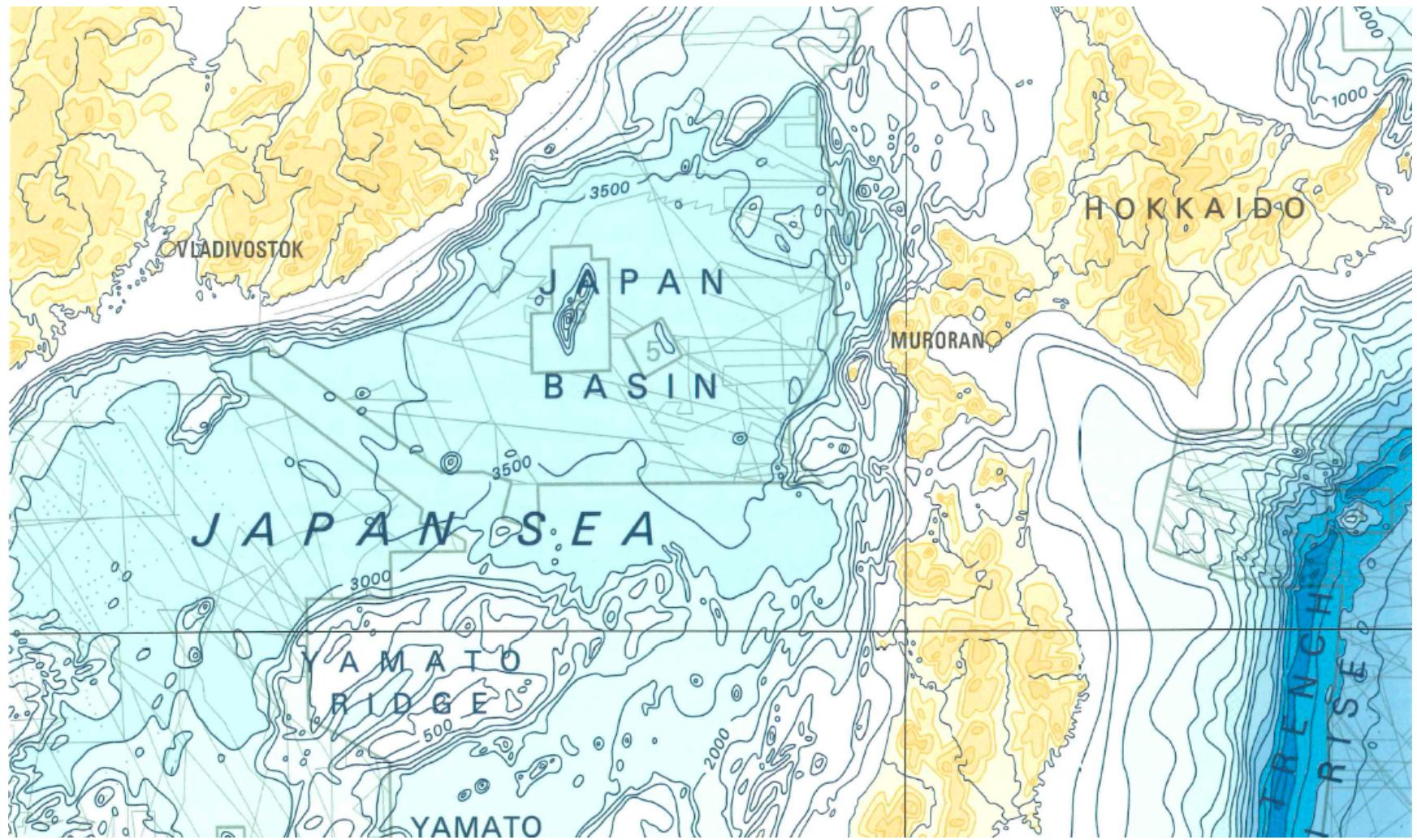
Oliver Byrne, Elements of Euclid



Redrawn from Oliver Byrne, *The First Six Books of the Elements of Euclid in which coloured diagrams and symbols are used instead of letters for the greater ease of learners* (London, 1847), pp. 48–49.

