Data Visualization

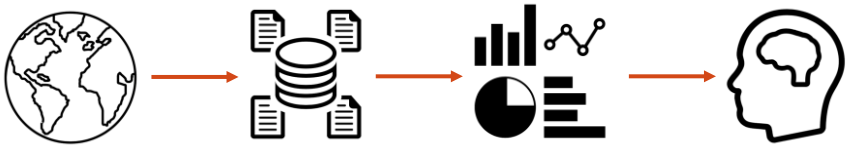
EXAMPLES OF (UN)TRUSTWORTHY VISUALIZATIONS

Good visualization design is

1. Trustworthy
2. Accessible
3. Elegant

A. Kirk. *Data Visualization*, SAGE Publications, 2016.

How charts lie?



Dubious data

Misrepresenting data

Cherry-picking data

Oversimplifying, Ignoring uncertainty

Confirmation bias

3

Dubious data

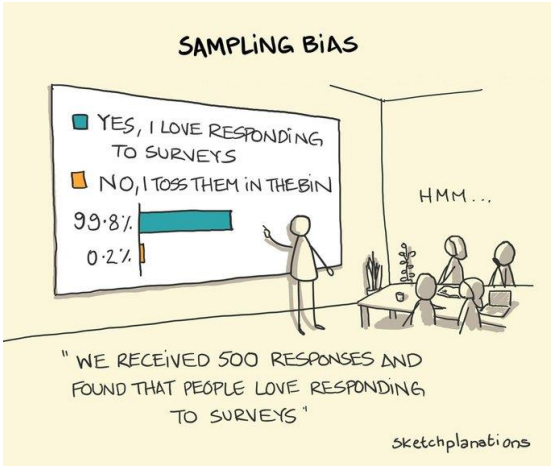
Unrepresentative data
- Missing data
- Polls on unrepresentative populations
- Measurements on unrepresentative samples

Biased data
- Question framing in polls
- Choice of measures

Wrong comparisons
- Non-comparable data
- Absolute instead of cumulative data (and vice versa)
- Absolute instead of relative data

4

Unrepresentative samples



https://sketchplanations.com/sampling-bias

5

Unrepresentative samples

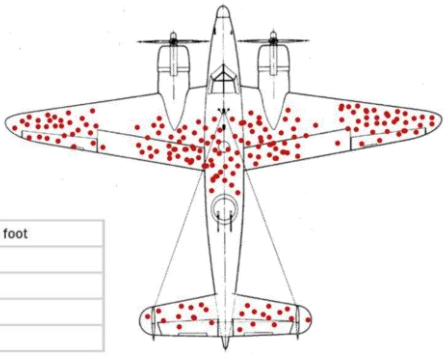
https://www.reddit.com/r/dataisbeautiful/comments/9pkka4/all_recorded_meteorite_impacts_in_the_us_from

6

Unrepresentative samples

Abraham Wald and the Missing Bullet Holes

Armour planes so that they don't get shot by enemy fighters. Armour is heavy, so use it only where is really needed.



Section of plane	Bullet holes per square foot
Engine	1.11
Fuselage	1.73
Fuel system	1.55
Rest of the plane	1.8

https://medium.com/@penguinpress/an-excerpt-from-how-not-to-be-wrong-by-jordan-ellenberg-664e708cfc3d

7

Question framing in polls

Brexit referendum

- First proposal

"Should the United Kingdom remain a member of the European Union?"

yes/no

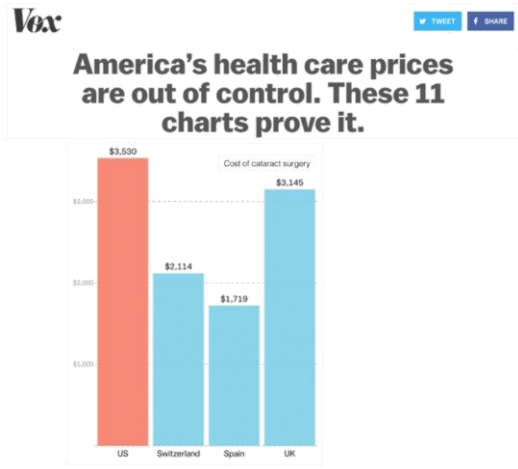
- Final question

"Should the United Kingdom remain a member of the European Union or leave the European Union?"

remain/leave

8

Non-comparable data used in comparisons



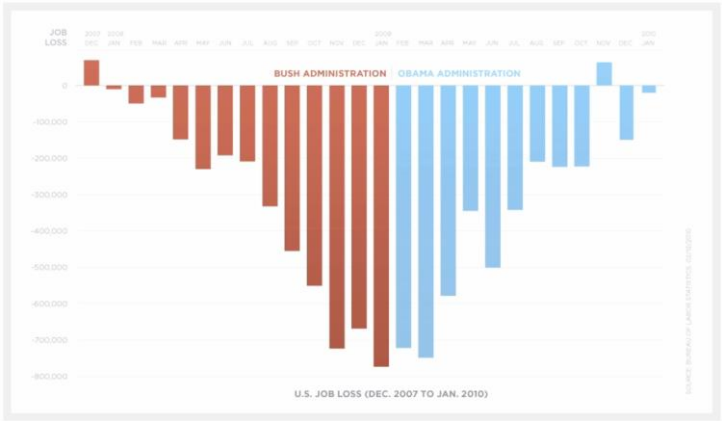
Two issues

- Prices not adjusted for purchasing power
- Different sources of data

The data source specifically warns against using this data for comparison

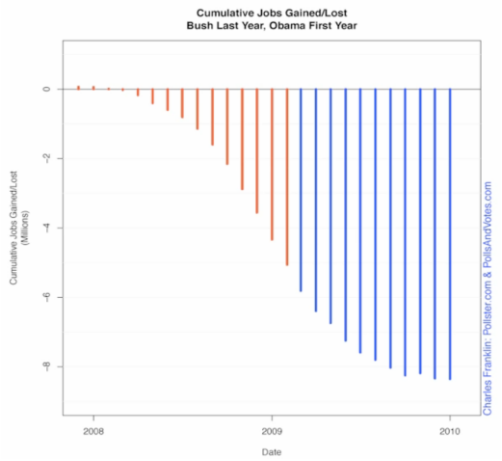
https://www.youtube.com/watch?v=Cd046xZhO_8&t=504s 9

Absolute instead of cumulative data



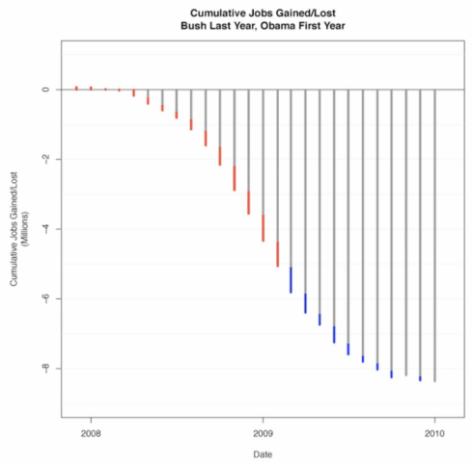
https://itunes.apple.com/us/course/data-literacy-and-data-visualization/id693097601 10

Cumulative data



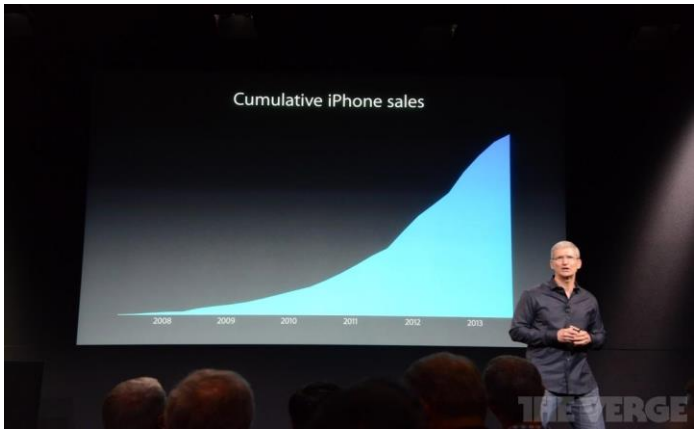
https://itunes.apple.com/us/course/data-literacy-and-data-visualization/id693097601 11

