ETC1010: Data Modelling and Computing

Week of Tidy Data: Lecture 2

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What is this song?

(you can use your phone!)

recap: from ED survey

- Traffic Light System: Green = "good!" ; Red = "Help!"
- R + Rstudio
- Tower of babel analogy for writing R code
- We are using , *not* for ETC1010?
- Functions are _
- columns in data frames are accessed with _ ?
- packages are installed with _ ?
- packages are loaded with _ ?
- Why do we care about Reproducibility?
- Output + input of rmarkdown
- I have an assignment group
- If I have an assignment group, have recorded my assignment group in the ED survey

Source: Artwork by @allison_horst

Overview

- `filter()`
- `select()`
- `mutate()`
- `arrange()`
- `group_by()`
- `summarise()`
- `count()`

Artwork by @allison_horst

R Packages

```
avail_pkg <- available.packages()
dim(avail_pkg)
```

```
## [1] 14738    17
```

As of 2019-08-09 there are 14738 R packages available

Name clashes

```
library(tidyverse)
```

Many R packages

- A blessing & a curse!
- So many packages available, it can make it hard to choose!
- Many of the packages are designed to solve a specific problem
- The tidyverse is designed to work with many other packages following a consistent philosophy
- What this means is that you shouldn't notice it!

Let's talk about data

Example: french fries

- Experiment in Food Sciences at Iowa State University.
- Aim: find if cheaper oil could be used to make hot chips
- Question: Can people distinguish between chips fried in the new oils relative to those current market leader oil.
- 12 tasters recruited
- Each sampled two chips from each batch
- Over a period of ten weeks.

Same oil kept for a period of 10 weeks! May be a bit gross!

Example: french-fries - gathering into long form

```
french_fries <- read_csv("data/french_fries.csv")
french_fries
```

```
## # A tibble: 6 x 9
##    time treatment subject   rep potato buttery grassy rancid painty
##   <dbl>     <dbl>   <dbl> <dbl>  <dbl>   <dbl>  <dbl>  <dbl>  <dbl>
## 1     1         1       3     1    2.9     0      0      0      5.5
## 2     1         1       3     2   14       0      0      1.1    0
## 3     1         1      10     1   11       6.4    0      0      0
## 4     1         1      10     2    9.9     5.9    2.9    2.2    0
## 5     1         1      15     1    1.2     0.1    0      1.1    5.1
## 6     1         1      15     2    8.8     3      3.6    1.5    2.3
```

This data set was brought to R by Hadley Wickham, and was one of the problems that inspired the thinking about tidy data and the plyr tools.

French fries - gathering into long form

```
fries_long <- french_fries %>%
  gather(key = type,
         value = rating,
         -time,
         -treatment,
         -subject,
         -rep)
```

```
fries_long
```

```
## # A tibble: 3,480 x 6
##     time treatment subject   rep type   rating
##    <dbl>     <dbl>   <dbl> <dbl> <fct>   <dbl>
##  1     1         1       3     1 potato    2.9
##  2     1         1       3     2 potato   14
##  3     1         1      10     1 potato   11
##  4     1         1      10     2 potato    9.9
##  5     1         1      15     1 potato    1.2
##  6     1         1      15     2 potato    8.8
##  7     1         1      16     1 potato    9
##  8     1         1      16     2 potato    8.2
##  9     1         1      19     1 potato    7
## 10     1         1      19     2 potato   13
## # … with 3,470 more rows
```

`filter()`: choose observations from your data

filter(): example

```
fries_long %>%
  filter(subject == 10)
```

```
## # A tibble: 300 x 6
##     time treatment subject   rep type   rating
##    <dbl>     <dbl>   <dbl> <dbl> <fct>   <dbl>
##  1     1         1      10     1 potato   11
##  2     1         1      10     2 potato    9.9
##  3     1         2      10     1 potato    9.3
##  4     1         2      10     2 potato   11
##  5     1         3      10     1 potato   11.3
##  6     1         3      10     2 potato   10.1
##  7     2         1      10     1 potato    8
##  8     2         1      10     2 potato   10.2
##  9     2         2      10     1 potato   11.2
## 10     2         2      10     2 potato    8.2
## # … with 290 more rows
```

`filter()`: details

Filtering requires comparison to find the subset of observations of interest. What do you think the following mean?

