

# Visualizing data with R and RStudio

ME 447/547

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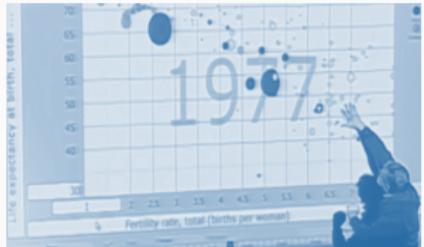
Richard Layton

March 2019

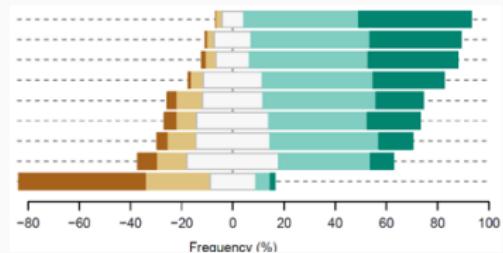
Rose-Hulman Institute of Technology

The course is designed to develop your skills in three areas

Rhetoric



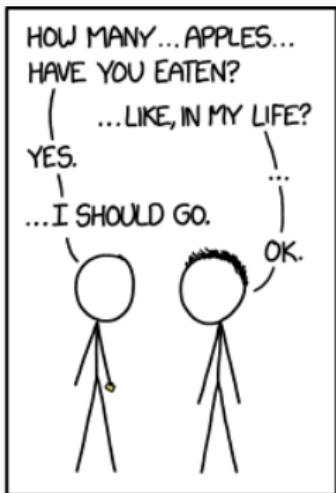
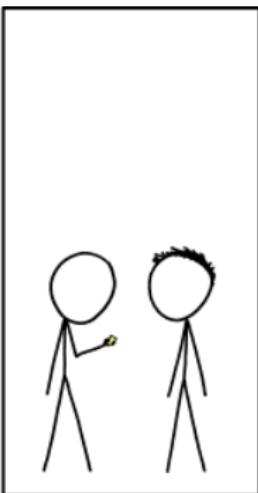
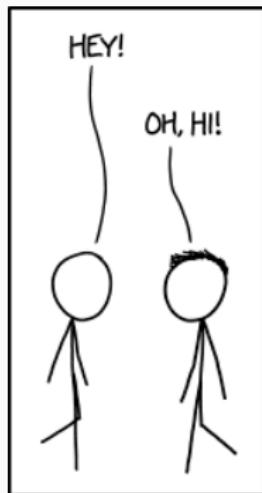
Repertoire



Means



Please sit with someone you don't know and introduce yourself

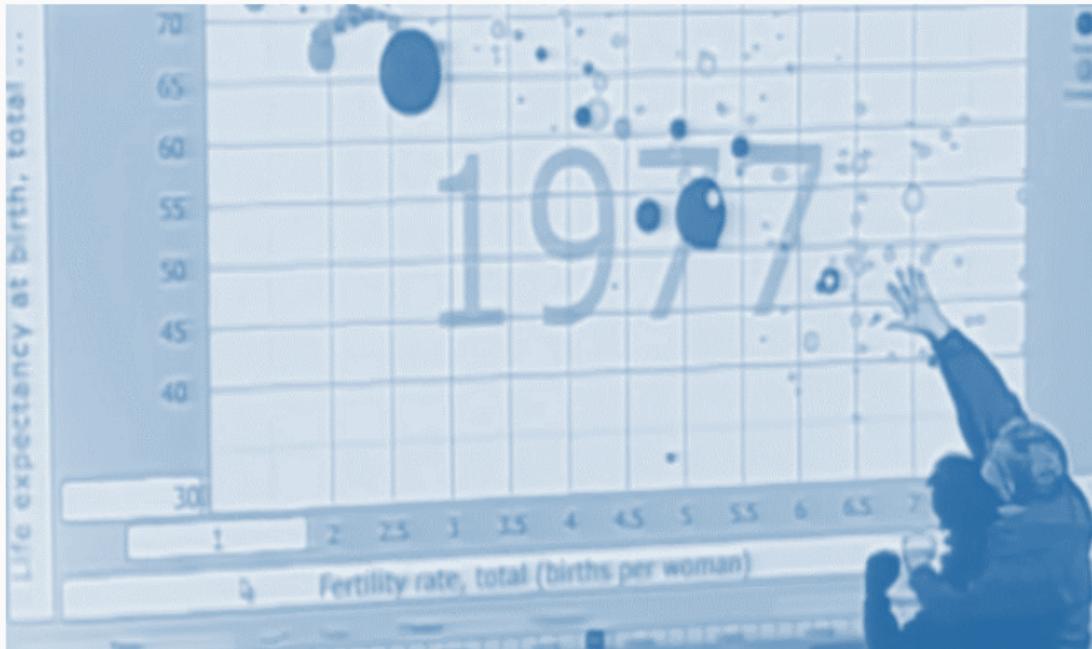


<https://www.xkcd.com/1976/>

# Visual rhetoric

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# Designers shape information visually for rhetorical ends



Hans Rosling 2006 TED Talk

# Consider the argument

How did Hans shape the information visually?

What were his rhetorical goals?

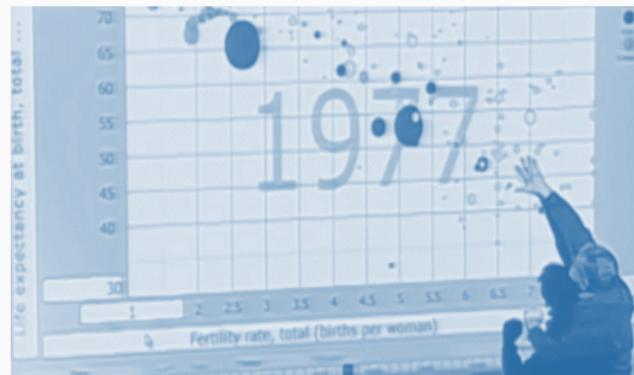


Image: TED2006

Consider a different, less credible, visual argument

True or False:  $N_{\text{people on welfare}} > N_{\text{people with a full time job}}$



Image: Media Matters

Consider a different, less credible, visual argument

True or False:  $N_{\text{people on welfare}} > N_{\text{people with a full time job}}$

