Reproducible science: Module 3

Dealing with data: Tidyverse

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Acknowledgements

The content of this module are based on materials from:

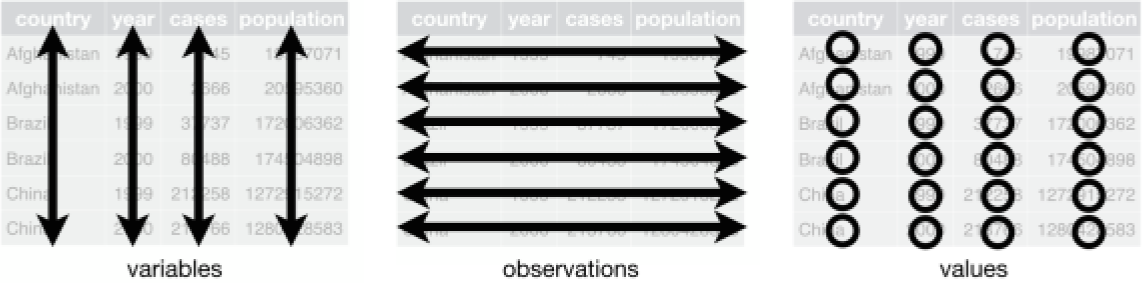
olivier gimenez's materials

What is tidyverse and advantages?

"A framework for managing data that aims at making the cleaning and preparing steps [muuuuuuuch] easier" (Julien Barnier). Main characteristics of a tidy dataset:

- the dataset is tibble;
- measured varaiable as a column;
- an observation represents a row with each value is in a different cell.

tidyverse consits of a compilation of r packages for data analysis.



Recognizing a tidy dataset

```
#> # A tibble: 12 x 4
#>   country      year type            count
#>   <chr>       <int> <chr>           <int>
#> 1 Afghanistan  1999 cases             745
#> 2 Afghanistan  1999 population   19987071
#> 3 Afghanistan  2000 cases            2666
#> 4 Afghanistan  2000 population   20595360
#> 5 Brazil       1999 cases           37737
#> 6 Brazil       1999 population 172006362
#> # … with 6 more rows
```

Is this a tidy data?

No

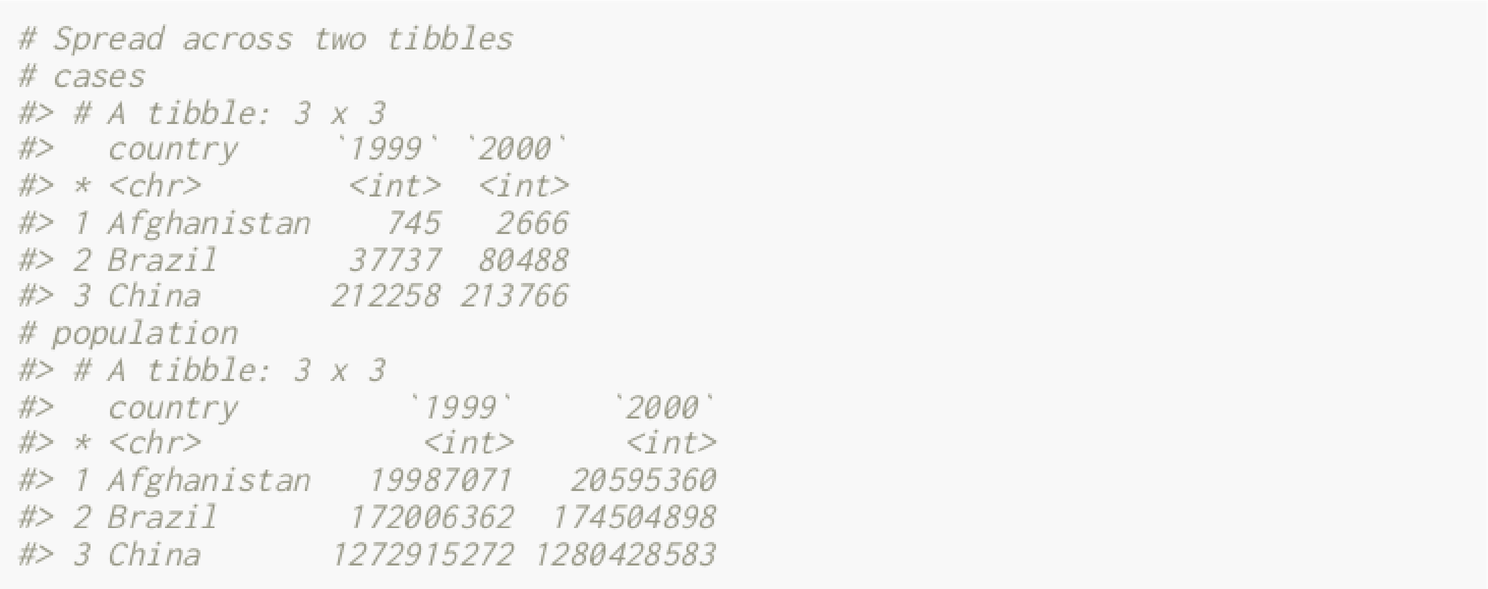
Recognizing a tidy dataset

```
#> # A tibble: 6 x 3
#>   country      year rate
#> * <chr>       <int> <chr>
#> 1 Afghanistan  1999 745/19987071
#> 2 Afghanistan  2000 2666/20595360
#> 3 Brazil       1999 37737/172006362
#> 4 Brazil       2000 80488/174504898
#> 5 China        1999 212258/1272915272
#> 6 China        2000 213766/1280428583
```

Is this a tidy data?

No

Recognizing a tidy dataset

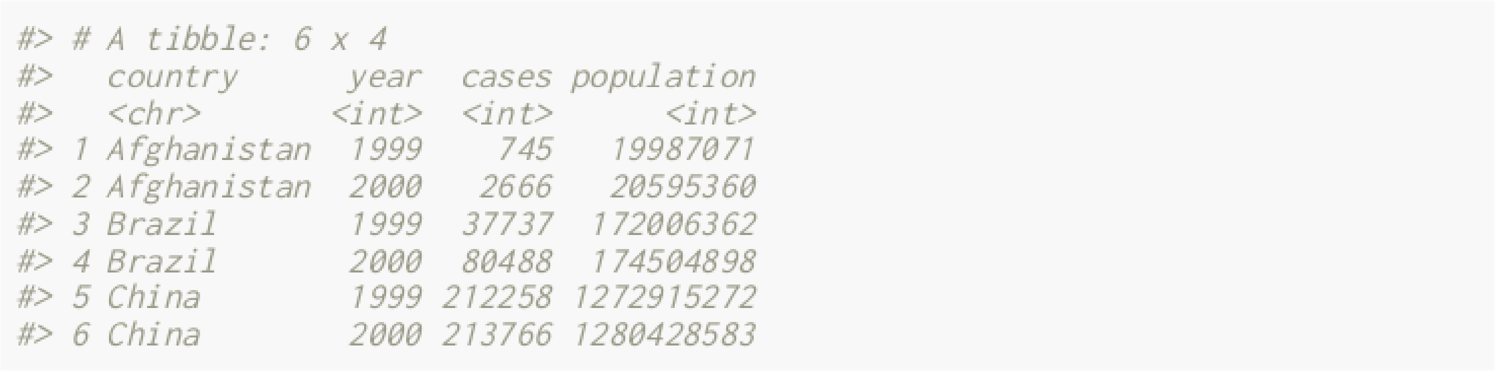


```
# Spread across two tibbles
# cases
#> # A tibble: 3 x 3
#>   country     `1999` `2000`
#> * <chr>        <int>  <int>
#> 1 Afghanistan    745   2666
#> 2 Brazil       37737  80488
#> 3 China       212258 213766
# population
#> # A tibble: 3 x 3
#>   country         `1999`     `2000`
#> * <chr>            <int>      <int>
#> 1 Afghanistan   19987071   20595360
#> 2 Brazil       172006362  174504898
#> 3 China       1272915272 1280428583
```

Is this a tidy data?

No

Recognizing a tidy dataset



```
#> # A tibble: 6 x 4
#>   country      year  cases population
#>   <chr>       <int>  <int>      <int>
#> 1 Afghanistan  1999    745   19987071
#> 2 Afghanistan  2000   2666   20595360
#> 3 Brazil       1999  37737  172006362
#> 4 Brazil       2000  80488  174504898
#> 5 China        1999 212258 1272915272
#> 6 China        2000 213766 1280428583
```

Is this a tidy data?

Yes

Tidyverse: Multiple r packages well compiled

Allows using a consistent format for which powerful tools work.