- `subject != 10`
- `x > 10`
- `x >= 10`
- `class %in% c("A", "B")`
- `!is.na(y)`

`filter()`: details

```
subject != 10
```

Find rows corresponding to all subjects except subject 10

`filter()`: details

```
x > 10
```

find all rows where variable `x` has values bigger than 10

`filter()`: details

```
x >= 10
```

finds all rows variable `x` is greater than or equal to 10.

`filter()`: details

```
class %in% c("A", "B")
```

finds all rows where variable `class` is either A or B

`filter()`: details

```
!is.na(y)
```

finds all rows that *DO NOT* have a missing value for variable `y`

Your turn: open french-fries.Rmd

Filter the french fries data to have:

- only week 1
- oil type 1 (oil type is called treatment)
- oil types 1 and 3 but not 2
- weeks 1-4 only

French Fries Filter: only week 1

```
fries_long %>% filter(time == 1)
```

```
## # A tibble: 360 x 6
##     time treatment subject   rep type   rating
##    <dbl>     <dbl>   <dbl> <dbl> <fct>   <dbl>
##  1     1         1       3     1 potato    2.9
##  2     1         1       3     2 potato   14
##  3     1         1      10     1 potato   11
##  4     1         1      10     2 potato    9.9
##  5     1         1      15     1 potato    1.2
##  6     1         1      15     2 potato    8.8
##  7     1         1      16     1 potato    9
##  8     1         1      16     2 potato    8.2
##  9     1         1      19     1 potato    7
## 10     1         1      19     2 potato   13
## # … with 350 more rows
```

French Fries Filter: oil type 1

```
fries_long %>% filter(treatment == 1)
```

```
## # A tibble: 1,160 x 6
##     time treatment subject   rep type   rating
##    <dbl>     <dbl>   <dbl> <dbl> <fct>   <dbl>
##  1     1         1       3     1 potato    2.9
##  2     1         1       3     2 potato   14
##  3     1         1      10     1 potato   11
##  4     1         1      10     2 potato    9.9
##  5     1         1      15     1 potato    1.2
##  6     1         1      15     2 potato    8.8
##  7     1         1      16     1 potato    9
##  8     1         1      16     2 potato    8.2
##  9     1         1      19     1 potato    7
## 10     1         1      19     2 potato   13
## # … with 1,150 more rows
```

French Fries Filter: oil types 1 and 3 but not 2

```
fries_long %>% filter(treatment != 2)
```

```
## # A tibble: 2,320 x 6
##     time treatment subject   rep type   rating
##    <dbl>     <dbl>   <dbl> <dbl> <fct>   <dbl>
##  1     1         1       3     1 potato    2.9
##  2     1         1       3     2 potato   14
##  3     1         1      10     1 potato   11
##  4     1         1      10     2 potato    9.9
##  5     1         1      15     1 potato    1.2
##  6     1         1      15     2 potato    8.8
##  7     1         1      16     1 potato    9
##  8     1         1      16     2 potato    8.2
##  9     1         1      19     1 potato    7
## 10     1         1      19     2 potato   13
## # … with 2,310 more rows
```

French Fries Filter: weeks 1-4 only

```
fries_long %>% filter(time %in% c("1", "2", "3", "4"))
```

```
## # A tibble: 1,440 x 6
##     time treatment subject   rep type   rating
##    <dbl>     <dbl>   <dbl> <dbl> <fct>   <dbl>
##  1     1         1       3     1 potato    2.9
##  2     1         1       3     2 potato   14
##  3     1         1      10     1 potato   11
##  4     1         1      10     2 potato    9.9
##  5     1         1      15     1 potato    1.2
##  6     1         1      15     2 potato    8.8
##  7     1         1      16     1 potato    9
##  8     1         1      16     2 potato    8.2
##  9     1         1      19     1 potato    7
## 10     1         1      19     2 potato   13
## # … with 1,430 more rows
```

[demo]

`select()`

- Chooses which variables to keep in the data set.
- Useful when there are many variables but you only need some of them for an analysis.