Vol2, Pg. 85

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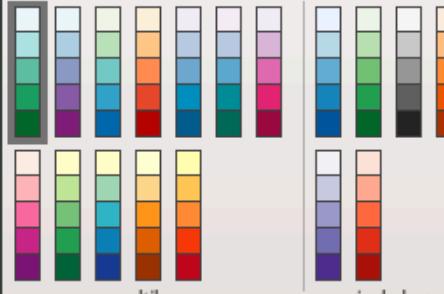
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ColorBrewer: Sequential (Ordinal)

number of data classes on your map
5 [learn more >](#)

the nature of your data
sequential [learn more >](#)

pick a color scheme: BuGn



multihue single hue

(optional) only show schemes that are:

colorblind safe print friendly
 photocopyable [learn more >](#)

pick a color system

237, 248, 251	<input checked="" type="radio"/> RGB <input type="radio"/> CMYK <input type="radio"/> HEX
178, 226, 226	adjust map context
102, 194, 164	<input type="checkbox"/> roads
44, 162, 95	<input type="checkbox"/> cities
0, 109, 44	<input checked="" type="checkbox"/> borders

[learn more >](#)

select a background

solid color

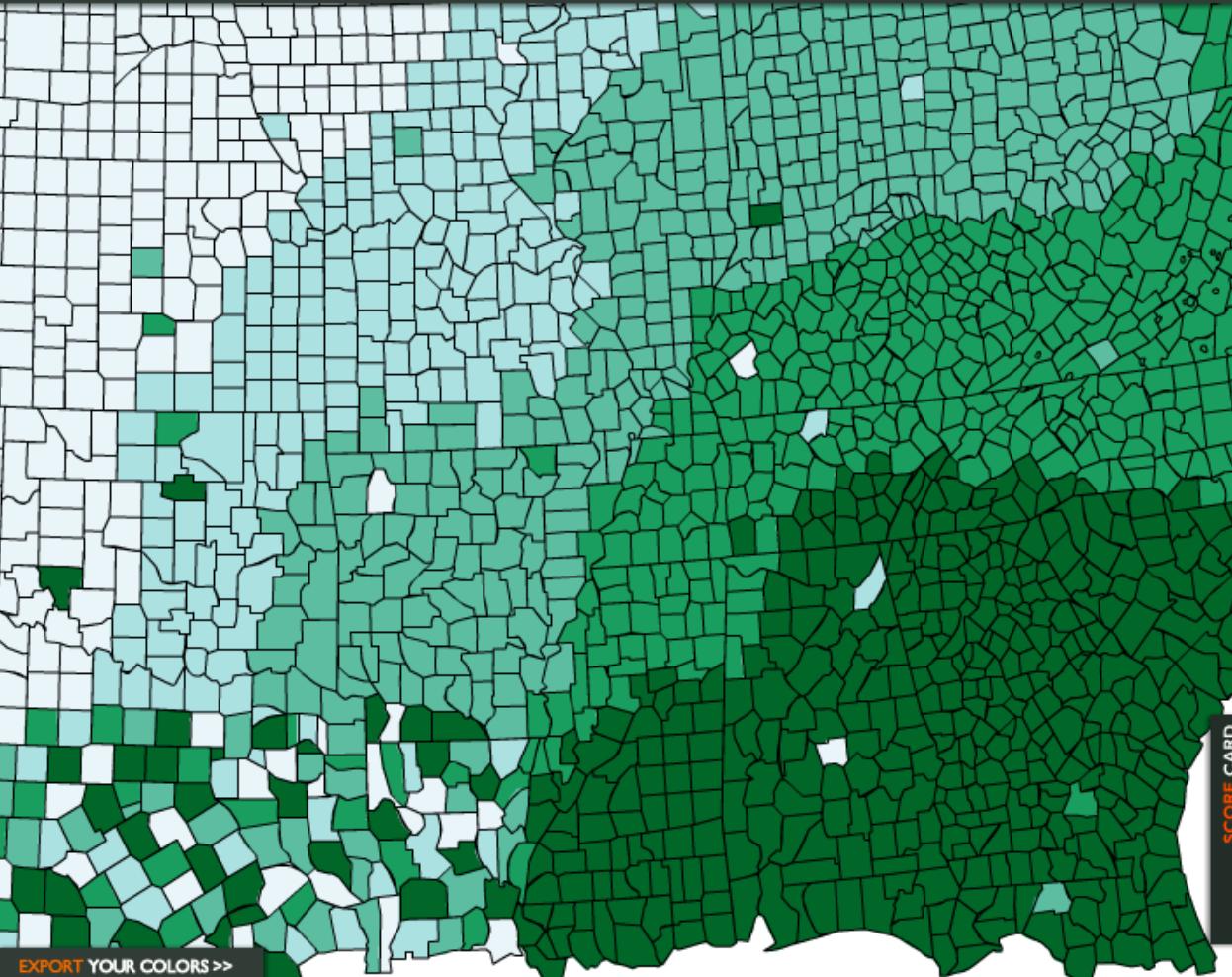
terrain

[color transparency](#)

EXPORT YOUR COLORS >>

how to use | updates | credits

COLORBREWER 2.0
color advice for cartography



SCORE CARD

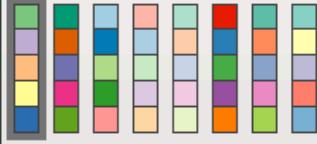
http://colorbrewer2.org/

ColorBrewer: Qualitative (Nominal)

number of data classes on your map
5 [learn more >](#)

the nature of your data
qualitative [learn more >](#)

pick a color scheme: Accent



(optional) only show schemes that are:
 colorblind safe print friendly
 photocopyable [learn more >](#)

pick a color system

I27, 201, I27	<input checked="" type="radio"/> RGB	<input type="radio"/> CMYK	<input type="radio"/> HEX
190, 174, 212			
253, 192, 134			
255, 255, 153			
56, 108, 176			

