A first course in data science

Teaching Data Science, Reproducibly @ ICOTS 2018

Mine Çetinkaya-Rundel & Colin Rundel

July 8, 2018

goal

a course that provides
a common (gateway) experience
to students wanting to get started with stats,
and that is

modern	place data front and center	quantitative (but without math prereqs)	different than HS stats	challenging, but not Intimidating

this course should...

emphasize modern and multivariate EDA + data visualization

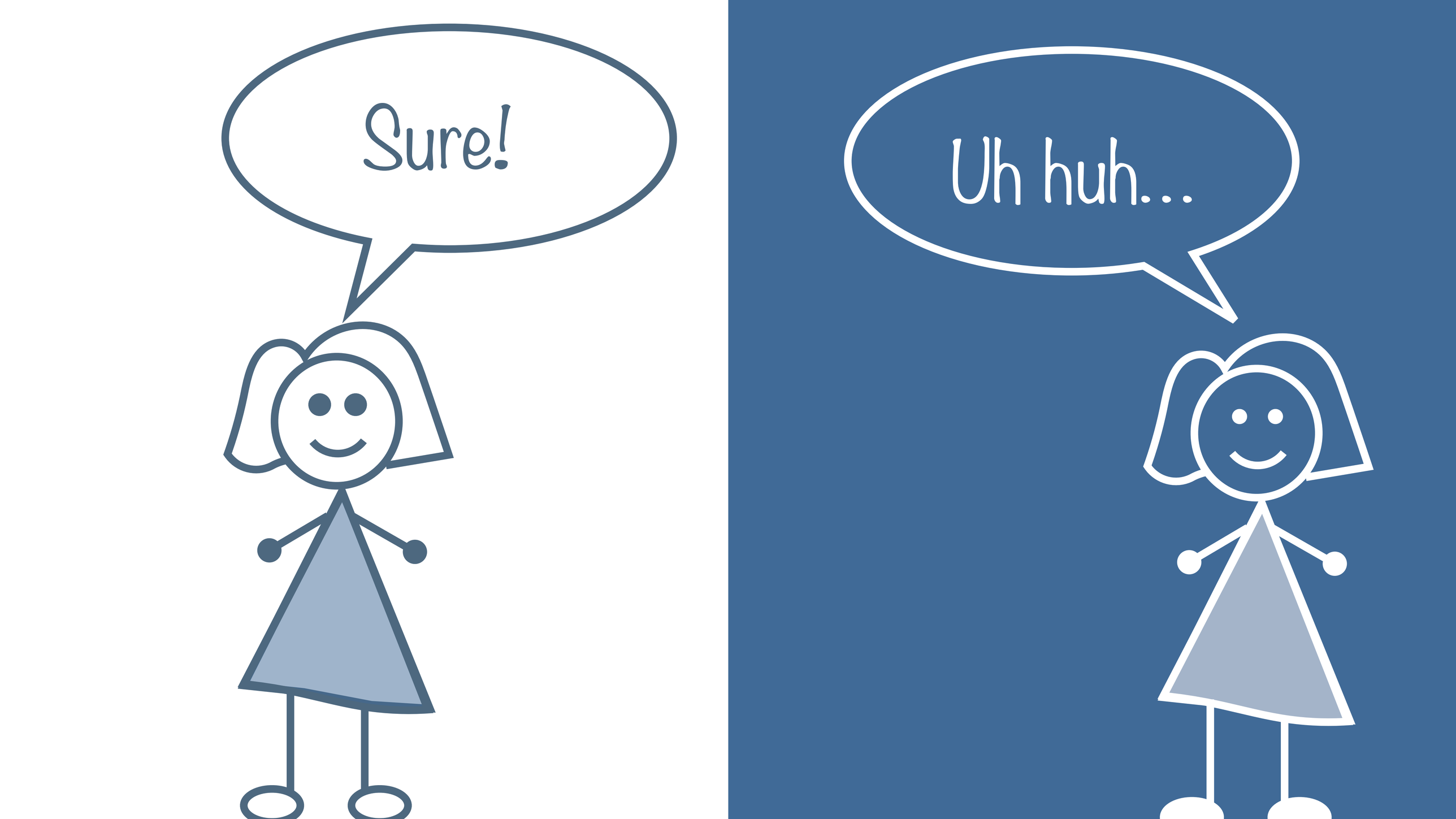
start at the beginning of data analysis cycle with data collection and cleaning

encourage + enforce working collaboratively (think, code, write, present)

teach (not just expect) reproducible computing

approach statistics from a model based perspective

underscore effective communication of findings


Sure!
Uh huh...


12345

1

rethink , don’t just add

don't start with this

- Exploratory data analysis
- Study design
- Probability
- Random variables
- Central Limit Theorem
- One sample mean HT and CI
- One sample proportion HT and CI
- Two sample mean HT and CI
- Two sample proportion HT and CI
- Chi-square test
- ANOVA
- Simple linear regression

and add all this

+ R
+ R Markdown
+ git / GitHub
+ data scraping
+ iteration
+ working with non-rectangular data
+ interactive visualization

...

curriculum

Fundamentals of data & data viz, revision exercises, confounding variables and Simpson's paradox (and git/GitHub)

Tidy data, data frames vs. summary tables, recoding and transforming variables, web scraping and iteration

Building and selecting models, visualizing interactions, prediction and model validation, inference via simulation & discussion of CLT

Interactive visualization and reporting with Shiny, Bayesian inference, text analysis, ???

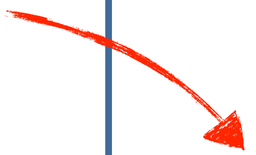
course overview

structure:

teams: in class exercises + projects
individual: HW + two take home midterms

assessment:

not just final work but also the process, peer evaluations and contribution diagnostics



more on this tomorrow!

2

cherish

day

one

course overview

minimize
time spent
on course logistics

maximize
time spent
creating a data
visualization

logistics

~min 10 of first class
give students a short link
to join the workspace

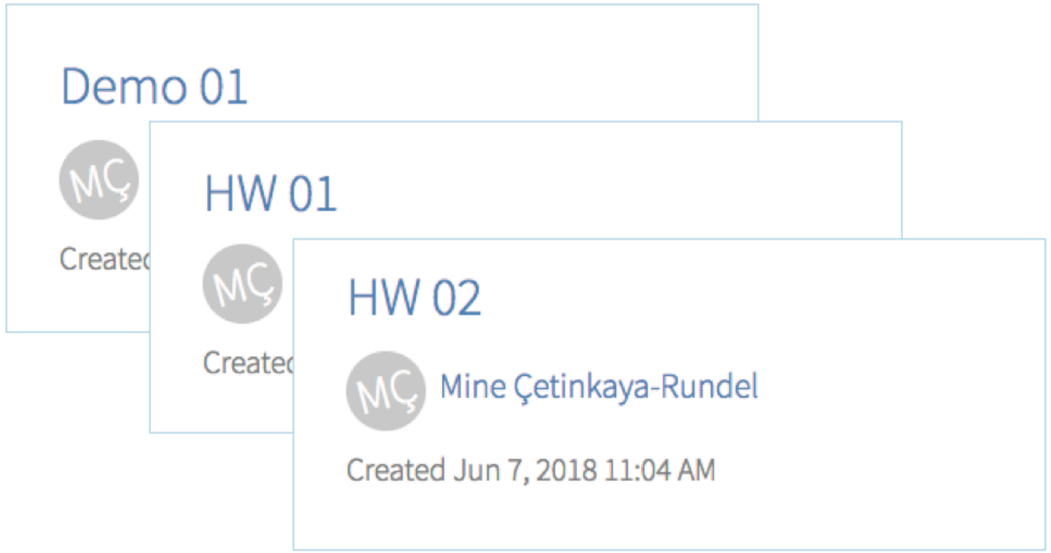
WORKSPACE

CLASS

more on this tomorrow!

