Data Visualization with R

Principles and Practice

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May 5, 2021

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Preamble

Plan for today

Things to speak about:

- ✓ The importance of data visualization;
- ✓ Basics of *good* data visualization;
- ✓ "The *good*, the *bad*, and the *ugly*" when it comes to data visualization—examples.

The rest of the course is hands-on, using *R* and *ggplot2*.

Introduction

Importance

There is more data than ever waiting to be analyzed, mined for patterns, summarized, or linked to other data.

We also observe a phenomenal level of growth in individual-level data: Internet, GPS-enabled smartphones, e-scooters, smartwatches, fitness trackers, automated sensors, smart speakers etc.

Importance

Presenting such information in an accurate and intuitive way for the purpose of highlighting causal connections will be crucial for our ability to make adequate choices in a democracy.

Principles

Data visualization (DV)

At the confluence between statistics and design, dealing with the search for the most effective and graphically intuitive way of making an argument on the basis of data.

In 2000, an estimated 900 billion ($9 * 10^{11}$) to 2 trillion ($2 * 10^{12}$) graphs were generated every year (Tufte, 2001).

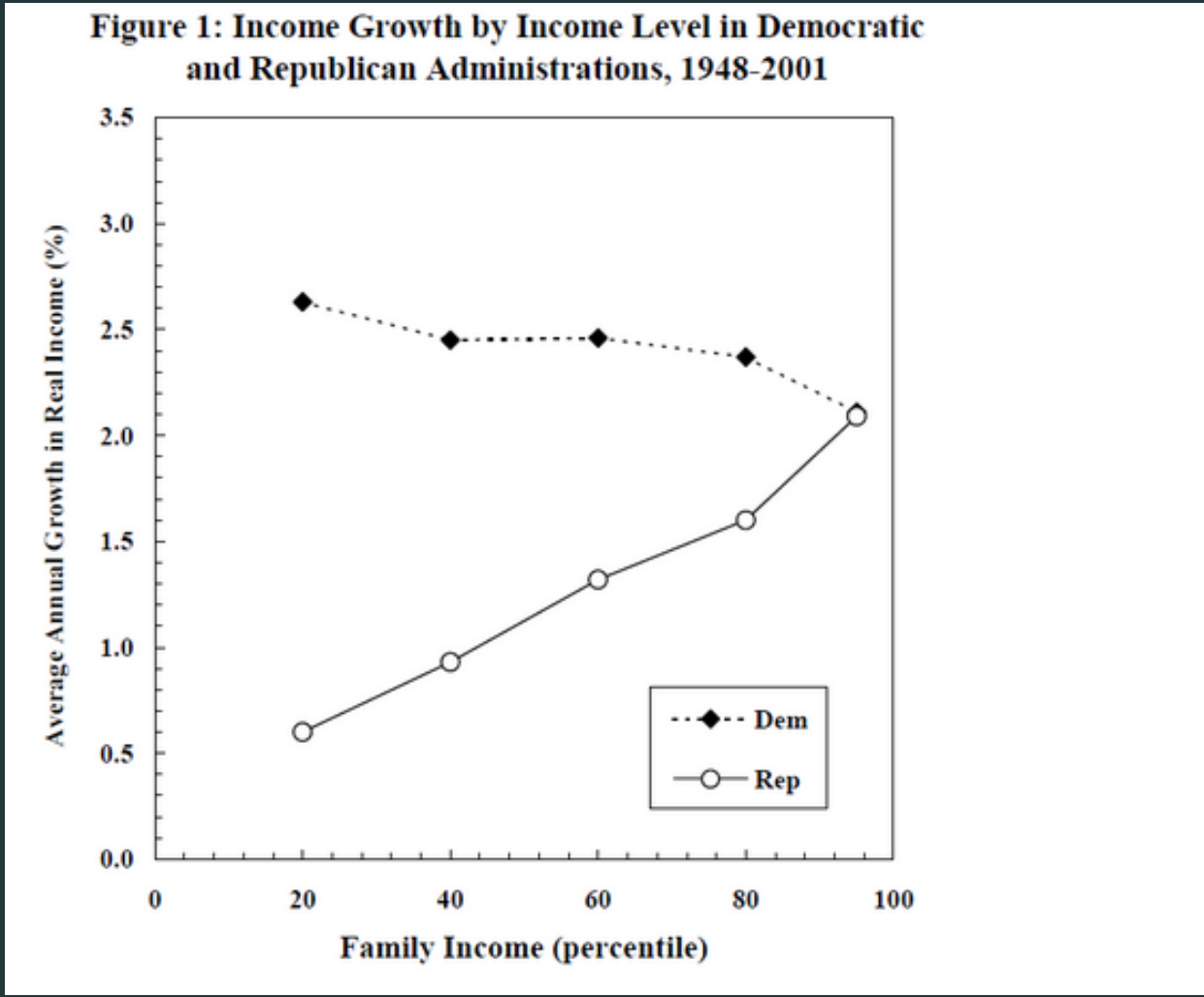
Goals of DV

Multiple:

- ✓ Making an argument;
- ✓ Minimizing any distractions from the central argument;
- ✓ Ensuring the integrity of the argument;

“Making a presentation is a moral act as well as an intellectual activity.” (Tufte, 2006, p. 141)

Simple, yet effective



Economic performance under US presidents (Bartels, 2008)

Goals of DV

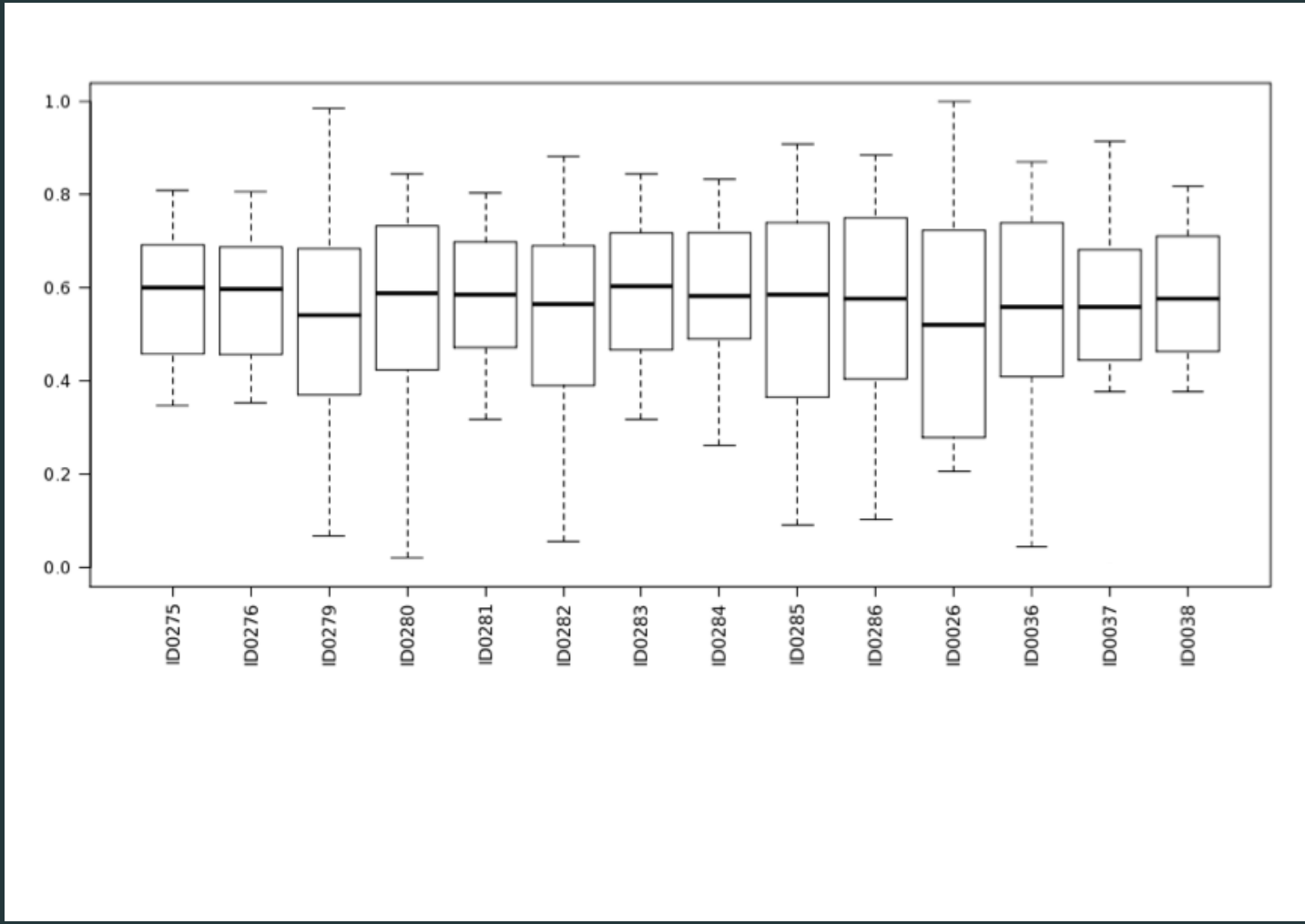
Two more:

- ✓ Summarizing a lot of information in a reduced space;
- ✓ Encouraging comparison.

Principles of DV (adapted from Tufte, 2001)

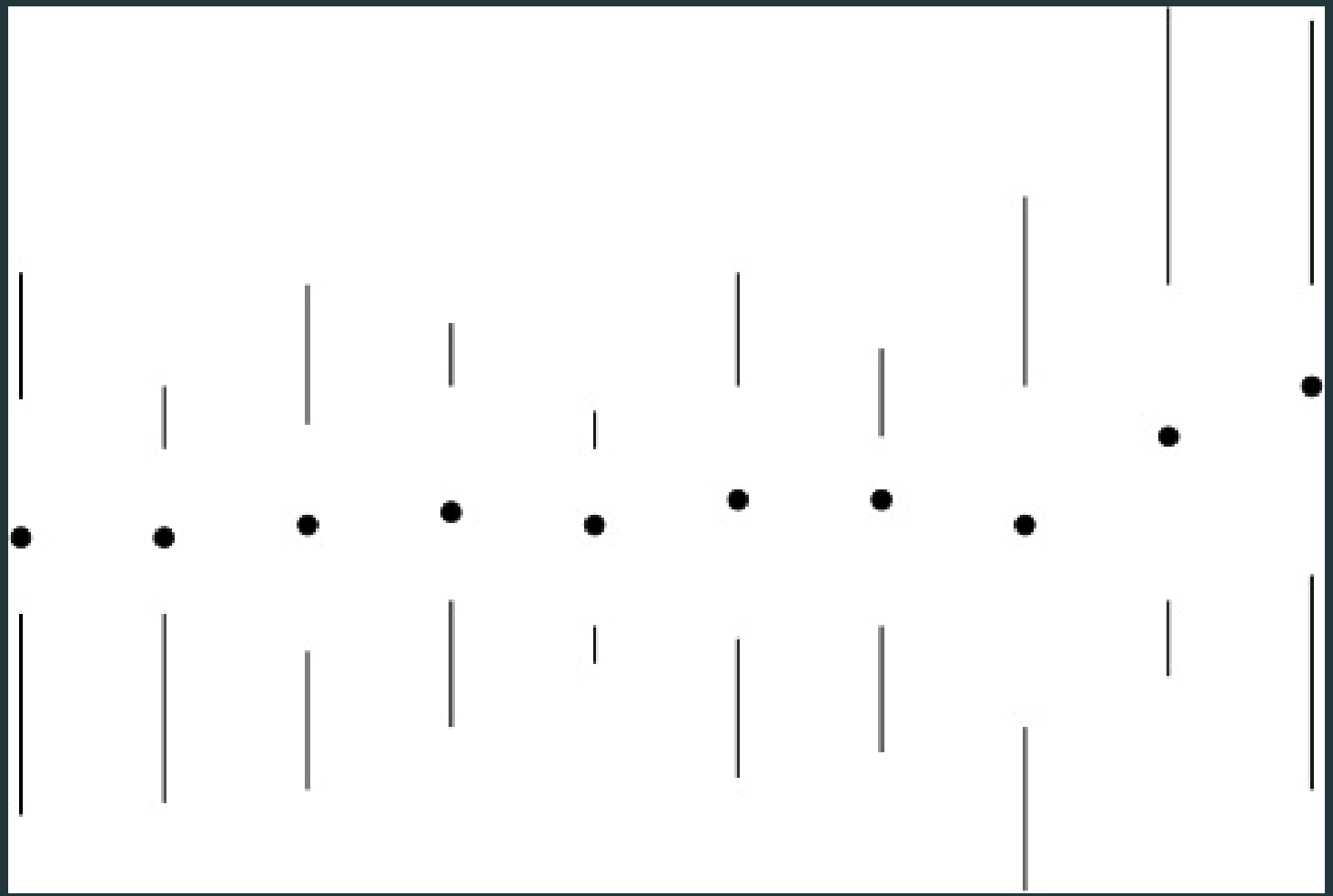
- ✓ The overarching purpose is to show the data;
- ✓ Minimize the data-ink ratio, as much as possible;
- ✓ Erase non-data-ink, as much as possible;
- ✓ Minimize redundant data-ink, as much as possible;
- ✓ Revise and edit;
- ✓ Mobilize every graphical element needed.

Keeping it simple



Should be as simple as it needs to be, but not more

Keeping it simple



ACCENT principles (from Burn, 1993)

Apprehension: ability to correctly perceive relations among variables.

Clarity: Ability to visually distinguish all the elements of a graph.

