



Data Science, from the ground up

bit.ly/user2017

Mine Çetinkaya-Rundel

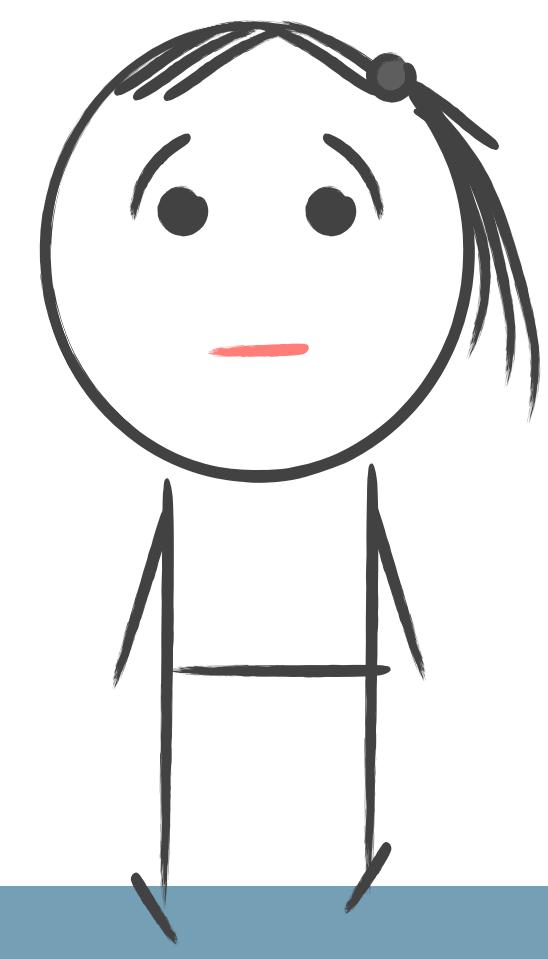
Duke University + RStudio

@minebocek

mine-cetinkaya-rundel

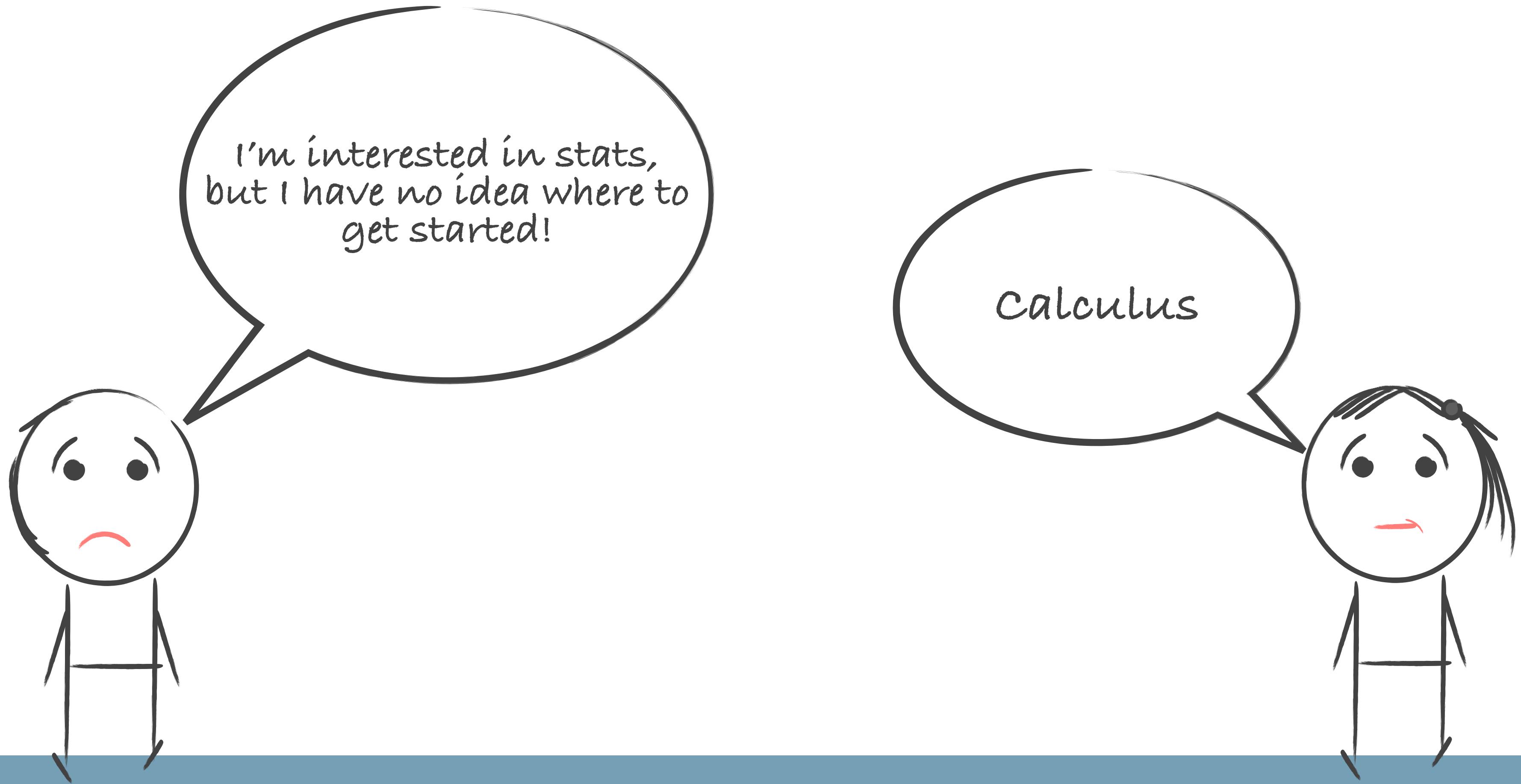
mine@rstudio.com

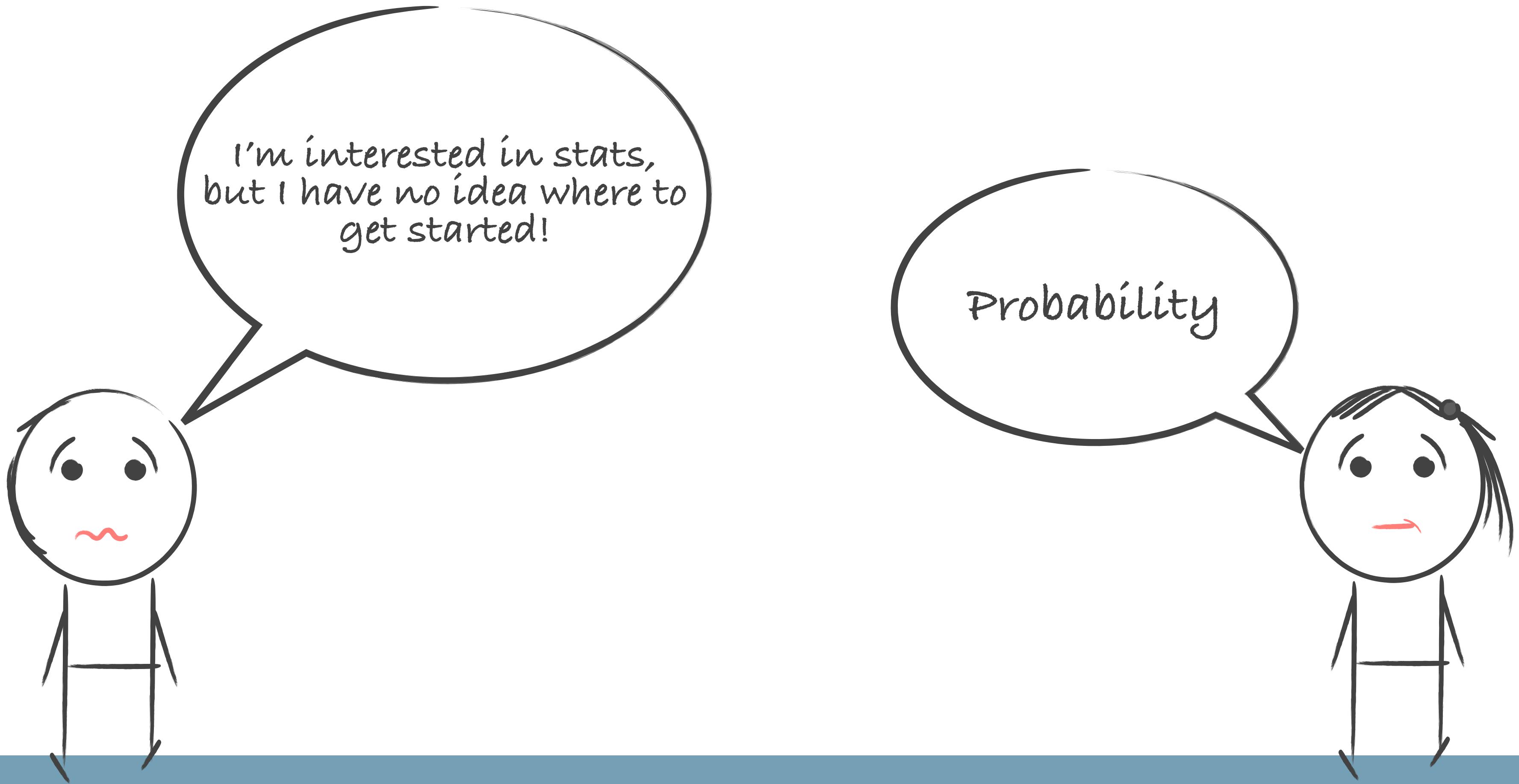
















motivation

computation

interest &
impact

syllabus

data analysis
examples

curricular
considerations

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goal

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

- * modern
- * places data front and center
- * quantitative (but not mathematical)
- * 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
computation

approach statistics
from a model
based perspective

underscore
effective
communication
of findings

and maybe more importantly...

ask questions that
students want to
answer

equip students
with the tools to
answer questions
of their own
choosing

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Better Living Through Data Science: Exploring / Modeling / Predicting / Understanding

Combines techniques from statistics, math, computer science, and social sciences, to learn how to use data to understand natural phenomena, explore patterns, model outcomes, and make predictions. Case studies include examples from election forecasts, movie reviews, and online dating match algorithms. Discussions around reproducibility, data sharing, data privacy will accompany these case studies.