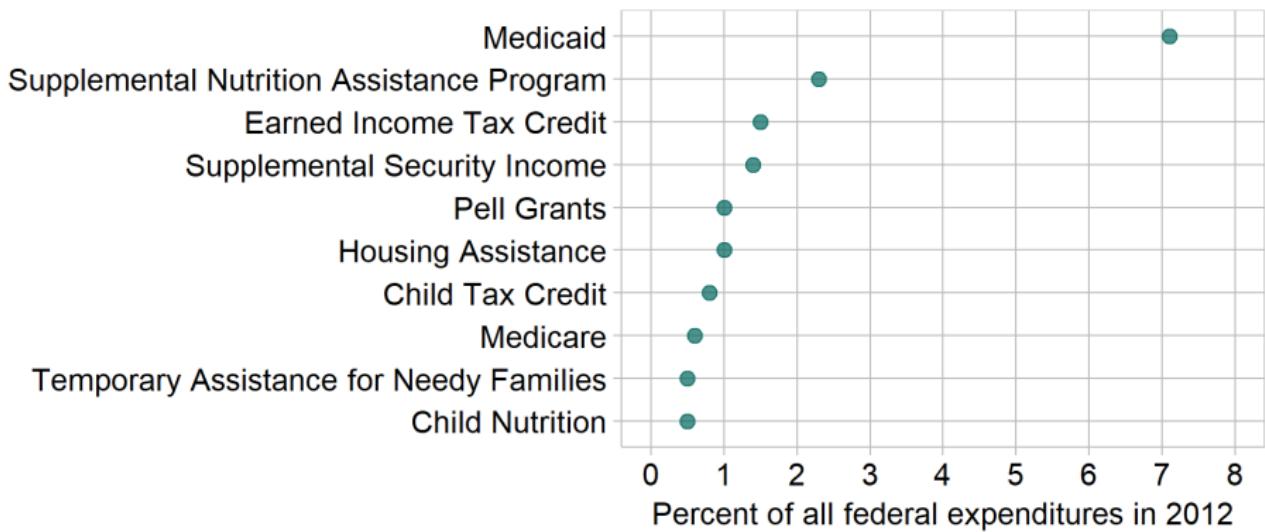


Image: Media Matters

False. One count is artificially high; the other is artificially low.  
The counts use different definitions of “people”.

# What does it mean to receive “welfare” benefits?

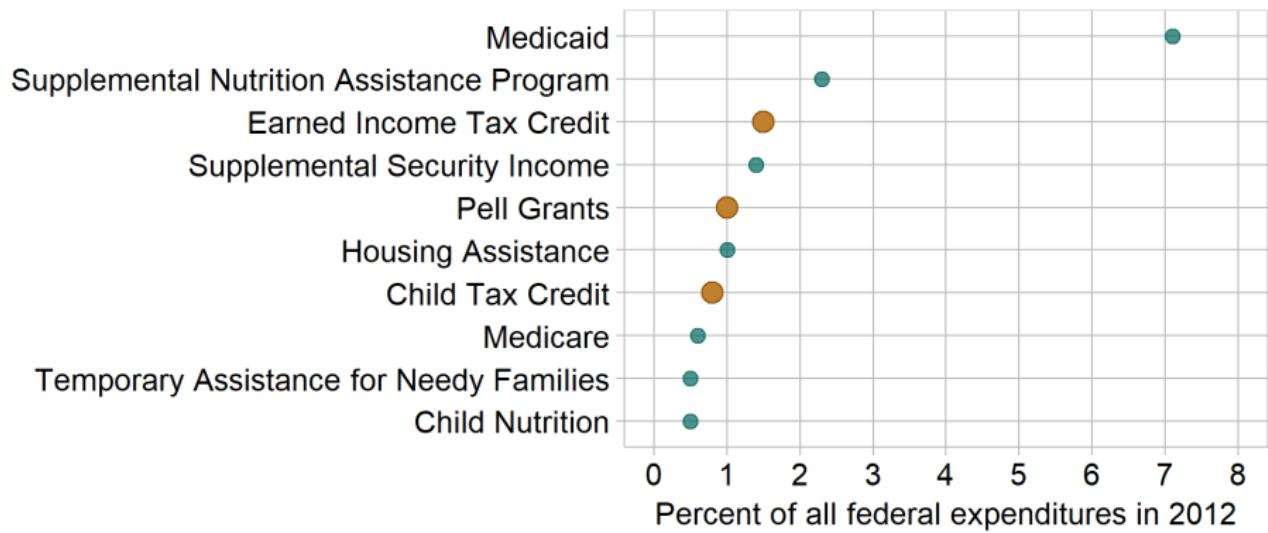
Federal means-tested programs and tax credits



In total, 17% of the 2012 US federal budget (\$590 B / \$3540 B).

# What does it mean to receive “welfare” benefits?

Federal means-tested programs and tax credits



In total, 17% of the 2012 US federal budget (\$590 B / \$3540 B).

Also, the visual argument belies the verbal argument

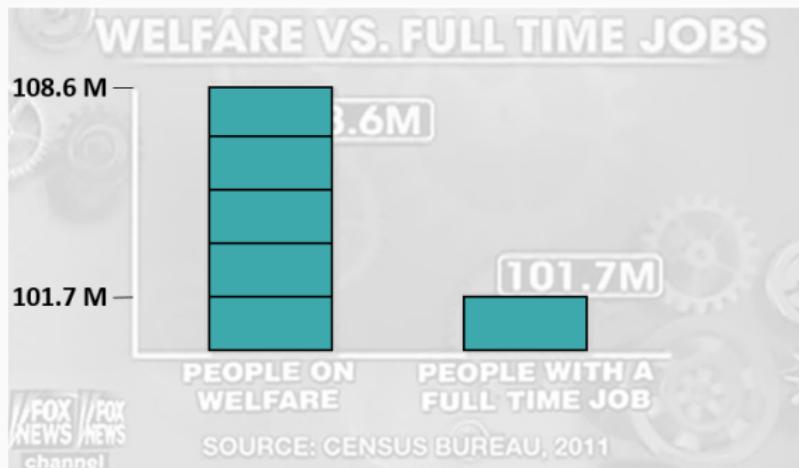
What is the **visual lie**?



# A visual argument prevails—as the designer well knows

**Verbal lie:** 7% more people receiving benefits than not

**Visual lie:** 500% more people receiving benefits than not



What were the designer's rhetorical goals?

# Ethical obligations are inherent in graph design



In data visualization, journalism meets engineering — Alberto Cairo

**journalism** increase knowledge among the public while minimizing harmful side effects

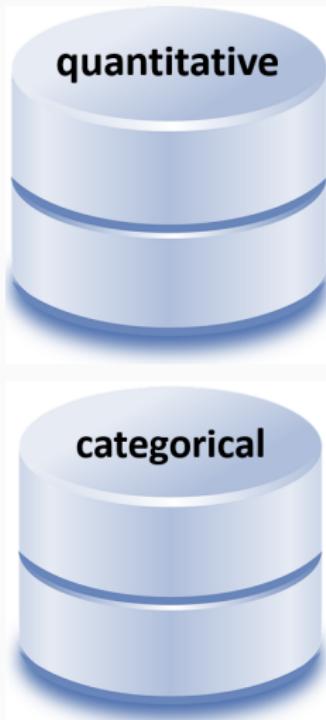
**engineering** give information a visual shape—model it, sculpt it—effectively and efficiently

(Cairo, 2014)

# Repertoire

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# Graph design begins by understanding the data structure ...