Consistency: Ability to interpret a graph based on similarity to previous graphs.

ACCENT principles

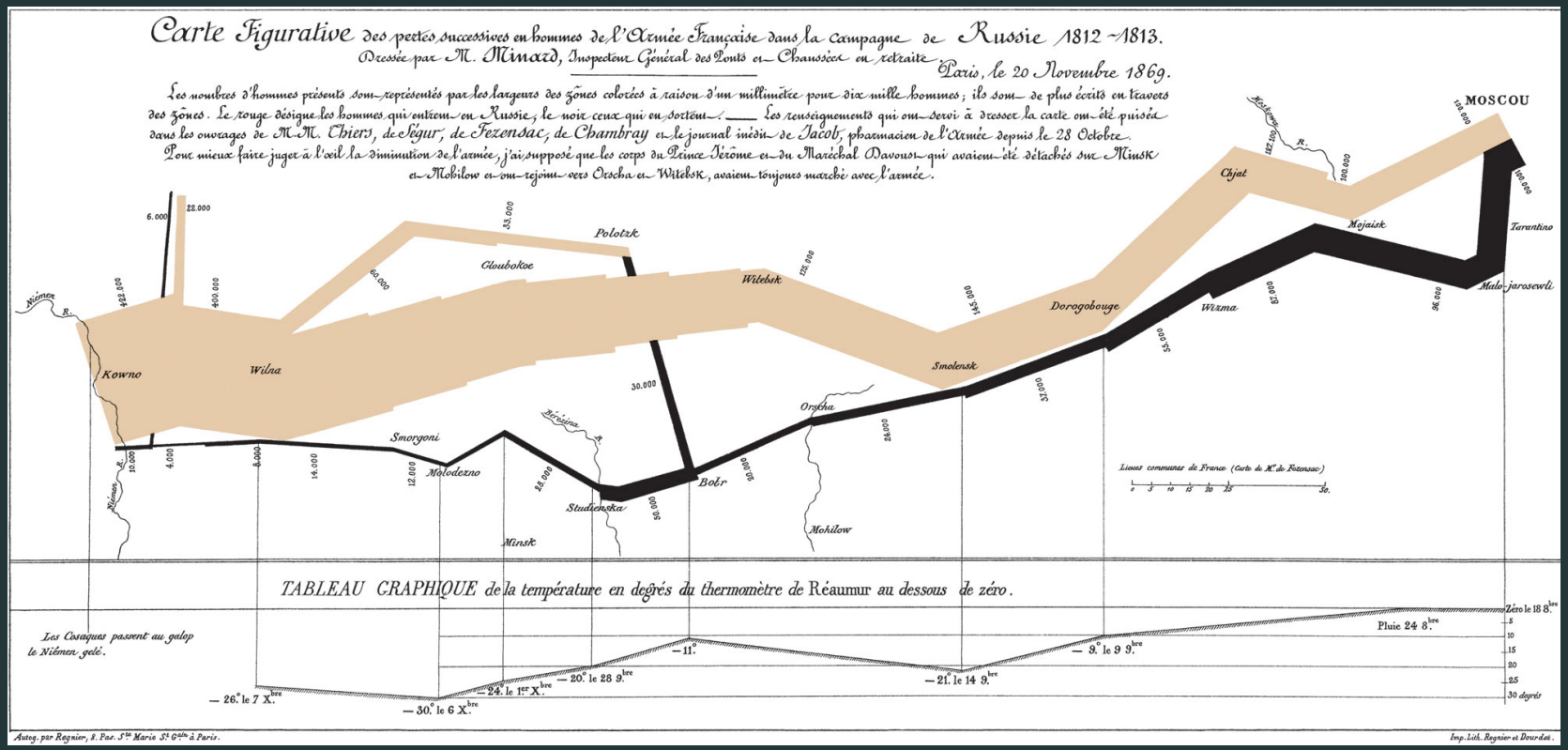
Efficiency: Ability to portray a possibly complex relation in as simple a way as possible.

Necessity: The need for the graph, and the graphical elements.

Truthfulness: Ability to determine the true value represented by any graphical element by its magnitude relative to the implicit or explicit scale.

Good examples

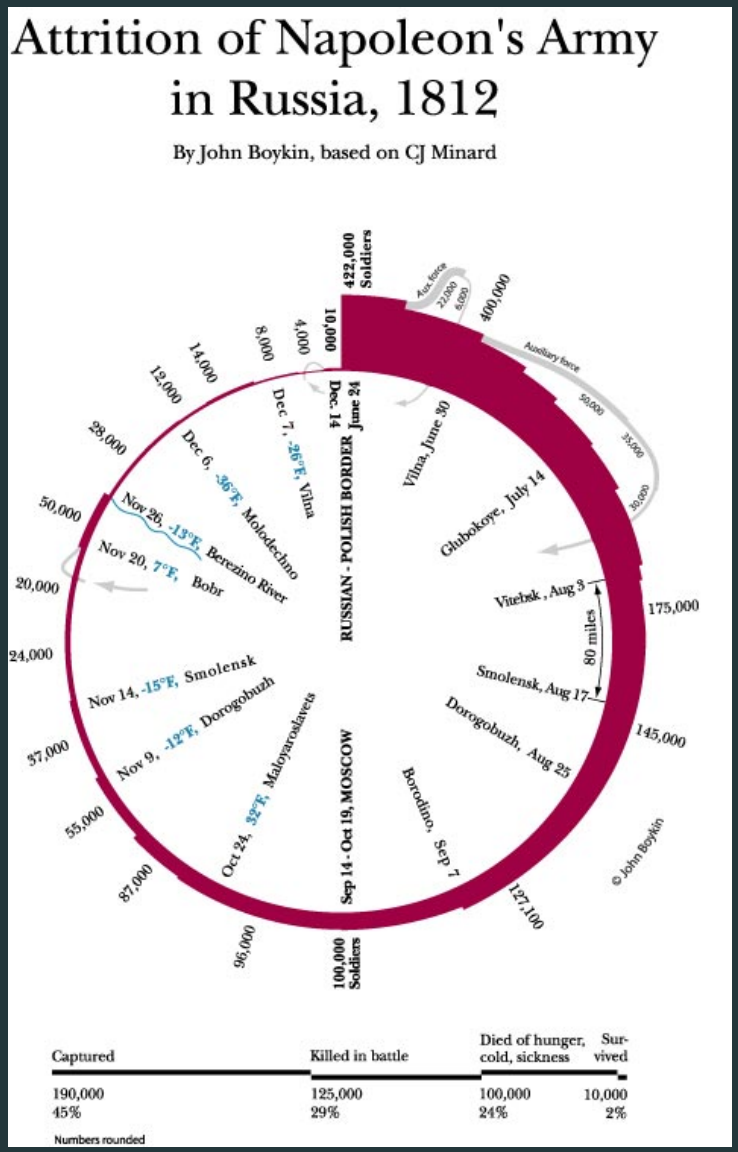
Napoleon's 1812–1813 campaign



Multiple dimensions on a 2-dimensional map

Temperature, deaths, movement, advance/retreat.

Multiple ways of presenting

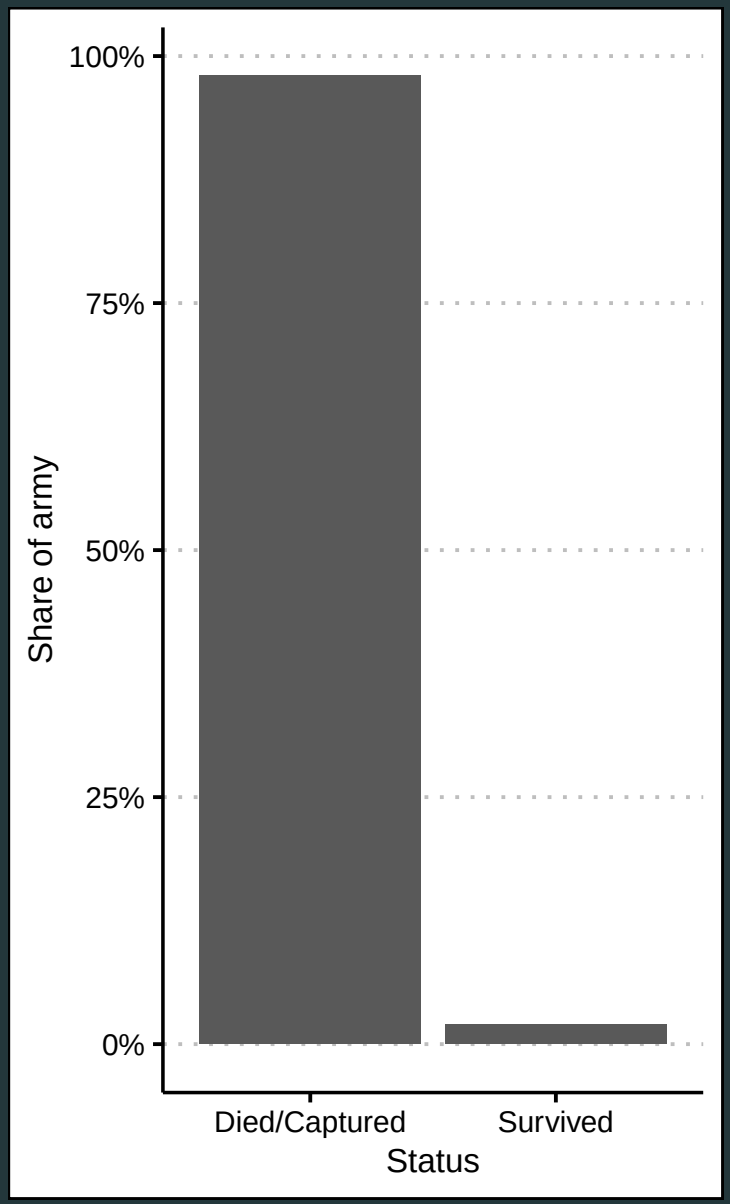


Map matters less than number of deaths, advance/retreat, and temperature.

Emphasis on dismal rate of survival.

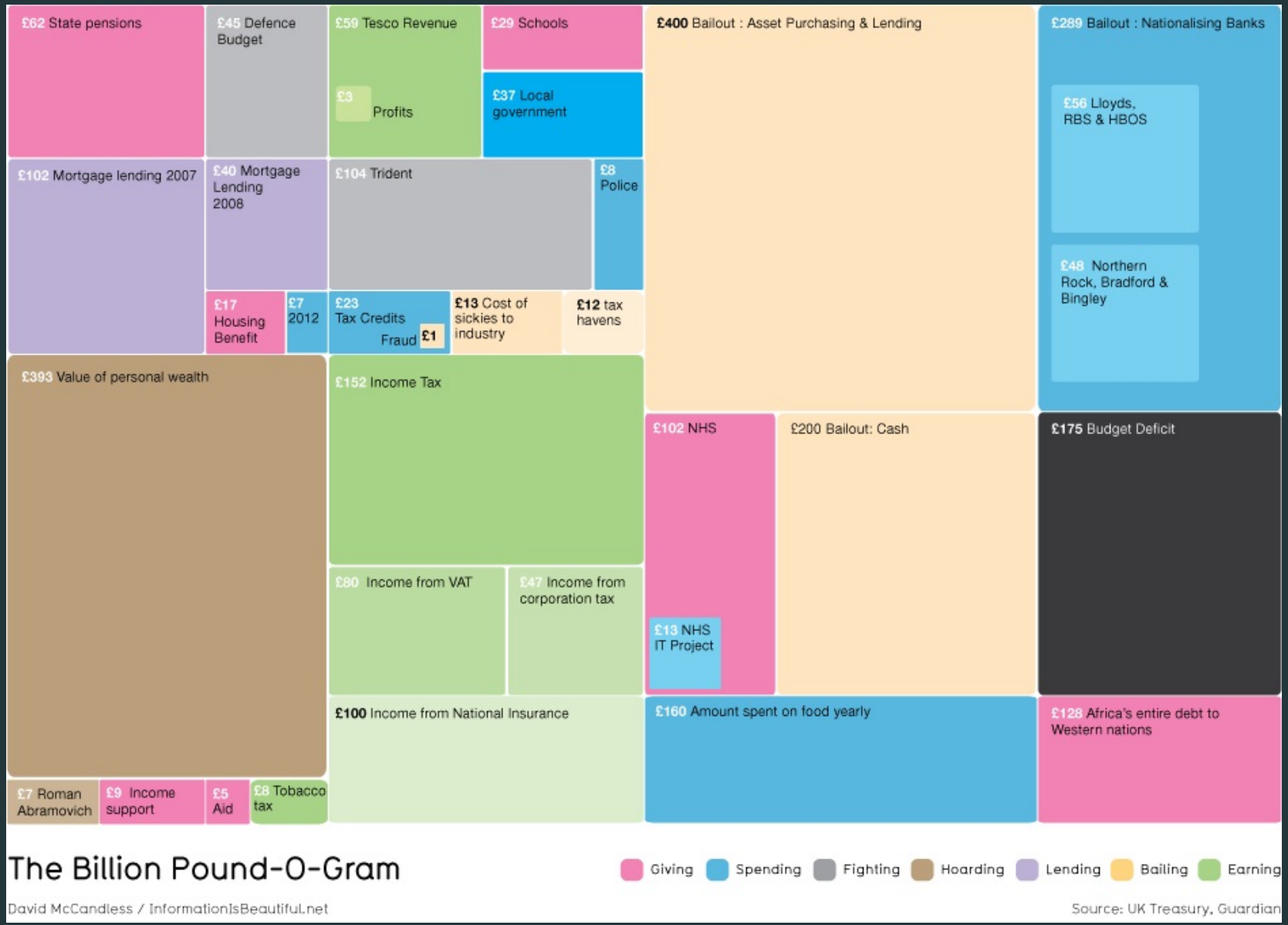
Temperature matters more in winter.

