Oh the places you'll go!

An introduction to some of what R has to offer

Daniel Anderson

Agenda

- Introductions
- Syllabus
- Introduce R
- Very basics of R (object assignment)
- R packages
- Guided practice (if time allows)

Overall purpose of today: Get you excited about R! Will be a lot of me showing, and not a lot of you doing. That will change quickly.

Who are you?

- Please introduce yourself.
    - Name/Program of study and things you're interested in
    - Prior experience with R
    - Why do you want to learn R?

Who am I?

Daniel Anderson

- Research Associate: Behavioral Research and Teaching
- Dad (two daughters: 5 and 3)
- Quantitative educational researcher who **loves** R
- Primary areas of interest
    - R and computational educational research
    - Open data, open science, and reproducible workflows
    - Growth modeling (primarily through multilevel models)

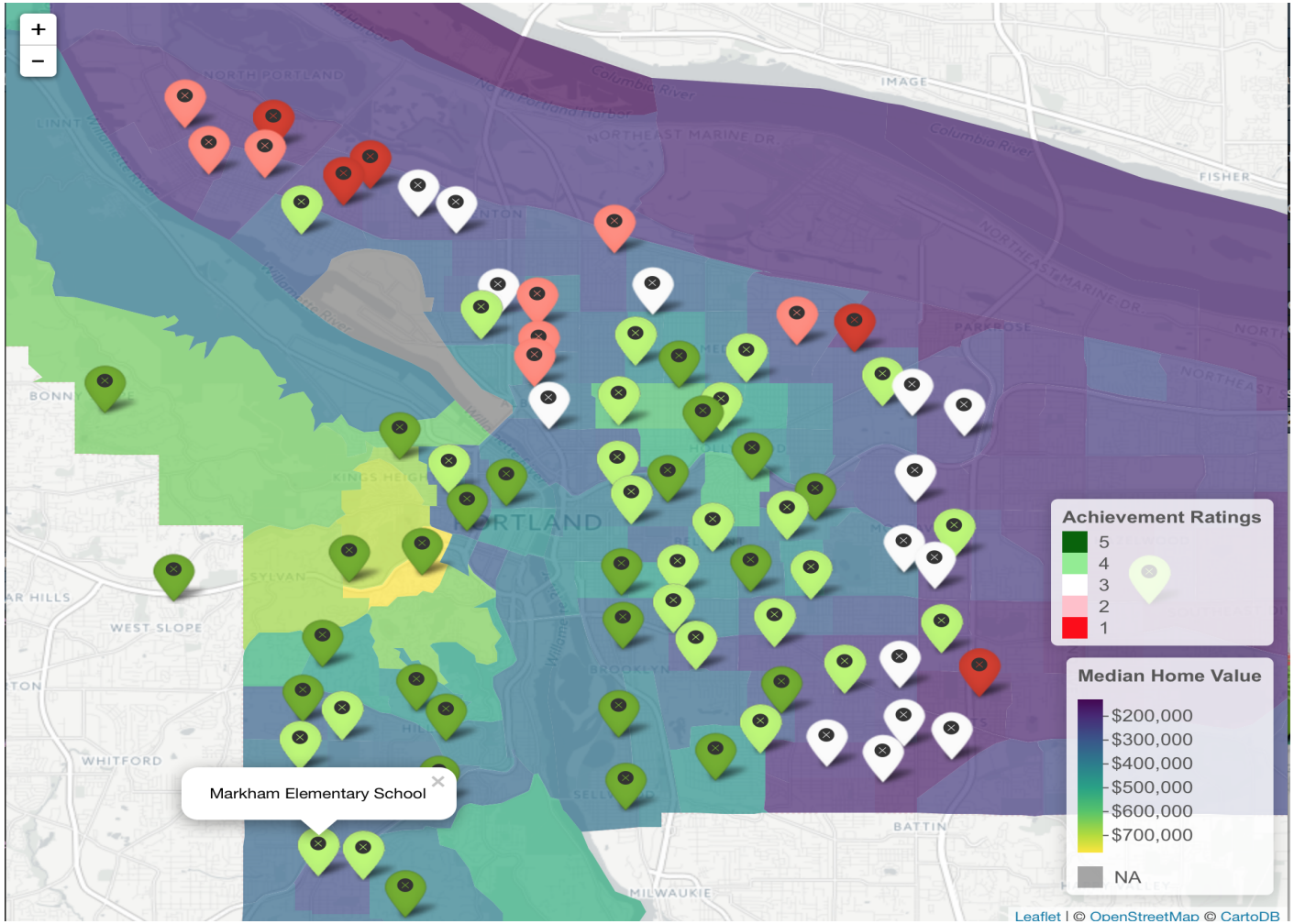
Before we get started...

A few announcements

- Datacamp!
- Cool stuff share Monday

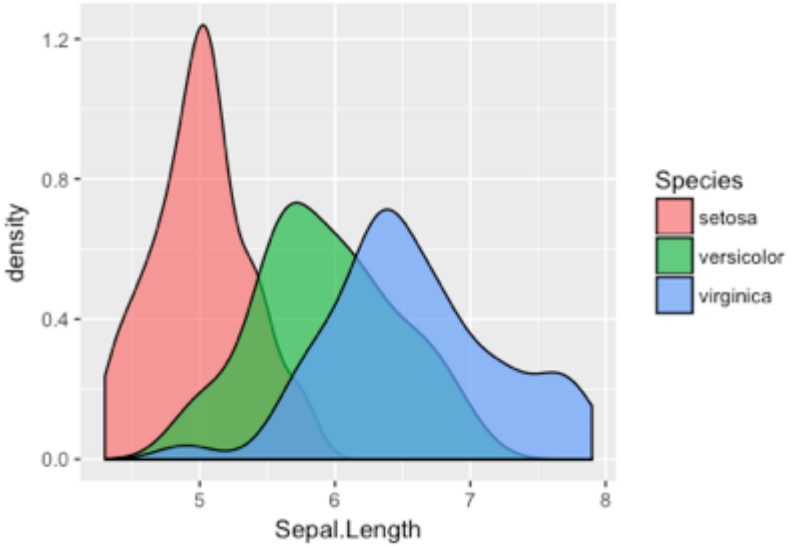
Example of a cool stuff share: 1

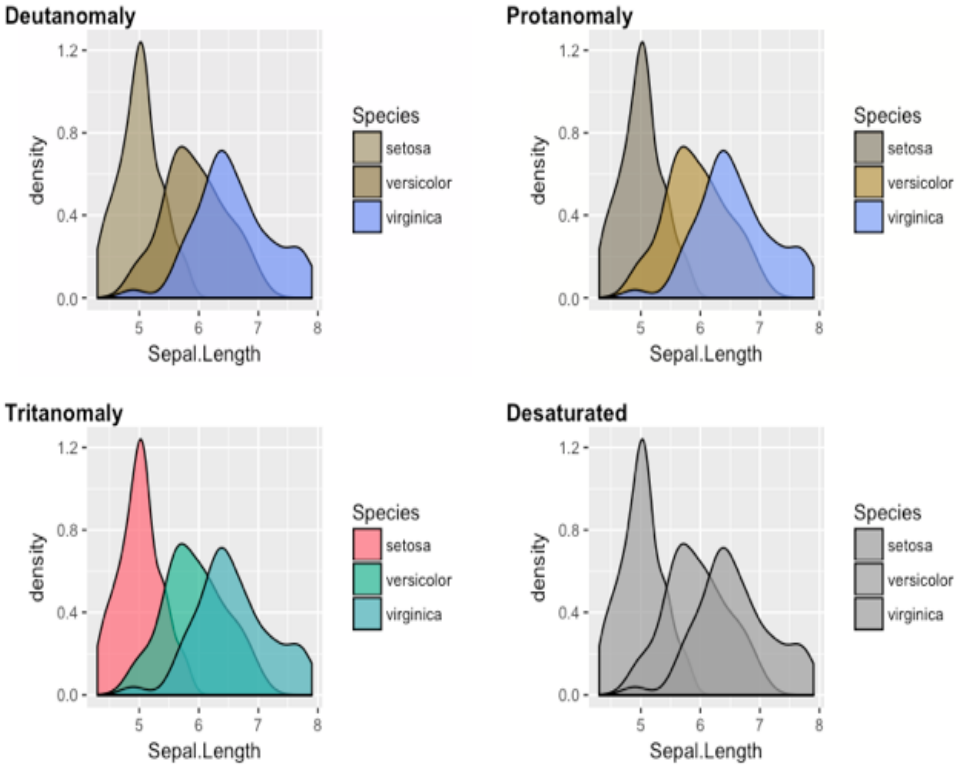
(One that I did, one that I saw)



The *colorblindr* package

Simulate what a plot would look like according to 4 different types of color blindness.





Syllabus

Student Learning Outcomes

1. Be able to produce dynamic and reproducible documents with R Markdown in both pdf and html format.
2. Understand the principles of tidy data, and when it is and is not useful to have your data in a tidy format.
3. Understand the tools for manipulating data into a tidy format and be able to apply these tools to reshape relatively complex datasets into a tidy format.
4. Understand and be able to apply the grammar of graphics, as implemented through the ggplot2 package, to tidy data for both exploratory and model-based plotting (exploratory plotting emphasized).

What this class is and is not

The purpose of this class is to provide you with a foundational set of skills for manipulating and exploring data visually while ensuring your work is transparent and reproducible. Basically, an intro to data science with R.

This class has three foci

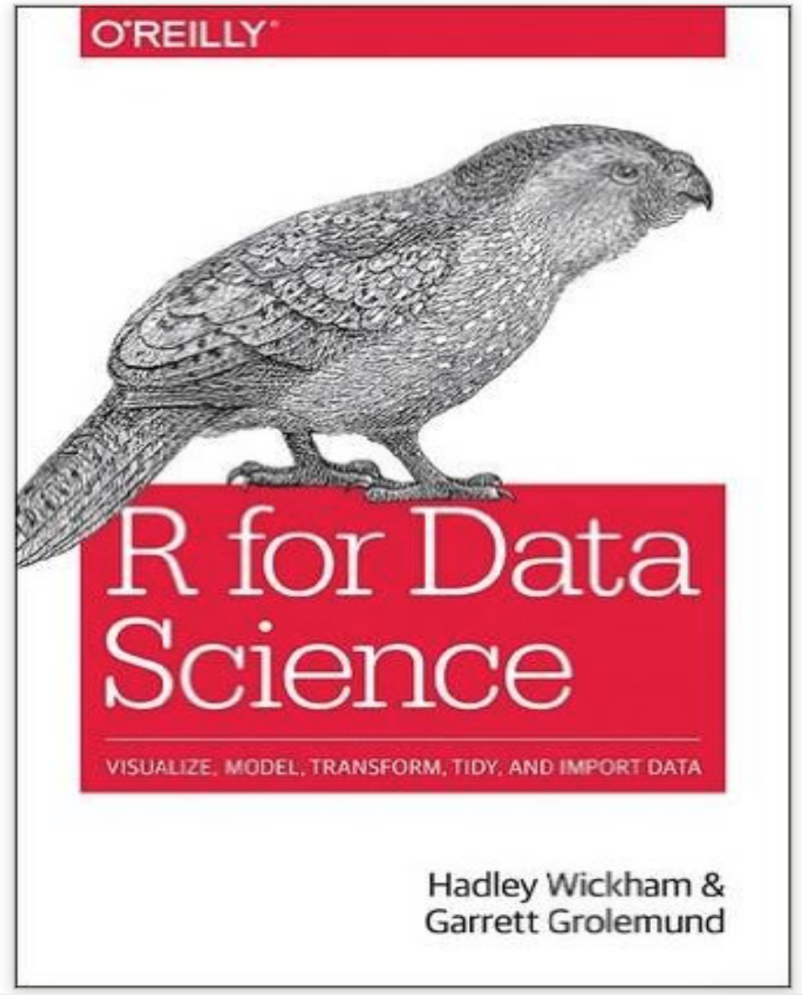
- Data structuring and manipulations
- Data visualization
- Reproducible workflows