Gain experience in data wrangling and munging, exploratory data analysis, predictive modeling, and data visualization, and effective communication of results. Course will focus on R statistical computing language.

No computing background necessary. For students in the FOCUS Program.

Part of the *What if? Explaining the Past, Predicting the Future* cluster.



first-year seminar for
undergrads interested in
quantitative fields

Intro to Data Science and Statistical Thinking

Intro to data science and statistical thinking. Learn to explore, visualize, and analyze data to understand natural phenomena, investigate patterns, model outcomes, and make predictions, and do so in a reproducible and shareable manner. Gain experience in data wrangling and munging, exploratory data analysis, predictive modeling, and data visualization, and effective communication of results. Work on problems and case studies inspired by and based on real-world questions and data.

The course will focus on the R statistical computing language. No statistical or computing background is necessary.



open to all students

course overview

curriculum:

data gathering + wrangling, EDA + viz, multivariate modeling, basic inference, communication

structure:

teams: in class exercises + projects
individual: HW + take home midterm and final

assessment:

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

assignments

culminating:

final open ended
project on data of
own choosing,
team based

periodic:

semi open ended
homework,
individual

in (every) class:

semi open ended
application
exercises,
team based

fast feedback:

learnr modules,
individual

Interactive Tutorials for R Mine

Secure <https://rstudio.github.io/learnr/>

learnr Home Exercises Questions Publishing Formats Examples

Interactive Tutorials for R

Overview

Getting Started

Tutorial Types

Exercises

Questions

Videos

Shiny Components

External Resources

Preserving Work

Publishing

Interactive Tutorials for R

Overview

The **learnr** package makes it easy to turn any [R Markdown](#) document into an interactive tutorial. Tutorials consist of content along with interactive components for checking and reinforcing understanding. Tutorials can include any or all of the following:

1. Narrative, figures, illustrations, and equations.
2. Code exercises (R code chunks that users can edit and execute directly).
3. Quiz questions.
4. Videos (supported services include YouTube and Vimeo).
5. Interactive Shiny components.

Tutorials automatically preserve work done within them, so if a user works on a few exercises or questions and returns to the tutorial later they can pick up right where they left off.

Examples

<https://rstudio.github.io/learnr/>

```
# on CRAN
> install.packages("learnr")
> library(learnr)
```

earnr package:

Data frames

The `flights` data frame in the `nmflights13` package is an example of a tibble. `flights` describes every flight that departed from New York City in 2013. The data comes from the US

Filter rows with `filter()`

allows you to subset observations based on their values. The first argument is the name of the data frame. The second and subsequent arguments are the expressions that filter the data frame. For example, we can select all flights on January 1st with:

```
filter(flights, month == 1, day == 1)
```

month	day	dep_time	sched_dep_time	dep_delay	arr_time
1	1	517	515	2	830
1	1	533	529	4	850
1	1	542	540	2	923
1	1	544	545	-1	1004
1	1	554	600	-6	812
1	1	554	558	-4	740
1	1	555	600	-5	913
1	1	557	600	-3	709
1	1	557	600	-3	838
1	1	558	600	-2	753

Rows 1-7 of 19 columns Previous 1 2 3 4 5 6 Next

run that line of code, dplyr executes the filtering operation and returns a new data frame. Functions never modify their inputs, so if you want to save the result, you'll need to assign operator, `←`.

Summarise Tables

Welcome

Summarise groups with `summarise()`

Combining multiple operations

Multiple steps

Imagine that we want to explore the relationship between the distance and average delay for each destination in `flights`. Using what you know about dplyr, you might write code like this:

```
by_dest <- group_by(flights, dest)
delay <- summarise(by_dest,
  count = n(),
  dist = mean(distance, na.rm = TRUE),
  delay = mean(arr_delay, na.rm = TRUE))
delay <- filter(delay, count > 20, dest != "HNL")
ggplot(data = delay, mapping = aes(x = dist, y = delay)) +
  geom_point(aes(size = count), alpha = 1/3) +
  geom_smooth(se = FALSE)
```

Scatter plot showing average arrival delay versus distance for destinations with more than 20 flights. The size of the points is proportional to the number of flights.

Summarizing Data

Data Visualization Basics Mine

Secure <https://tutorials.shinyapps.io/02-Vis-Basics/#section-geometric-objects>

Data Visualization Basics

Geometric objects

Geoms

Welcome

A code template

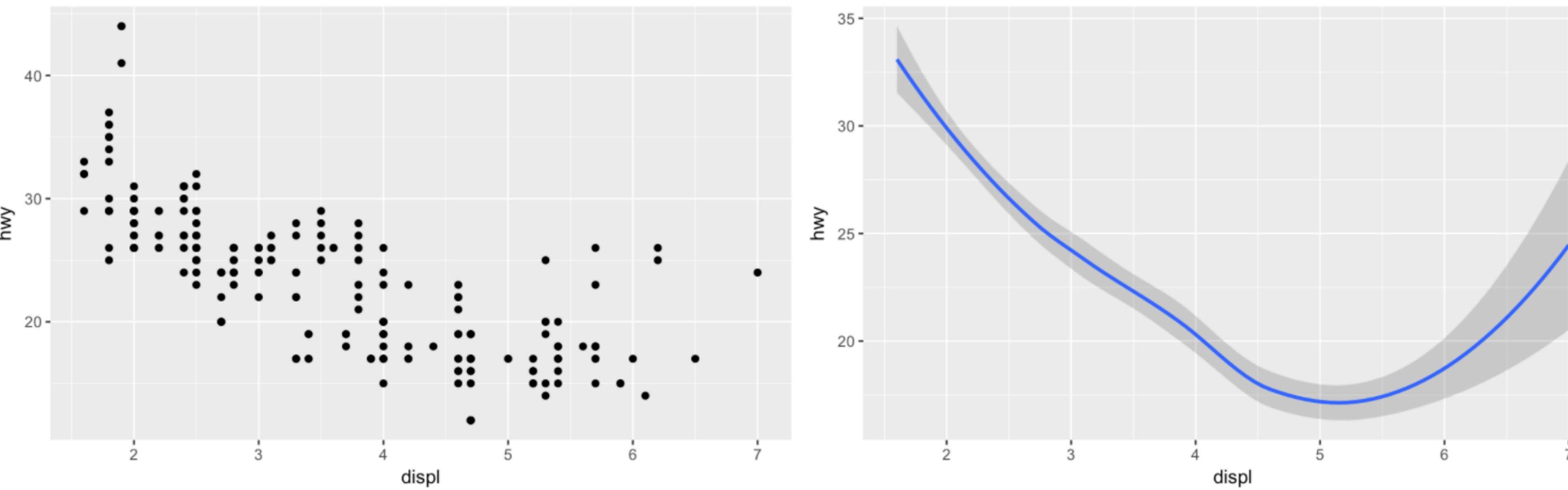
Aesthetic mappings

Geometric objects

The ggplot2 package

Start Over

How are these two plots similar?



Both plots contain the same x variable, the same y variable, and both describe the same data. But the plots are not identical. Each plot uses a different visual object to represent the data. In ggplot2 syntax, we say that they use different **geoms**.

A **geom** is the geometrical object that a plot uses to represent observations. People often describe plots by the type of geom that the plot uses. For example, bar charts use bar geoms, line charts use line geoms, boxplots use boxplot geoms, and so on. Scatterplots break the trend; they use the point geom.

As we see above, you can use different geoms to plot the same data. The plot on the left uses the point geom, and the plot on the right uses the smooth geom, a smooth line fitted to the data.

Continue

Data Visualization Basics

Secure https://tutorials.shinyapps.io/02-Vis-Basics/#section-aesthetic-mappings

✓ A strategy

Data Visualization Basics

We can add the `class` variable to the plot by mapping the levels of an aesthetic (like color) to the values of `class`. For example, we can color a point green if it belongs to the compact class, blue if it belongs to the midsize class, and so on.

Let's give this a try. Fill in the blank piece of code below with `color = class`. What happens? Delete the commenting symbols (`#`) before running your code. (If you prefer British English, you can use `colour` instead of `color`.)

Welcome

A code template

Aesthetic mappings

Geometric objects

The ggplot2 package

Code Start Over Hint Run Code Submit Answer

```
1 ggplot(data = mpg) +  
2 | geom_point(mapping = aes(x = displ, y = hwy, color = class))  
3
```

Start Over

displ

hwy

class

- 2seater
- compact
- midsize
- minivan
- pickup
- subcompact
- suv

"Great Job! You can now tell which class of car each point represents by examining the color of the point."