Makes data manipulation pretty natural

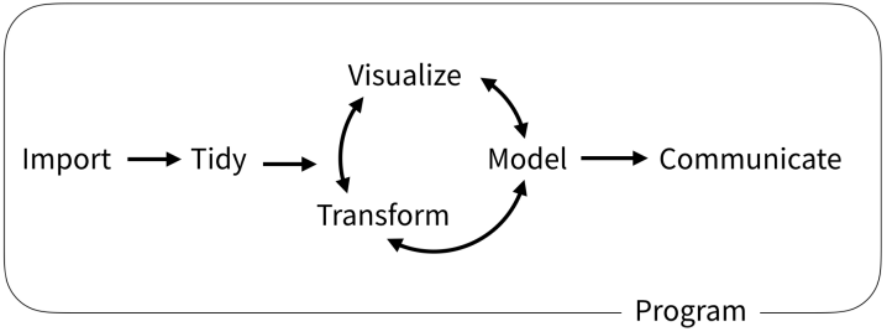
- ggplot2 - visualizing stuff;
- dplyr, tidyr - data manipulation;
- purrr - advanced programming;
- readr - import data;
- tibble - improved data.frame format;
- forcats - working with factors;
- stringr - working with chain of characters.

Simplified flowchart of data science?

Any data analysis follows this typical flow:

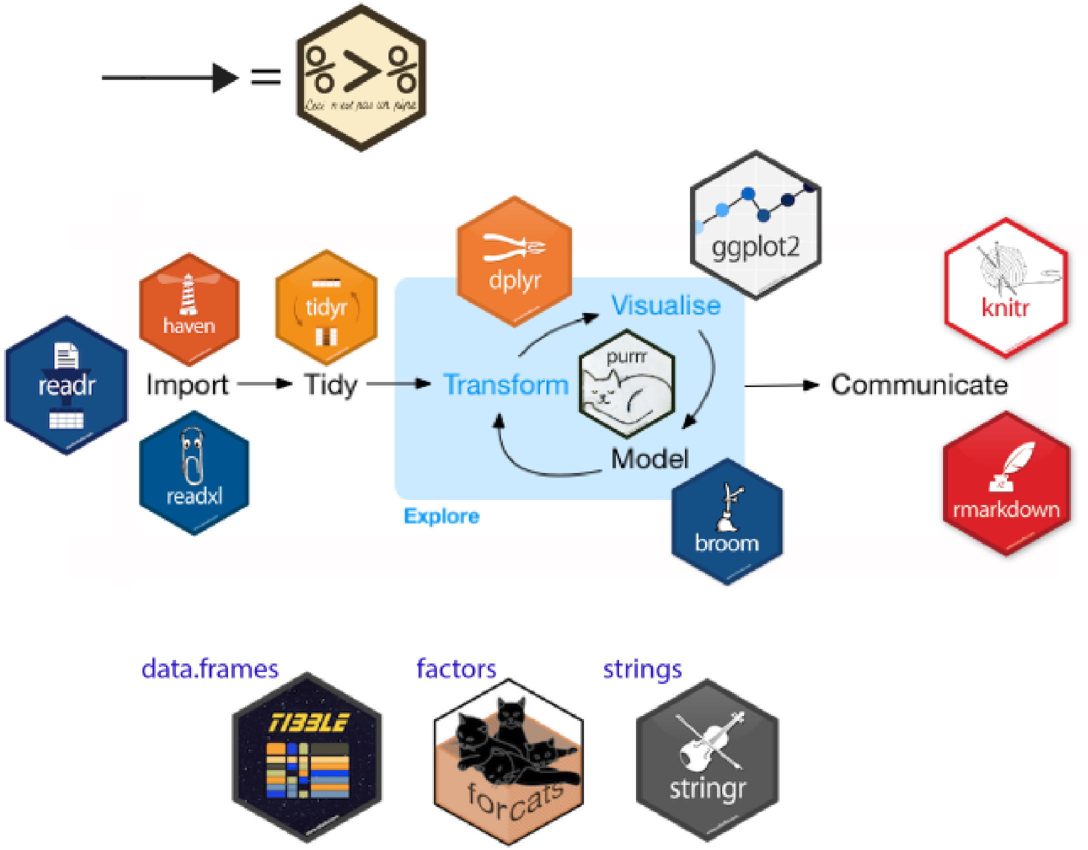
1. Import data;
2. Clean data;
3. Exploratory analysis. A cycle between:
    - Visualization;
    - modeling;
    - Transformation
4. Communicate

If these steps happen at multiple software then errors are highly inevitable.

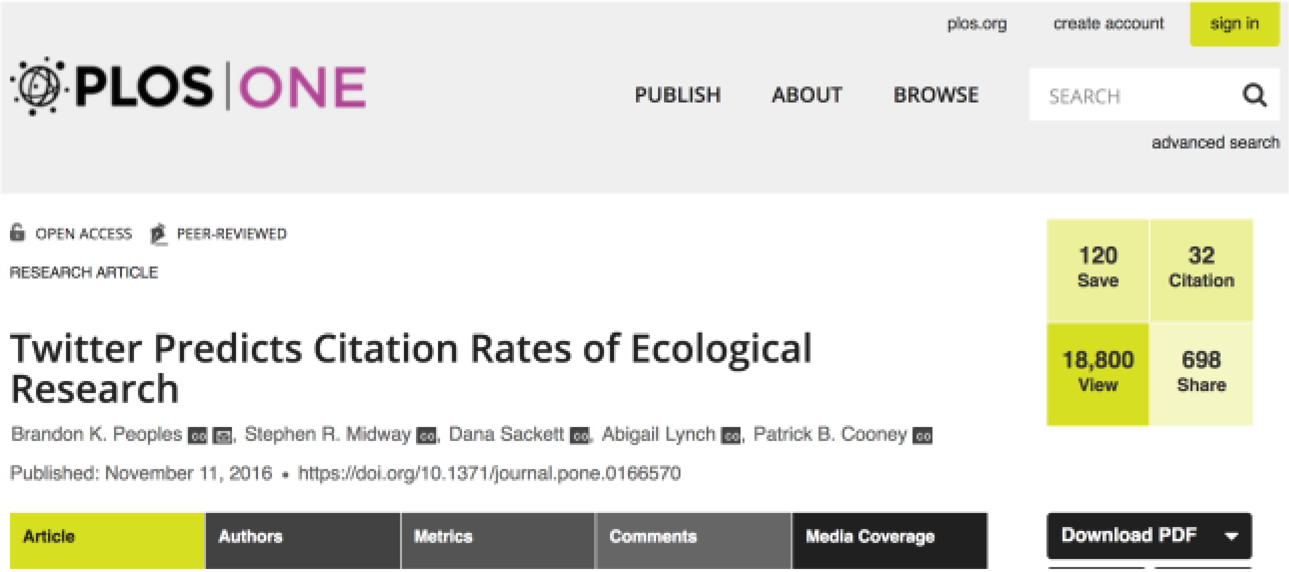


Reproducibilit equals effecient use of time

Tidyverse saves: same flowchart in tidyverse



Practice in tidyverse “Use twitter to predict citation rate”



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RESEARCH ARTICLE

Twitter Predicts Citation Rates of Ecological Research

Brandon K. Peoples, Stephen R. Midway, Dana Sackett, Abigail Lynch, Patrick B. Cooney

Published: November 11, 2016 • https://doi.org/10.1371/journal.pone.0166570

120 Save	32 Citation
18,800 View	698 Share

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We will use an existing data supporting the above publication to learn some functions within **tidyverse**.

Import data

readr::read_csv function:

- creates tibbles instead of data.frame;
- no names to rows;
- allows column names with special characters (see next slide);
- more clever on screen display than w/ data.frames (see next slide);
- no partial matching on column names;
- warning if attempt to access unexisting column;
- is incredibly fast.

Import data

```r
# Set the url from where to download the data
url<-"https://doi.org/10.1371/journal.pone.0166570.s001"
# name the file to be downloaded and save as destfile object
destfile <- "twitter_cit_data.csv"
# Apply download.file function in R to download from url
download.file(url, destfile)
library(tidyverse)
```

```
## Warning: package 'ggplot2' was built under R version 4.1.1

## Warning: package 'readr' was built under R version 4.1.1
```

```r
# Read the data file with read_csv() and save with name "citations_ra
citations_raw<-read_csv(file="twitter_cit_data.csv")
head(citations_raw)
```

Import data

```
citations_raw
```

```
## # A tibble: 1,599 x 12
##    `Journal identity` `5-year journal im~ `Year published` Volume Issue Au
##    <chr>                            <dbl>            <dbl>  <dbl> <chr> <c
##  1 Ecology Letters                   16.7             2014     17 12    Mo
##  2 Ecology Letters                   16.7             2014     17 12    Ju
##  3 Ecology Letters                   16.7             2014     17 12    Ca
##  4 Ecology Letters                   16.7             2014     17 11    Se
##  5 Ecology Letters                   16.7             2014     17 11    Ka
##  6 Ecology Letters                   16.7             2014     17 10    Na
##  7 Ecology Letters                   16.7             2014     17 10    Ts
##  8 Ecology Letters                   16.7             2014     17 9     Ba
##  9 Ecology Letters                   16.7             2014     17 9     Pi
## 10 Ecology Letters                   16.7             2014     17 9     Cl
## # ... with 1,589 more rows, and 6 more variables: Collection date <chr>,
## #   Publication date <chr>, Number of tweets <dbl>, Number of users <dbl>,
## #   Twitter reach <dbl>, Number of Web of Science citations <dbl>
```