This class is not

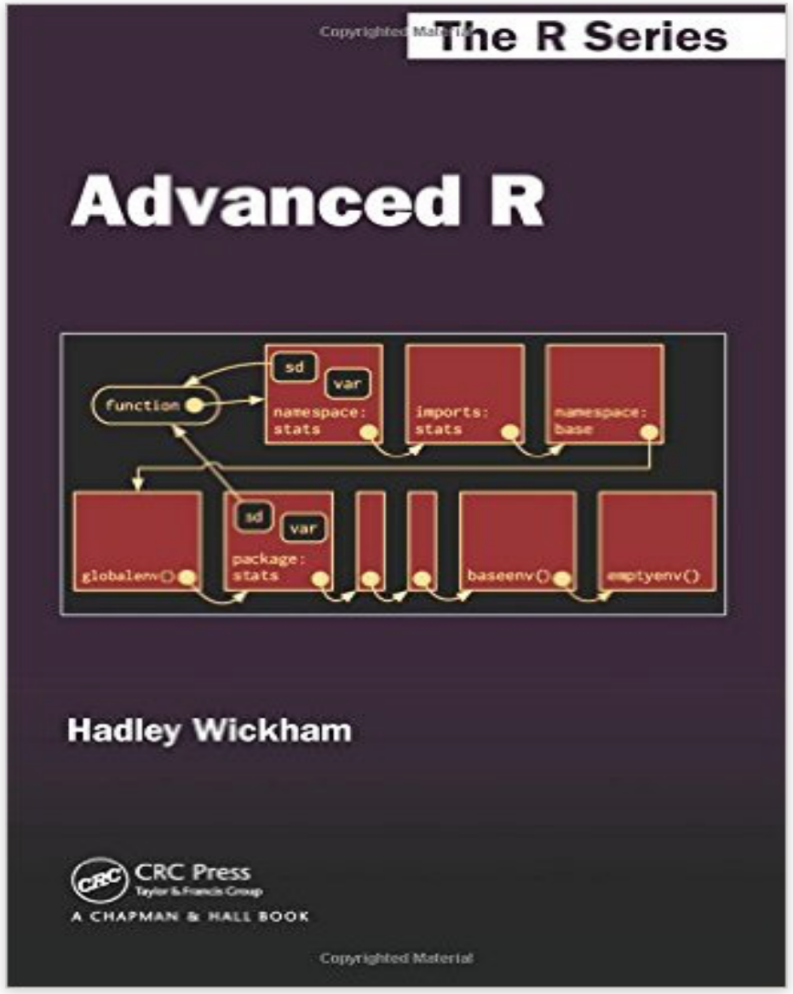
- All encompassing (there's a TON we will not get to)
- A statistics course (we'll use stats in examples, though)
- A programming course (that would be a follow-up second course)

Required Textbook (free)

This Course



Next Course (if there is one)

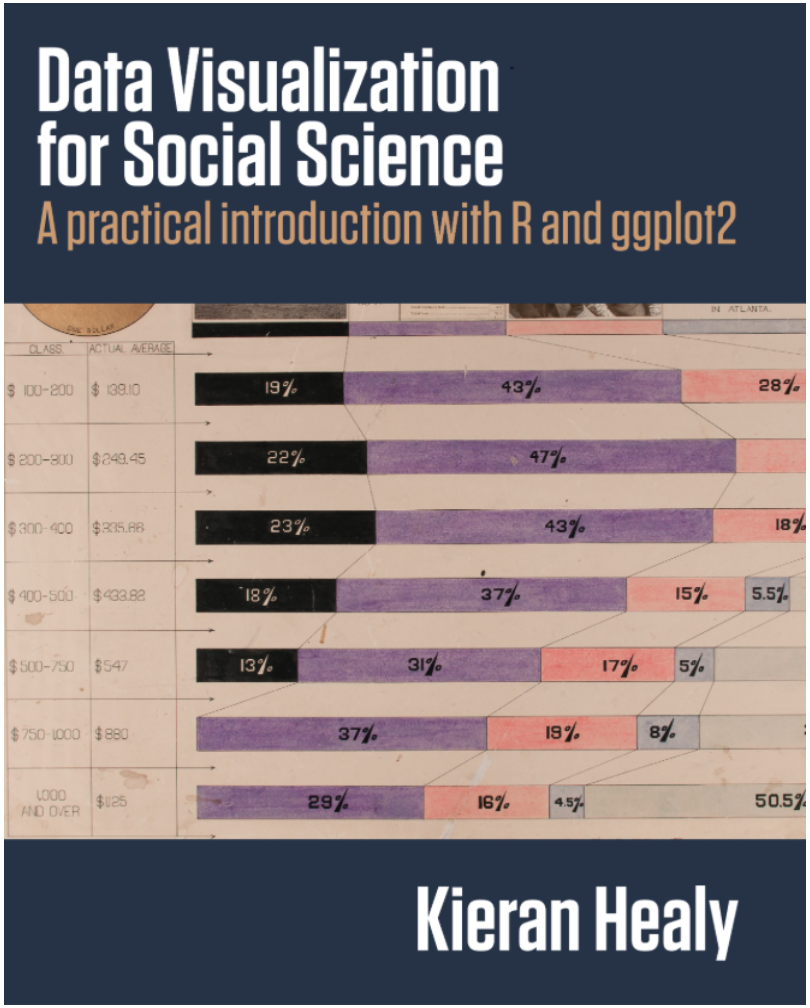


These books are both available for free!

- R for Data Science: http://r4ds.had.co.nz
- Advanced R: http://adv-r.had.co.nz

Other books

Freely available at http://socviz.co



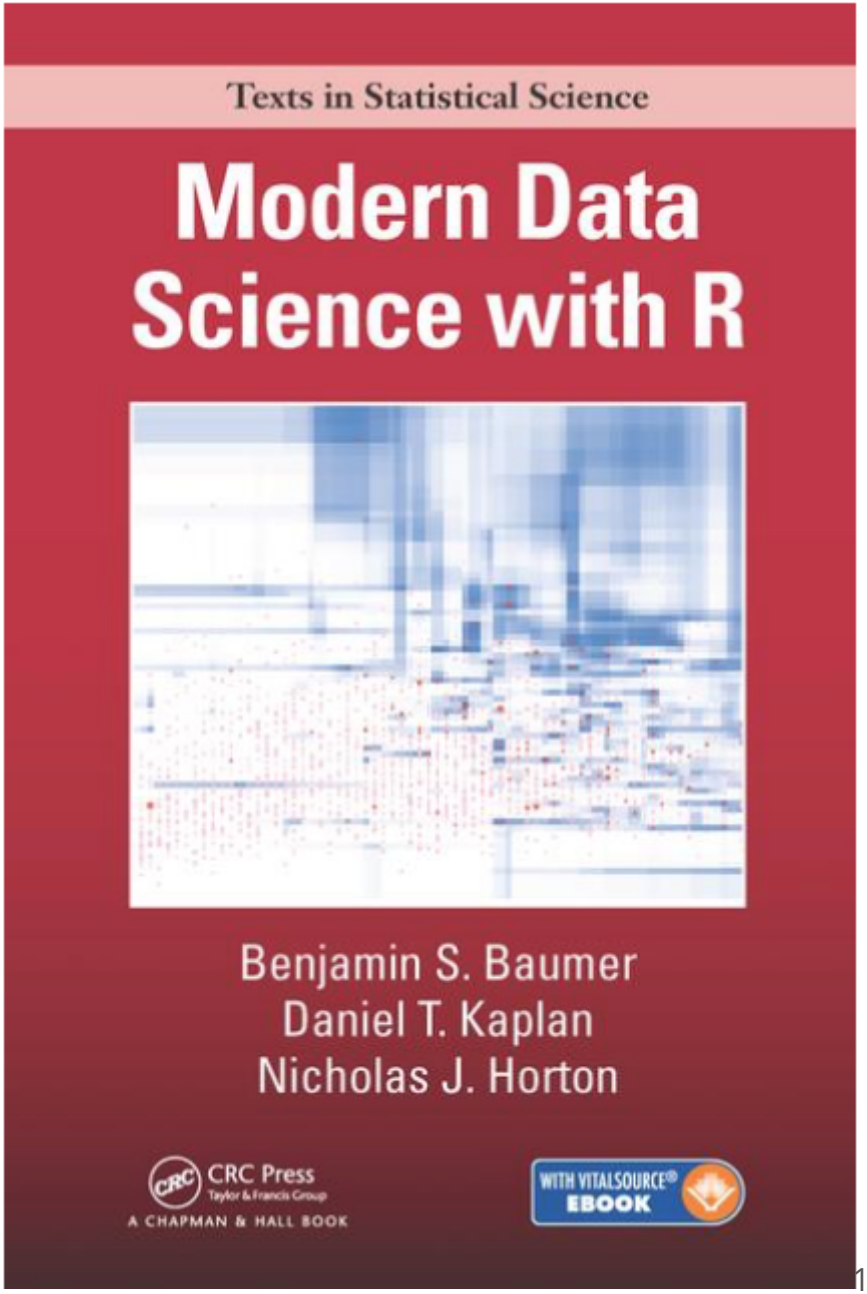
Other readings (also all free)

- Grolemund – Tidy data: http://garrettgman.github.io/tidying/
- R-Markdown
  - Lesson 1: http://rmarkdown.rstudio.com/lesson-1.html
  - Lesson 2: http://rmarkdown.rstudio.com/lesson-2.html
  - Lesson 3: http://rmarkdown.rstudio.com/lesson-3.html
  - Lesson 4: http://rmarkdown.rstudio.com/lesson-4.html
- Sanchez, G. (2013). Handling and Processing Strings in R. Freely available online at http://gastonsanchez.com/Handling_and_Processing_Strings_in_R.pdf
- Wickham, H. (2014). Tidy Data. Journal of Statistical Software. 59(10), 1-23.

Another book

Another book I highly recommend is by Ben Baumer, Daniel Kaplan, and Nicholas Horton.

- A bit more advanced than our class, but the intro chapters are foundational (i.e., in line with our class).
- I'll be using datasets and some examples from this book.
- Only downside is it's pretty spendy (~$100)



There are a few other books out there that I'll be providing you chapters from. Overall, there's a ton of resources out there and part of the challenge at times can be separating the junk from the good stuff. I'll help you wade those waters.

