Data Wrangling in R

http://sisbid.github.io/Data-Wrangling/

Course Info

Course name	Data Wrangling in R
Instructors	Carrie Wright and Ava Hoffman
Course website	http://sisbid.github.io/Data-Wrangling/
Goals	Teach you how to get and clean data
Pre-reqs	Hopefully some R programming

What we will cover in this course:

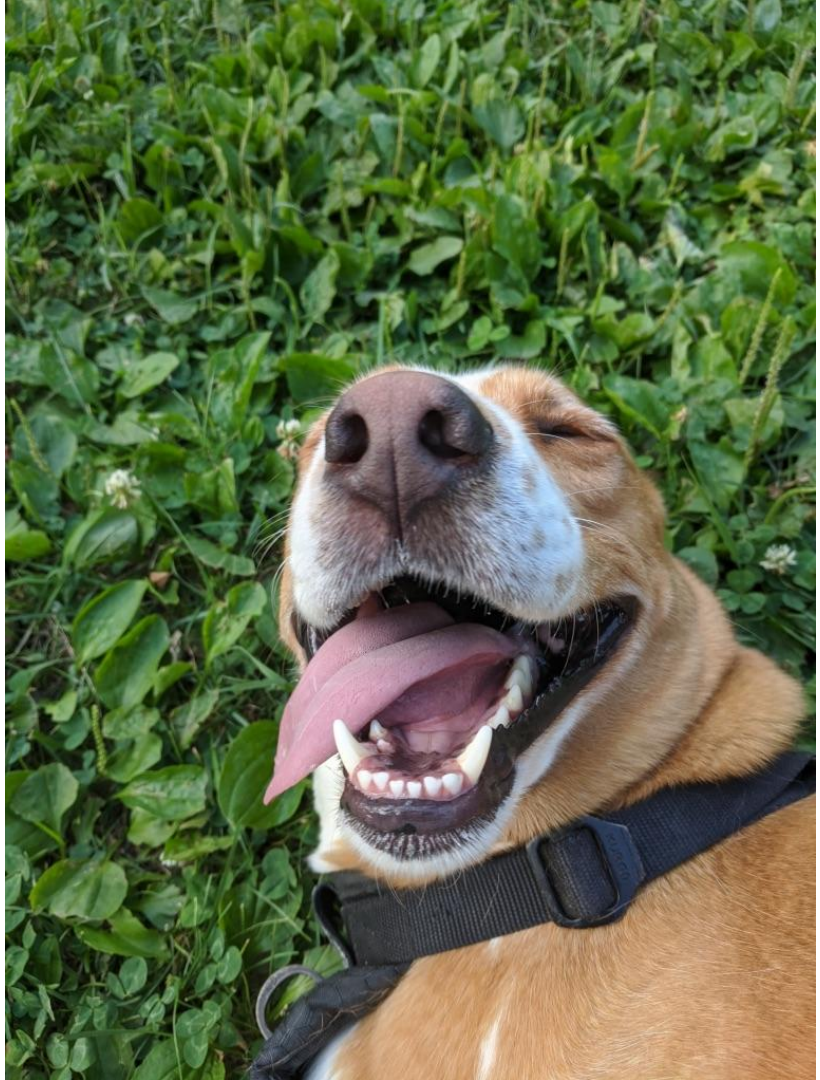
1) Why data wrangling is important?
2) Version control - Git/GitHub
3) Importing data (and outporting)
4) Subsetting data
5) Summarizing data
6) Cleaning data
7) Reshaping data
8) Data merging and joining
9) Functional programming (efficiently applying functions)
10) Working with factors, strings, dates
11) Working with genomic data in R

The Tidyverse

Newer packages designed for data science that make R code more intuitive.

How many people feel about data wrangling

How we feel about data wrangling



Carrie

About us

Ava

Carrie Wright, Ph.D.

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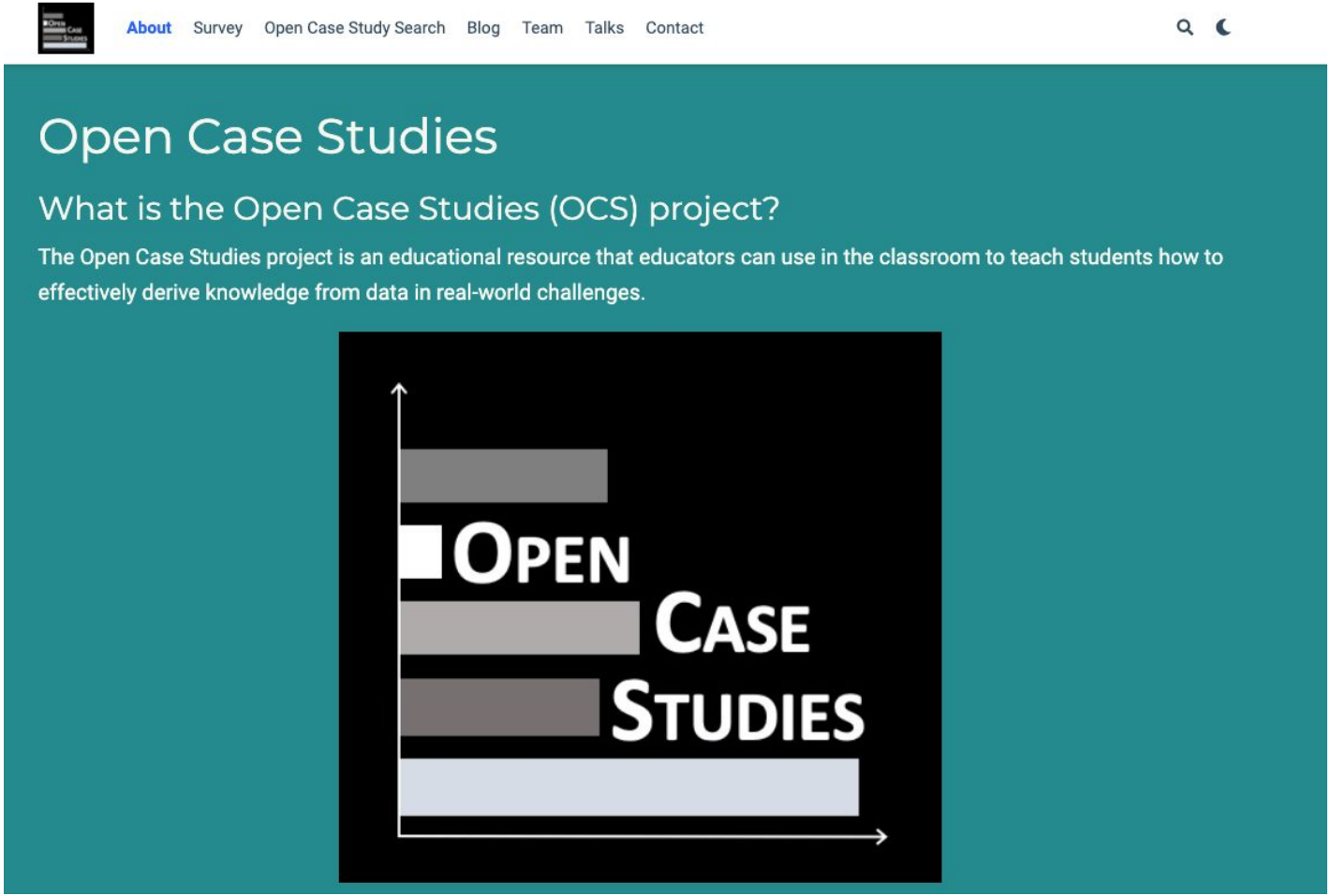
About

Carrie Wright is a Senior Staff Scientist at the Fred Hutchinson Cancer Research Center. Dr. Wright's work is focused on innovating ways to make data science and computational biology more accessible. She is a member of the Open Case Studies team, the Genomic Data Science Community Network (GDSCN), and the Informatics Technology for Cancer Research (ITCR) Training Network (ITN). She also currently leads the ITCR Training and Outreach Working Group.

Previously, Dr. Wright was an Assistant Scientist in the Department of Biostatistics at the Johns Hopkins Bloomberg School of Public Health (JHSPH) and a member of the Johns Hopkins Data Science Lab (DaSL).

Prior to joining the JHSPH, Dr. Wright was a Postdoctoral Fellow at the Lieber Institute for Brain Development (LIBD), where her research focused on uncovering genetic mechanisms in psychiatric disease (with a particular emphasis on non-coding RNA) through the utilization of data science tools. At LIBD, Dr. Wright co-founded the LIBD rstats club, a community designed to encourage others to learn more about R programming and statistics. Dr. Wright has also served as an instructor for the Baltimore Underground Science Space and the Johns Hopkins Center for Talented Youth.

https://carriewright11.github.io/



https://www.opencasestudies.org/

ABOUT

RESEARCH

RESOURCES

FUN STUFF

RESUME / CV

AVA HOFFMAN

BALTIMORE, USA · AVAMARIEHOFFMAN @ GMAIL.COM

Hi! 👋🏻

I'm a data scientist and ecologist. I'm currently exploring ways to make genomics research more accessible by connecting communities to cloud-based resources. I get really excited about things at the intersection of ecology and data, like population genetics and statistical modeling in nature. Lately, I've been especially interested in how plants evolve in man-made ecosystems (cities!) and how we can link those findings to public health outcomes.

I like coding, climbing things, everything DIY, and taking stuff apart to see how it works. I'm also working to get a community upcycling collective called Bed Roll Baltimore going!

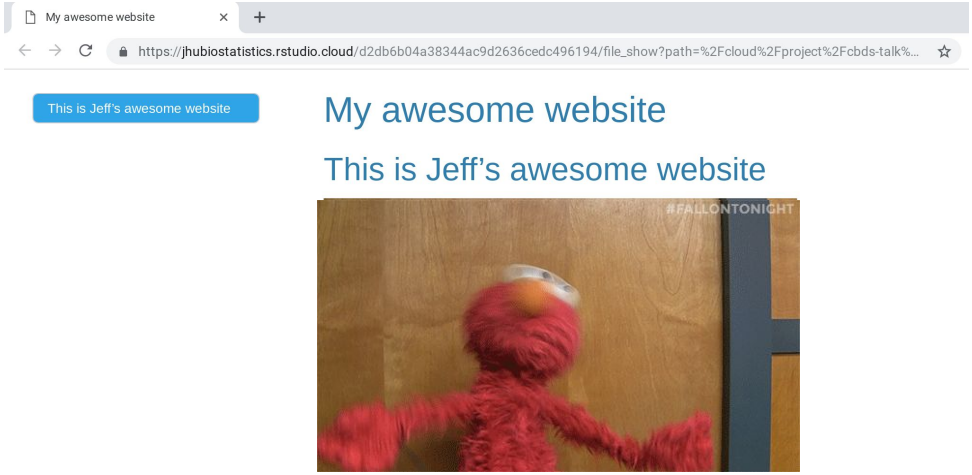
https://www.avahoffman.com/

Why this class

rmarkdown

```
---
title: "My awesome website"
output:
    html_document:
        toc: true
        toc_float: true
        theme: cerulean
---
# This is Jeff's awesome website

![](https://media.giphy.com/media/drXGoW1iudhKw/giphy.gif)
```



flexdashboard

````
---
title: "How does your BMI measure up?"
output: flexdashboard::flex_dashboard
runtime: shiny
---

Inputs {.sidebar}
-------------------------------------

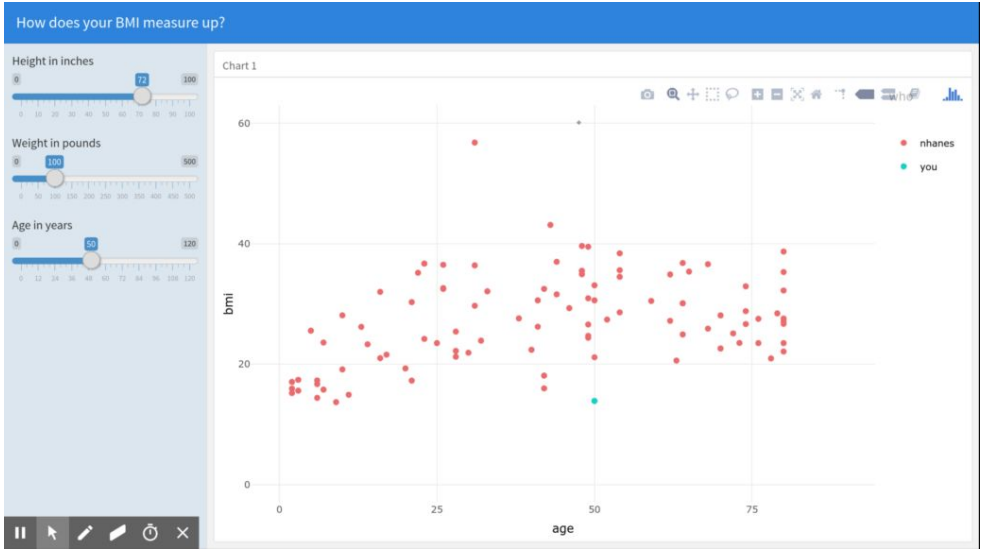
```{r}
library(flexdashboard); library(NHANES); library(plotly);library(dplyr)
sliderInput("height", "Height in inches",0,100,72)
sliderInput("weight", "Weight in pounds",0,500,100)
sliderInput("age", "Age in years",0,120,50)

```

Column
-------------------------------------

### Chart 1

```{r}
nhanes = sample_n(NHANES,100)
renderPlotly({
  df = data.frame(bmi = c(nhanes$BMI,input$weight*0.45/(input$height*0.025)^2),
                  age = c(nhanes$Age,input$age),
                  who = c(rep("nhanes",100),"you"))
  ggplotly(ggplot(df) +
             geom_point(aes(x=age,y=bmi,color=who)) +
             scale_x_continuous(limits=c(0,90)) +
             scale_y_continuous(limits=c(0,60)) +
             theme_minimal()
           )
})
```
````



httr

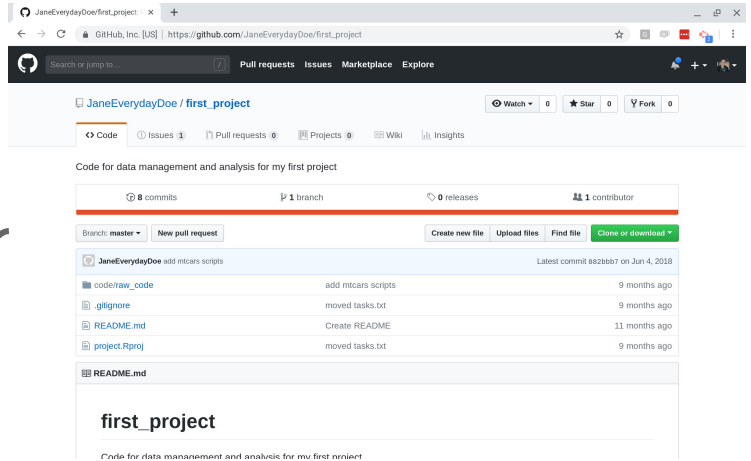
```
library(httr)
library(dplyr)

username = 'janeeverydaydoe'

url_git = 'https://api.github.com/'


api_response =
GET(url = paste0(url_git, 'users/',
username, '/repos'))

content(api_response)[[1]]
```




```
$id
[1] 130377298
$node_id
[1] "MDEwOlJlcG9zaXRvcnkxMzAzNzcyOTg="
$name
[1] "first_project"
$full_name
[1] "JaneEverydayDoe/first_project"
$owner$gravatar_id
[1] ""
$owner$url
[1] "https://api.github.com/users/JaneEverydayDoe"
```

...

But also...

Genomic signatures to guide the use of chemotherapeutics

Anil Potti[1,2], Holly K Dressman[1,3], Andrea Bild[1,3], Richard F Riedel[1,2], Gina Chan[4], Robyn Sayer[4], Janiel Cragun[4], Hope Cottrill[4], Michael J Kelley[2], Rebecca Petersen[5], David Harpole[5], Jeffrey Marks[5], Andrew Berchuck[1,6], Geoffrey S Ginsburg[1,2], Phillip Febbo[1,2,3], Johnathan Lancaster[4] & Joseph R Nevins[1,2,3]

Using *in vitro* drug sensitivity data coupled with Affymetrix microarray data, we developed gene expression signatures that predict sensitivity to individual chemotherapeutic drugs. Each signature was validated with response data from an independent set of cell line studies. We further show that many of these signatures can accurately predict clinical response in individuals treated with these drugs. Notably, signatures developed to predict response to individual agents, when combined, could also predict response to multidrug regimens. Finally, we integrated the chemotherapy response signatures with signatures of

ARTICLE LINKS

- Supplementary info

ARTICLE TOOLS

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SEARCH PUBMED FOR

- Anil Potti
- Holly K Dressman
- Andrea Bild
- Richard F Riedel

https://doi.org/10.1038/nm1491

Please watch!!!