Number of variables?

Continuous or discrete?

Number of variables?

Nominal or ordinal?

Number of levels each?

... and by knowing the prior art suited to that structure

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strip plot

box and whisker plot

multiway

scatterplot

dot plot

line graph

conditioning plot

scatterplot matrix

63

parallel coordinate plot

cycle plot

mosaic plot

financial (OHLC) plot

diverging stacked bar

linked micromaps

proportional symbol map

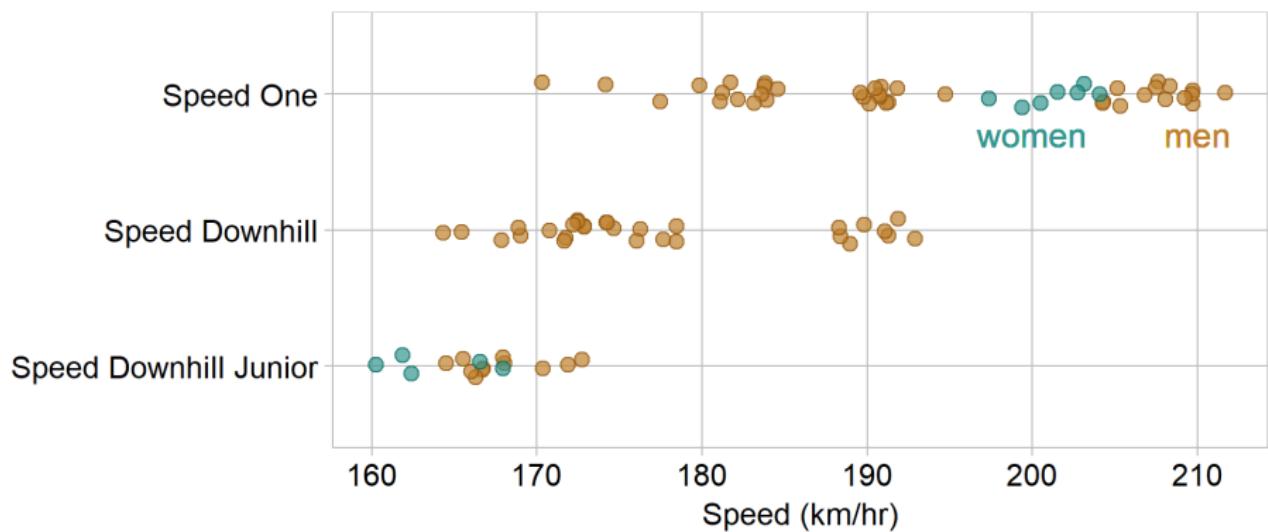
dot density map

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## Gallery – strip plot, jitter plot, or 1D scatterplot

Quantitative: speed (continuous),  $N_{\text{obs}} = 91$

Categorical: event (nominal, 3 levels), sex (nominal, 2 levels)

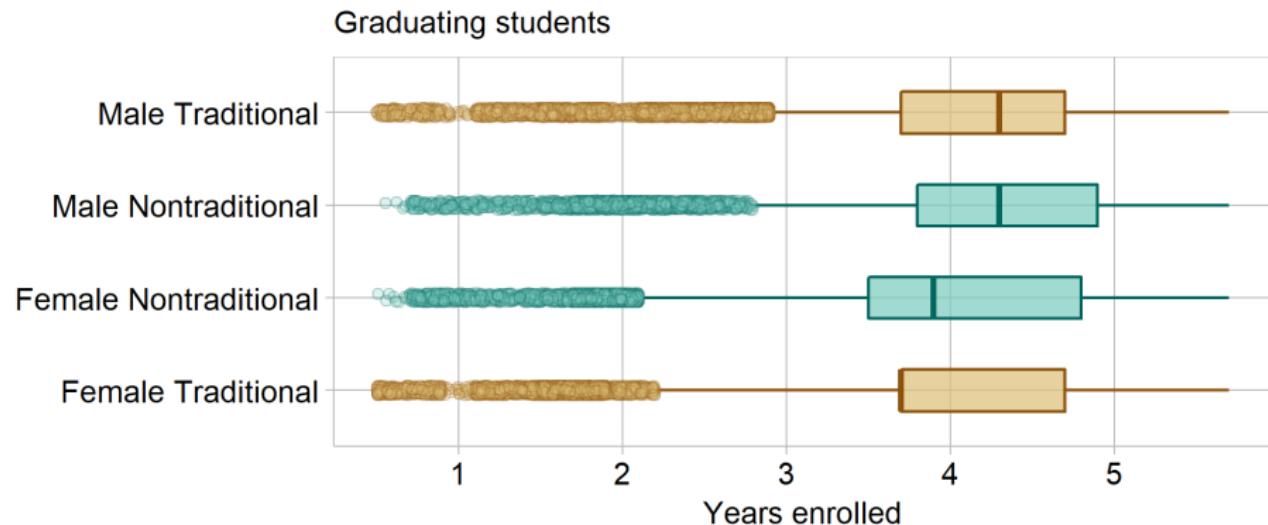


Data source (Unwin, 2015)

## Gallery – box and whisker or box plot

Quantitative: Years enrolled (continuous),  $N_{\text{obs}} = 269057$

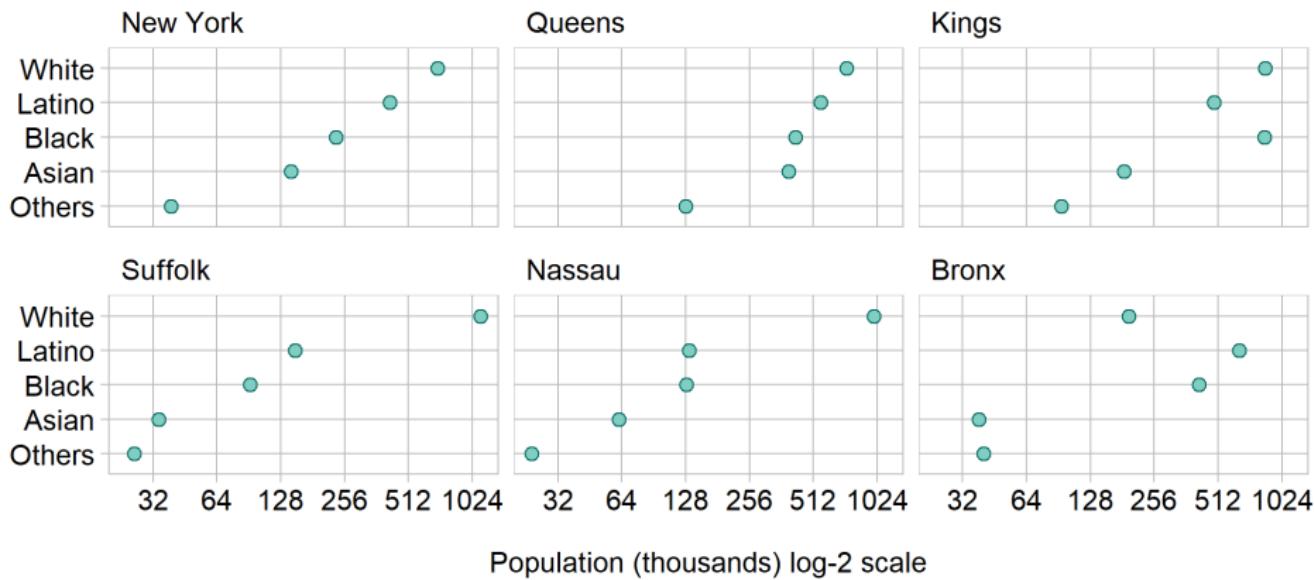
Categorical: Path + sex (nominal, 4 levels)