Before next class

Style guide! Have good grammar when you code.

http://adv-r.had.co.nz/Style.html

Some quick advice:

- Keep everything lower case, unless there's a clear resason not to
- Use style that helps you spot errors in your code more quickly
- Whatever you do, be consistent

Weekly homeworks

- Why? Sounds torturous
  - I'm a firm believer that the only way you can truly learn R is to practice, practice, practice. So - lots built in.
- All homeworks **must** be , which we'll talk a lot about.
- Homework assignments should be challenging but should not take over your weekend (and certainly not week). First, work hard, but get help if you get stuck (from your classmates and me).
- Homeworks can be completed collaboratively (and I encourage it).
- Scored on a completion basis only (not accuracy, this is mostly about making sure you're putting in the time/effort).
- Assigned each Thursday and due before the start of class the following Thursday.

Please come to me if you need help!

Weekly homeworks (10 points each)

1. Creating an R Markdown Document
2. Importing and Manipulating data
3. Data visualization
4. Tidy data
5. Full example 1 (more advanced and)
6. Full example 2 (review)
7. Joins
8. Full example 3 (strings)

These mostly follow the lecture topics.

Final Project

If you need data for your final project contact me now! Final project can be completed independently or in groups of up to 3 people. End result should be a mini manuscript (intro, methods, results, discussion).

Project outline due by the start of the first class, Week 5.

Final project must

- Be reproducible
- Move data from its raw "messy" format to a tidy data format
- Include at least two exploratory plots
- Include at least summary statistics of the data in tables, although fitted models are a plus.
- Does **not** have to be APA format - kudos to you if you do. If you're hoping to move forward with a reproducible work flow outside of this class, I'd recommend trying the package.

For future reference

Final project must use the following functions:

- `gather`, `separate`, `select`, `filter`, `spread`, `*_join`, `group_by`, and `summarize`

Final project outline

Due Week 4 and should include

- Description of the data to be used
- Discussion of preparatory work that needs to be done, and how it will meet the final requirements (i.e., use the functions on the previous slide)
- Anything else you can think of that you want feedback from me on Primary purpose is for me to assess the feasibility of your project and help provide you with guidance.

Final project presentation

Order randomly assigned and should cover the following (i.e., slides dedicated to each)

- Share your journey (everyone, at least for a minute or two)
- Discuss challenges you had along the way
- Celebrate your successes
- Discuss challenges you are still facing
- Discuss substantive findings
- Show off your cool data figures!
- Disucss next R hurdle you want to tackle

Labs

- Every Thursday throughout the term
- Time allotment will vary (~45 minutes to the entire class session)
- Generally, labs will include some guided practice and a "challenge"
- Immensely important to learning, and therefore contribute to your grade (5 points each). Contact me beforehand if you're going to miss a lab.
- The final two weeks will be for final project presentations and attendance counts towards your lab grade for that week.

Grading

- **Homework**: 8 @ 10 points each = 80 points (28%)
- **Final Project**: 120 points (42%)
- **Final Project Outline**: 10 points (4%)
- **Final Project Presentation**: 25 points (9%)
- **Labs**: 10 @ 5 points each = 50 points (18%)

Total Possible: 285 points

Grading

LOWER POINT RANGE	GRADE	UPPER POINT RANGE
≥ 97% (276 pts)	A+	
≥ 93% (265 pts)	A	(276 pts) < 97%
≥ 90% (256 pts)	A-	(265 pts) < 93%
≥ 87% (248 pts)	B+	(256 pts) < 90%
≥ 83% (237 pts)	B	(248 pts) < 87%
≥ 80% (228 pts)	B-	(237 pts) < 83%
≥ 77% (219 pts)	C+	(228 pts) < 80%
≥ 73% (208 pts)	C	(219 pts) < 77%
< 70% (200 pts)	C-	(208 pts) < 73%
	F	(200 pts) < 70%

Orientation of this course

- This course is oriented around the .
  - Very conscious decision that I really believe is the correct one.
  - The is an alternative to base R functions

What is R?

What is R?

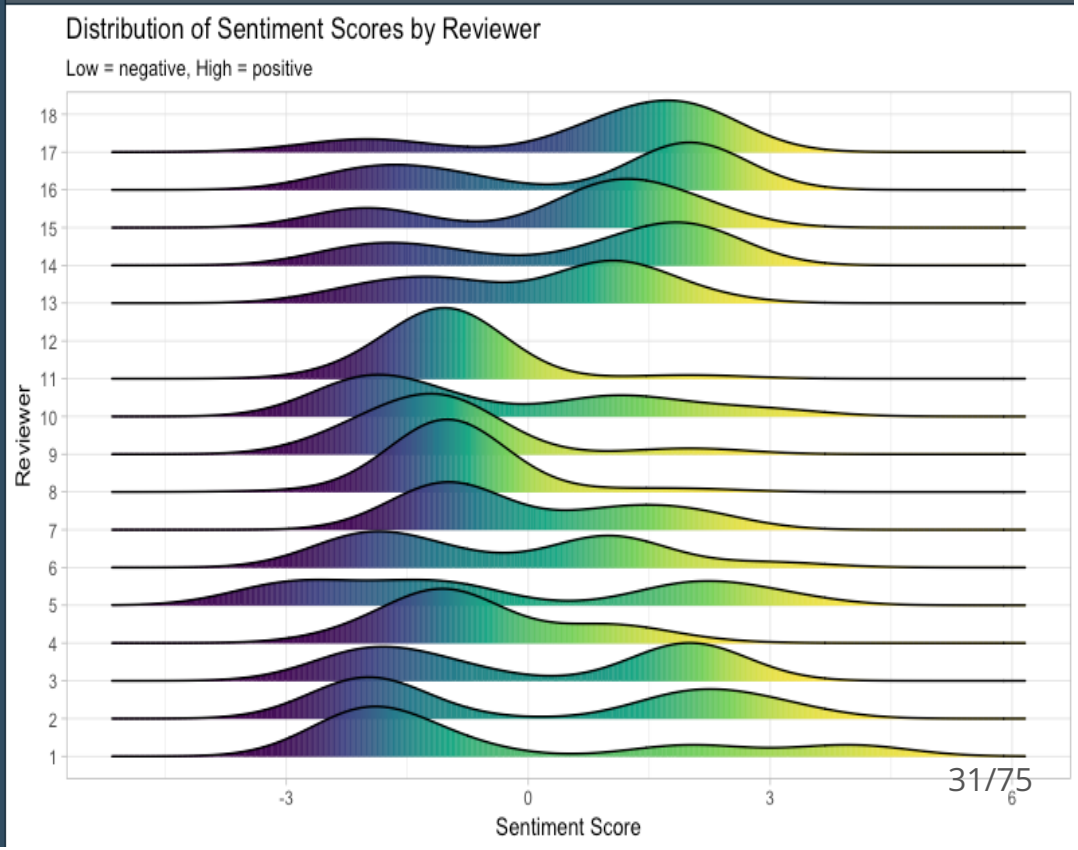
- A programming language
- Tremendously powerful and flexible statistical software that happens to be free
- No point-and-click interface
- Incredible array of external "packages" available for specialized analyses, data visualizations, or to automate much of the data "munging" process

Code-based interface

RStudio

```
  mutate(lemma = reorder(lemma, n)) %>%
  ggplot(aes(lemma, n)) +
    geom_col() +
    xlab(NULL) +
    coord_flip()

ggsave(width = 6.5, height = 9.5, "word_freq.pdf")


library(ggjoy)
words %>%
  inner_join(get_sentiments("afinn")) %>%
  mutate(reviewer = forcats::fct_reorder(as.factor(reviewer), score),
         reviewer = as.factor(as.numeric(reviewer))) %>%
  ggplot(aes(score, reviewer, fill = ..ecdf..)) +
    geom_joy_gradient(calc_ecdf = TRUE) +
    scale_fill_viridis_c() +
    theme(legend.position = "none") +
  xlab("Sentiment Score") +
  ylab("Reviewer") +
  ggtitle("Distribution of Sentiment Scores by Reviewer",
          "Low = negative, High = positive")

ggsave(width = 6.5, height = 9.5, "rater_sentiments.pdf")

word_sents <- words %>%
  inner_join(get_sentiments("bing")) %>%
  group_by(reviewer) %>%
  count(sentiment) %>%
  mutate(tot_rat = sum(n),
         n = ifelse(sentiment == "negative", n*-1, n))
```

```
+         reviewer = as.factor(as.numeric(reviewer))) %>%
+   ggplot(aes(score, reviewer, fill = ..ecdf..)) +
+     geom_joy_gradient(calc_ecdf = TRUE) +
+     scale_fill_viridis_c() +
+     theme(legend.position = "none") +
+   xlab("Sentiment Score") +
+   ylab("Reviewer") +
+   ggtitle("Distribution of Sentiment Scores by Reviewer",
+           "Low = negative, High = positive")
Joining, by = "word"
Picking joint bandwidth of 0.721
>
```