Forensic Bioinformatics

http://www.birs.ca/events/2013/5-day-workshops/13w5083/videos/watch/201308141121-Baggerly.mp4

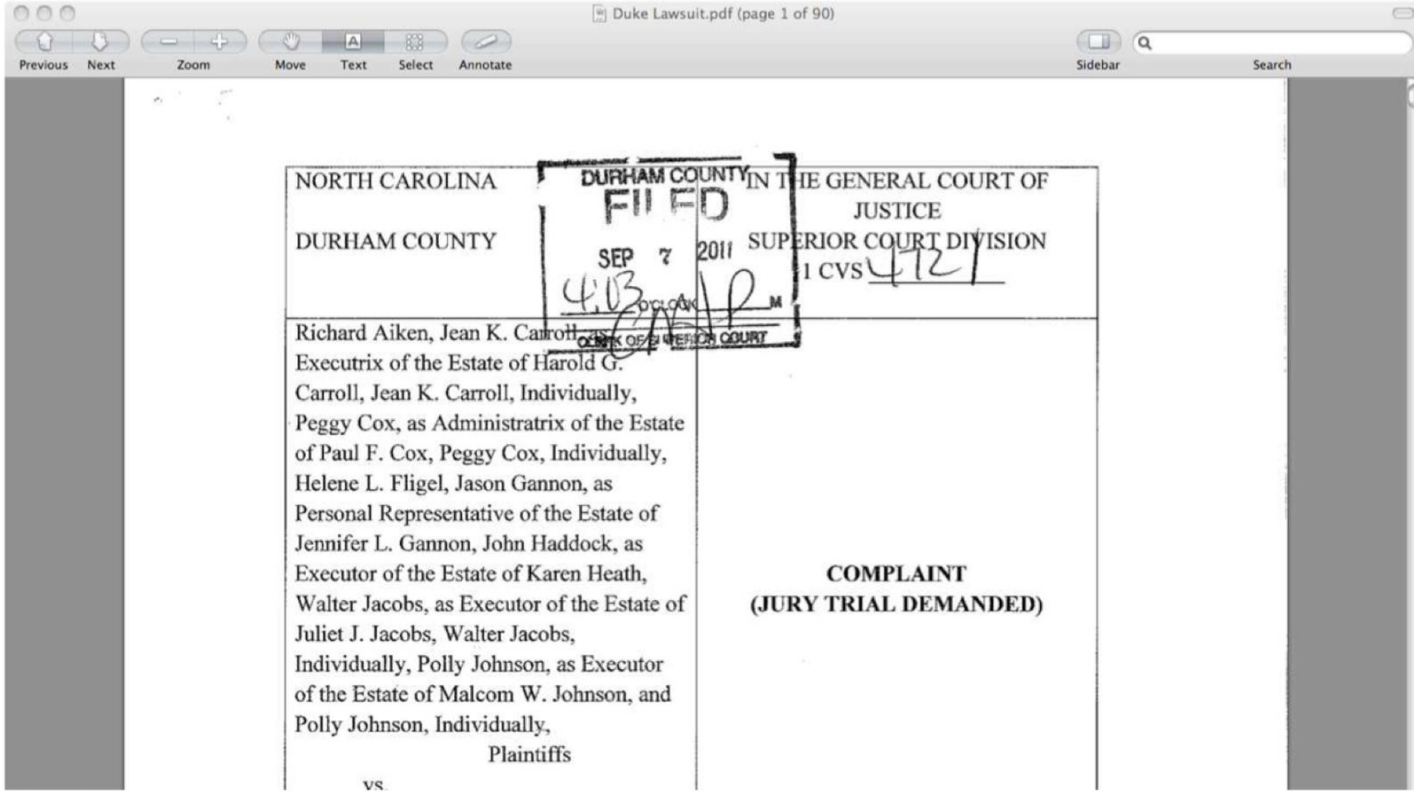
Nature Medicine **12**, 1294–1300 (2006) | Cite this article

5843 Accesses | **426** Citations | **95** Altmetric | Metrics

A Retraction to this article was published on 07 January 2011

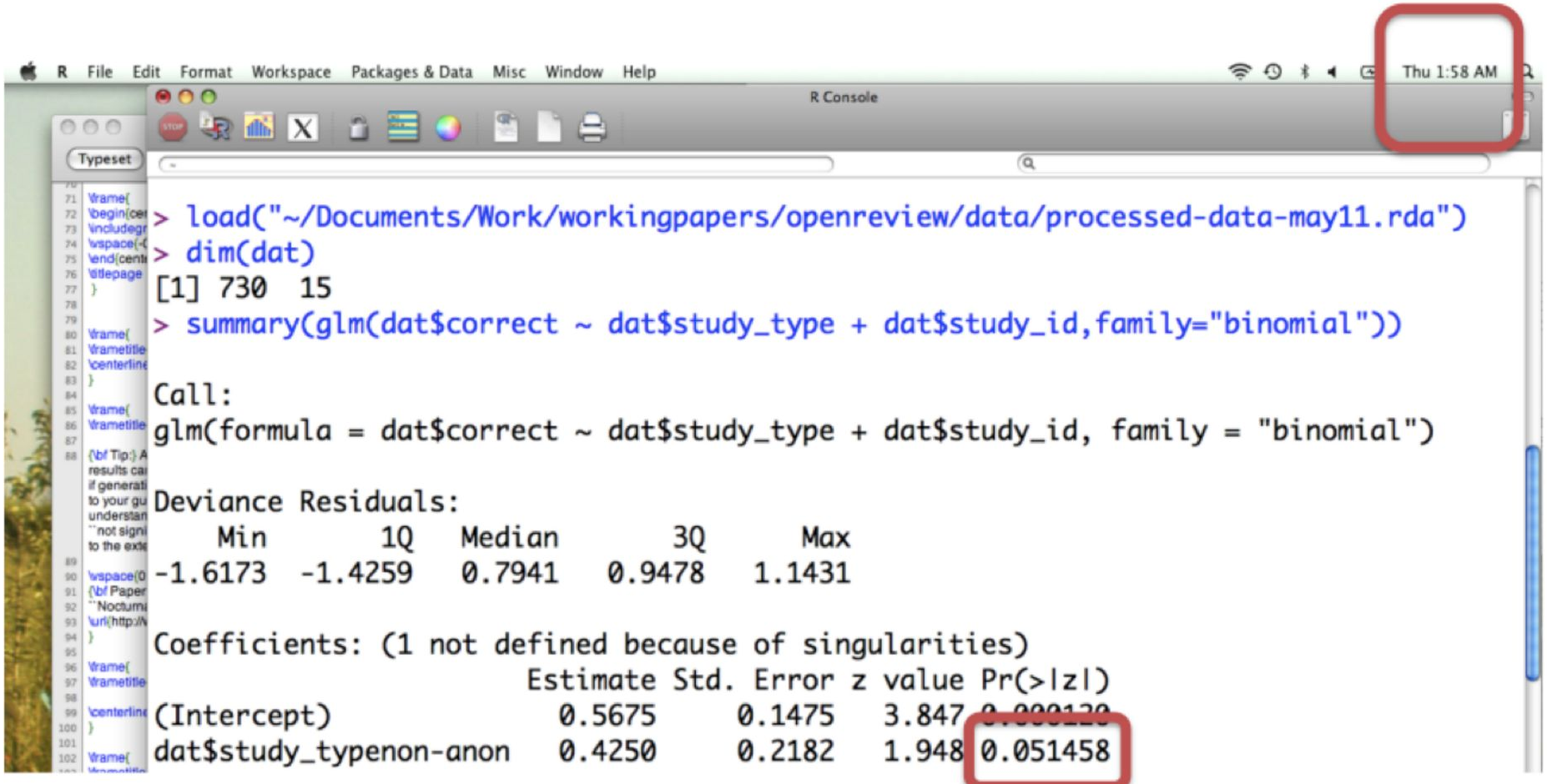
A Corrigendum to this article was published on 01 August 2008

A Corrigendum to this article was published on 01 November 2007

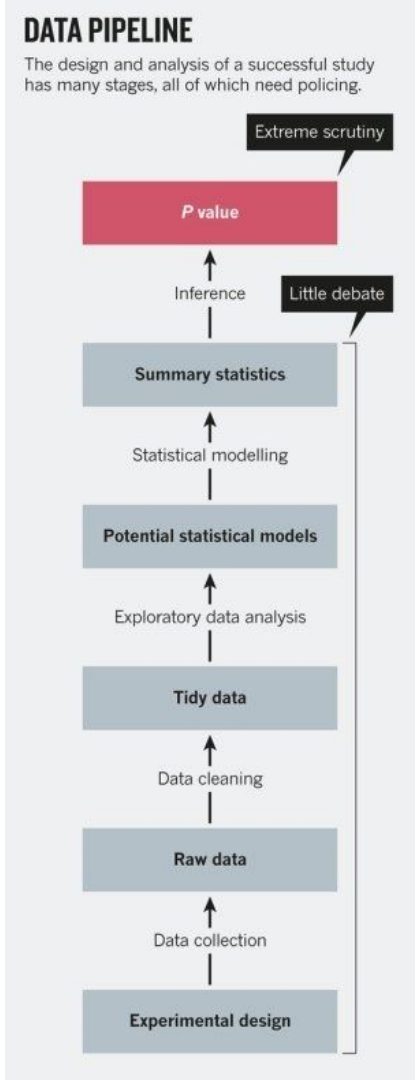


https://www.dukechronicle.com/article/2015/05/duke-lawsuit-involving-cancer-patients-linked-anil-potti-settled

Doesn’t seem that important….


R File Edit Format Workspace Packages & Data Misc Window Help
Thu 1:58 AM
R Console
Typeset
> load("~/Documents/Work/workingpapers/openreview/data/processed-data-may11.rda")
> dim(dat)
[1] 730 15
> summary(glm(dat$correct ~ dat$study_type + dat$study_id,family="binomial"))
Call:
glm(formula = dat$correct ~ dat$study_type + dat$study_id, family = "binomial")
Deviance Residuals:
Min 1Q Median 3Q Max
-1.6173 -1.4259 0.7941 0.9478 1.1431
Coefficients: (1 not defined because of singularities)
Estimate Std. Error z value Pr(>|z|)
(Intercept) 0.5675 0.1475 3.847
dat$study_typenon-anon 0.4250 0.2182 1.948 0.051458

ON THE ONE
HAND...



- Most of the attention is on the last step
- This course is about all the steps that come before
- They are *critical* for getting things rights

Leek and Peng Nature 2015

The garden of forking paths: Why multiple comparisons can be a problem, even when there is no "fishing expedition" or "p-hacking" and the research hypothesis was posited ahead of time*

Andrew Gelman† and Eric Loken‡

14 Nov 2013

"I thought of a labyrinth of labyrinths, of one sinuous spreading labyrinth that would encompass the past and the future . . . I felt myself to be, for an unknown period of time, an abstract perceiver of the world." — Borges (1941)

Explorable Multiverse Analyses

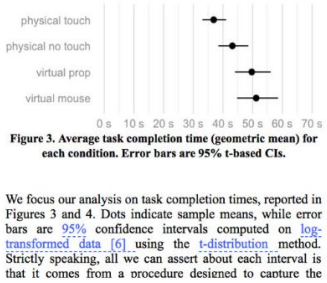
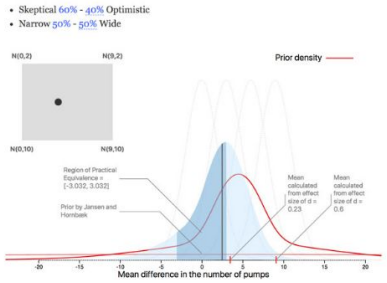


Figure 3. Average task completion time (geometric mean) for each condition. Error bars are 95% t-based CIs.

We focus our analysis on task completion times, reported in Figures 3 and 4. Dots indicate sample means, while error bars are 95% confidence intervals computed on log-transformed data [6] using the t-distribution method. Strictly speaking, all we can assert about each interval is that it comes from a procedure designed to capture the



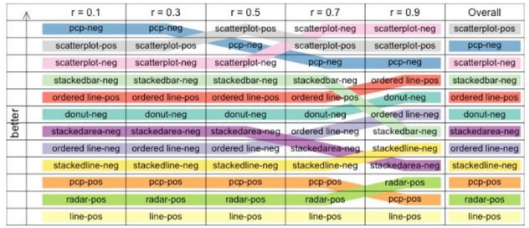
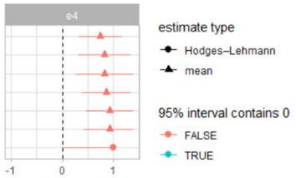


Figure 4. Perceptually-driven ranking of visualizations depending on the correlation sign (-neg / -pos), as a function of correlation value (r) and overall (right column).



Pierre Dragicevic (Inria), Yvonne Jansen (CNRS - Sorbonne Université), Abhraneel Sarma (University of Michigan)
Matthew Kay (University of Michigan), Fanny Chevalier (University of Toronto)

With **explorable multiverse analysis reports**, readers of research papers can explore alternative analysis options by interacting with the paper itself. This new approach to statistical reporting draws from two recent ideas: multiverse analysis, a philosophy of statistical reporting where paper authors report the outcomes of many different statistical analyses in order to show how fragile or robust their findings are; and explorable explanations, narratives that can be read as normal explanations but where the reader can also become active by dynamically changing some elements of the explanation.

https://explorablemultiverse.github.io/

And so we data wrangle

TECHNOLOGY | For Big-Data Scientists, 'Janitor Work' Is Key Hurdle to Insights

TECHNOLOGY

For Big-Data Scientists, 'Janitor Work' Is Key Hurdle to Insights

By STEVE LOHR AUG. 17, 2014

amazon web services | intel CLOUD INSIGHTS

Why Novartis is Looking Beyond On-Premises... READ ›

Case Study: Cloud Supercomputing from AWS Powers... READ ›

Get Started with AWS

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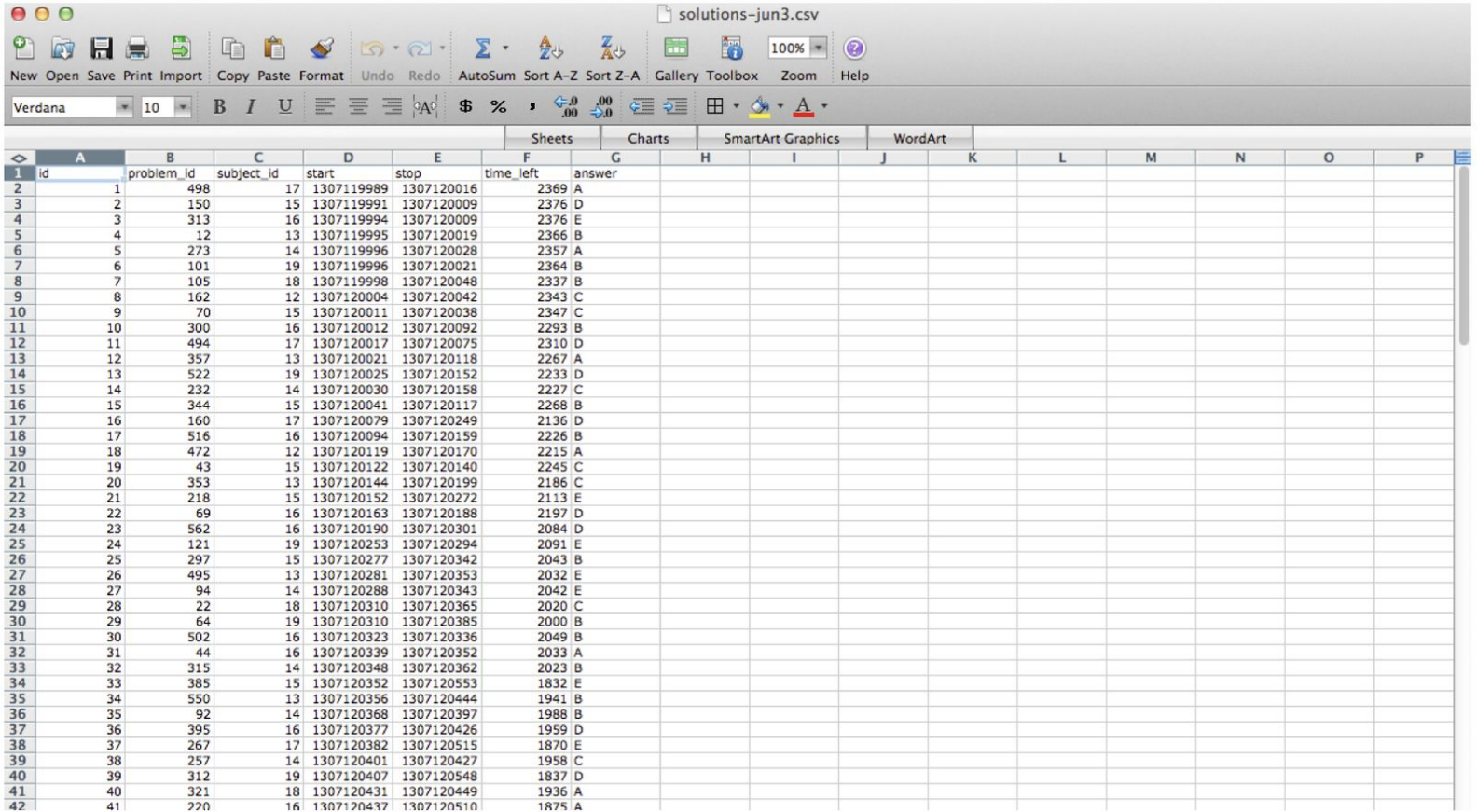
http://www.nytimes.com/2014/08/18/technology/for-big-data-scientists-hurdle-to-insights-is-janitor-work.html?_r=0