students make a copy of project,
which comes with all
required packages installed
+ Rmd of demo analysis

PROJECT



ASSIGNMENT

stick with a consistent grammar

consistent grammar

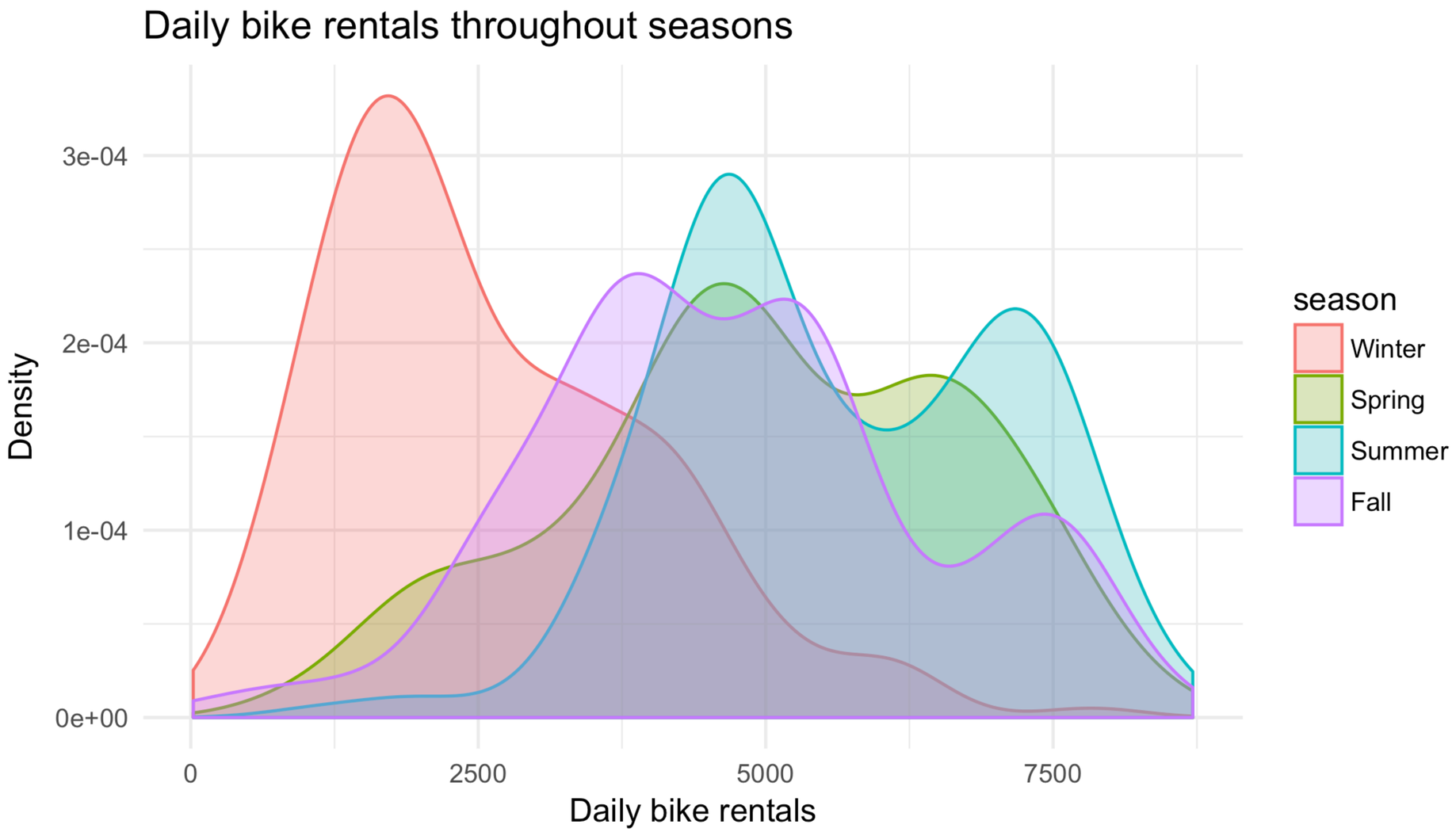
choose a grammar that grows with the complexity of the analysis

