Working with Tidy Data

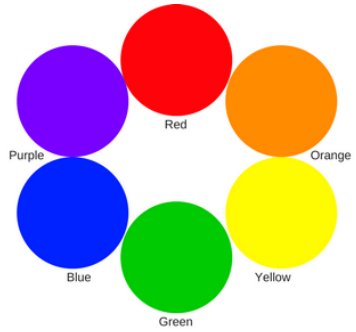
27 January 2020

Modern Research Methods

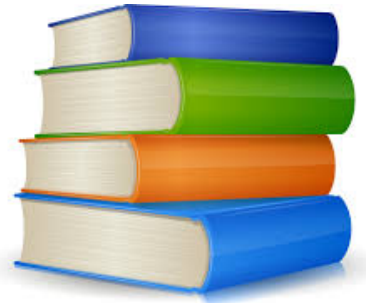
Course Website: https://cumulativescience.netlify.com/

Last Time: Variable types

- **Qualitative** – describe quality (no intrinsic ordering)



- **Quantitative** – describe quantity
  - **Binary** – 1 or 0 (or, TRUE or FALSE)
  - **Integers** – whole numbers
  - **Real numbers** – have fractional/decimal part



What is the metaphysical status of variable types?

Variable types are not inherent; they're determined by the analyst so you can do the analysis you want.

V1	V2	V3	V4

KEY ANALYSIS

e.g., Are there more x than y?

Is x greater than y?

Class attendance

How many students showed up to class today? (*binary*)

Student	Attendance
Kyla	TRUE
Kara	FALSE
Zara	TRUE

How many times did each student comment in class today? (*integer*)

Student	Attendance
Kyla	1
Kara	NA
Zara	3

What was the most common type of attention of students in class today? (*qualitative*)

Student	Attendance
Kyla	“quiet”
Kara	NA
Zara	“inquisitive”

How many seconds early was each student today? (*real number*)

Student	Attendance
Kyla	120.457
Kara	NA
Zara	125.332

Variables, Observations, and Values

- **Variable** – unique measurement or quantity
  - e.g., temperature, mood, attendance, # of books owned, reaction time, color
- **Observation**– Smallest unit you have data about (person, trial in an experiment, city, school)
- **Value** – Quantity/quality associated with a particular variable and observation

Variable – Jan. high temp. in PGH
Observation – day
Value – 38 degrees

Variable – age of students in MRM
Observation – student
Value – 19.3 years

Variable – Condition
Observation – person
Value – tennis class or chess class

Working with data in R

- Data is typically read into R from a local file
- Lots of different file formats (.csv, .txt, .tsv, .xlsx)
- We'll work mostly with a plain text format, called "comma separated value" (.csv)
- Each observation is separated by a comma

lewis_2018_exp1.csv

```
exp,subids,trial_num,category,condition,proportion_basic_level_responses
1,1,9,vehicles,three_subordinate,0
1,2,9,animals,three_basic,1
1,3,9,animals,three_superordinate,1
1,4,9,vehicles,three_superordinate,1
1,5,9,animals,three_superordinate,1
1,6,9,vegetables,three_subordinate,0
1,7,9,vegetables,three_basic,0.5
1,8,9,animals,three_basic,1
```

```
> lf_data
# A tibble: 600 x 6
     exp subids trial_num category   condition           proportion_basic_level_responses
   <dbl>  <dbl>     <dbl> <chr>      <chr>                                          <dbl>
 1     1      1         9 vehicles   three_subordinate                                  0
 2     1      2         9 animals    three_basic                                        1
 3     1      3         9 animals    three_superordinate                                1
 4     1      4         9 vehicles   three_superordinate                                1
 5     1      5         9 animals    three_superordinate                                1
 6     1      6         9 vegetables three_subordinate                                  0
 7     1      7         9 vegetables three_basic                                        0.5
 8     1      8         9 animals    three_basic                                        1
 9     1      9         9 animals    three_superordinate                                1
10     1     10         9 animals    three_subordinate                                  0
# … with 590 more rows
```

readr functions

function	reads
read_csv()	**Comma separatedvalues**
read_csv2()	Semi-colon separated values
read_delim()	General delimited files
read_fwf()	Fixed width files
read_log()	Apache log files
read_table()	Space separated
read_tsv()	Tab delimited values

read_csv()

readr functions share a common syntax

```
df <- read_csv("path/to/file.csv", …)
```

object to save output into

path from working directory to file

```
lf_data <- read_csv("data/lewis_2018_exp1.csv")
```

