Data Wrangling in R with the Tidyverse (Part 2)

More data wrangling

Changing *all* columns at once

`mutate_all()`, `rename_all()`: applies a function to *all* columns:
`mutate_all(FUNCTION, FUNCTION_ARGUMENTS)`

```
# mutate_all changes the data in all columns  demo_data %>% mutate_all(as.character) %>%
head(2)
```

1	931897 15 years old Female 10th White White	17.17 9	54.43
2	333862 17 years old Female 12th White White	20.24 87	57.15
#	rename_all changes all column names		

```
# A tibble: 3 x 8 re
demo_data %>% rename_all(str_sub, end = 2) %>% head(3)
       ag                        se     gr     ra             ra                bm     st
    <dbl> <chr>                <chr>  <chr>  <chr>          <chr>            <dbl>  <dbl>
1 931897 15 years old          Female 10th   White          White             17.2
2 333862 17 years old          Female 12th   White          White                     54.
3  36253 18 years old or…      Male   11th   Hispanic/La…   Hispanic/L…       4
```

Changing *some* columns at once

`mutate_at()`,`rename_at()`: uses `vars()` to select specific variables to apply a function to i.e. `mutate_at(vars(SELECT), FUNCTION, FUNCTION_ARGUMENTS)`

```
# mutate_at changes the data in specified columns
demo_data %>% mutate_at(vars(contains("race"), sex), as.factor) %>% head(2)
```

```
# A tibble: 2 x 8
  record age          sex    grade race4 race7   bmi stweight
   <dbl> <chr>        <fct>  <chr> <fct> <fct> <dbl>    <dbl>
1 931897 15 years old Female 10th  White White  17.2     54.4
2 333862 17 years old Female 12th  White White  20.2     57.2
```

```
# rename_at changes specified column names
demo_data %>% rename_at(vars(record:grade),toupper) %>% head(3)
```

```
# A tibble: 3 x 8
  RECORD AGE              SEX    GRADE race4          race7           bmi stweight
   <dbl> <chr>            <chr>  <chr> <chr>          <chr>         <dbl>    <dbl>
1 931897 15 years old     Female 10th  White          White          17.2     54.4
2 333862 17 years old     Female 12th  White          White          20.2     57.2
3  36253 18 years old o… Male   11th  Hispanic/L… Hispanic/…    NA       NA
```

Changing *some* columns at once

`mutate_if()`, `rename_if()`, `select_if()`: uses a function that returns TRUE/FALSE to select columns and applies function on the TRUE columns:
`mutate_if(BOOLEAN, FUNCTION, FUNCTION_ARGUMENTS)`

```
demo_data %>% mutate_if(is.numeric, round, digits = 0) %>% head(3)
```

# A tibble: 3 x 8					
record age	sex	gra de	race4	race7 b mi	stweigh t
<dbl> <chr>	<chr >	<ch r>	<chr>	<chr> <db	<dbl>

demo_data %>% rename_if(is.character,	str_su b,	end = 2)	% > %	head(3)
# A tibble: 3 x 8 record ag se gr	ra	ra		bmi stweight
<dbl> <chr> <chr> <chr>	<chr>	<chr>		<dbl> <dbl>

Add one or more rows: `add_row()`

```r
arrange(record) %>% head(3)
```

```
# A tibble: 3 x 8
```

	record	age	sex	grade	race4	race7	bmi	stweight
	<dbl>	<chr>	<chr>	<chr>	<chr>	<chr>	<dbl>	<dbl>
1	100	<NA>	Female	9th	<NA>	<NA>	NA	NA
2	30592	<NA>	<NA>	<NA>	<NA>	<NA>	NA	NA
3	30593	<NA>	<NA>	9th	Hispanic/Latino	Hispanic/Latino	NA	NA

```r
demo_data %>% add_row(record=100:102, bmi=c(25,30,18)) %>%
  arrange(record) %>% head(3)
```

```
# A tibble: 3 x 8
```

	record	age	sex	grade	race4	race7	bmi	stweight
	<dbl>	<chr>	<chr>	<chr>	<chr>	<chr>	<dbl>	<dbl>
1	100	<NA>	<NA>	<NA>	<NA>	<NA>	25	NA
2	101	<NA>	<NA>	<NA>	<NA>	<NA>	30	NA
3	102	<NA>	<NA>	<NA>	<NA>	<NA>	18	NA

Add one or more columns: `add_column()`

```
head(3)
```

```
# A tibble: 3 x 9
  record study_date age           sex    grade race4     race7      bmi stweight
<dbl> <chr>      <chr>    <chr>    <chr> <chr> 1         <chr>    <dbl>    <dbl>
931897 2019-04-10 15 years … Female 10th White           White     17.2     54.4
2 333862 2019-04-10 17 years … Female 12th   White       White    20.2     57.2
3  36253 2019-04-10 18 years … Male    11th   Hispani… Hispan…  NA       NA
```

```
head(3)
```

```
# A tibble: 3 x 9
     id record age          sex    grade race4     race7       bmi stweight
  <int>  <dbl> <chr>        <chr>  <chr> <chr>     <chr>      <dbl>    <dbl>
1      1 931897 15 years old Female 10th  White     White       17.2     54.4
2      2 333862 17 years old Female 12th  White     White      20.2     57.2
3      3  36253 18 years ol… Male   11th  Hispanic… Hispanic…  NA       NA
```

Frequency tables: `janitor` package's `tabyl` function

```
# default table
demo_data %>% tabyl(grade)
```

```
 grade    n percent valid_percent
  10th 4907 0.24535
           0.2504338
 11th 4891 0.24455       0.2496172
 12th 4577 0.22885       0.2335919
  9th 5219 0.26095       0.2663570
 <NA>   406 0.02030              NA
```

```
# output can be treated as tibble
demo_data %>% tabyl(grade) %>% select(-n)
```

```
 grade percent valid_percent 10th 0.24535
       0.2504338
 11th 0.24455       0.2496172
 12th 0.22885       0.2335919
  9th 0.26095       0.2663570
 <NA> 0.02030              NA
```

`adorn_` your table!

```
demo_data %>%  tabyl(grade) %>%
  adorn_totals("row") %>%
  adorn_pct_formatting(digits=2)
```

```
 grade               n percent
  valid_percent 10th      4907 25.04%
          24.54%                24.96%
 11th    4891   24.45%          23.36%
 12th    4577   22.88%          26.64%
  9th    5219   26.10%               -
 Total 20000 100.00%           100.00%
 <NA>     406    2.03%
```

2x2 `tabyl`s

```r
# default 2x2 table
demo_data %>% tabyl(grade, sex)
```

```
 grad  Femal  Male NA_
 12th   2277  2263  37
  9th   2492  2684  43
 <NA>    126   195  85
```

What adornments does the tabyl to right have?

```
grade      Female         Male           NA_
<NA>       1.3% (126)     1.9% (195)     36.8% (85)
Total    100.0% (9592)  100.0% (10177)  100.0% (231)
```

- Notice `grade` is not sorted in a pleasing way. We will learn how to deal with this when we discuss `factors` as a data type in R.
- Base R has a `table` function, but it is clunkier and the output is not a data frame. See the [tabyl vignette](#) for more information, adorn options, & 3-way `tabyl`s

Numerical data summaries: `summarize()`

- We can summarize data as a whole, or in groups with `group_by()`
- `group_by()` is very powerful, see [data wrangling cheatsheet]()
- Can also use `summarize_at()`, `summarize_if()`, `summarize_all()`

```
# summary of all data as a whole demo_data
%>%
  summarize(bmi_mean =mean(bmi,na.rm=TRUE),
             bmi_sd = sd(bmi,na.rm=TRUE))
```

```
# A tibble: 1 x 2 bmi_mean bmi_sd
                        <dbl>  <dbl>
                   1 23.5       4.99
```

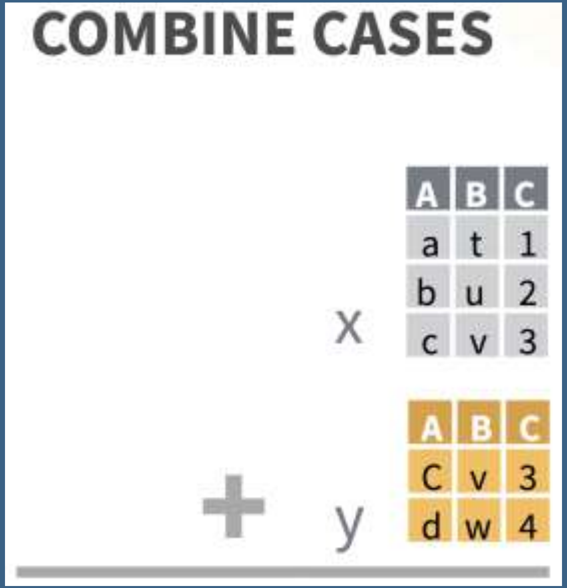
What does `na.rm=TRUE` do and what happens if we leave it out?

```
# summary by group variable demo_data %>%

  summarize(n_per_group = n(),
            bmi_mean =mean(bmi,na.rm=TRUE),
            bmi_sd = sd(bmi,na.rm=TRUE))
```

```
# A tibble: 5 x 4
  grade n_per_group bmi_mean bmi_sd
  <chr>       <int>    <dbl>  <dbl>
```