Moving to code/programming

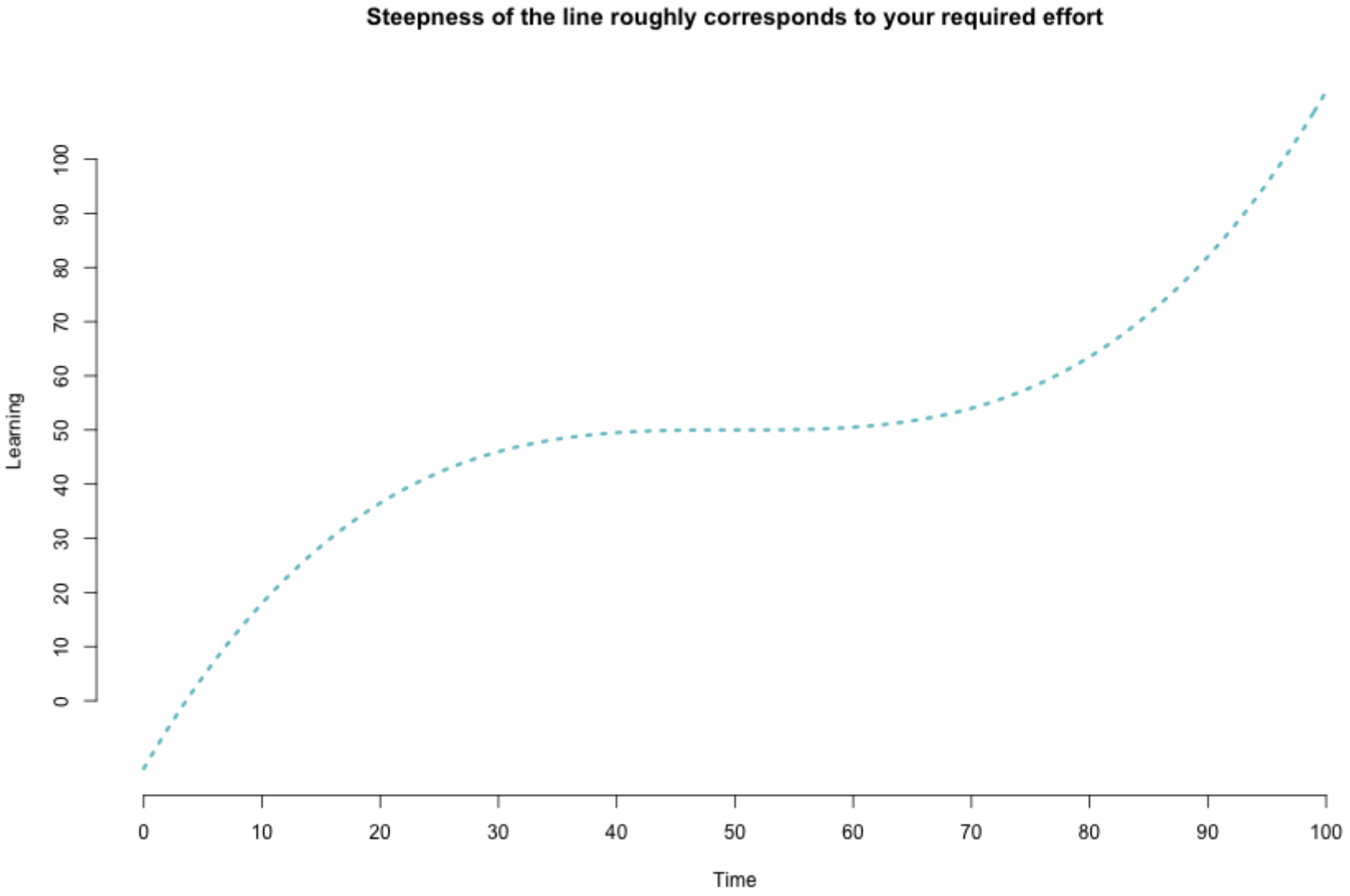
Advantages

- Flexibility
  - Only limited by your own creativity (and current level of programming skills, which are ever-evolving)
- Transparency
  - Documented record of every step taken in your data preparation and analysis
- Efficiency
  - Many (most?) tasks can be automated and/or applied to multiple datasets/variables simultaneously or essentially simultaneously

Disadvantages

- Steep learning curve
  - Absolutely requires a significant time investment, both to learn initially and build fluency
  - Equivalent to learning a new language
- You will lose patience with point-and-click interfaces
- Likely to become "one of the converted"

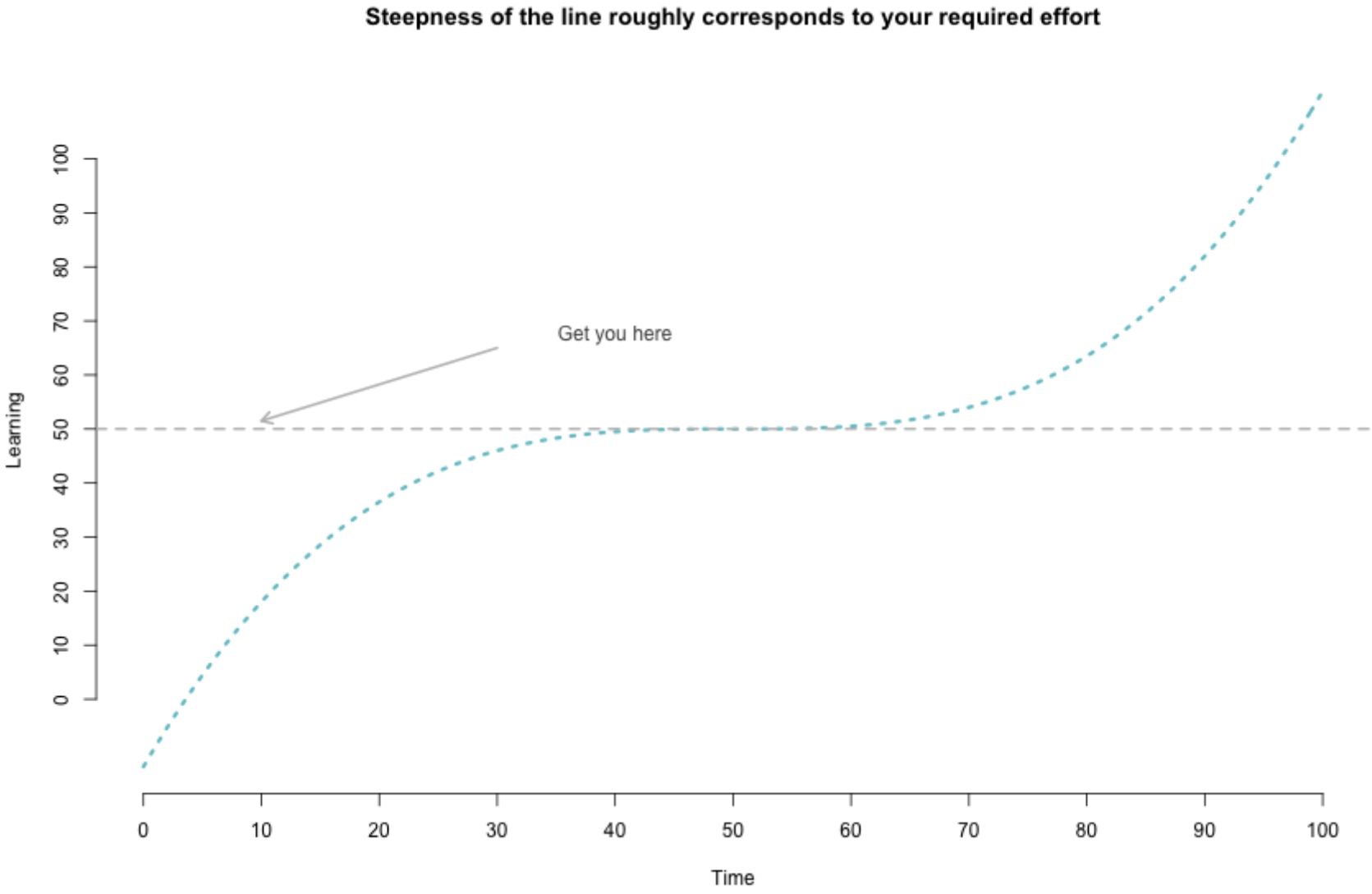
The R Learning Curve



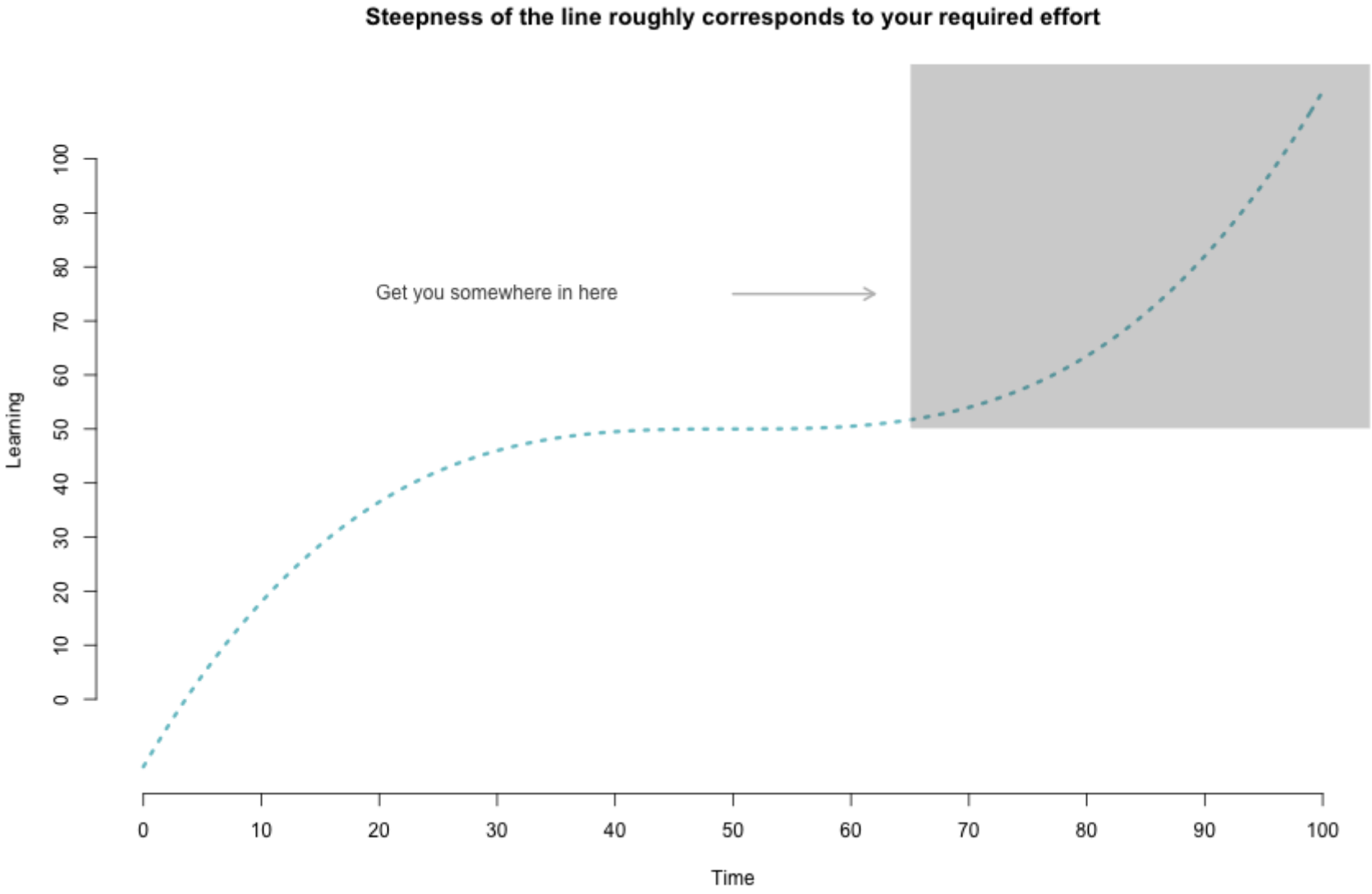
How to learn R?

- Three most important ingredients: time, time, and more time
- A sprinkling of dedication and determination help.
- Be patient and forgiving with yourself. It will feel slow at first. Most people have not trained themselves to think in this way.

My goal for this course



My goals for a second course



R as a big calculator

```
3 + 2
```

```
## [1] 5
```

```
(1/-(3/2)^2) / 2^-1/9
```

```
## [1] -0.09876543
```

Object Assignment

```
a <- 3
b <- 2
a + b
```

```
## [1] 5
```

```
a / (a + b)
```

```
## [1] 0.6
```

Object re-assignment

```
a <- 3
a
```

```
## [1] 3
```

```
a <- 7
a
```

```
## [1] 7
```

Object Assignment (continued)

Objects can be of a variety of types.

```
string <- "Hello world!"
logical <- TRUE
double <- 3.2587021
Integer <- 6L
```

In this case, we can't exactly do arithmetic with all of these. For example

```
string + double
```

```
## Error in string + double: non-numeric argume
```

But, these objects can be extremely useful in programming.