What you wished data looked like



solutions-jun3.csv

id	problem_id	subject_id	start	stop	time_left	answer
1	498	17	1307119989	1307120016	2369	A
2	150	15	1307119991	1307120009	2376	D
3	313	16	1307119994	1307120009	2376	E
4	12	13	1307119995	1307120019	2366	B
5	273	14	1307119996	1307120028	2357	A
6	101	19	1307119996	1307120021	2364	B
7	105	18	1307119998	1307120048	2337	B
8	162	12	1307120004	1307120042	2343	C
9	70	15	1307120011	1307120038	2347	C
10	300	16	1307120012	1307120092	2293	B
11	494	17	1307120017	1307120075	2310	D
12	357	13	1307120021	1307120118	2267	A
13	522	19	1307120025	1307120152	2233	D
14	232	14	1307120030	1307120158	2227	C
15	344	15	1307120041	1307120117	2268	B
16	160	17	1307120079	1307120249	2136	D
17	516	16	1307120094	1307120159	2226	B
18	472	12	1307120119	1307120170	2215	A
19	43	15	1307120122	1307120140	2245	C
20	353	13	1307120144	1307120199	2186	C
21	218	15	1307120152	1307120272	2113	E
22	69	16	1307120163	1307120188	2197	D
23	562	16	1307120190	1307120301	2084	D
24	121	19	1307120253	1307120294	2091	E
25	297	15	1307120277	1307120342	2043	B
26	495	13	1307120281	1307120353	2032	E
27	94	14	1307120288	1307120343	2042	E
28	22	18	1307120310	1307120365	2020	C
29	64	19	1307120310	1307120385	2000	B
30	502	16	1307120323	1307120336	2049	B
31	44	16	1307120339	1307120352	2033	A
32	315	14	1307120348	1307120362	2023	B
33	385	15	1307120352	1307120553	1832	E
34	550	13	1307120356	1307120444	1941	B
35	92	14	1307120368	1307120397	1988	B
36	395	16	1307120377	1307120426	1959	D
37	267	17	1307120382	1307120515	1870	E
38	257	14	1307120401	1307120427	1958	C
39	312	19	1307120407	1307120548	1837	D
40	321	18	1307120431	1307120449	1936	A
41	220	16	1307120437	1307120510	1875	A

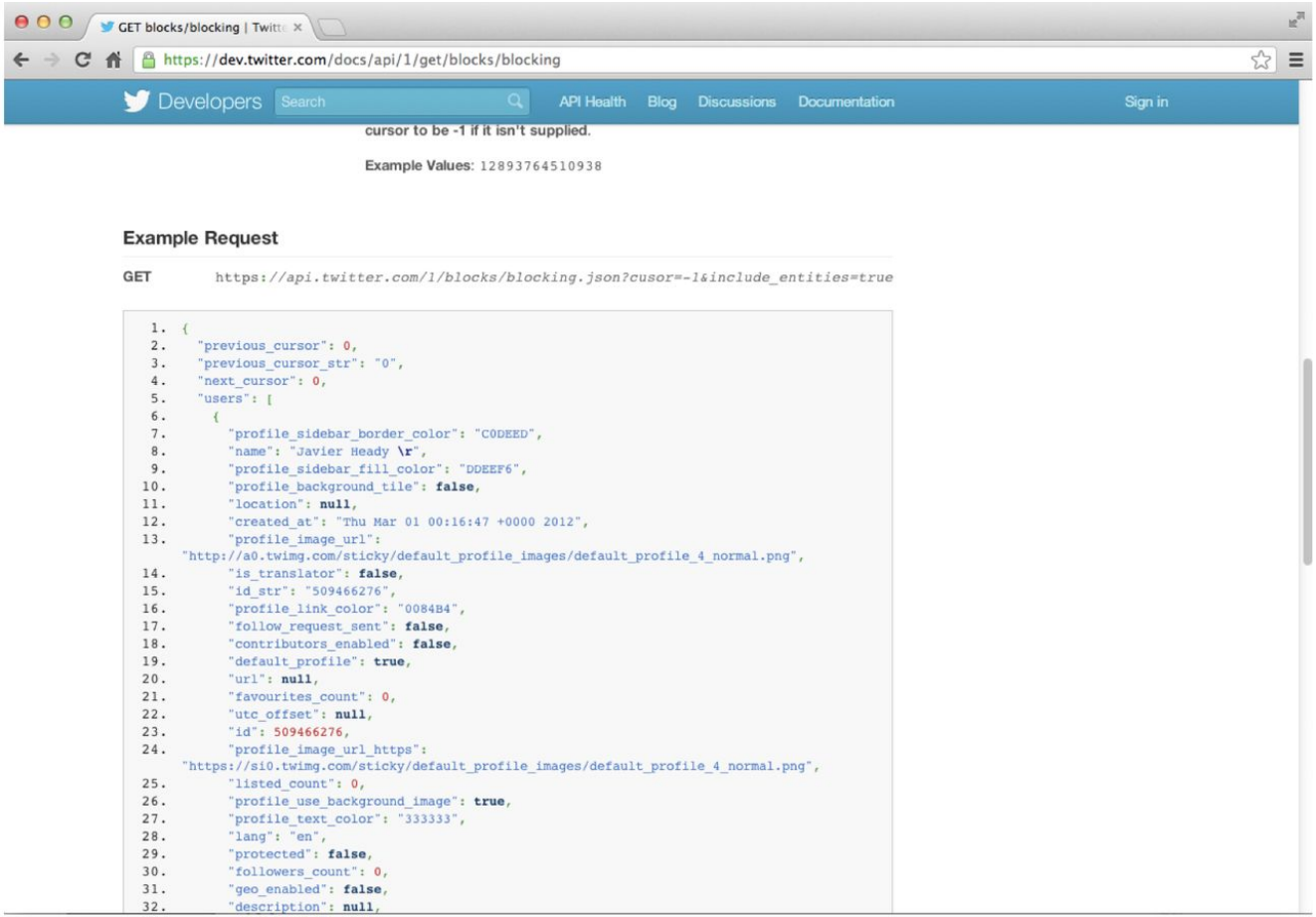
What it actually looks like

http://healthdesignchallenge.com/

```
@HWI-EAS121:4:100:1783:550#0/1
CGTTACGAGATCGGAAGAGCGGTTCAGCAGGAATGCCGAGACGGATCTCGTATGCGGTCTGCTGCGTGACAAGACAGGGG
+HWI-EAS121:4:100:1783:550#0/1
aaaaa`b_aa`aa`YaX]aZ`aZM^Z]YRa]YSG[[ZREQLHESDHNDDHNMEEDDMPENITKFLFEEDDDHEJQMEDDD
@HWI-EAS121:4:100:1783:1611#0/1
GGGTGGGCATTTCCACTCGCAGTATGGGTTGCCGCACGACAGGCAGCGGTCAGCCTGCGCTTTGGCCTGGCCTTCGGAAA
+HWI-EAS121:4:100:1783:1611#0/1
a```^\__`_```^a``a`^a_^__]a_]\]`a_______`_^^`]X]_]XTV_\]]NX_XVX]]_TTTTG[VTHPN]VFDZ
@HWI-EAS121:4:100:1783:322#0/1
CGTTTATGTTTTTGAATATGTCTTATCTTAACGGTTATATTTTAGATGTTGGTCTTATTCTAACGGTCATATATTTTCTA
+HWI-EAS121:4:100:1783:322#0/1
abaa`^aaaaabbbaabababbbbbb`bbbb_bbbbbbbb`bbbaV^_a``a``]``aT]a__V\]]_]^a`]a_abbaV__
@HWI-EAS121:4:100:1783:1394#0/1
GGGTCTTTATTGGTCTGGTGATCCCCCATATTCTCCGGTTGTGTGGTTTAACCGATCATCGCGCATTACTTCCCGGCTGC
+HWI-EAS121:4:100:1783:1394#0/1
```[aa\b^^[]aabbb][`a_abbb`a``bbbbbabaabaaaab_VZa_^___bab_X`[a\HV_[_]_[^_X\T_VQQ
@HWI-EAS121:4:100:1783:207#0/1
CCCTGGGAGATCGGAAGAGCGGTTCAGCAGGAATGCCGAGACCGATCTCGTATGCCGTCTTCTGCTTGAAAAAAAAAACA
+HWI-EAS121:4:100:1783:207#0/1
abba`Xa\^\\`aa]ba__bba[a_O_a`aa`aa`a]^V]X_a^YS\R_\H_[]\ZTDUZZUSOPX]]POP\GS\WSHHD
@HWI-EAS121:4:100:1783:455#0/1
GGGTAATTCAGGGACAATGTAATGGCTGCACAAAAAAATACATCTTTCATGTTCCATTGCACCATTGACAAATACATATT
+HWI-EAS121:4:100:1783:455#0/1
abb_babbabaabbbbbbbbbbbbbbba\`b`\abbbabbbbabbbbbbaabbbbb`bb`ab_O_bab_Q_bbabaa_a
```
```

What it actually looks like

https://dev.twitter.com/docs/api/1/get/blocks/blocking



What it actually looks like

```
--------------------------   ALLERGIES   -------------------------

ast Updated: 01 Dec 2011 @ 0851

llergy Name:         TRIMETHOPRIM
ocation:             DAYT29
ate Entered:         09 Mar 2011
eaction:
llergy Type:         DRUG
A Drug Class:        ANTI-INFECTIVES,OTHER
bserved/Historical:  HISTORICAL
omments:             The reaction to this allergy was MILD (NO SQUELAE)

llergy Name:         TRAMADOL
ocation:             DAYT29
ate Entered:         09 Mar 2011
eaction:             URINARY RETENTION
llergy Type:         DRUG
A Drug Class:        NON-OPIOID ANALGESICS
bserved/Historical:  HISTORICAL
omments:             gradually worsening difficulty emptying bladder
```

```
--------------------------   MEDICATION HISTOR

Last Updated: 11 Apr 2011 @ 1737

Medication: AMLODIPINE BESYLATE 10MG TAB
Instructions: TAKE ONE TABLET BY MOUTH TAKE ON
GRAPEFRUIT JUICE--
Status: Active
Refills Remaining: 3
Last Filled On: 20 Aug 2010
Initially Ordered On: 13 Aug 2010
Quantity: 45
Days Supply: 90
Pharmacy: DAYTON
Prescription Number: 2718953

Medication: IBUPROFEN 600MG TAB
Instructions: TAKE ONE TABLET BY MOUTH FOUR TI
Status: Active
Refills Remaining: 3
Last Filled On: 20 Aug 2010
Initially Ordered On: 01 Jul 2010
```

Jenny Bryan @JennyBryan · Apr 20

I'm seeking TRUE, crazy spreadsheet stories. Happy to get the actual sheet or just a description of the crazy. Also: I can keep a secret.

Slide from Jenny Bryan
(https://github.com/jennybc/2016-06_spreadsheets/blob/master/2016-06_useR-stanford.pdf)

Enron North America - West Gas

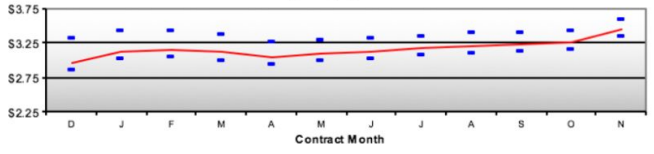
November 9, 2001

ENA - West Gas Contacts

Houston Office		Regional Offices		
Barry Tycholiz	(713) 853-1587	Mark Whitt	(303) 575-6473	Denver
Kim Ward	(713) 853-0685	Paul Lucci	(303) 575-6474	Denver
Stephanie Miller	(713) 853-1688	Tyrell Harrison	(303) 575-6478	Denver
Philip Polsky	(713) 853-5181	Dave Fuller	(503) 464-3732	Portland

Forward Prices (US$/MMBtu)

	NYMEX SETTLE	NYMEX Δ
Cash		
ROM		
Dec-01	2.960	0.090
Dec-01 to Mar-02	3.088	0.083
Apr-02 to Oct-02	3.166	0.084
Nov-02 to Mar-03	3.651	0.090
One Year Strip*	3.165	0.084



IF NWPL Rocky Mountains	Fixed Price		Basis	
	BID	OFFER	BID	OFFER
Cash	1.890	1.910		
ROM	2.060	2.080		
Dec-01	2.395	2.415	(0.565)	(0.545)
Dec-01 to Mar-02	2.594	2.614	(0.494)	(0.474)
Apr-02 to Oct-02	2.581	2.601	(0.585)	(0.565)
Nov-02 to Mar-03	3.356	3.376	(0.295)	(0.275)
One Year Strip*	2.634	2.654	(0.530)	(0.510)

IF CIG Rocky Mountains	Fixed Price		Basis	
	BID	OFFER	BID	OFFER
Cash	1.940	1.960		
ROM	1.960	1.980		
Dec-01	2.345	2.365	(0.615)	(0.595)
Dec-01 to Mar-02	2.548	2.568	(0.540)	(0.520)
Apr-02 to Oct-02	2.471	2.491	(0.695)	(0.675)
Nov-02 to Mar-03	3.311	3.331	(0.340)	(0.320)
One Year Strip*	2.551	2.571	(0.614)	(0.594)

IF EL Paso Permian	Fixed Price		Basis	
	BID	OFFER	BID	OFFER
Cash	2.375	2.395		
ROM	2.420	2.440		
Dec-01	2.700	2.720	(0.260)	(0.240)
Dec-01 to Mar-02	2.855	2.875	(0.233)	(0.213)
Apr-02 to Oct-02	3.009	3.029	(0.158)	(0.138)
Nov-02 to Mar-03	3.499	3.519	(0.153)	(0.133)
One Year Strip*	2.982	3.002	(0.182)	(0.162)

IF EL Paso San Juan	Fixed Price		Basis	
	BID	OFFER	BID	OFFER
Cash	2.450	2.470		
ROM	2.350	2.370		
Dec-01	2.560	2.580	(0.400)	(0.380)
Dec-01 to Mar-02	2.743	2.763	(0.345)	(0.325)
Apr-02 to Oct-02	2.801	2.821	(0.365)	(0.345)
Nov-02 to Mar-03	3.421	3.441	(0.230)	(0.210)
One Year Strip*	2.817	2.837	(0.347)	(0.327)

AECO / NIT	Fixed Price		Basis	
	BID	OFFER	BID	OFFER
Cash	2.376	2.396		
ROM	2.398	2.418		
Dec-01	2.552	2.572	(0.408)	(0.388)
Dec-01 to Mar-02	2.616	2.636	(0.472)	(0.452)
Apr-02 to Oct-02	2.661	2.681	(0.505)	(0.485)
Nov-02 to Mar-03	3.216	3.236	(0.435)	(0.415)
One Year Strip*	2.676	2.696	(0.488)	(0.468)

IF NWPL Canadian Border (Sumas)	Fixed Price		Basis	
	BID	OFFER	BID	OFFER
Cash	2.480	2.500		
ROM	2.460	2.480		
Dec-01	2.800	2.820	(0.160)	(0.140)
Dec-01 to Mar-02	2.892	2.912	(0.196)	(0.176)
Apr-02 to Oct-02	2.796	2.816	(0.370)	(0.350)
Nov-02 to Mar-03	3.706	3.726	0.055	0.075
One Year Strip*	2.880	2.900	(0.285)	(0.265)

IF PEPL TX-OK	Fixed Price		Basis	
	BID	OFFER	BID	OFFER
Cash	2.530	2.550		
ROM	2.530	2.550		
Dec-01	2.828	2.848	(0.133)	(0.113)
Dec-01 to Mar-02	2.958	2.978	(0.130)	(0.110)
Apr-02 to Oct-02	3.046	3.066	(0.120)	(0.100)
Nov-02 to Mar-03	3.531	3.551	(0.120)	(0.100)
One Year Strip*	3.041	3.061	(0.123)	(0.103)

Slide from Jenny Bryan
(https://github.com/jennybc/2016-06_spreadsheets/blob/master/2016-06_useR-stanford.pdf)

Desiree Narango
@DLNarango

Follow

Today's updates on #otherpeoplesdata:

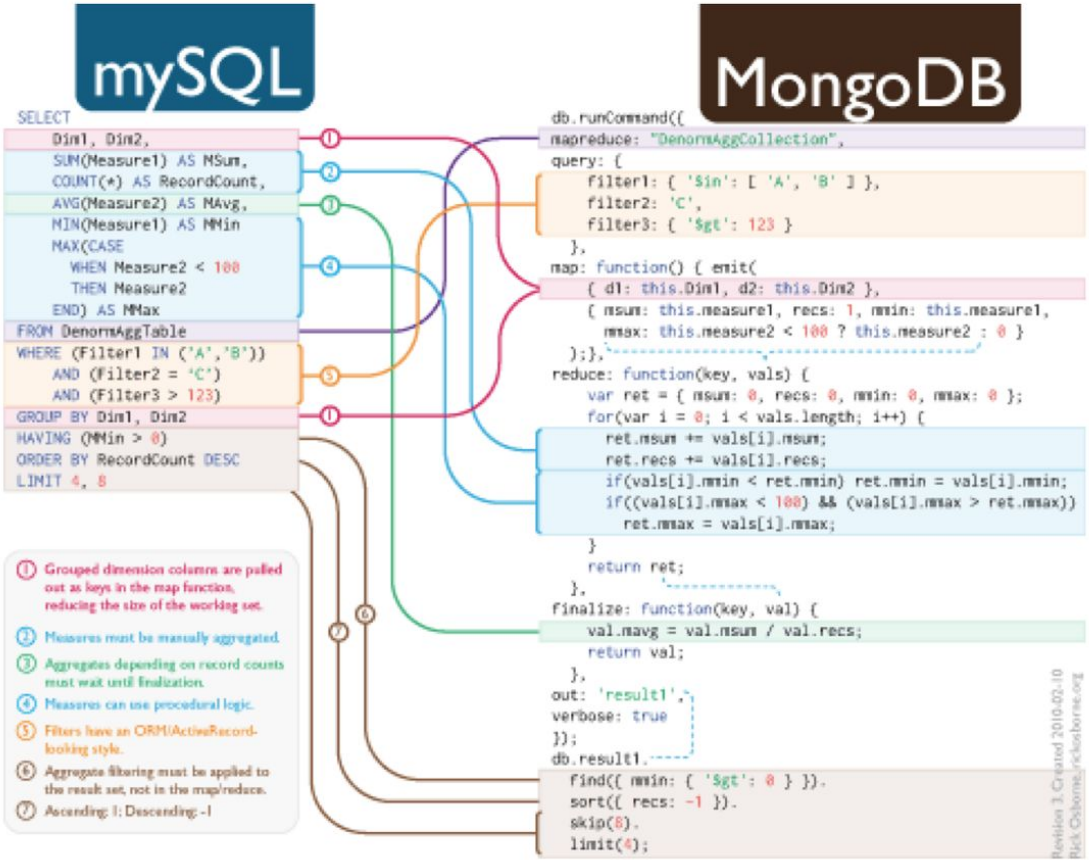
8:56 AM - 22 Oct 2018

1 Like

Where you wish data was

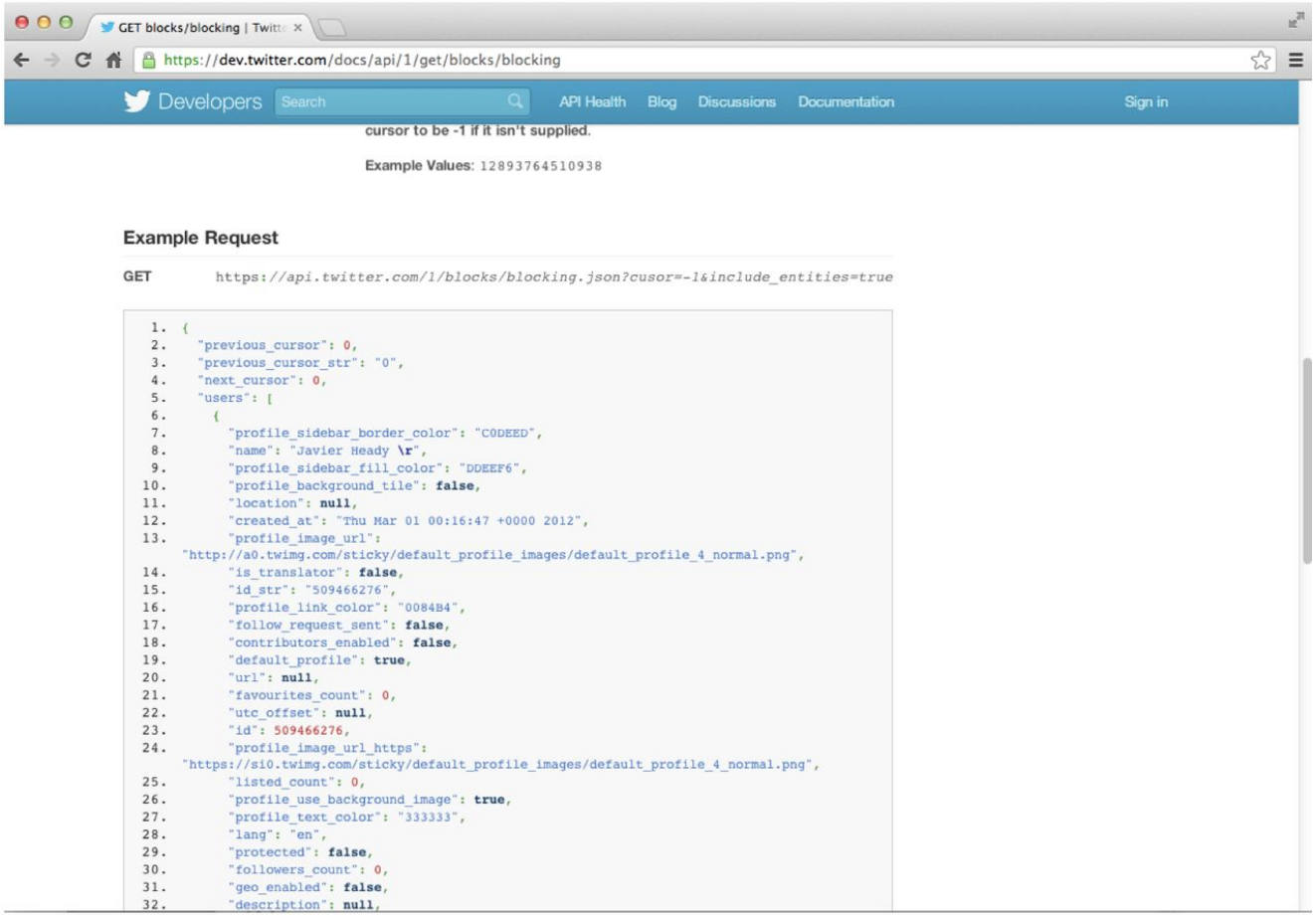
Where data actually is

https://rickosborne.org/blog/2010/02/infographic-migrating-from-sql-to-mapreduce-with-mongodb/



Where data actually is

https://dev.twitter.com/docs/api/1/get/blocks/blocking



Raw & processed data

http://en.wikipedia.org/wiki/Data

“Data are values of qualitative or quantitative variables, belonging to a set of items.”

http://en.wikipedia.org/wiki/Data

"Data are values of qualitative or quantitative variables, belonging to a set of items."

Set of items: Sometimes called the population; the set of objects you are interested in

http://en.wikipedia.org/wiki/Data

"Data are values of qualitative or quantitative variables, belonging to a set of items."

Variables: A measurement or characteristic of an item

http://en.wikipedia.org/wiki/Data

"Data are values of qualitative or quantitative variables, belonging to a set of items."

Qualitative: Country of origin, sex, treatment
Quantitative: Height, weight, blood pressure

Data sharing

1. The raw data.
2. A tidy data set
3. A code book describing each variable and its values in the tidy data set.
4. An explicit and exact recipe you used to go from 1 -> 2,3

http://vita.had.co.nz/papers/tidy-data.pdf

Journal of Statistical Software

MMMMMM YYYY, Volume VV, Issue II. *http://www.jstatsoft.org/*

Tidy Data

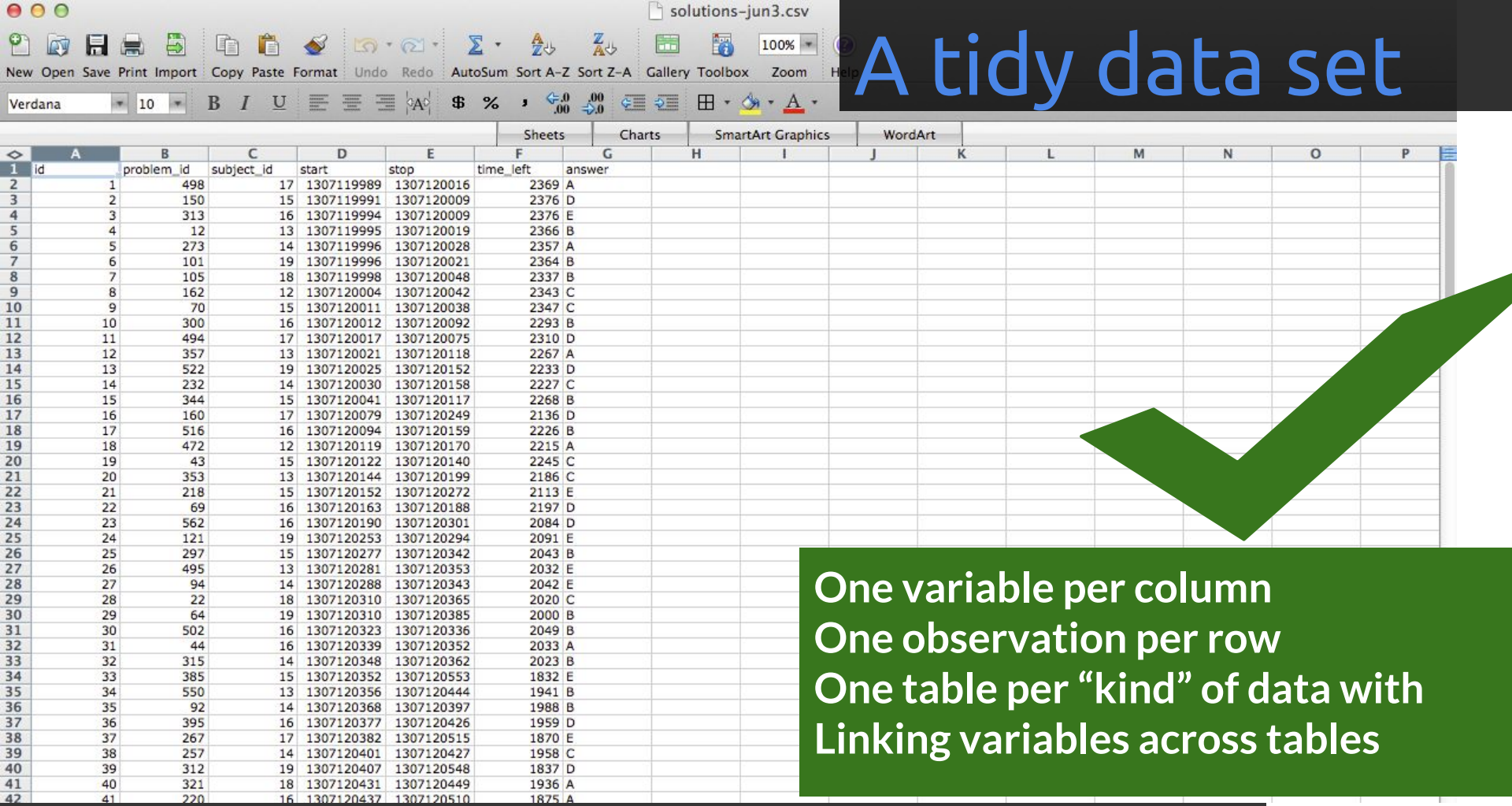
Hadley Wickham
RStudio

https://twitter.com/hadleywickham

Abstract

A huge amount of effort is spent cleaning data to get it ready for analysis, but there has been little research on how to make data cleaning as easy and effective as possible. This paper tackles a small, but important, component of data cleaning: data tidying. Tidy datasets are easy to manipulate, model and visualise, and have a specific structure: each variable is a column, each observation is a row, and each type of observational unit is a table. This framework makes it easy to tidy messy datasets because only a small set of tools are needed to deal with a wide range of un-tidy datasets. This structure also makes it easier to develop tidy tools for data analysis, tools that both input and output tidy datasets. The advantages of a consistent data structure and matching tools are demonstrated with a case study free from mundane data manipulation chores.

A tidy data set



	id	problem_id	subject_id	start	stop	time_left	answer
1	1	498	17	1307119989	1307120016	2369	A
2	2	150	15	1307119991	1307120009	2376	D
3	3	313	16	1307119994	1307120009	2376	E
4	4	12	13	1307119995	1307120019	2366	B
5	5	273	14	1307119996	1307120028	2357	A
6	6	101	19	1307119996	1307120021	2364	B
7	7	105	18	1307119998	1307120048	2337	B
8	8	162	12	1307120004	1307120042	2343	C
9	9	70	15	1307120011	1307120038	2347	C
10	10	300	16	1307120012	1307120092	2293	B
11	11	494	17	1307120017	1307120075	2310	D
12	12	357	13	1307120021	1307120118	2267	A
13	13	522	19	1307120025	1307120152	2233	D
14	14	232	14	1307120030	1307120158	2227	C
15	15	344	15	1307120041	1307120117	2268	B
16	16	160	17	1307120079	1307120249	2136	D
17	17	516	16	1307120094	1307120159	2226	B
18	18	472	12	1307120119	1307120170	2215	A
19	19	43	15	1307120122	1307120140	2245	C
20	20	353	13	1307120144	1307120199	2186	C
21	21	218	15	1307120152	1307120272	2113	E
22	22	69	16	1307120163	1307120188	2197	D
23	23	562	16	1307120190	1307120301	2084	D
24	24	121	19	1307120253	1307120294	2091	E
25	25	297	15	1307120277	1307120342	2043	B
26	26	495	13	1307120281	1307120353	2032	E
27	27	94	14	1307120288	1307120343	2042	E
28	28	22	18	1307120310	1307120365	2020	C
29	29	64	19	1307120310	1307120385	2000	B
30	30	502	16	1307120323	1307120336	2049	B
31	31	44	16	1307120339	1307120352	2033	A
32	32	315	14	1307120348	1307120362	2023	B
33	33	385	15	1307120352	1307120553	1832	E
34	34	550	13	1307120356	1307120444	1941	B
35	35	92	14	1307120368	1307120397	1988	B
36	36	395	16	1307120377	1307120426	1959	D
37	37	267	17	1307120382	1307120515	1870	E
38	38	257	14	1307120401	1307120427	1958	C
39	39	312	19	1307120407	1307120548	1837	D
40	40	321	18	1307120431	1307120449	1936	A
41	41	220	16	1307120437	1307120510	1875	A

One variable per column
One observation per row
One table per “kind” of data with
Linking variables across tables

Reference: http://brianknaus.com/software/srtoolbox/s_4_1_sequence80.txt

Code book

Decoder.docx

anything doesn't make sense.

Files:

1 Demographics: tab 1 is schizophrenia patients, tab 2 is controls.

A. Cohort: M = Mannheim (Germany), C = Cologne (Germany), H= Hopkins. We had a few of our own patients so we included them too.

B. patient identification number

C. Age at time of CSF collection

D. Gender

E. BMI

F. Ethnicity (mostly Caucasian)

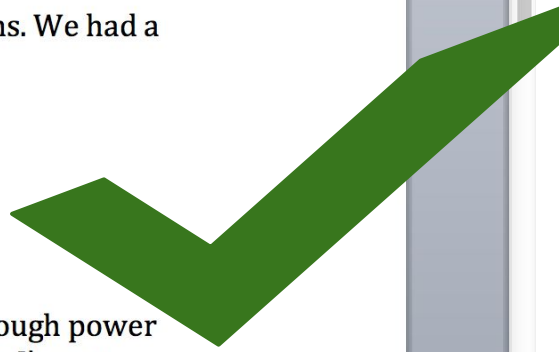
G. Diagnosis: DSM/ICD-10 diagnosis

H. Group: control, schizophrenia, or prodromal. I don't think we have enough power to run them as three groups so I combined prod… sure if this was ok. Is it appropriate to do a ttes… SZ?