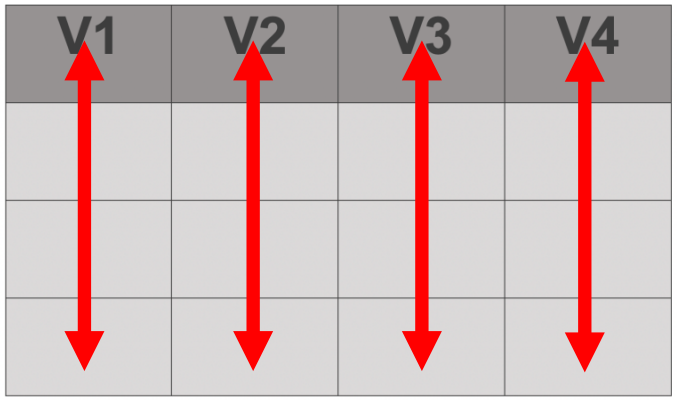
Missing data in R

- Missing data in R: NA (“not available”)
- is.na(x) – Boolean (gives TRUE or FALSE), testing whether x has value NA
- Why might data be missing?
  - Participant didn’t respond (e.g. got fussy, got bored, ended experiment)
  - Experimenter error
  - Not collected because variable not applicable
  - Lots of others…

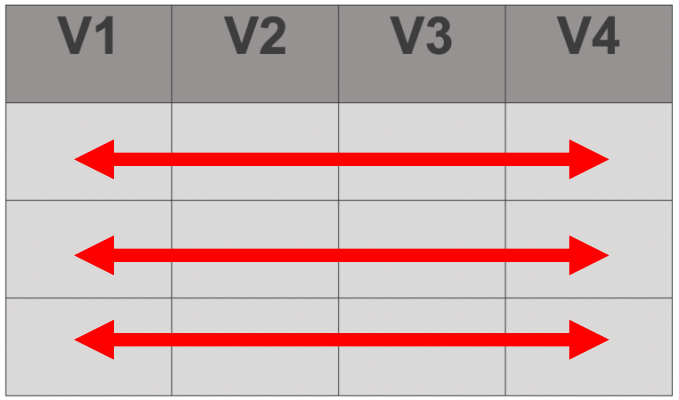
Tidy data

- When analyzing data, we want the data to be *tidy* ("long format")
- In a tidy dataset:

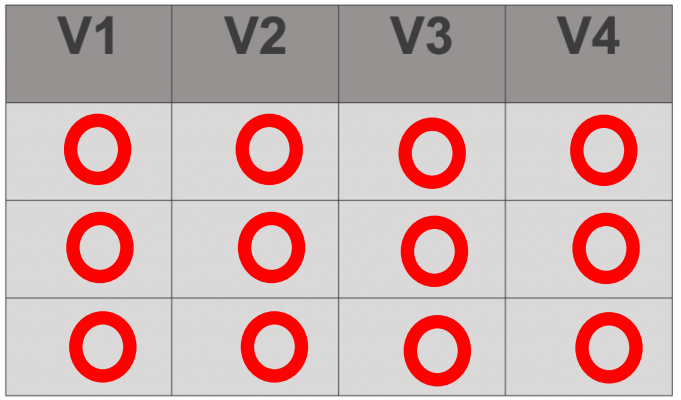
Each **variable** is its own column



Each **observation** is its own row



Each **value** is its own cell



* Allows R to use vectorized observations

Variable – Jan. high temp in PGH
Observation – day
Value – 38 degrees

Tidy data of Pittsburgh January 2020 Temperature

Observation →

Date	High Temp.	Low Temp.
1/1/2020	38	28
1/2/2020	48	28
1/3/2020	51	45

↑ Variable

Sketch the tidy data…

Of the data from an experiment where you randomly assigned 20 people to attend MRM at 6am and 20 people to attend MRM at 2pm. You measured:

(1) students' score on a quiz (out of 10), and

(2) students' subjective feeling of wakefulness (out of 7).