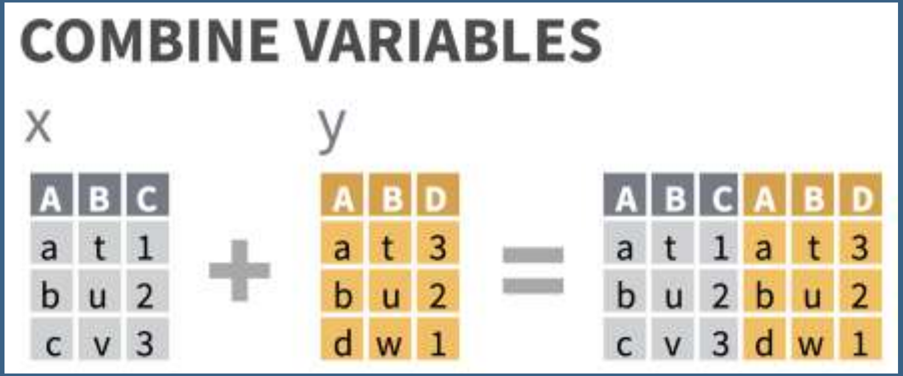
1 <NA>	406	23.5	6.45
2 10th	4907	23.2	4.76
3 11th	4891	23.8	4.89
4 12th	4577	24.2	5.20
5 9th	5219	22.8	4.92

Combining data sets



A	B	C
a	t	1
b	u	2
c	v	3

A	B	C
C	v	3
d	w	4



A	B	C
a	t	1
b	u	2
c	v	3

A	B	D
a	t	3
b	u	2
d	w	1

A	B	C	A	B	D
a	t	1	a	t	3
b	u	2	b	u	2
c	v	3	d	w	1

Rows (cases): paste data below each other

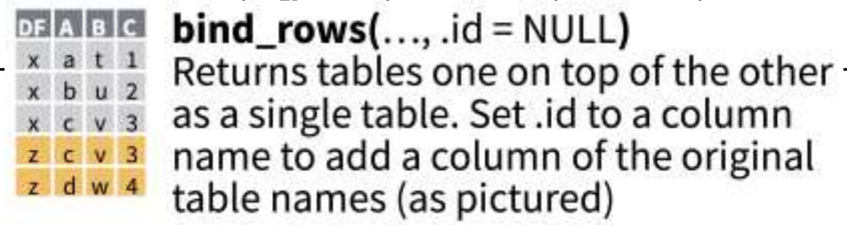
`bind_rows()` combines rows from different data sets
& accounts for different column names

```
data1
```

```
bind_rows(data1,data2, .id = "group")
```

#	A tibble: 2	x 4	
	id name	height	age
	<int> <chr>	<dbl>	<dbl>
1	1 Nina	2	4
2	2 Yi	1	2
2	8 Al	1.7	1
3	9 Juan	1.8	2

#	A tibble: 5	x 6			
	group id	name	height	age	years
	<chr> <int>	<chr>	<dbl>	<dbl>	<dbl>
1	1	Nina	2	4	NA
2					NA
3	2 7		2	NA	3



DF	A	B	C
x	a	t	1
x	b	u	2
x	c	v	3
z	c	v	3
z	d	w	4

bind_rows(…, .id = NULL)
Returns tables one on top of the other as a single table. Set .id to a column name to add a column of the original table names (as pictured)

[dplyr data transformation cheatsheet]

Columns (variables): *DO NOT USE `bind_cols()`!!*

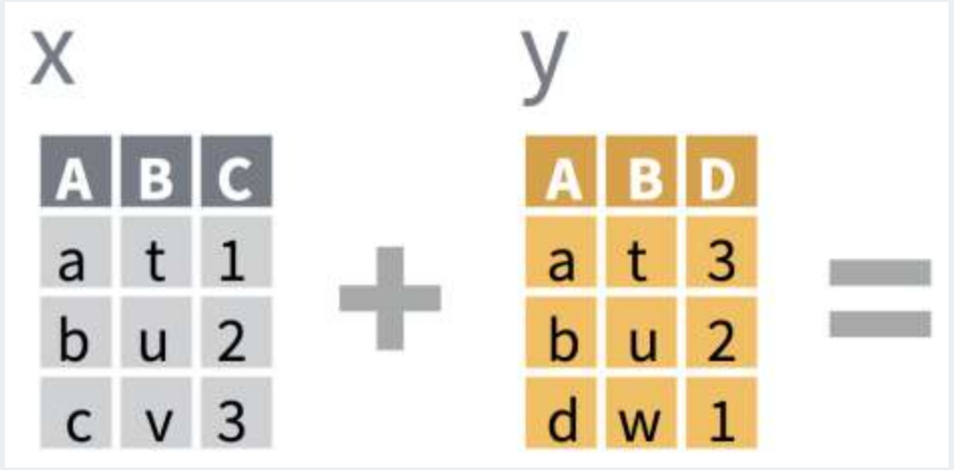
- `bind_cols()` blindly pastes columns next to each other without preserving order of variables that they have in common
  - Use `join` to preserve ordering - see next slides

```
# datasets must have same number of rows to use bind_cols()
demo_sub <- demo_data %>%                    # first 20 rows of demo_data
slice(1:20)                                  # first 20 rows of qn_data
qn_sub <- qn_data %>% slice(1:20)
bind_cols(demo_sub, qn_sub)                  # blindly bind columns; 2nd record column got
                                             renamed
```

```
>  <chr> 1 9.32e5
e… <NA>
718 Neve… <NA>
 <NA> 4 1.10e6 15
 14  y… Male   9th

 <NA> 7 9.27e5 16
```

`join`ing your data sets

- `Join` uses overlapping or selected columns to combine two or more data sets.
- Also called "merging" or "mutating join".
- Function names are based off of SQL operations for databases.

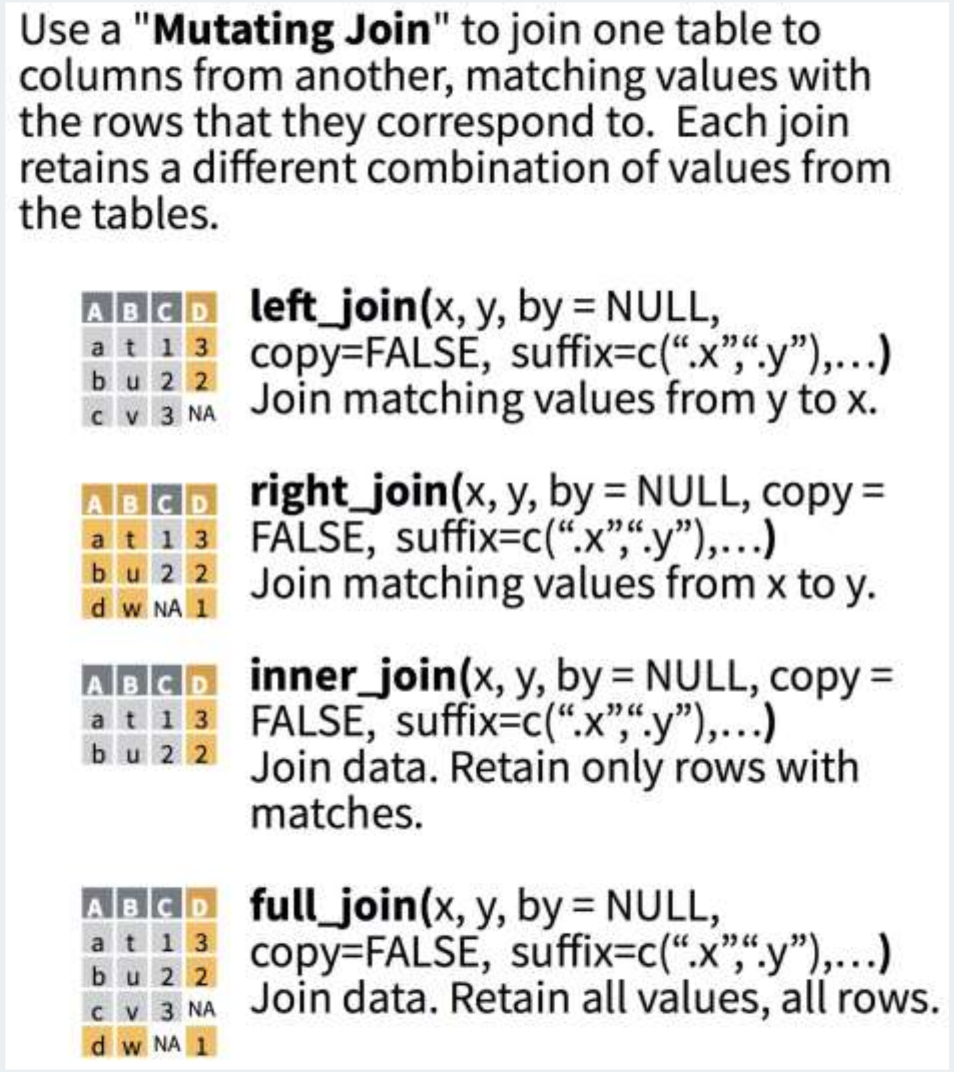


x

A	B	C
a	t	1
b	u	2
c	v	3

y

A	B	D
a	t	3
b	u	2
d	w	1



Use a "**Mutating Join**" to join one table to columns from another, matching values with the rows that they correspond to. Each join retains a different combination of values from the tables.