but that doesn't require constantly climbing a steep learning curve

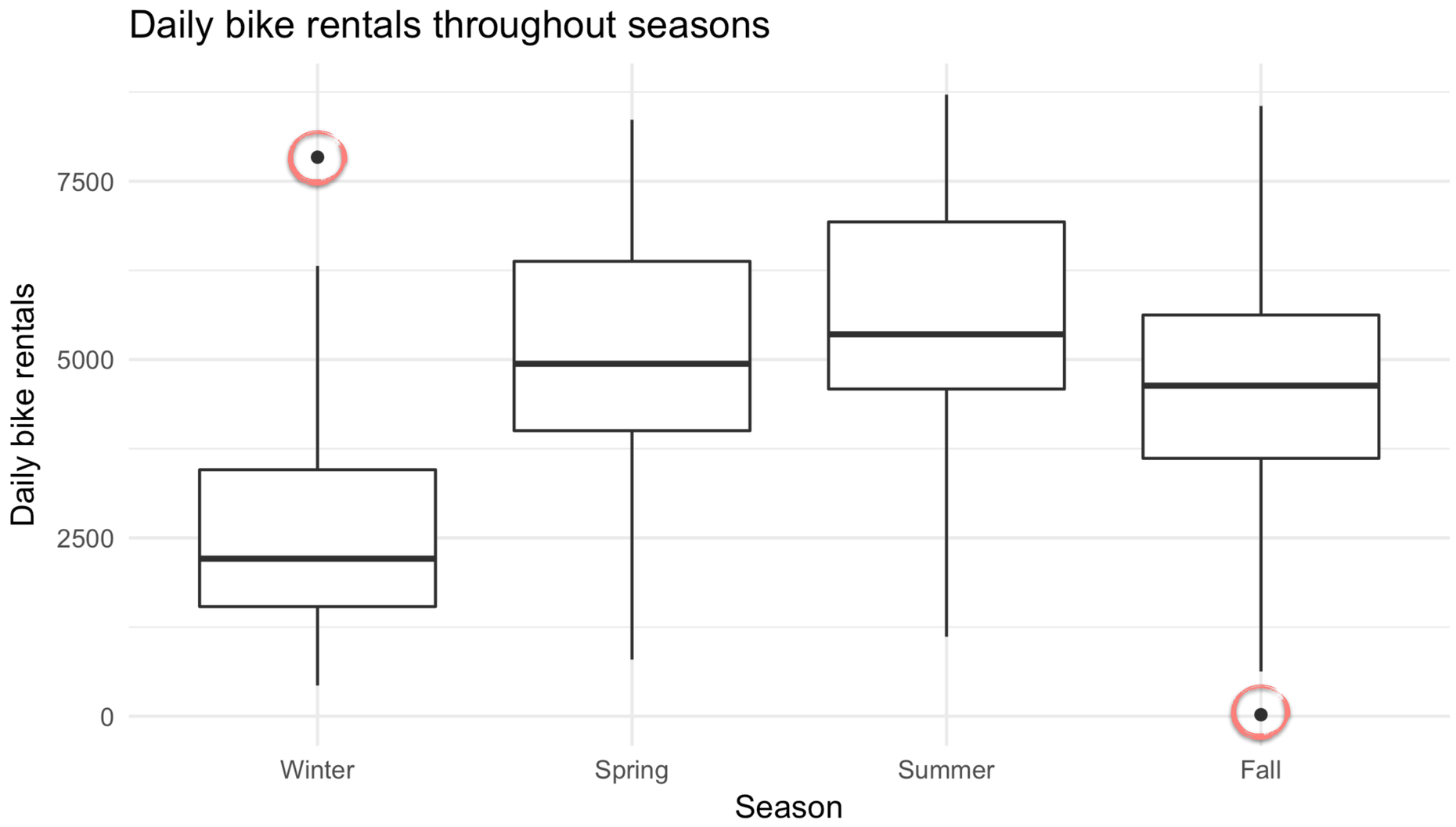
4 use real and relatable examples

citibikes in DC

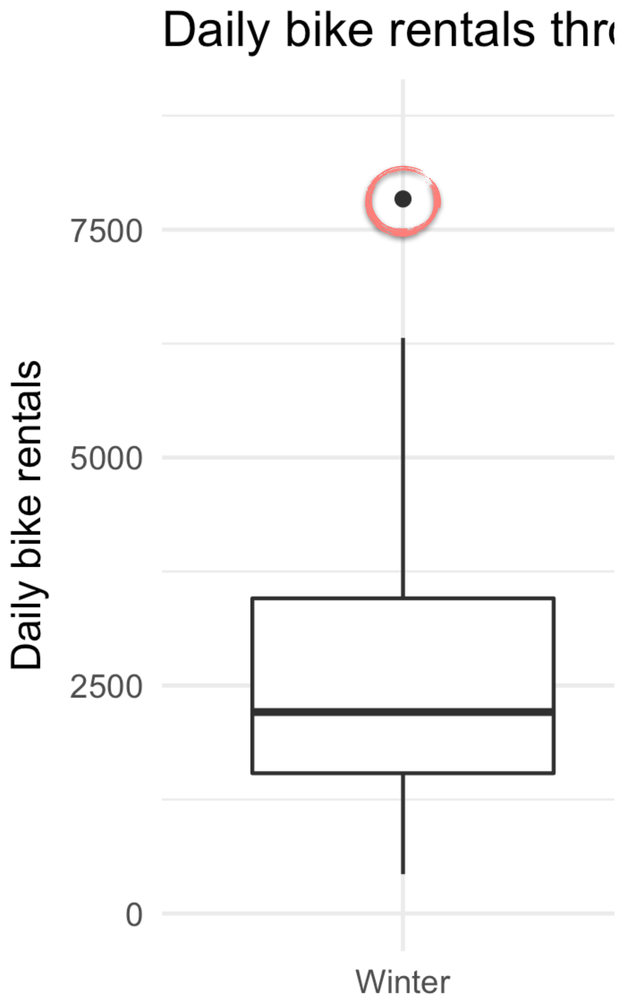
Question 8. Create a visualization displaying the relationship between bike rentals and season. Interpret the plot in context of the data.



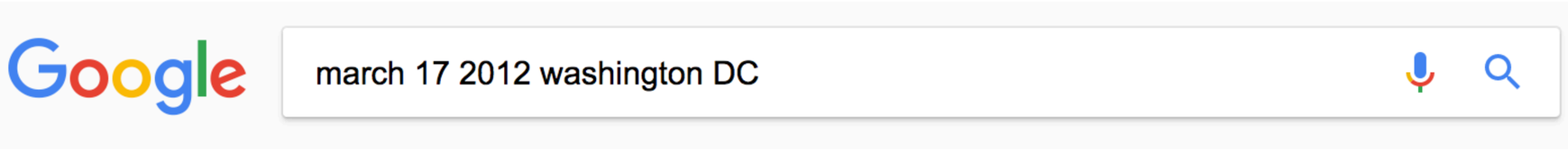
Question 8. Create a visualization displaying the relationship between bike rentals and season. Interpret the plot in context of the data.



Question 8. Create a visualization displaying the relationship between bike rentals and season. Interpret the plot in context of the data.

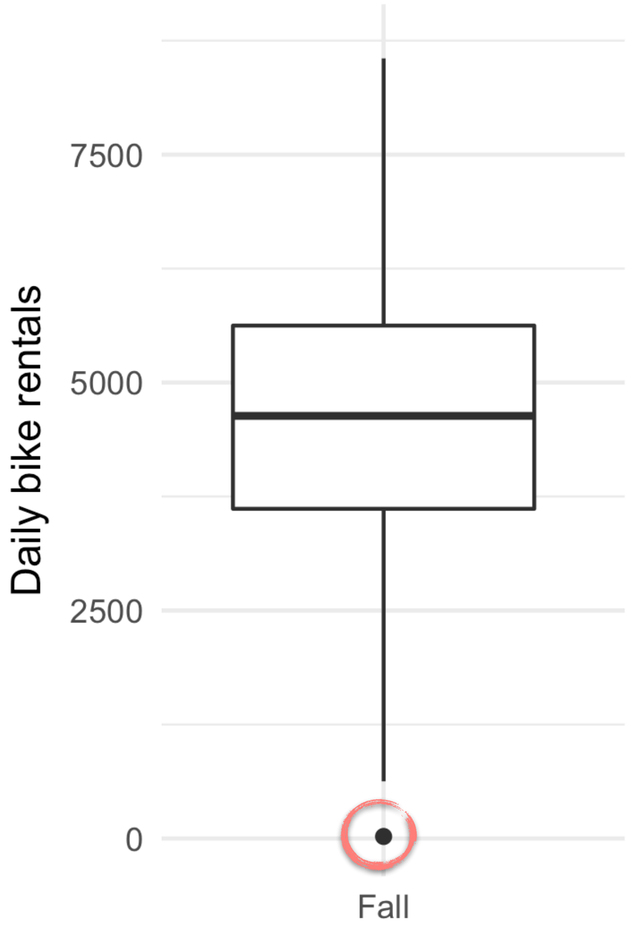



```
bike %>%
  filter(season == "Winter") %>%
  summarise(min = max(cnt), day_min = dteday[which.max(cnt)])
## # A tibble: 1 x 2
##     min day_min
##   <dbl> <date>
## 1  7836 2012-03-17
```