Tidy data of MRM class time experiment

Observation →

Student	Condition	Quiz score	Wakefulness
Charles	6am	4	3
Vali	6am	7	4
Juan	6am	3	1
Bruno	1pm	9	5
Margaret	1pm	6	6
Kwame	1pm	5	7
Josh	1pm	8	6

↑ Variable

Airplanes on Hand in the AAF, By Major Type: Jul 1939 to Aug 1945

End of Month	Total	Very Heavy Bombers	Heavy Bombers	Medium Bombers	Light Bombers	Fighters	Recon-naissance	Transports	Trainers	Communi-cations
1939										
Jul	2,402	-	16	400	276	494	356	118	735	7
Aug	2,440	-	18	414	276	492	359	129	745	7
[Germany invades Poland, 1 Sep 1939]										
Sep	2,473	-	22	428	278	489	359	136	754	7
Oct	2,507	-	27	446	277	490	365	137	758	7
Nov	2,536	-	32	458	275	498	375	136	755	7
Dec	2,546	-	39	464	274	492	378	131	761	7
1940										
Jan	2,588	-	45	466	271	464	409	128	798	7
Feb	2,658	-	49	470	271	458	415	128	860	7
Mar	2,709	-	54	468	267	453	415	125	920	7
Apr	2,806	-	54	468	263	451	416	125	1,022	7
May	2,906	-	54	470	259	459	410	124	1,123	7
Jun	2,966	-	54	478	166	477	414	127	1,243	7
[France surrenders to Germany, 25 Jun 1940] [Battle of Britain begins, 10 July 1940]										
Jul	3,102	-	56	483	161	500	410	128	1,357	7
Aug	3,295	-	65	485	158	539	407	128	1,506	7

Source: Army Air Forces Statistical Digest, WW II

	A	AA	AB	AC	AD	AE	AF	AG	AH
1	Estimated HIV Prevalence% - (Ages 15-49)	2004	2005	2006	2007	2008	2009	2010	2011
2	Abkhazia								
3	Afghanistan						0.06	0.06	0.06
4	Akrotiri and Dhekelia								
5	Albania								
6	Algeria	0.1	0.1	0.1	0.1	0.1			
7	American Samoa								
8	Andorra								
9	Angola	1.9	1.9	1.9	1.9	2	2.1	2.1	2.1
10	Anguilla								
11	Antigua and Barbuda								
12	Argentina	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4
13	Armenia	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
14	Aruba								
15	Australia	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
16	Austria	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4
17	Azerbaijan	0.06	0.06	0.06	0.1	0.1	0.1	0.1	0.1
18	Bahamas	3	3	3	3.1	3.1	2.9	2.8	2.8

Source: Gapminder, Estimated HIV prevalence among 15-49 year olds

Working with tidy data in R

Isolating information

(in lab on Friday)

select() - extract **variables**

filter() - extract **cases**

arrange() - reorder **cases**

Deriving information

summarise() - summarise **variables**

group_by() - group **cases**

mutate() - create new **variables**

Note: All functions in the tidyverse should be used with tidy data!

summarise()

summarise()

Compute table of summaries.

babynames

year	sex	name	n	prop
1880	M	John	9655	0.0815
1880	M	William	9532	0.0805
1880	M	James	5927	0.0501
1880	M	Charles	5348	0.0451
1880	M	Garrett	13	0.0001
1881	M	John	8769	0.081

total	max
127538	99680

n()

The number of rows in a dataset/group

```
babynames %>% summarise(n = n())
```

babynames

year	sex	name	n	prop
1880	M	John	9655	0.0815
1880	M	William	9532	0.0805
1880	M	James	5927	0.0501
1880	M	Charles	5348	0.0451
1880	M	Garrett	13	0.0001
1881	M	John	8769	0.081

n
1858689

n_distinct()

The number of distinct values in a variable

```
babynames %>% summarise(n = n(), nname = n_distinct(name))
```

babynames

year	sex	name	n	prop
1880	M	John	9655	0.0815
1880	M	William	9532	0.0805
1880	M	James	5927	0.0501
1880	M	Charles	5348	0.0451
1880	M	Garrett	13	0.0001
1881	M	John	8769	0.081

→

n	nname
1858689	95025

Summary functions

Take a vector as input.

Return a single value as output.

Summary Functions

to use with summarise()

summarise() applies summary functions to columns to create a new table. Summary functions take vectors as input and return single values as output.