## Gallery – multiway

Quantitative: Population (continuous),  $N_{\text{obs}} = 30$

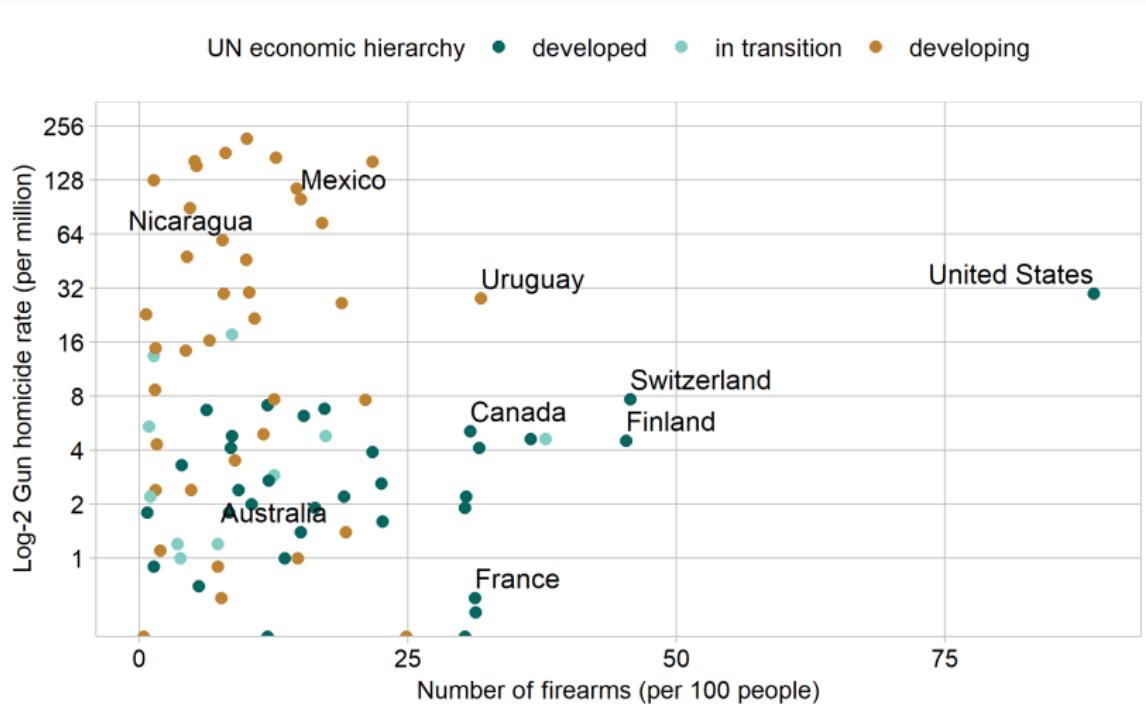
Categorical: Race/ethnicity (nominal, 5L) & county (nominal, 6L)



## Gallery – scatterplot

Quantitative: Gun homicides & gun ownership (continuous),  $N_{\text{obs}} = 90$

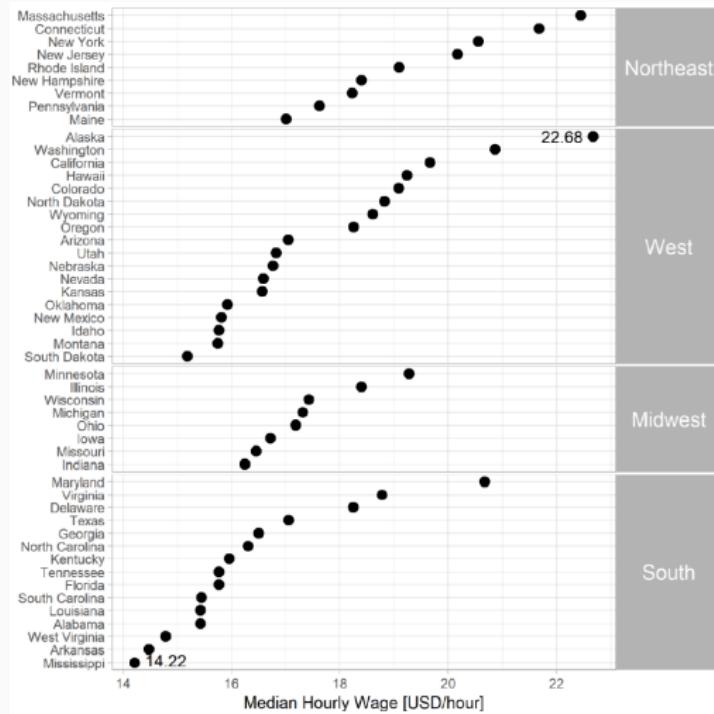
Categorical: Country (nominal, 90L) & economic hierarchy (nominal, 3L)



## Gallery – Cleveland dot plot

Quantitative: 2016 median hourly wage (continuous),  $N_{\text{obs}} = 50$

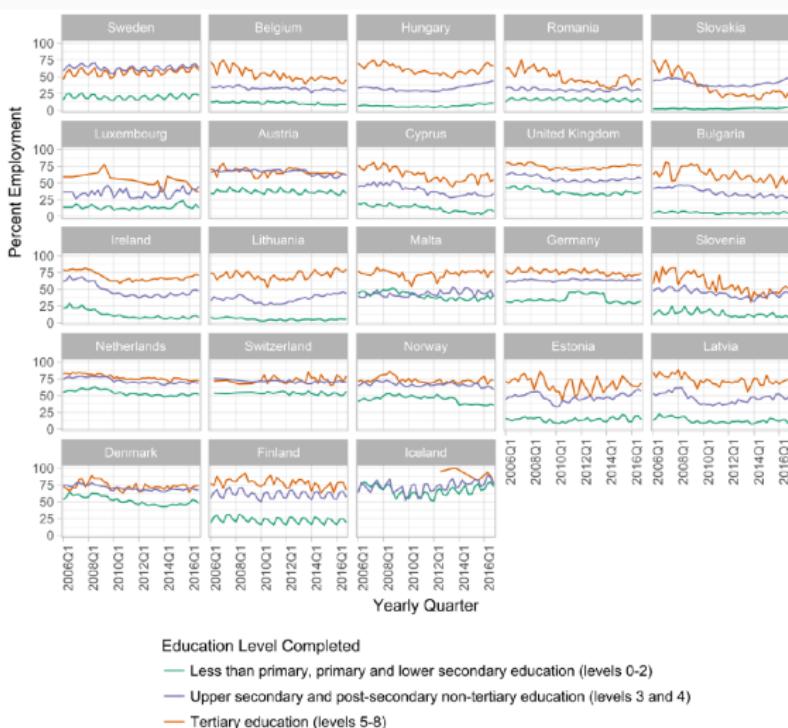
Categorical: State (nominal, 50 levels) & region (nominal, 4 levels)