Focus on a single aspect

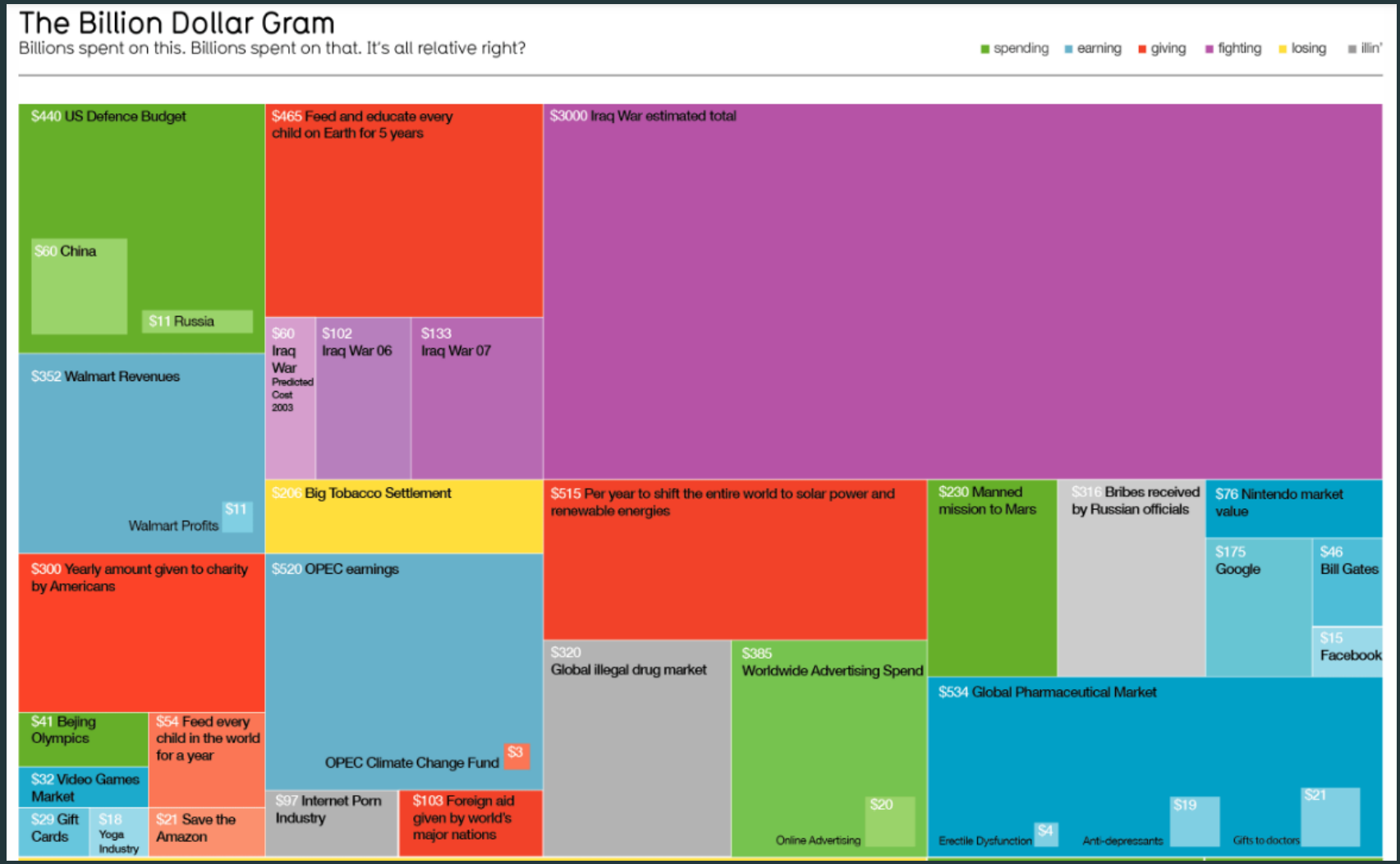


A simple point shouldn't require a complex graph.

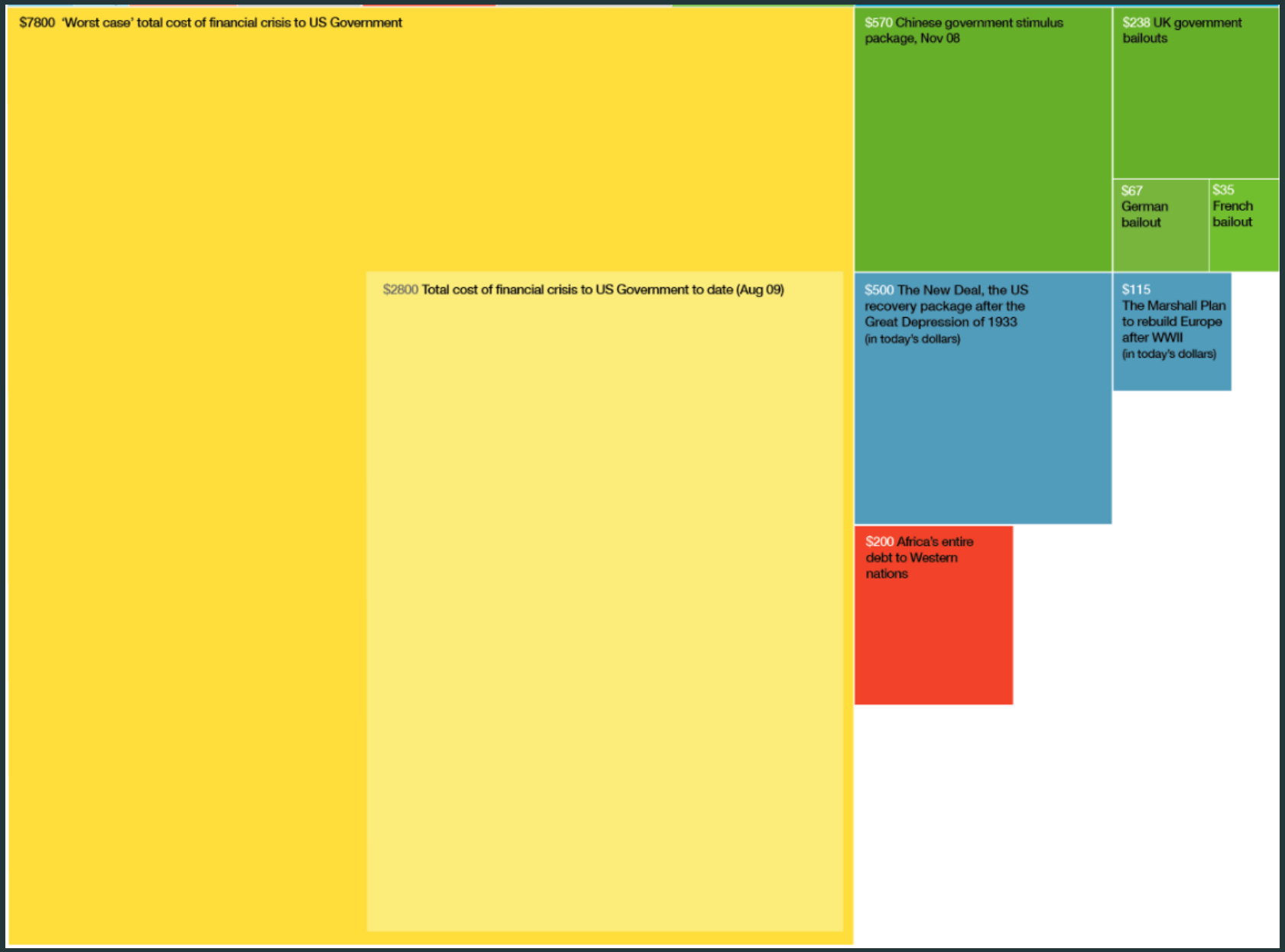
Getting a sense of large numbers



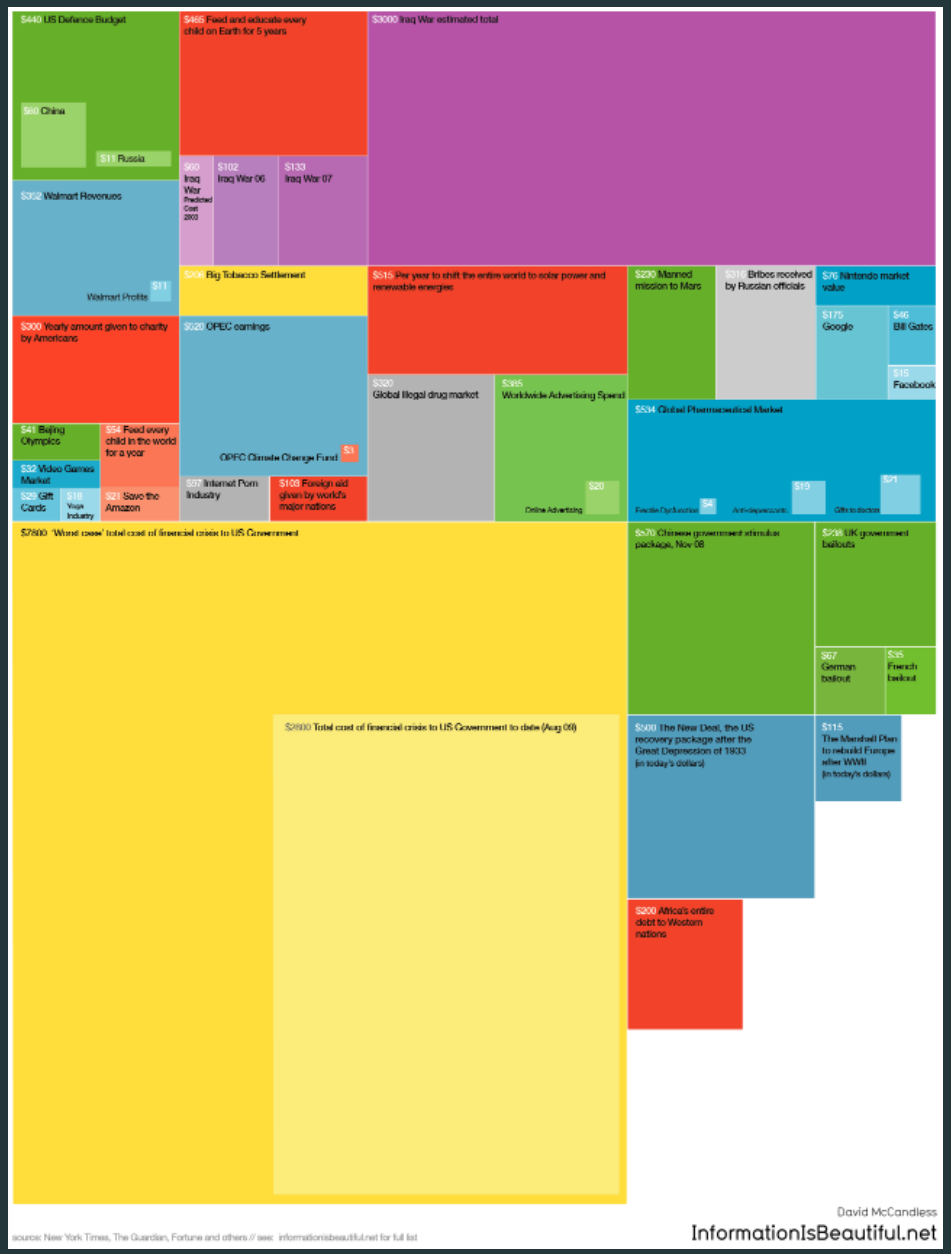
(not really intended for accurate comparisons…



…but rather for relative dimensions)