Absolute and cumulative data



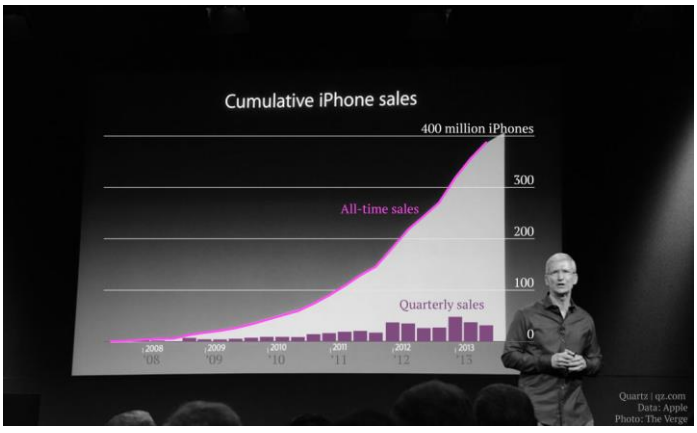
https://itunes.apple.com/us/course/data-literacy-and-data-visualization/id693097601 12

Cumulative instead of absolute data



https://qz.com/122921/the-chart-tim-cook-doesnt-want-you-to-see/ 13

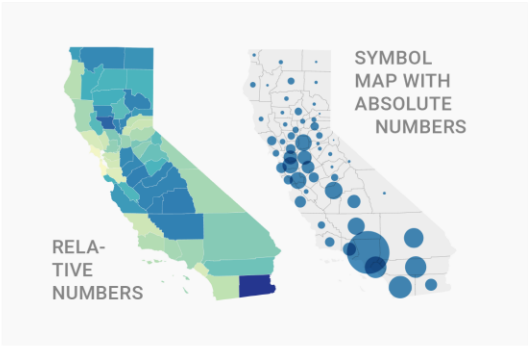
Cumulative and absolute data



https://qz.com/122921/the-chart-tim-cook-doesnt-want-you-to-see/ 14

Absolute instead of relative data

NOT IDEAL



BETTER

https://academy.datawrapper.de/article/134-what-to-consider-when-creating-choropleth-maps

15

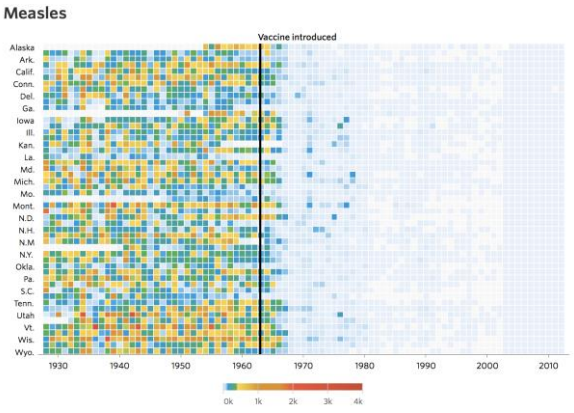
Dubious data

Garbage in, garbage out

Can still work if the issues are explained

16

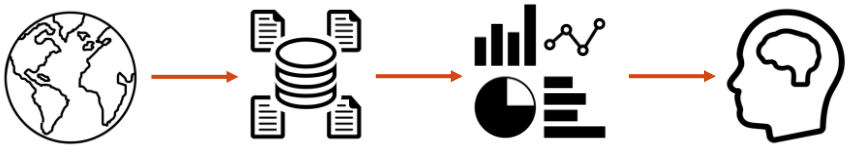
Dubious data explained



http://graphics.wsj.com/infectious-diseases-and-vaccines/

17

How charts lie?



Dubious data

Misrepresenting data

Cherry-picking data

Oversimplifying, Ignoring uncertainty

Confirmation bias

18

Misrepresenting data

Ignoring conventions
- Placement of dependent and independent variables
- Pie charts that do not add up to 100%

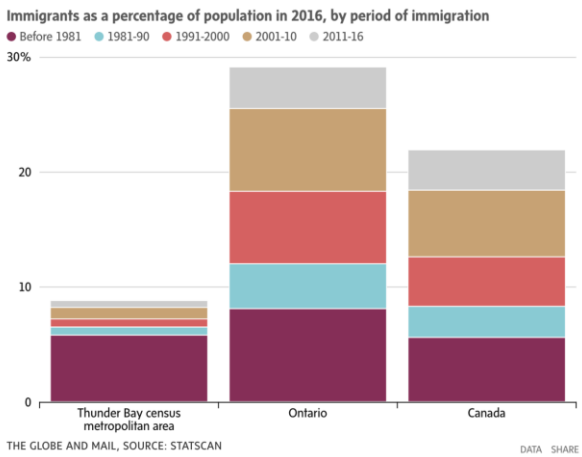
Abusing scales
- Distorted axis
- Truncated/elongated axis
- Dual axes
- Improper scaling of areas and pictograms

Unnecessary 3-D

Improper categorization

19

Time not on an axis



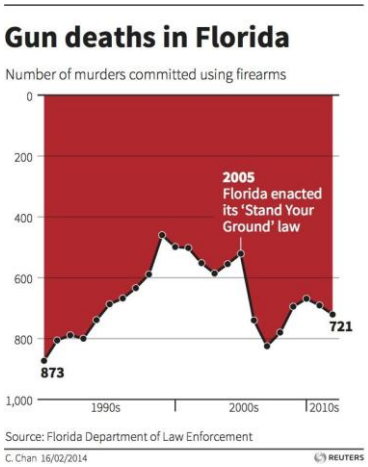
https://viz.wtf/post/187558414596/the-axis-choices-are-interesting-this-thing-is

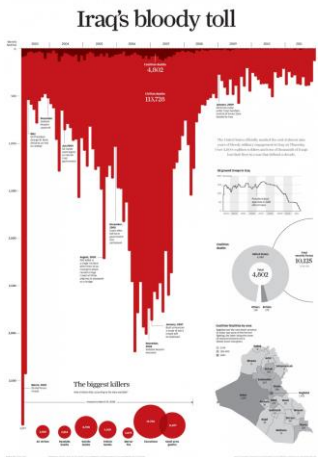
20

Over 100% pie chart

https://twitter.com/dergigi/status/1243315176000180224/

Distorted axis: Inverted y axis



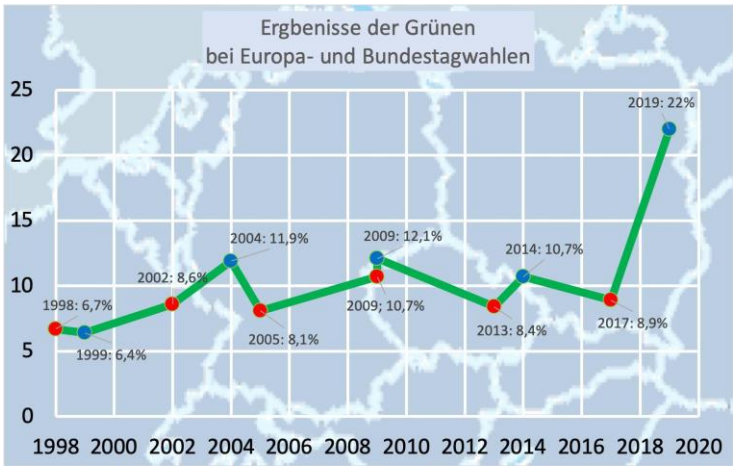


http://www.businessinsider.com/gun-deaths-in-florida-increased-with-stand-your-ground-2014-2
http://www.scmp.com/infographics/article/1284683/iraqs-bloody-toll