# Gallery – line graph

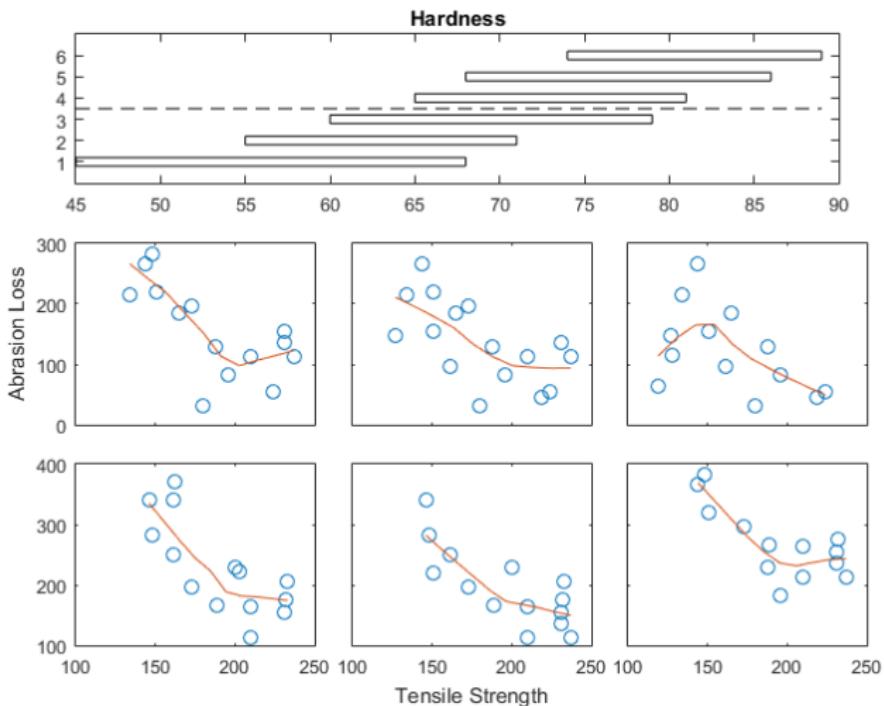
Quantitative: Percent employment (continuous),  $N_{\text{obs}} = 1656$

Categorical: Country (nominal, 23L), education (ord, 3L), quarter (ord, 24L)



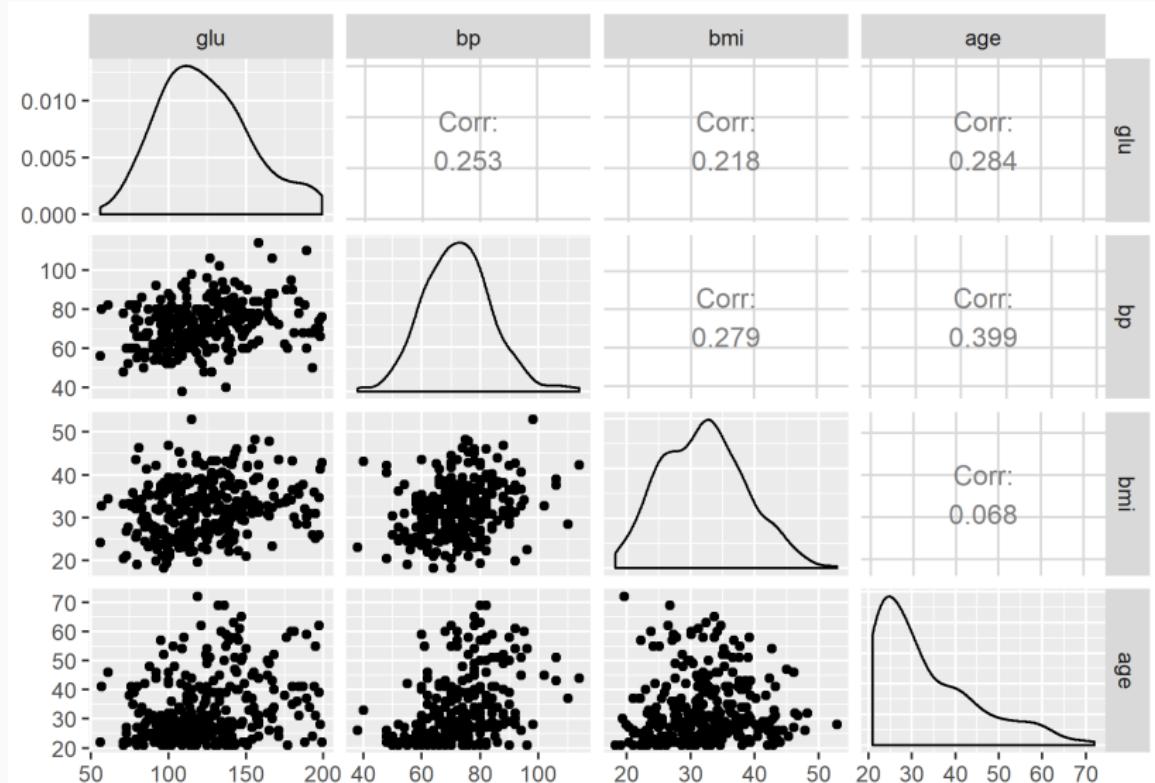
## Gallery – conditioning plot

Quantitative: Rubber abrasion loss, tensile strength, & hardness  
(all continuous),  $N_{\text{obs}} = 30$