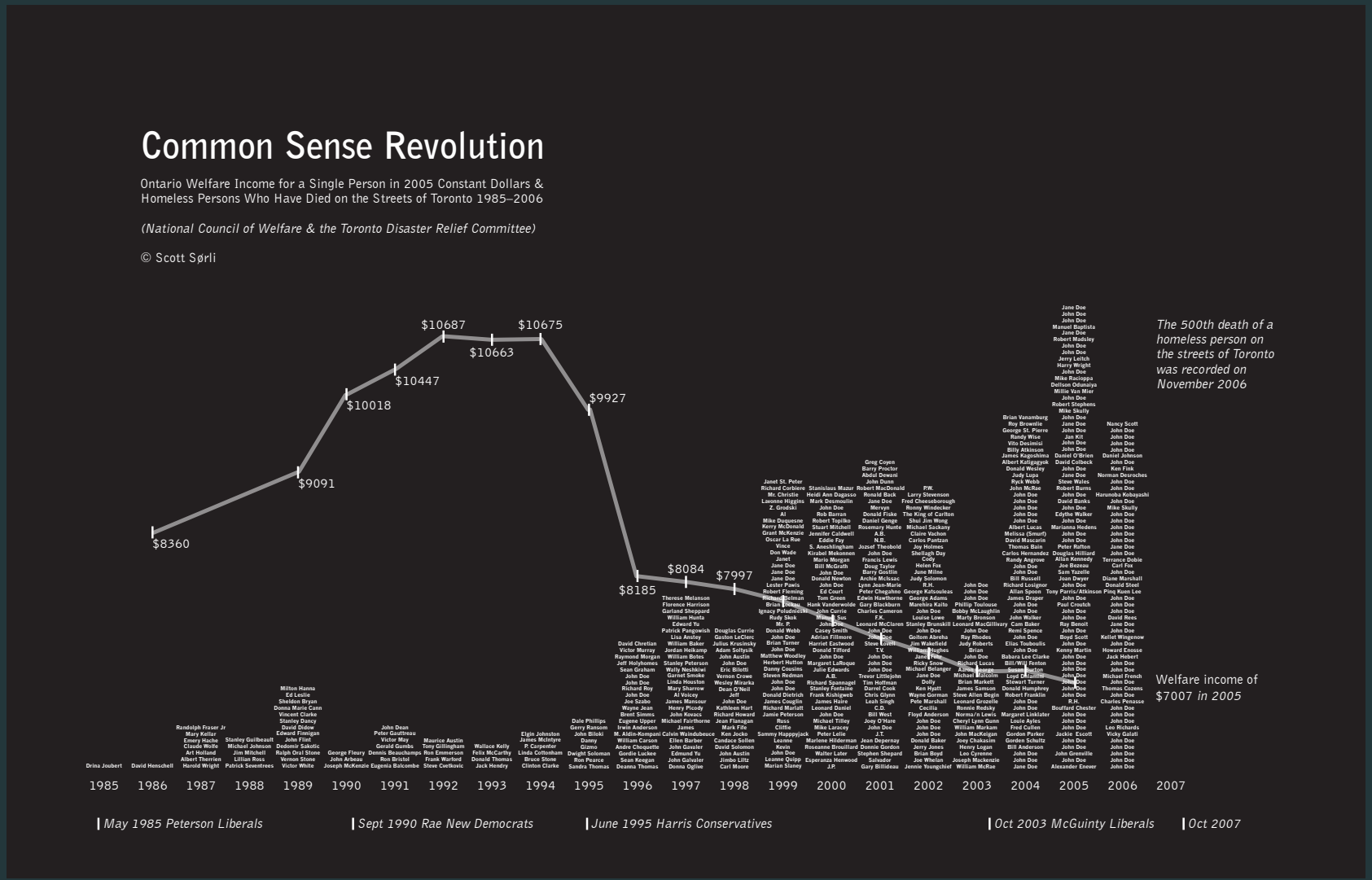
Putting it into perspective



Cost of crisis over 2008–2016 estimated at 4.6 trillion USD.

https://hbr.org/2018/09/the-social-and-political-costs-of-the-financial-crisis-10-years-later

Ontario welfare benefits



Bad examples

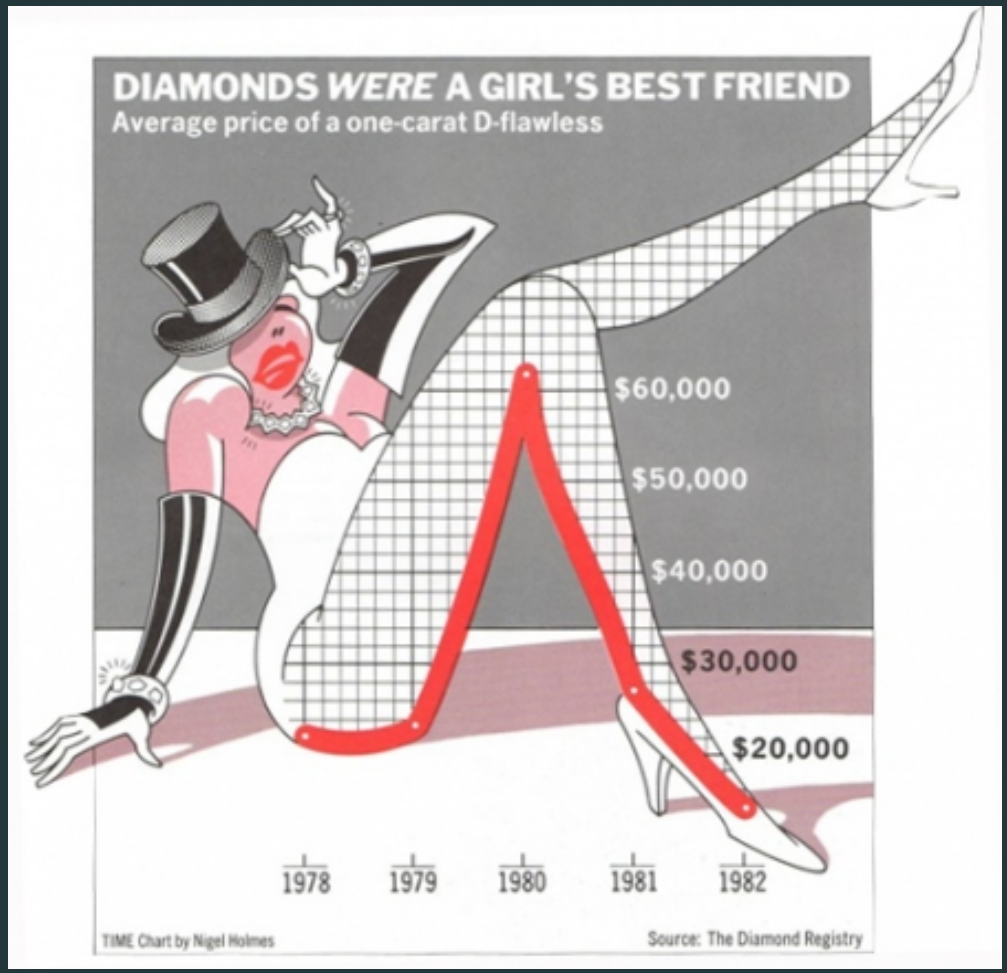
Violations of basic rules (Tufte, 2001)

1. Showing more dimensions than there are in the data
2. Showing surfaces which are disconnected from the underlying quantities
3. Varying the design even though the data isn't varying
4. Failing to adjust for inflation, population change etc. in time-series data
5. Failing to provide adequate context for the data
6. Failing to put proper labels on axes

Chartjunk

Unnecessary features galore (keep in mind, though: they might be easier to recall)

Chartjunk

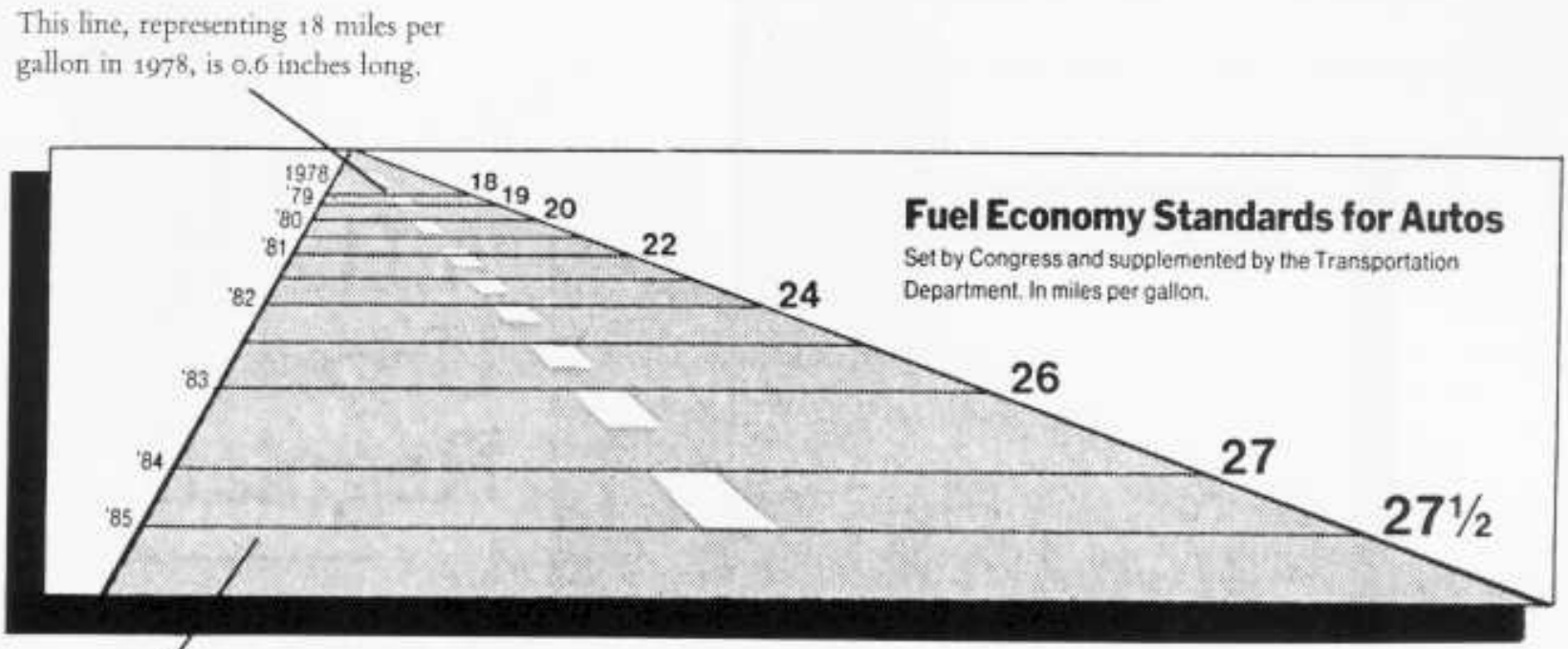


Unnecessary features (and sexism) galore (these are aesthetic violations, following Healy, 2018)

Chartjunk

Unnecessary features, and poor choice of display

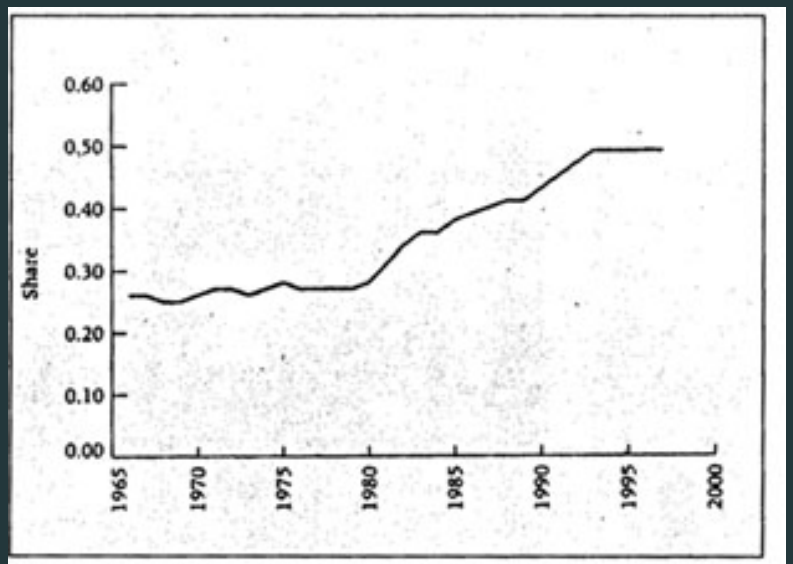
Toying with perception



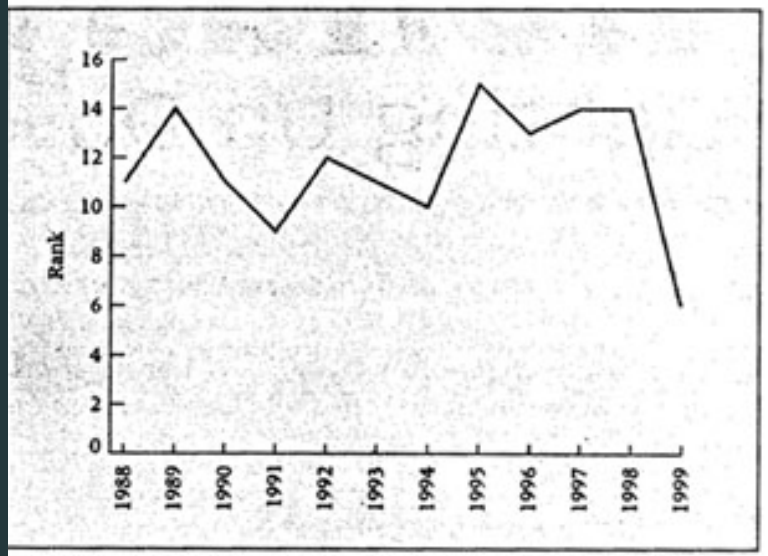
New York Times, August 9, 1978, p. D-2.

Supports the point of radical government overreach

Toying with perception



BY THE NUMBERS: OVER 35 YEARS, CORNELL'S TUITION HAS TAKEN AN INCREASINGLY LARGER SHARE OF ITS MEDIAN STUDENT FAMILY INCOME.



PECKING ORDER: OVER 12 YEARS, CORNELL'S RANKING IN *US NEWS & WORLD REPORT* HAS RISEN AND FALLEN ERRATICALLY.

3 things seem wrong here to me.