Distorted axis

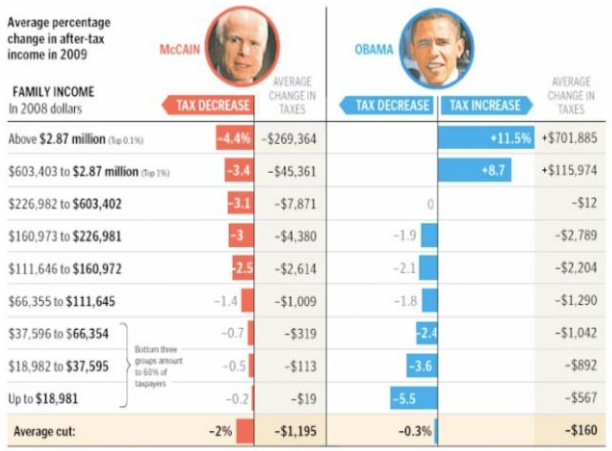
https://twitter.com/maartenzam/status/1132961446592172032?s=12

Fixed axis



https://twitter.com/maartenzam/status/1132961446592172032?s=12

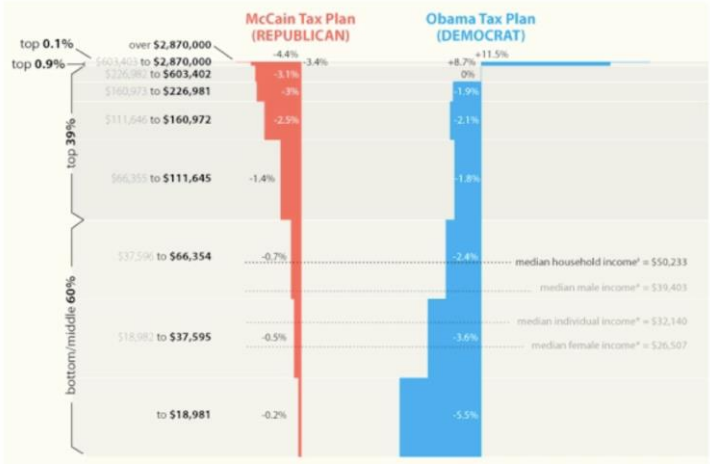
Unequal intervals



Average percentage change in after-tax income in 2009 — FAMILY INCOME In 2008 dollars	McCAIN TAX DECREASE	McCAIN AVERAGE CHANGE IN TAXES	OBAMA TAX DECREASE	OBAMA TAX INCREASE	OBAMA AVERAGE CHANGE IN TAXES
Above $2.87 million (Top 0.1%)	-4.4%	-$269,364		+11.5%	+$701,885
$603,403 to $2.87 million (Top 1%)	-3.4	-$45,361		+8.7	+$115,974
$226,982 to $603,402	-3.1	-$7,871	0		-$12
$160,973 to $226,981	-3	-$4,380	-1.9		-$2,789
$111,646 to $160,972	-2.5	-$2,614	-2.1		-$2,204
$66,355 to $111,645	-1.4	-$1,009	-1.8		-$1,290
$37,596 to $66,354 (Bottom three groups amount to 60% of taxpayers)	-0.7	-$319	-2.4		-$1,042
$18,982 to $37,595	-0.5	-$113	-3.6		-$892
Up to $18,981	-0.2	-$19	-5.5		-$567
Average cut:	-2%	-$1,195	-0.3%		-$160

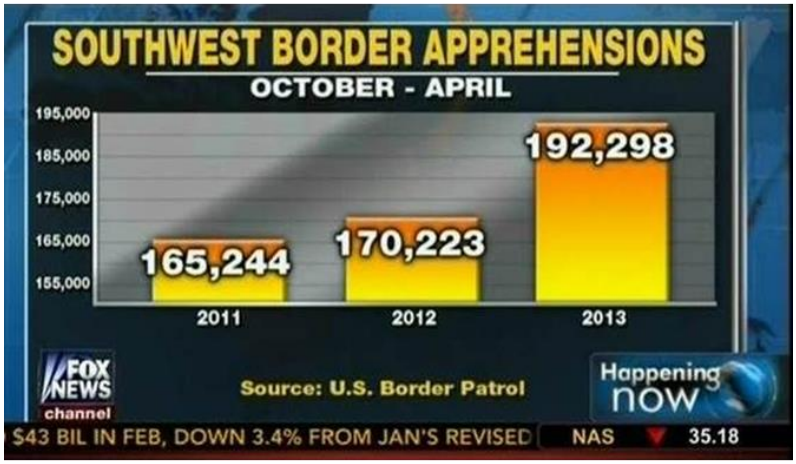
https://itunes.apple.com/us/course/data-literacy-and-data-visualization/id693097601 25

Fixed intervals



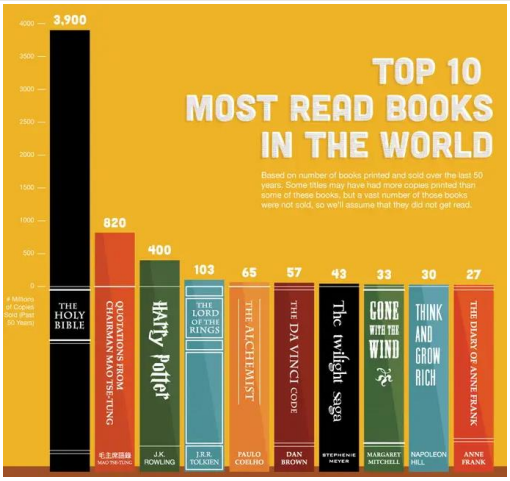
https://itunes.apple.com/us/course/data-literacy-and-data-visualization/id693097601 26

Bar chart with truncated axis



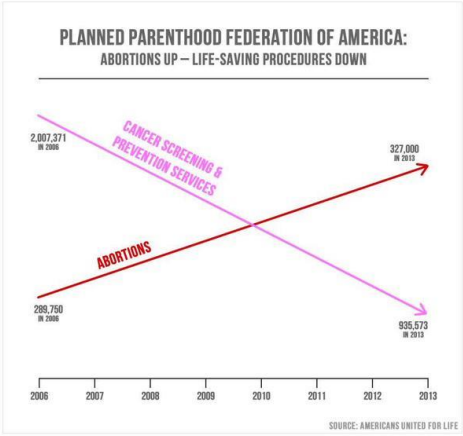
https://medium.com/@stephen.tracy/how-to-lie-with-charts-97396e4642 27

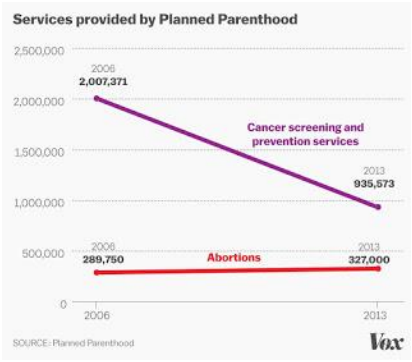
Bar chart with elongated axis



https://www.businessinsider.com/infographic-the-top-10-most-read-books-in-the-world-2012-5 28