A	B	C	D
a	t	1	3
b	u	2	2
c	v	3	NA

left_join(x, y, by = NULL, copy=FALSE, suffix=c(".x",".y"),...**)** Join matching values from y to x.

A	B	C	D
a	t	1	3
b	u	2	2
d	w	NA	1

right_join(x, y, by = NULL, copy = FALSE, suffix=c(".x",".y"),...**)** Join matching values from x to y.

A	B	C	D
a	t	1	3
b	u	2	2

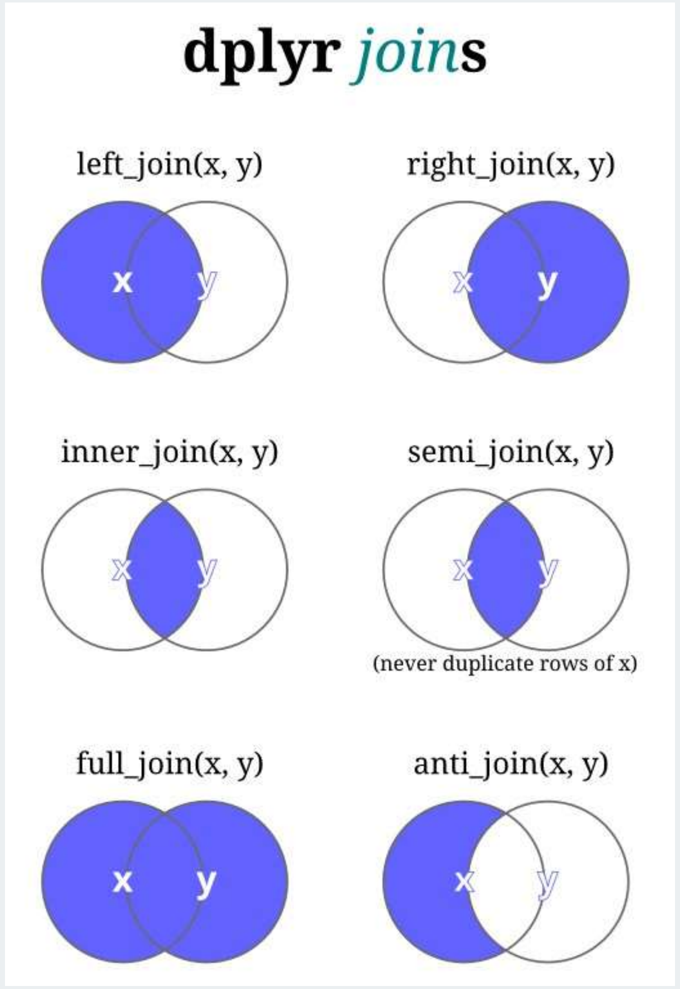
inner_join(x, y, by = NULL, copy = FALSE, suffix=c(".x",".y"),...**)** Join data. Retain only rows with matches.

A	B	C	D
a	t	1	3
b	u	2	2
c	v	3	NA
d	w	NA	1

full_join(x, y, by = NULL, copy=FALSE, suffix=c(".x",".y"),...**)** Join data. Retain all values, all rows.

dplyr data transformation cheatsheet

`join` options visually



Hiroaki Yutani

Most commonly used: `left_join()`

- `left_join(x,y)` includes all observations in `x`, regardless of whether they match ones in `y` or not.
- It includes all columns in `y`, but only rows that match `x`'s observations.

```
df1 <- tibble(a = c(1, 2), b = 2:1)  df2 <-
tibble(a = c(1, 3), c = 10:11) df1
df2
```

```
left_join(df1, df2)
```

```
# A tibble: 2 x 3
        a      b      c
  <dbl> <int> <int>
```

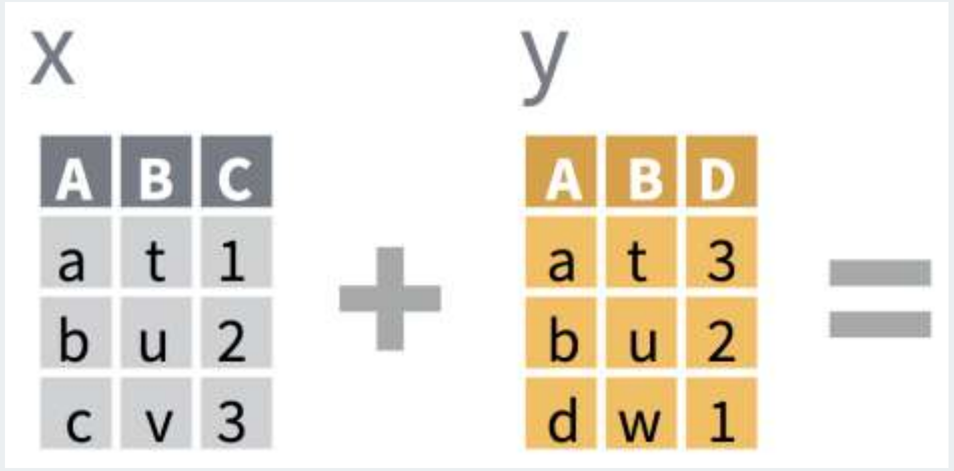
#	A	tibble: 2	x	2	1	1	2	10
		a b			2	2	1	NA

```
2      2      1
# A tibble: 2 x 2
              a      c
        <dbl> <int>
1      1     10
2      3     11
```

- Which common column(s) were used to merge the datasets?
- What if we want to specify which columns to join by when merging? see next slide…

Which columns will be used to join?

- If no columns are specified to join by, then *all* overlapping (intersecting) column names will be used
- Often we want to specify which columns to use,
  - and also how to rename duplicated columns that were not merged



x

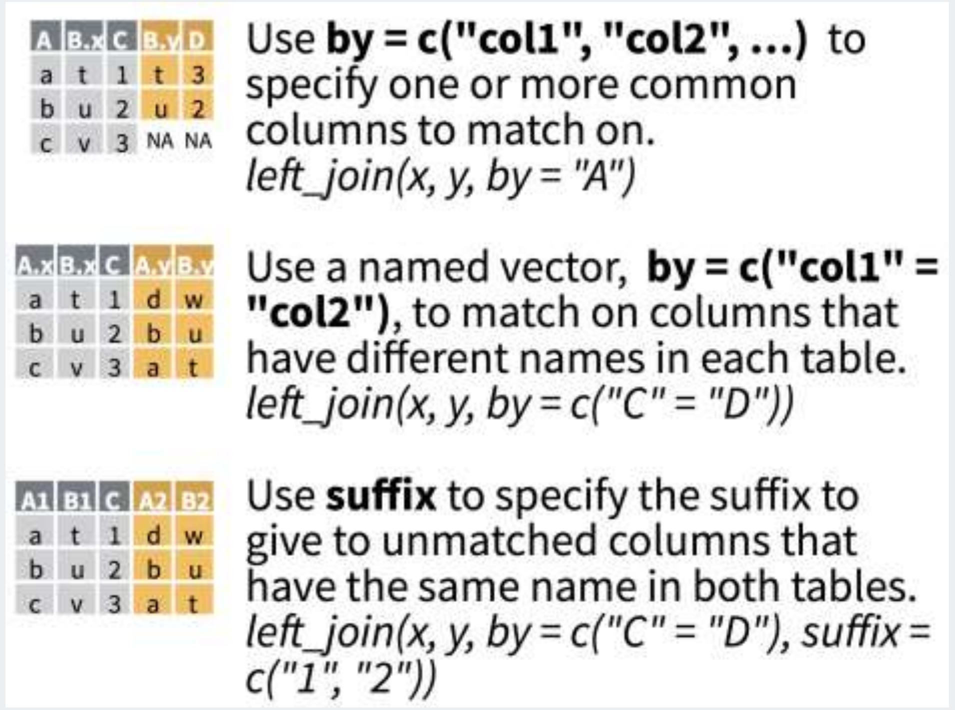
A	B	C
a	t	1
b	u	2
c	v	3

+

y

A	B	D
a	t	3
b	u	2
d	w	1

=



A	B.x	C	B.y	D
a	t	1	t	3
b	u	2	u	2
c	v	3	NA	NA

Use **by = c("col1", "col2", ...)** to specify one or more common columns to match on.
left_join(x, y, by = "A")

A.x	B.x	C	A.y	B.y
a	t	1	d	w
b	u	2	b	u
c	v	3	a	t

Use a named vector, **by = c("col1" = "col2")**, to match on columns that have different names in each table.
left_join(x, y, by = c("C" = "D"))