Toying with perception

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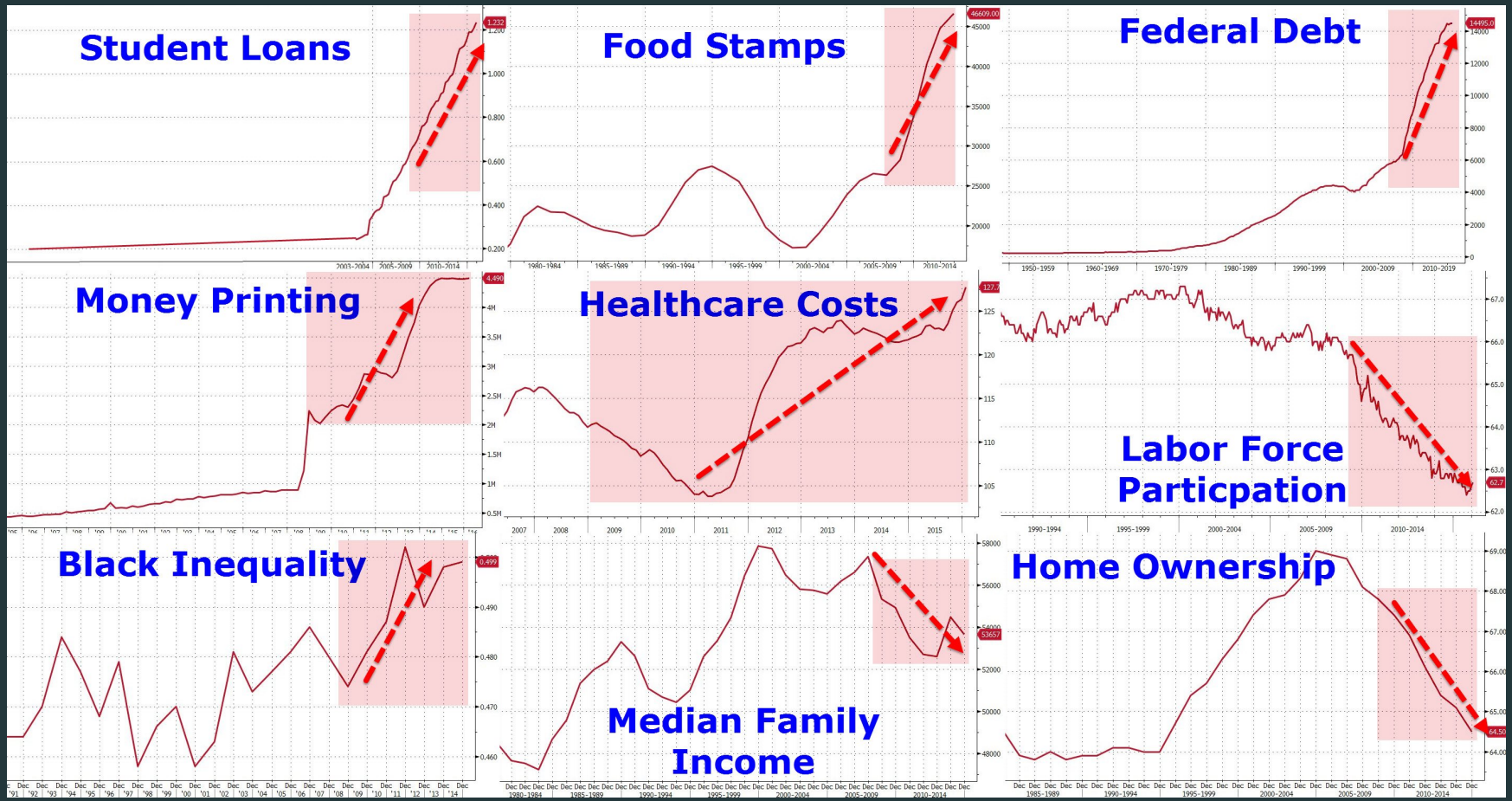
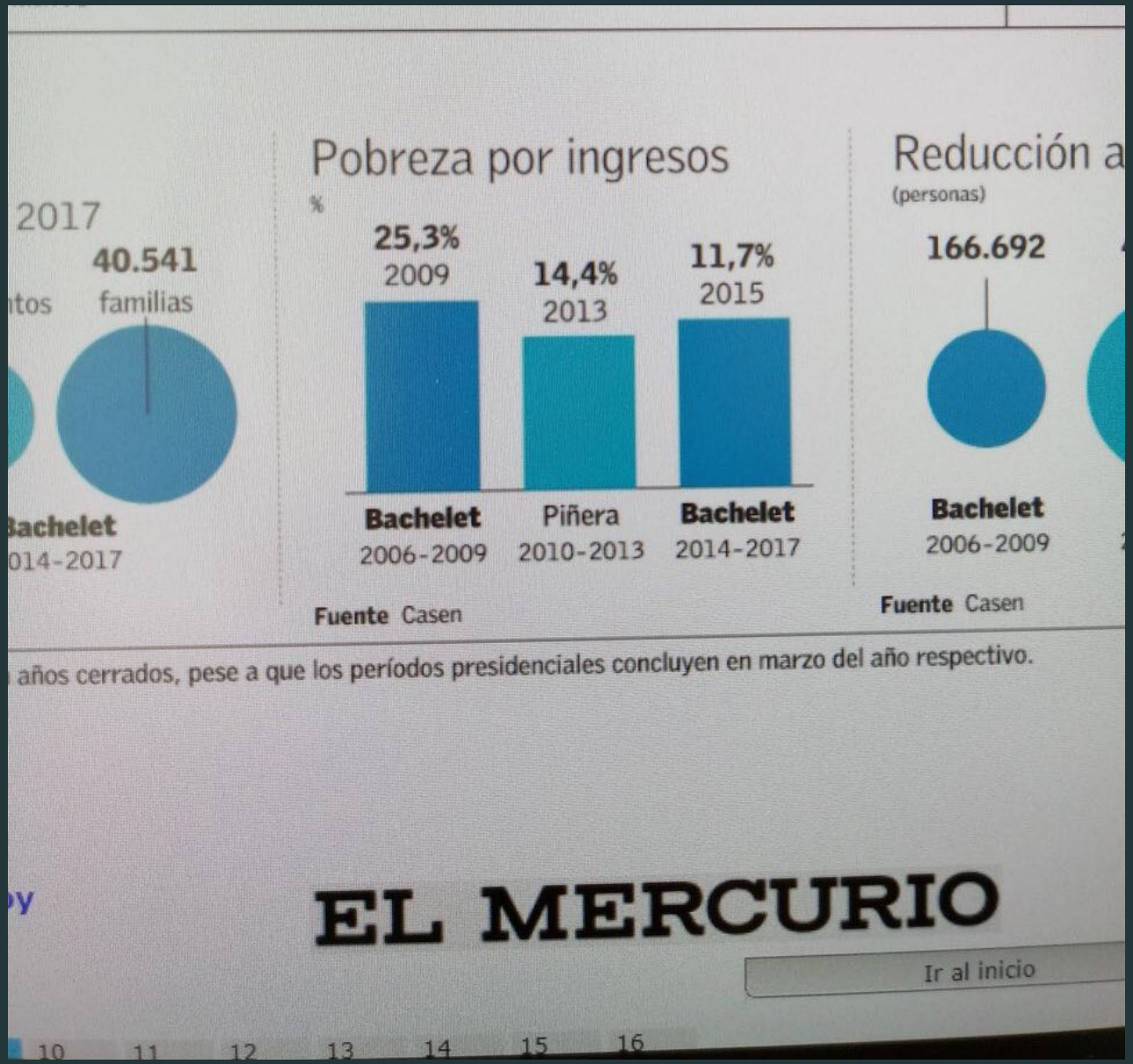
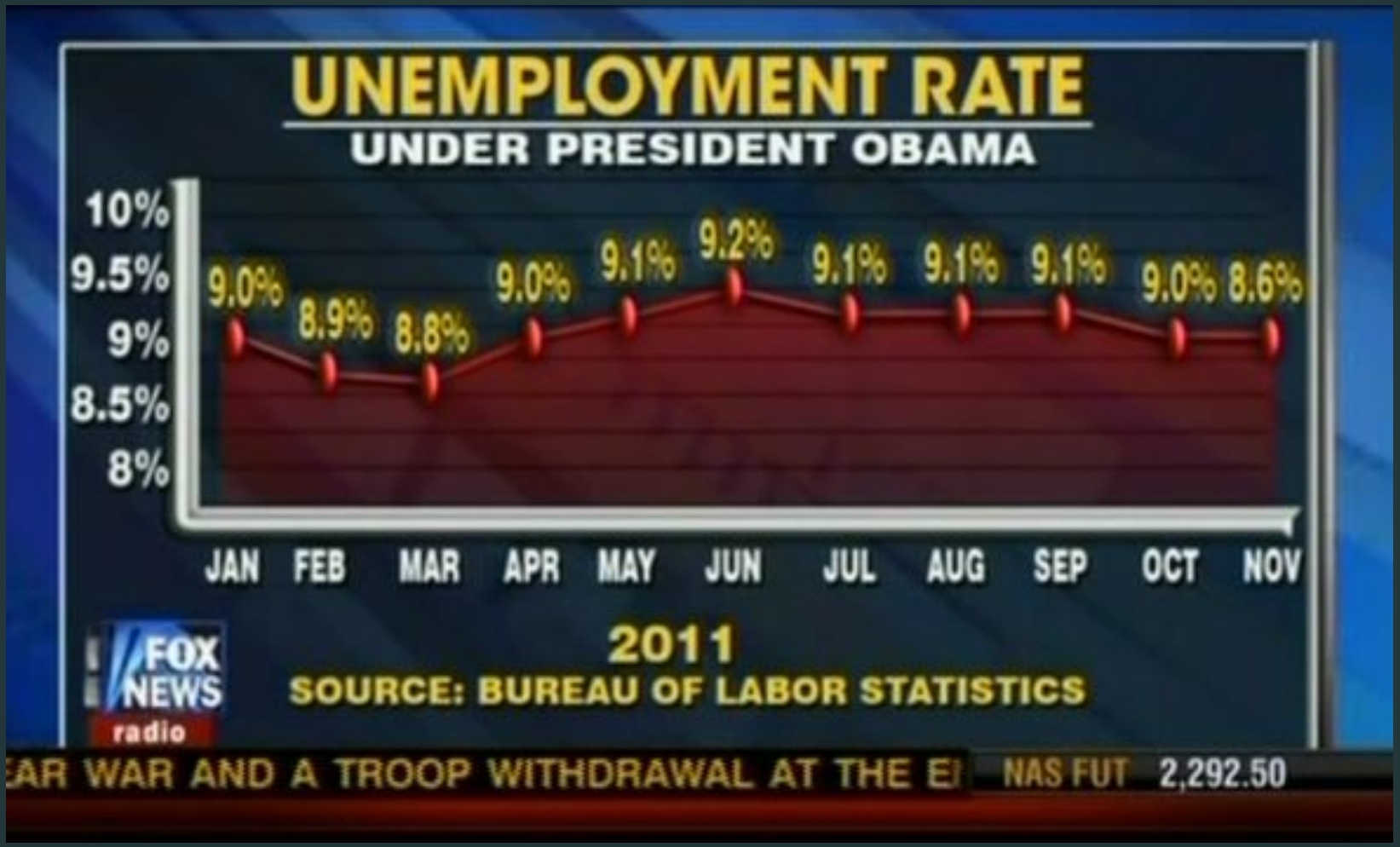