Tidy/transform: Rename columns

To rename columns, use function *rename()* new_name=old_name

```r
citations_temp <- rename(citations_raw,
       journal = 'Journal identity',
       impactfactor = '5-year journal impact factor',
       pubyear = 'Year published',
       colldate = 'Collection date',
       pubdate = 'Publication date',
       nbtweets = 'Number of tweets',
       woscitations = 'Number of Web of Science citations')
head(citations_temp,5,6)
```

```
## # A tibble: 5 x 12
##   journal   impactfactor pubyear Volume Issue Authors  colldate pubdate nb
##   <chr>            <dbl>   <dbl>  <dbl> <chr> <chr>    <chr>    <chr>
## 1 Ecology ~         16.7    2014     17 12    Morin e~ 2/1/2016 9/16/2~
## 2 Ecology ~         16.7    2014     17 12    Jucker ~ 2/1/2016 10/13/~
## 3 Ecology ~         16.7    2014     17 12    Calcagn~ 2/1/2016 10/21/~
## 4 Ecology ~         16.7    2014     17 11    Segre e~ 2/1/2016 8/28/2~
## 5 Ecology ~         16.7    2014     17 11    Kaufman~ 2/1/2016 8/28/2~
## # ... with 3 more variables: Number of users <dbl>, Twitter reach <dbl>,
## #   woscitations <dbl>
```

Tidy: Clean up column names

To clean columns, use function *clean_names()* from the package janitor from it will fill space in column names by "_".

```
janitor::clean_names(citations_raw)
```

```
## # A tibble: 1,599 x 12
##    journal_identity x5_year_journal_impa~ year_published volume issue auth
##    <chr>                            <dbl>          <dbl>  <dbl> <chr> <chr
##  1 Ecology Letters                   16.7           2014     17 12    Mori
##  2 Ecology Letters                   16.7           2014     17 12    Juck
##  3 Ecology Letters                   16.7           2014     17 12    Calc
##  4 Ecology Letters                   16.7           2014     17 11    Segr
##  5 Ecology Letters                   16.7           2014     17 11    Kauf
##  6 Ecology Letters                   16.7           2014     17 10    Nast
##  7 Ecology Letters                   16.7           2014     17 10    Tsch
##  8 Ecology Letters                   16.7           2014     17 9     Barr
##  9 Ecology Letters                   16.7           2014     17 9     Pint
## 10 Ecology Letters                   16.7           2014     17 9     Clou
## # ... with 1,589 more rows, and 6 more variables: collection_date <chr>,
## #   publication_date <chr>, number_of_tweets <dbl>, number_of_users <dbl>,
## #   twitter_reach <dbl>, number_of_web_of_science_citations <dbl>
```

Tidy: Create and modify columns

The well known function to create and modify columns is *mutate()*, This function takes first the tibble names, the new_name= what you want to do to old column.

```
citations <- mutate(citations_temp, journal = as.factor(journal))
#Pay attention that I store in "citations"
citations
```

```
## # A tibble: 1,599 x 12
##    journal  impactfactor pubyear Volume Issue Authors  colldate pubdate nb
##    <fct>           <dbl>   <dbl>  <dbl> <chr> <chr>    <chr>    <chr>
##  1 Ecology~         16.7    2014     17 12    Morin e~ 2/1/2016 9/16/2~
##  2 Ecology~         16.7    2014     17 12    Jucker ~ 2/1/2016 10/13/~
##  3 Ecology~         16.7    2014     17 12    Calcagn~ 2/1/2016 10/21/~
##  4 Ecology~         16.7    2014     17 11    Segre e~ 2/1/2016 8/28/2~
##  5 Ecology~         16.7    2014     17 11    Kaufman~ 2/1/2016 8/28/2~
##  6 Ecology~         16.7    2014     17 10    Nasto e~ 2/2/2016 7/28/2~
##  7 Ecology~         16.7    2014     17 10    Tschirr~ 2/2/2016 8/6/20~
##  8 Ecology~         16.7    2014     17 9     Barnech~ 2/2/2016 6/17/2~
##  9 Ecology~         16.7    2014     17 9     Pinto-S~ 2/2/2016 6/12/2~
## 10 Ecology~         16.7    2014     17 9     Clough ~ 2/2/2016 7/17/2~
## # ... with 1,589 more rows, and 3 more variables: Number of users <dbl>,
```

Tidy: Create and modify columns

Check now the levels of journal variable

```
levels(citations$journal)
```

```
##  [1] "Animal Conservation"                "Conservation Letters"
##  [3] "Diversity and Distributions"        "Ecological Applications"
##  [5] "Ecology"                            "Ecology Letters"
##  [7] "Evolution"                          "Evolutionary Applications"
##  [9] "Fish and Fisheries"                 "Functional Ecology"
## [11] "Global Change Biology"              "Global Ecology and Biogeography"
## [13] "Journal of Animal Ecology"          "Journal of Applied Ecology"
## [15] "Journal of Biogeography"            "Limnology and Oceanography"
## [17] "Mammal Review"                      "Methods in Ecology and Evolution"
## [19] "Molecular Ecology Resources"        "New Phytologist"
```

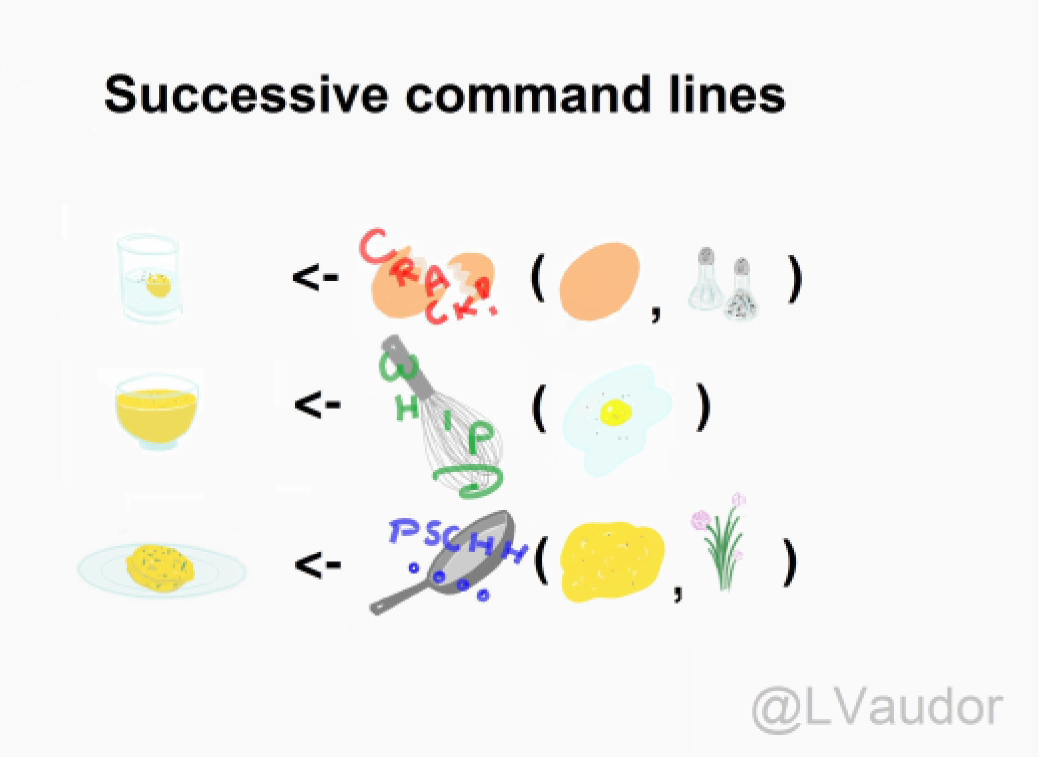
Piping: Make your manipulations easier

Piping was borrowed from other languages, got incorporated into R after a question in Pipe question in 2012. Pipe which is the bar "|" on your keyboard.