Data Visualization Basics Mine

Secure <https://tutorials.shinyapps.io/02-Vis-Basics/#section-geometric-objects>

Data Visualization Basics

Exercise 2

What does the `se` argument to `geom_smooth()` do?

- Nothing. `se` is not an argument of `geom_smooth()`
- chooses a method for calculating the smooth line
- controls whether or not to show errors
- Adds or removes a standard error ribbon around the smooth line

[Submit Answer](#)

[Start Over](#)

[Continue](#)

motivation

computation

interest & impact

syllabus

data analysis examples

curricular considerations

computation

core:

R + RStudio server

toolkit:

(mostly)

tidyverse

reproducibility:

R Markdown +
Git / GitHub

core:
R + RStudio server

why?

start up instructions

Local install

- Install R: <https://cran.r-project.org/>
- Install RStudio: <https://www.rstudio.com/products/rstudio/>
- Install the following packages:
 - rmarkdown
 - knitr
 - tidyverse
 - ...
- Load these packages

vs. # RStudio Server

- Go to smith.stat.duke.edu:8787
- Log in with your Net ID & pass

core: R + RStudio Server

goal:

minimize
onboarding friction
and time to 1st
data viz

how:

avoid local
installation with
RStudio Server
(Pro)

at the end:

provide
instructions for +
help with
local install

why?

toolkit:
(mostly)
tidyverse

recoding a binary variable

base R

```
mtcars$transmission <-  
  ifelse(mtcars$am == 0,  
         "automatic",  
         "manual")
```

vs. # tidyverse

```
mtcars <- mtcars %>%  
  mutate(  
    transmission =  
    case_when(  
      am == 0 ~ "automatic",  
      am == 1 ~ "manual"  
    ))
```

recoding a multi-level variable

base R

```
mtcars$gear_char <-  
  ifelse(mtcars$gear == 3,  
         "three",  
         ifelse(mtcars$gear == 4,  
                "four",  
                "five"))
```

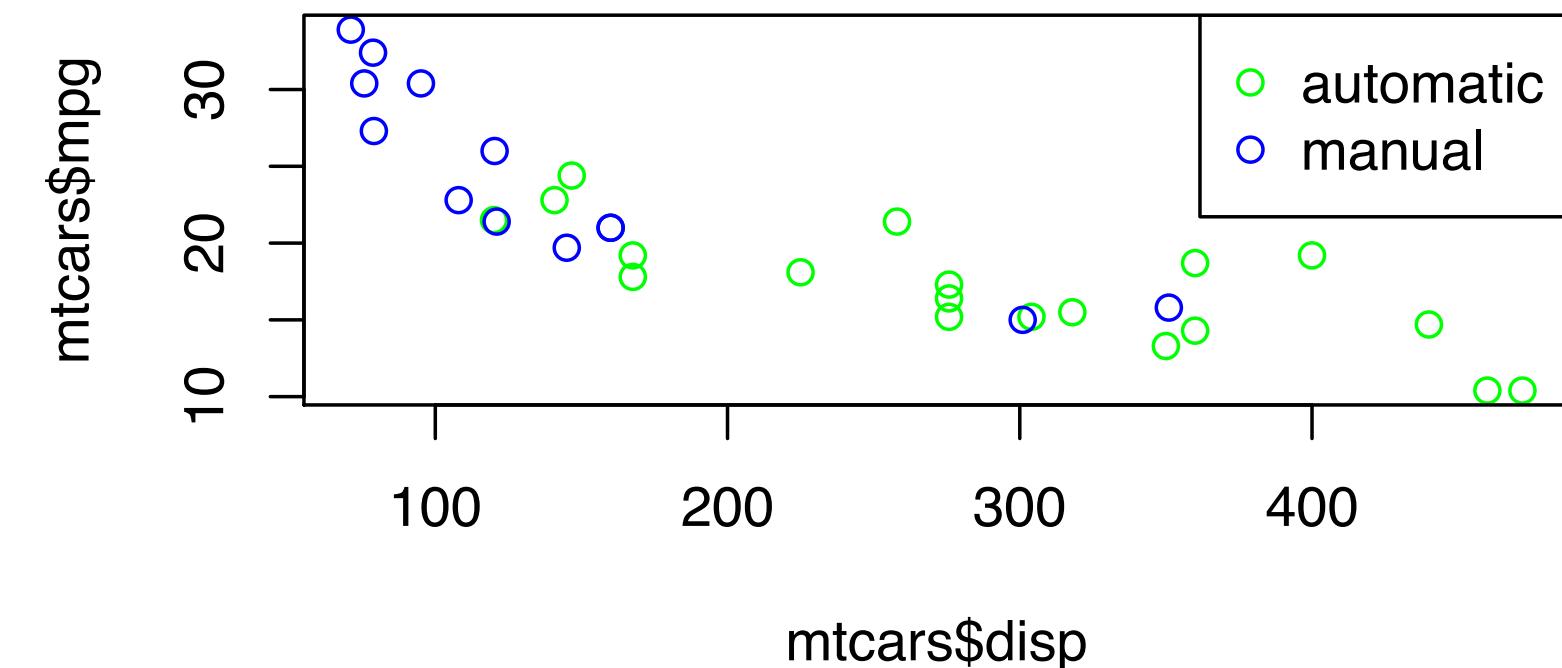
vs. # tidyverse

```
mtcars <- mtcars %>%  
  mutate(  
    gear_char =  
      case_when(  
        gear == 3 ~ "three",  
        gear == 4 ~ "four",  
        gear == 5 ~ "five"))
```

visualizing multiple variables

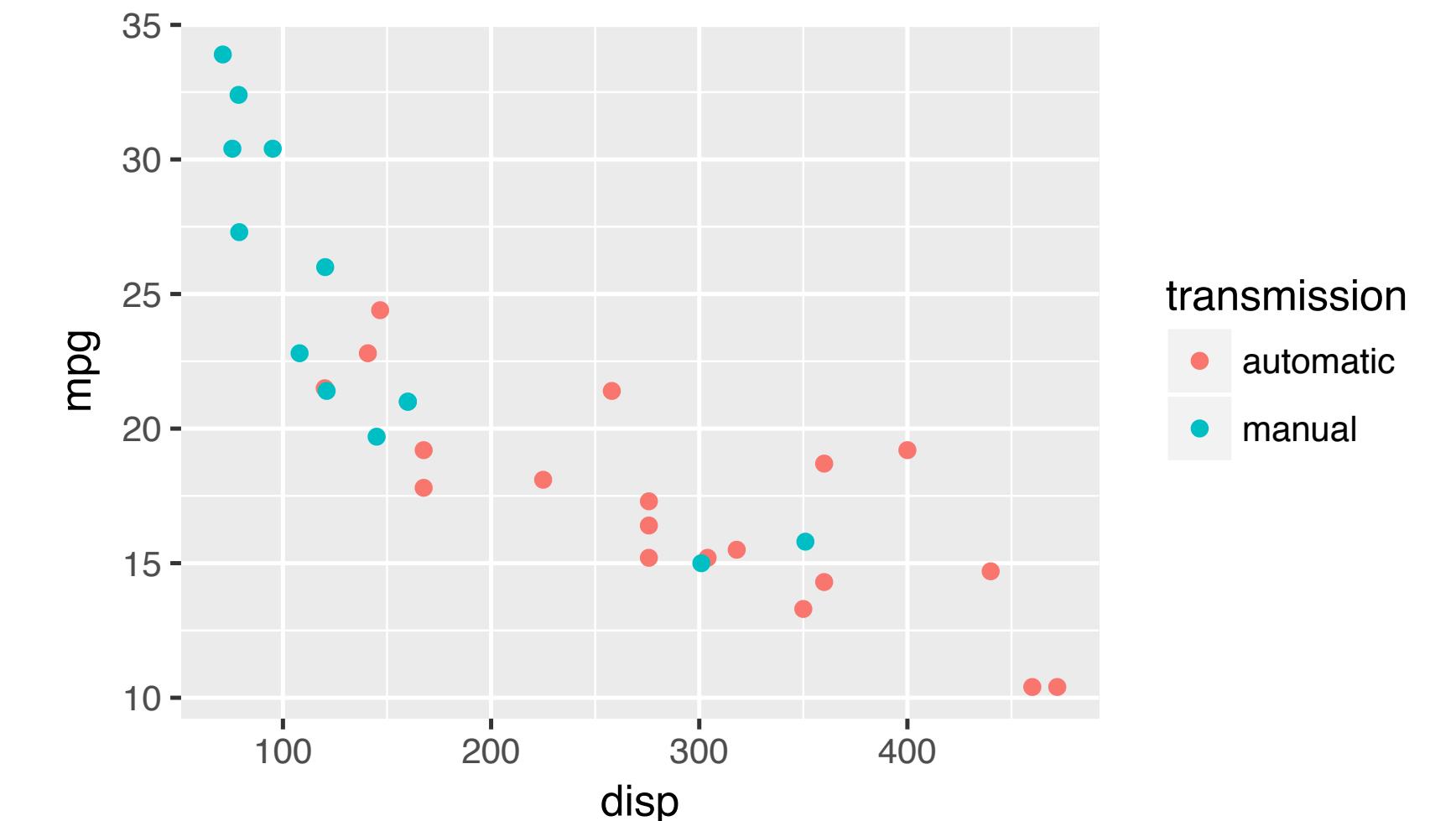
base R

```
mtcars$trans_color <-  
  ifelse(mtcars$transmission == "automatic",  
         "green",  
         "blue")  
  
plot(mtcars$mpg ~ mtcars$disp,  
     col = mtcars$trans_color)  
legend("topright",  
      legend = c("automatic", "manual"),  
      pch = 1, col = c("green", "blue"))
```



vs. # tidyverse

```
ggplot(mtcars,  
       aes(x = disp, y = mpg,  
            color = transmission)) +  
  geom_point()
```