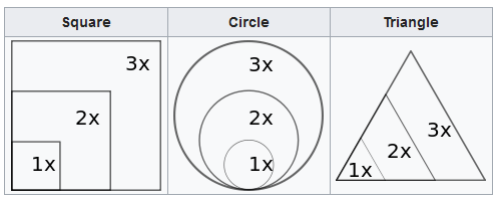
Dual axes



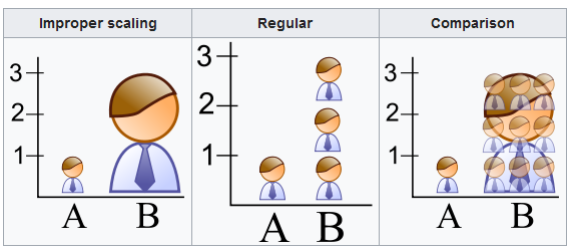


http://www.thefunctionalart.com/2015/10/if-you-see-bullshit-say-bullshit.html

Improper scaling of areas/pictograms

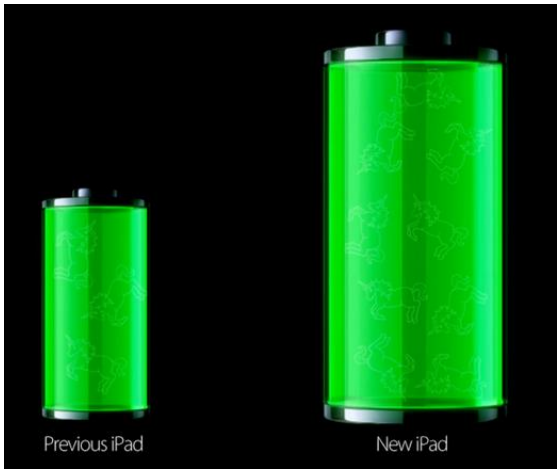


Even worse, if the elements are 3-D



https://en.wikipedia.org/wiki/Misleading_graph

Improper scaling of areas/pictograms



70 % increase in battery life

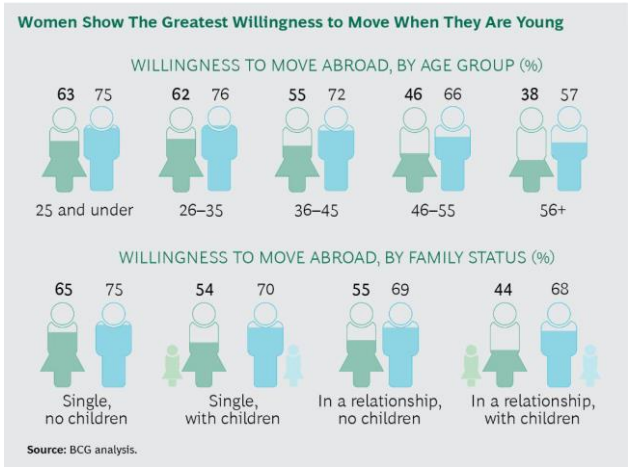
Instead of 1.7 the area factor is 2.8

https://gizmodo.com/why-i-paid-150-to-import-a-tamagotchi-smartwatch-i-can-1848094289 31

Improper scaling of areas/pictograms

https://www.bcg.com/publications/2017/people-organization-behavior-culture-getting-the-most-from-diversity-dollars.aspx?linkId=59621326&redir=true 32

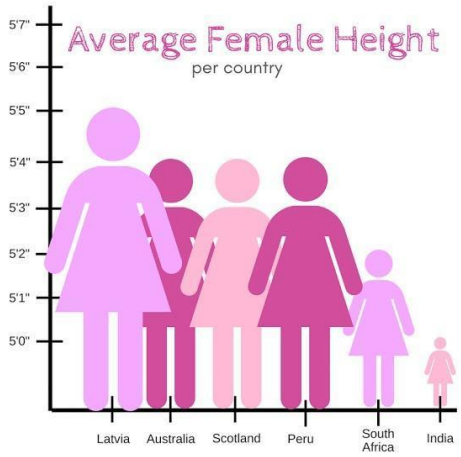
Proper scaling of areas/pictograms



https://www.bcg.com/en-us/publications/2017/people-organization-leadership-talent-women-on-the-move.aspx?linkId=58878371&redir=true

33

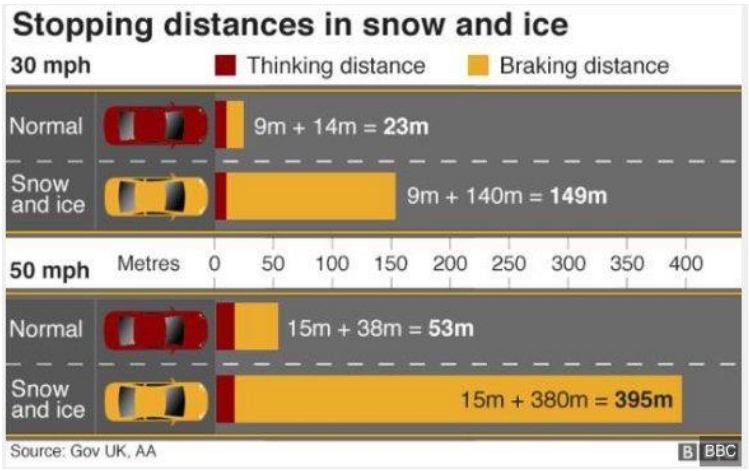
Improper scaling of areas/pictograms AND axis



https://twitter.com/graphcrimes/status/1448190784239554563

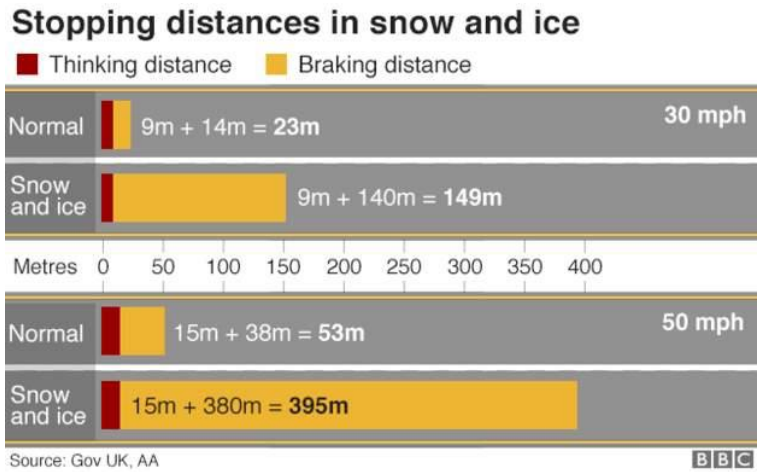
34

Improper scaling of areas/pictograms



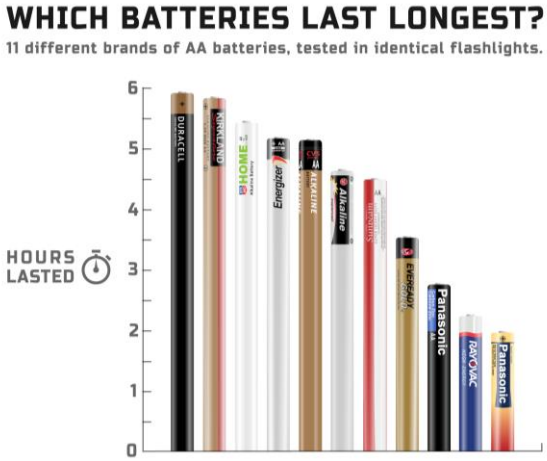
https://twitter.com/bengoldacre/status/1091326000384929793

Improper scaling of areas/pictograms – fixed



https://t.co/dMvGp5R8VH

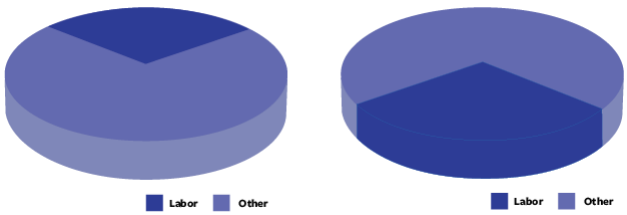
Proper scaling of areas/pictograms



https://www.reddit.com/r/dataisbeautiful/comments/855y7m/11_different_brands_of_aa_batteries_tested_in/

37

Unnecessary 3-D



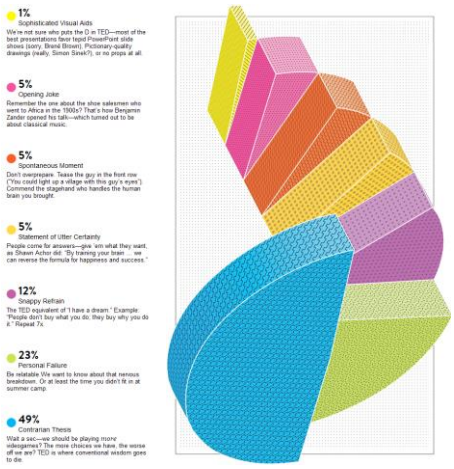
http://nautil.us/issue/19/illusions/five-ways-to-lie-with-charts

