

Intro to R

Data Cleaning

Before Cleaning - Subsetting with
Brackets

Select specific elements using an index

Often you only want to look at subsets of a data set at any given time. Elements of an R object are selected using the brackets (`[` and `]`).

For example, `x` is a vector of numbers and we can select the second element of `x` using the brackets and an index (2):

```
x = c(1, 4, 2, 8, 10)
x[2]
```

```
[1] 4
```

`dplyr`:

```
nth(x, n = 2)
```

```
[1] 4
```

Select specific elements using an index

We can select the fifth or second AND fifth elements below:

```
x = c(1, 2, 4, 8, 10)
x[5]
```

```
[1] 10
```

```
x[c(2, 5)]
```

```
[1] 2 10
```

```
nth(x, n = c(2, 5)) # nth only returns one number
```

```
Error: `n` must be a single integer.
```

Subsetting by deletion of entries

You can put a minus (-) before integers inside brackets to remove these indices from the data.

```
x[-2] # all but the second
```

```
[1] 1 4 8 10
```

Note that you have to be careful with this syntax when dropping more than 1 element:

```
x[-c(1,2,3)] # drop first 3
```

```
[1] 8 10
```

```
# x[-1:3] # shorthand. R sees as -1 to 3  
x[-(1:3)] # needs parentheses
```

```
[1] 8 10
```

Select specific elements using logical operators

What about selecting rows based on the values of two variables? We use logical statements. Here we select only elements of `x` greater than 2:

```
x
```

```
[1] 1 2 4 8 10
```

```
x > 2
```

```
[1] FALSE FALSE  TRUE  TRUE  TRUE
```

```
x[ x > 2 ]
```

```
[1] 4 8 10
```

Select specific elements using logical operators

You can have multiple logical conditions using the following:

- `&` : AND
- `|` : OR

```
x[ x > 2 & x < 5 ]
```

```
[1] 4
```

```
x[ x > 5 | x == 2 ]
```

```
[1] 2 8 10
```

which function

The `which` functions takes in logical vectors and returns the index for the elements where the logical value is `TRUE`.

```
which(x > 5 | x == 2) # returns index
```

```
[1] 2 4 5
```

```
x[ which(x > 5 | x == 2) ]
```

```
[1] 2 8 10
```

```
x[ x > 5 | x == 2 ]
```

```
[1] 2 8 10
```


Data Cleaning

In general, data cleaning is a process of investigating your data for inaccuracies, or recoding it in a way that makes it more manageable.

MOST IMPORTANT RULE - LOOK AT YOUR DATA!

Useful checking functions

- `is.na` - is TRUE if the data is FALSE otherwise
- `!` - negation (NOT)
 - if `is.na(x)` is TRUE, then `!is.na(x)` is FALSE
- `all` takes in a logical and will be TRUE if ALL are TRUE
 - `all(!is.na(x))` - are all values of `x` NOT NA
- `any` will be TRUE if ANY are true
 - `any(is.na(x))` - do we have any NA's in `x`?
- `complete.cases` - returns TRUE if EVERY value of a row is NOT NA
 - very stringent condition
 - FALSE missing one value (even if not important)
 - `tidyr::drop_na` will drop rows with **any** missing

Dealing with Missing Data

Missing data types

One of the most important aspects of data cleaning is missing values.

Types of “missing” data:

- `NA` - general missing data
- `NaN` - stands for “**N**ot **a** **N**umber”, happens when you do $0/0$.
- `Inf` and `-Inf` - Infinity, happens when you take a positive number (or negative number) by 0.

Finding Missing data

Each missing data type has a function that returns `TRUE` if the data is missing:

- `NA` - `is.na`
- `NaN` - `is.nan`
- `Inf` and `-Inf` - `is.infinite`
- `is.finite` returns `FALSE` for all missing data and `TRUE` for non-missing

Missing Data with Logicals

One important aspect (esp with subsetting) is that logical operations return NA for NA values. Think about it, the data could be > 2 or not we don't know, so R says there is no TRUE or FALSE, so that is missing:

```
x = c(0, NA, 2, 3, 4, -0.5, 0.2)
x > 2
```

```
[1] FALSE      NA FALSE    TRUE    TRUE FALSE  FALSE
```

Missing Data with Logicals

What to do? What if we want if $x > 2$ and x isn't NA?