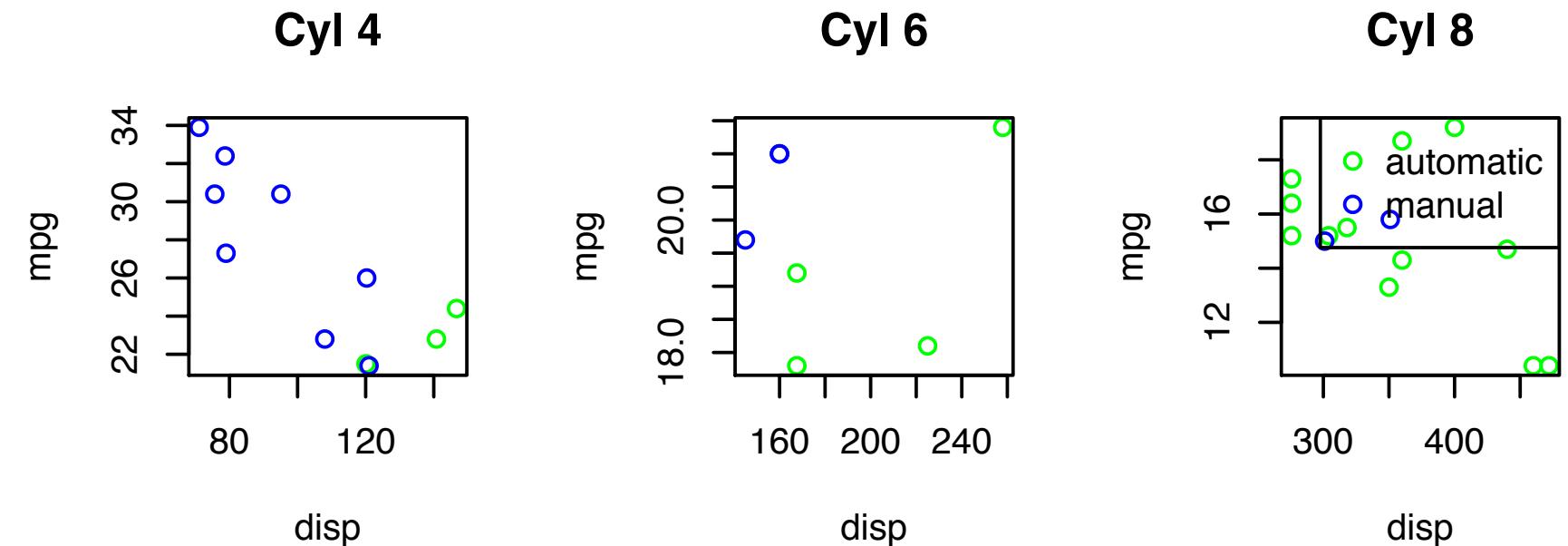


visualizing even more variables

base R

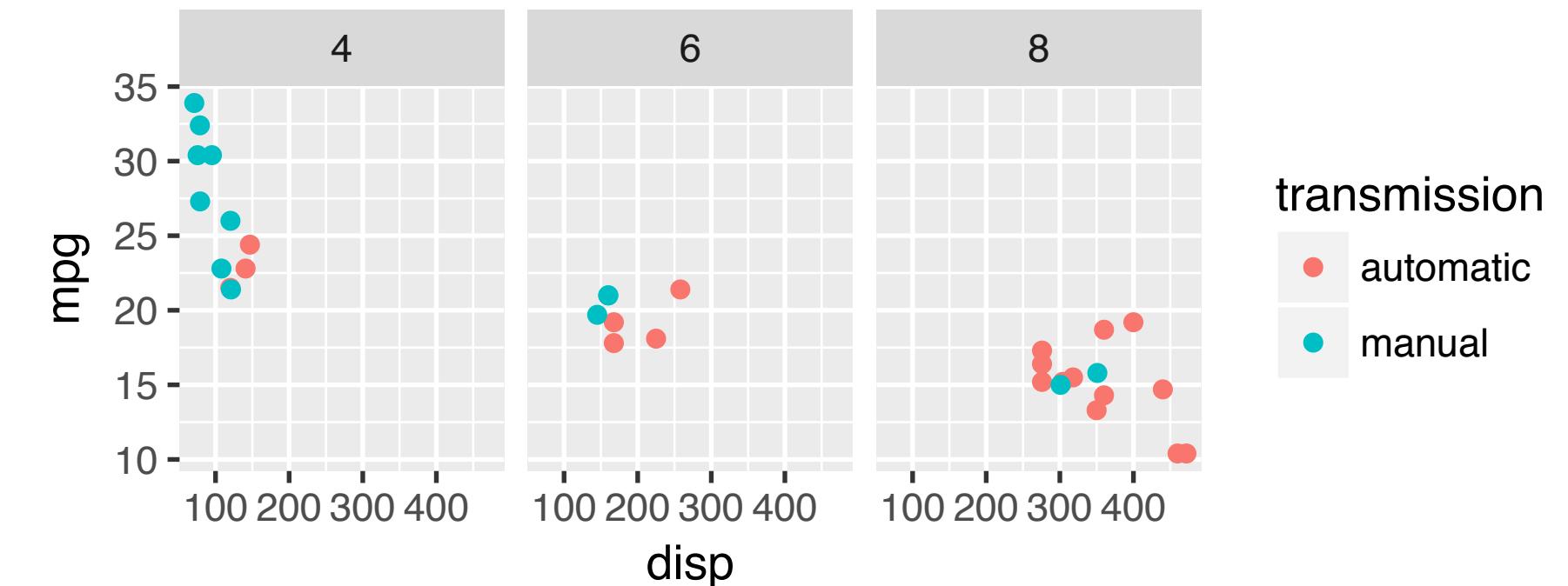
```
mtcars_cyl4 = mtcars[mtcars$cyl == 4, ]
mtcars_cyl6 = mtcars[mtcars$cyl == 6, ]
mtcars_cyl8 = mtcars[mtcars$cyl == 8, ]

par(mfrow = c(1, 3))
plot(mpg ~ disp, data = mtcars_cyl4,
     col = trans_color, main = "Cyl 4")
plot(mpg ~ disp, data = mtcars_cyl6,
     col = trans_color, main = "Cyl 6")
plot(mpg ~ disp, data = mtcars_cyl8,
     col = trans_color, main = "Cyl 8")
legend("topright",
       legend = c("automatic", "manual"),
       pch = 1, col = c("green", "blue"))
```



vs. # tidyverse

```
ggplot(mtcars,
       aes(x = disp, y = mpg,
           color = transmission)) +
  geom_point() +
  facet_wrap(~ cyl)
```



toolkit: (mostly) tidyverse

(closer to)
human readable

consistent syntax

ease of
multivariate
visualizations

why?

reproducibility:

R Markdown +
Git / GitHub

R Markdown

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

Git + GitHub

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

motivation

computation

interest & impact

syllabus

**data analysis
examples**

curricular
considerations

#1 paris paintings



data expeditions



element of an
undergrad course
that introduces
students to
exploratory data
analysis

pairs of grad
students, work
with course
instructor to
formulate question
& pathway

graduate student
participants
receive
a travel grant

meet the experts



Hilary Coe Cronheim
PhD, Art History

Sandra Van Ginhoven
PhD, Art History



data source: auction catalogs



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

	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
1	winningbidder	winningbiddertype	endbuyer	Interm	type_intermed	Height_in	Width_in	Surface_Rect	Diam_in	Surface_Rnd	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

paris paintings

data:

painting
auction data
1764 - 1780
[3,393 x 57]

visualize:

data visualization to
explore patterns and
possible interactions

clean:

data cleaning and
wrangling

model:

model $\log(\text{price})$ and
perform procedural
and expert opinion
based model
selection