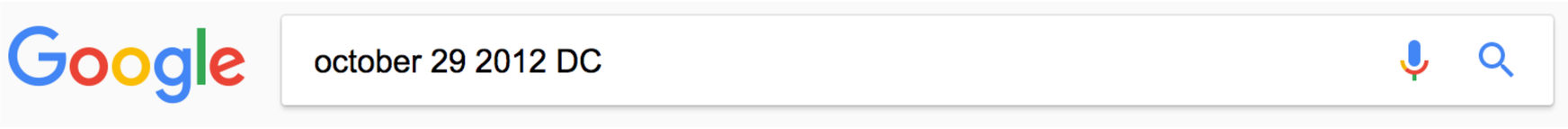


President Obama at the Dubliner on St. Patrick's Day | whitehouse.gov
https://obamawhitehouse.archives.gov/.../2012/.../17/president-obama-dubliner-st-patr...
17 Mar 2012 - President Barack Obama is reflected in a mirror at the Dubliner, an Irish pub in **Washington, D.C.**, with his Irish cousin, Henry Healy, and Ollie Hayes, a pub owner in Moneygall, Ireland, on St. Patrick's Day, **Saturday, March 17, 2012**. (Official White House Photo by Pete Souza). President Obama Greets the ...

Question 8. Create a visualization displaying the relationship between bike rentals and season. Interpret the plot in context of the data.




```
bike %>%
  filter(season == "Fall") %>%
  summarise(min = min(cnt), day_min = dteday[which.min(cnt)])
## # A tibble: 1 x 2
##     min day_min
##   <dbl> <date>
## 1  22.0 2012-10-29
```



Washington DC shuts down in preparation for hurricane Sandy | US ...
https://www.theguardian.com/.../2012/oct/29/washington-dc-shutdown-hurricane-sand...
28 Oct 2012 - Panic buying and fears over capability of power companies as first light rains reach city.

Hurricane Sandy: high winds and flooding hit US east coast – Monday ...
https://www.theguardian.com/.../us.../2012/oct/29/hurricane-sandy-new-york-live-blo...
30 Oct 2012 - Announces plans for a Storm Recovery Support Call Center operated by @Delaware_DHSS will open tomorrow at noon. Gov. Markell: The message for tonight is to hunker down. Weather Underground (@wunderground). 470,000 without power in 13 states and **DC**. **October 29**,

learning goals

main
prediction and
model selection

get for free
use of
outside data

paris paintings

data source: auction catalogs

89 Deux tableaux très riches de compoſition, d'une belle exécution, & dont le mérite eſt très remarquable, chacun de 17 pouces 3 lignes de haut, ſur 23 pouces de large; le premier, peint ſur bois, vient du Cabinet de Madame la Comteſſe de Verrue; il repréſente un départ pour la chaſſe : on y voit ſur le devant un

1066 -

enrich

Le ſecond tableau, qui eſt ſur toile, fait voir un terrein d'une grande étendue, près la mer qui eſt à gauche, & ſur laquelle ſont des vaiſſeaux : on y voit auſſi des bagages que l'on décharge d'un charriot, des hommes, des femmes, des enfants, deux chevaux qui mangent, & des mulets chargés de bagages.

Two paintings very rich in composition, of a beautiful execution, and whose merit is very remarkable, each 17 inches 3 lines high, 23 inches wide; the first, painted on wood, comes from the Cabinet of Madame la Comtesse de Verrue; it represents a departure for the hunt: it shows in the front a child on a white horse, a man who gives the horn to gather the dogs, a falconer and other figures nicely distributed across the width of the painting; two horses drinking from a fountain; on the right in the corner a lovely country house topped by a terrace, on which people are at the table, others who play instruments; trees and fabriques pleasantly enrich the background.

data transcription

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
1	name	sale	lot	dealer	year	origin_ author	origin_ cat	school_ pntg	diff_origin	price	count	subject	authorstandard	artistliving	authorstyle	author	winnir
2517	R1777-86	R1777	86	R	1777	D/FL	D/FL	D/FL	0	620.0	1	2 femmes, enfants, paysage vu à travers une arcade	Bega, Cornelis Pieterszoon	0	n/a	Corneille Bega	Lebrur
2518	R1777-87	R1777	87	R	1777	D/FL	D/FL	D/FL	0	12,000.0	1	Course du hareng	Wouwerman, Philips	0	n/a	Philippe Wouwerman	Donjeu
2519	R1777-88	R1777	88	R	1777	D/FL	D/FL	D/FL	0	8,000.0	1	Paysage sablonneux	Wouwerman, Philips	0	n/a	Philippe Wouwerman	Lambe
2520	R1777-89a	R1777	89	R	1777	D/FL	D/FL	D/FL	0	5,300.0	1	Départ pour la chasse	Wouwerman, Philips	0	n/a	Philippe Wouwerman	Langlie

	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
1	winningbidder	winningbiddertype	endbuyer	interm	type_interm ed	Height_in	Width_in	Surface_Rect	Diam_in	Surface_Rn d	Shape	Surface	material	mat	quantity	nfigures	engraved
2516	Feuillet	D	D	0		16	20	320			squ_rect	320	toile	t	1	0	0
2517	Lebrun, Jean-Baptiste-Pierre	D	D	0		13.25	11	145.75			squ_rect	145.75	bois	b	1	0	0
2518	Donjeux, Vincent	D	D	0		23	29.25	672.75			squ_rect	672.75	toile	t	1	50	0
2519	Lambert, John (Chevalier Lambert)	C	C	0		23	30	690			squ_rect	690	toile	t	1	0	1
2520	Langlier, Jacques for Poullain, Antoine	DC	C	1	D	17.25	23	396.75			squ_rect	396.75	bois	b	1	0	0

	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF
1	nfigures	engraved	original	prevcoll	othartist	paired	figures	finished	lrgfont	relig	landsALL	lands_ sc	lands_ figs	lands_ment	arch	mytho	peasant	othgenre	singlefig	portrait	still_life	discauth	history	allegory	pastorale	other
2516	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2517	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
2518	50	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2519	0	1	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2520	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