Omelette: Base r approach

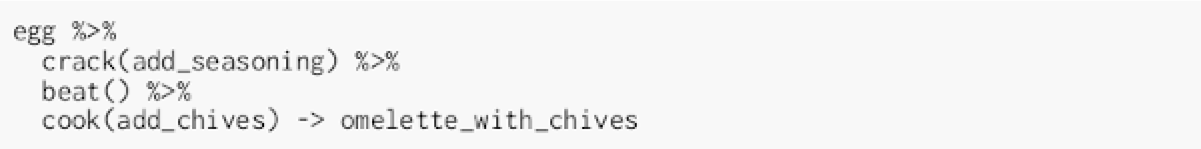
You need to do complicated programming: create multiple intermediate objects; embed, needs some understanding of coding and is prone to errors.

```
white_and_yolk <- crack(egg, add_seasoning)
omelette_batter <- beat(white_and_yolk)
omelette_with_chives <- cook(omelette_batter,add_chives)
```

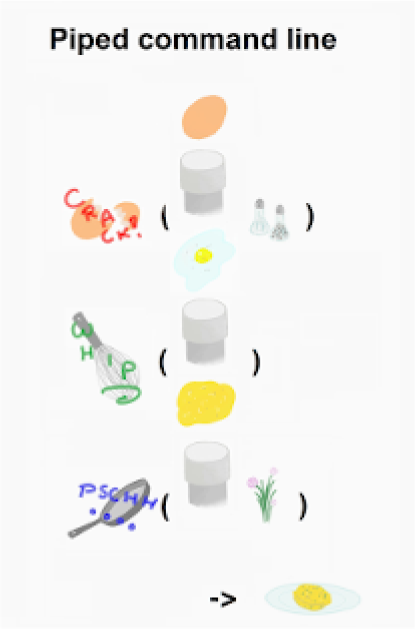


Omelette: Piping approach

Simpler programming using piping. Piping consists of: taking results from previous function as a starting point of a new function;less prone to errors and consume less memory.



```
egg %>%
  crack(add_seasoning) %>%
  beat() %>%
  cook(add_chives) -> omelette_with_chives
```



Example of piping

Take the tibble "citations_raw" **then** rename some columns then the new tibble containing the renamed tibble and *then* convert the column "journal" from current class ("character") to factor.

```r
citations_raw %>%
  rename(journal = 'Journal identity',
       impactfactor = '5-year journal impact factor',
       pubyear = 'Year published',
       colldate = 'Collection date',
       pubdate = 'Publication date',
       nbtweets = 'Number of tweets',
       woscitations = 'Number of Web of Science citations') %>%
  mutate(journal = as.factor(journal))
```

Please notice every time I say **"then"** this is equal to **"%>%"**.

Naming final object of pipe

```
citations <- citations_raw %>%
  rename(journal = 'Journal identity',
       impactfactor = '5-year journal impact factor',
       pubyear = 'Year published',
       colldate = 'Collection date',
       pubdate = 'Publication date',
       nbtweets = 'Number of tweets',
       woscitations = 'Number of Web of Science citations') %>%
  mutate(journal = as.factor(journal))
head(citations)
```

```
## # A tibble: 6 x 12
##   journal   impactfactor pubyear Volume Issue Authors   colldate pubdate nb
##   <fct>            <dbl>   <dbl>  <dbl> <chr> <chr>     <chr>    <chr>
## 1 Ecology ~         16.7    2014     17 12    Morin e~ 2/1/2016 9/16/2~
## 2 Ecology ~         16.7    2014     17 12    Jucker ~ 2/1/2016 10/13/~
## 3 Ecology ~         16.7    2014     17 12    Calcagn~ 2/1/2016 10/21/~
## 4 Ecology ~         16.7    2014     17 11    Segre e~ 2/1/2016 8/28/2~
## 5 Ecology ~         16.7    2014     17 11    Kaufman~ 2/1/2016 8/28/2~
## 6 Ecology ~         16.7    2014     17 10    Nasto e~ 2/2/2016 7/28/2~
## # ... with 3 more variables: Number of users <dbl>, Twitter reach <dbl>,
## #   woscitations <dbl>
```

Naming final object of pipe 2

```r
citations_raw %>%
  rename(journal = 'Journal identity',
         impactfactor = '5-year journal impact factor',
         pubyear = 'Year published',
         colldate = 'Collection date',
         pubdate = 'Publication date',
         nbtweets = 'Number of tweets',
         woscitations = 'Number of Web of Science citations') %>%
  mutate(journal = as.factor(journal))-> citations2
head(citations2)
```

```
## # A tibble: 6 x 12
##   journal   impactfactor pubyear Volume Issue Authors  colldate pubdate nb
##   <fct>            <dbl>   <dbl>  <dbl> <chr> <chr>    <chr>    <chr>
## 1 Ecology ~         16.7    2014     17 12    Morin e~ 2/1/2016 9/16/2~
## 2 Ecology ~         16.7    2014     17 12    Jucker ~ 2/1/2016 10/13/~
## 3 Ecology ~         16.7    2014     17 12    Calcagn~ 2/1/2016 10/21/~
## 4 Ecology ~         16.7    2014     17 11    Segre e~ 2/1/2016 8/28/2~
## 5 Ecology ~         16.7    2014     17 11    Kaufman~ 2/1/2016 8/28/2~
## 6 Ecology ~         16.7    2014     17 10    Nasto e~ 2/2/2016 7/28/2~
## # ... with 3 more variables: Number of users <dbl>, Twitter reach <dbl>,
## #   woscitations <dbl>
```

Pipe synthax

- *Verb(Subject,Complement)* replaced by *Subject %>% Verb(Complement)*;
- No need to name unimportant intermediate variables;
- Clear syntax (readability).

If you want you can first write what you want to accomplished in a text with "then" as step wise, then code it by replace "then" by the pipe with its operator "%>%" of course.

Other functions in Tidyverse

Select columns

select() is the function one uses to select different variables i a tibble. You just need to remember that it follows a pipe operator (%>%), and it takes the name of columns one desires to select.

```
citations %>%
  select(journal, impactfactor, nbtweets)
```

```
## # A tibble: 1,599 x 3
##    journal         impactfactor nbtweets
##    <fct>                  <dbl>    <dbl>
##  1 Ecology Letters         16.7       18
##  2 Ecology Letters         16.7       15
##  3 Ecology Letters         16.7        5
##  4 Ecology Letters         16.7        9
##  5 Ecology Letters         16.7        3
##  6 Ecology Letters         16.7       27
##  7 Ecology Letters         16.7        6
##  8 Ecology Letters         16.7       19
##  9 Ecology Letters         16.7       26
## 10 Ecology Letters         16.7       44
## # ... with 1,589 more rows
```

Drop columns or deselect variables

The opposite of selecting, which is deselecting. One just need to be more logical in the writing. Would you like to guess?

```r
citations %>%
  select(-Volume, -Issue, -Authors)
```

```
## # A tibble: 1,599 x 9
##    journal     impactfactor pubyear colldate pubdate   nbtweets `Number of
##    <fct>              <dbl>   <dbl> <chr>    <chr>        <dbl>
##  1 Ecology Le~         16.7    2014 2/1/2016 9/16/2014       18
##  2 Ecology Le~         16.7    2014 2/1/2016 10/13/20~       15
##  3 Ecology Le~         16.7    2014 2/1/2016 10/21/20~        5
##  4 Ecology Le~         16.7    2014 2/1/2016 8/28/2014        9
##  5 Ecology Le~         16.7    2014 2/1/2016 8/28/2014        3
##  6 Ecology Le~         16.7    2014 2/2/2016 7/28/2014       27
##  7 Ecology Le~         16.7    2014 2/2/2016 8/6/2014         6
##  8 Ecology Le~         16.7    2014 2/2/2016 6/17/2014       19
##  9 Ecology Le~         16.7    2014 2/2/2016 6/12/2014       26
## 10 Ecology Le~         16.7    2014 2/2/2016 7/17/2014       44
## # ... with 1,589 more rows, and 2 more variables: Twitter reach <dbl>,
## #   woscitations <dbl>
```

Split a column in several columns

separate is the function used to split a column into several of course you need to indicate what symbol is the separator (e.g., space, -, /, etc.).

```
head(citations$pubdate)
```

```
## [1] "9/16/2014"  "10/13/2014" "10/21/2014" "8/28/2014"  "8/28/2014" 
## [6] "7/28/2014"
```

```
citations %>%
  select(journal, impactfactor, nbtweets, pubdate)%>%
  separate(pubdate,c('month','day','year'),'/')
```

```
## # A tibble: 1,599 x 6
##    journal         impactfactor nbtweets month day   year 
##    <fct>                  <dbl>    <dbl> <chr> <chr> <chr>
##  1 Ecology Letters         16.7       18 9     16    2014 
##  2 Ecology Letters         16.7       15 10    13    2014 
##  3 Ecology Letters         16.7        5 10    21    2014 
##  4 Ecology Letters         16.7        9 8     28    2014 
##  5 Ecology Letters         16.7        3 8     28    2014 
##  6 Ecology Letters         16.7       27 7     28    2014 
##  7 Ecology Letters         16.7        6 8     6     2014 
```

Transform column in date format

Many of us work with ecological data that record date, and we find it hard to keep these on readable format in R. Within, tidyverse there is a package that specially deals with date formatting variables/columns. The package is called **lubridate**.

```
library(lubridate)
citations %>%
  mutate(pubdate = mdy(pubdate),
         colldate = mdy(colldate))%>%
  select(journal,impactfactor, nbtweets, pubdate, colldate)
```

```
## # A tibble: 1,599 x 5
##    journal         impactfactor nbtweets pubdate    colldate
##    <fct>                  <dbl>    <dbl> <date>     <date>
##  1 Ecology Letters         16.7       18 2014-09-16 2016-02-01
##  2 Ecology Letters         16.7       15 2014-10-13 2016-02-01
##  3 Ecology Letters         16.7        5 2014-10-21 2016-02-01
##  4 Ecology Letters         16.7        9 2014-08-28 2016-02-01
##  5 Ecology Letters         16.7        3 2014-08-28 2016-02-01
##  6 Ecology Letters         16.7       27 2014-07-28 2016-02-02
##  7 Ecology Letters         16.7        6 2014-08-06 2016-02-02
##  8 Ecology Letters         16.7       19 2014-06-17 2016-02-02
```