A1	B1	C	A2	B2
a	t	1	d	w
b	u	2	b	u
c	v	3	a	t

Use **suffix** to specify the suffix to give to unmatched columns that have the same name in both tables.
left_join(x, y, by = c("C" = "D"), suffix = c("1", "2"))

dplyr data transformation cheatsheet

Check for overlapping column names

Goal: merge the demographics (`demo_data`) and questionnaire (`qn_data`) together.
What column names do these datasets have in common?

```
colnames(demo_data)
```

```
[1] "record"   "age"                "grade"    "race4"    "race7"
               "sex"
[7] "bmi"      "stweight"
```

```
colnames(qn_data)
```

```
[1] "record" "q8"     "q12"   "q3          "qn24"
```

```
intersect(colnames(demo_data), colnames(qn_data))
```

```
[1] "record"
```

Merge `demo_data` and `qn_data` together

Let's do a full join so that we keep all data from both datasets

```
merged_data <-  full_join(demo_data,
  qn_data,
          by = "record")

# Check dimensions of original and new data
```

```
dim(demo_data); dim(qn_data); dim(merged_da
```

```
[1] 20000     8
```

```
[1] 10000     5
```

```
[1] 20000    12
```

```
merged_data
```

```
# A tibble: 20,000 x 12
   record age   sex   grade race4 race7   bmi stweight q8    q12   q31
    <dbl> <chr> <chr> <chr> <chr> <chr> <dbl>    <dbl> <ch   <ch   <chr>
                                                       r>    r>
1 9.32e5 15 y… Fema… 10th  White White  17.2     54.4 Nev   <NA   Yes
                                                       e…    >
2 3.34e5 17 y… Fema… 12th  White White  20.2     57.2 <NA   <NA   <NA>
                                                       >     >
```

Practice

1. Add a column of `1`'s to `qn_data` called `qn_yes` and save the resulting data as `qn_data2`.

2. Join `demo_data` and `qn_data2` by column `record`. Keep all rows from `demo_data` and only rows from `qn_data2` that match records in `demo_data`. Call the resulting data `all_data`.

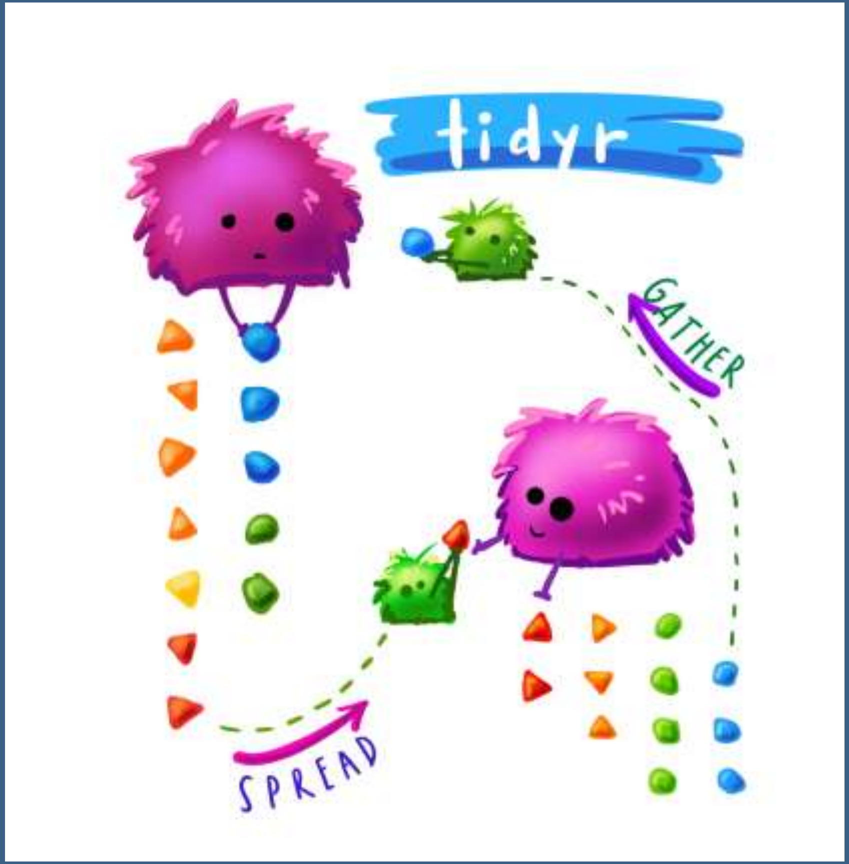
3. Create a `tabyl()` of `qn_yes` for the data `all_data`.

4. Create a 2x2 table of `qn_yes` vs `grade`. Note about the data:

- q8 =How often wear bicycle helmet
- q12=Texted while driving
- q31=Ever smoked
- qn24 =Bullied past 12 months

Reshaping data

wide vs. long



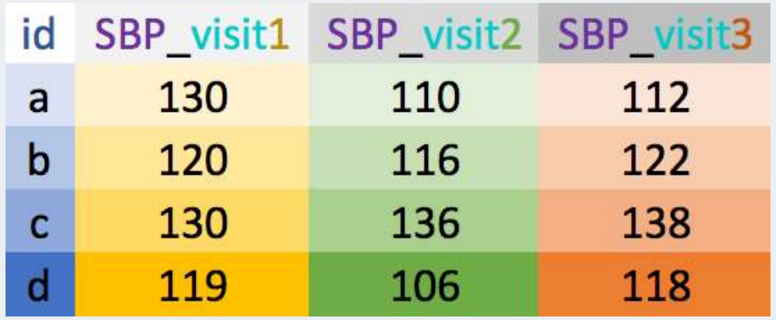
Allison Horst

tidyr

Wide vs. long data

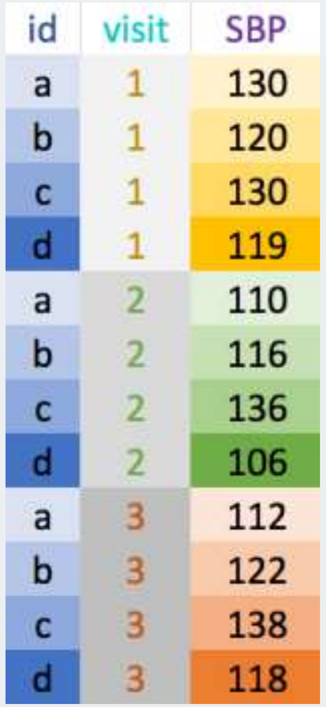
- **Wide** data has one row per subject, with multiple columns for their repeated measurements
- **Long** data has multiple rows per subject, with one column for the measurement variable and another indicating from when/where the repeated measures are from

wide



id	SBP_visit1	SBP_visit2	SBP_visit3
a	130	110	112
b	120	116	122
c	130	136	138
d	119	106	118

long



id	visit	SBP
a	1	130
b	1	120
c	1	130
d	1	119
a	2	110
b	2	116
c	2	136
d	2	106
a	3	112
b	3	122
c	3	138
d	3	118

Example wide dataset

Copy and paste the code below into R to create this example dataset

```r
BP_wide <- tibble(id = letters[1:4],
                     sex = c("F", "M", "M", "F"),  SBP_v1 = c(130, 120, 130, 119),
                     SBP_v2 = c(110, 116, 136, 106),
                     SBP_v3 = c(112, 122, 138, 118))
BP_wide
```

# A tibble: 4	x 5		
id sex	SBP_v1	SBP_v2	SBP_v3
<chr> <chr>	<dbl>	<dbl>	<dbl>
1 a F	130	110	112
2 b M	120	116	122
3 c M	130	136	138
4 d F	119	106	118

- What do you think the data in the table are measures of?
- How can we tell the data are wide?

Wide to long: `gather()`

```
BP_wide
```

```
# A tibble: 4 x 5
  id     sex    SBP_v1 SBP_v2 SBP_v3
    <chr> <chr> <dbl>    <dbl>
        <dbl>   1 a        F
        130              110
        112
    2 b M          120      116      122
    3 c M          130      136      138
    4 d F          119      106      118
```

`gather` columns into rows to make the data long. Need to **specify**:

- **new column names**
  - **key**: stores row names of wide data's gathered columns
  - **value**: stores data values
- **which columns to gather**

```
BP_long <- BP_wide %>%
  gather(key = "visit", value = "SBP",
         SBP_v1:SBP_v3)
BP_long
```

```
# A tibble: 12 x 4
   id    sex                SBP
   <chr>visit<chr> <chr>  <dbl>
 1 a         F     SBP_v1   130
 2 b         M     SBP_v1   120
  3 c        M      SBP_v1  130
  4 d        F      SBP_v1  119
  5 a        F      SBP_v2  110
  6 b        M      SBP_v2  116
 7  c        M      SBP_v2  136
 8  d        F      SBP_v2  106
  9 a        F      SBP_v3  112
 10 b        M      SBP_v3  122
 11 c        M      SBP_v3  138
```

Long to wide: `spread()`

```
BP_long
```

```
# A tibble: 12 x 4
   id    sex   visit    SBP
   <chr> <chr> <chr>  <dbl>
 1 a     F     SBP_v1   130
 2 b     M     SBP_v1   120
 3 c     M     SBP_v1   130
 4 d     F     SBP_v1   119
 5 a     F     SBP_v2   110
 6 b     M     SBP_v2   116
 7 c     M     SBP_v2   136
 8 d     F     SBP_v2   106
 9 a     F     SBP_v3   112
10 b     M     SBP_v3   122
11 c     M     SBP_v3   138
12 d     F     SBP_v3   118
```