Don't do $x \neq \text{NA}$, do $x > 2$ and x is NOT NA:

```
x != NA
```

```
[1] NA NA NA NA NA NA NA
```

```
x > 2 & !is.na(x)
```

```
[1] FALSE FALSE FALSE  TRUE  TRUE FALSE FALSE
```

Missing Data with Logicals

What about seeing if a value is equal to multiple values? You can do `(x == 1 | x == 2) & !is.na(x)`, but that is not efficient.

```
(x == 0 | x == 2) # has NA
```

```
[1] TRUE     NA  TRUE FALSE FALSE FALSE FALSE
```

```
(x == 0 | x == 2) & !is.na(x) # No NA
```

```
[1] TRUE FALSE TRUE FALSE FALSE FALSE FALSE
```

what to do?

Missing Data with Logicals: %in%

Filter removes missing values, have to keep them if you want them:

```
df = tibble(x = x)
df %>% filter(x > 2)
```

```
# A tibble: 2 x 1
      x
  <dbl>
1     3
2     4
```

```
df %>% filter(between(x, -1, 3) | is.na(x))
```

```
# A tibble: 6 x 1
      x
  <dbl>
1     0
2    NA
3     2
4     3
5   -0.5
6    0.2
```

dplyr::filter

Be careful with missing data using subsetting:

```
x %in% c(0, 2, NA) # this
```

```
[1]  TRUE  TRUE  TRUE FALSE FALSE FALSE FALSE
```

```
x %in% c(0, 2) | is.na(x) # versus this
```

```
[1]  TRUE  TRUE  TRUE FALSE FALSE FALSE FALSE
```

Missing Data with Operations

Similarly with logicals, operations/arithmetic with `NA` will result in `NA`s:

```
x + 2
```

```
[1] 2.0 NA 4.0 5.0 6.0 1.5 2.2
```

```
x * 2
```

```
[1] 0.0 NA 4.0 6.0 8.0 -1.0 0.4
```

Lab Part 1

[Website](#)

Tables and Tabulations

Useful checking functions

- `unique` - gives you the unique values of a variable
- `table(x)` - will give a one-way table of `x`
 - `table(x, useNA = "ifany")` - will have row NA
- `table(x, y)` - will give a cross-tab of `x` and `y`
- `df %>% count(x, y)`
 - `df %>% group_by(x, y) %>% tally`

Creating One-way Tables

Here we will use `table` to make tabulations of the data. Look at `?table` to see options for missing data.

```
unique(x)
```

```
[1] 0.0 NA 2.0 3.0 4.0 -0.5 0.2
```

```
table(x, useNA = "ifany")
```

```
x
-0.5    0  0.2    2    3    4 <NA>
   1    1    1    1    1    1    1
```

```
df %>% count(x)
```

```
# A tibble: 7 x 2
      x         n
  <dbl> <int>
1 -0.5         1
2  0           1
3  0.2         1
4  2           1
5  3           1
6  4           1
7 NA          1
```

Creating One-way Tables

useNA = "ifany" will not have NA in table heading if no NA:

```
table(c(0, 1, 2, 3, 2, 3, 3, 2, 2, 3),  
      useNA = "ifany")
```

```
0 1 2 3  
1 1 4 4
```

```
tibble(x = c(0, 1, 2, 3, 2, 3, 3, 2, 2, 3)) %>% count(x)
```

```
# A tibble: 4 x 2  
      x     n  
  <dbl> <int>  
1     0     1  
2     1     1  
3     2     4  
4     3     4
```


Creating One-way Tables

You can set `useNA = "always"` to have it always have a column for NA

```
table(c(0, 1, 2, 3, 2, 3, 3, 2, 2, 3),  
      useNA = "always")
```

0	1	2	3	<NA>
1	1	4	4	0

Tables with Factors

If you use a `factor`, all levels will be given even if no exist! - (May be wanted or not):

```
fac = factor(c(0, 1, 2, 3, 2, 3, 3, 2, 2, 3),  
             levels = 1:4)  
tab = table(fac)  
tab
```

```
fac  
1 2 3 4  
1 4 4 0
```

```
tab[ tab > 0 ]
```

```
fac  
1 2 3  
1 4 4
```

Factors cont

```
tibble(x = fac) %>% count(x)
```

```
# A tibble: 4 x 2
  x         n
  <fct> <int>
1 1         1
2 2         4
3 3         4
4 <NA>      1
```