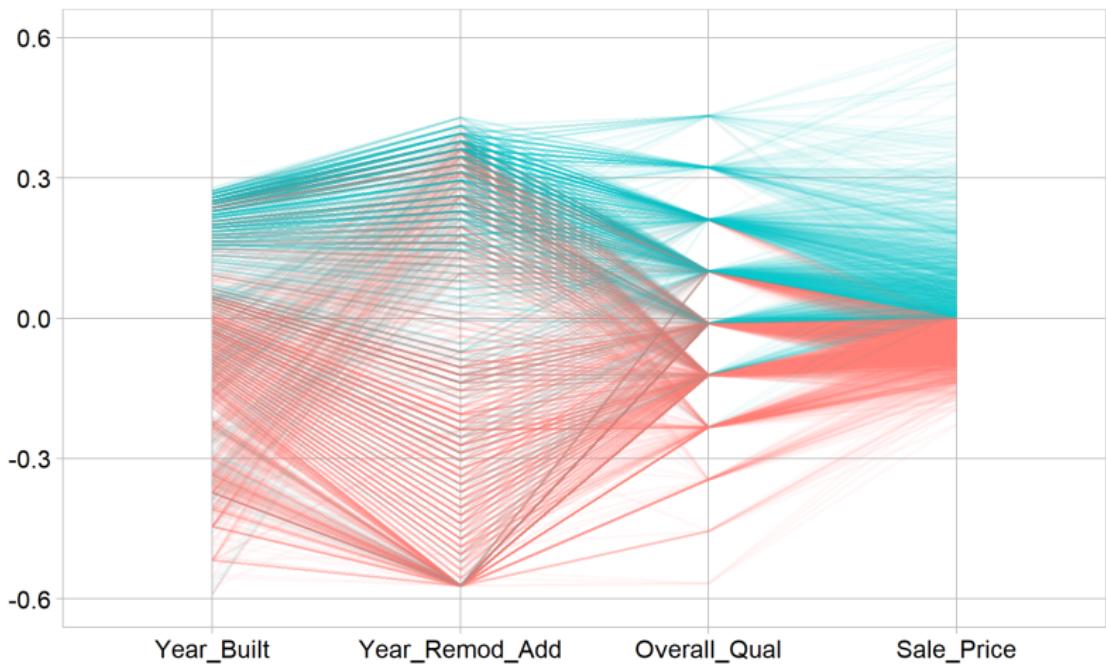
## Gallery – scatterplot matrix

Quantitative: glucose, blood pressure, BMI, age (continuous),  $N_{\text{obs}} = 300$



## Gallery – parallel coordinate

Quantitative: Year built, remodeled, & sale price (continuous),  
quality (discrete)  $N_{\text{obs}} = 2930$

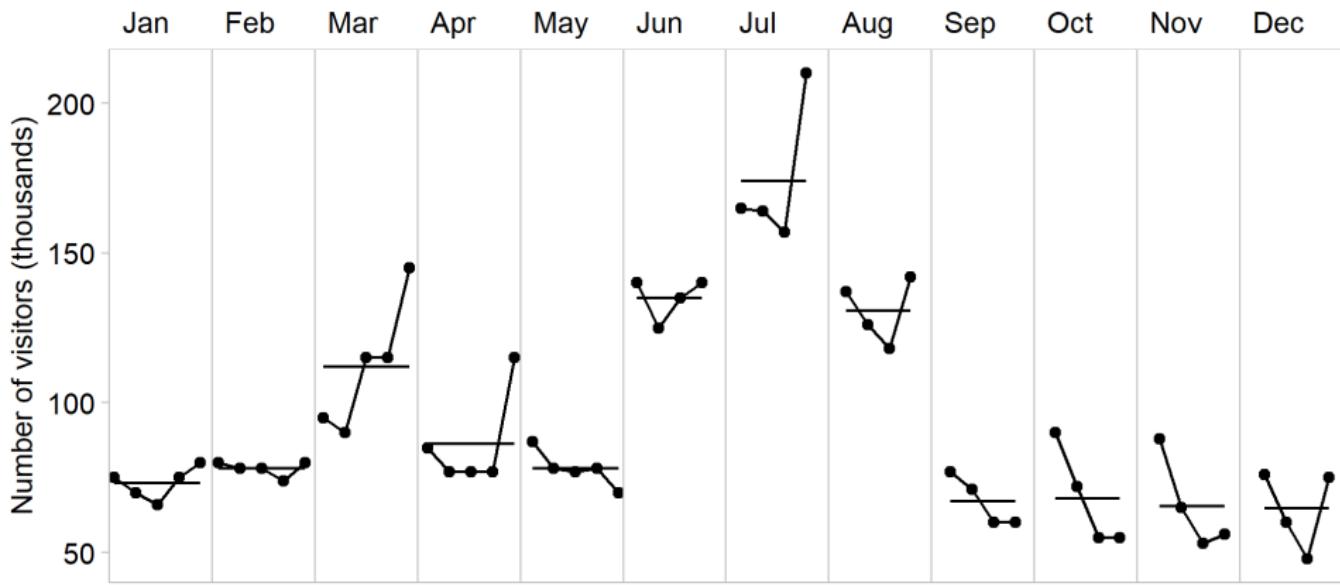


## Gallery – cycle plot

Quantitative: Number of visitors (continuous),  $N_{\text{obs}} = 53$

Categorical: Month (ordinal, 12 levels), year (ordinal, 5 levels)

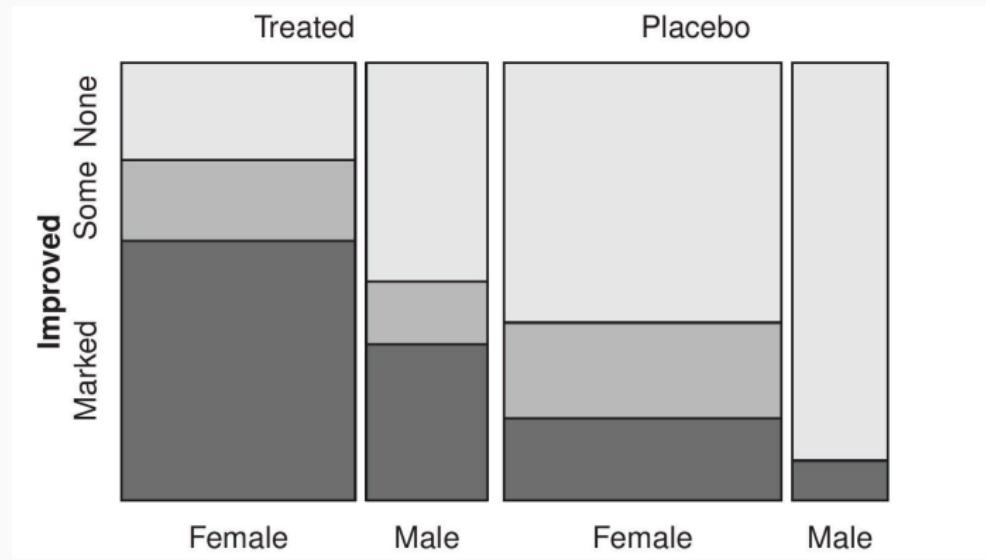
St. Louis Science Center attendance, 1998 to 2002



## Gallery – mosaic plot

Quantitative: Frequency (continuous),  $N_{\text{obs}} = 84$

Categorical: Sex (nomi, 2L), treatment (nomi, 2L), outcome (ordi, 3L)