For easy date format manipulation

Check out ?lubridate::lubridate for more functions

```
library(lubridate)
citations %>%
  mutate(pubdate = mdy(pubdate),
         pubyear2 = year(pubdate))%>%
  select(journal,impactfactor, pubdate, colldate, pubyear2)
```

```
## # A tibble: 1,599 x 5
##    journal         impactfactor pubdate    colldate pubyear2
##    <fct>                  <dbl> <date>     <chr>       <dbl>
##  1 Ecology Letters         16.7 2014-09-16 2/1/2016     2014
##  2 Ecology Letters         16.7 2014-10-13 2/1/2016     2014
##  3 Ecology Letters         16.7 2014-10-21 2/1/2016     2014
##  4 Ecology Letters         16.7 2014-08-28 2/1/2016     2014
##  5 Ecology Letters         16.7 2014-08-28 2/1/2016     2014
##  6 Ecology Letters         16.7 2014-07-28 2/2/2016     2014
##  7 Ecology Letters         16.7 2014-08-06 2/2/2016     2014
##  8 Ecology Letters         16.7 2014-06-17 2/2/2016     2014
##  9 Ecology Letters         16.7 2014-06-12 2/2/2016     2014
## 10 Ecology Letters         16.7 2014-07-17 2/2/2016     2014
## # ... with 1,589 more rows
```

Join tables together

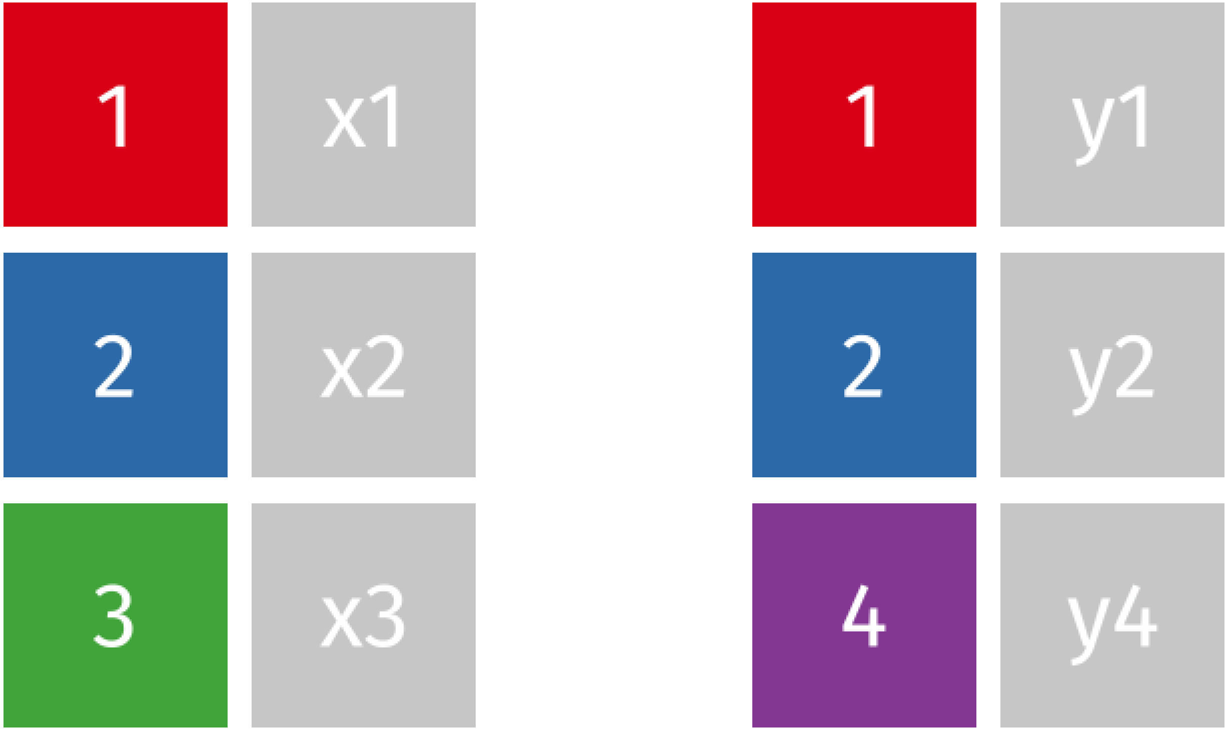
Join two tables

Joining tables are the correspondents of merge function in base R. There is a great tutorial to all sort of joining in tidyverse made available by Garrick Aden-Buie. The joining of tables can be categorized into several types. However, we will only study the following:

- Inner join;
- Left join;
- Right join;
- Semi join;
- Union join;
- Anti join.