Functions and getting help

R functions

- Anything that carries out an operation in R is a function, even `+`.
- Functions (outside of primitive functions) are preceded by `()`
  - e.g., `sum()`, `lm()`

Getting help

- `?` can be helpful, but often too advanced early on
  - Helpful for understanding the formal arguments of a function
  - Scroll down to the examples first
- Google is your best friend
- Other good websites
  - http://stackoverflow.com
  - Mailing lists:
    - https://stat.ethz.ch/mailman/listinfo/r-help

R Packages

R packages

R ships with considerable functionality. It also comes with a set of packages

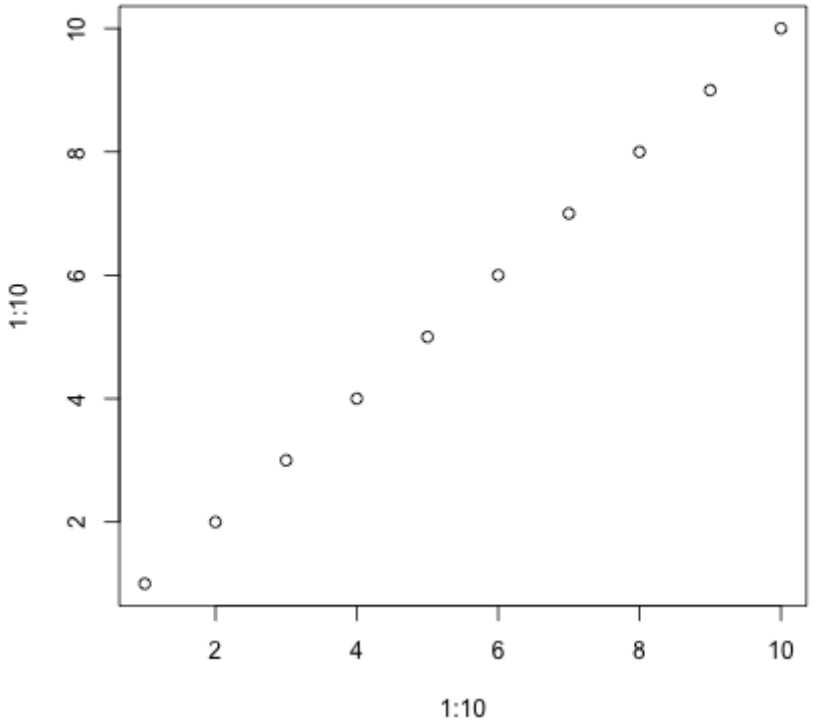
- e.g.
  - "base"
  - "graphics"
  - "stats"

R also comes with a set of packages installed, but not loaded on launch

- e.g.
  - "boot"
  - "MASS"
  - "Matrix"

Pre-loaded packages operate "out of the box". For example, `plot` is part of the package, which ships with R.

```
plot(x = 1:10, y = 1:10)
```



R packages (continued)

Packages that come installed, but not pre-loaded, require an explicit call to the library first. For example, to simulate data from a multivariate normal distribution we could use `MASS::mvrnorm`.

```
# Set up simulation parameters
n_obs <- 1000
means <- c(100, 50)
error_cv <- matrix(c(100, 44,
                     44, 49), byrow = TRUE, ncol = 2) # part of base

cov2cor(error_cv) # part of stats package
```

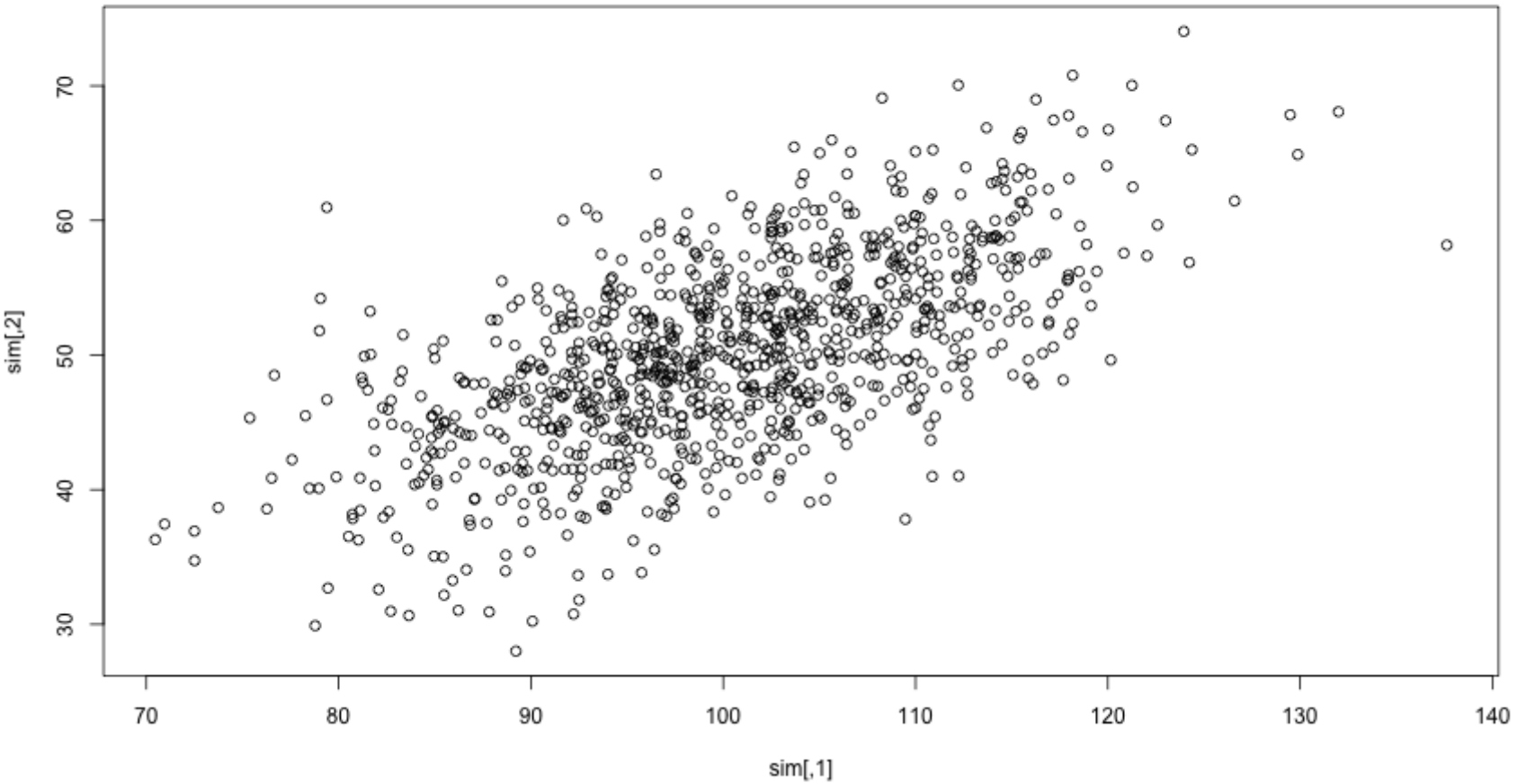
```
##           [,1]      [,2]
## [1,] 1.0000000 0.6285714
## [2,] 0.6285714 1.0000000
```

Simulation, continued

```
library(MASS) # pre-installed package
sim <- mvrnorm(n = n_obs, mu = means, Sigma = error_cv)
head(sim)
```

```
##           [,1]     [,2]
## [1,] 120.83111 57.57135
## [2,] 102.68509 51.72533
## [3,]  98.84173 45.72817
## [4,]  88.48961 55.49168
## [5,]  86.90686 44.02828
## [6,] 114.51243 64.21404
```

```
plot(sim)
```



```
cor(sim)
```

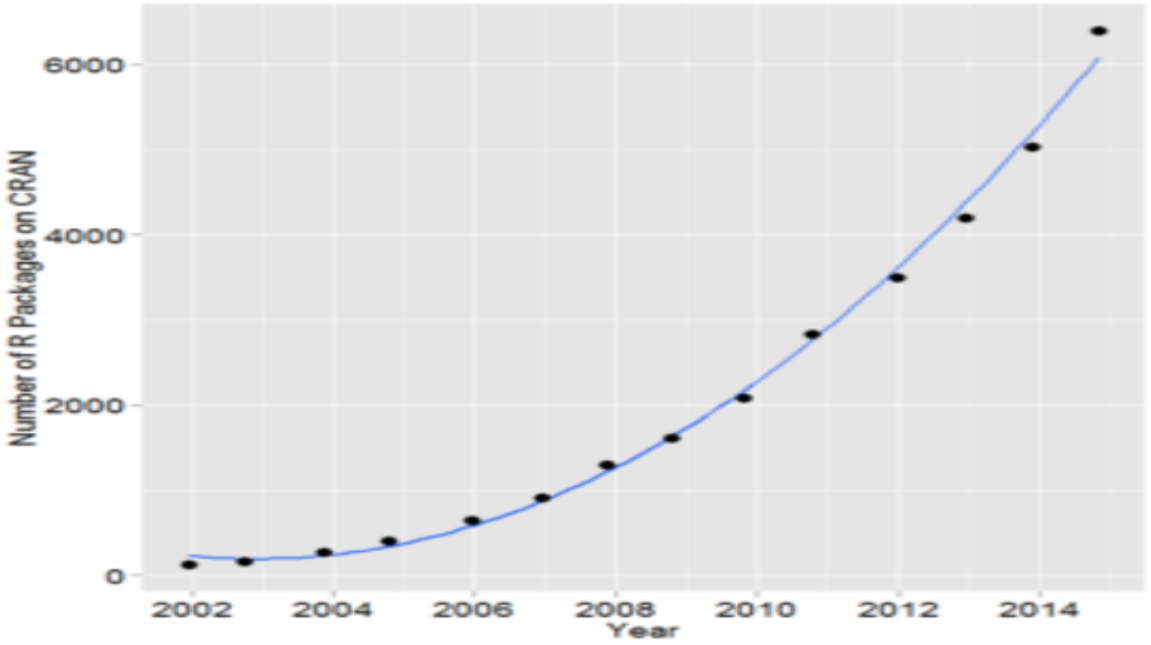
```
##           [,1]      [,2]
## [1,] 1.0000000 0.6305852
## [2,] 0.6305852 1.0000000
```

Overall takeaway

There is a of functionality that comes with R right from your initial download. But, the functionality can be extended further by installing other packages.