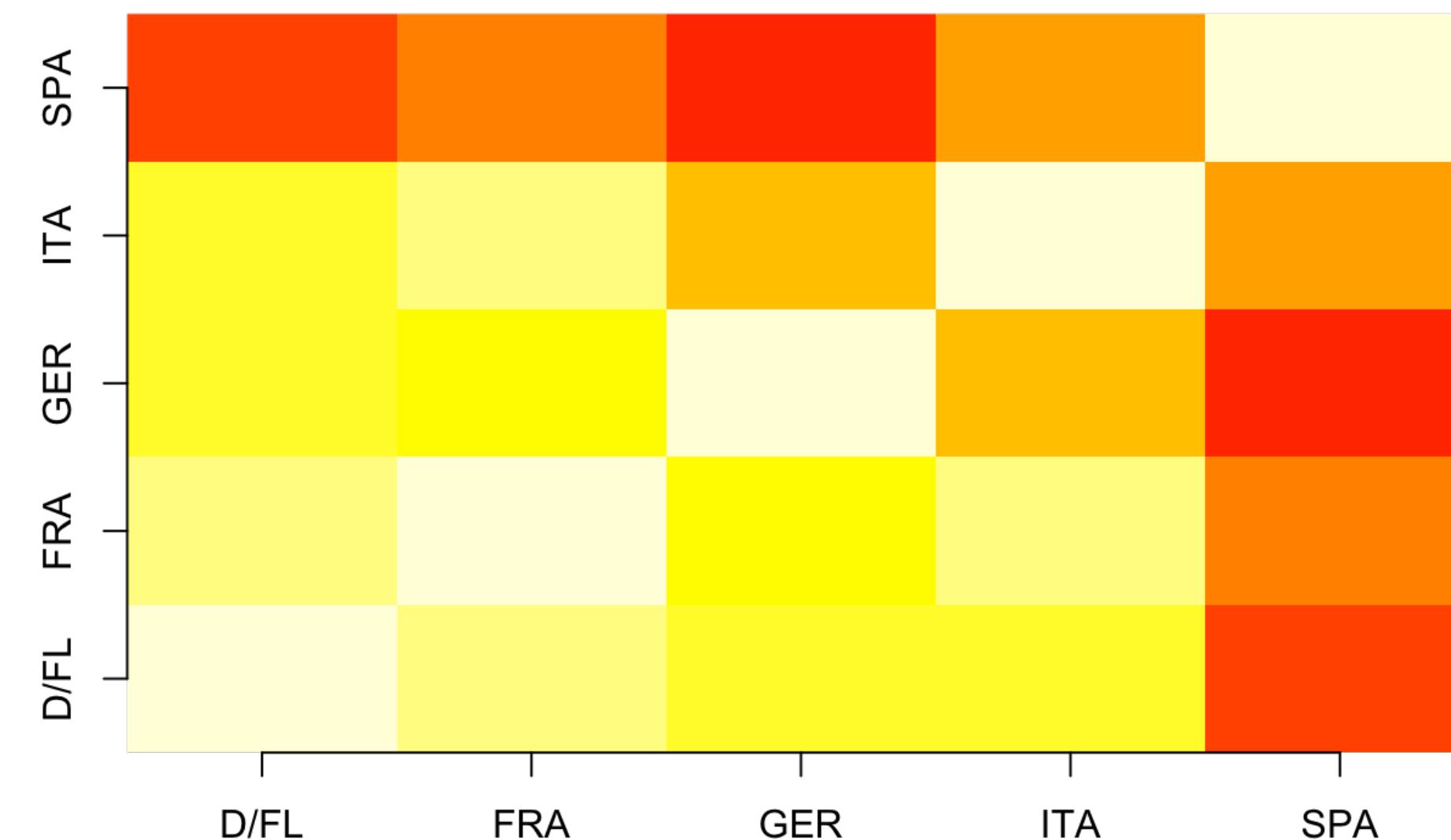
sample exploration #1

similarity of schools

Calculate a similarity score between different classes of art - score between 0 and 1, higher scores reflect a greater degree of similarity among features; i.e. a score of 1 would indicate identical vectors while a score of 0 would indicate vectors with no features in common.

```
similarity = function (vec1, vec2) {  
  mag1 = sqrt(vec1 %*% vec1)  
  mag2 = sqrt(vec2 %*% vec2)  
  return(vec1 %*% vec2 / mag1 / mag2)  
}
```

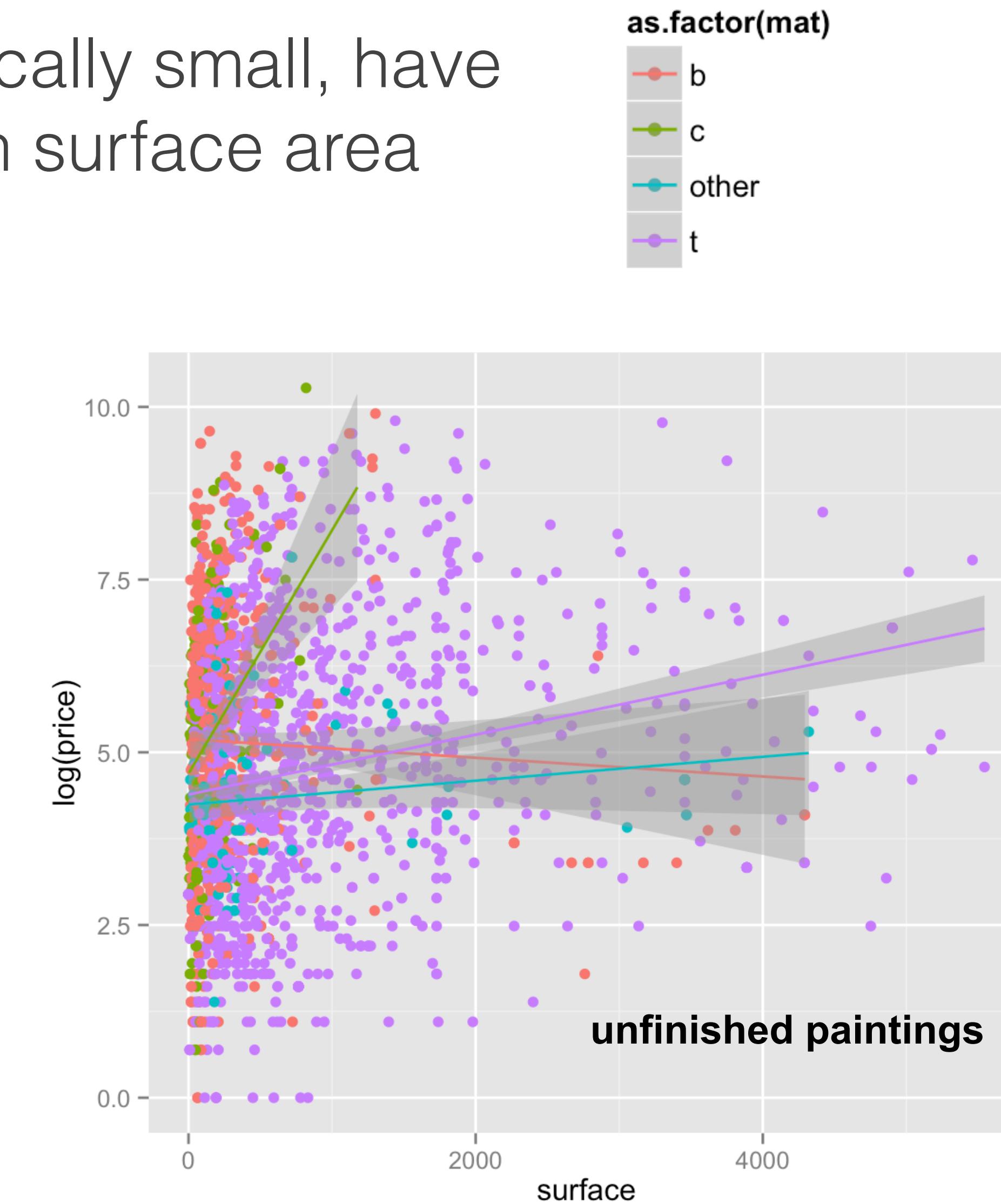
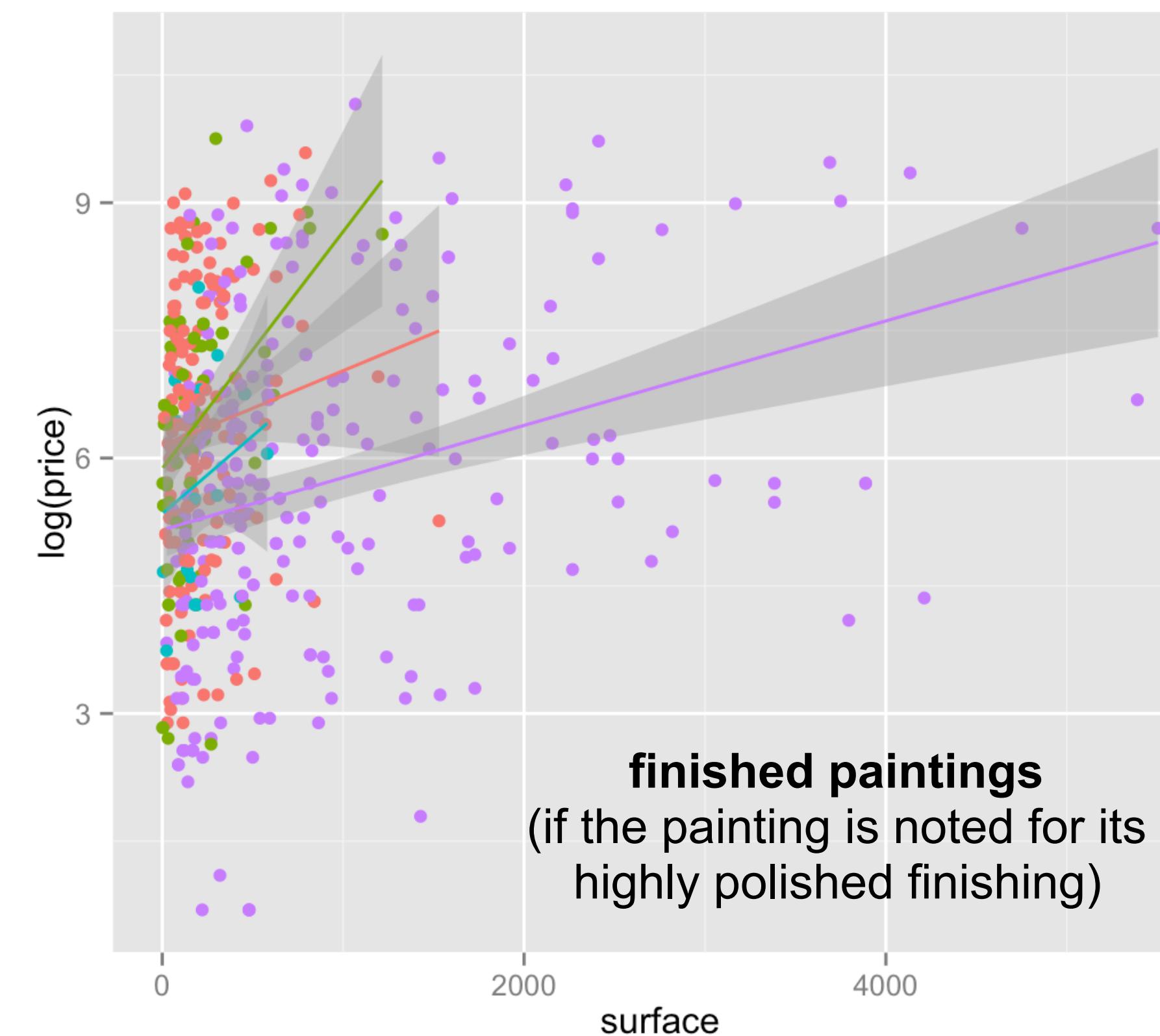
Spanish art is most notably different from the other schools (Lighter colors indicate similarities, while deep red indicates large differences).