I. Medication: mostly untreated

J. Education more or less than 13 years

K. current smoking status: yes or no



Variable names
Variable descriptions
Variable units
Study design quirks

RStudio

Recipe

Go to file/function

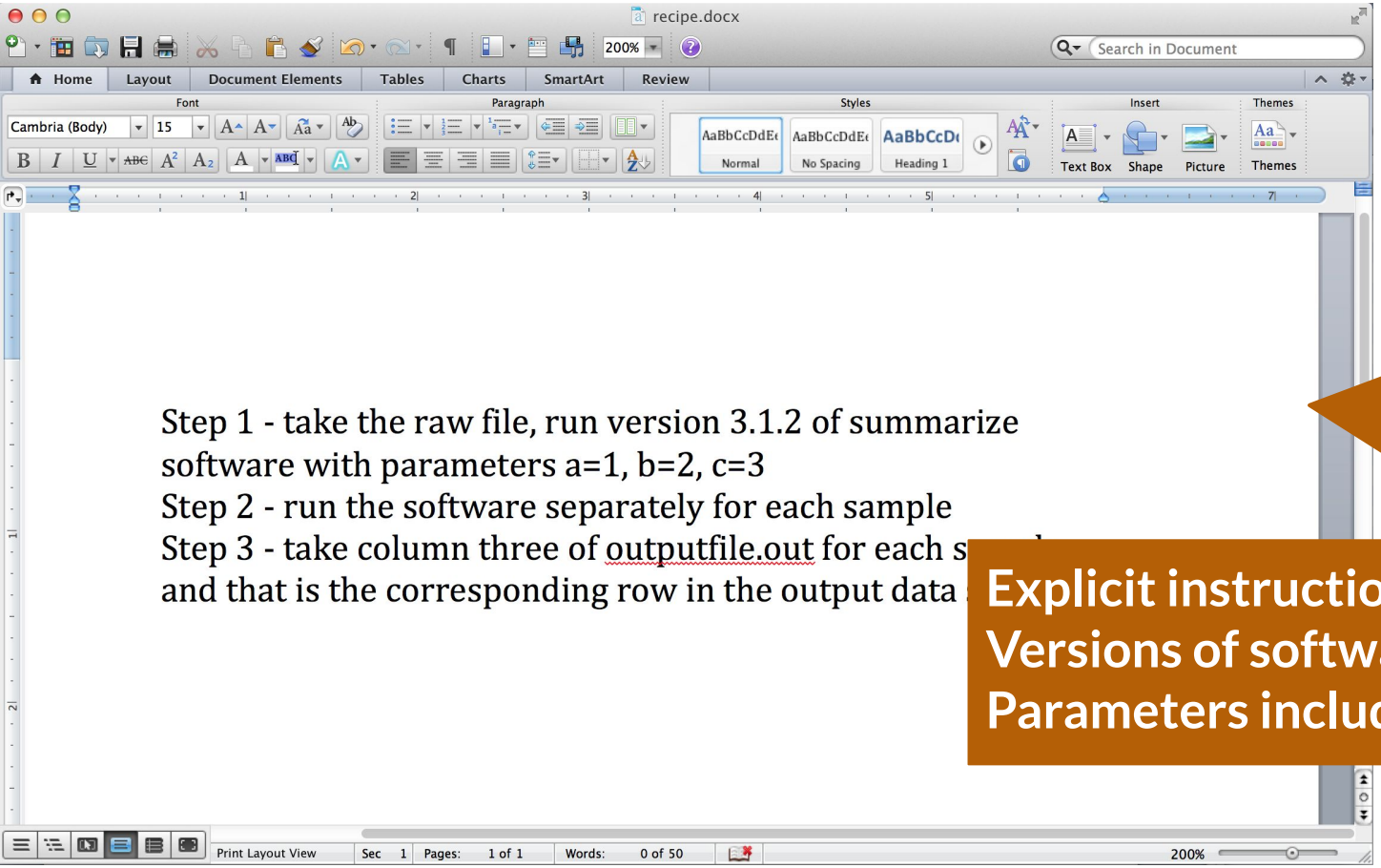
geuvadis.Rmd

Knit HTML | Run | Chunks

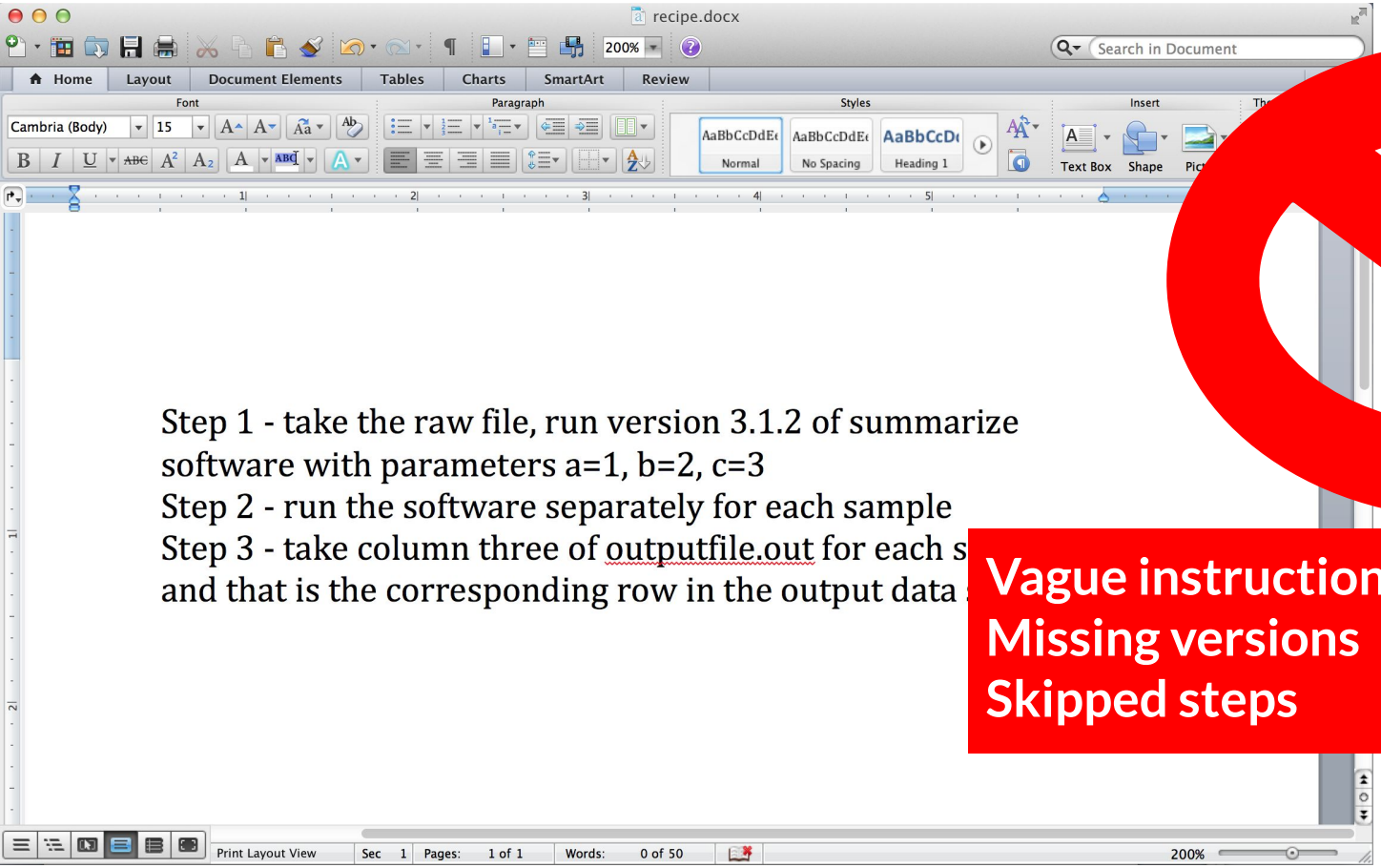
```
33  library(sva)
34  library(ffpe)
35  library(RColorBrewer)
36  library(corrplot)
37  library(limma)
38  trop = RSkittleBrewer('tropical')
39  ```
40
41
42  ## Load the data
43
44  You will need to download the GEUVADIS ballgown object from this site: https://github.com/a...uzee
    /ballgown_code
45
46
47  ```{r loaddata,dependson="load"}
48  load("fpkm.rda")
49  pd = ballgown::pData(fpkm)
50  pd$dirname = as.character(pd$dirname)
51  ss = function(x, pattern, slot=1,...) sapply(strsplit
52  pd$IndividualID = ss(pd$dirname, "_", 1)
53  tfpkm = expr(fpkm)$trans
54  ```
55
56  ## Subset to non-duplicates
57
58  You will need the GEUVADIS quality control information and population information available from these
```

1:1 (Top Level) R Markdown

R/Python Code
Input raw data -> output tidy
No parameters



Explicit instructions
Versions of software
Parameters included



Vague instructions
Missing versions
Skipped steps

When..	Be sure to...	So Do this...	Avoid this...	Why?
Naming variables (aka assigning column headers)	Use meaningful variable names	`AgeAtDiagnosis`	`ADx`	`ADx` is an unclear and uninformative abbreviation
Naming variables	Avoid spacing in column headers	`AgeAtDiagnosis`	`Age At Diagnosis`	Spacing in variable names makes the analyst's life more difficult
Naming variables	Use consistent capitalization	`AgeAtDiagnosis`	Using both `AgeAtDiagnosis` and `ageatdiagnosis`	Using consistent column names across tables/spreadsheets simplifies any merging the statistician may have to do.
Naming variables	Avoid using separators, but if it's necessary, use an underscore (`_`)	`IGF1` (or `IGF_1`)	`IGF.1`, `IGF-1`, `IGF/1`, `IGF,1`	Separators (commas, periods, hyphens, slashes, spaces etc.) often have different meanings in coding languages than they do in text. Avoiding them avoids error.
Coding variables	Avoid unnecessary spaces	'male'	'male '	That extra space after 'male ' makes it different from 'male' without a space.
Coding variables	Be consistent!	'male'	'Male',`male', and 'M',	In the eyes of the statistician, 'Male',`male', and 'M' could be incorrectly perceived as three different values.
Coding variables	Be careful of spelling errors	'male'	'maale'	That extra 'a' makes these two different categories.
Coding date and time	Use ISO 8601 coding	'YYYY-MM-DD'	'MM/DD/YY` and `Month Day, Year`	Consistency simplifies the analyst's life, and YYYY-MM-DD will not be misconstrued if opened in Excel.
Coding missing data	Not leave any cells blank and use a consistent value	'NA'	'0', '-9', red-highlighted blank cells, '.', ' ', '-', ...	Each cell should be filled with a consistent value. Pick a way to denote missingness (ideally 'NA') and stick with it. Avoid using numbers or punctuation to denote missing data.
Entering data	Stick to text and numbers	Convey all information with direct text/numerical entry	Using cell highlighting or font color to convey information	Your analyst may not use the same platform for analysis as you used for data entry, so avoiding font color and cell highlighting will minimize issues.
Generating an Excel file	Save the data in an appropriate format	Use one worksheet per table and save as CSV or text files	Multiple worksheets	Statisticians require this format to import your data onto other platforms.
Entering Data	Avoid entering unnecessary lines of text at the start	Start your first row with variable names	Adding lines of text	This violates the rules of tidy data and makes processing more difficult. Include this information in the "Code book" instead.
Opening files in Excel	Know and avoid its pitfalls	Consistently include one value per cell and be careful of date and time data.	Using macros, splitting cells, and merging cells	These formats are not amenable to data analysis on other platforms.

Ellis SE, Leek JT. (2017) How to share data for collaboration. *PeerJ Preprints* 5:e3139v5https://doi.org/10.7287/peerj.preprints.3139v5

Rules for Tidy Spreadsheets

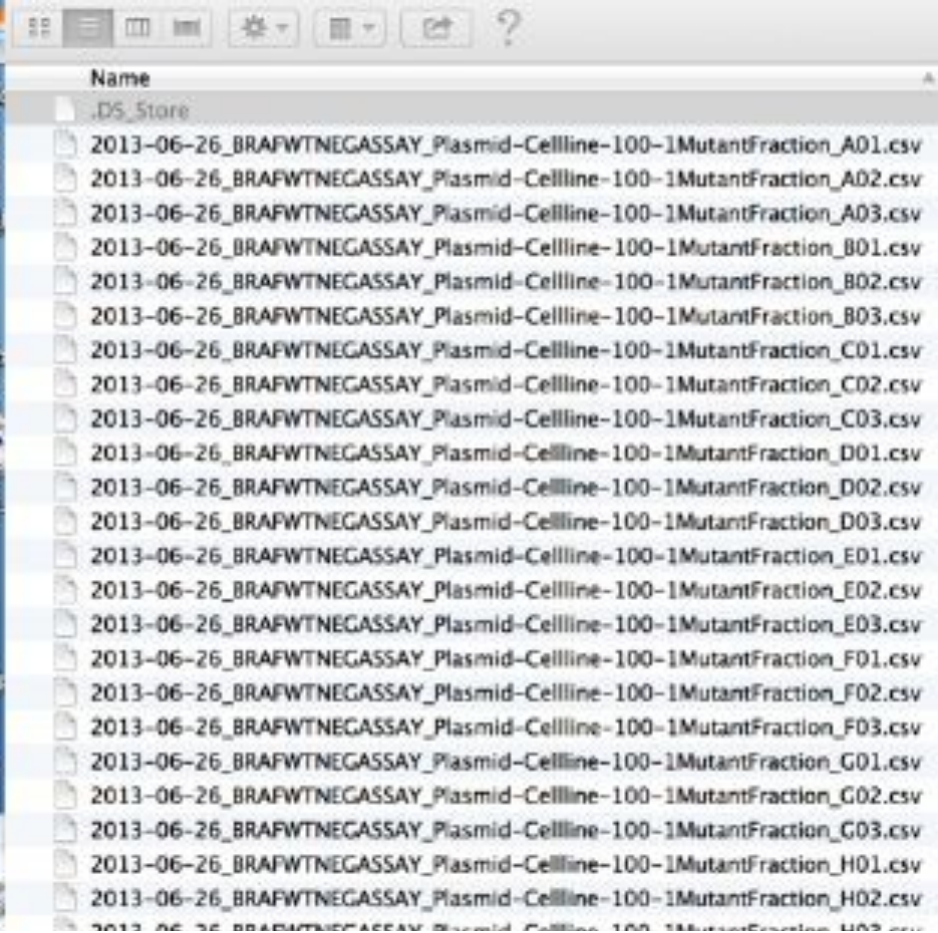
1. Be consistent
2. Choose good names for things
3. Write dates as YYYY-MM-DD
4. No empty cells
5. Put just one thing in a cell
6. Don't use font color or highlighting as data
7. Save the data as plain text files

https://doi.org/10.1080/00031305.2017.1375989

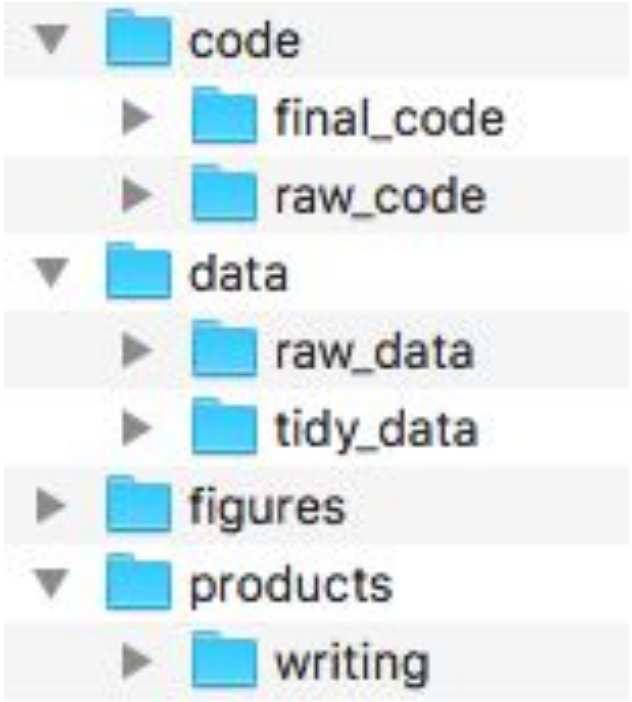
Organize thyself

"File organization and naming are powerful weapons against chaos."