`select()`: a comma separated list of variables, by name.

```
french_fries %>%
  select(time,
         treatment,
         subject)
```

```
## # A tibble: 696 x 3
##     time treatment subject
##    <dbl>     <dbl>   <dbl>
##  1     1         1       3
##  2     1         1       3
##  3     1         1      10
##  4     1         1      10
##  5     1         1      15
##  6     1         1      15
##  7     1         1      16
##  8     1         1      16
##  9     1         1      19
## 10     1         1      19
## # … with 686 more rows
```

`select()`: drop selected variables by prefixing with `-`

```
french_fries %>%
  select(-time,
         -treatment,
         -subject)
```

```
## # A tibble: 696 x 6
##      rep potato buttery grassy rancid painty
##    <dbl>  <dbl>   <dbl>  <dbl>  <dbl>  <dbl>
##  1     1    2.9     0      0      0      5.5
##  2     2   14       0      0      1.1    0
##  3     1   11       6.4    0      0      0
##  4     2    9.9     5.9    2.9    2.2    0
##  5     1    1.2     0.1    0      1.1    5.1
##  6     2    8.8     3      3.6    1.5    2.3
##  7     1    9       2.6    0.4    0.1    0.2
##  8     2    8.2     4.4    0.3    1.4    4
##  9     1    7       3.2    0      4.9    3.2
## 10     2   13       0      3.1    4.3   10.3
## # … with 686 more rows
```

`select()`: Using it

Inside `select()` you can use text-matching of the names like `starts_with()`, `ends_with()`, `contains()`, `matches()`, or `everything()`

```
french_fries %>%
  select(contains("e"))
```

```
## # A tibble: 696 x 5
##     time treatment subject   rep buttery
##    <dbl>     <dbl>   <dbl> <dbl>   <dbl>
##  1     1         1       3     1     0
##  2     1         1       3     2     0
##  3     1         1      10     1     6.4
##  4     1         1      10     2     5.9
##  5     1         1      15     1     0.1
##  6     1         1      15     2     3
##  7     1         1      16     1     2.6
##  8     1         1      16     2     4.4
##  9     1         1      19     1     3.2
## 10     1         1      19     2     0
## # … with 686 more rows
```

`select()`: Using it

You can use `:` to choose variables in order of the columns

```
french_fries %>%
  select(time:subject)
```

```
## # A tibble: 696 x 3
##     time treatment subject
##    <dbl>     <dbl>   <dbl>
##  1     1         1       3
##  2     1         1       3
##  3     1         1      10
##  4     1         1      10
##  5     1         1      15
##  6     1         1      15
##  7     1         1      16
##  8     1         1      16
##  9     1         1      19
## 10     1         1      19
## # … with 686 more rows
```

Your turn: back to the french fries data

- `select()` time, treatment and rep
- `select()` subject through to rating
- drop subject

Artwork by @allison_horst

`mutate()`: create a new variable; keep existing ones

```
french_fries
```

```
## # A tibble: 696 x 9
##     time treatment subject   rep potato buttery grassy rancid painty
##    <dbl>     <dbl>   <dbl> <dbl>  <dbl>   <dbl>  <dbl>  <dbl>  <dbl>
##  1     1         1       3     1    2.9     0      0      0      5.5
##  2     1         1       3     2   14       0      0      1.1    0
##  3     1         1      10     1   11       6.4    0      0      0
##  4     1         1      10     2    9.9     5.9    2.9    2.2    0
##  5     1         1      15     1    1.2     0.1    0      1.1    5.1
##  6     1         1      15     2    8.8     3      3.6    1.5    2.3
##  7     1         1      16     1    9       2.6    0.4    0.1    0.2
##  8     1         1      16     2    8.2     4.4    0.3    1.4    4
##  9     1         1      19     1    7       3.2    0      4.9    3.2
## 10     1         1      19     2   13       0      3.1    4.3   10.3
## # … with 686 more rows
```

`mutate()`: create a new variable; keep existing ones

```
french_fries %>%
  mutate(rainty = rancid + painty)
```

```
## # A tibble: 696 x 10
##     time treatment subject   rep potato buttery grassy rancid painty rainty
##    <dbl>     <dbl>   <dbl> <dbl>  <dbl>   <dbl>  <dbl>  <dbl>  <dbl>  <dbl>
##  1     1         1       3     1    2.9       0      0      0    5.5    5.5
##  2     1         1       3     2   14         0      0      1.1  0      1.1
##  3     1         1      10     1   11         6.4    0      0    0      0
##  4     1         1      10     2    9.9       5.9    2.9    2.2  0      2.2
##  5     1         1      15     1    1.2       0.1    0      1.1  5.1    6.20
##  6     1         1      15     2    8.8       3      3.6    1.5  2.3    3.8
##  7     1         1      16     1    9         2.6    0.4    0.1  0.2    0.3
##  8     1         1      16     2    8.2       4.4    0.3    1.4  4      5.4
##  9     1         1      19     1    7         3.2    0      4.9  3.2    8.1
## 10     1         1      19     2   13         0      3.1    4.3 10.3   14.6
## # … with 686 more rows
```