sample exploration #2

material and price

Copper paintings, though typically small, have a notably strong interaction with surface area



as.factor(mat)

- b
- c
- other
- t

student experience

non-standard
application piqued
student interest

“massive” data
overwhelming but
expert input
refreshing

unfamiliar
variables made
narrative
challenging

novel
application
pushed
creativity

#2 basketball



← → ⌂ i goduke.statsgeek.com/basketball-m/seasons/schedule.php?season=2014-15 ☆ 🔍 ⚡

2014-15 Schedule & Results							
Date	[Rk] Opponent	Duke Rank	Location (Venue)	Score (OT)	Att.	Tip Time	TV
11/14	~ Presbyterian	4	Durham, N.C. (Cameron Indoor Stadium)	W 113-44	9,314	6 p.m.	ESPNU
11/15	~ Fairfield	4	Durham, N.C. (Cameron Indoor Stadium)	W 109-59	9,314	8 p.m.	ESPN3
11/18	!! vs. [19] Michigan State	4	Indianapolis, Ind. (Bankers Life Fieldhouse)	W 81-71	19,306	7 p.m.	ESPN
11/21	~ vs. Temple	4	Brooklyn, N.Y. (Barclays Center)	W 74-54	10,135	9:30 p.m.	TruTV
11/22	~ vs. Stanford	4	Brooklyn, N.Y. (Barclays Center)	W 70-59	10,046	9:30 p.m.	TruTV
11/26	Furman	4	Durham, N.C. (Cameron Indoor Stadium)	W 93-54	9,314	5 p.m.	ESPNU
11/30	Army	4	Durham, N.C. (Cameron Indoor Stadium)	W 93-73	9,314	12 p.m.	ESPNU
12/3	# at [2] Wisconsin	4	Madison, Wisc. (Kohl Center)	W 80-70	17,279	9:30 p.m.	ESPN
12/15	Elon	2	Durham, N.C. (Cameron Indoor Stadium)	W 75-62	9,314	7 p.m.	ESPNU
12/18	vs. Connecticut	2	East Rutherford, N.J. (Izod Center)	W 66-56	16,541	8 p.m.	ESPN
12/29	Toledo	2	Durham, N.C. (Cameron Indoor Stadium)	W 86-69	9,314	7 p.m.	ESPN2
12/31	Wofford	2	Durham, N.C. (Cameron Indoor Stadium)	W 84-55	9,314	3 p.m.	RSN
1/3	* Boston College	2	Durham, N.C. (Cameron Indoor Stadium)	W 85-62	9,314	4 p.m.	RSN
1/7	* at Wake Forest	2	Winston-Salem, N.C. (Joel Coliseum)	W 73-65	12,651	9 p.m.	ACCN
1/11	* at N.C. State	2	Raleigh, N.C. (PNC Arena)	L 75-87	19,500	1:30 p.m.	CBS
1/13	* Miami	4	Durham, N.C. (Cameron Indoor Stadium)	L 74-90	9,314	9 p.m.	ESPNU
1/17	* at [6] Louisville	4	Louisville, Ky. (KFC Yum! Center)	W 63-52	22,791	12 p.m.	ESPN
1/19	* Pittsburgh	5	Durham, N.C. (Cameron Indoor Stadium)	W 79-65	9,314	7 p.m.	ESPN
1/25	at St. Johns	5	New York, N.Y. (Madison Square Garden)	W 77-68	19,812	2 p.m.	FOX
1/28	* at [8] Notre Dame	4	Notre Dame, Ind. (Joyce Center)	L 73-77	9,149	7:30 p.m.	ESPN2
1/31	* at [2] Virginia	4	Charlottesville, Va. (John Paul Jones Arena)	W 69-63	14,593	7 p.m.	ESPN
2/4	* Georgia Tech	4	Durham, N.C. (Cameron Indoor Stadium)	W 72-66	9,314	7 p.m.	ESPN2
2/7	* [10] Notre Dame	4	Durham, N.C. (Cameron Indoor Stadium)	W 90-60	9,314	1 p.m.	CBS
2/9	* at Florida State	4	Tallahassee, Fla. (Donald L. Tucker Center)	W 73-70	11,498	7 p.m.	ESPN
2/14	* at Syracuse	4	Syracuse, N.Y. (Carrier Dome)	W 80-72	35,446	6 p.m.	ESPN
2/18	* [15] North Carolina	4	Durham, N.C. (Cameron Indoor Stadium)	W 92-90 •	9,314	9 p.m.	ESPN/ACCN
2/21	* Clemson	4	Durham, N.C. (Cameron Indoor Stadium)	W 78-56	9,314	4 p.m.	ESPN
2/25	* at Virginia Tech	4	Blacksburg, Va. (Cassell Coliseum)	W 91-86 •	9,847	9 p.m.	ESPN2
2/28	* Syracuse	4	Durham, N.C. (Cameron Indoor Stadium)	W 73-54	9,314	7 p.m.	ESPN
3/4	* Wake Forest	3	Durham, N.C. (Cameron Indoor Stadium)	W 94-51	9,314	8 p.m.	ACCN
3/7	* at [19] North Carolina	3	Chapel Hill, N.C. (Dean Dome)	W 84-77	21,750	9 p.m.	ESPN
3/12	\$\$\$ vs. N.C. State	2	Greensboro, N.C. (Greensboro Coliseum)	W 77-53	22,026	7 p.m.	ESPN
3/13	\$\$\$\$ vs. [11] Notre Dame	2	Greensboro, N.C. (Greensboro Coliseum)	L 64-74	22,026	9 p.m.	ESPN
3/20	!! vs. Robert Morris	4	Charlotte, N.C. (Time Warner Cable Arena)	W 85-56	16,945	7 p.m.	CBS
3/22	!!! vs. San Diego State	4	Charlotte, N.C. (Time Warner Cable Arena)	W 68-49	18,482	2 p.m.	CBS
3/27	!!!! vs. [19] Utah	4	Houston, Texas (NRG Stadium)	W 63-57	21,168	7:45 p.m.	CBS
3/29	!!!!!! vs. [7] Gonzaga	4	Houston, Texas (NRG Stadium)	W 66-52	20,744	4 p.m.	CBS
4/4	!!!!!! vs. [23] Michigan State	4	Indianapolis, Ind. (Lucas Oil Stadium)	W 81-61	72,238	6 p.m.	TBS/TNT
4/6	!!!!!!! vs. [3] Wisconsin	4	Indianapolis, Ind. (Lucas Oil Stadium)	W 68-63	71,149	9:15 p.m.	CBS