adjust map context
 roads
 cities
 borders

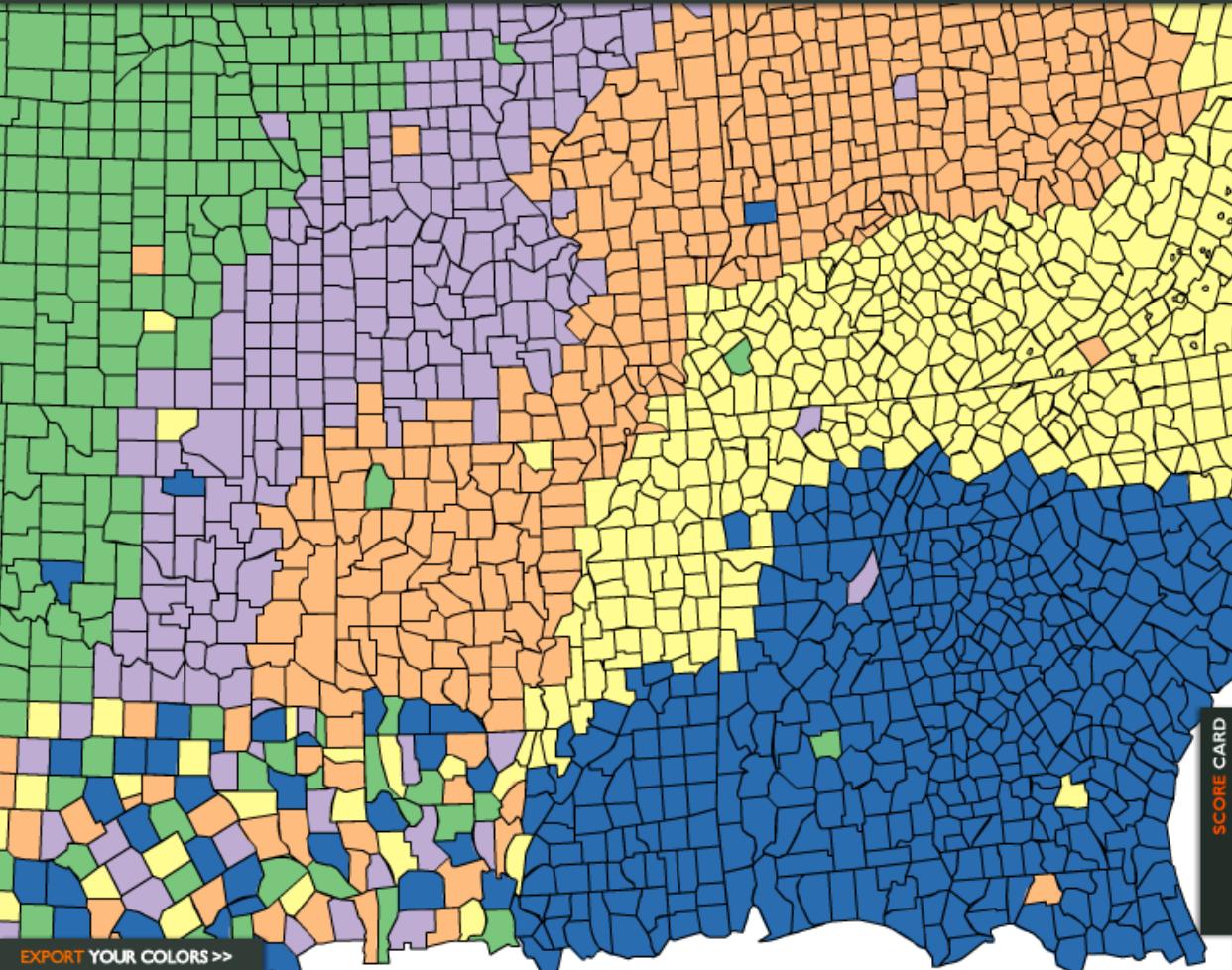
select a background
 solid color
 terrain

[color transparency](#)

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COLORBREWER 2.0
color advice for cartography



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SCORE CARD

<http://colorbrewer2.org/>

ColorBrewer: Diverging

number of data classes on your map
5 [learn more >](#)

the nature of your data
diverging [learn more >](#)

pick a color scheme: BrBG



(optional) only show schemes that are:
 colorblind safe print friendly
 photocopy-able [learn more >](#)