Your turn: french fries

Compute a new variable called `lrating` by taking a log of the rating

summarise(): boil data down to one row observation

```
fries_long
```

```
## # A tibble: 6 x 6
##    time treatment subject   rep type   rating
##   <dbl>     <dbl>   <dbl> <dbl> <fct>   <dbl>
## 1     1         1       3     1 potato    2.9
## 2     1         1       3     2 potato   14
## 3     1         1      10     1 potato   11
## 4     1         1      10     2 potato    9.9
## 5     1         1      15     1 potato    1.2
## 6     1         1      15     2 potato    8.8
```

```
fries_long %>%
  summarise(rating = mean(rating, na.rm = TRUE))
```

```
## # A tibble: 1 x 1
##   rating
##    <dbl>
## 1   3.16
```

But what if we want to get a summary for each `type`?

use `group_by()`

Using `summarise()` + `group_by()`

Produce summaries for every group:

```
fries_long %>%
  group_by(type) %>%
  summarise(rating = mean(rating, na.rm=TRUE))
```

```
## # A tibble: 5 x 2
##   type    rating
##   <fct>    <dbl>
## 1 buttery  1.82
## 2 grassy   0.664
## 3 painty   2.52
## 4 potato   6.95
## 5 rancid   3.85
```

Your turn: Back to french-fries.Rmd

- Compute the average rating by subject
- Compute the average rancid rating per week

french fries answers

```
fries_long %>%
  group_by(subject) %>%
  summarise(rating = mean(rating, na.rm=TRUE))
```

```
## # A tibble: 12 x 2
##    subject rating
##      <dbl>  <dbl>
##  1       3   2.46
##  2      10   4.24
##  3      15   2.16
##  4      16   3.00
##  5      19   4.54
##  6      31   4.00
##  7      51   4.39
##  8      52   2.72
##  9      63   3.48
## 10      78   1.94
## 11      79   1.94
## 12      86   2.94
```

french fries answers

```
fries_long %>%
  filter(type == "rancid") %>%
  group_by(time) %>%
  summarise(rating = mean(rating, na.rm=TRUE))
```

```
## # A tibble: 10 x 2
##     time rating
##    <dbl>  <dbl>
##  1     1   2.36
##  2     2   2.85
##  3     3   3.72
##  4     4   3.60
##  5     5   3.53
##  6     6   4.08
##  7     7   3.89
##  8     8   4.27
##  9     9   4.67
## 10    10   6.07
```

`arrange()`: orders data by a given variable.

Useful for display of results (but there are other uses!)

```
fries_long %>%
  group_by(type) %>%
  summarise(rating = mean(rating, na.rm=TRUE))
```

```
## # A tibble: 5 x 2
##   type    rating
##   <fct>    <dbl>
## 1 buttery  1.82
## 2 grassy   0.664
## 3 painty   2.52
## 4 potato   6.95
## 5 rancid   3.85
```

arrange()

```
fries_long %>%
  group_by(type) %>%
  summarise(rating = mean(rating, na.rm=TRUE)) %>%
  arrange(rating)
```

```
## # A tibble: 5 x 2
##   type    rating
##   <fct>    <dbl>
## 1 grassy   0.664
## 2 buttery  1.82
## 3 painty   2.52
## 4 rancid   3.85
## 5 potato   6.95
```

Your turn: french-fries.Rmd - arrange

- Arrange the average rating by type in decreasing order
- Arrange the average subject rating in order lowest to highest.