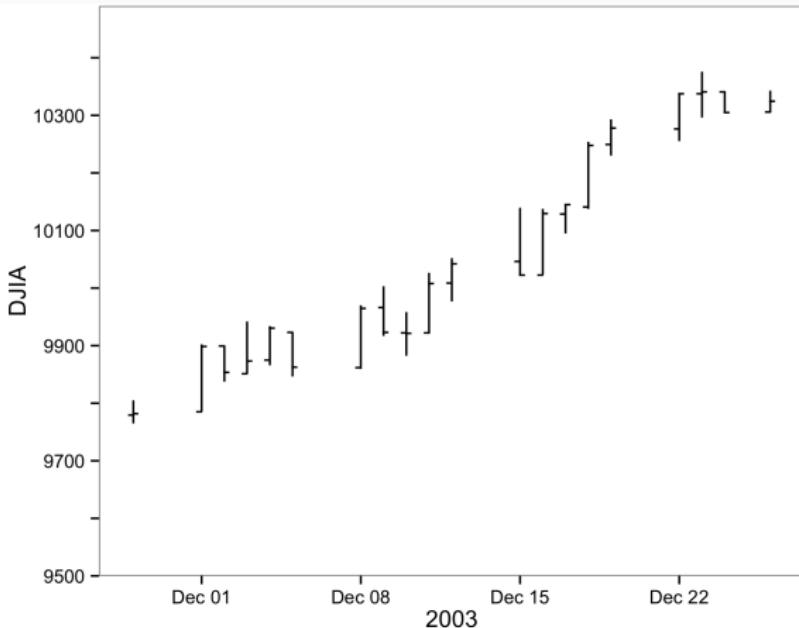


David Meyer, Achim Zeileis, and Kurt Hornik (2017) *vcd: Visualizing Categorical Data*, R package version 1.4-4,  
arthritis treatment data.

## Gallery – financial (OHLC) plot

Quantitative: Opening, high, low, closing price (continuous),  $N_{\text{obs}} = 20$

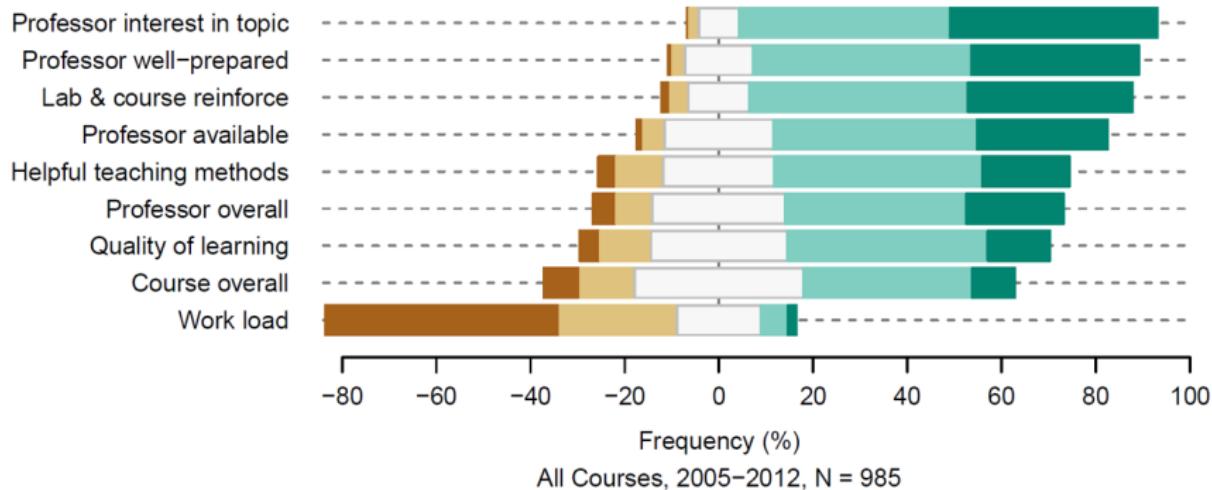
Categorical: Date (ordinal, 20 levels)



## Gallery – diverging stacked bar

Quantitative: Frequency (continuous),  $N_{\text{obs}} = 985$

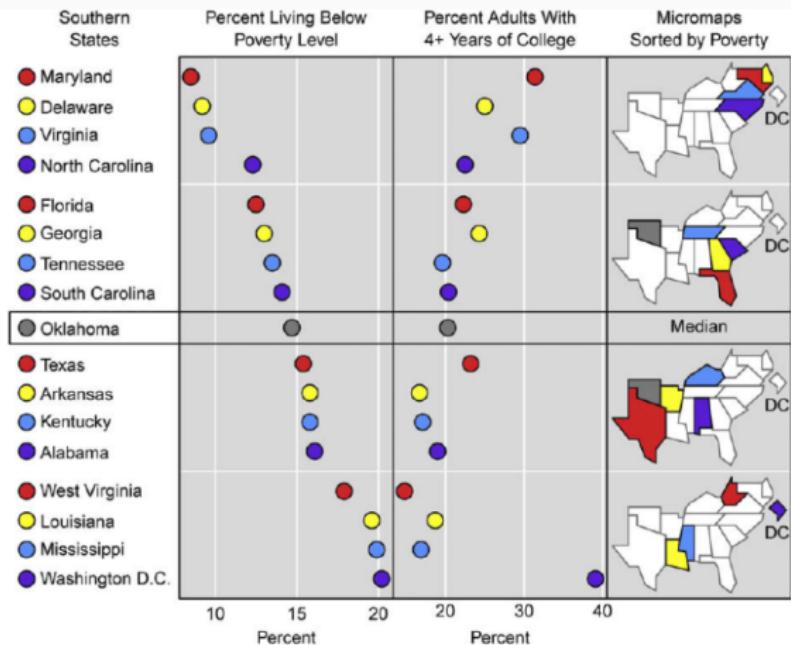
Categorical: Survey questions (nominal, 7L), responses (ordinal, 5L)



# Gallery – linked micromaps

Quantitative: Percent poverty, percent college (continuous),  $N_{\text{obs}} = 17$