38

Unnecessary 3-D

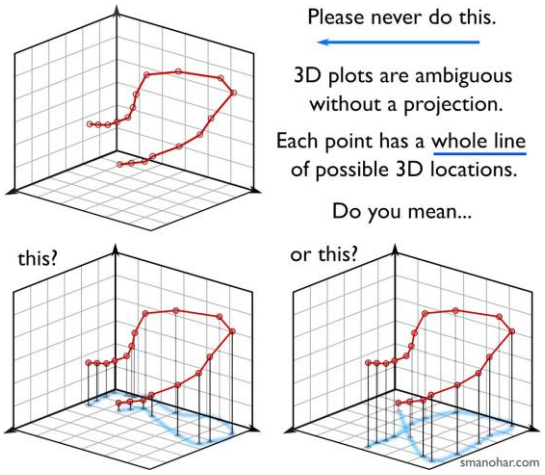
Unnecessary 3-D

ANATOMY OF A WINNING TED TALK



https://www.wired.com/2013/04/tedtalk/

When 3-D is necessary



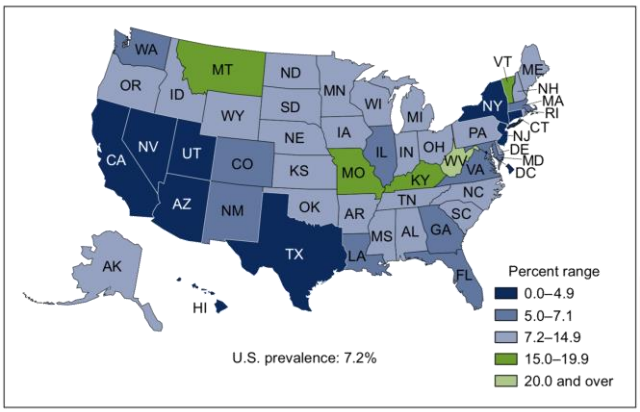
https://twitter.com/BrainInTheMind/status/1517543839833243649?s=20&t=etxXt5ldI3Q6hxVQqJiaMA

41

Improper categorization

Also bad choice of color!

Figure 1. Prevalence of maternal smoking at any time during pregnancy, by state: United States, 2016



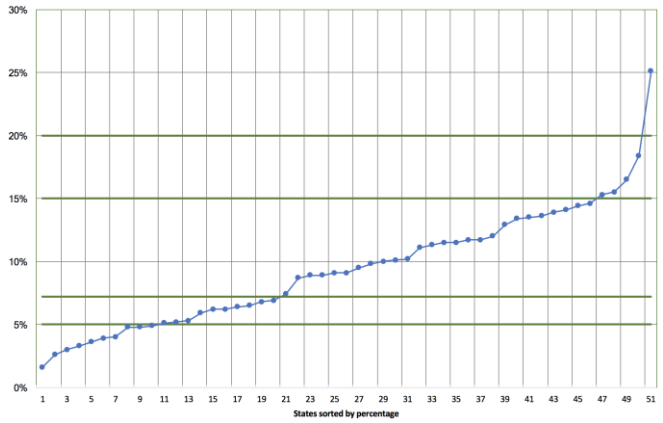
4.9
2.1
7.7
4.9

NOTE: Access data table for Figure 1 at: https://www.cdc.gov/nchs/data/databriefs/db305_table.pdf#1.
SOURCE: NCHS National Vital Statistics System, Natality.

https://www.cdc.gov/nchs/data/databriefs/db305.pdf

42

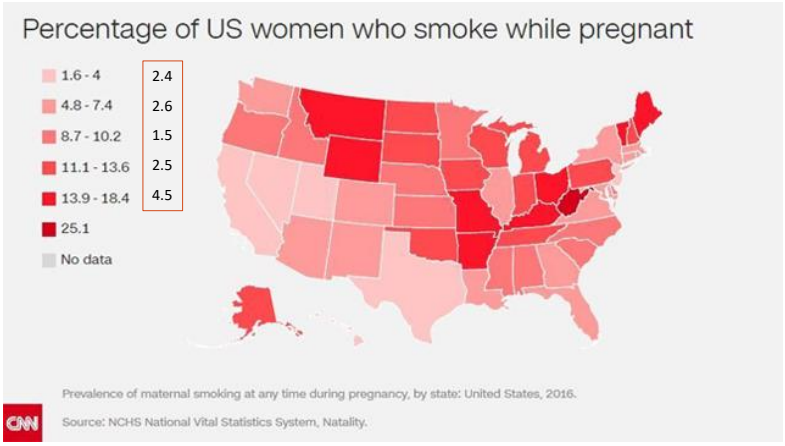
Improper categorization



https://www.cdc.gov/nchs/data/databriefs/db305_table.pdf#1

43

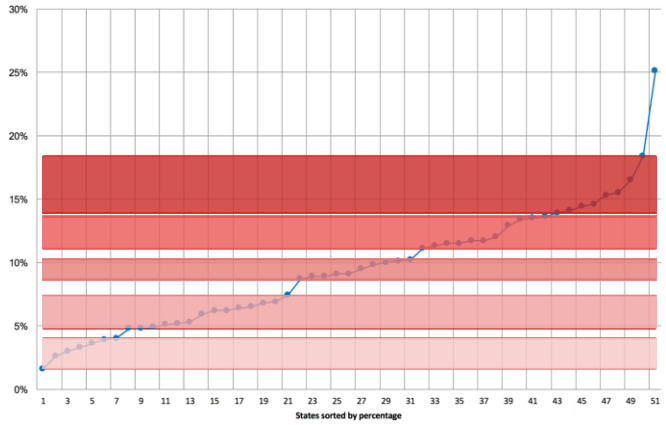
Improper categorization



https://meredith.images.worldnow.com/images/16207225_G.png?auto=webp&disable=upscale&width=800

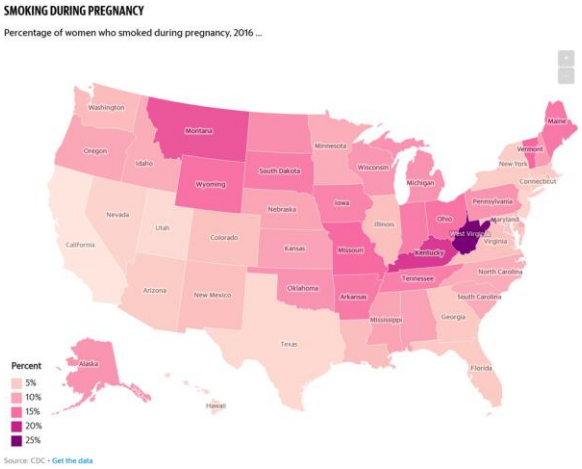
44

Improper categorization



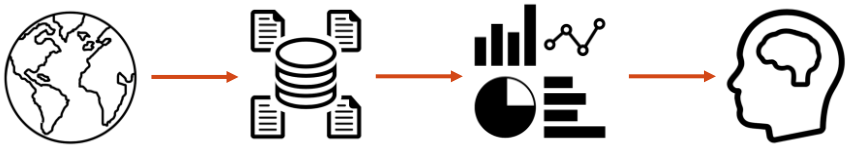
https://www.cdc.gov/nchs/data/databriefs/db305_table.pdf#1

Improper categorization



https://www.reddit.com/r/dataisbeautiful/comments/9svpwd/smoking_during_pregnancy_by_us_state_oc/

How charts lie?