Inner join

```
inner_join(x, y)
```

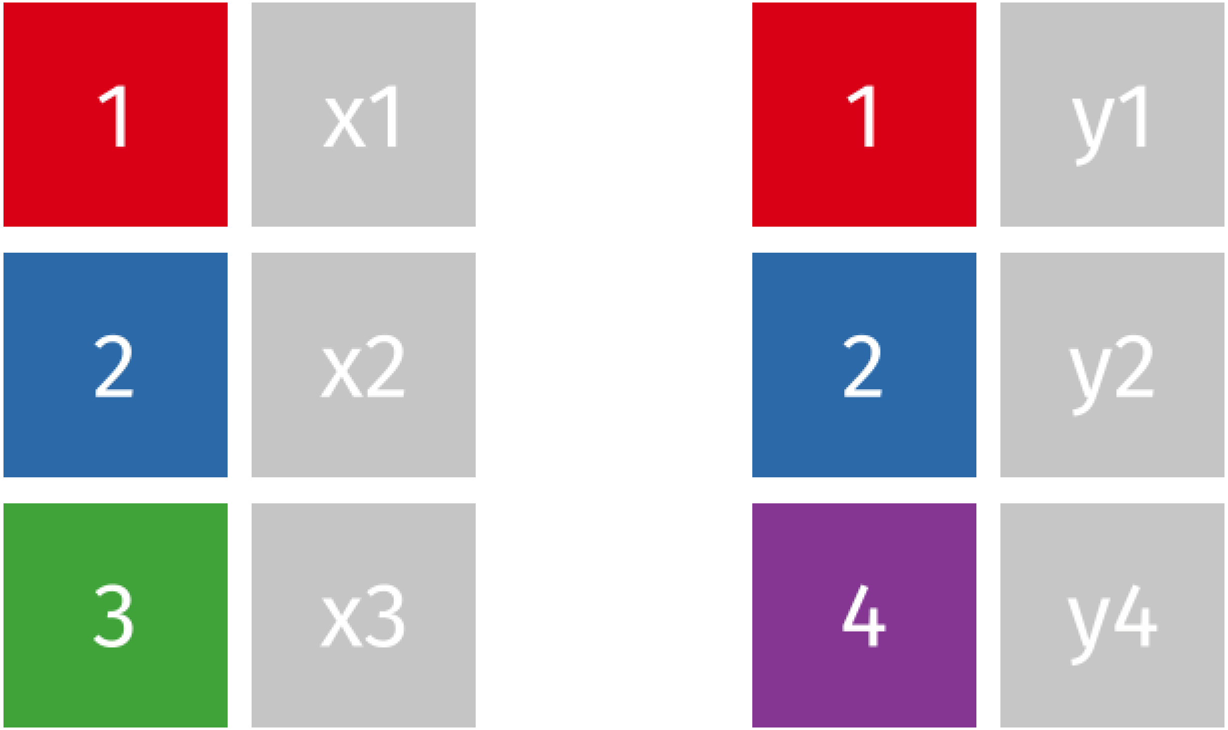


1	x1
2	x2
3	x3

1	y1
2	y2
4	y4

Left join

```
left_join(x, y)
```

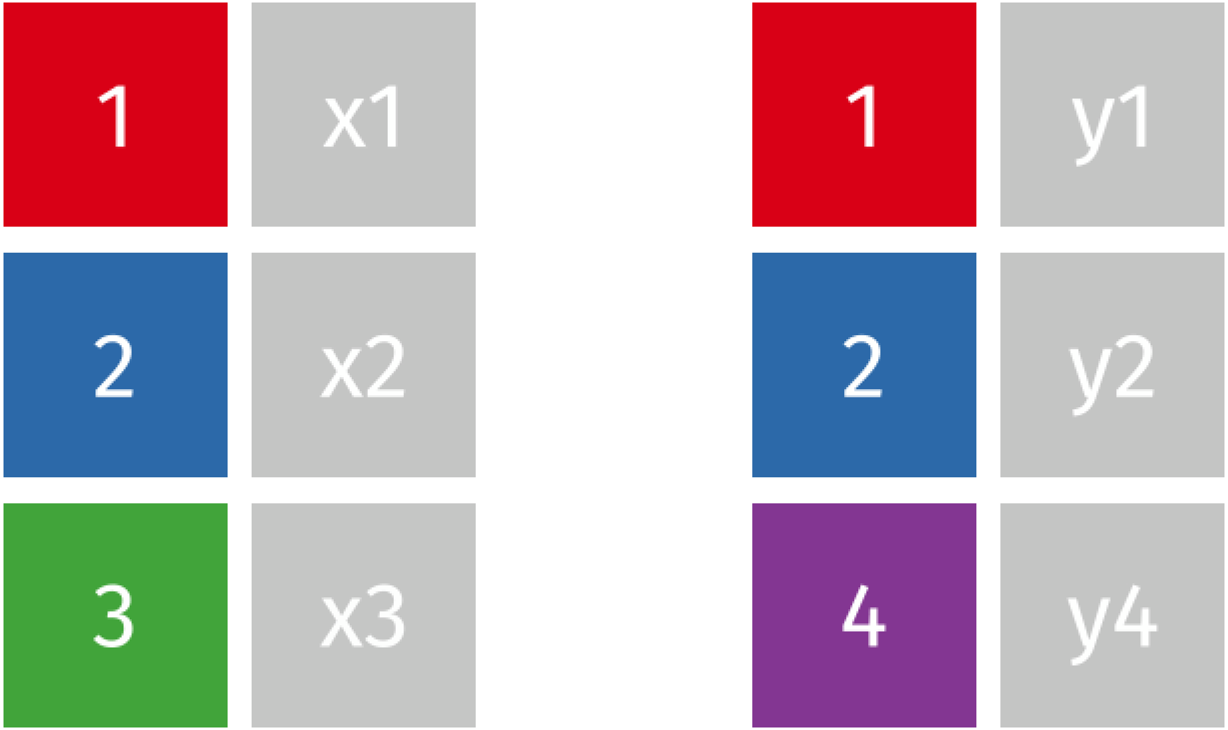


1	x1
2	x2
3	x3

1	y1
2	y2
4	y4

Right join

```
right_join(x, y)
```

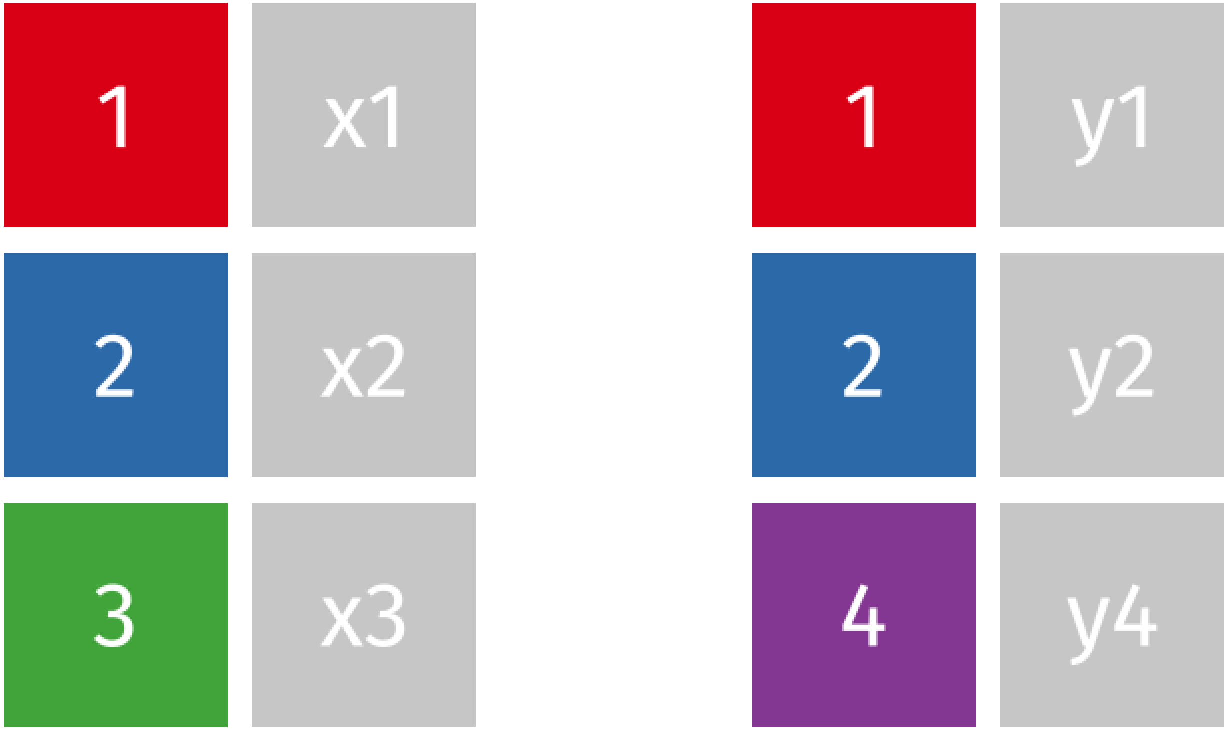


1	x1
2	x2
3	x3

1	y1
2	y2
4	y4

Semi join

```
semi_join(x, y)
```

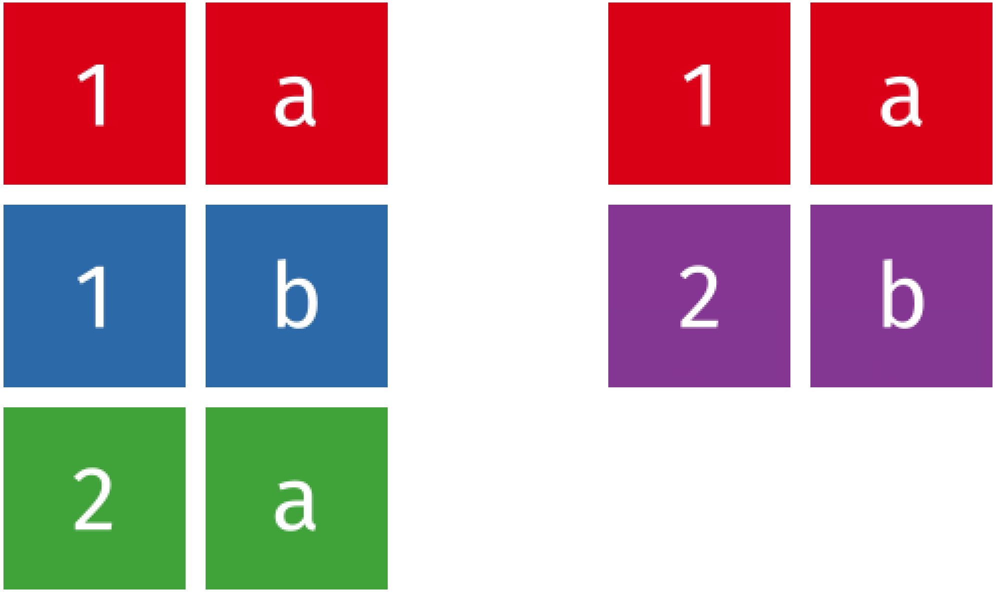


1	x1
2	x2
3	x3

1	y1
2	y2
4	y4

Union join

```
union(x, y)
```

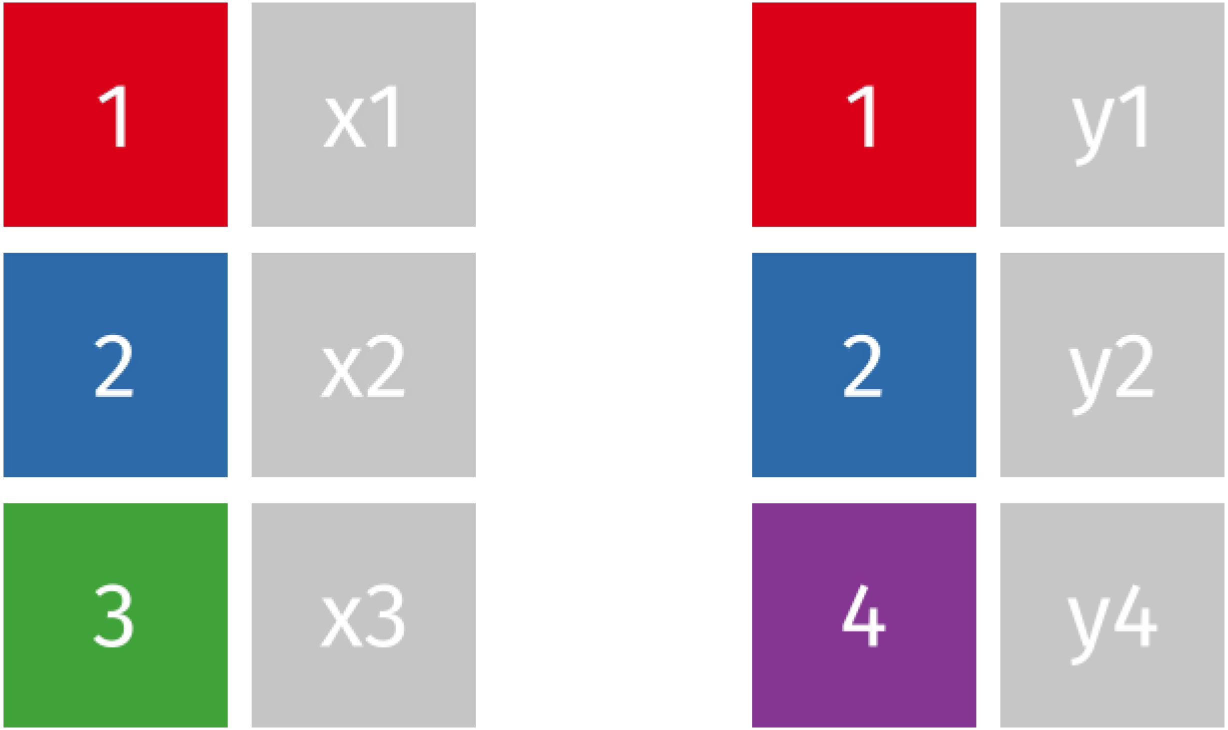


1	a
1	b
2	a

1	a
2	b

Anti join

```
anti_join(x, y)
```



1	x1
2	x2
3	x3

1	y1
2	y2
4	y4

Character manipulation

Select rows of papers with > 3 authors

```
citations %>%
#str_detect() detect characters in a given column
    filter(str_detect(Authors,'et al'))
```

```
## # A tibble: 1,280 x 12
##    journal  impactfactor pubyear Volume Issue Authors   colldate pubdate nb
##    <fct>           <dbl>   <dbl>  <dbl> <chr> <chr>     <chr>    <chr>
##  1 Ecology~         16.7    2014     17 12    Morin e~ 2/1/2016 9/16/2~
##  2 Ecology~         16.7    2014     17 12    Jucker ~ 2/1/2016 10/13/~
##  3 Ecology~         16.7    2014     17 12    Calcagn~ 2/1/2016 10/21/~
##  4 Ecology~         16.7    2014     17 11    Segre e~ 2/1/2016 8/28/2~
##  5 Ecology~         16.7    2014     17 11    Kaufman~ 2/1/2016 8/28/2~
##  6 Ecology~         16.7    2014     17 10    Nasto e~ 2/2/2016 7/28/2~
##  7 Ecology~         16.7    2014     17 10    Tschirr~ 2/2/2016 8/6/20~
##  8 Ecology~         16.7    2014     17 9     Barnech~ 2/2/2016 6/17/2~
##  9 Ecology~         16.7    2014     17 9     Pinto-S~ 2/2/2016 6/12/2~
## 10 Ecology~         16.7    2014     17 9     Clough ~ 2/2/2016 7/17/2~
## # ... with 1,270 more rows, and 3 more variables: Number of users <dbl>,
## #   Twitter reach <dbl>, woscitations <dbl>
```

Select columns with rows of papers with > 3 authors

```r
citations %>%
  filter(str_detect(Authors,'et al')) %>%
  select(Authors)
```

```
## # A tibble: 1,280 x 1
##    Authors
##    <chr>
##  1 Morin et al
##  2 Jucker et al
##  3 Calcagno et al
##  4 Segre et al
##  5 Kaufman et al
##  6 Nasto et al
##  7 Tschirren et al
##  8 Barnechi et al
##  9 Pinto-Sanchez et al
## 10 Clough et al
## # ... with 1,270 more rows
```

Select columns with rows of papers with < 3 authors

```
citations %>%
  filter(!str_detect(Authors,'et al')) %>% ##!  for saying "not".
  select(Authors)
```

```
## # A tibble: 319 x 1
##    Authors
##    <chr>
##  1 Neutle and Thorne
##  2 Kellner and Asner
##  3 Griffin and Willi
##  4 Gremer and Venable
##  5 Cavieres
##  6 Haegman and Loreau
##  7 Kearney
##  8 Locey and White
##  9 Quintero and Weins
## 10 Lesser and Jackson
## # ... with 309 more rows
```

Select authors of columns with rows of papers with < 3 authors

```
citations %>%
  filter(!str_detect(Authors,'et al')) %>% ##!  for saying "not".
pull(Authors) %>%
  head(10)
```

```
##  [1] "Neutle and Thorne"  "Kellner and Asner"  "Griffin and Willi"
##  [4] "Gremer and Venable" "Cavieres"           "Haegman and Loreau"
##  [7] "Kearney"            "Locey and White"    "Quintero and Weins"
## [10] "Lesser and Jackson"
```

Rows of papers with less than 3 authors in journal with IF < 5

```
citations %>%
  filter(!str_detect(Authors,'et al'), impactfactor < 5)
```

```