Other packages

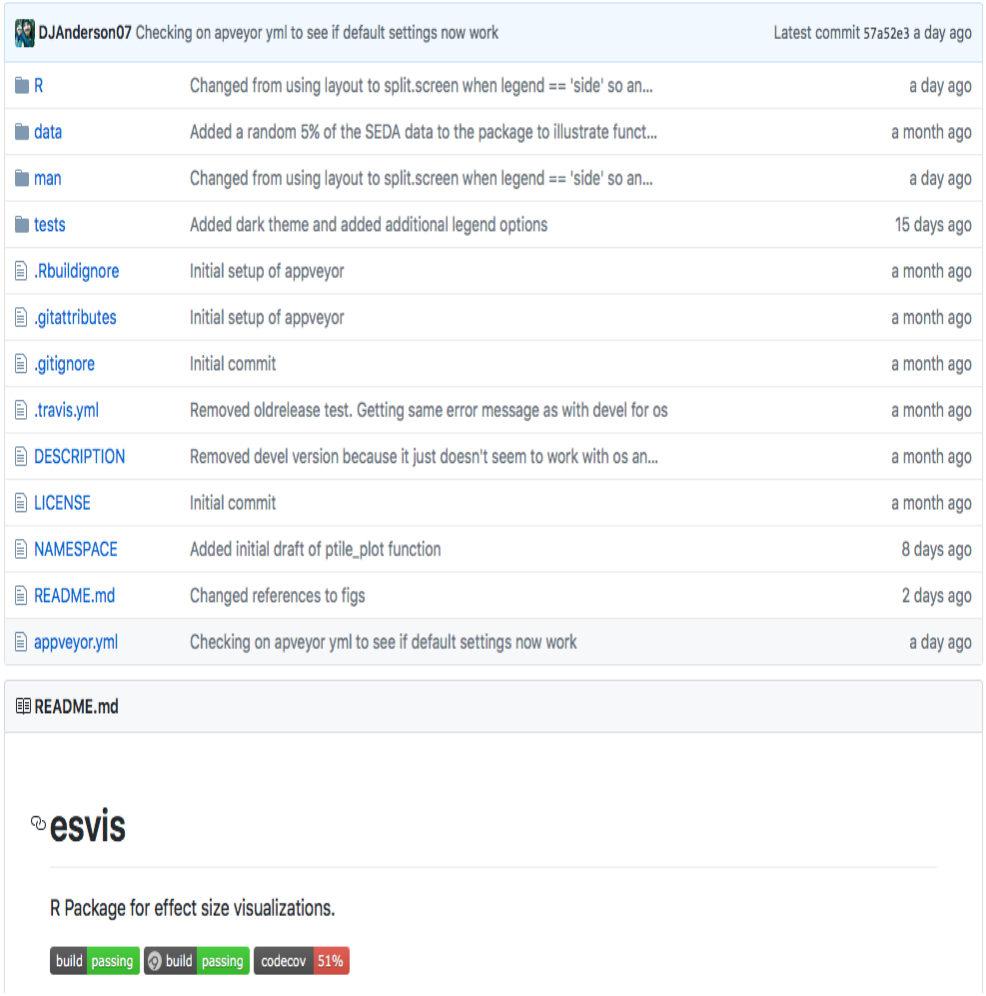
On CRAN



- Any of these can be installed with `install.packages("pkg_name")`. You will then have access to all the functionality of the package.
- Notice this plot only goes to mid-2014. As of this writing (09/20/17), there are 11,460 packages available on CRAN! See https://cran.r-project.org/web/packages/

Other packages

On github



DJAnderson07 Checking on apveyor yml to see if default settings now work — Latest commit 57a52e3 a day ago

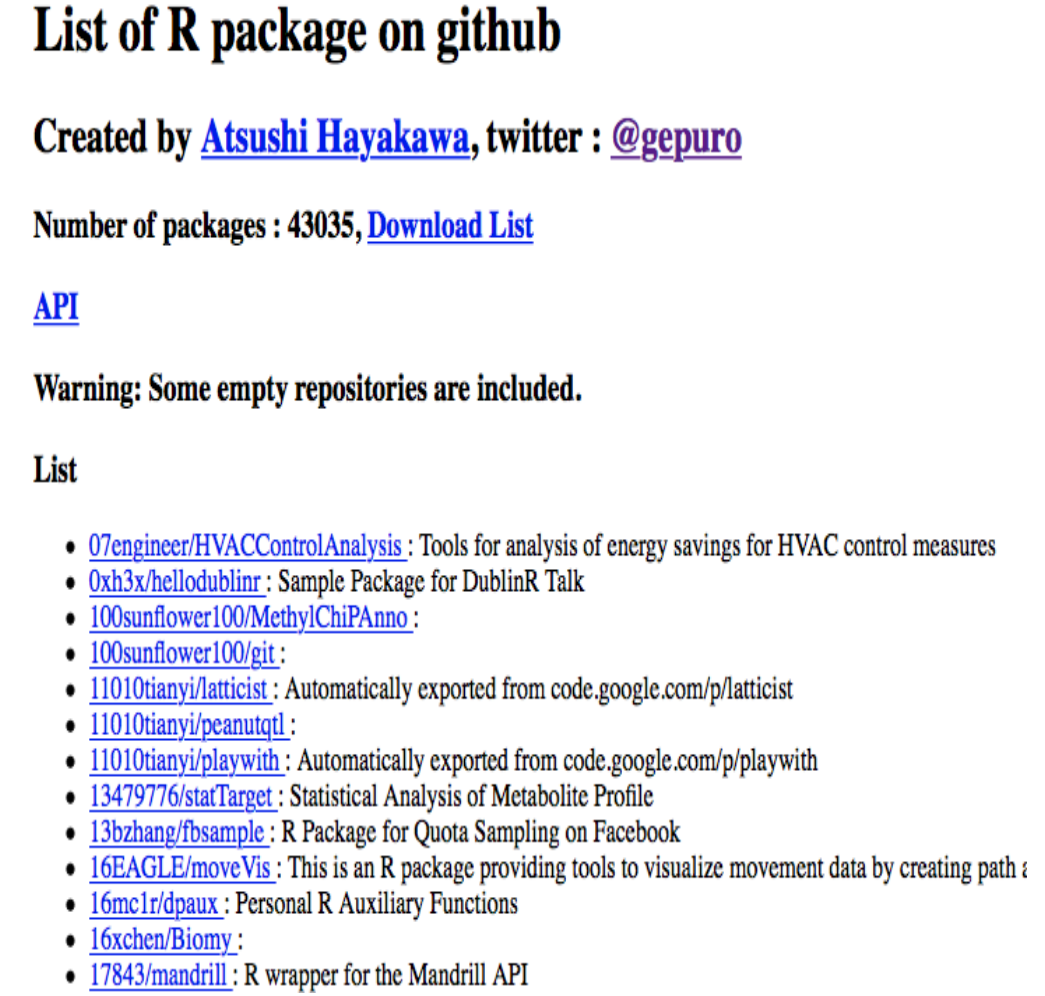
R	Changed from using layout to split.screen when legend == 'side' so an...	a day ago
data	Added a random 5% of the SEDA data to the package to illustrate funct...	a month ago
man	Changed from using layout to split.screen when legend == 'side' so an...	a day ago
tests	Added dark theme and added additional legend options	15 days ago
.Rbuildignore	Initial setup of appveyor	a month ago
.gitattributes	Initial setup of appveyor	a month ago
.gitignore	Initial commit	a month ago
.travis.yml	Removed oldrelease test. Getting same error message as with devel for os	a month ago
DESCRIPTION	Removed devel version because it just doesn't seem to work with os an...	a month ago
LICENSE	Initial commit	a month ago
NAMESPACE	Added initial draft of ptile_plot function	8 days ago
README.md	Changed references to figs	2 days ago
appveyor.yml	Checking on apveyor yml to see if default settings now work	a day ago

README.md

esvis

R Package for effect size visualizations.

build passing | build passing | codecov 51%



List of R package on github

Created by Atsushi Hayakawa, twitter : @gepuro

Number of packages : 43035, Download List

API

Warning: Some empty repositories are included.

List

- 07engineer/HVACControlAnalysis : Tools for analysis of energy savings for HVAC control measures
- 0xh3x/hellodublinr : Sample Package for DublinR Talk
- 100sunflower100/MethylChiPAnno :
- 100sunflower100/git :
- 11010tianyi/latticist : Automatically exported from code.google.com/p/latticist
- 11010tianyi/peanutqtl :
- 11010tianyi/playwith : Automatically exported from code.google.com/p/playwith
- 13479776/statTarget : Statistical Analysis of Metabolite Profile
- 13bzhang/fbsample : R Package for Quota Sampling on Facebook
- 16EAGLE/moveVis : This is an R package providing tools to visualize movement data by creating path a
- 16mc1r/dpaux : Personal R Auxiliary Functions
- 16xchen/Biomy :
- 17843/mandrill : R wrapper for the Mandrill API

Installing from github

First, install the package from CRAN

```
install.packages("devtools")
```

Next, load the library to access the `install_github` function. For example, to install my package

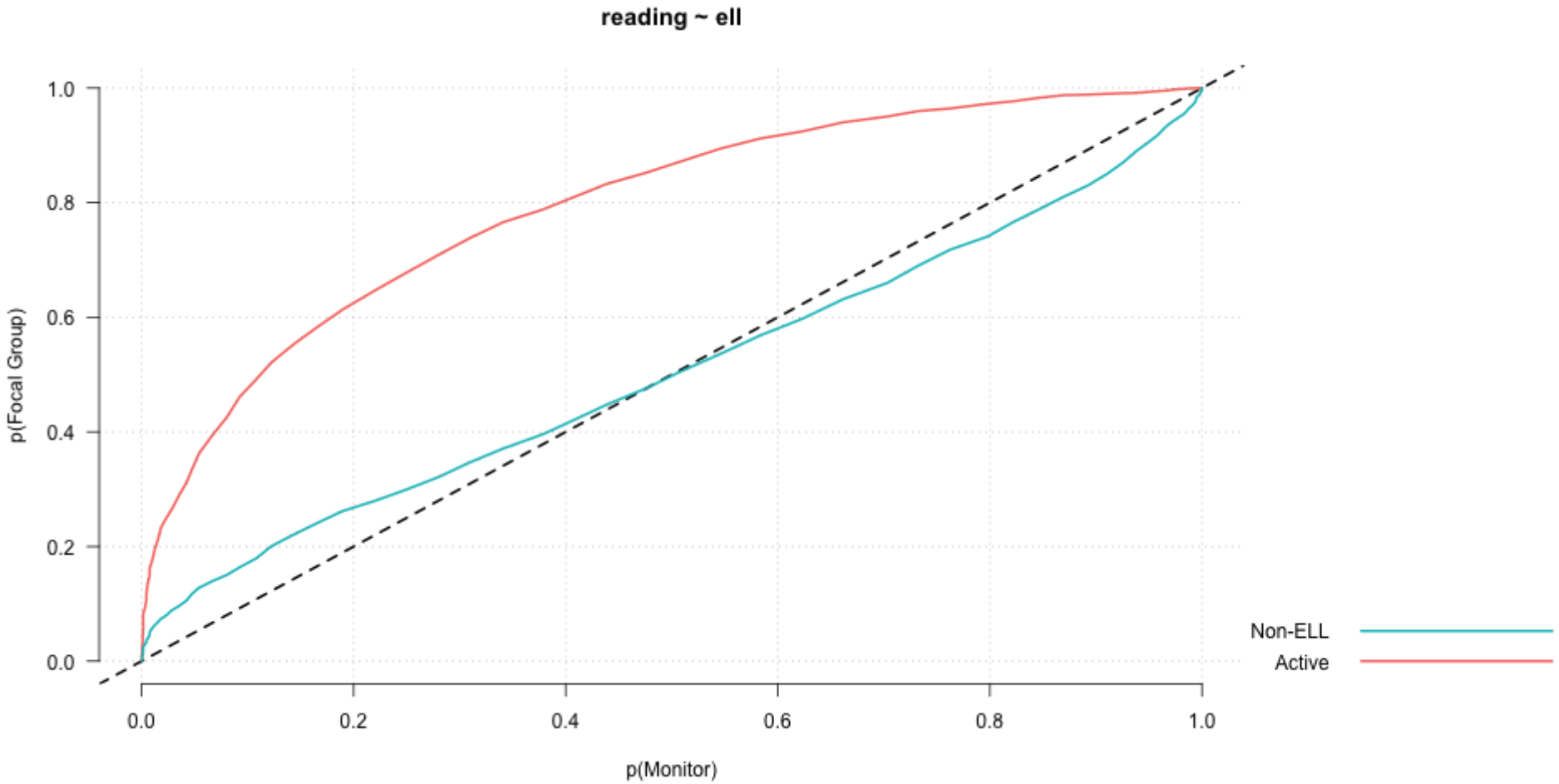
```
library(devtools)
install_github("DJAnderson07/esvis")
```