Counts

dplyr::**n()** - number of values/rows
dplyr::**n_distinct()** - # of uniques
sum(!is.na()) - # of non-NA's

Location

mean() - mean, also **mean(is.na())**
median() - median

Logicals

mean() - Proportion of TRUE's
sum() - # of TRUE's

Position/Order

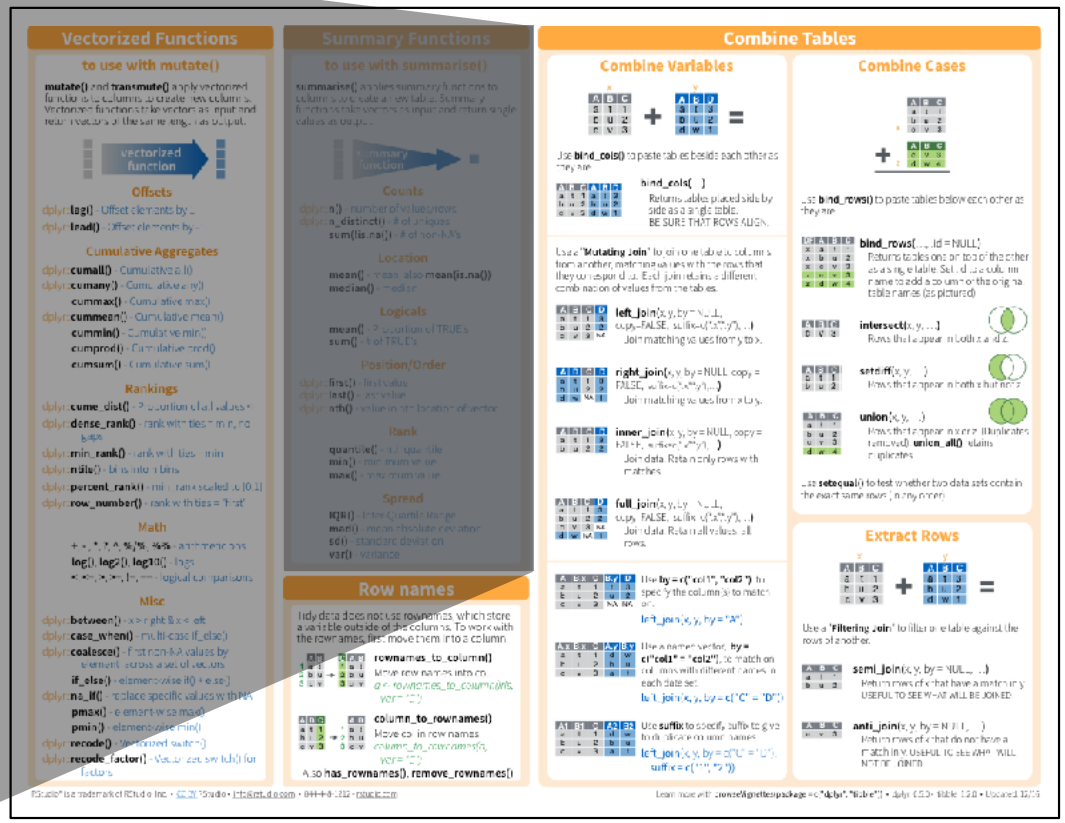
dplyr::**first()** - first value
dplyr::**last()** - last value
dplyr::**nth()** - value in nth location of vector

Rank

quantile() - nth quantile
min() - minimum value
max() - maximum value

Spread

IQR() - Inter-Quartile Range
mad() - mean absolute deviation
sd() - standard deviation
var() - variance



Grouping cases

group_by()

Groups cases by common values of one or more columns.

```
babynames %>%
  group_by(sex)
```

```
Source: local data frame [1,825,433 x 5]
Groups: sex [2]

   year   sex      name     n       prop
  <dbl> <chr>     <chr> <int>      <dbl>
1  1880     F      Mary  7065 0.07238359
```

group_by()

Groups cases by common values.

```
babynames %>%
  group_by(sex) %>%
  summarise(total = sum(n))
```

sex	total
F	167070477
M	170064949

ungroup()

TWO grouping variables

Removes grouping criteria from a data frame.

```
babynames %>%
  group_by(name, sex) %>%
  summarise(total = sum(n)) %>%
  arrange(desc(total))
#       name   sex   total
#  1   James     M 5120990
#  2    John     M 5095674
#  3  Robert     M 4803068
#  4 Michael     M 4323928
#  5    Mary     F 4118058
```

ungroup()