pick a color system

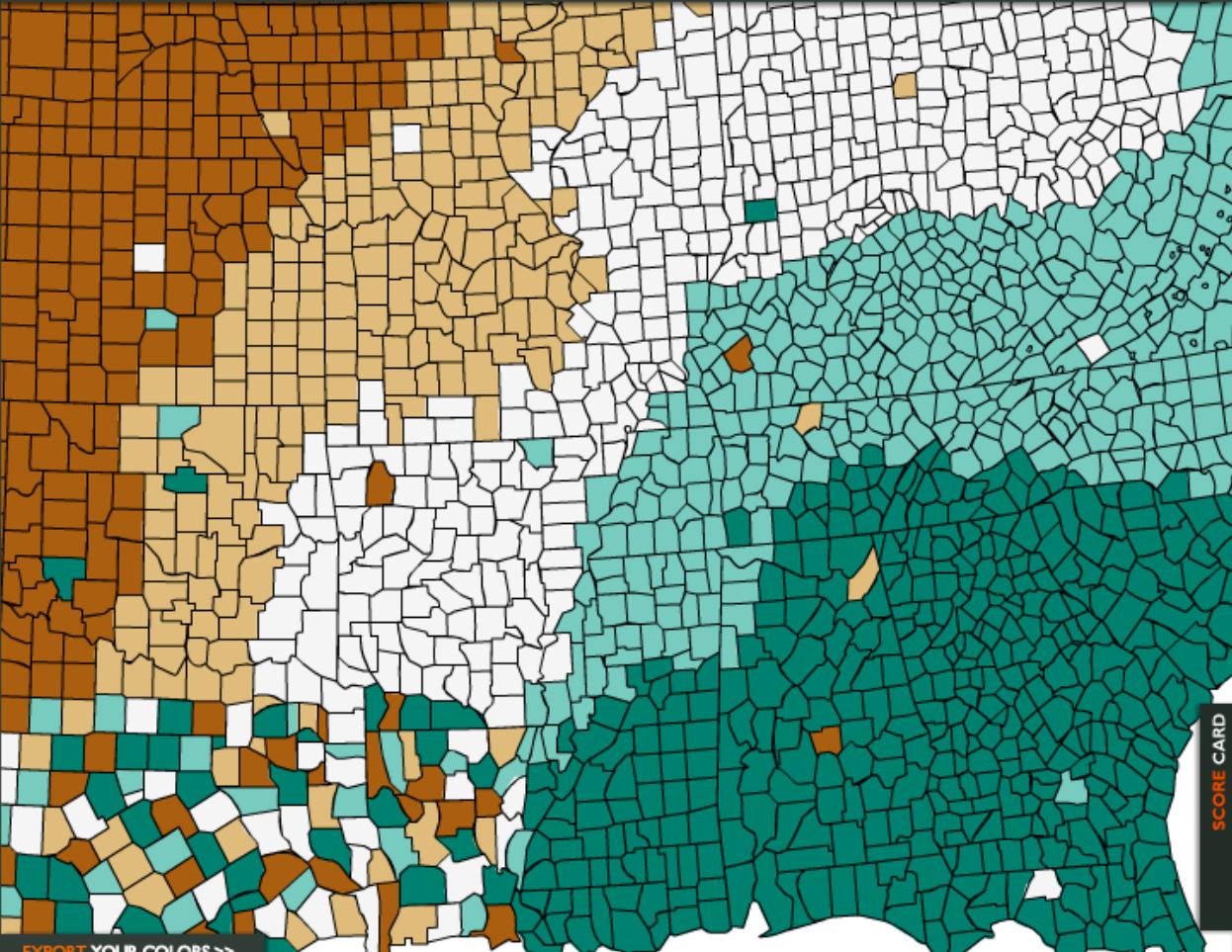
166, 97, 26	<input checked="" type="radio"/> RGB	<input type="radio"/> CMYK	<input type="radio"/> HEX
223, 194, 125	<input type="radio"/> RGB	<input type="radio"/> CMYK	<input type="radio"/> HEX
245, 245, 245	<input type="radio"/> RGB	<input type="radio"/> CMYK	<input type="radio"/> HEX
128, 205, 193	<input type="radio"/> RGB	<input type="radio"/> CMYK	<input type="radio"/> HEX
1, 133, 113	<input type="radio"/> RGB	<input type="radio"/> CMYK	<input type="radio"/> HEX

adjust map context
 roads
 cities
 borders

select a background
 solid color terrain

color transparency

[learn more >](#) [EXPORT YOUR COLORS >>](#)



COLORBREWER 2.0
color advice for cartography

<http://colorbrewer2.org/>

Guides for Enhancing Visual Quality

Attractive displays of statistical info

- have a properly chosen format and design
- use words, numbers and drawing together
- reflect a balance, a proportion, a sense of relevant scale
- display an accessible complexity of detail
- often have a narrative quality, a story to tell about the data
- are drawn in a professional manner, with the technical details of production done with care
- avoid content-free decoration, including chartjunk