## # A tibble: 77 x 12
##    journal  impactfactor pubyear Volume Issue  Authors colldate pubdate nb
##    <fct>           <dbl>   <dbl>  <dbl> <chr>  <chr>   <chr>    <chr>
##  1 Molecul~         4.9     2014     14 6      Gautier 2/27/20~ 5/14/2~
##  2 Molecul~         4.9     2014     14 5      Gambel~ 2/27/20~ 3/7/20~
##  3 Molecul~         4.9     2014     14 4      Kekkon~ 2/27/20~ 3/10/2~
##  4 Molecul~         4.9     2014     14 3      Bhatta~ 2/27/20~ 12/8/2~
##  5 Molecul~         4.9     2014     14 1      Christ~ 2/28/20~ 10/25/~
##  6 Molecul~         4.9     2013     13 4      Villar~ 2/28/20~ 5/2/20~
##  7 Molecul~         4.9     2013     13 4      Wang    2/28/20~ 4/25/2~
##  8 Molecul~         4.9     2012     12 1      Joly    2/28/20~ 9/7/20~
##  9 Animal ~         3.21    2014     17 6      Plavsic 2/9/2016 4/17/2~
## 10 Animal ~         3.21    2014     17 Suppl~ Knox a~ 2/11/20~ 11/13/~
## # ... with 67 more rows, and 3 more variables: Number of users <dbl>,
## #   Twitter reach <dbl>, woscitations <dbl>
```

Convert words to lowercase

```
citations %>%
  mutate(authors_lowercase = str_to_lower(Authors)) %>%
  select(authors_lowercase)
```

```
## # A tibble: 1,599 x 1
##    authors_lowercase
##    <chr>
##  1 morin et al
##  2 jucker et al
##  3 calcagno et al
##  4 segre et al
##  5 kaufman et al
##  6 nasto et al
##  7 tschirren et al
##  8 barnechi et al
##  9 pinto-sanchez et al
## 10 clough et al
## # ... with 1,589 more rows
```

Remove all spaces in variable names

```
citations%>%
  mutate(journal = str_remove_all(journal," ")) %>%
  select(journal) %>%
  unique() %>%
  head(5)
```

```
## # A tibble: 5 x 1
##   journal
##   <chr>
## 1 EcologyLetters
## 2 GlobalChangeBiology
## 3 GlobalEcologyandBiogeography
## 4 MolecularEcologyResources
## 5 DiversityandDistributions
```

Basic exploratory data analysis

Count ()

This helps to count the number of occurrences.

```
citations %>%
  count(journal, sort = TRUE) ## Embedded sorting within count()
```

```
## # A tibble: 20 x 2
##    journal                              n
##    <fct>                            <int>
##  1 New Phytologist                    144
##  2 Ecology                            108
##  3 Evolution                          108
##  4 Global Change Biology              108
##  5 Global Ecology and Biogeography    108
##  6 Journal of Biogeography            108
##  7 Ecology Letters                    106
##  8 Diversity and Distributions        105
##  9 Animal Conservation                102
## 10 Methods in Ecology and Evolution    90
## 11 Evolutionary Applications           74
## 12 Functional Ecology                  54
## 13 Journal of Animal Ecology           54
## 14 Journal of Applied Ecology          54
```

Count() for multiple variables

```
citations %>%
  count(journal, pubyear)
```

```
## # A tibble: 59 x 3
##    journal                     pubyear     n
##    <fct>                         <dbl> <int>
##  1 Animal Conservation            2012    18
##  2 Animal Conservation            2013    18
##  3 Animal Conservation            2014    66
##  4 Conservation Letters           2012    17
##  5 Conservation Letters           2013    18
##  6 Conservation Letters           2014    18
##  7 Diversity and Distributions    2012    36
##  8 Diversity and Distributions    2013    33
##  9 Diversity and Distributions    2014    36
## 10 Ecological Applications        2012    24
## # ... with 49 more rows
```