copy

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11/22	~ vs. Stanford	4	Brooklyn, N.Y. (Barclays Center)	W 70-59	10,046	9:30 p.m.	TruTV
11/26	Furman	4	Durham, N.C. (Cameron Indoor Stadium)	W 93-54	9,314	5 p.m.	ESPNU
11/30	Army	4	Durham, N.C. (Cameron Indoor Stadium)	W 93-73	9,314	12 p.m.	ESPNU
12/3	# at [2] Wisconsin	4	Madison, Wisc. (Kohl Center)	W 80-70	17,279	9:30 p.m.	ESPN
12/15	Elon	2	Durham, N.C. (Cameron Indoor Stadium)	W 75-62	9,314	7 p.m.	ESPNU
12/18	vs. Connecticut	2	East Rutherford, N.J. (Izod Center)	W 66-56	16,541	8 p.m.	ESPN
12/29	Toledo	2	Durham, N.C. (Cameron Indoor Stadium)	W 86-69	9,314	7 p.m.	ESPN2
12/31	Wofford	2	Durham, N.C. (Cameron Indoor Stadium)	W 84-55	9,314	3 p.m.	RSN
1/3	* Boston College	2	Durham, N.C. (Cameron Indoor Stadium)	W 85-62	9,314	4 p.m.	RSN
1/7	* at Wake Forest	2	Winston-Salem, N.C. (Joel Coliseum)	W 73-65	12,651	9 p.m.	ACCN
1/11	* at N.C. State	2	Raleigh, N.C. (PNC Arena)	L 75-87	19,500	1:30 p.m.	CBS
1/13	* Miami	4	Durham, N.C. (Cameron Indoor Stadium)	L 74-90	9,314	9 p.m.	ESPNU
1/17	* at [6] Louisville	4	Louisville, Ky. (KFC Yum! Center)	W 63-52	22,791	12 p.m.	ESPN
1/19	* Pittsburgh	5	Durham, N.C. (Cameron Indoor Stadium)	W 79-65	9,314	7 p.m.	ESPN
1/25	at St. Johns	5	New York, N.Y. (Madison Square Garden)	W 77-68	19,812	2 p.m.	FOX
1/28	* at [8] Notre Dame	4	Notre Dame, Ind. (Joyce Center)	L 73-77	9,149	7:30 p.m.	ESPN2
1/31	* at [2] Virginia	4	Charlottesville, Va. (John Paul Jones Arena)	W 69-63	14,593	7 p.m.	ESPN
2/4	* Georgia Tech	4	Durham, N.C. (Cameron Indoor Stadium)	W 72-66	9,314	7 p.m.	ESPN2
2/7	* [10] Notre Dame	4	Durham, N.C. (Cameron Indoor Stadium)	W 90-60	9,314	1 p.m.	CBS
2/9	* at Florida State	4	Tallahassee, Fla. (Donald L. Tucker Center)	W 73-70	11,498	7 p.m.	ESPN
2/14	* at Syracuse	4	Syracuse, N.Y. (Carrier Dome)	W 80-72	35,446	6 p.m.	ESPN
2/18	* [15] North Carolina	4	Durham, N.C. (Cameron Indoor Stadium)	W 92-90 •	9,314	9 p.m.	ESPN/ACCN
2/21	* Clemson	4	Durham, N.C. (Cameron Indoor Stadium)	W 78-56	9,314	4 p.m.	ESPN
2/25	* at Virginia Tech	4	Blacksburg, Va. (Cassell Coliseum)	W 91-86 •	9,847	9 p.m.	ESPN2
2/28	* Syracuse	4	Durham, N.C. (Cameron Indoor Stadium)	W 73-54	9,314	7 p.m.	ESPN
3/4	* Wake Forest	3	Durham, N.C. (Cameron Indoor Stadium)	W 94-51	9,314	8 p.m.	ACCN
3/7	* at [19] North Carolina	3	Chapel Hill, N.C. (Dean Dome)	W 84-77	21,750	9 p.m.	ESPN
3/12	\$\$\$ vs. N.C. State	2	Greensboro, N.C. (Greensboro Coliseum)	W 77-53	22,026	7 p.m.	ESPN
3/13	\$\$\$\$ vs. [11] Notre Dame	2	Greensboro, N.C. (Greensboro Coliseum)	L 64-74	22,026	9 p.m.	ESPN
3/20	!! vs. Robert Morris	4	Charlotte, N.C. (Time Warner Cable Arena)	W 85-56	16,945	7 p.m.	CBS
3/22	!!! vs. San Diego State	4	Charlotte, N.C. (Time Warner Cable Arena)	W 68-49	18,482	2 p.m.	CBS
3/27	!!!! vs. [19] Utah	4	Houston, Texas (NRG Stadium)	W 63-57	21,168	7:45 p.m.	CBS
3/29	!!!!!! vs. [7] Gonzaga	4	Houston, Texas (NRG Stadium)	W 66-52	20,744	4 p.m.	CBS
4/4	!!!!!! vs. [23] Michigan State	4	Indianapolis, Ind. (Lucas Oil Stadium)	W 81-61	72,238	6 p.m.	TBS/TNT
4/6	!!!!!!! vs. [3] Wisconsin	4	Indianapolis, Ind. (Lucas Oil Stadium)	W 68-63	71,149	9:15 p.m.	CBS

paste

A	B	C	D	E	F	G	H	I	J
3	Day	2013 Opponent	2013	2013 Opponent	2013	2013	2013	2013	2013
4	14-Nov	~	Presbyterian		4 Durham, N.C. (W)	113-44	9,314	6 p.m.	ESPNU
5	15-Nov	~	Fairfield		4 Durham, N.C. (W)	109-59	9,314	8 p.m.	ESPN3
6	18-Nov	¶¶	vs. [19] Michigan		4 Indianapolis, Ind. W	81-71	19,306	7 p.m.	ESPN
7	21-Nov	~	vs. Temple		4 Brooklyn, N.Y. W	74-54	10,135	9:30 p.m.	TruTV
8	22-Nov	~	vs. Stanford		4 Brooklyn, N.Y. W	70-59	10,046	9:30 p.m.	TruTV
9	26-Nov		Furman		4 Durham, N.C. (W)	93-54	9,314	5 p.m.	ESPNU
10	30-Nov		Army			93-73	9,314	12 p.m.	ESPNU
11	3-Dec	#	at [2] Wisconsin				17,279	9:30 p.m.	ESPN
12	15-Dec		Elon				9,314	7 p.m.	ESPNU
13	18-Dec		vs. Connecticut				16,541	8 p.m.	ESPN
14	29-Dec		Toledo				9,314	7 p.m.	ESPN2
15	31-Dec		Wofford				9,314	3 p.m.	RSN
16	3-Jan	*	Boston U				9,314	4 p.m.	RSN
17	7-Jan	*	at Wake Forest				9,314	9 p.m.	ACCN
18	11-Jan	*	at N.C. State					1:30 p.m.	CBS
19	13-Jan	*	Miami (Fla.)					9 p.m.	ESPNU
20	17-Jan	*	at [6] Louisville					12 p.m.	ESPN
21	19-Jan	*	Pittsburgh					7 p.m.	ESPN
22	25-Jan		at St. John's				9,314	2 p.m.	FOX
23	28-Jan	*	at [8] Notre Dame				9,314	7:30 p.m.	ESPN2
24	31-Jan	*	at [2] Virginia				9,314	7 p.m.	ESPN
25	4-Feb	*	Georgia Tech				9,314	7 p.m.	ESPN2
26	7-Feb	*	[10] Notre Dame				9,314	1 p.m.	CBS
27	9-Feb	*	at Florida State				11,498	7 p.m.	ESPN
28	14-Feb	*	at Syracuse				35,446	6 p.m.	ESPN
29	18-Feb	*	[15] North Carolina				9,314	9 p.m.	ESPN/ACCN
30	21-Feb	*	Clemson		Durham, N.C. (W)	9,314	9,314	4 p.m.	ESPN
31	25-Feb	*	at Virginia Tech		4 Blacksburg, Va. W	91-86	9,847	9 p.m.	ESPN2
32	28-Feb	*	Syracuse		4 Durham, N.C. (W)	73-54	9,314	7 p.m.	ESPN
33	4-Mar	*	Wake Forest		3 Durham, N.C. (W)	94-51	9,314	8 p.m.	ACCN
34	7-Mar	*	at [19] North Carolina		3 Chapel Hill, N.C. W	84-77	21,750	9 p.m.	ESPN
35	12-Mar	\$\$\$	vs. N.C. State		2 Greensboro, N.C. W	77-53	22,026	7 p.m.	ESPN
36	13-Mar	\$\$\$\$	vs. [11] Notre Dame		2 Greensboro, N.C. L	64-74	22,026	9 p.m.	ESPN
37	20-Mar	!!	vs. Robert Morris		4 Charlotte, N.C. W	85-56	16,945	7 p.m.	CBS
38	22-Mar	!!!	vs. San Diego State		4 Charlotte, N.C. W	68-49	18,482	2 p.m.	CBS
39	27-Mar	!!!!	vs. [19] Utah		4 Houston, Texas W	63-57	21,168	7:45 p.m.	CBS
40	29-Mar	!!!!!	vs. [7] Gonzaga		4 Houston, Texas W	66-52	20,744	4 p.m.	CBS
41	4-Apr	!!!!!!	vs. [23] Michigan		4 Indianapolis, Ind. W	81-61	72,238	6 p.m.	TBS/TNT
42	6-Apr	!!!!!!	vs. [3] Wisconsin		4 Indianapolis, Ind. W	68-63	71,149	9:15 p.m.	CBS

scrape

```
# Load packages -----
library(rvest)
library(stringr)
library(dplyr)

# Read page with season data -----
page <- read_html("http://goduke.statsgeek.com/basketball-m/seasons/schedule.php?season=2014-15")

# Harvest fields -----
date <- page %>%
  html_nodes(".stattextline b") %>%
  html_text()

opponent <- page %>%
  html_nodes(".stattextltgray2:nth-child(3)") %>%
  html_text() %>%
  str_trim()

venue <- page %>%
  html_nodes(".stattextltgray2:nth-child(5)") %>%
  html_text() %>%
  str_trim()

# Put fields into a tibble -----
blue_devils_1415 <- data_frame(date, opponent, venue)
```

voila!

blue_devils_1415 *

Filter

	date	opponent	venue
1	11/14	Presbyterian	Durham, N.C. (Cameron Indoor Stadium)
2	11/15	Fairfield	Durham, N.C. (Cameron Indoor Stadium)
3	11/18	vs. [19] Michigan State	Indianapolis, Ind. (Bankers Life Fieldhouse)
4	11/21	vs. Temple	Brooklyn, N.Y. (Barclays Center)
5	11/22	vs. Stanford	Brooklyn, N.Y. (Barclays Center)
6	11/26	Furman	Durham, N.C. (Cameron Indoor Stadium)
7	11/30	Army	Durham, N.C. (Cameron Indoor Stadium)
8	12/3	at [2] Wisconsin	Madison, Wisc. (Kohl Center)
9	12/15	Elon	Durham, N.C. (Cameron Indoor Stadium)
10	12/18	vs. Connecticut	East Rutherford, N.J. (Izod Center)
11	12/29	Toledo	Durham, N.C. (Cameron Indoor Stadium)
12	12/31	Wofford	Durham, N.C. (Cameron Indoor Stadium)

Showing 1 to 13 of 39 entries

best laid plans...