You then have access to all the functionality of that package once you load it. Let's look at these data:

SID	COHORT	SPED	ETHNICITY	FRL	ELL	SEASON	READING	MATH
332347	1	Non-Sped	Hispanic	FRL	Active	Spring	167	192
400047	1	Non-Sped	Native Am.	FRL	Non-ELL	Spring	191	191
400047	1	Non-Sped	Native Am.	FRL	Non-ELL	Fall	183	182
400047	1	Non-Sped	Native Am.	FRL	Non-ELL	Winter	178	179
400277	1	Non-Sped	Native Am.	FRL	Non-ELL	Winter	199	197
400277	1	Non-Sped	Native Am.	FRL	Non-ELL	Fall	203	196

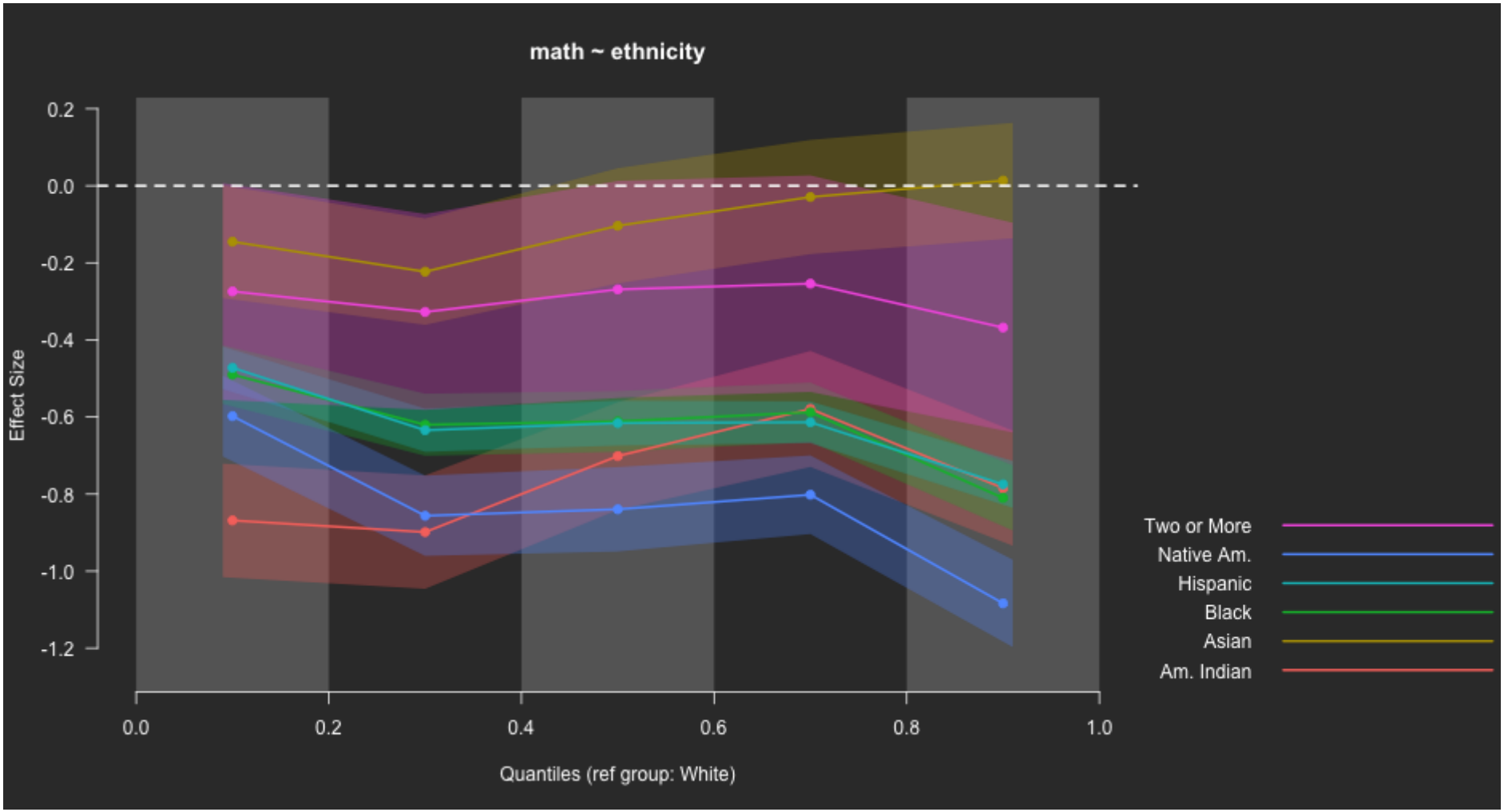
PP-Plot

```
library(esvis)
pp_plot(reading ~ ell, d)
```



Binned quantile effect sizes

```
binned_plot(math ~ ethnicity, d, qtiles = seq(0, 1, .2), theme = "dark")
```



ES Calculation

```
hedg_g(math ~ ethnicity, d, ref_group = "White")
```

```
##   ref_group   foc_group  estimate
## 1     White       Asian 0.1068644
## 2     White Two or More 0.3166034
## 3     White    Hispanic 0.6335197
## 4     White       Black 0.6293799
## 5     White  Am. Indian 0.7641845
## 6     White  Native Am. 0.8213924
```

```
auc(math ~ ethnicity, d)
```

```
##      ref_group   foc_group  estimate
## 1        White       Asian 0.5350915
## 2        White Two or More 0.5821795
## 3        White    Hispanic 0.6741454
## 4        White       Black 0.6748681
## 5        White  Am. Indian 0.6955814
## 6        White  Native Am. 0.7305532
## 7        Asian Two or More 0.5429502
```

Is this exciting!?! YES!!!

Why is this such a big deal?

- With just a basic knowledge of R you have access to literally thousands of packages
  - Expanding on a daily basis
  - Provides access to cutting edge and specialized functionality for analysis, data visualization, and data munging
  - Some of the most modern thinking on data analysis topics are often represented in these packages

A few examples of amazing packages

First: the data

https://cepa.stanford.edu/seda/overview

(data loaded from code not displayed)

```
head(seda)
```

```
##   year grade   leaid                          leaname fips stateabb
## 1 2009     3 5301350 CLE ELUM-ROSLYN SCHOOL DISTRICT   53       WA
## 2 2009     3 4032370                 WESTERN HEIGHTS   40       OK
## 3 2009     3 4031950                       WAUKOMIS   40       OK
## 4 2009     3 1300290                  BARROW COUNTY   13       GA
## 5 2009     3 1304540              SOCIAL CIRCLE CITY   13       GA
## 6 2009     3 1907920 COLO-NESCO COMM SCHOOL DISTRICT   19       IA
##   mean_link_ela se_link_ela mean_link_math se_link_math time time2
## 1      205.4105    5.527168       221.0476     4.088524    0     0
## 2      176.4205    3.254465       210.9097     1.958732    0     0
## 3      192.3103    9.503721       217.2896     5.370912    0     0
## 4      201.5906    1.672783       220.0416     1.206892    0     0
## 5      203.6270    3.515068       224.9344     2.304581    0     0
## 6      218.0754    6.857743       236.9710     4.348451    0     0
```

lme4

Let's fit a multilevel linear growth model for ELA

Question: How much does the progression from Grades 3-7 vary by state?

```
# install.packages("lme4")
library(lme4)
```

```
## Loading required package: Matrix
```

```
mlm <- lmer(mean_link_ela ~ 1 + time +
                (1 + time|leaname) +
                (1 + time|stateabb),
            data = seda)
```

```
summary(mlm)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: mean_link_ela ~ 1 + time + (1 + time | leaname) + (1 + time |
##     stateabb)
##    Data: seda
##
## REML criterion at convergence: 382536.8
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -10.9751  -0.4706  -0.0004   0.4656   7.2354
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  leaname  (Intercept) 172.846  13.1471
##           time          2.156   1.4683  -0.29
##  stateabb (Intercept)  78.571   8.8640
##           time          0.673   0.8204  -0.44
##  Residual               31.900   5.6480
## Number of obs: 54155, groups:  leaname, 11153; stateabb, 51
##
## Fixed effects:
```

Prettier output? Use a different package!

```
# install.packages("sjPlot")
library(sjPlot)
sjt.lmer(mlm, p.kr = FALSE) # Note, second argument generally not necessary
```

	mean_link_ela		
	B	*CI*	*p*
Fixed Parts			
(Intercept)	205.25	202.76 – 207.75	<.001
time	11.59	11.35 – 11.83	<.001
Random Parts			
σ2		31.900	
τ00, leaname		172.846	
τ00, stateabb		78.571	
ρ01		-0.290	
Nleaname		11153	
Nstateabb		51	
ICCleaname		0.610	
ICCstateabb		0.277	
Observations		54155	
R2 / Ω02		.954 / .954	

,

mean_link_ela

Plot differences between states

```
library(lattice) # pre-installed package
re <- ranef(mlm, condVar = TRUE)
qqmath(re)
```

Compare to a curvilinear model

```
mlm_c <- lmer(mean_link_ela ~ 1 + time + time2 +
                (1 + time|leaname) +
                (1 + time|stateabb),
              data = seda)
```

For more abbreviated (and essential) output

```
library(arm)
display(mlm_c, detail = TRUE)
```

```
## lmer(formula = mean_link_ela ~ 1 + time + time2 + (1 + time |
##     leaname) + (1 + time | stateabb), data = seda)
##             coef.est coef.se t value
## (Intercept) 205.93     1.27  161.67
## time         10.24     0.14   75.49
## time2         0.34     0.01   23.19
##
## Error terms:
##  Groups    Name        Std.Dev. Corr
##  leaname   (Intercept) 13.17
##            time         1.49    -0.30
```