Dubious data

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Confirmation bias

47

Cherry-picking data

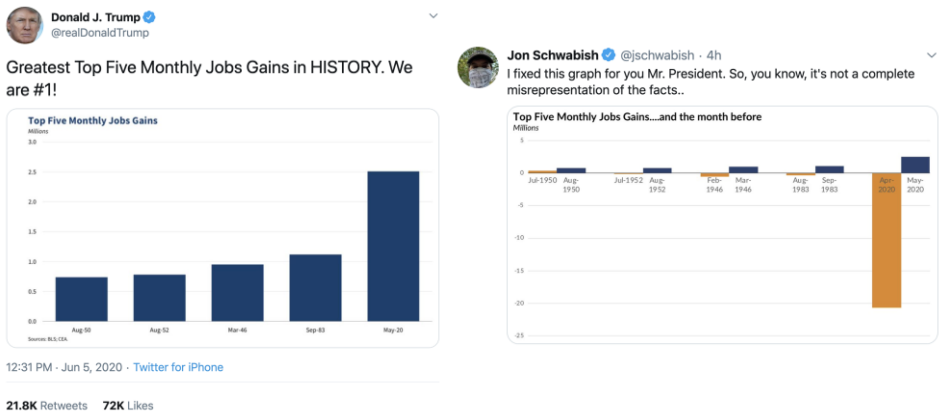
A chart shows as much as it hides, so think about what might be missing

- Hiding (unfavorable) data
- Concealing existing patterns
- Simpson's paradox
- Suggesting patterns that are not there

Correlation ≠ causation

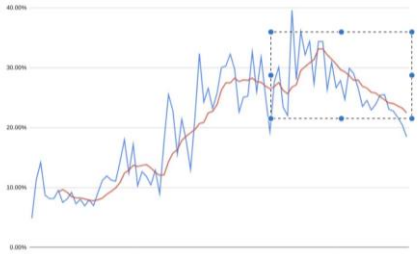
48

Hiding (unfavorable) data



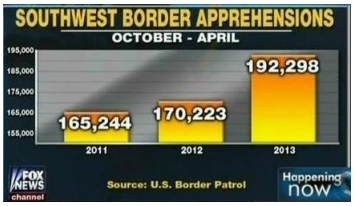
http://www.thefunctionalart.com/2020/06/psychopathic-charts-lines-that-should.html

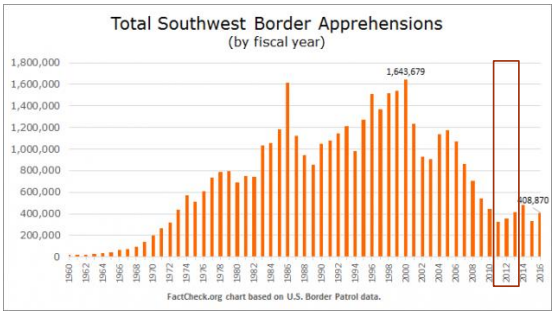
Hiding (unfavorable) data



https://twitter.com/medel2020/status/1280676453768736768

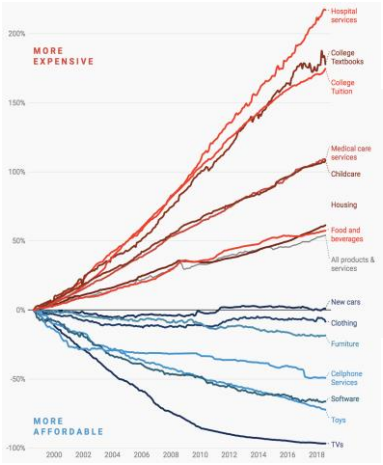
Concealing existing patterns

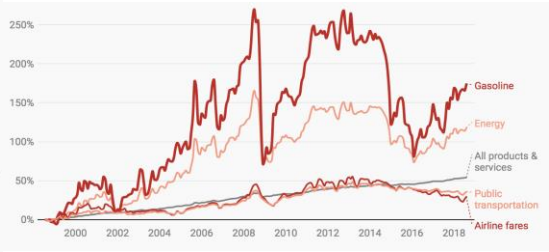




https://www.businessinsider.com/the-27-worst-charts-of-all-time-2013-6#welcome-to-fox-where-the-line-graphs-are-made-up-and-the-points-dont-matter-12

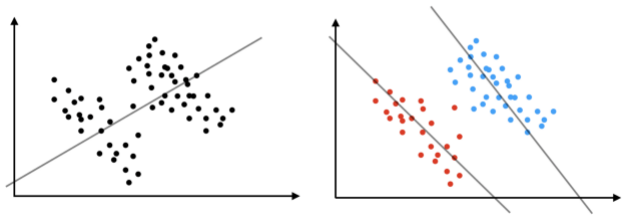
Concealing existing patterns





https://blog.datawrapper.de/weekly47-cpi-dollars-for-college/

Simpson's paradox

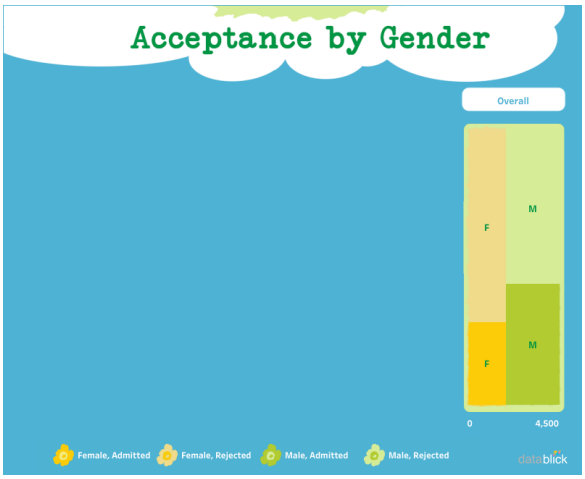


The overall trend reverses when data is grouped by categories

https://towardsdatascience.com/simpsons-paradox-and-interpreting-data-6a0443516765 53

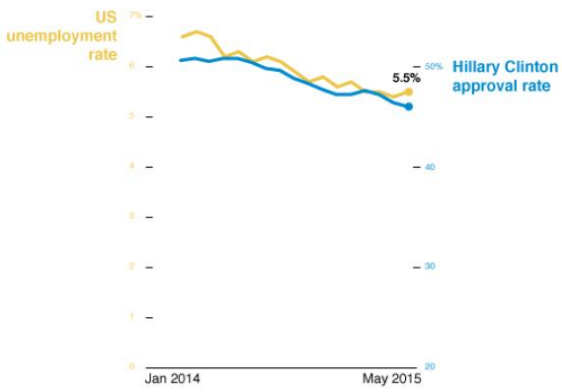
Simpson's paradox

Admission of applicants to UC Berkeley



https://public.tableau.com/app/profile/jonathan.drummey/viz/marimekko-mosaicplot/MarimekkowGT 54

Suggesting patterns that are not there

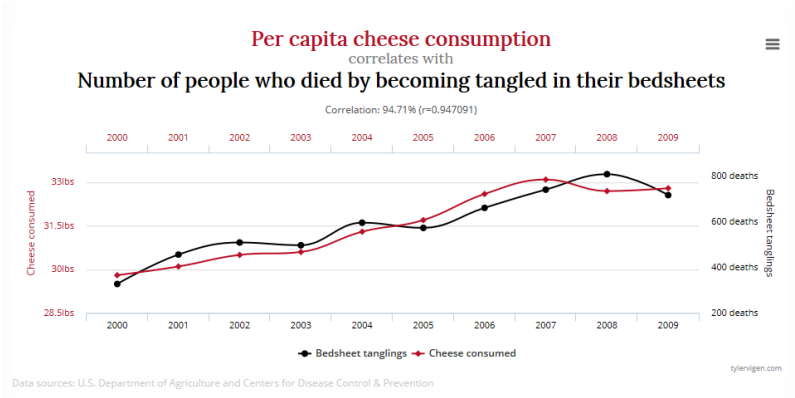


https://news.nationalgeographic.com/2015/06/150619-data-points-five-ways-to-lie-with-charts/

55

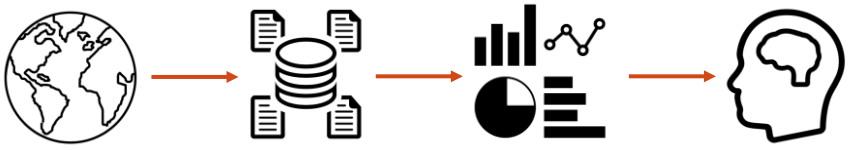
Suggesting patterns that are not there

Spurious correlations: http://www.tylervigen.com/spurious-correlations



56

How charts lie?



Dubious data

Misrepresenting data

Cherry-picking data

Oversimplifying, Ignoring uncertainty

Confirmation bias

57

Oversimplifying, Ignoring uncertainty

- Oversimplifying
- Misrepresenting uncertainty
- Concealing uncertainty

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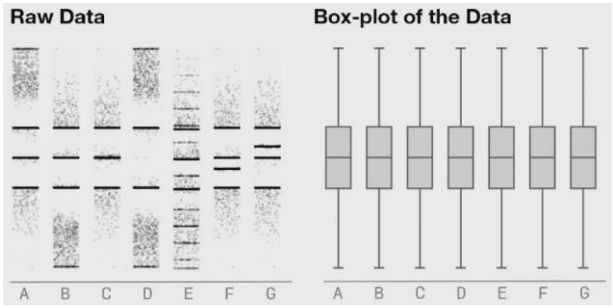
Oversimplifying

Clarify, not (over)simplify!