Removes grouping criteria from a data frame.

```
babynames %>%
  group_by(name, sex) %>%
  ungroup() %>%
  summarise(total = sum(n)) %>%
  arrange(desc(total))
#       total
# 1 340851912
```

mutate()

mutate()

Create new columns.

babynames

year	sex	name	n	prop
1880	M	John	9655	0.0815
1880	M	William	9532	0.0805
1880	M	James	5927	0.0501
1880	M	Charles	5348	0.0451
1880	M	Garrett	13	0.0001
1881	M	John	8769	0.081

year	sex	name	n	prop	percent
1880	M	John	9655	0.0815	8.15
1880	M	William	9532	0.0805	8.05
1880	M	James	5927	0.0501	5.01
1880	M	Charles	5348	0.0451	4.51
1880	M	Garrett	13	0.0001	0.01
1881	M	John	8769	0.081	8.1

mutate()

Create new columns.

```
babynames %>%
  mutate(percent = round(prop*100, 2), nper = round(percent))
```

babynames

year	sex	name	n	prop
1880	M	John	9655	0.0815
1880	M	William	9532	0.0805
1880	M	James	5927	0.0501
1880	M	Charles	5348	0.0451
1880	M	Garrett	13	0.0001
1881	M	John	8769	0.081

year	sex	name	n	prop	percent	nper
1880	M	John	9655	0.0815	8.15	8
1880	M	William	9532	0.0805	8.05	8
1880	M	James	5927	0.0501	5.01	5
1880	M	Charles	5348	0.0451	4.51	5
1880	M	Garrett	13	0.0001	0.01	0
1881	M	John	8769	0.081	8.1	8

Recap: Single table verbs

Extract variables with **select()**

Extract cases with **filter()**

Arrange cases, with **arrange()**.

Make tables of summaries with **summarise()**.

Make new variables, with **mutate()**.

Sketch the data frame…

city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

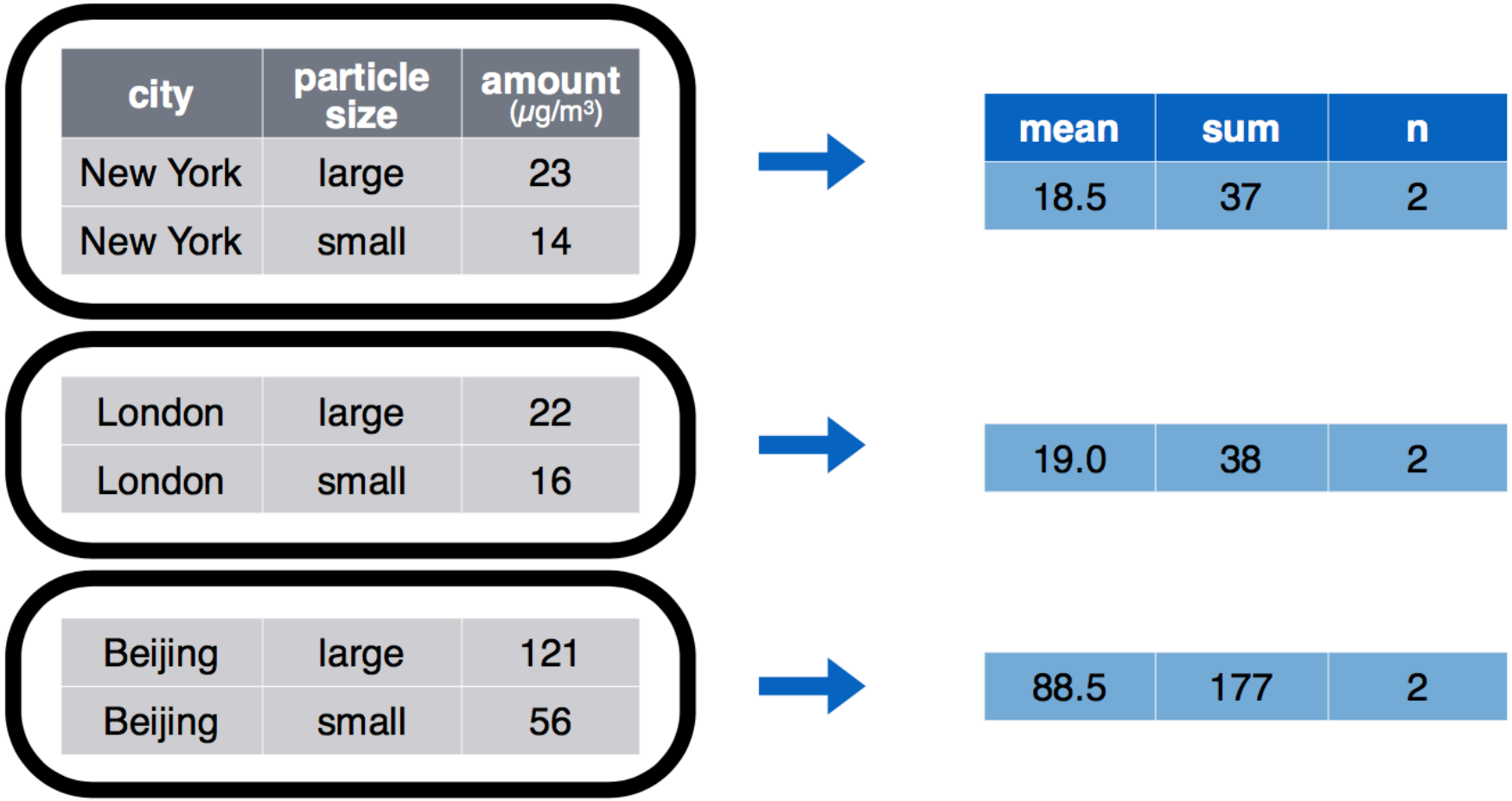
city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