arrange() answers

```
fries_long %>%
  group_by(type) %>%
  summarise(rating = mean(rating, na.rm=TRUE)) %>%
  arrange(desc(rating))
```

```
## # A tibble: 5 x 2
##   type    rating
##   <fct>    <dbl>
## 1 potato   6.95
## 2 rancid   3.85
## 3 painty   2.52
## 4 buttery  1.82
## 5 grassy   0.664
```

arrange() answers

```
fries_long %>%
  group_by(subject) %>%
  summarise(rating = mean(rating, na.rm=TRUE)) %>%
  arrange(rating)
```

```
## # A tibble: 12 x 2
##    subject rating
##      <dbl>  <dbl>
##  1      78   1.94
##  2      79   1.94
##  3      15   2.16
##  4       3   2.46
##  5      52   2.72
##  6      86   2.94
##  7      16   3.00
##  8      63   3.48
##  9      31   4.00
## 10      10   4.24
## 11      51   4.39
## 12      19   4.54
```

`count()` the number of things in a given column

```
fries_long %>%
  count(type, sort = TRUE)
```

```
## # A tibble: 5 x 2
##   type        n
##   <fct>   <int>
## 1 buttery   696
## 2 grassy    696
## 3 painty    696
## 4 potato    696
## 5 rancid    696
```

Your turn: `count()`

- count the number of subjects
- count the number of types

French Fries: Putting it together to problem solve

French Fries: Are ratings similar?

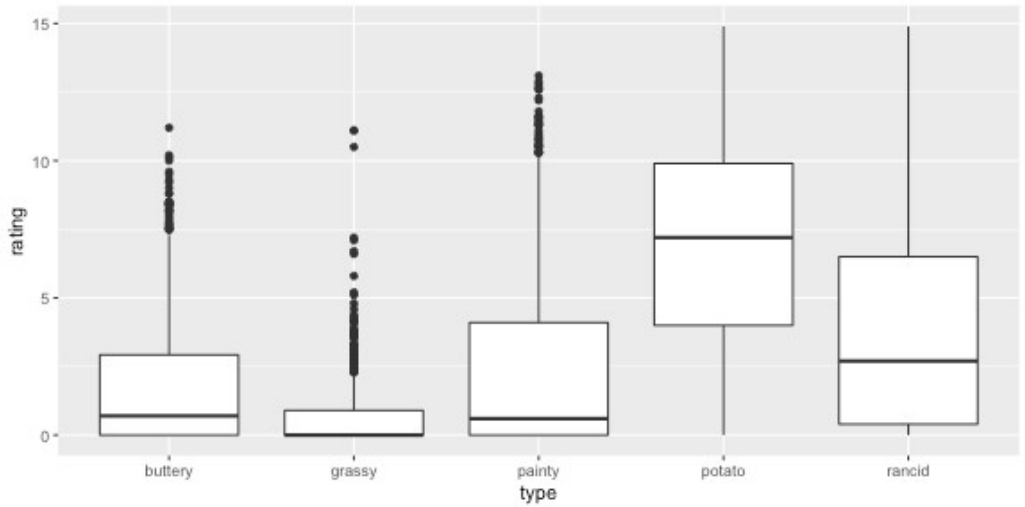
```
fries_long %>%
  group_by(type) %>%
  summarise(m = mean(rating,
                     na.rm = TRUE),
            sd = sd(rating,
                    na.rm = TRUE)) %>%
  arrange(-m)
```

```
## # A tibble: 5 x 3
##   type        m    sd
##   <fct>   <dbl> <dbl>
## 1 potato  6.95   3.58
## 2 rancid  3.85   3.78
## 3 painty  2.52   3.39
## 4 buttery 1.82   2.41
## 5 grassy  0.664  1.32
```

The scales of the ratings are quite different. Mostly the chips are rated highly on potato'y, but low on grassy.

French Fries: Are ratings similar?

```
ggplot(fries_long,
       aes(x = type,
           y = rating)) +
  geom_boxplot()
```



French Fries: Are reps like each other?

```
fries_spread <- fries_long %>%
  spread(key = rep,
         value = rating)

fries_spread
```