- **mat** - category of material (a=silver, al=alabaster, ar=slate, b=wood, bc=wood and copper, br=bronze frames, bt=canvas on wood, c=copper, ca=cardboard, co=cloth, e=wax, g=grissaille technique, h=oil technique, m=marble, mi=miniature technique, o=other, p=paper, pa=pastel, t=canvas, ta=canvas?, v=glass, n/a=NA, (blanks)=NA)
- **Shape** - shape of painting

```
pp <- pp %>%
  mutate(
    Shape = fct_collapse(Shape, oval = c("oval", "ovale"),
                                round = c("round", "ronde"),
                                squ_rect = "squ_rect",
                                other = c("octogon", "octagon", "miniature")),
    mat = fct_collapse(mat, metal = c("a", "br", "c"),
                            canvas = c("co", "t", "ta"),
                            paper = c("p", "ca"),
                            wood = "b",
                            other = c("e", "g", "h", "mi", "o", "pa", "v", "al", "ar", "m"))
  )
```

learning goals

main

data provenance

modelling

diagnostic, log transformation

get for free

iterative

data

cleanup, i.e.

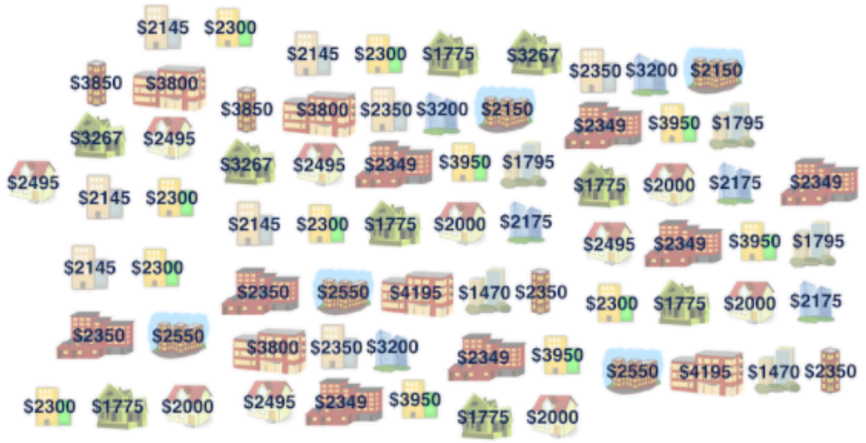
working with other people's data


manhattan apartments

observed sample

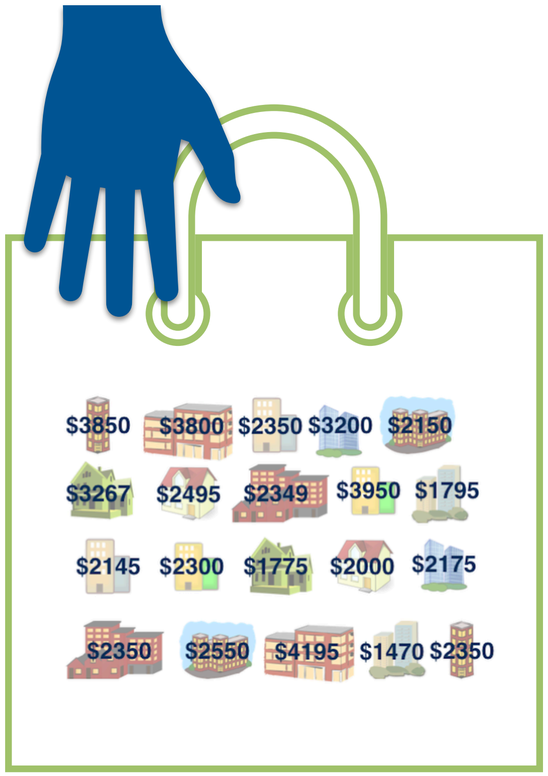
Sample median = $2350 😱

population



Population median = ❓

first, tactile simulation



Sample:

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20

Ordered sample:

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20

Bootstrap median:

then, computational simulation

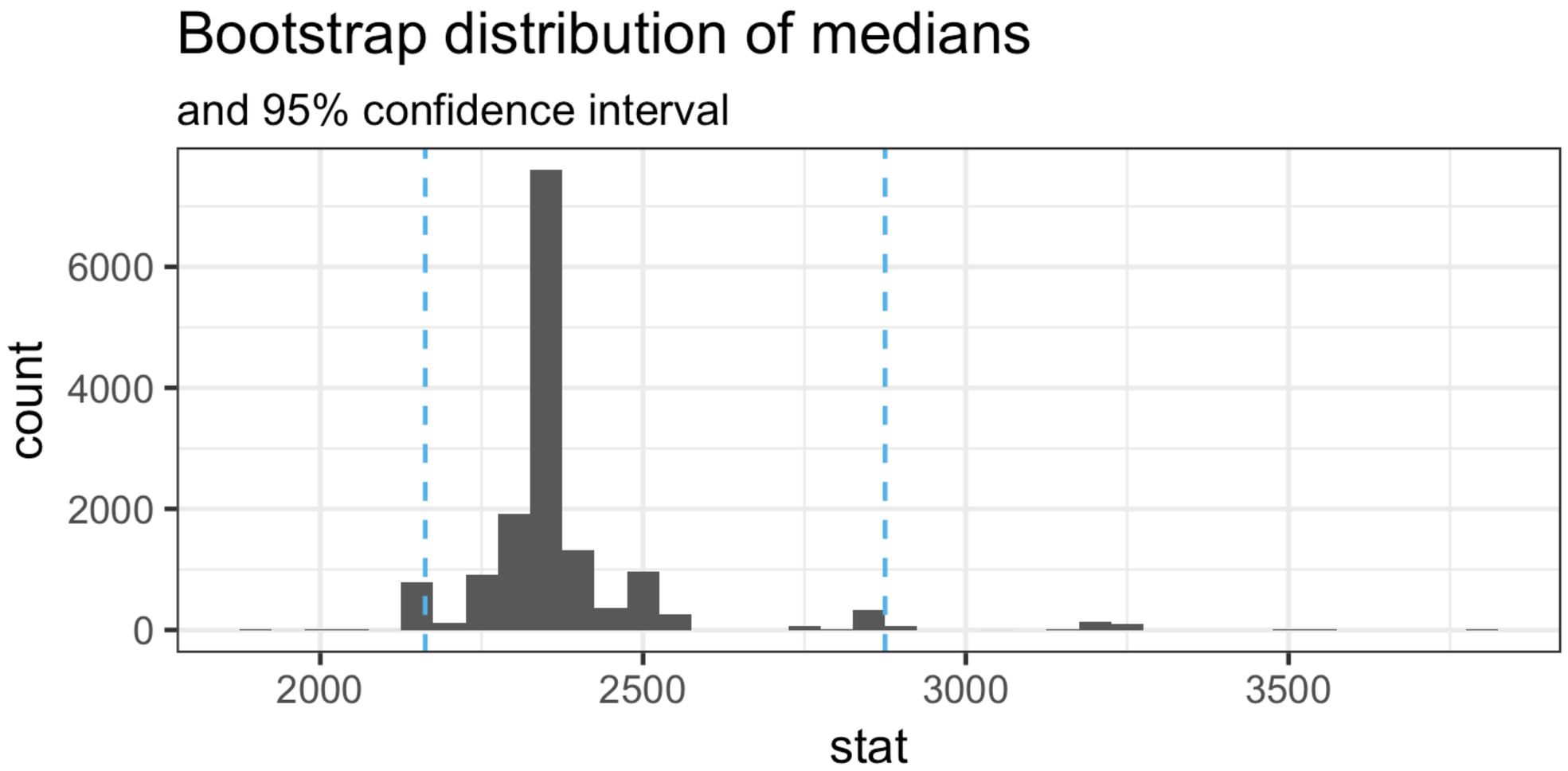
```
library(infer)

manhattan %>%

  # specify the variable of interest
  specify(response = rent) %>%

  # generate 15000 bootstrap samples
  generate(reps = 15000, type = "bootstrap") %>%

  # calculate the median of each bootstrap sample
  calculate(stat = "median")
```