- Jenny Bryan



Slide via Jenny Bryan:
http://www.slideshare.net/jenniferbryan5811/cm002-deep-thoughts


code
final_code
raw_code
data
raw_data
tidy_data
figures
products
writing

Raw data

```
--------------------------  ALLERGIES  --------------------------

ast Updated: 01 Dec 2011 @ 0851

llergy Name:        TRIMETHOPRIM
ocation:            DAYT29
ate Entered:        09 Mar 2011
eaction:
llergy Type:        DRUG
A Drug Class:       ANTI-INFECTIVES,OTHER
bserved/Historical: HISTORICAL
omments:            The reaction to this allergy was MILD (NO SQUELAE)

llergy Name:        TRAMADOL
ocation:            DAYT29
ate Entered:        09 Mar 2011
eaction:            URINARY RETENTION
llergy Type:        DRUG
A Drug Class:       NON-OPIOID ANALGESICS
bserved/Historical: HISTORICAL
omments:            gradually worsening difficulty emptying bladder
```

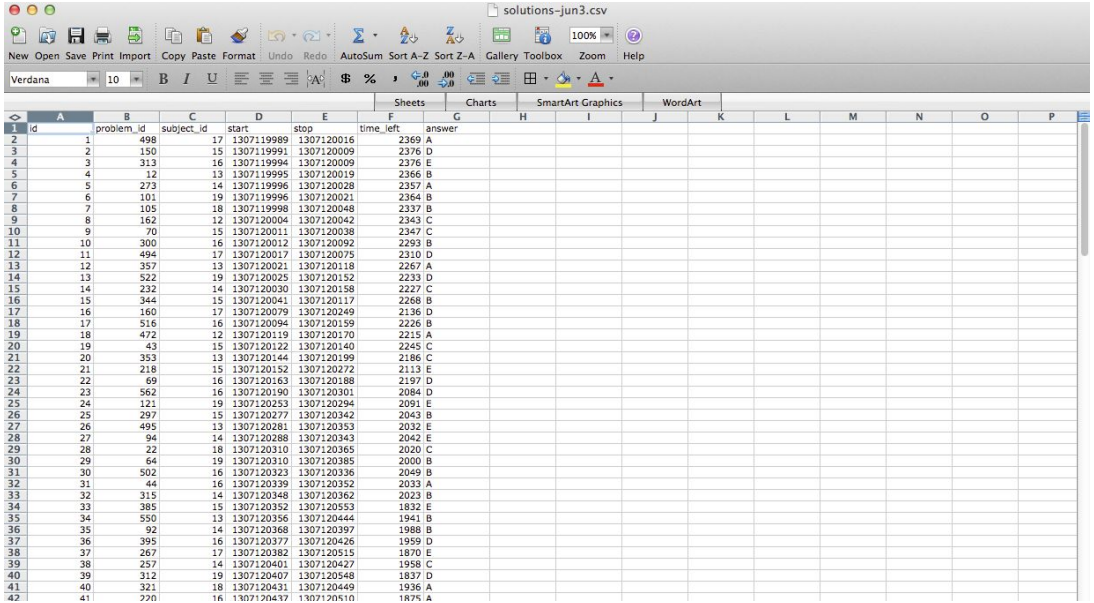
```
--------------------------  MEDICATION HISTORY  ----------------

Last Updated: 11 Apr 2011 @ 1737

Medication: AMLODIPINE BESYLATE 10MG TAB
Instructions: TAKE ONE TABLET BY MOUTH TAKE ONE-HALF TABLET FOR
GRAPEFRUIT JUICE--
Status: Active
Refills Remaining: 3
Last Filled On: 20 Aug 2010
Initially Ordered On: 13 Aug 2010
Quantity: 45
Days Supply: 90
Pharmacy: DAYTON
Prescription Number: 2718953

Medication: IBUPROFEN 600MG TAB
Instructions: TAKE ONE TABLET BY MOUTH FOUR TIMES A DAY WITH FOOD
Status: Active
Refills Remaining: 3
Last Filled On: 20 Aug 2010
Initially Ordered On: 01 Jul 2010
```

Processed data



solutions-jun3.csv

id	problem_id	subject_id	start	stop	time_left	answer
1	498	17	1307119989	1307120016	2369	A
2	150	15	1307119991	1307120009	2376	D
3	313	16	1307119994	1307120009	2376	E
4	12	13	1307119995	1307120019	2366	B
5	273	14	1307119996	1307120028	2357	A
6	101	19	1307119996	1307120021	2364	B
7	105	18	1307119998	1307120048	2337	B
8	162	12	1307120004	1307120042	2343	C
9	70	15	1307120011	1307120038	2347	C
10	300	16	1307120012	1307120092	2293	B
11	494	17	1307120017	1307120075	2310	D
12	357	13	1307120021	1307120118	2267	A
13	522	19	1307120025	1307120152	2233	D
14	232	14	1307120030	1307120158	2227	C
15	344	15	1307120041	1307120117	2268	B
16	160	17	1307120079	1307120249	2136	D
17	516	16	1307120094	1307120159	2226	B
18	472	12	1307120119	1307120170	2215	A
19	43	15	1307120122	1307120140	2245	C
20	353	13	1307120144	1307120199	2186	C
21	218	15	1307120152	1307120272	2113	E
22	69	16	1307120163	1307120188	2197	D
23	562	16	1307120190	1307120301	2084	D
24	121	19	1307120253	1307120294	2091	E
25	297	15	1307120277	1307120342	2043	B
26	495	13	1307120281	1307120353	2032	E
27	94	14	1307120288	1307120343	2042	E
28	22	18	1307120310	1307120365	2020	C
29	64	19	1307120310	1307120385	2000	B
30	502	16	1307120323	1307120336	2049	B
31	44	16	1307120339	1307120352	2033	A
32	315	14	1307120348	1307120362	2023	B
33	385	15	1307120352	1307120553	1832	E
34	550	13	1307120356	1307120444	1941	B
35	92	14	1307120368	1307120397	1988	B
36	395	16	1307120377	1307120426	1959	D
37	267	17	1307120382	1307120515	1870	E
38	257	14	1307120401	1307120427	1958	C
39	312	19	1307120407	1307120548	1837	D
40	321	18	1307120431	1307120449	1936	A
41	220	16	1307120432	1307120510	1875	A

- Processed data should be named so it is easy to see which script generated the data.
- The processing script - processed data mapping should occur in the README
- Processed data should be tidy

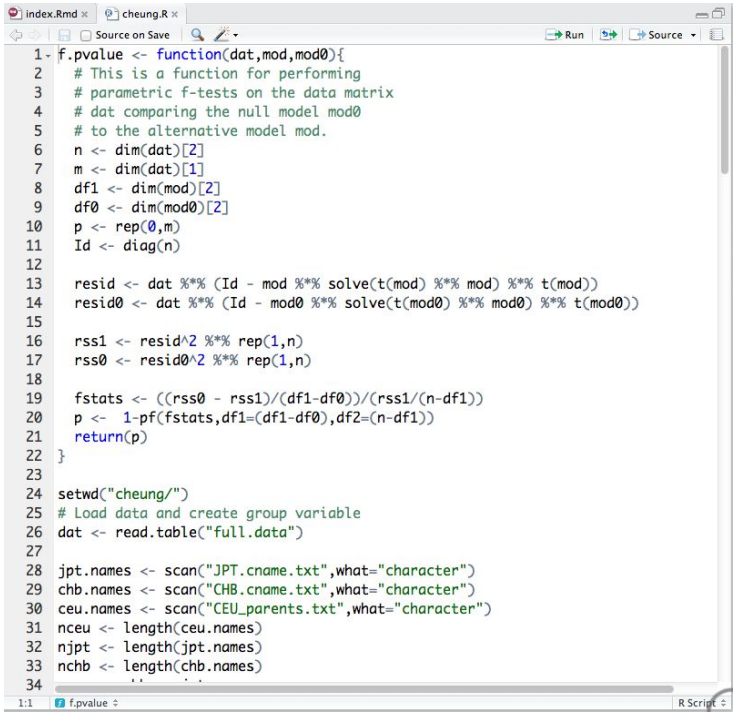
Raw scripts

raw_cheung_analysis.R

```r
library(chron)
library(affy)
library(oligoClasses)
celfiles <- list.celfiles("~/Projects/batchreview/",listGzipped=T)
dts <- sapply(celfiles,celfileDate)

ll <- strsplit(dts,"-")

yy <- as.numeric(lapply(ll,function(x){x[1]}))
mm <- as.numeric(lapply(ll,function(x){x[2]}))
dd <- as.numeric(lapply(ll,function(x){x[3]}))

jul <- julian(mm,dd,yy)

# Identify the arrays corresponding to CEU parents
ceuparents <-scan("~/Documents/Work/workingpapers/CHEUNG/CEU_parents.txt",what="character")
tmp <- list.files("~/Documents/Work/workingpapers/CHEUNG/CEU_data")

rep <- rep(c(0,1),each=100)
for(i in 1:length(ceuparents)){


}


tmp <- tmp[9:272]
array <- as.character(sapply(strsplit(tmp,"_"),function(x){x[1]}))
sample <- as.character(sapply(strsplit(tmp,c("_")),function(x){x[2]}))
sample <- as.character(sapply(strsplit(sample,c("\\.")),function(x){x[1]}))
rp <- as.character(sapply(strsplit(tmp,"_"),function(x){x[3]}))
rp <-  as.character(sapply(strsplit(rp,c("\\.")),function(x){x[1]}))


ceufiles <- array[sample %in% ceuparents]
```

- May be less commented (but comments help you!)
- May be multiple versions
- May include analyses that are later discarded

Final scripts



- Clearly commented
  - Small comments liberally - what, when, why, how
  - Bigger commented blocks for whole sections
- Include processing details
- Only analyses that appear in the final write-up

README.md

This is the README file for my_first_project

Last updated: 02-Mar-2018

The folders in this project are:

- *data* - is the folder where you can find all the collected data.
- *figures* - is where you can find all the plots, data pictures, and other images.
- *code* - is where you can find code files for collecting, cleaning up, or analyzing data.
- *products* - is where you can find reports, presentations, or products

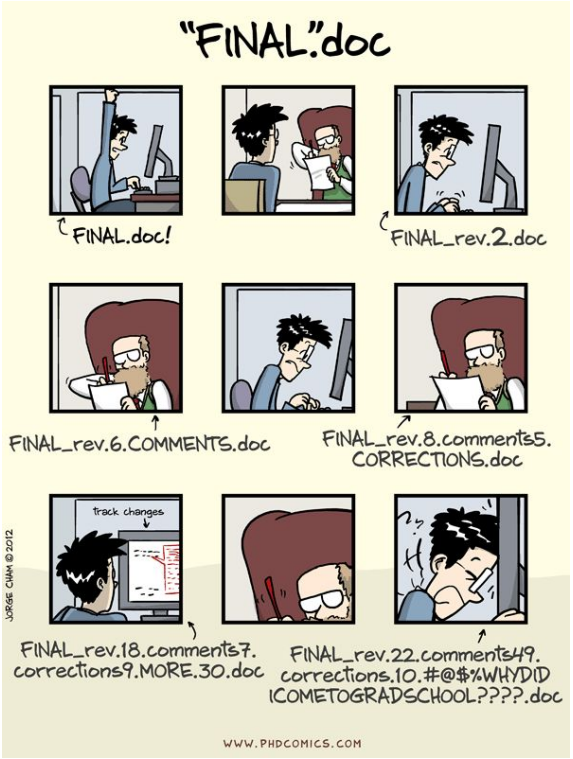
Data on crime is obtained from International Crime Data collected between 2015-2018 and is publicly available. Data on happiness is collected from the Survey of International Happiness.

Contributors:

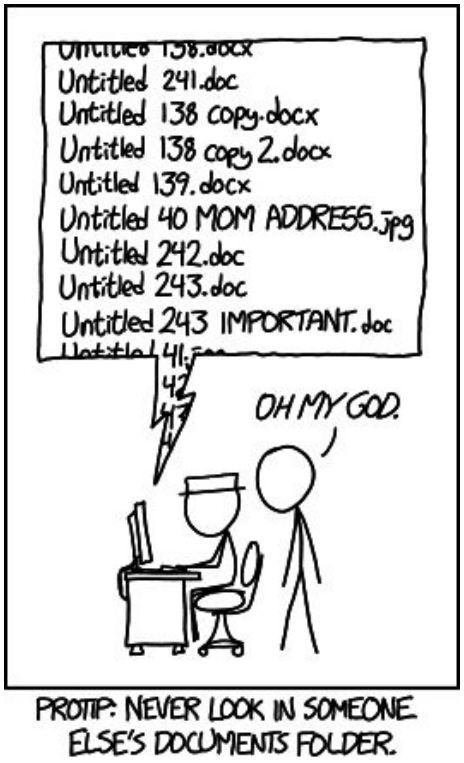
- Jane Everyday Doe, jane.everyday.doe@gmail.com
- John Everyday Doe, john.everyday.doe@gmail.com

Cite: Doe, J, and Doe, J, Sample Analysis Using Sample Data, Working Paper, 2018

Just no



http://www.phdcomics.com/comics/archive.php?comicid=1531



https://xkcd.com/1459/

key principles of file naming for data science projects:

- Machine readable
- Human readable
- Be nicely ordered

Source: Jenny Bryan

Bad Naming	Good Naming
2013 my report.md	2013_my_report.md
malik's_report.md	maliks_report.md
01_zoë_report.md	01_zoe_report.md
AdamHooverReport.md	adam-hoover-report.md
executivereportpepsiv1.md	executive_report_pepsi_v1.md

2018_jan_sales_cust001_prod001.md
2017_mar_sales_cust001_prod001.md
2016_may_sales_cust001_prod008.md
2017_jan_sales_cust120_prod007.md
2015_oct_sales_cust034_prod001.md
2015_oct_sales_cust034_prod002.md

Year	Month	Type	Customer ID	Product ID
2018	jan	sales	001	001
2017	mar	sales	001	001
2016	may	sales	001	008
2017	jan	sales	120	007
2015	oct	sales	034	001
2015	oct	sales	034	002

Which one is better?

analysis.R
or
2017-exploratory_analysis_crime.R?

Which one is better?

05-21-2017-analysis-cust001.R
or
2017-05-21-analysis-cust001.R?

Structure of a filename

processed_pvalue_data_from_pubmed_oct24.rda

What did I do to this data

processed_pvalue_data_from_pubmed_oct24.rda

What kind of data is this?

processed_pvalue_data_from_pubmed_oct24.rda

Where did it come from?

processed_pvalue_data_from_pubmed_oct24.rda

When did I get it?

processed_pvalue_data_from_pubmed_oct24.rda

Underscores/slashes not dots/whitespace

processed_pvalue_data_from_pubmed_oct24.rda

Consistency is the main rule

processed_pvalue_data_from_pubmed_oct24.rda
raw_pvalue_data_from_pubmed_oct24.rda

Your closest collaborator is you six months ago, but you don't reply to emails

- Karl Broman

http://kbroman.org/Tools4RR/assets/lectures/06_org_eda.pdf

Step 1: slow down and document.
Step 2: have sympathy for your future self.
Step 3: have a system.

- Karl Broman

http://kbroman.org/Tools4RR/assets/lectures/06_org_eda.pdf

R + RStudio

The R Project for Statistical Computing

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Getting Started

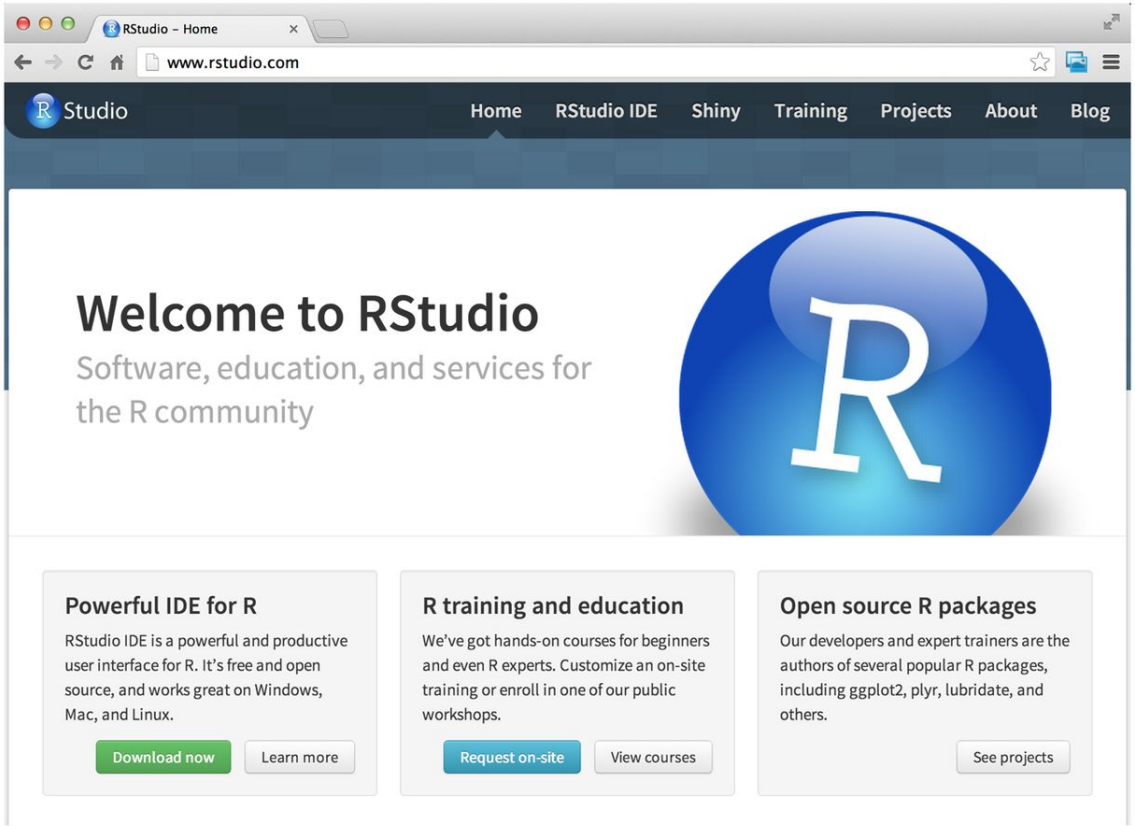
R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS. To **download R**, please choose your preferred CRAN mirror.

If you have questions about R like how to download and install the software, or what the license terms are, please read our answers to frequently asked questions before you send an email.