Count sum of tweets per journal

```
citations %>%
  count(journal, wt = nbtweets, sort = TRUE)
```

```
## # A tibble: 20 x 2
##    journal                                  n
##    <fct>                                <dbl>
##  1 Ecology Letters                       1538
##  2 Animal Conservation                   1268
##  3 Journal of Applied Ecology            1012
##  4 Methods in Ecology and Evolution       699
##  5 Global Change Biology                  613
##  6 Conservation Letters                   542
##  7 New Phytologist                        509
##  8 Global Ecology and Biogeography        379
##  9 Ecology                                335
## 10 Evolution                              335
## 11 Journal of Animal Ecology              323
## 12 Fish and Fisheries                     261
## 13 Evolutionary Applications              238
## 14 Journal of Biogeography                209
## 15 Diversity and Distributions            200
## 16 Mammal Review                          166
```

Group variables to compute stats [summarise()]

```
citations %>%
  group_by(journal) %>%
  summarise(avg_tweets = mean(nbtweets))
```

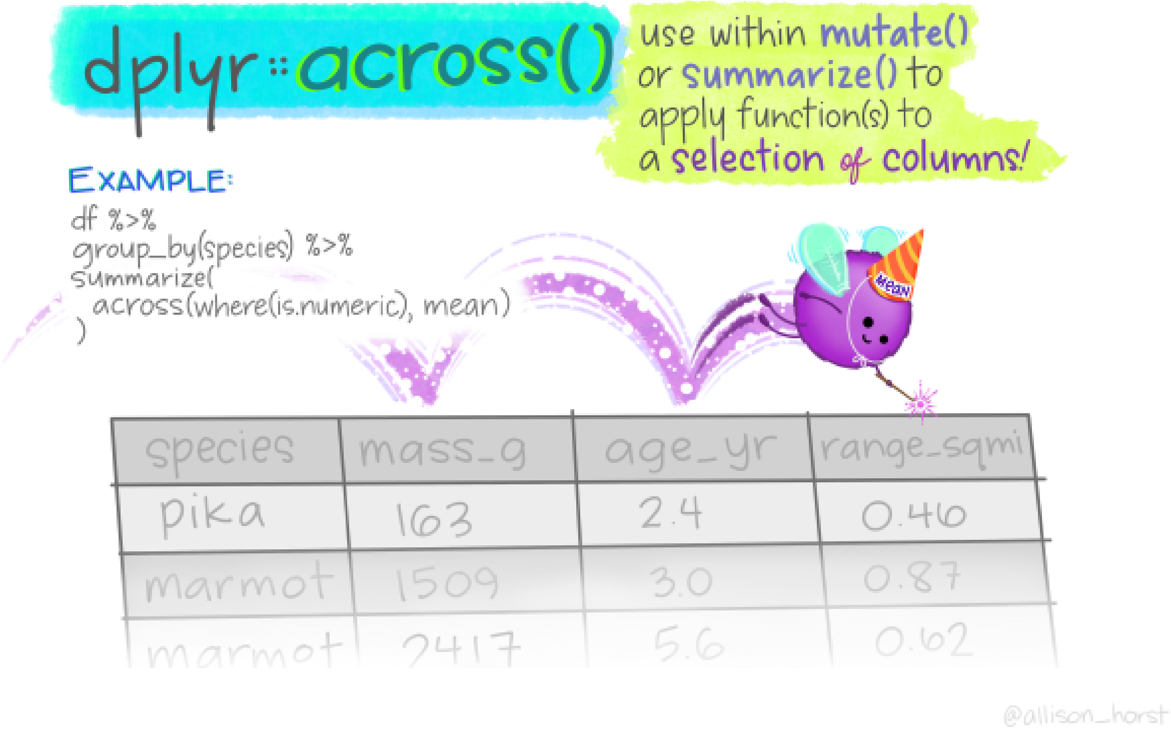
```
## # A tibble: 20 x 2
##    journal                                avg_tweets
##    <fct>                                       <dbl>
##  1 Animal Conservation                        12.4
##  2 Conservation Letters                       10.2
##  3 Diversity and Distributions                 1.90
##  4 Ecological Applications                     2.60
##  5 Ecology                                     3.10
##  6 Ecology Letters                            14.5
##  7 Evolution                                   3.10
##  8 Evolutionary Applications                   3.22
##  9 Fish and Fisheries                          7.25
## 10 Functional Ecology                          2.87
## 11 Global Change Biology                       5.68
## 12 Global Ecology and Biogeography             3.51
## 13 Journal of Animal Ecology                   5.98
```

Order stuff [arrange()]

```
citations %>%
  group_by(journal) %>%
  summarise(avg_tweets = mean(nbtweets)) %>%
  # decreasing order but (without desc for increasing)
  arrange(desc(avg_tweets))-> arrangedat
head(arrangedat, 10)
```

```
## # A tibble: 10 x 2
##    journal                             avg_tweets
##    <fct>                                    <dbl>
##  1 Journal of Applied Ecology              18.7
##  2 Ecology Letters                         14.5
##  3 Animal Conservation                     12.4
##  4 Conservation Letters                    10.2
##  5 Methods in Ecology and Evolution         7.77
##  6 Fish and Fisheries                       7.25
##  7 Journal of Animal Ecology                5.98
##  8 Global Change Biology                    5.68
##  9 Mammal Review                            5.35
## 10 New Phytologist                          3.53
```

Work on several columns [dplyr::across()]



dplyr::across()
use within mutate() or summarize() to apply function(s) to a selection of columns!
EXAMPLE:
mean
@allison_horst

```
df %>%
group_by(species) %>%
summarize(
  across(where(is.numeric), mean)
)
```

species	mass_g	age_yr	range_sqmi
pika	163	2.4	0.46
marmot	1509	3.0	0.87
marmot	2417	5.6	0.62

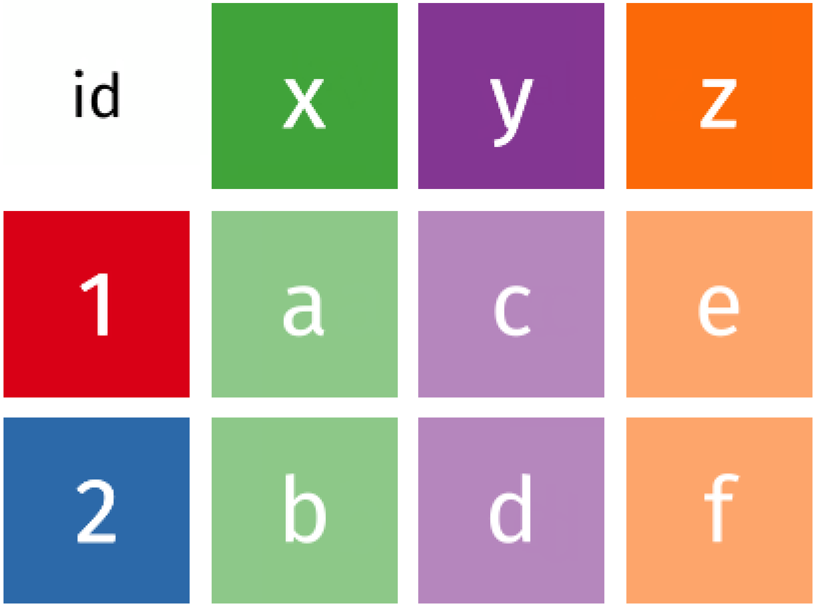
Compute mean across multiple variables

```
citations %>%
  group_by(journal) %>%
  summarize(across(where(is.numeric), mean))
```

```
## # A tibble: 20 x 8
##    journal impactfactor pubyear Volume nbtweets `Number of user~ `Twitter
##    <fct>          <dbl>   <dbl>  <dbl>    <dbl>            <dbl>
##  1 Animal~         3.21   2013.  16.5     12.4              9.71
##  2 Conser~         6.4    2013.   6.02    10.2              8.85
##  3 Divers~         5.4    2013   19        1.90             1.77
##  4 Ecolog~         5.06   2013   23        2.60             2.5
##  5 Ecology         6.16   2013   94        3.10             2.87
##  6 Ecolog~        16.7    2013.  16.0     14.5             14.0
##  7 Evolut~         5.25   2013   67        3.10             2.93
##  8 Evolut~         4.6    2013.   6.05     3.22             3.07
##  9 Fish a~         8.1    2013   14        7.25             6.19
## 10 Functi~         5.28   2013   27        2.87             2.74
## 11 Global~         8.7    2013   19        5.68             4.94
## 12 Global~         7.18   2013   22        3.51             3.15
## 13 Journa~         5.32   2013.  81.9      5.98             5.59
## 14 Journa~         5.93   2013   50       18.7             15.8
## 15 Journa~         4.59   2013   40        1.94             1.86
```

Tidying tibbles [wide(), long()]

wide



id	x	y	z
1	a	c	e
2	b	d	f

Data manipulation with tidyverse: in depth study

Learn the tidyverse: books, workshops and online courses Selection of books:

- R for Data Science and Advanced R;
- Tidy Tuesdays videos by D. Robinson;
- Material of the stat545 course on Data wrangling, exploration, and analysis with R at the University of British Columbia;
- List of best R packages (with their description) on data import, wrangling and visualization.

Thank you for listening!

Any questions now or email me at **dossa@xtbg.org.cn**

Slides created via the R package **xaringan**.

The chakra comes from remark.js, **knitr**, and R Markdown.