To clarify, add detail.

Edward Tufte

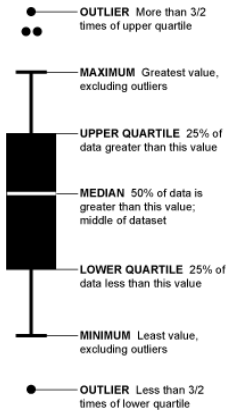
Oversimplifying



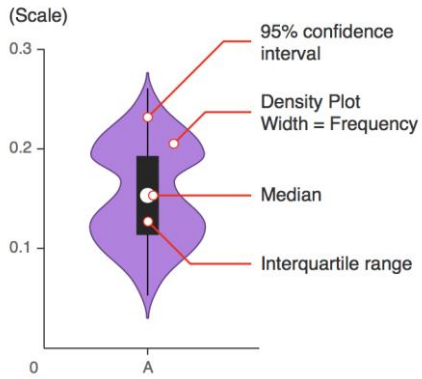
https://www.autodeskresearch.com/publications/samestats

Box plot vs. violin plot

Box (and whisker) plot



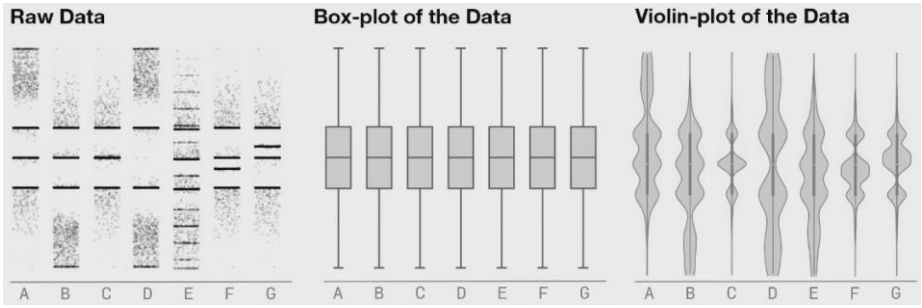
Violin plot



https://flowingdata.com/2008/02/15/how-to-read-and-use-a-box-and-whisker-plot/
https://datavizcatalogue.com/methods/violin_plot.html

61

Oversimplifying

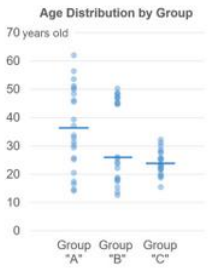


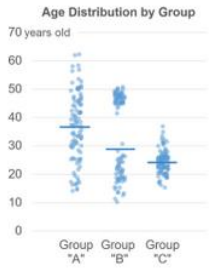
https://www.autodeskresearch.com/publications/samestats

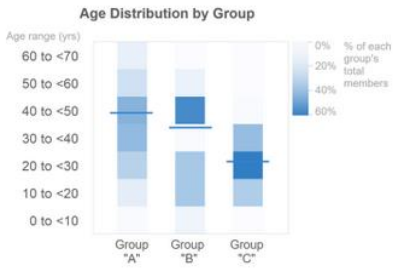
62

Oversimplifying

Other alternatives to boxplots



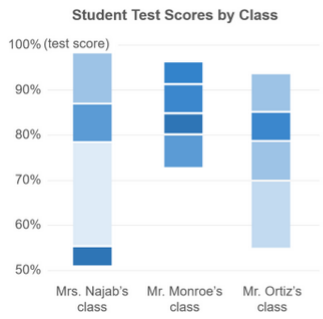


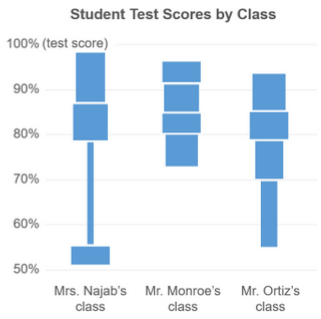


https://nightingaledvs.com/ive-stopped-using-box-plots-should-you/ 63

Oversimplifying

Other alternatives to boxplots





https://nightingaledvs.com/ive-stopped-using-box-plots-should-you/ 64

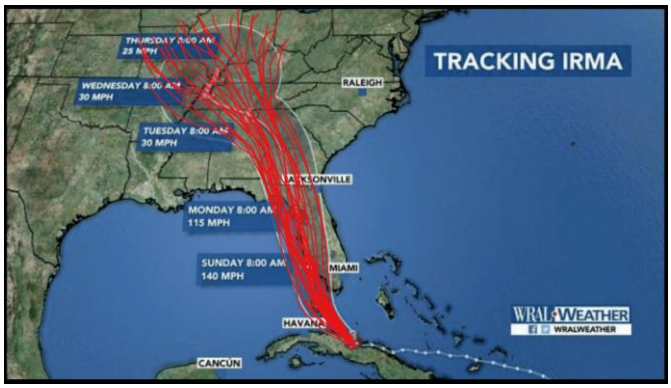
Misrepresenting uncertainty

The cone of uncertainty is widely misinterpreted

https://www.youtube.com/watch?v=Cd046xZhO_8&t=504s

Misrepresenting uncertainty

The cone of uncertainty is widely misinterpreted



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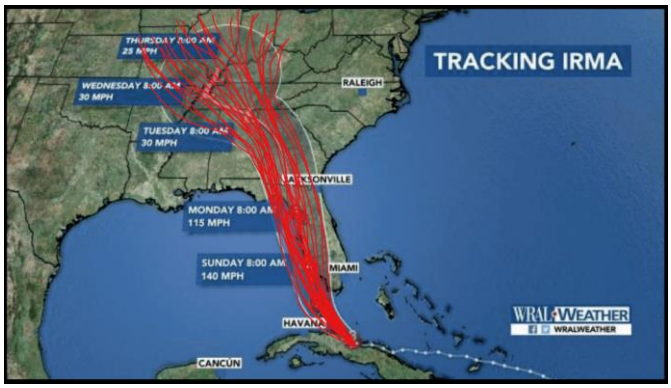

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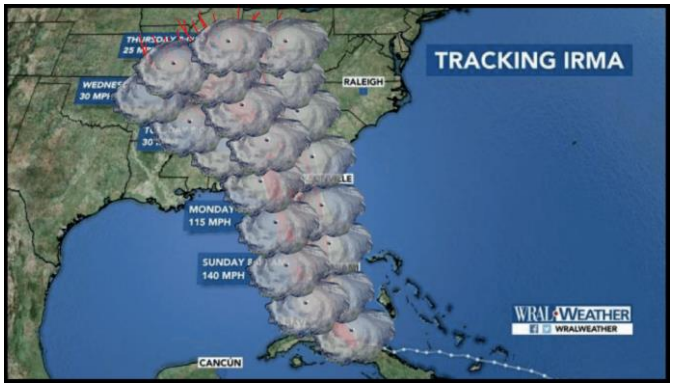