`spread` rows into columns to make the data wide. Need to **specify** which columns in the long data to use:

- **key** column: has the variable names
- **value** column: has the data values

```
BP_wide2 <- BP_long %>%
  spread(key = "visit", value = "SBP")
BP_wide2
```

```
# A tibble: 4 x 5
  id    sex   SBP_v1 SBP_v2 SBP_v3
    <chr> <chr> <dbl>   <dbl>
      <dbl> 1 a       F
      130             110
      112
    2 b M       120     116     122
    3 c M       130     136     138
    4 d F       119     106     118
```

Clean up long data's visit column (key column)

```r
BP_long
```

```
# A tibble: 12 x 4
   id    sex   visit      SBP
                         <dbl>
 1 a     F     SBP_v1     130
 2 b     M     SBP_v1     120
 3 c     M     SBP_v1     130
 4 d     F     SBP_v1     119
 5 a     F     SBP_v2     110
 6 b     M     SBP_v2     116
 7 c     M     SBP_v2     136
 8 d     F     SBP_v2     106
 9 a     F     SBP_v3     112
10 b     M     SBP_v3     122
11 c     M     SBP_v3     138
```

```r
BP_long2 <- BP_long %>% mutate(visit =
          str_replace(visit,"SBP_v",""))
BP_long2
```

```
# A tibble: 12 x 4
   id    sex   visit   SBP
   <chr> <chr> <chr> <dbl>
 1 a     F     1       130
 2 b     M     1       120
 3 c     M     1       130
 4 d     F     1       119
 5 a     F     2       110
11 c     M     3       138
12 d     F     3       118
 8 d     F     2       106
```

Make cleaned-up long data wide

```
head(BP_long2, 2)
```

```
# A tibble: 2 x 4
  id     sex    visit    SBP
    <chr> <chr> <chr>
  <dbl> 1 a      F         1
        130
    2 b M      1         120
```

```
BP_wide3 <- BP_long2 %>%
  spread(key = "visit", value = "SBP")
BP_wide3
```

```
# A tibble: 4 x 5
  id     sex      `1`    `2`    `3`
    <chr> <chr> <dbl> <dbl>
  <dbl> 1 a      F         130
        110      112
    2 b M        120    116    122
4 d 3 c M        139    136    138
```

Problem: have numbers as column names, since `spread`'s default is to use the levels of the `key` as the new row names.

Solution: have row names start with the `key` column's name `sep`arated by a character

```
BP_wide4 <- BP_long2 %>%
  spread(key = "visit", value = "SBP",
         sep="_") # specify separating char
BP_wide4
```

```
# A tibble: 4 x 5
  id     sex    visit_1 visit_2 visit_3
    <chr> <chr> <dbl>    <dbl>    <dbl>
  1 a    F               130
         110             112
    2 b M          120      116      122
4 d 3 c M          139      136      138
```

Practice

Copy and paste the code below into R to create the dataset `DBP_wide`

```
DBP_wide <- tibble(id = letters[1:4],
                   sex = c("F", "M", "M", "F"), v1.DBP = c(88, 84, 102, 70),
                   v2.DBP = c(78, 78, 96, 76),
                   v3.DBP = c(94, 82, 94, 74),
                   age=c(23, 56, 41, 38)
                   )
```

1. Make `DBP_wide` into a long dataframe based on the repeated DBP columns and save it as `DBP_long`.
2. Clean up the visit column of `DBP_long` so that the values are 1, 2, 3, and save it as `DBP_long`.
3. Make `DBP_long` wide with column names `visit.1, visit.2, visit.3` for the DBP values, and save it as `DBP_wide2`.
4. Join `DBP_long` with `BP_long2` so that we have one data frame with columns id, sex, visit, SBP, DBP, and age. Save this as `BP_both_long`.

Data cleaning

(messy NAs, names, strings, dates, factors)

stringr glue forcats lubridate

Removing missing data: `drop_na()`

A small data example:

```
mydata <- tibble(id = 7:9,
                 name = c("Bo","Al","Juan")
                 height = c(2, NA, 1.8),
                 years = c(51,35,NA))
mydata
```

```
# A tibble: 3 x 4
     id name  height years
  <int> <chr>  <dbl> <dbl>
```

1	7	Bo	2	51
2	8	Al	NA	35
3	9	Juan	1.8	NA

Remove *all* rows with **any missing data**

```
mydata %>% drop_na()
```

```
# A tibble: 1 x 4
                     id name  height years
      <int> <chr>   <dbl> <dbl> 1     7 Bo
                                 2         51
```

Remove rows with `NA` in **selected columns**

```
mydata %>% drop_na(height)
```

```
# A tibble: 2 x 4
                      me   height years
                      hr>   <dbl> <dbl>
```

1	7	Bo	2	51
2	9	Juan	1.8	NA

Replace NAs with another value: replace_na()

Use with mutate()

```
mydata
```

```
# A tibble: 3 x 4
     id name  height years
  <int> <chr>  <dbl> <dbl>
1     7 Bo         2    51
2     8 Al        NA    35
3     9 Juan     1.8    NA
```

```
mydata %>%
  mutate(height = replace_na(height, "Unknown"),
            years = replace_na(years, 0) )
```

```
# A tibble:       x 4
3
        id name   height
2     8 Al        Unknown   35
3     9           1.8        0
        Juan
                  l>
1     7 Bo        2

                  51
```

replace_na() advanced example

Replaces NAs in all columns starting with "q" with the string "No answer"

```
qn_data %>%


  tabyl(q8, q31)
```

q8	No	No	answer	Yes
Always wore a helmet	411		58	216
Did not ride a bicycle	1318		343	1223
Most of the time wore a helmet	320		31	173
Never wore a helmet	1429		418	1672
No answer	267		212	300
Rarely wore a helmet	481		73	405
Sometimes wore a helmet	351		53	246

Convert (i.e. "No answer", 9999, etc) to `NA`: `na_if()`

```
all_data %>% tabyl(race4)
```

race4	n percent	valid_percent
All other races	4713 0.23565	0.2443235
Black or African American	4093 0.20465	0.2121825
[illegible]	[illegible]	[illegible]
[illegible]	0.29070	[illegible]
<NA>	710 0.03550	NA

```
all_data %>%

  tabyl(race4)
```

```
    race4    n percent valid_percent Black or African
                 American 4093 0.20465     0.2807848
          Hispanic/Latino 4670 0.23350     0.3203677
                    White 5814 0.29070     0.3988475
                     <NA> 5423 0.27115            NA
```

`na_if()` for all your data

Avoid this by reading in your data correctly:

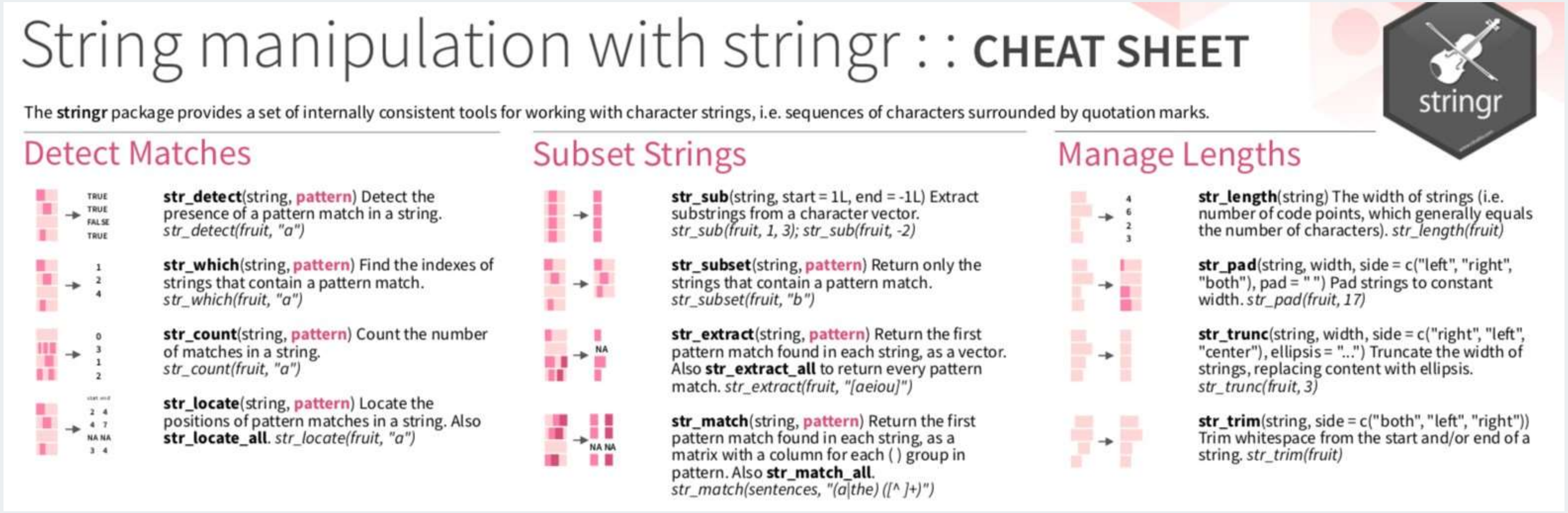
```
smalldata <- read_csv("data/small_data.csv",
                      na = c("","9999","NA")) # specify your own missing values
```

Otherwise `na_if()` everything:

```
# replace all "" with NA all_data %>%


# replace all 9999's with NA all_data %>%



  mutate_if(is.numeric, .funs = na_if(.,9999))
```

Working with character strings

- Use the package `stringr` (loaded with `tidyverse`)
- Paste strings or values together with package `glue` (installed, not loaded w/ `tidyverse`)
- *advanced tip*: learn "regular expressions" (regex) for pattern matching (see cheatsheet) and matching multiple characters/strings at once



String manipulation with stringr : : **CHEAT SHEET**

stringr

The **stringr** package provides a set of internally consistent tools for working with character strings, i.e. sequences of characters surrounded by quotation marks.