Bootstrap distribution of medians
and 95% confidence interval
count
6000
4000
2000
0
2000
2500
3000
3500
stat

learning goals

main
estimation
via
bootstrapping

get for free
discussion on
representativeness
of samples

breweries

data

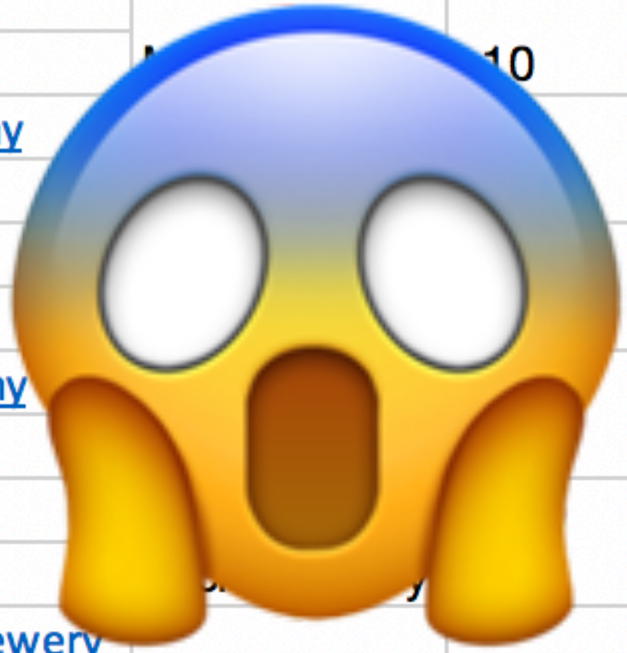
North Carolina Breweries

241 active | 25 closed

Name	Type	Beer Count	My Count	Est.
1718 Brewing Ocracoke Ocracoke	Brewpub	3	-	2018
217 Brew Works Wilson	Microbrewery	10	-	2017
3rd Rock Brewing Company Trenton	Microbrewery	13	-	2016
7 Clans Brewing Cherokee	Client Brewer	1	-	2018
Andrews Brewing Company Andrews	Microbrewery	18	-	2014
Angry Troll Brewing Elkin	Microbrewery	8	-	2017
Appalachian Mountain Brewery Boone	Microbrewery	79	-	2013
Archetype Brewing Asheville	Microbrewery	24	-	2017

copy-paste

	A	B	C	D	E
1	**Name**	**Type**	**Beer Count**	**My Count**	**Est.**
2	1718 Brewing Ocracoke				
3	Ocracoke	Brewpub	3	-	2018
4	217 Brew Works				
5	Wilson		10	-	2017
6	3rd Rock Brewing Company				
7	Trenton			-	2016
8	7 Clans Brewing				
9	Cherokee			-	2018
10	Andrews Brewing Company				
11	Andrews			-	2014
12	Angry Troll Brewing				
13	Elkin			-	2017
14	Appalachian Mountain Brewery				
15	Boone	Microbrewery	79	-	2013
16	Archetype Brewing				
17	Asheville	Microbrewery	24	-	2017



scrape

```
library(tidyverse)
library(rvest)

page ← read_html("https://www.ratebeer.com/breweries/north%20carolina/33/213/")

names ← page %>%
  html_nodes("#brewerTable a:nth-child(1)") %>%
  html_text() %>%
  str_trim()

active_cities ← page %>%
  html_nodes(".filter") %>%
  html_text()

closed_cities ← page %>%
  html_nodes("#brewerTable span") %>%
  html_text()

cities ← c(active_cities, closed_cities)

…

ncbreweries ← tibble(
  name = names,
  city = cities,
  …
)

write_csv(ncbreweries, path = "data/ncbreweries.csv")
```

tidy data

	name	city	type	beercount	est	status	url
1	1718 Brewing Ocracoke	Ocracoke	Brewpub	3	2018	Active	https://www.ratebeer.com//brewers/171
2	217 Brew Works	Wilson	Microbrewery	10	2017	Active	https://www.ratebeer.com//brewers/217
3	3rd Rock Brewing Company	Trenton	Microbrewery	13	2016	Active	https://www.ratebeer.com//brewers/3rd-
4	7 Clans Brewing	Cherokee	Client Brewer	1	2018	Active	https://www.ratebeer.com//brewers/7-cl
5	Andrews Brewing Company	Andrews	Microbrewery	18	2014	Active	https://www.ratebeer.com//brewers/and
6	Angry Troll Brewing	Elkin	Microbrewery	8	2017	Active	https://www.ratebeer.com//brewers/ang
7	Appalachian Mountain Brewery	Boone	Microbrewery	79	2013	Active	https://www.ratebeer.com//brewers/app
8	Archetype Brewing	Asheville	Microbrewery	24	2017	Active	https://www.ratebeer.com//brewers/arch
9	Asheville Brewing Company	Asheville	Brewpub	88	2003	Active	https://www.ratebeer.com//brewers/ashe
10	Ass Clown Brewing Company	Cornelius	Microbrewery	108	2011	Active	https://www.ratebeer.com//brewers/ass-
11	Aviator Brewing Company	Fuquay Varina	Microbrewery	60	2008	Active	https://www.ratebeer.com//brewers/avia
12	Balsam Falls Brewing Company	Sylva	Microbrewery	25	2018	Active	https://www.ratebeer.com//brewers/bals
13	Barking Duck Brewing Company	Mint Hill	Microbrewery	16	2014	Active	https://www.ratebeer.com//brewers/bark
14	Barrel Culture Brewing and Blending	Durham	Microbrewery	40	2017	Active	https://www.ratebeer.com//brewers/barr

functions

Secure | https://www.ratebeer.com/brewers/1718-brewing-ocracoke/35300/

1718 Brewing Ocracoke

Brew Pub
1129 Irvin Garrish HWY, Ocracoke, North Carolina, USA 27960
(252) 928-2337
Mon-Sat: 12 ot 9 pm

ocracokebrewing.com
Associated place: **1718 Brewing Ocracoke**

BREWERS: **Discover our brewer resources here.**
Are you affiliated with this brewery?