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69

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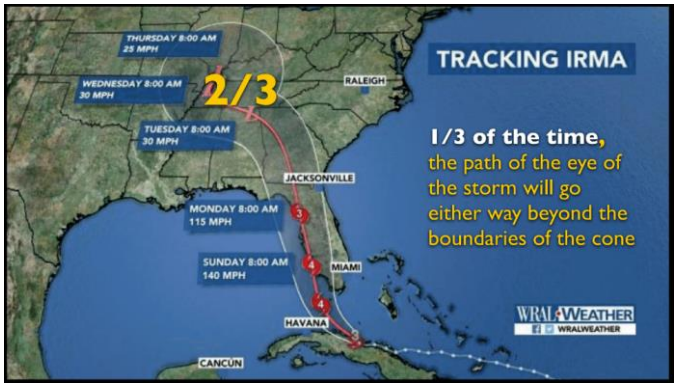
The cone of uncertainty is widely misinterpreted

https://www.youtube.com/watch?v=Cd046xZhO_8&t=504s

70

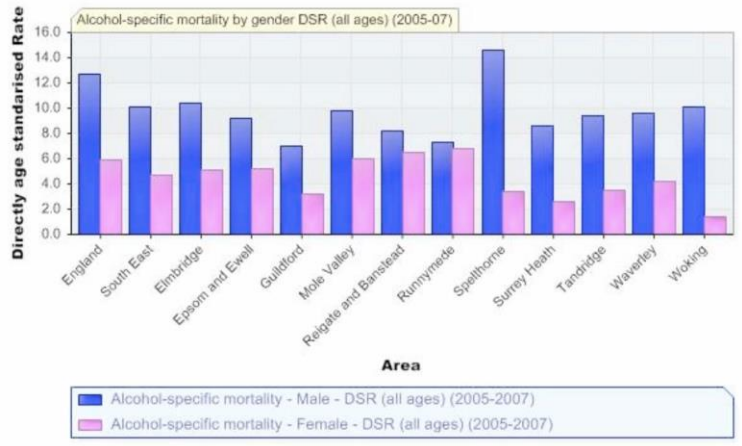
Misrepresenting uncertainty

The cone of uncertainty is widely misinterpreted



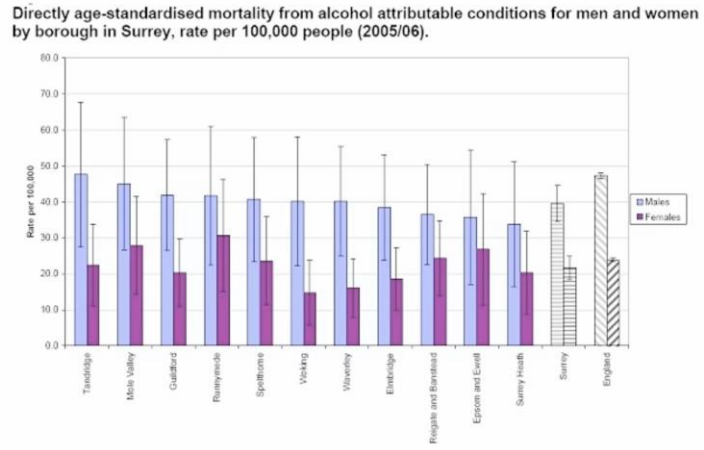
https://www.youtube.com/watch?v=Cd046xZhO_8&t=504s

Concealing uncertainty



https://itunes.apple.com/us/course/data-literacy-and-data-visualization/id693097601

Concealing uncertainty



https://itunes.apple.com/us/course/data-literacy-and-data-visualization/id693097601

How charts lie?

Dubious data

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Oversimplifying, Ignoring uncertainty

Confirmation bias

Confirmation bias

Confirmation bias is the tendency to search for, interpret, favor, and recall information in a way that confirms or supports one's prior beliefs or values

Charts lie because we lie to ourselves – we see what we want to see

The bias blind spot

- We think only others are biased
- This makes us more susceptible to bias

Confirmation bias does not affect only chart interpretation, but also visualization design, data analysis and even data collection

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Confirmation bias

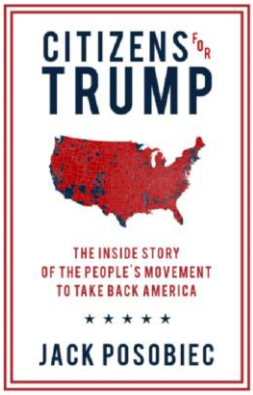
https://twitter.com/TreyYingst/status/862669407868391424

76

Confirmation bias

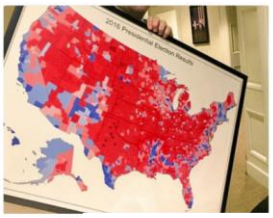
https://www.youtube.com/watch?v=Cd046xZhO_8&t=504s 77

Confirmation bias



https://www.youtube.com/watch?v=Cd046xZhO_8&t=504s 78

Confirmation bias



Surface on the county-level map:

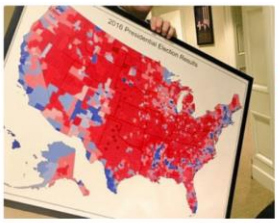
Red: 80%

Blue: 20%

https://www.youtube.com/watch?v=Cd046xZhO_8&t=504s

79

Confirmation bias



Surface on the county-level map:

Red: 80%

Blue: 20%

SHARE OF THE POPULAR VOTE IN THE 2016 PRESIDENTIAL ELECTION

Donald Trump	46.1%	62,984,825 votes
Hillary Clinton	48.2%	65,853,516 votes
Other candidates	5.7%	

https://www.youtube.com/watch?v=Cd046xZhO_8&t=504s

80

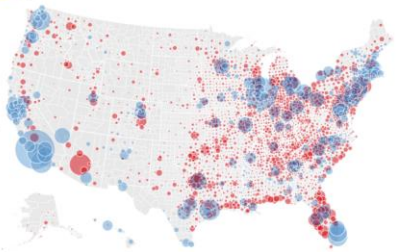
Confirmation bias

Surface on the county-level map:

Red: 80%

Blue: 20%

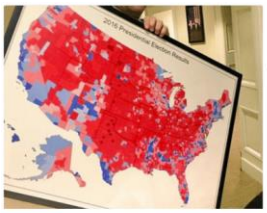
Bubble size is proportional to the number of votes received just by the candidate who won on each county



https://www.youtube.com/watch?v=Cd046xZhO_8&t=504s

81

Confirmation bias



SHARE OF THE POPULAR VOTE IN THE 2016 PRESIDENTIAL ELECTION

Donald Trump	46.1%	62,984,825 votes
Hillary Clinton	48.2%	65,853,516 votes
Other candidates	5.7%	

PERCENTAGE OF ELIGIBLE VOTERS

Didn't vote	40.0%
Voted for Donald Trump	27.7%
Voted for Hillary Clinton	28.9%
Voted for other candidates	3.4%

VOTES FOR DONALD TRUMP

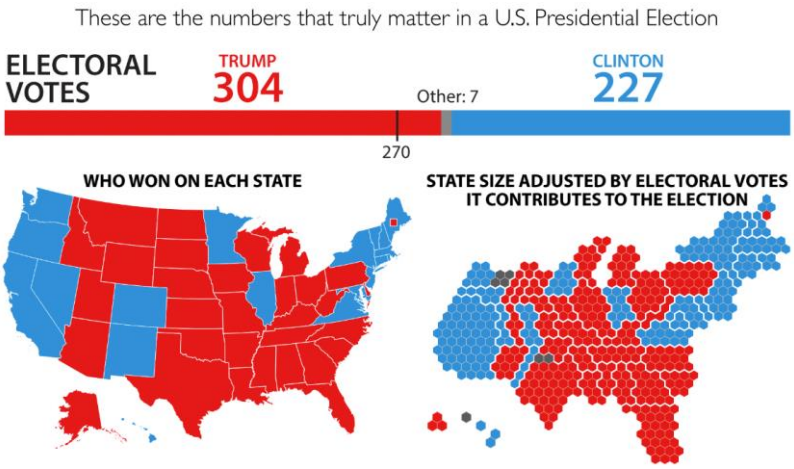
VOTES FOR HILLARY CLINTON

Bubble size is proportional to the number of votes per county

https://www.youtube.com/watch?v=Cd046xZhO_8&t=504s

82

Confirmation bias



https://www.youtube.com/watch?v=Cd046xZhO_8&t=504s

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To achieve trustworthiness (1)

- List the source(s) of data
- Show representative and unbiased data (or clearly denote and explain why this is not the case)
- Compare only data that can be meaningfully compared
- Be mindful of the choice between absolute and cumulative values
- Use relative instead of absolute data in comparisons
- Follow conventions
- Do not abuse scales

84

To achieve trustworthiness (2)

- Do not use 3-D representations for non 3-D data
- Choose categories mindfully
- Do not oversimplify
- Present the entire relevant data
- Do not suggest patterns that are not there
- Show uncertainty
- Be wary of confirmation bias

However… some rules can be bent (as long as you know what you are doing)

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