Detect Matches

str_detect(string, pattern) Detect the presence of a pattern match in a string. *str_detect(fruit, "a")*

str_which(string, pattern) Find the indexes of strings that contain a pattern match. *str_which(fruit, "a")*

str_count(string, pattern) Count the number of matches in a string. *str_count(fruit, "a")*

str_locate(string, pattern) Locate the positions of pattern matches in a string. Also **str_locate_all**. *str_locate(fruit, "a")*

Subset Strings

str_sub(string, start = 1L, end = -1L) Extract substrings from a character vector. *str_sub(fruit, 1, 3); str_sub(fruit, -2)*

str_subset(string, pattern) Return only the strings that contain a pattern match. *str_subset(fruit, "b")*

str_extract(string, pattern) Return the first pattern match found in each string, as a vector. Also **str_extract_all** to return every pattern match. *str_extract(fruit, "[aeiou]")*

str_match(string, pattern) Return the first pattern match found in each string, as a matrix with a column for each ( ) group in pattern. Also **str_match_all**. *str_match(sentences, "(a|the) ([^]+)")*

Manage Lengths

str_length(string) The width of strings (i.e. number of code points, which generally equals the number of characters). *str_length(fruit)*

str_pad(string, width, side = c("left", "right", "both"), pad = " ") Pad strings to constant width. *str_pad(fruit, 17)*

str_trunc(string, width, side = c("right", "left", "center"), ellipsis = "...") Truncate the width of strings, replacing content with ellipsis. *str_trunc(fruit, 3)*

str_trim(string, side = c("both", "left", "right")) Trim whitespace from the start and/or end of a string. *str_trim(fruit)*

stringr cheatsheet

`str_detect()` find strings

```
mydata <- tibble(name = c("J.M.","Ella","Jay"), state = c("New Mexico","New York","Oregon"))
```

Filter based on string detection

```
mydata %>% filter(str_detect(name,"J"))
```

```
# A tibble: 2 x 2 name  state
<chr> <chr>
1 J.M.  New Mexico
2 Jay   Oregon
```

Creates a column of TRUE/FALSE if detected

```
mydata %>% mutate(
  new_state = str_detect(state,"New"))
```

```
# A tibble: 3 x 3
  name  state      new_state
  <chr> <chr>      <lgl>
1 J.M.  New Mexico TRUE
2 Ella  New York   TRUE
3 Jay   Oregon     FALSE
```

str_replace_all(), str_replace()

```
mydata %>% mutate(state_old = str_replace_all(state, "New", "Old"))
```

```
# A tibble: 3 x 3
  name  state      state_old
  <chr> <chr>      <chr>
1 J.M.  New Mexico Old Mexico
2 Ella  New York   Old York
3 Jay   Oregon     Oregon
```

```
mydata %>% mutate(
```

name2 = str_replace(name, "l", "-"),		#	first instance		
name3 = str_replace_all(name, "l", "-"),		#	all instances		
name4 = str_replace_all(name, fixed("."),	""))	#	special characters	wi th	fixed ()

```
# A tibble: 3 x 5
  name  state      name2 name3 name4
  <chr> <chr>      <chr> <chr> <chr>
1 J.M.  New Mexico J.M.  J.M.  JM
2 Ella  New York   E-la  E--a  Ella
3 Jay   Oregon     Jay   Jay   Jay
```

`str_sub()`: shorten strings

Based on position `1` (`start = 1`) to length of string (`end = -1`)

```
mydata %>% mutate(
  short_name  = str_sub(name, start = 1, end = 2), # specify start to end
  short_name2 = str_sub(name, end = 2),            # specify only end
  short_state = str_sub(state, end = -3)           # negative endices, from end
)
```

```
# A tibble: 3 x 5
  name  state      short_name short_name2 short_state
  <chr> <chr>      <chr>      <chr>       <chr>
1 J.M.  New Mexico J.         J.          New Mexi
2 Ella  New York   El         El          New Yo
3 Jay   Oregon     Ja         Ja          Oreg
```

Paste strings together with `glue()`

- `paste()` is the base R way of pasting strings (surprise, it's hard to use)
- `glue()` is most useful when pasting data columns together
- **column *names* or function *operations* go inside `{}`**
- See the glue vignette

```
all_data %>%

  select(record, info) %>% head(5)
```

```
# A tibble: 5 x 2 record info
 <dbl> <S3: glue>
1   931897 Student 931897 is 15 years old with BMI = 17.2
2   333862 Student 333862 is 17 years old with BMI = 20.2
3    36253 Student 36253 is 18 years old or older with BMI = NA
4 1095530 Student 1095530 is 15 years old with BMI = 28
5 1303997 Student 1303997 is 14 years old with BMI = 24.5
```

Using `glue` to summarize data

- Useful for tables (will cover this more in another session)
- Example, calculate the S.E. of the mean and create a column with "mean (SE)" of bmi:

```r
demo_data %>%  group_by(sex) %>%  summarize(n_sex = n(),
          bmi_mean = mean(bmi,na.rm=TRUE), bmi_sd = sd(bmi,na.rm=TRUE)) %>%
```

```r
  mutate(bmi_mean_se = glue("{round(bmi_mean,1)} ({signif(bmi_sd/sqrt(n_sex),2)})"))
```

```
# A tibble: 3 x 5
  sex    n_sex bmi_mean bmi_sd bmi_mean_se
  <chr>  <int>    <dbl>  <dbl> <S3: glue>
1 <NA>     231      NaN    NaN      NaN (NaN)
2 Female  9592     23.3      4.96 23.3
                               (0.051)
3 Male   10177     23.7      5.01 23.7
                               (0.05)
```

Wrangle dates with `lubridate`

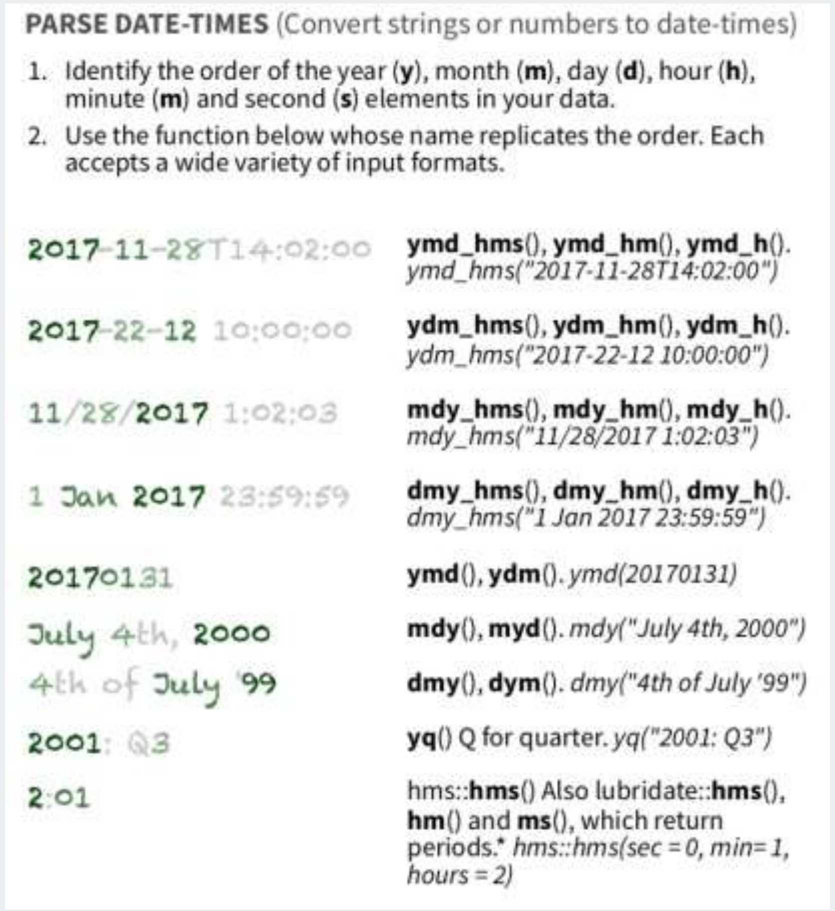
- Convert characters to special "Date" type
- Convert *terrible excel date formats* into workable data
- Easy date magic examples: add and
  - subtract dates

  convert to minutes/years/etc change
  - timezones

  add 1 month to a date...
- `lubridate` cheat sheet
- `read_csv` and `read_excel` etc automatically import dates correctly

Allison Horst

What kind of date do you have?