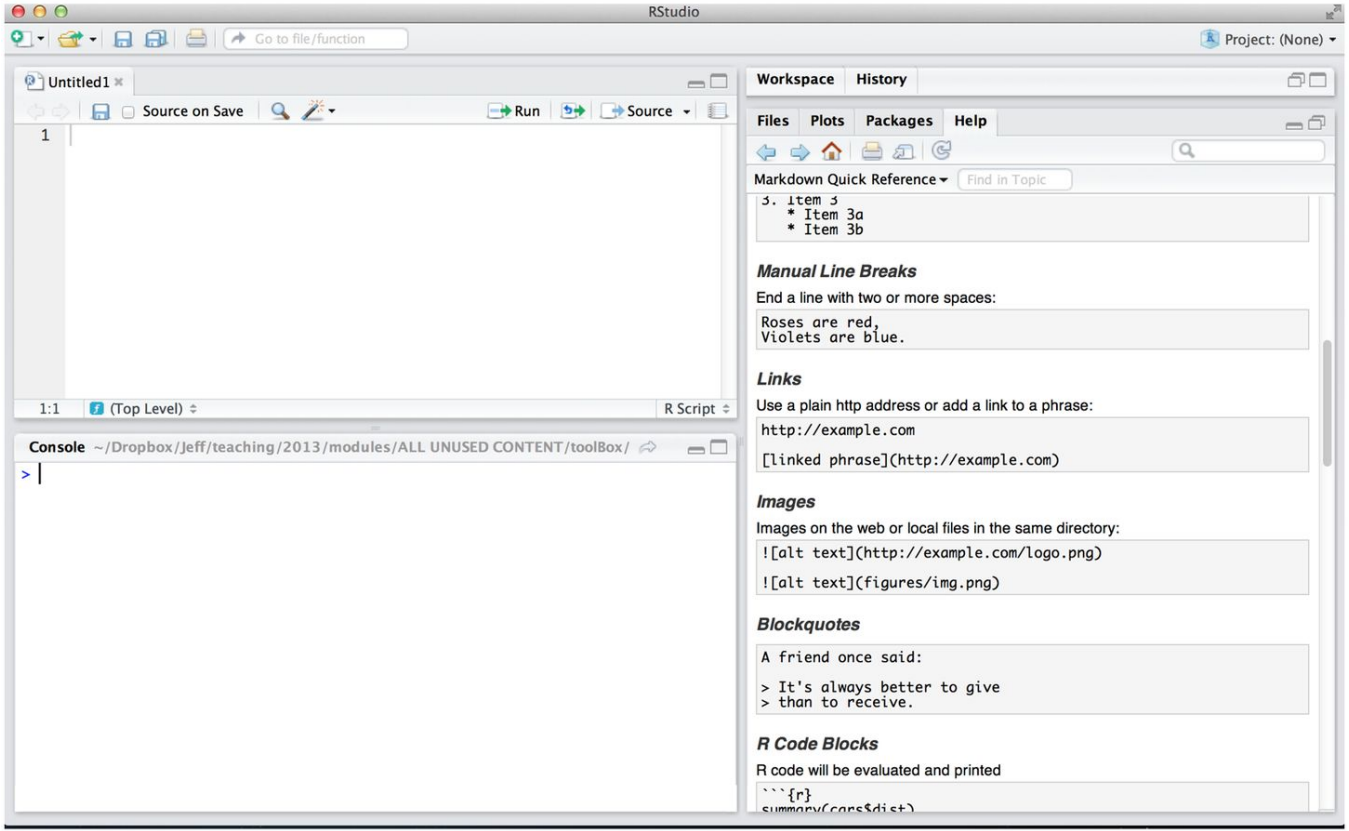
News

- **The R Journal Volume 7/1** is available.
- **R version 3.2.1 (World-Famous Astronaut)** has been released on 2015-06-18.
- **R version 3.1.3 (Smooth Sidewalk)** has been released on 2015-03-09.
- **useR! 2015**, will take place at the University of Aalborg, Denmark, June 30 - July 3, 2015.
- **useR! 2014**, took place at the University of California, Los Angeles, USA June 30 - July 3, 2014.

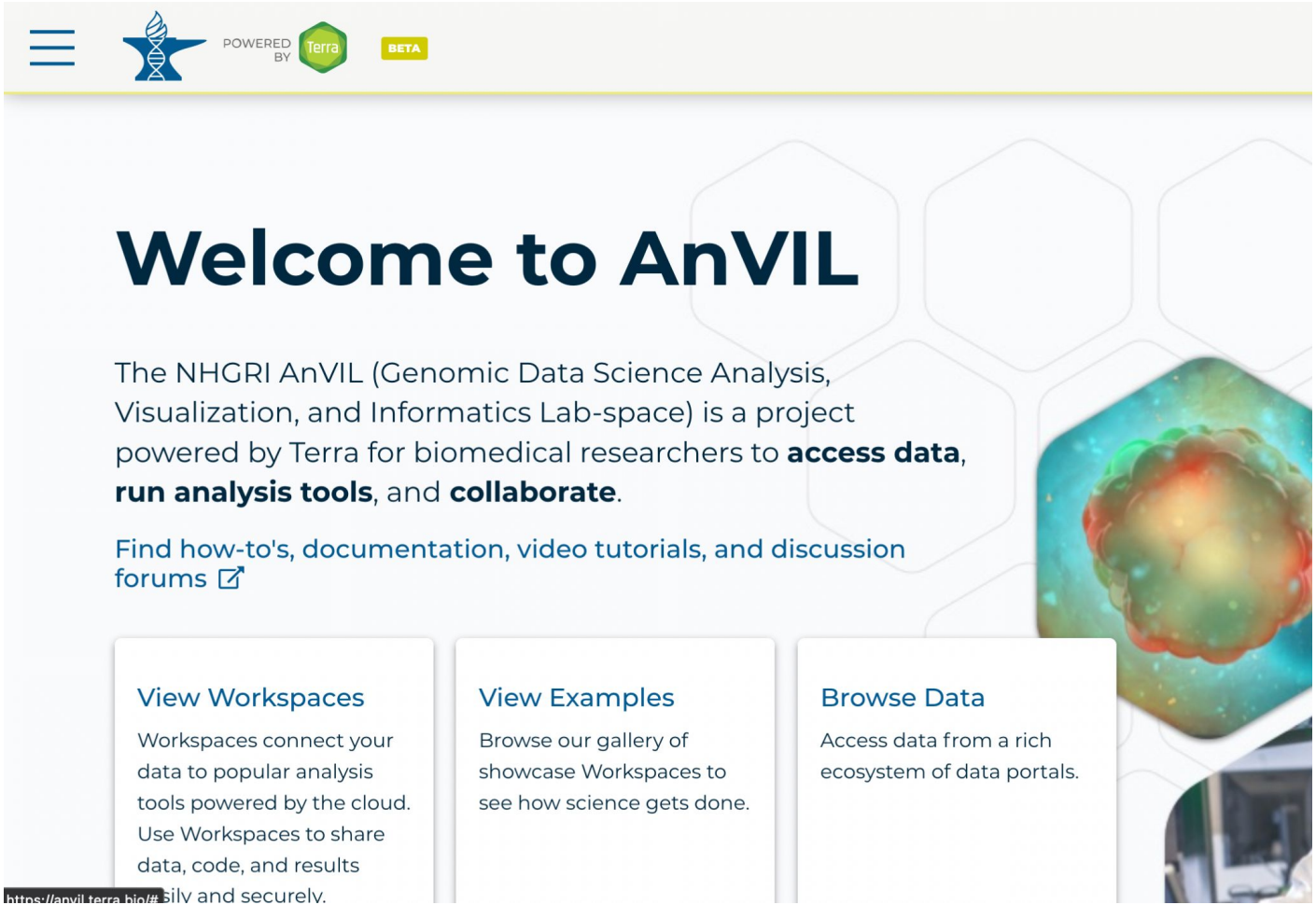
www.r-project.org



https://www.rstudio.com/

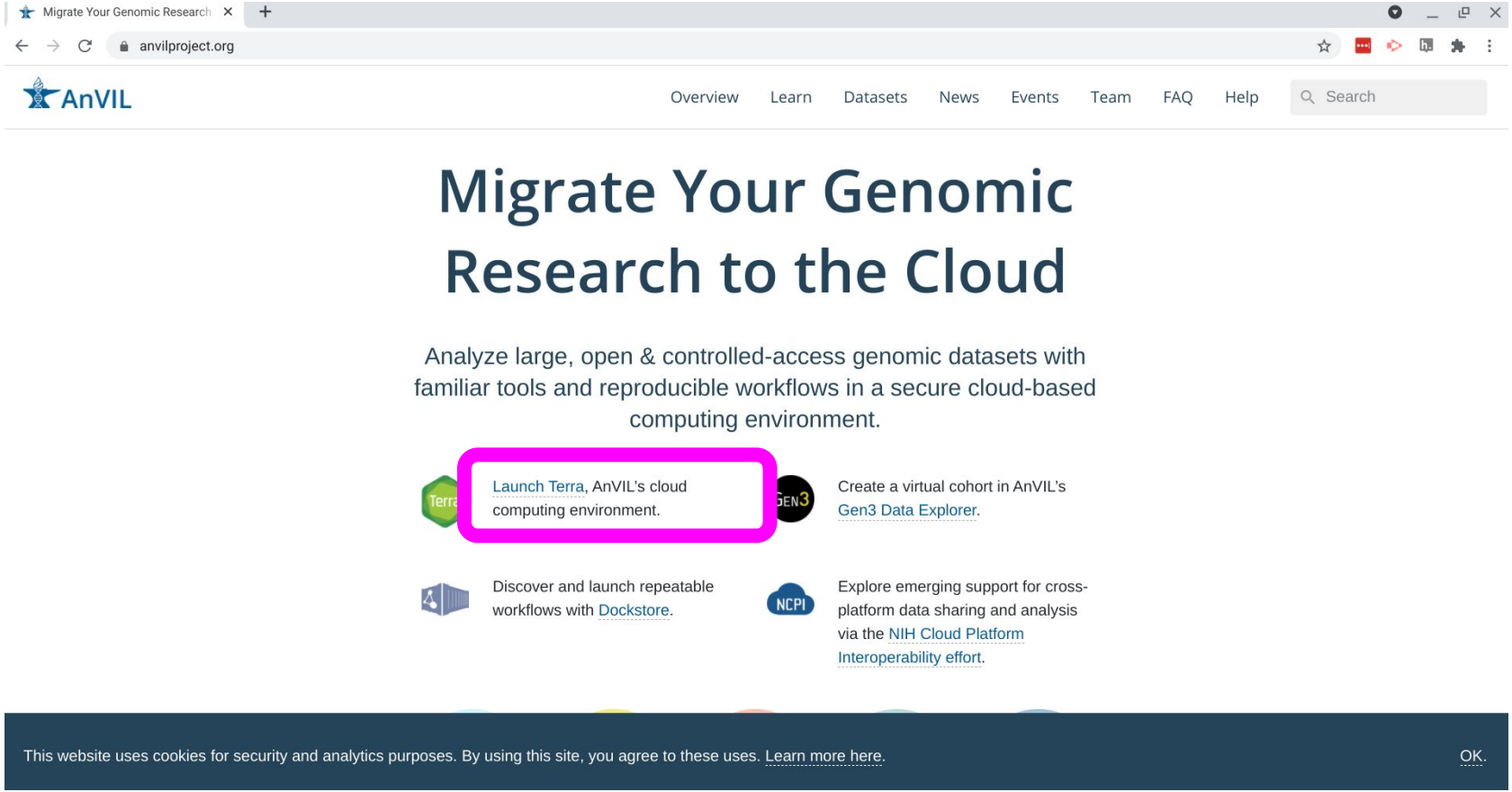


https://www.rstudio.com/



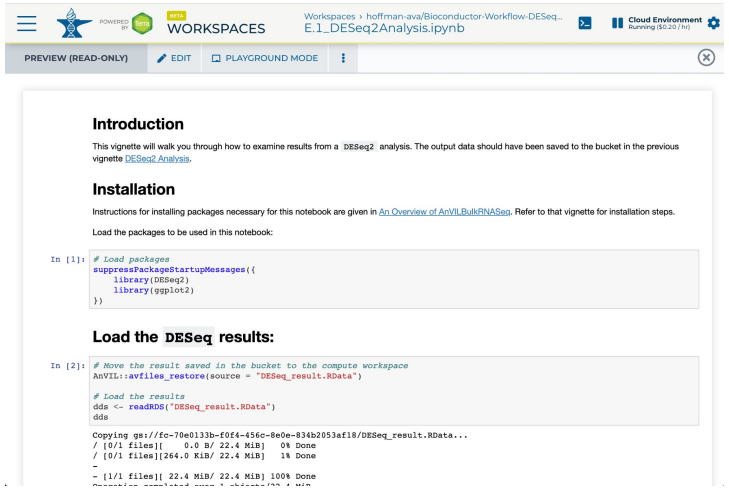
https://anvil.terra.bio

What is AnVIL???



https://anvilproject.org/

AnVIL is “renting computers”



Standard Computing

- You buy a laptop one time
- You get that one laptop
- You pay little per use

Cloud computing

- You use any web browser
- You rent the computers
- You pay per hour/gigabyte/etc.