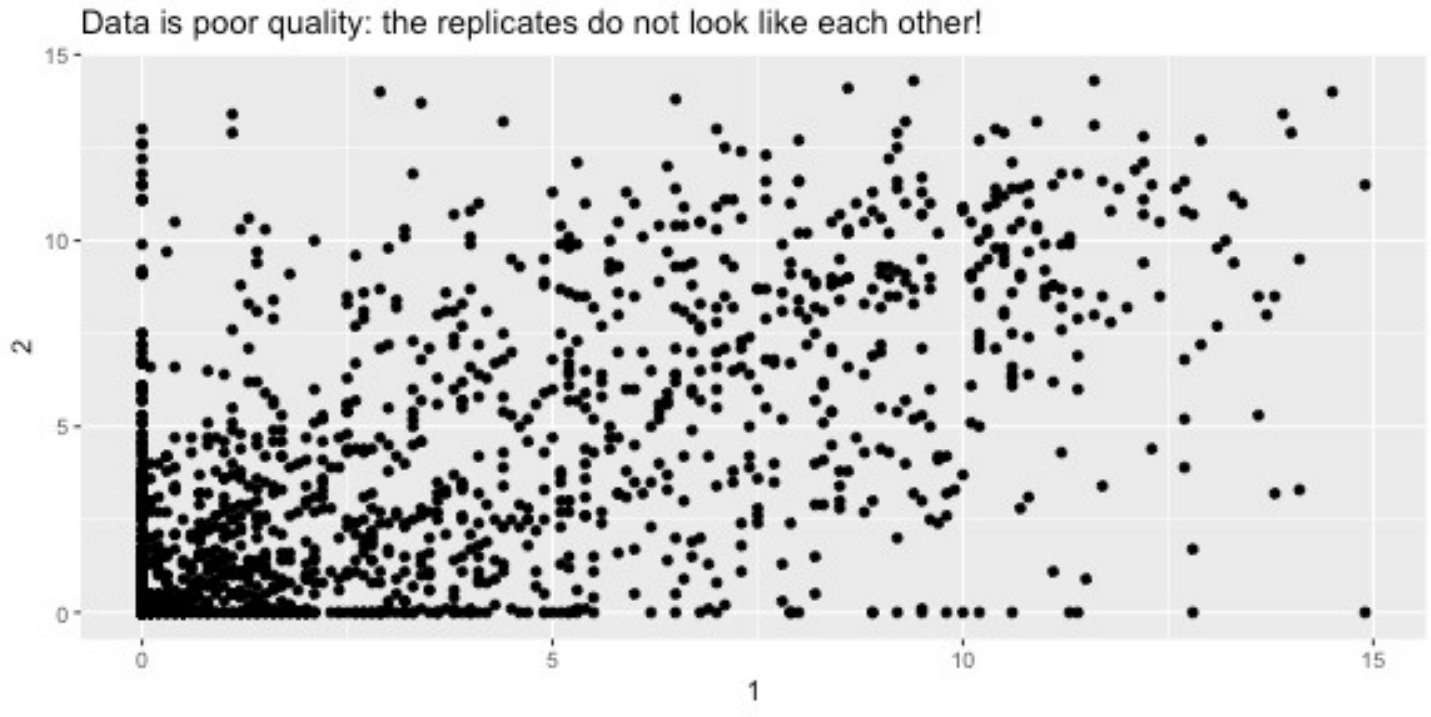
```
## # A tibble: 1,740 x 6
##     time treatment subject type      `1`   `2`
##    <dbl>     <dbl>   <dbl> <fct>   <dbl> <dbl>
##  1     1         1       3 buttery   0     0
##  2     1         1       3 grassy    0     0
##  3     1         1       3 painty    5.5   0
##  4     1         1       3 potato    2.9  14
##  5     1         1       3 rancid    0     1.1
##  6     1         1      10 buttery   6.4   5.9
##  7     1         1      10 grassy    0     2.9
##  8     1         1      10 painty    0     0
##  9     1         1      10 potato   11     9.9
## 10     1         1      10 rancid    0     2.2
## # … with 1,730 more rows
```

French Fries: Are reps like each other?

```
summarise(fries_spread,
          r = cor(`1`, `2`, use = "complete.obs"))
```

```
## # A tibble: 1 x 1
##       r
##   <dbl>
## 1 0.668
```

```
ggplot(fries_spread,
       aes(x = `1`,
           y = `2`)) +
geom_point() +
labs(title = "Data is poor quality: the replicates do not look like each other!")
```