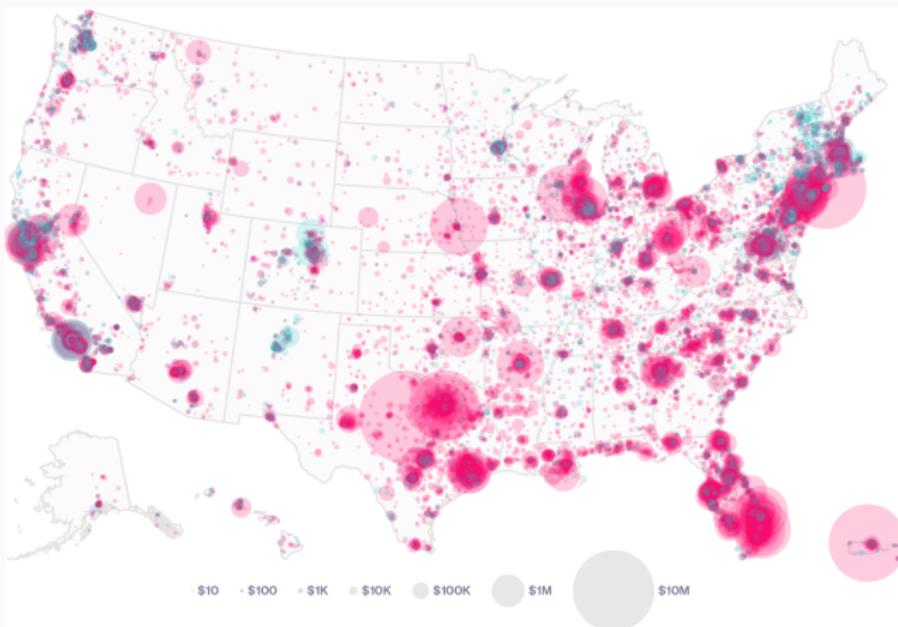
Categorical: State and geographic location (nominal, 17L)



Linda Pickle & Danial Carr (2010) Visualizing health data with micromaps, *Spatial and spatio-temporal epidemiology*, Vol. 1, pp. 143–50. <https://bit.ly/2H967PH>

## Gallery – proportional symbol map

Categorical: Contribution (ordinal, 7 levels), party (nominal, 2 levels), ZIP code location (nominal, 42k levels),  $N_{\text{obs}} = 42k$



Zach Mider, Christopher Cannon, and Adam Pearce (Sep 15, 2015) Here's exactly where the candidates' cash came from, <https://www.bloomberg.com/politics/graphics/2015-presidential-money-map/>

## Gallery – dot density map

Quantitative: One dot per person,  $N_{\text{obs}} = 308M$

Categorical: Race/ethnicity (nominal, 5L), geospatial location (nominal)

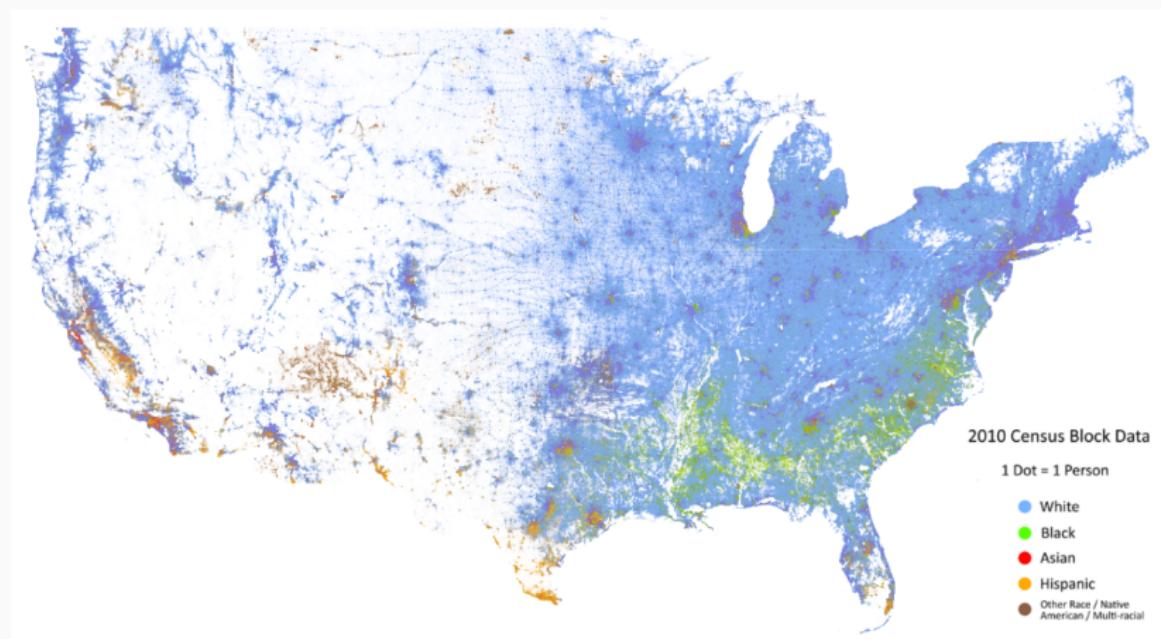
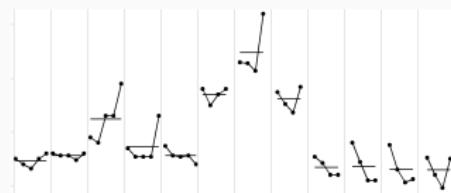


Image Copyright, 2013, Weldon Cooper Center for Public Service, Rector and Visitors of the University of Virginia  
(Dustin A. Cable, creator) <http://demographics.virginia.edu/DotMap/>

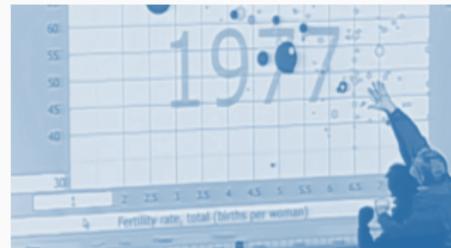
# Implications for the designer



Grasp the **data structure** first



Explore **data-suitable** designs



Align the **visual and verbal** arguments

Tell a truthful and compelling story

# Means

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# Use the right tool for the job

	RStudio	primary interface, integrates all our software
	R	tidying data and creating graphs
	R markdown	writing the portfolio, interleaving prose with code
	Git	local version control
	GitHub	collaborating and publishing the portfolio

# The main topical threads weave through the calendar

data  
software  
visual rhetoric  
repertoire of graphs  
portfolio

calendar		
		agenda & assignments
		paper reprint, with permission e-copy on Moodle, with permission
1	M	Course goals and outcomes [ <a href="#">slides</a> ] <a href="#">Syllabus</a> <a href="#">Sign-out two reprints</a>
	T	Introduction to visual rhetoric <a href="#">Install software</a>
	R	Relating data structure to graph design Doumont (2009) Designing the graph
	F	<a href="#">Software studio</a>
2	M	Graph basics with ggplot2 [ <a href="#">exercises</a> ]
	T	Tufte (1997) Decision to launch Challenger
	R	Data basics [ <a href="#">exercises</a> ]

# References

Cairo A (2014) *Ethical infographics*. The Investigative Reporters and Editors Journal, Spring 2014

<https://www.dropbox.com/s/pqgmg02yz0pgju4/EthicalInfographics.pdf>

Robbins N (2013) *Creating More Effective Graphs*. Chart House, Wayne, NJ

Unwin A (2015) *GDAdata: Datasets for the book Graphical Data Analysis with R*. R package version 0.93

<https://CRAN.R-project.org/package=GDAdata>