★ Follow

Beers | Reviews | Distribution Map | Distributors

Name	ABV	Added
1718 Ocracoke Coffee Kölsch Kölsch	5.0	4/20/2018
1718 Ocracoke Good Bones IPA India Pale Ale (IPA)	-	4/20/2018
1718 Ocracoke Pepperberry Saison Saison	7.1	4/20/2018

learning goals

main
data
harvesting

get for free
parsing
text strings

iteration

teach tools for good science

literate programming

reproducibility:

train new analysts whose only workflow is a reproducible one

efficiency:

consistent formatting + built in "show your work" = easier grading

pedagogy:

code + output + prose together

syntax highlighting + notebooks FTW!

key to success:

iterative development: knit early, and often

version control

version control:

lots of mistakes along the way, need ability keep track of history (revert)

accountability:

transparent commit history

collaboration:

platform and interface designed to enable collaboration

early intro:

mastery takes time, start early (day 1)

marketability + discoverability

1 rethink, don’t just add

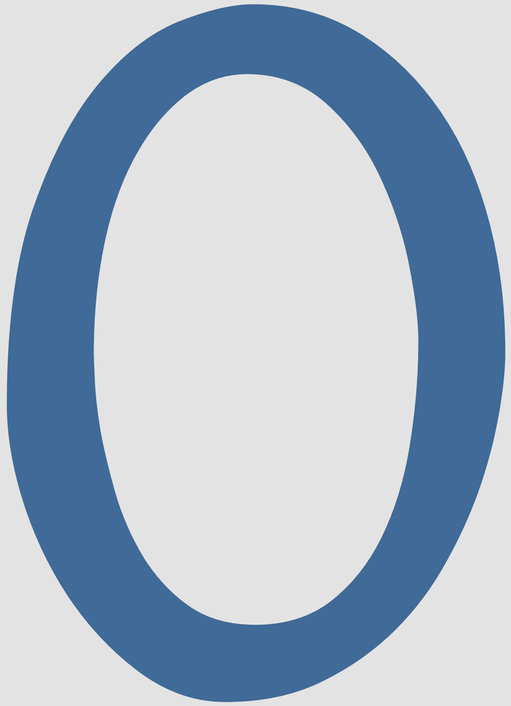
2 cherish day one

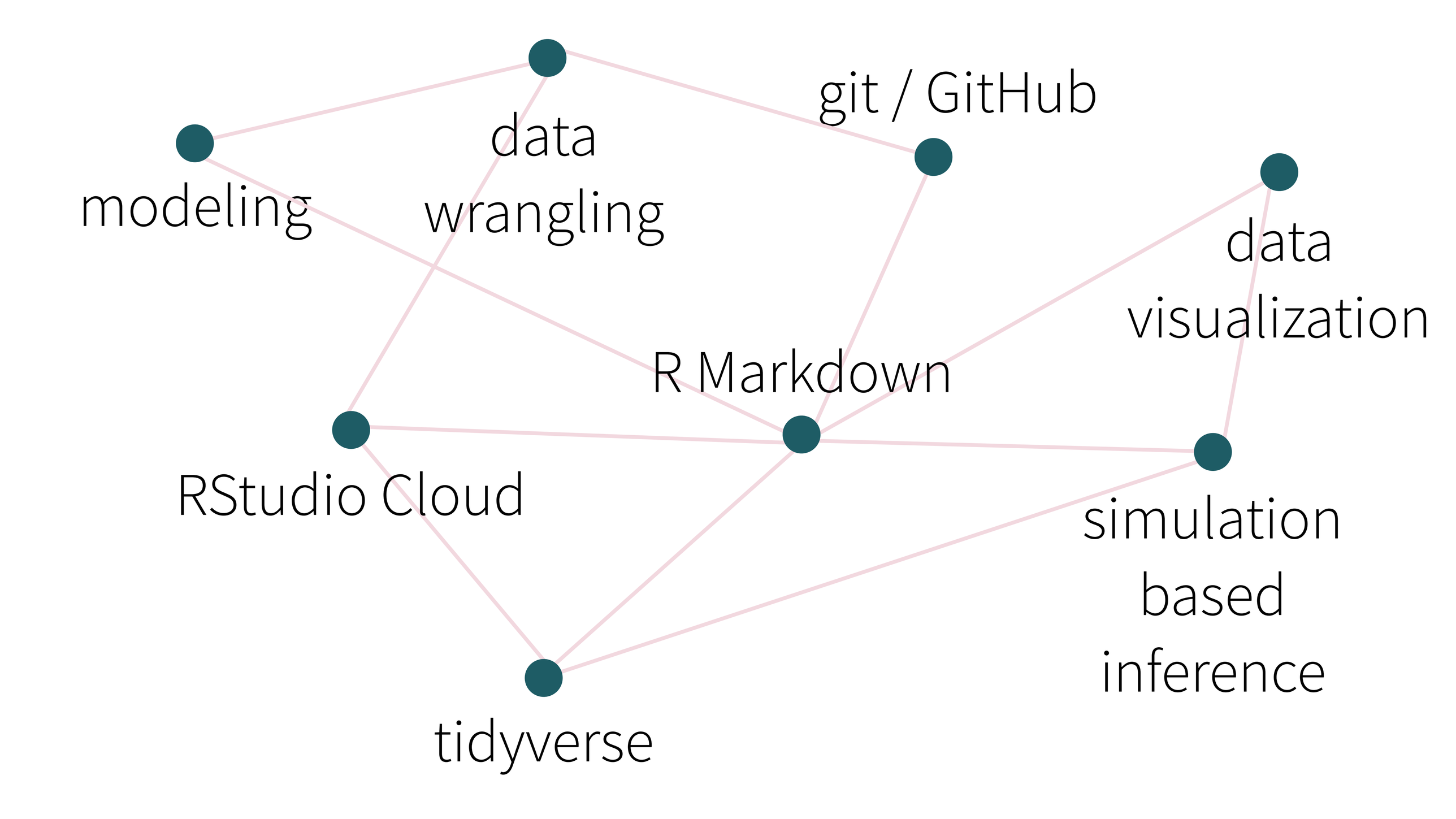
3 stick with a consistent grammar

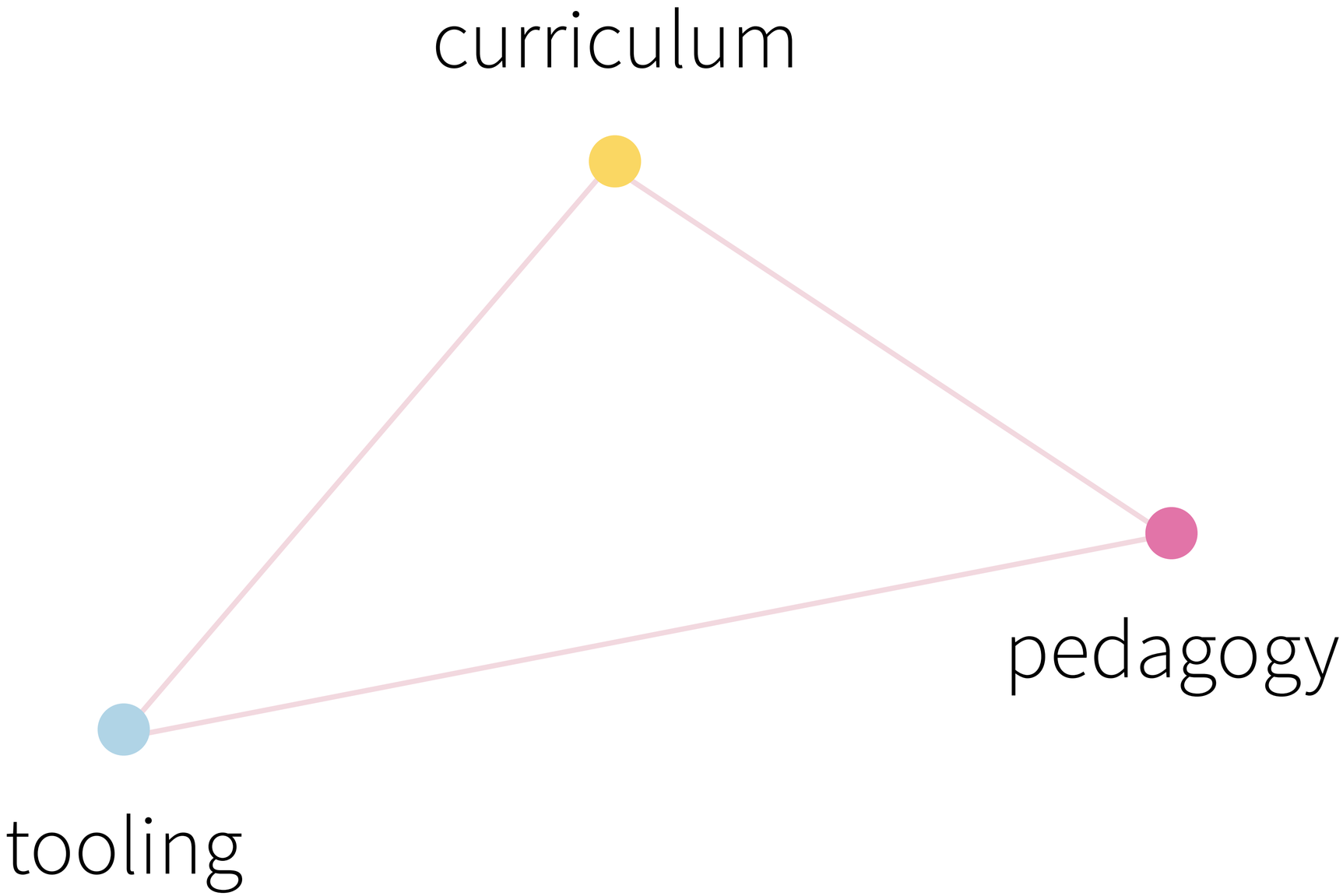
4 use real and relatable examples

5 teach tools for good science

you're not alone




modeling
data wrangling
git / GitHub
data visualization
R Markdown
RStudio Cloud
simulation based inference
tidyverse


curriculum
pedagogy
tooling

bit.ly/dsbox-web

bit.ly/dsbox-repo

Search...

Hello #dsbox

Course content

Technology stack

Pedagogy

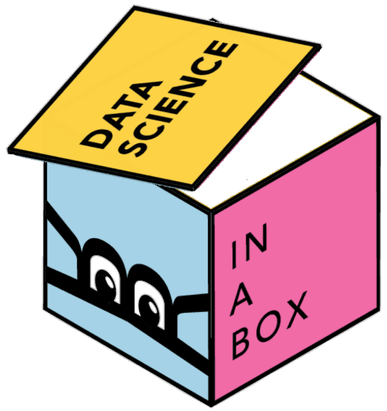
Built with ♥ and blogdown

Data Science in a Box