Mine CetinkayaRundel

@minebocek

Students upset b/c website they need to scrape data from for hw assignment is down. Bad assignment or good lesson in working w/ real data?

RETWEET

1

LIKES

10



9:48 AM - 26 Nov 2015

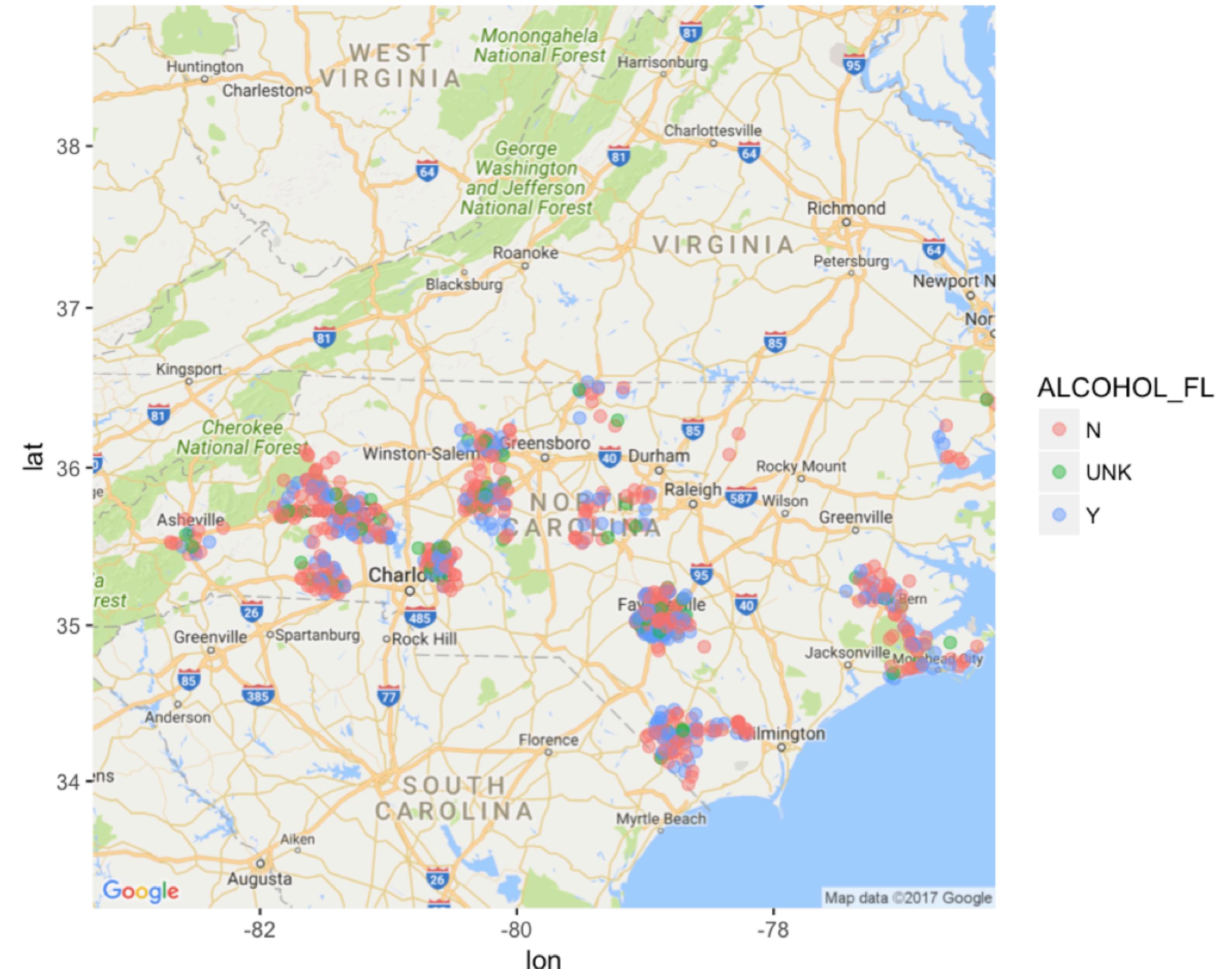
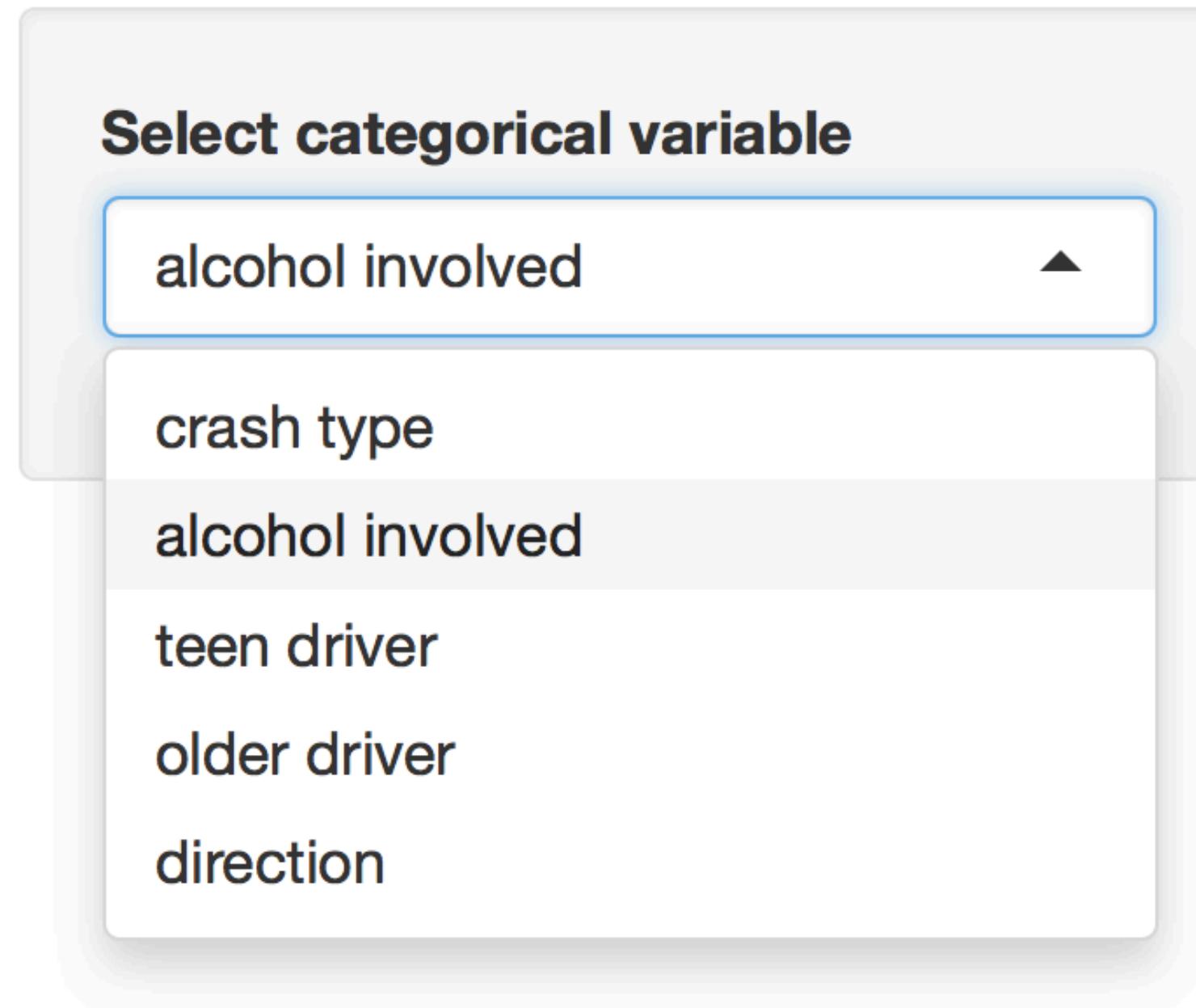
#3 interactivity



```
> library(shiny)
```



Modeling the Distributions of Fatal Car Crashes



motivation

computation

interest &
impact

syllabus

data analysis
examples

curricular
considerations

interest

duke focus:

first-year undergrads
modeling cluster:
“What if? Explaining
the Past, Predicting
the Future”

interest in What If:

no hard data, but
“definitely significant
increase in
applications the last
two years than
previous years”

interest in DS:

% of
What If applicants
interested in DS
2015: 76%
2016: 83%

impact

pipeline for stats:

2014: 19% declared
2015: 31% declared
2016: ~40%
expressed interest

diversity:

% female
2014: 44%
2015: 50%
2016: 35%

~25% in Probability

curricular:

basis for
gateway to stats
major course
to be offered in
Spring 2018!

motivation

computation

interest &
impact

syllabus

data analysis
examples

**curricular
considerations**

curricular considerations

move away from
ad-hoc computing
education
and/or
expecting students
to pick it up
along the way

uniformity of tools is
important: choose a
toolkit that works for
you and stick to it
throughout the
curriculum

teach computing
early (without any
prereqs) and often!



 @minebocek

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 mine@stat.duke.edu

bit.ly/user2017