PARSE DATE-TIMES (Convert strings or numbers to date-times)

1. Identify the order of the year (**y**), month (**m**), day (**d**), hour (**h**), minute (**m**) and second (**s**) elements in your data.
2. Use the function below whose name replicates the order. Each accepts a wide variety of input formats.

2017-11-28T14:02:00	**ymd_hms**(), **ymd_hm**(), **ymd_h**(). *ymd_hms("2017-11-28T14:02:00")*
2017-22-12 10:00:00	**ydm_hms**(), **ydm_hm**(), **ydm_h**(). *ydm_hms("2017-22-12 10:00:00")*
11/28/2017 1:02:03	**mdy_hms**(), **mdy_hm**(), **mdy_h**(). *mdy_hms("11/28/2017 1:02:03")*
1 Jan 2017 23:59:59	**dmy_hms**(), **dmy_hm**(), **dmy_h**(). *dmy_hms("1 Jan 2017 23:59:59")*
20170131	**ymd**(), **ydm**(). *ymd(20170131)*
July 4th, 2000	**mdy**(), **myd**(). *mdy("July 4th, 2000")*
4th of July '99	**dmy**(), **dym**(). *dmy("4th of July '99")*
2001: Q3	**yq**() Q for quarter. *yq("2001: Q3")*
2:01	hms::**hms**() Also lubridate::**hms**(), **hm**() and **ms**(), which return periods.* *hms::hms(sec = 0, min= 1, hours = 2)*

`lubridate` cheat sheet

```
timedata <-
 tibble(name = c("Yi","Bo","DJ"),
        dob=c("10/31/1952","1/12/1984","2/02/2002"))
timedata %>%
mutate(dob_date = mdy(dob),
   dob_wrong = dmy(dob)) # wrong order
```

# A tibble: 3 x 4 name dob	dob_date	dob_wrong
<chr> <chr>	<date>	<date>
1 Yi 10/31/1952	1952-10-31	NA
2 Bo 1/12/1984	1984-01-12	1984-12-01
3 DJ 2/02/2002	2002-02-02	2002-02-02

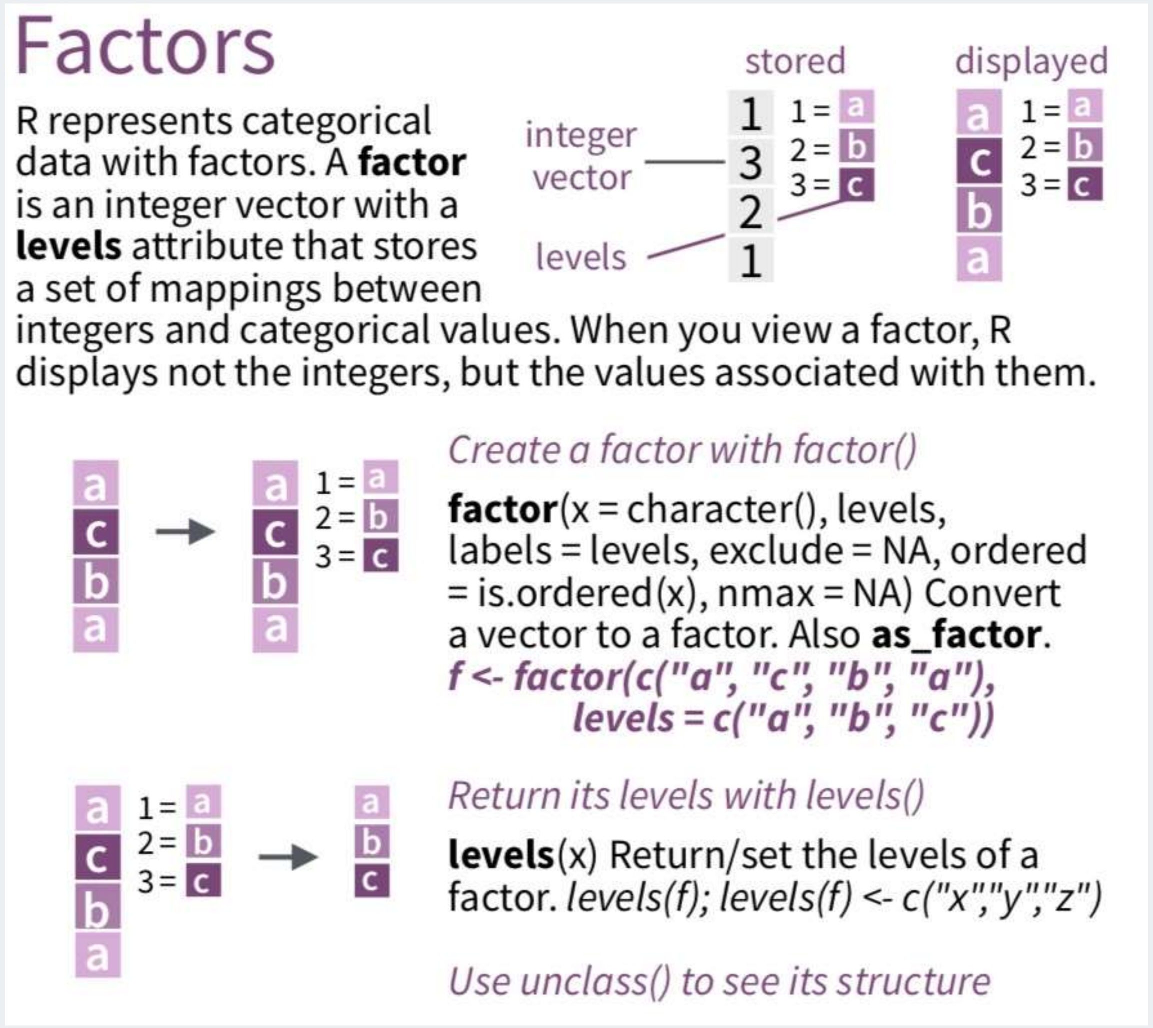
Math with dates

```
timedata %>% mutate(
  dob = mdy(dob),                        # convert to a date
  dob_year = year(dob),                  # extract the year
  time_since_birth = dob %--% today(),   # create an "interval"
  age = time_since_birth %/% years(1),   # modulus on "years"
  dobplus = dob + days(10)               # add 10 days
)
```

```
# A tibble: 3 x 6
  name  dob        dob_year time_since_birth                 age dobplus
  <chr> <date>        <dbl> <S4: Interval>                 <dbl> <date>
1 Yi    1952-10-31     1952 1952-10-31 UTC--2019-05-23 UTC    66 1952-11-10
2 Bo    1984-01-12     1984 1984-01-12 UTC--2019-05-23 UTC    35 1984-01-22
3 DJ    2002-02-02     2002 2002-02-02 UTC--2019-05-23 UTC    17 2002-02-12
```

Factors - categorical data

- Clean and order factors with `forcats` package
- Will go over this for `ggplot2` (visualization), statistical modeling (i.e. for `lm()`), and probably a workshop for creating tables
- See [`forcats` cheatsheet](#) and `forcats` vignette



Factors

R represents categorical data with factors. A **factor** is an integer vector with a **levels** attribute that stores a set of mappings between integers and categorical values. When you view a factor, R displays not the integers, but the values associated with them.

stored
displayed
integer vector
levels
1 = a
2 = b
3 = c

Create a factor with factor()

factor(x = character(), levels, labels = levels, exclude = NA, ordered = is.ordered(x), nmax = NA) Convert a vector to a factor. Also **as_factor**.

f <- factor(c("a", "c", "b", "a"), levels = c("a", "b", "c"))

Return its levels with levels()

levels(x) Return/set the levels of a factor. *levels(f); levels(f) <- c("x","y","z")*

Use unclass() to see its structure

forcats examples - specify levels fct_relevel()

```r
mydata <- tibble( id = 1:4,
grade=c("9th","10th","11th","9th")) %>%

levels(mydata$grade_fac)
```

```
 [1] "10th" "11th" "9th"
```

```r
mydata %>% arrange(grade_fac)
```

```
# A tibble: 4 x 3
     id grade grade_fac
  <int> <chr> <fct>
1     2 10th  10th
2     3 11th  11th
3     1 9th   9th
4     4 9th   9th
```

```r
mydata <- mydata %>% mutate(

levels(mydata$grade_fac)
```

```
 [1] "9th"  "10th" "11th"
```

```r
mydata %>% arrange(grade_fac)
```

```
# A tibble: 4 x 3
     id grade grade_fac
  <int> <chr> <fct>
1     1 9th   9th
2     4 9th   9th
3     2 10th  10th
4     3 11th  11th
```

forcats examples - collapse levels

```
mydata <- tibble(loc = c("SW","NW","NW","NE","SE","SE"))

mydata %>% mutate(  loc_fac = factor(loc),

  loc2 = fct_collapse(loc_fac,                         # collapse levels
                      south = c("SW","SE"),
loc3 = fct_lump(loc_fac, n=2, other_level = "other") # most common 2 levels + other
                      north = c("NE","NW")),
)
```

```
# A tibble: 6 x 4
  loc   loc_fac loc2  loc3
  <chr> <fct>   <fct> <fct>
1 SW    SW      south other
2 NW    NW      north NW
3 NW    NW      north NW
4 NE    NE      north other
5 SE    SE      south SE
6 SE    SE      south SE
```