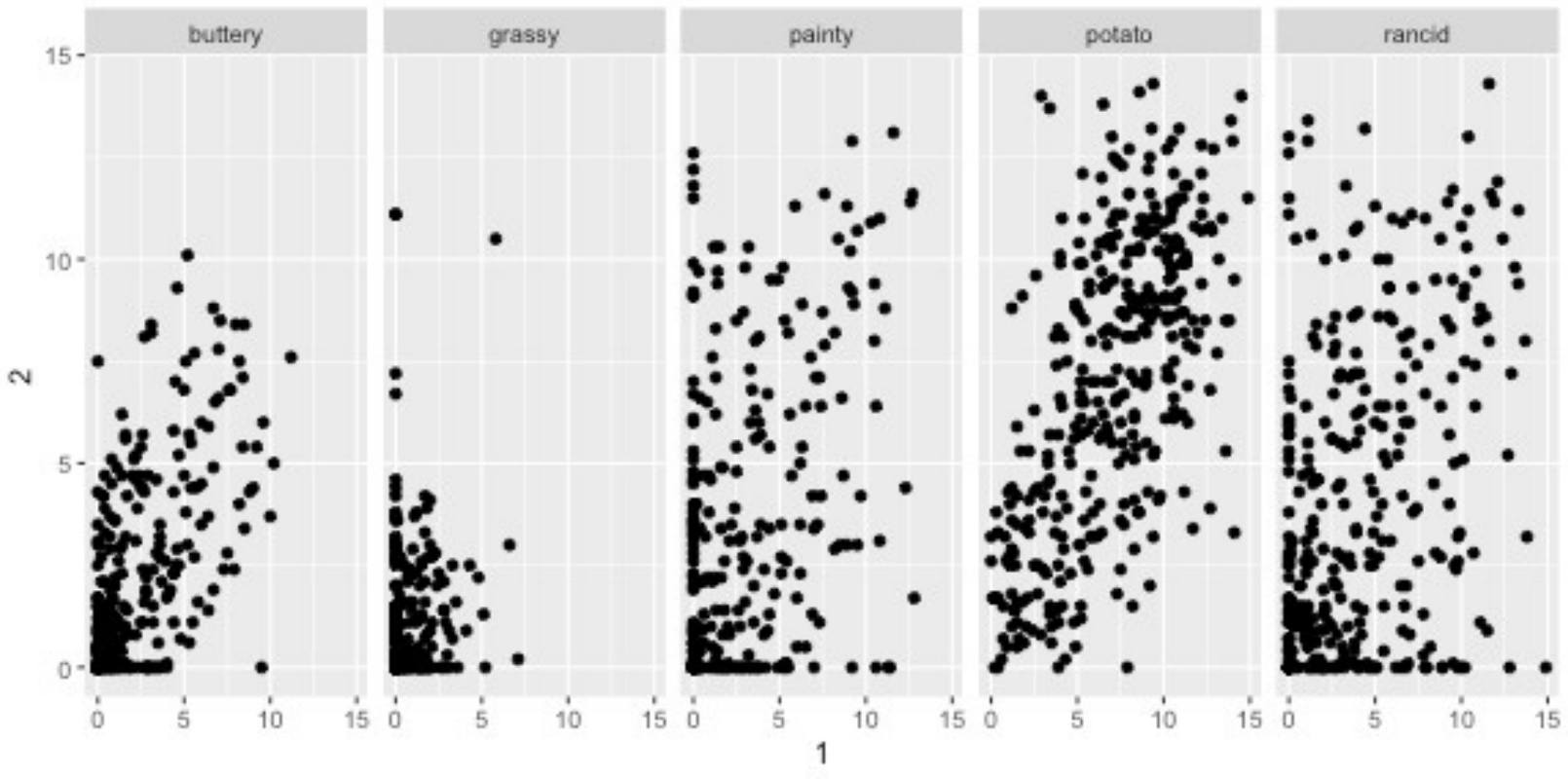
French Fries: Replicates by rating type

```
fries_spread %>%
  group_by(type) %>%
  summarise(r = cor(x = `1`,
                    y = `2`,
                    use = "complete.obs"))
```

```
## # A tibble: 5 x 2
##   type        r
##   <fct>   <dbl>
## 1 buttery 0.650
## 2 grassy  0.239
## 3 painty  0.479
## 4 potato  0.616
## 5 rancid  0.391
```

French Fries: Replicates by rating type

```
ggplot(fries_spread, aes(x=`1`, y=`2`)) +
  geom_point() + facet_wrap(~type, ncol = 5)
```



How does PISA work?

Lab exercise: Exploring data PISA data

Open `pisa.Rmd` on rstudio cloud.

Time to take the lab quiz.

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