Toying with perception

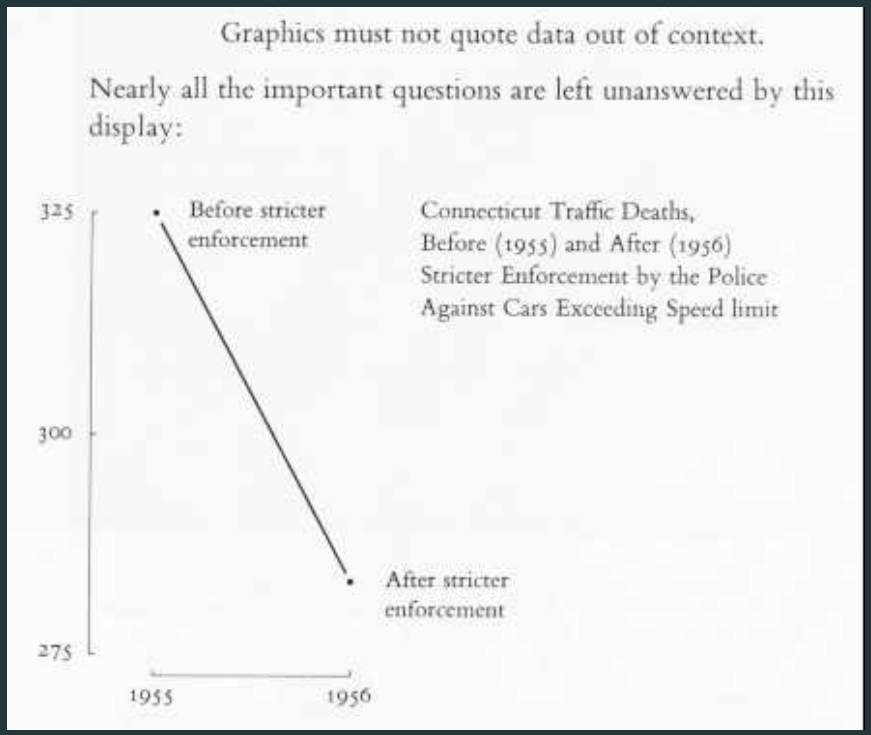


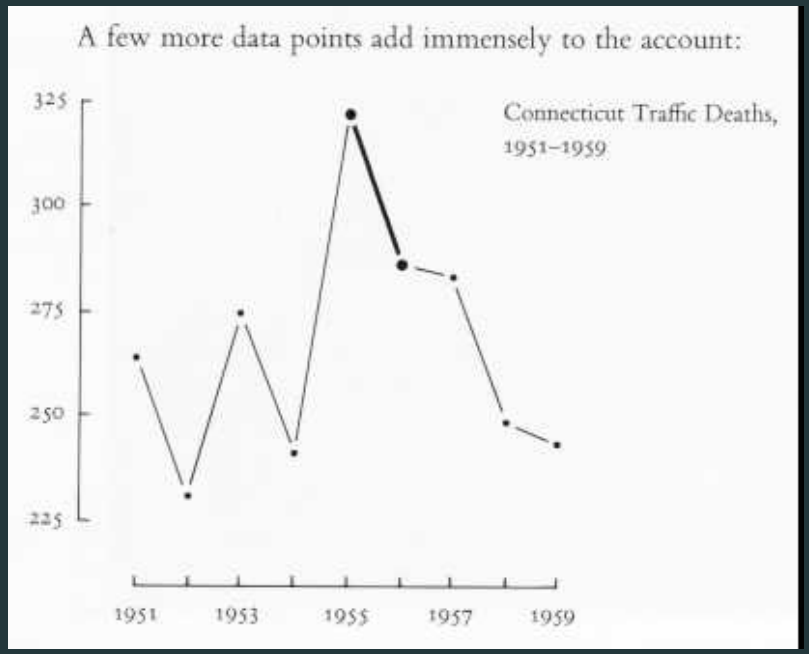
“Perfect storm” of a bad plot



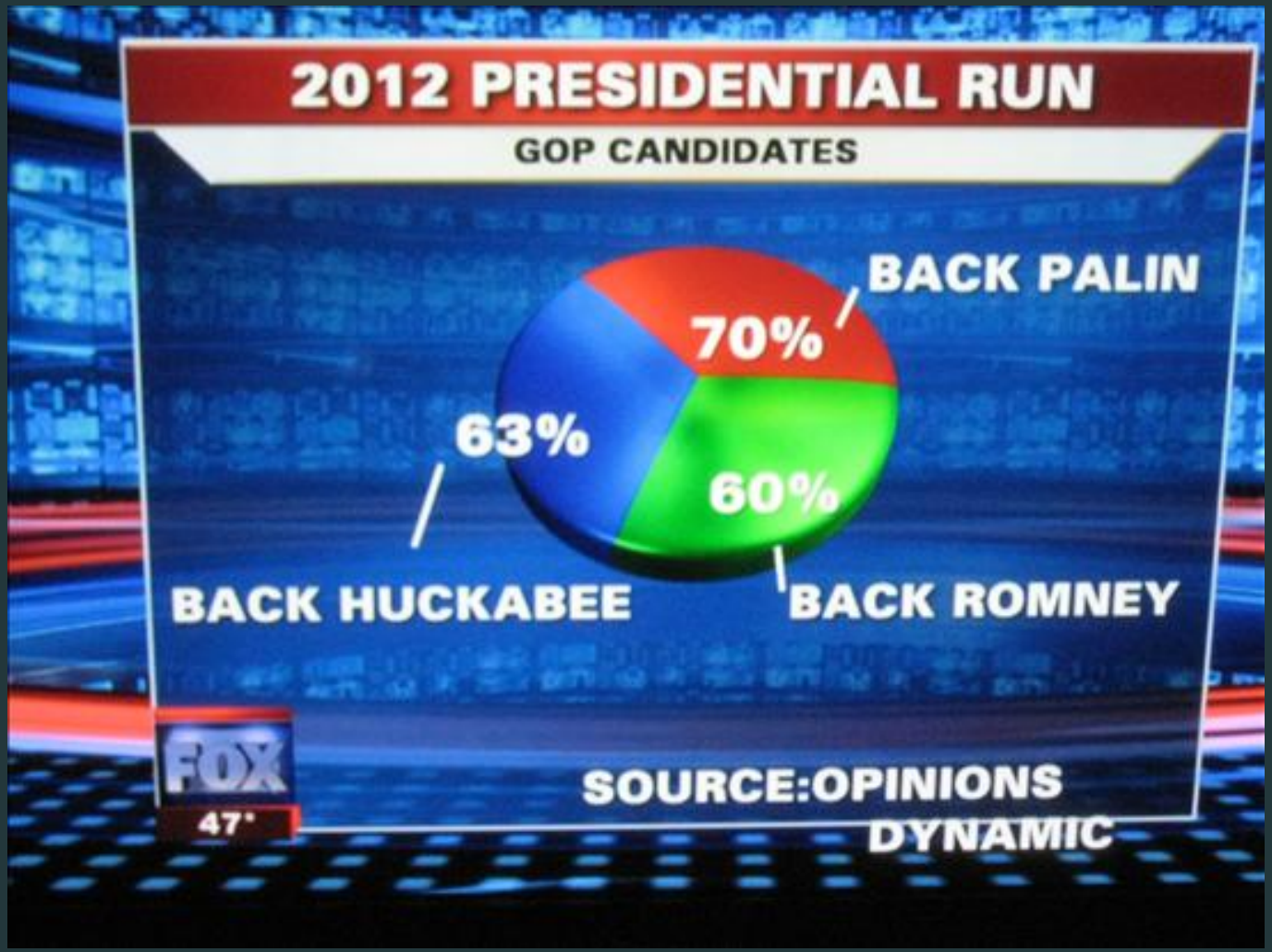
At least 3 things are wrong here

Trimming a trend





Statistics misreported



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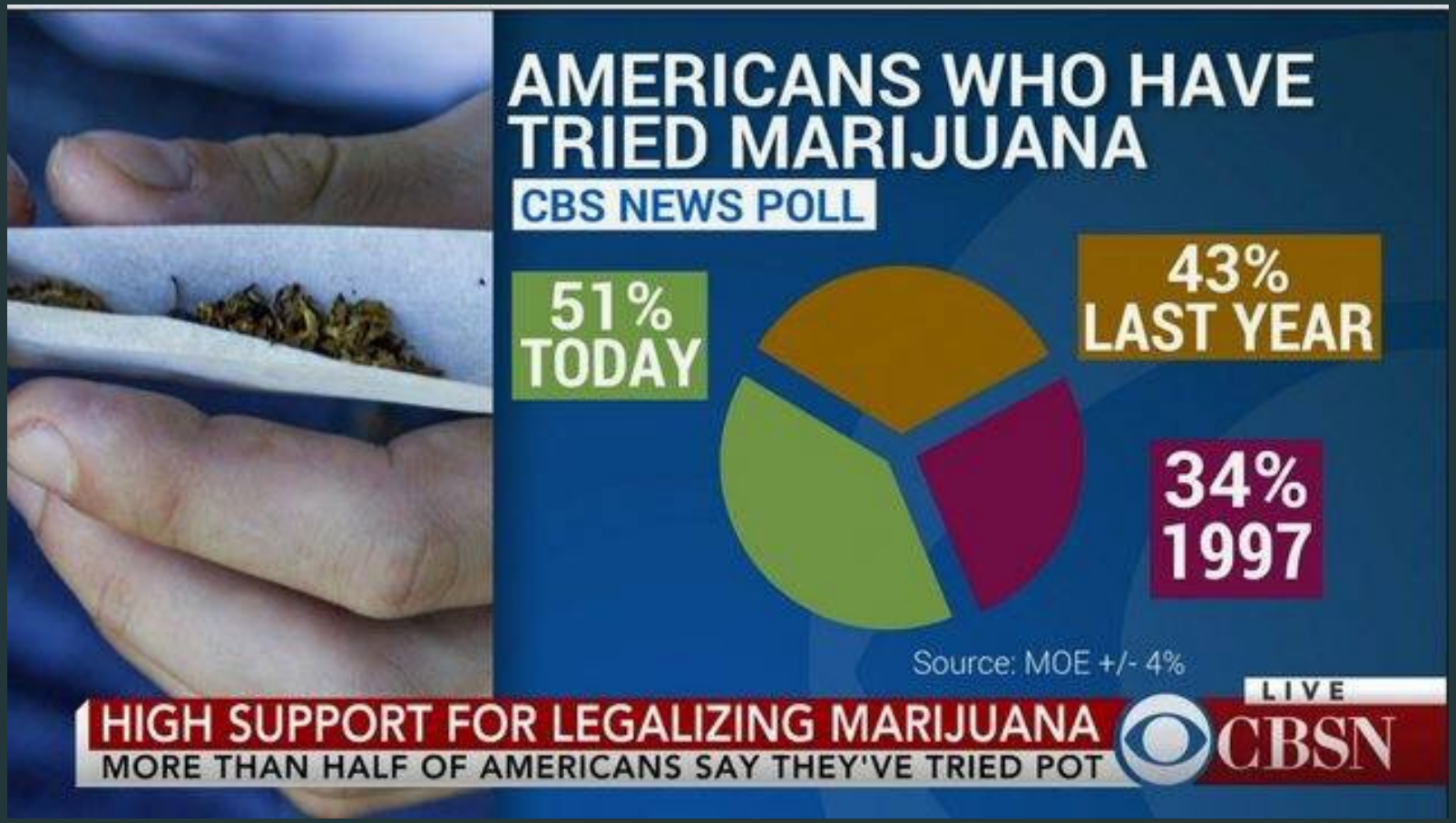
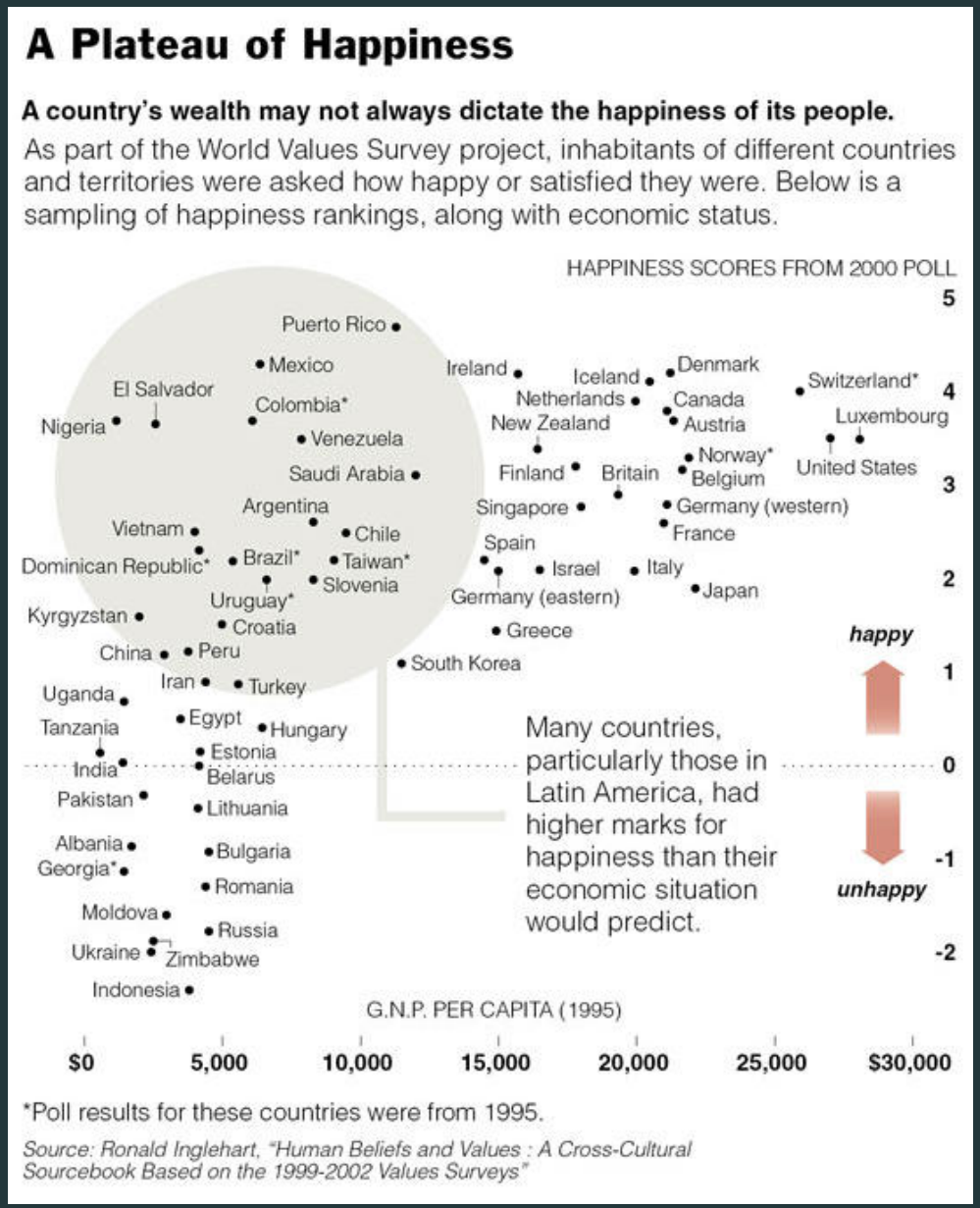
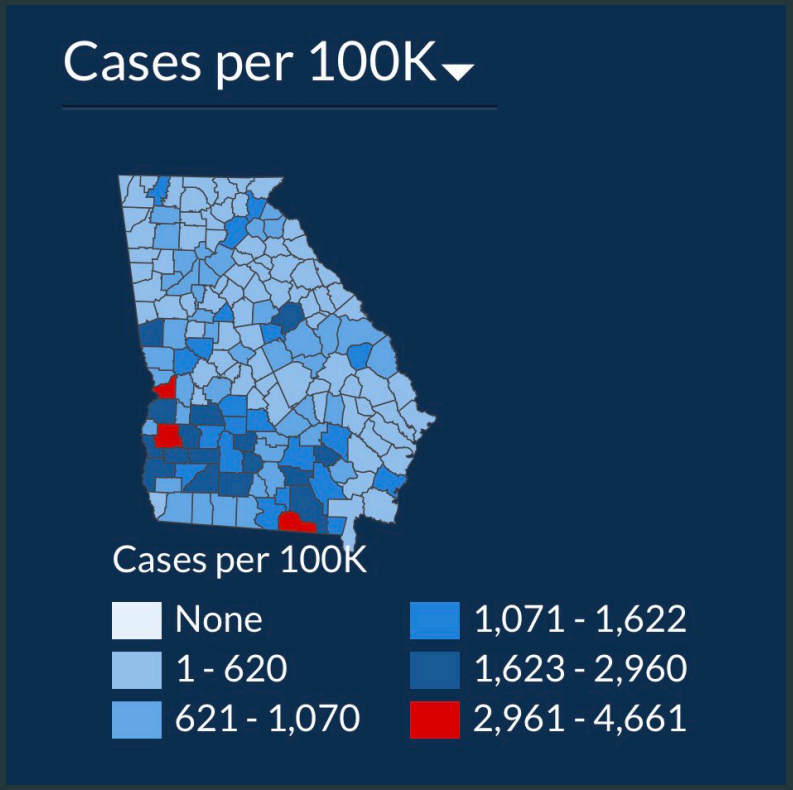