How can we effectively and efficiently teach data science to students with little to no background in computing and statistical thinking? How can we equip them with the skills and tools for reasoning with various types of data and leave them wanting to learn more?

This introductory data science course that is our (working) answer to this question. The core content of the course focuses on data acquisition and wrangling, exploratory data analysis, data visualization, inference, modeling, and effective communication of results. Time permitting, the course also introduces additional concepts and tools like interactive visualization and reporting Bayesian inference. A heavy emphasis is placed on a consitent syntax (with tools from the tidyverse), reproducibility (with R Markdown) and version control and collaboration (with git/GitHub). In addition, out-of-class learning is supplemented with interactive tutorials. The goal of the course is to bring students from zero to being able to work in a team to complete a fully reproducible data analysis project on a dataset of their choice and answering questions they care about.

Data Science in a Box contains the materials required to teach (or learn from) the course described above, all of which are freely-available and open-source. They include course materials such as slide decks, homework assignments, guided labs, sample exams, a final project assignment, as well as pedagogical tips, computing infrastructure, technology stack, and course logistics.



slides x 26

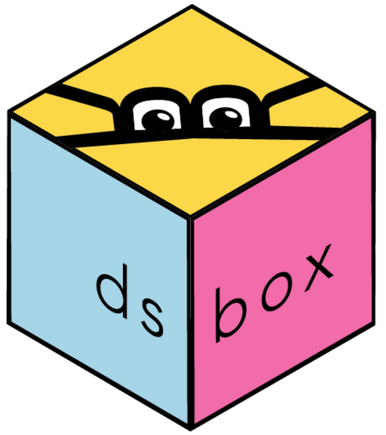
labs x 10

assignments x 6

project x 1

exams x 2

dsbox



Datasets for the Data Science Course in a Box

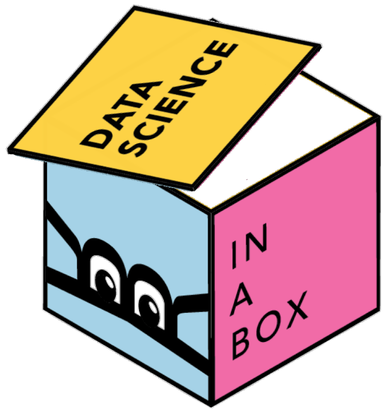
```
install_github("rstudio-education/dsbox")
```

course infrastructure

using the tech stack

lesson plans

pedagogical tips



more on these tomorrow!