It can feel a little weird

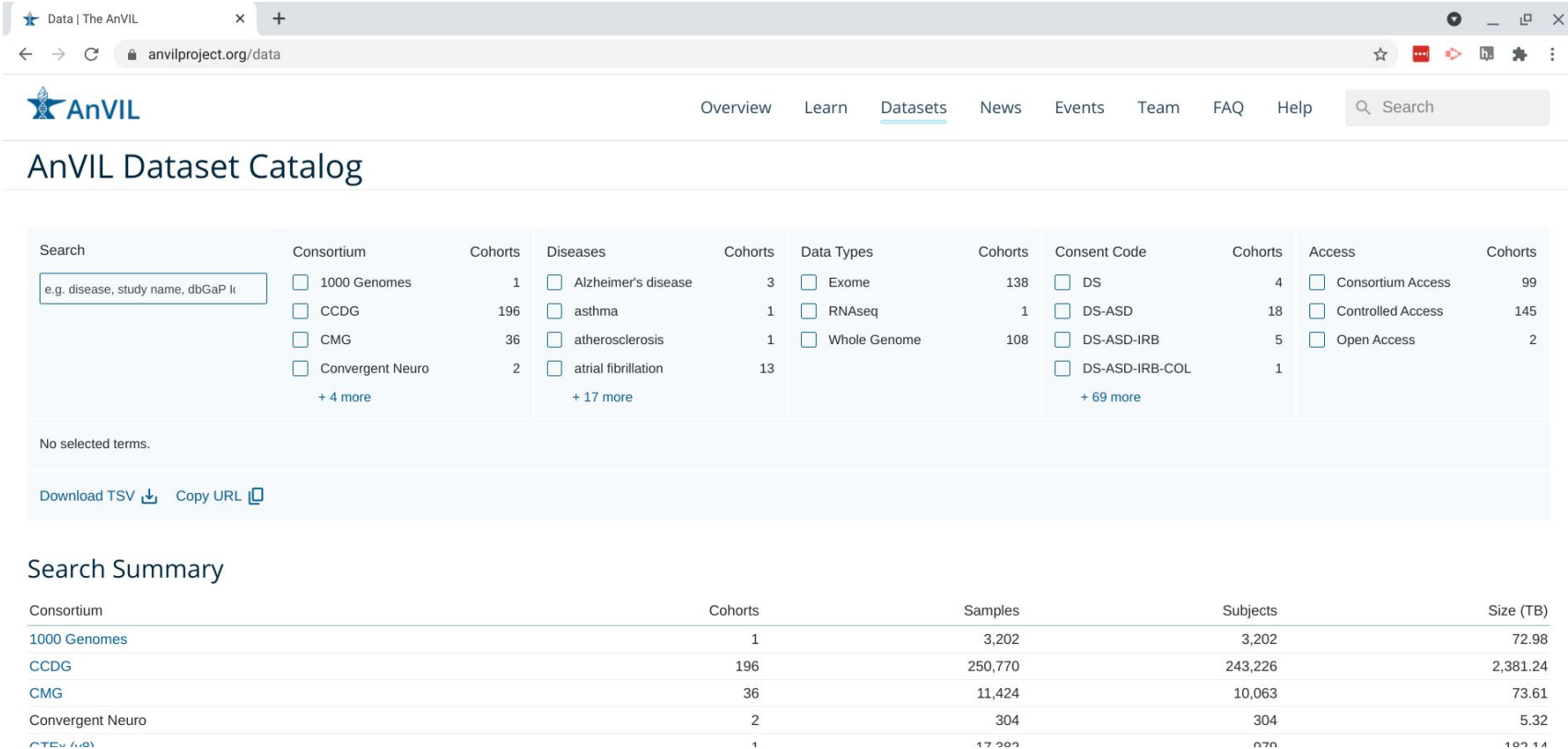
<u>Purchased car</u>

- You buy the car
- You fill up at a station
- You pay less per mile

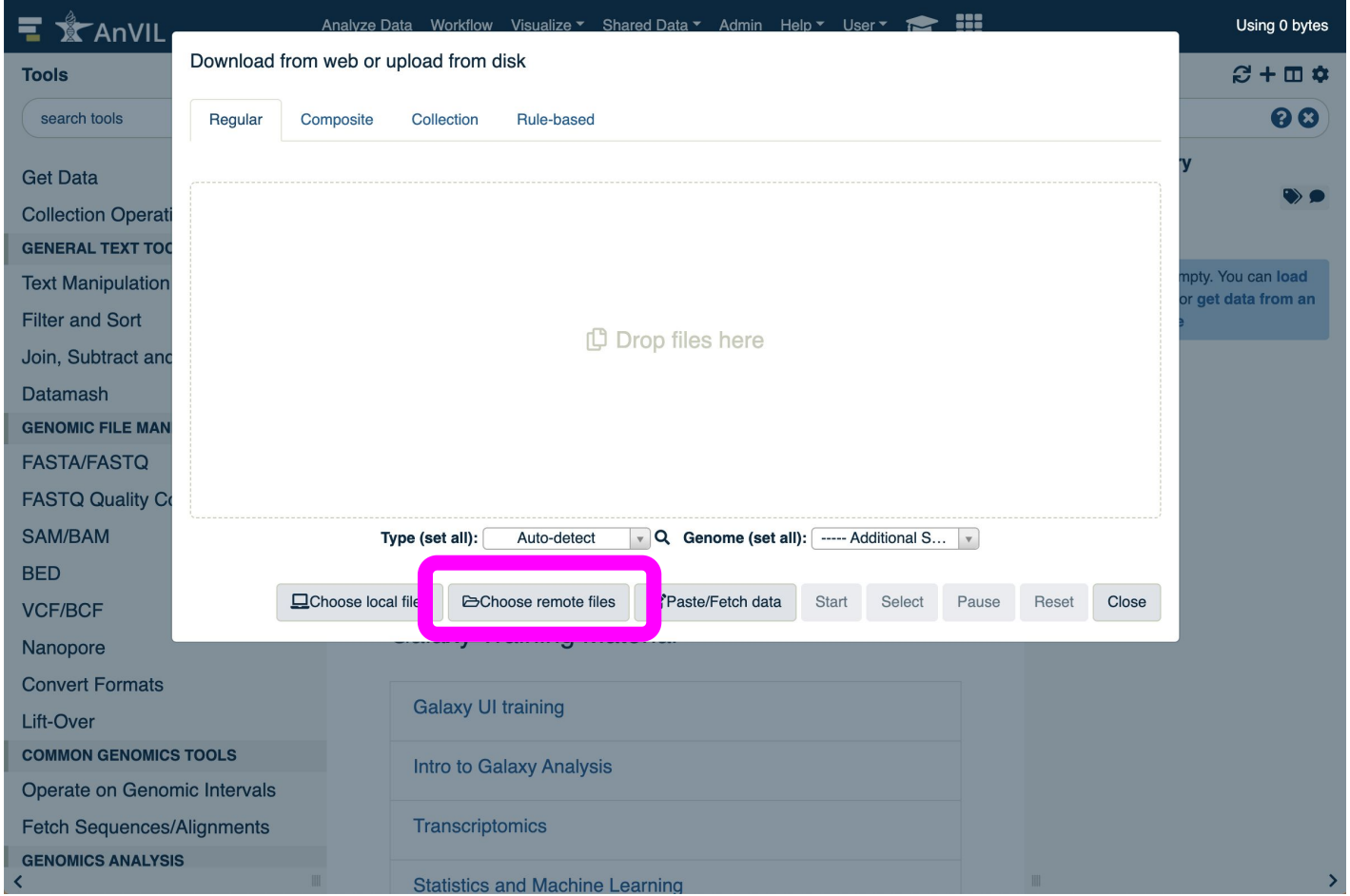
<u>ZipCar</u>

- You don’t buy the car
- You pay by the mile
- You may pay more per mile

AnVIL: Data + Sharing + Platforms



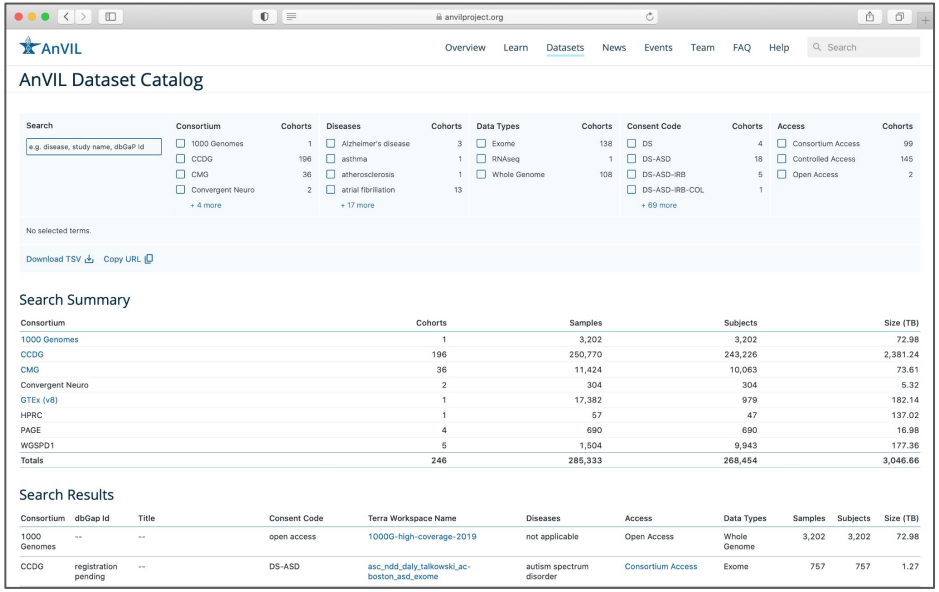
https://anvilproject.org/data


AnVIL
Analyze Data
Workflow
Visualize
Shared Data
Admin
Help
User
Using 0 bytes
Tools
search tools
Get Data
Collection Operati
GENERAL TEXT TOC
Text Manipulation
Filter and Sort
Join, Subtract and
Datamash
GENOMIC FILE MAN
FASTA/FASTQ
FASTQ Quality C
SAM/BAM
BED
VCF/BCF
Nanopore
Convert Formats
Lift-Over
COMMON GENOMICS TOOLS
Operate on Genomic Intervals
Fetch Sequences/Alignments
GENOMICS ANALYSIS
Download from web or upload from disk
Regular
Composite
Collection
Rule-based
Drop files here
Type (set all):
Auto-detect
Genome (set all):
----- Additional S…
Choose local file
Choose remote files
Paste/Fetch data
Start
Select
Pause
Reset
Close
Galaxy UI training
Intro to Galaxy Analysis
Transcriptomics
Statistics and Machine Learning

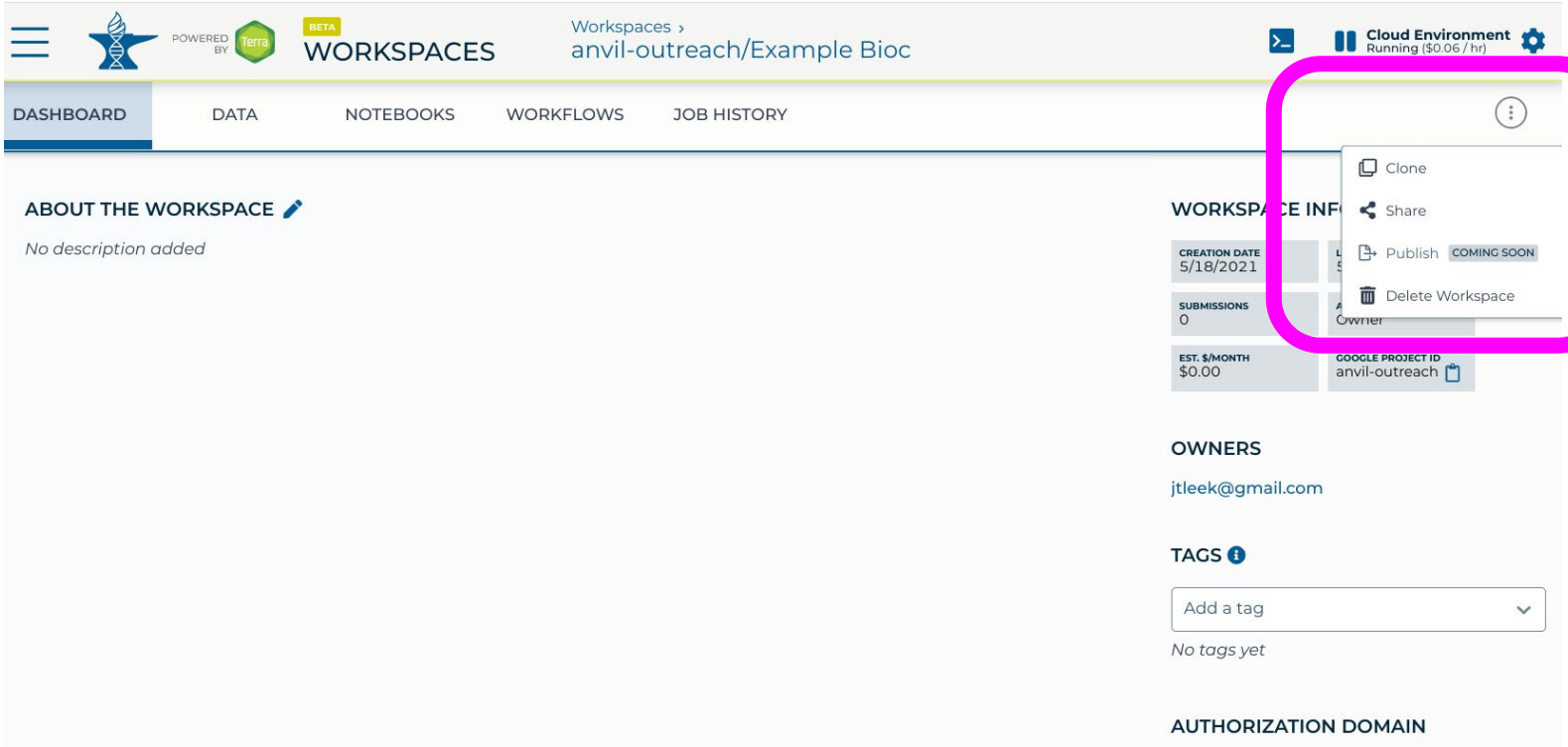
AnVIL Data Dashboard

Extensive unrestricted and protected data sets already available within AnVIL

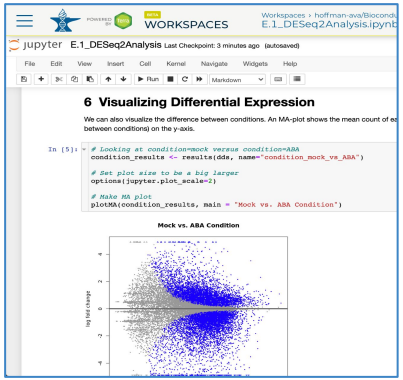
- 246 cohorts (CCDG, CMG, GTEx,1000G, eMerge)
- 285k subjects
- 3Pb and rapidly growing
- Open access (e.g. 1000G), dbGaP authenticated (e.g. GTex) and consortium authenticated (e.g. CCDG) options available



https://anvilproject.org/data


POWERED BY Terra
BETA
WORKSPACES
Workspaces ›
anvil-outreach/Example Bioc
Cloud Environment
Running ($0.06 / hr)
DASHBOARD
DATA
NOTEBOOKS
WORKFLOWS
JOB HISTORY
Clone
Share
Publish
COMING SOON
Delete Workspace
ABOUT THE WORKSPACE
No description added
WORKSPACE INFO
CREATION DATE
5/18/2021
SUBMISSIONS
0
Owner
EST. $/MONTH
$0.00
GOOGLE PROJECT ID
anvil-outreach
OWNERS
jtleek@gmail.com
TAGS
Add a tag
No tags yet
AUTHORIZATION DOMAIN

AnVIL Analysis Platforms

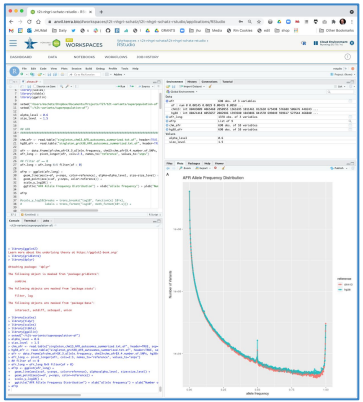


jupyter

+ Code, text and plots in one document
+ Supports coding in Python or R
- Least scalable, not a complete IDE

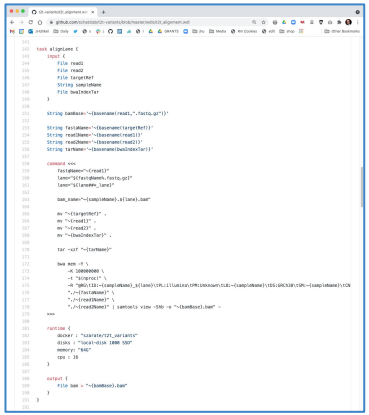
Galaxy

+ Graphical interface for thousands of tools and workflows
+ Highly accessible and reproducible
- Tools must be preconfigured to use



RStudio®

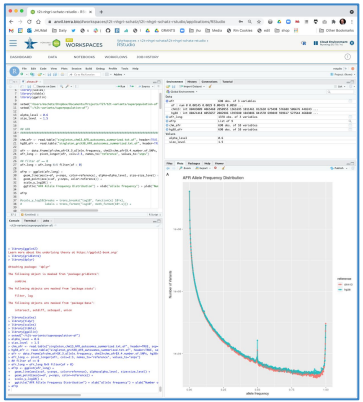
+ Feature rich IDE for programming in R
+ Rich statistics & ML and visualizations
- Limited support for other programming languages



{wdl}

+ Extremely scalable and flexible
- Most technically demanding
- Unpredictable and potentially large costs

AnVIL Analysis Platforms



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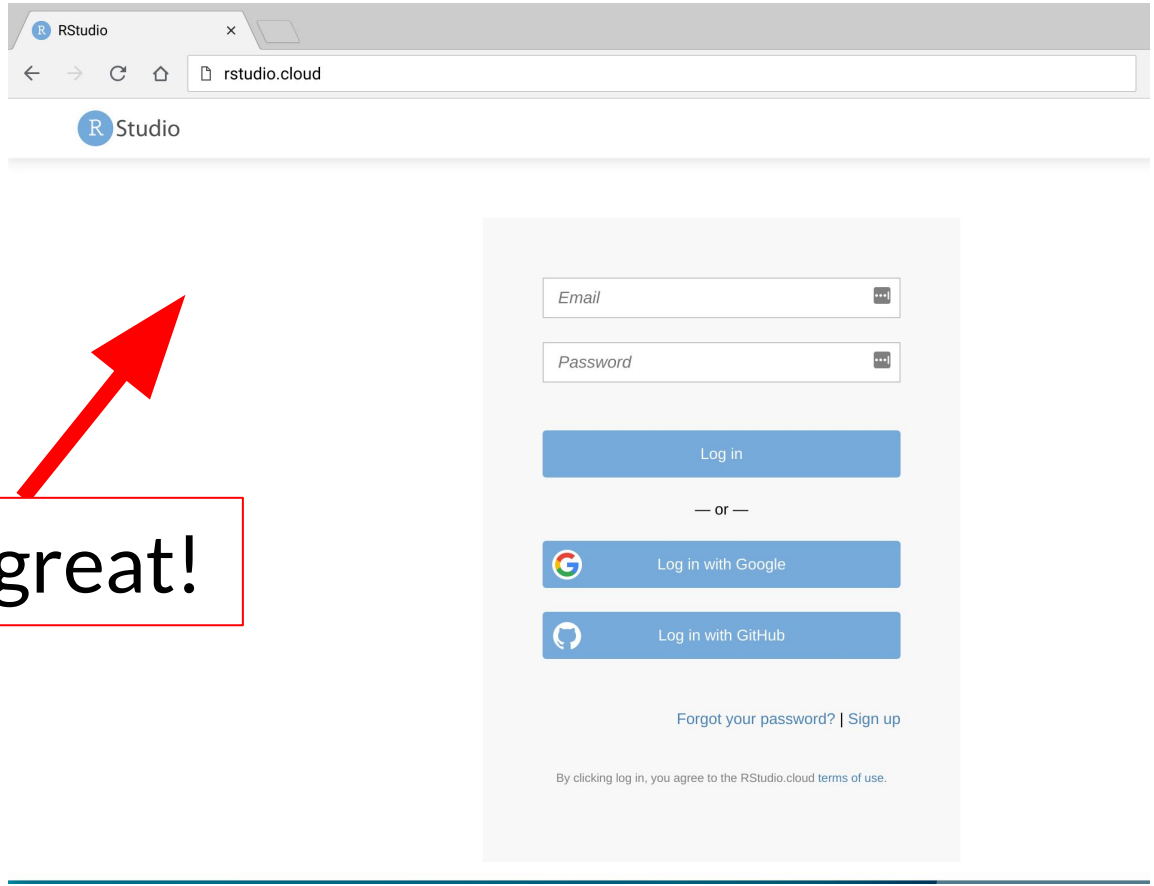

Also great!

https://rstudio.cloud