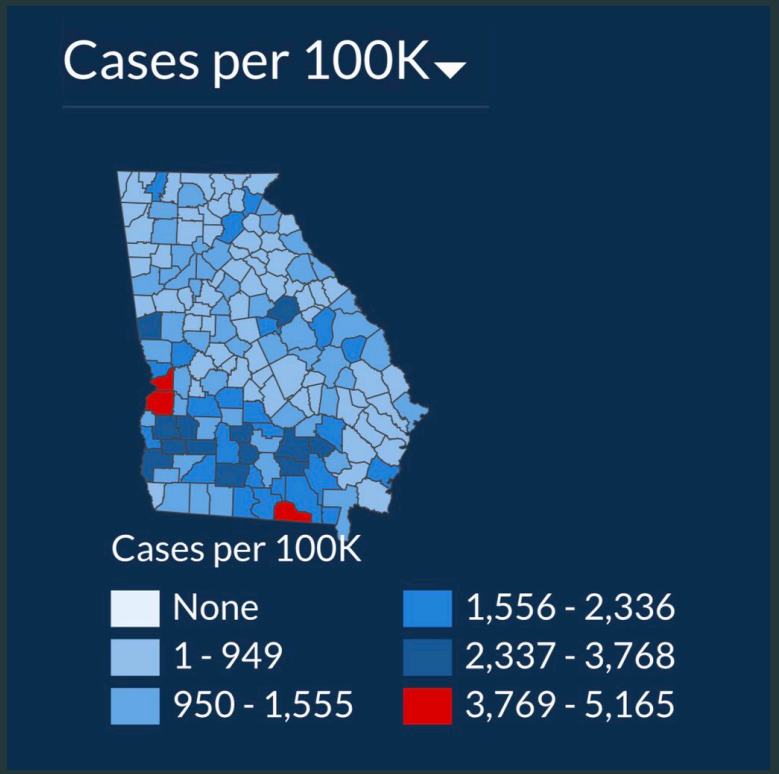
Statistics misreported



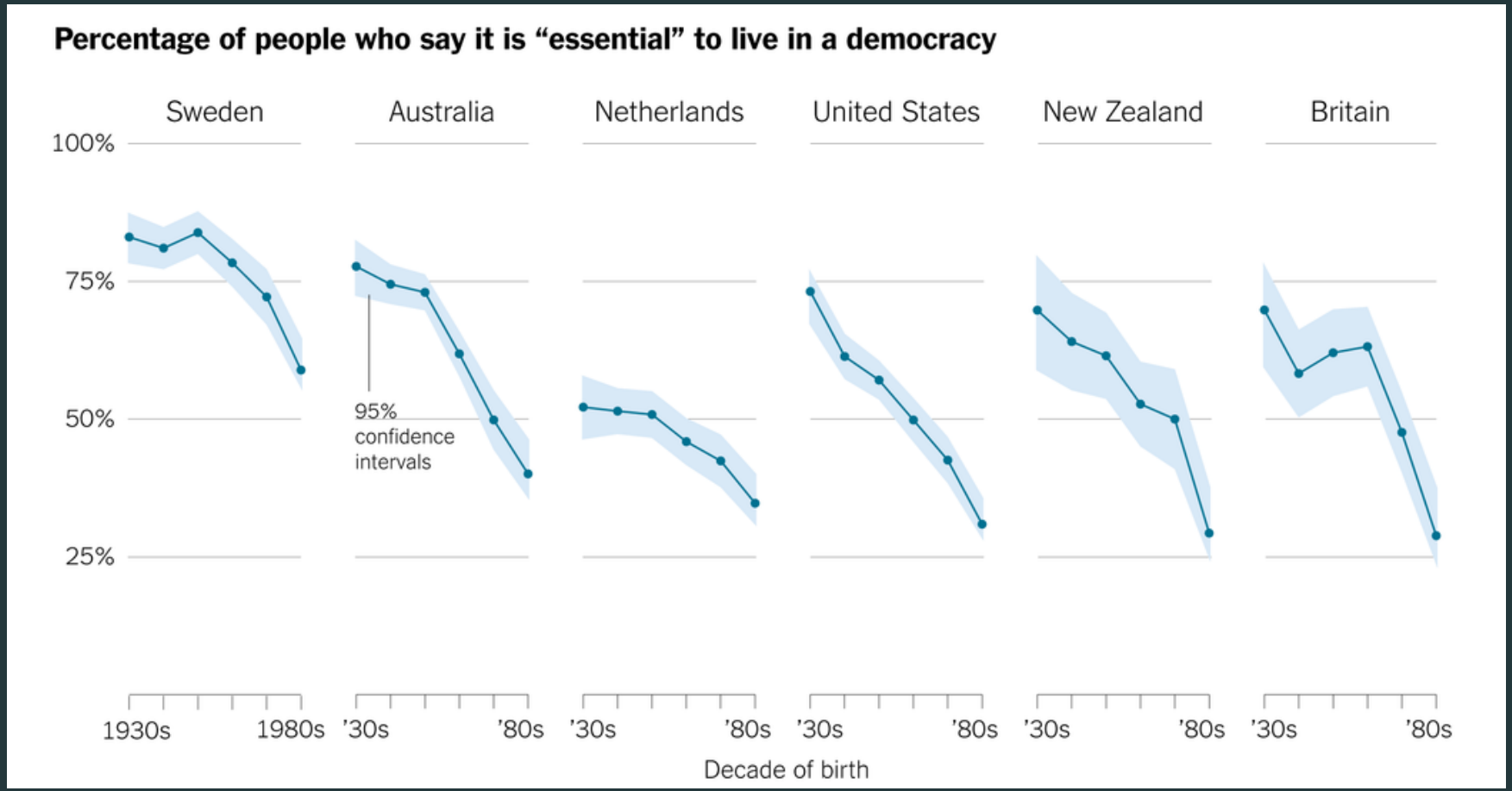
The puzzle is based on the assumption that the relation-ship should be linear.

Statistics misreported



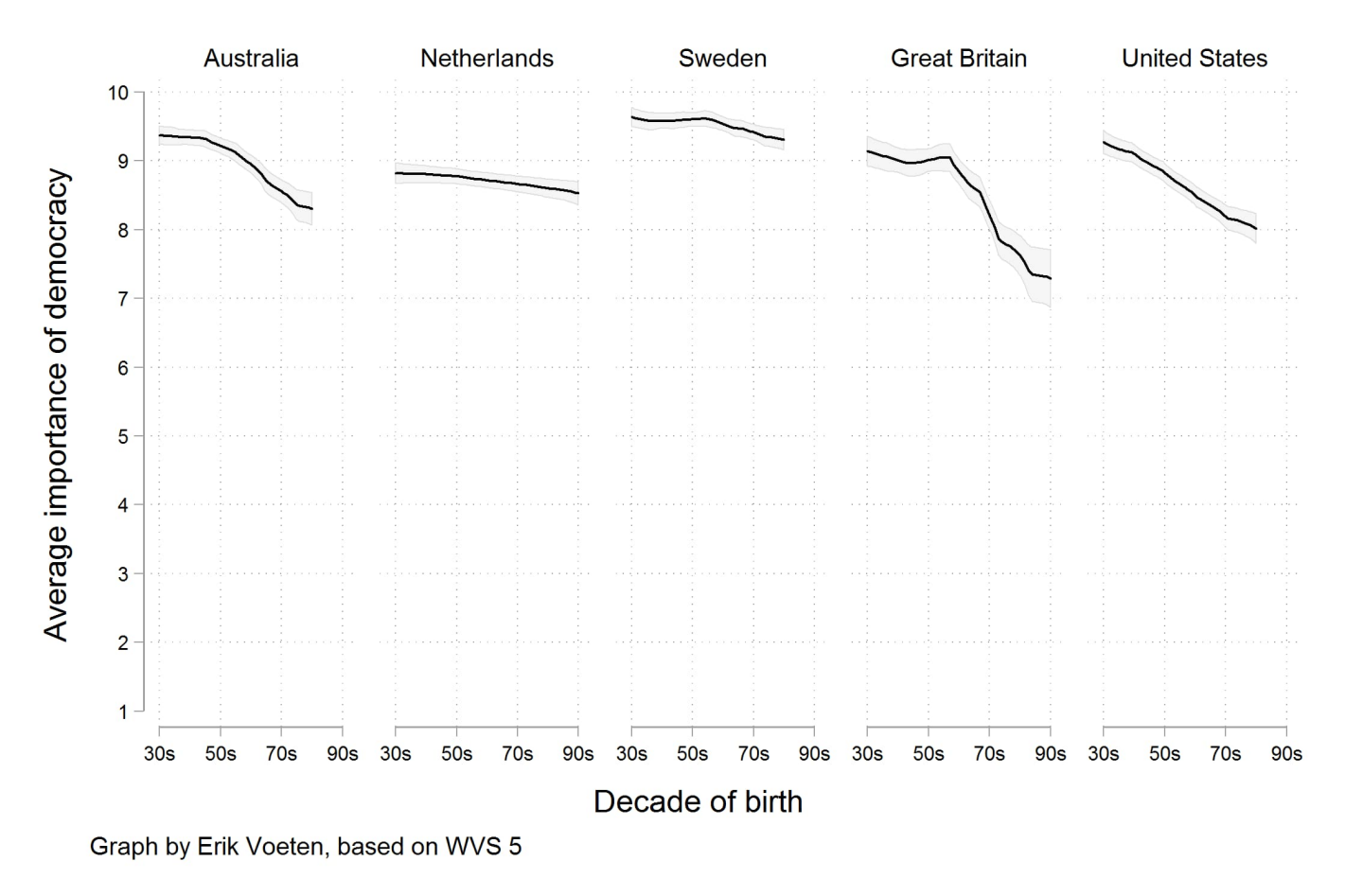


Bad data



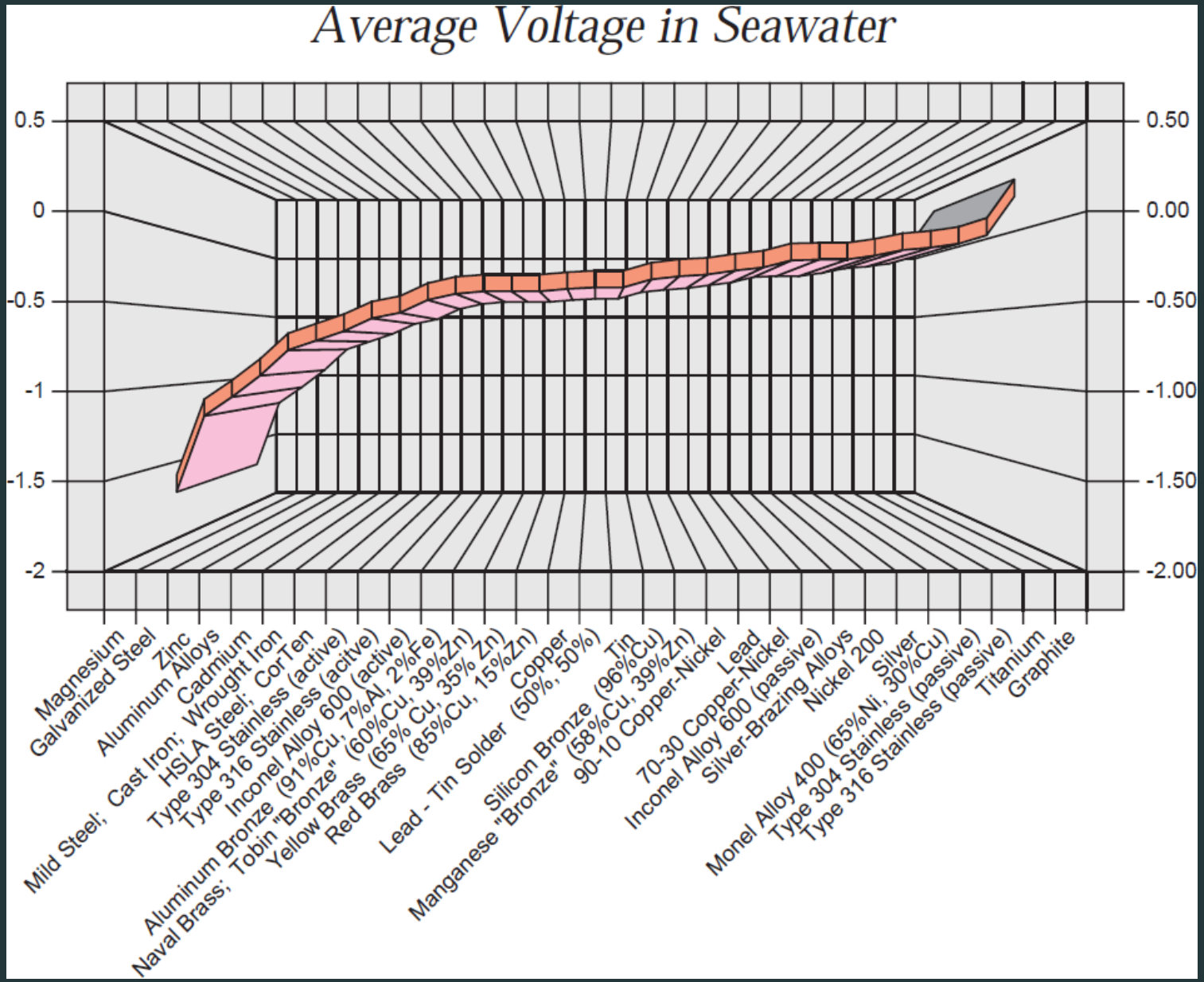
Difference between those who respond “10” and the rest.