Compare models

```
anova(mlm, mlm_c)
```

```
## refitting model(s) with ML (instead of REML)
```

```
## Data: seda
## Models:
## mlm: mean_link_ela ~ 1 + time + (1 + time | leaname) + (1 + time |
## mlm:     stateabb)
## mlm_c: mean_link_ela ~ 1 + time + time2 + (1 + time | leaname) + (1 +
## mlm_c:     time | stateabb)
##       Df    AIC    BIC  logLik deviance  Chisq Chi Df Pr(>Chisq)
## mlm    9 382555 382635 -191268   382537
## mlm_c 10 382023 382112 -191002   382003 533.11      1  < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

A few other examples

The ggplot2 package

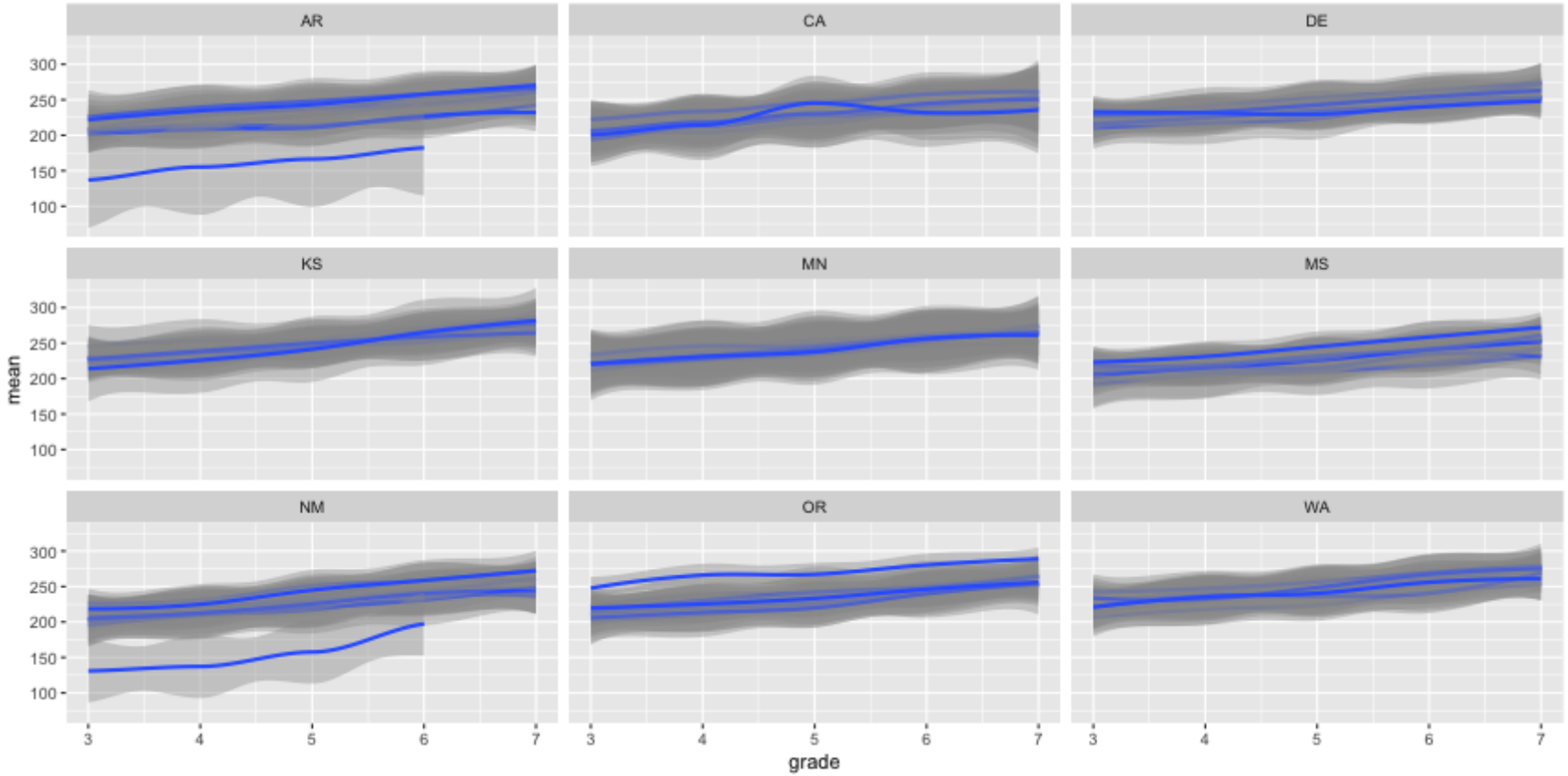
(we'll talk about this package a lot all term long)

```
head(s2)
```

```
##         year grade   leaid                        leaname fips stateabb
## AR.668  2009     3  507770      HIGHLAND SCHOOL DISTRICT    5       AR
## AR.773  2009     3 5900112   LUKACHUKAI COMMUNITY SCHOOL   59       AR
## AR.3267 2009     3  508610 LAKE HAMILTON SCHOOL DISTRICT    5       AR
## AR.3743 2009     3  500043 MOUNTAIN HOME SCHOOL DISTRICT    5       AR
## AR.4128 2009     3  508010        HUGHES SCHOOL DISTRICT    5       AR
## AR.5689 2009     3  504800      CROSSETT SCHOOL DISTRICT    5       AR
##         time time2 Subject     mean       se
## AR.668     0     0     ela 208.8605 3.097313
## AR.773     0     0     ela 114.1453 7.952303
## AR.3267    0     0     ela 213.4426 2.723927
## AR.3743    0     0     ela 212.5173 2.666646
## AR.4128    0     0     ela 197.0950 7.475408
## AR.5689    0     0     ela 192.4590 3.492340
```

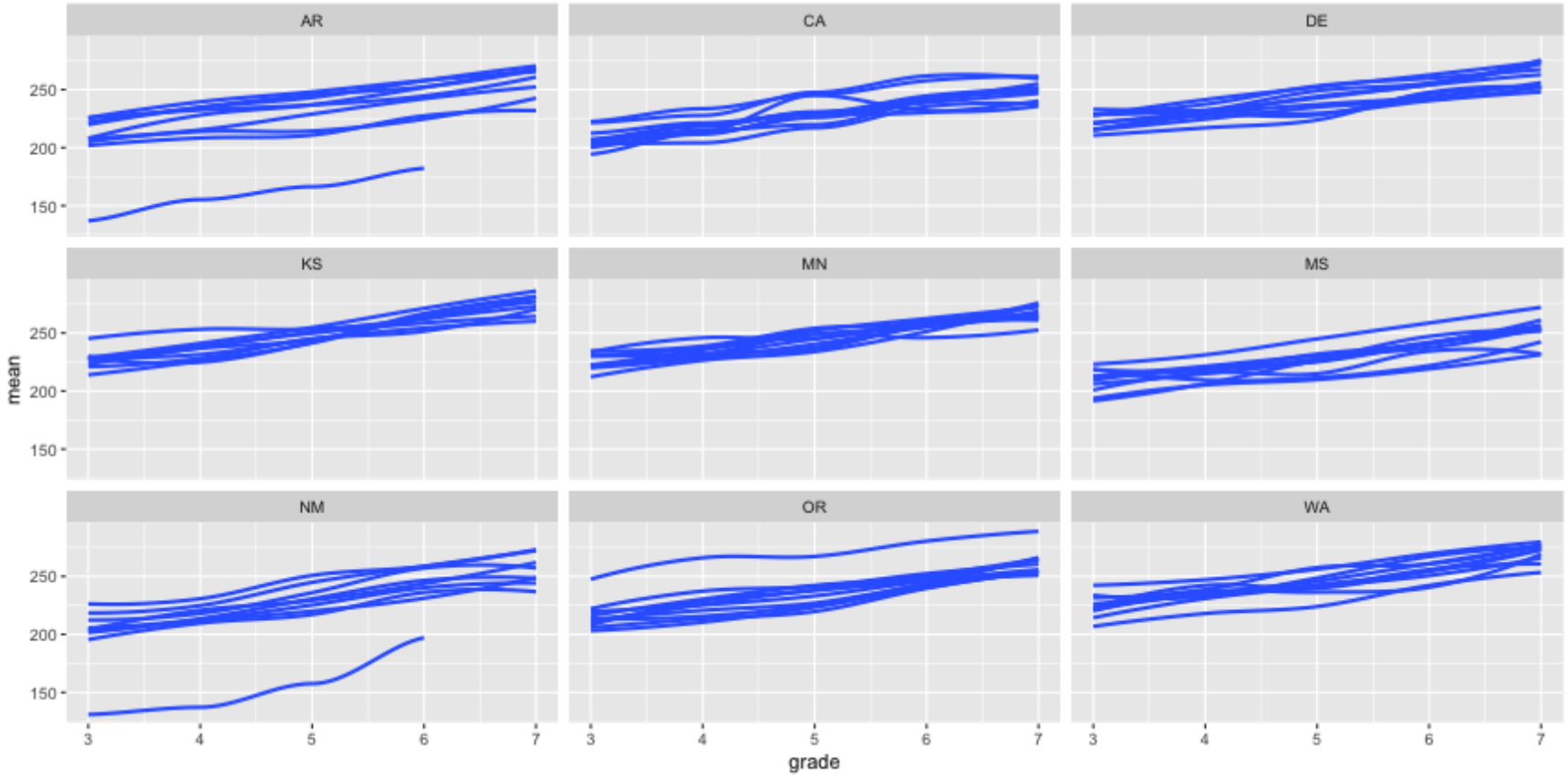
ggplot Ex 1

```
ggplot(data = s2, aes(x = grade, y = mean, group = leaid)) +
    geom_smooth() +
    facet_wrap(~stateabb)
```



ggplot Ex 2

```
ggplot(data = s2, aes(x = grade, y = mean, group = leaid)) +
    geom_smooth(se = FALSE) +
    facet_wrap(~stateabb)
```



Quickly...

A few other new exciting advancements

shiny

- showcase
- mediation
- shiny stan

```
library(shinystan)
launch_shinystan_demo()
```

plotly

Book https://plotly-book.cpsievert.me/linking-views-with-shiny.html

The *gganimate* extension to *ggplot2*

```
## Warning: Deprecated: please use `purrr::possibly()` instead
```

```
## Warning: Deprecated: please use `purrr::possibly()` instead
```

```
## Warning: Deprecated: please use `purrr::possibly()` instead
```

```
## Warning: Deprecated: please use `purrr::possibly()` instead
```

```
## Warning: Deprecated: please use `purrr::possibly()` instead
```

```
## Error in mutate_impl(.data, dots): Evaluation error: object 'E' not found.
```

```
## Warning: Deprecated: please use `purrr::possibly()` instead
```

```
## Warning: Deprecated: please use `purrr::possibly()` instead
```

```
## Warning: Deprecated: please use `purrr::possibly()` instead
```

What does LOESS (and LOWESS) stand for again?

- Locally weighted scatterplot smoothing
- non-parametric
- Similar in for to k-nearest neighbor models

Let's visualize it!

Animating LOESS fits with different spans

```
## Error in mutate_impl(.data, dots): Evaluation error: object 'E' not found.
```

```
## Error in ggplot(dat, aes(E, NOx)): object 'dat' not found
```

```
## Error in gg_animate(p): could not find function "gg_animate"
```

Credit: David Robinson (http://varianceexplained.org/files/loess.html)

Slightly smoother version of basically the same thing - the tweener package.

Other advancements

- ggplot extensions: http://www.ggplot2-exts.org/gallery/
- html widgets: http://www.htmlwidgets.org/

Dynamic documents

We'll talk a lot about this, starting next week!

Next time

- Getting started with R
- Reproducible Research
- LAB: Producing a dynamic document

Homework 1 will be assigned