Other "janitor" work

Clean messy column names with `clean_names()`

```
mydata <- tibble("First Name"= c("Yi","DJ"), "last init" = c("C","R"),
                 "% in" = c(0.1, 0.5), "ñ$$$"= 1:2, " "=3:2,"     hi"=c("a","b"),
                 "null"=c(NA,NA))
mydata
```

```
# A tibble: 2 x 7
  `First Name` `last init` `% in` `ñ$$$`    ` ` `     hi` null
```

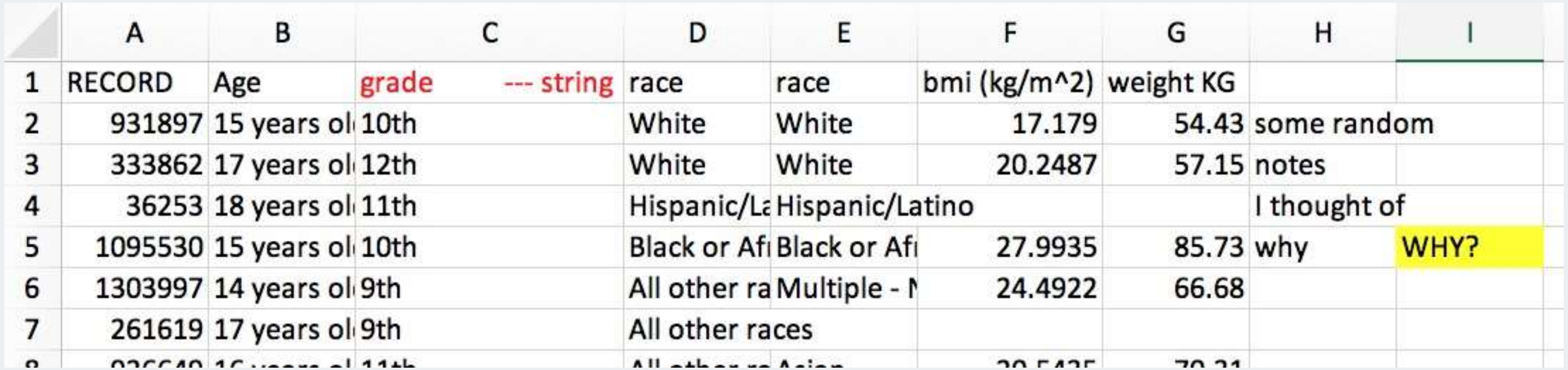
<chr>	<chr>	<dbl>	<int>	<int> <chr>	<lgl>
1 Yi	C	0.1	1	3 a	NA
2 DJ	R	0.5	2	2 b	NA

```
  remove_empty(c("rows","cols"))     # also useful
```

```
# A tibble: 2 x 6
  first_name last_init percent_in     n     x hi
```

<chr>	<chr>	<dbl>	<int>	<int> <chr>
1 Yi	C	0.1	1	3 a
2 DJ	R	0.5	2	2 b

Clean names of your excel sheet



	A	B	C	D	E	F	G	H	I
1	RECORD	Age	grade --- string	race	race	bmi (kg/m^2)	weight KG		
2	931897	15 years ol	10th	White	White	17.179	54.43	some random	
3	333862	17 years ol	12th	White	White	20.2487	57.15	notes	
4	36253	18 years ol	11th	Hispanic/La	Hispanic/Latino			I thought of	
5	1095530	15 years ol	10th	Black or Afi	Black or Afi	27.9935	85.73	why	WHY?
6	1303997	14 years ol	9th	All other ra	Multiple - N	24.4922	66.68		
7	261619	17 years ol	9th	All other races					

```r
library(readxl)
read_excel("data/messy_names.xlsx", .name_repair = janitor::make_clean_names)
```

```
# A tibble: 20,000 x 9
   record age   grade_string race   race_2 bmi_kg_m_2 weight_kg x     x_2
    <dbl> <chr> <chr>        <chr>  <chr>       <dbl>     <dbl> <chr> <chr>
1  931897 15 y… 10th         White  White        17.2      54.4 some… <NA>
2  333862 17 y… 12th         White  White        20.2      57.2 notes <NA>
```

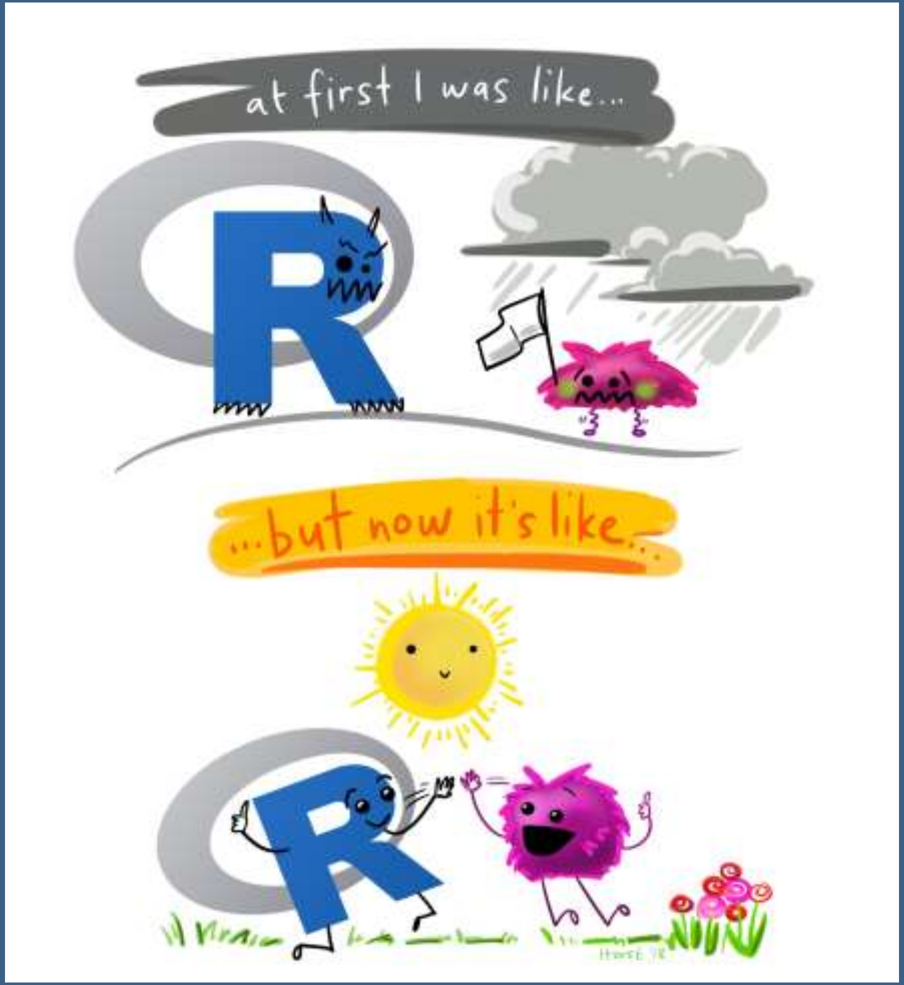
Practice

Copy and paste the code below into R to create the dataset `messy_data`

```r
messy_data <- tibble(NAME = c("J N","A C","D E"),
                     `months follow up` = c("", 10, 11),
                     `Date of visit` = c("July 31, 2003", "Nov 12, 2005", "Aug 3, 2007"))
```

1. Clean column names with `clean_names()`.
2. Replace missing ("") data in `months_follow_up` with NA.
3. Convert `months_follow_up` to a numeric variable.
4. Convert `date_of_visit` to a date.
5. Create a column called `date_last_visit` that is the date of visit *plus* months of follow up.
6. Remove rows (cases) with missing data in `months_follow_up`.
7. Remove the spaces in `name`.

This was a *lot*, but learning R gets easier!



Allison Horst

Resources - `tidyverse` & data wrangling

Links

- Learn the tidyverse
- Data wrangling cheatsheet

Some of this is drawn from materials in online books/lessons:

- R for Data Science - by Garrett Grolemund & Hadley Wickham
- Modern Dive - An Introduction to Statistical and Data Sciences via R by Chester Ismay & Albert Kim
- A gRadual intRoduction to the tidyverse - Workshop for Cascadia R 2017 by Chester Ismay and Ted Laderas
- "Tidy Data" by Hadley Wickham

Possible future workshop topics:

- reproducible reports in R (probably next) R Markdown and knitr
  - Create dynamic Word, html, pdf documents with code + output tables
- ggplot2 visualization
- advanced tidyverse: functions, purrr
- statistical modeling in R
- **Fill out feedback forms to suggest more or help us prioritize!**

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This workshop info:

- Code for these slides on github: jminnier/berd_r_courses
- all the R code in an R script
- answers to practice problems can be found here: html