Better data



Only 2 countries out of 5 keep their pattern; less concerning than before.

Poor choice of graphs



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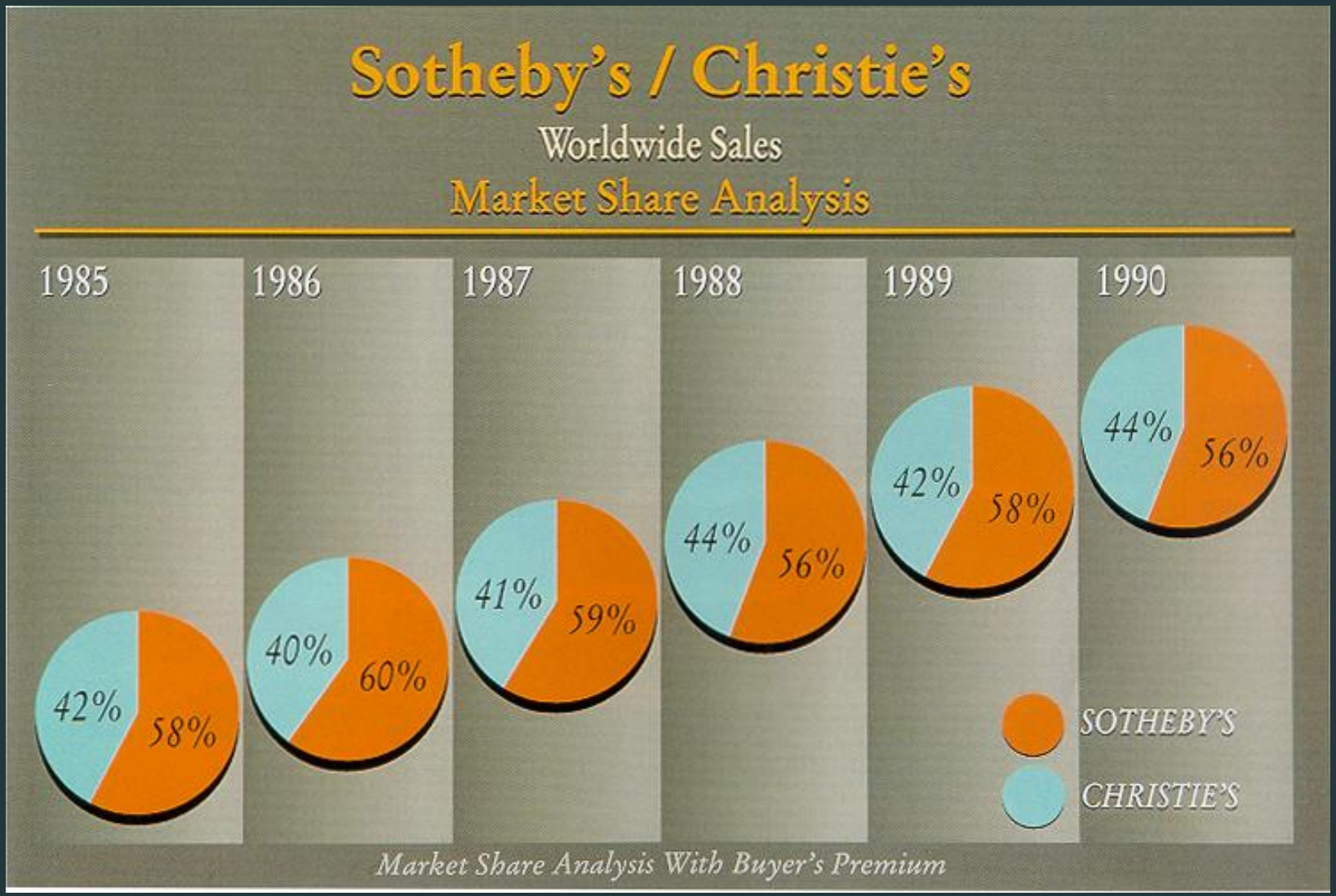

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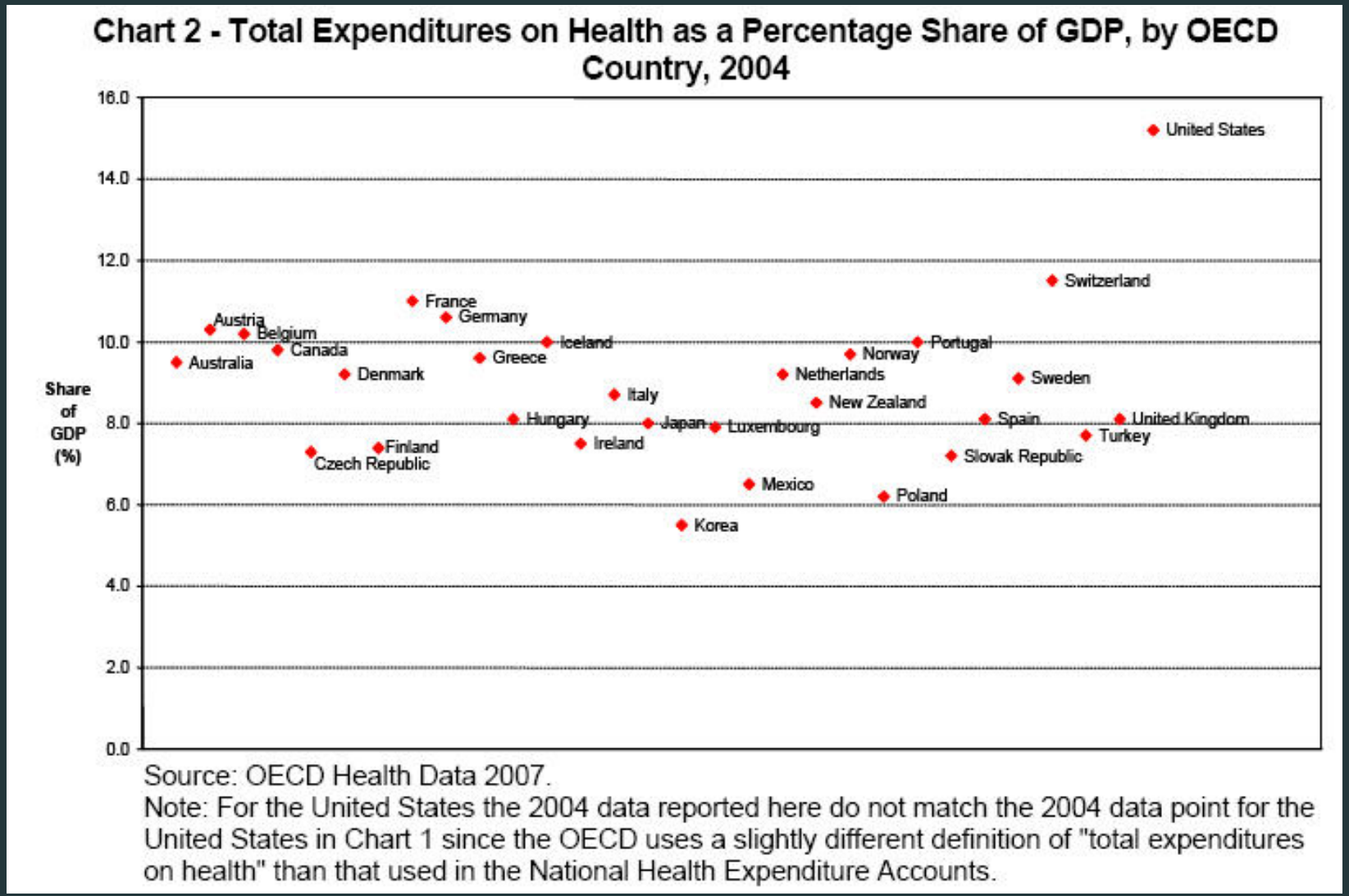
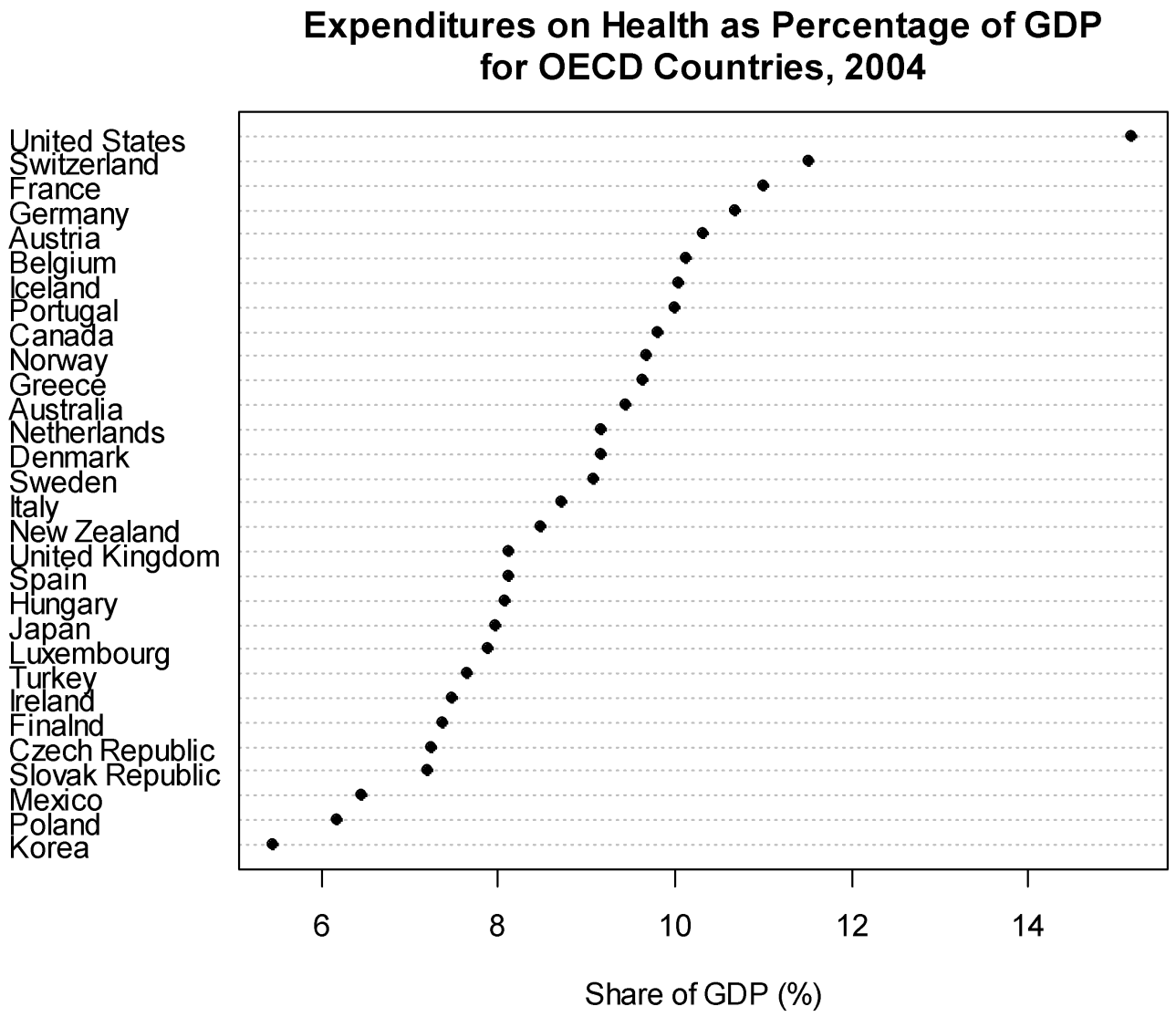


Source: OECD Health Data 2007.
Note: For the United States the 2004 data reported here do not match the 2004 data point for the United States in Chart 1 since the OECD uses a slightly different definition of "total expenditures on health" than that used in the National Health Expenditure Accounts.

Improved display



Conclusion

Conclusion

Good data visualization involves thinking about the argument to be made, making choices among alternatives, and taking into consideration issues such as audience, parsimony, integrity.

It will rarely result from canned routines and default options found in statistical packages.

Conclusion

With *ggplot2*, we wouldn't be able to fall prey to some bad practices, like creating chartjunk.

However, there is still potential for other design issues: redundant information, large ink/data ratio, etc.

Thank you for the kind attention!

References

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