mean	sum	n
42	252	6

Sketch the data frame…

city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

```
pollution %>%
  group_by(city) %>%
  summarise(mean = mean(amount), sum = sum(amount), n = n())
```



group_by() + summarise()

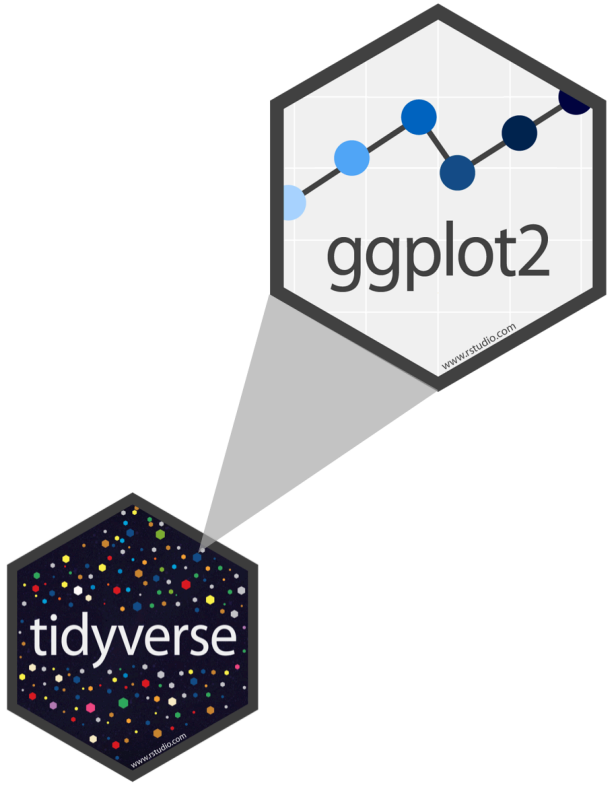
dplyr

Sketch the data frame…

city	particle size	amount ($\mu g/m^3$)
New York	large	23
New York	small	14
London	large	22
London	small	16
Beijing	large	121
Beijing	small	56

```
pollution %>%
  group_by(city, size) %>%
  summarise(mean = mean(amount), sum = sum(amount), n = n())
```

Next Time: Plotting



Reading:

3 Make a plot

This Chapter will teach you how to use ggplot's core functions to produce a series of scatterplots. From one point of view, we will proceed slowly and carefully, taking our time to understand the logic behind the commands that you type. The reason for this is that the central activity of visualizing data with ggplot more or less *always* involves the same sequence of steps. So it is worth learning what they are.

Office Hours:

Jaeah 11:30-1:30pm **today** only;

Molly 4:30-6:30pm Wednesday (Porter 223A)

Acknowledgements

Slides 14-15 adapted from
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Slides 16-35 adapted from
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