Creating Two-way Tables

A two-way table. If you pass in 2 vectors, `table` creates a 2-dimensional table.

```
tab <- table(c(0, 1, 2, 3, 2, 3, 3, 2, 2, 3),  
             c(0, 1, 2, 3, 2, 3, 3, 4, 4, 3),  
             useNA = "always")  
tab
```

	0	1	2	3	4	<NA>
0	1	0	0	0	0	0
1	0	1	0	0	0	0
2	0	0	2	0	2	0
3	0	0	0	4	0	0
<NA>	0	0	0	0	0	0

Creating Two-way Tables

```
tab_df = tibble(x = c(0, 1, 2, 3, 2, 3, 3, 2, 2, 3),  
                 y = c(0, 1, 2, 3, 2, 3, 3, 4, 4, 3))  
tab_df %>% count(x, y)
```

```
# A tibble: 5 x 3  
      x     y     n  
  <dbl> <dbl> <int>  
1     0     0     1  
2     1     1     1  
3     2     2     2  
4     2     4     2  
5     3     3     4
```

Finding Row or Column Totals

`margin.table` finds the marginal sums of the table. `margin` is 1 for rows, 2 for columns in general in R. Here is the column sums of the table:

```
tab
```

	0	1	2	3	4	<NA>
0	1	0	0	0	0	0
1	0	1	0	0	0	0
2	0	0	2	0	2	0
3	0	0	0	4	0	0
<NA>	0	0	0	0	0	0

```
margin.table(tab, 2)
```

	0	1	2	3	4	<NA>
1	1	1	2	4	2	0

Proportion Tables

`prop.table` finds the marginal proportions of the table. Think of it dividing the table by it's respective marginal totals. If `margin` not set, divides by overall total.

```
prop.table(tab)
```

	0	1	2	3	4	<NA>
0	0.1	0.0	0.0	0.0	0.0	0.0
1	0.0	0.1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.2	0.0	0.2	0.0
3	0.0	0.0	0.0	0.4	0.0	0.0
<NA>	0.0	0.0	0.0	0.0	0.0	0.0

```
prop.table(tab,1) * 100
```

	0	1	2	3	4	<NA>
0	100	0	0	0	0	0
1	0	100	0	0	0	0
2	0	0	50	0	50	0
3	0	0	0	100	0	0
<NA>						

Creating Two-way Tables

```
tab_df %>%  
  count(x, y) %>%  
  group_by(x) %>% mutate(pct_x = n / sum(n))
```

```
# A tibble: 5 x 4  
# Groups:   x [4]  
      x     y     n pct_x  
  <dbl> <dbl> <int> <dbl>  
1     0     0     1     1  
2     1     1     1     1  
3     2     2     2    0.5  
4     2     4     2    0.5  
5     3     3     4     1
```


Creating Two-way Tables

```
library(scales)
tab_df %>%
  count(x, y) %>%
  group_by(x) %>% mutate(pct_x = percent(n / sum(n)))
```

```
# A tibble: 5 x 4
# Groups:   x [4]
      x     y     n pct_x
  <dbl> <dbl> <int> <chr>
1     0     0     1 100%
2     1     1     1 100%
3     2     2     2  50%
4     2     4     2  50%
5     3     3     4 100%
```

Lab Part 2

[Website](#)

Download Salary FY2014 Data

From <https://data.baltimorecity.gov/City-Government/Baltimore-City-Employee-Salaries-FY2015/nsfe-bg53>, from <https://data.baltimorecity.gov/api/views/nsfe-bg53/rows.csv>

Read the CSV into R `Sal`:

```
Sal = jhur::read_salaries() # or  
Sal = read_csv("https://jhudatascience.org/intro_to_r/data/Baltimore_City_Empl  
Sal = rename(Sal, Name = name)
```

Checking for logical conditions

- `any()` - checks if there are any TRUES
- `all()` - checks if ALL are true

```
head(Sal, 2)
```

```
# A tibble: 2 x 7
  Name      JobTitle      AgencyID Agency      HireDate AnnualSalary GrossP
  <chr>     <chr>         <chr>    <chr>      <chr>     <chr>      <chr>
1 Aaron, Pa... Facilities/Off... A03031    OED-Employm... 10/24/1... $55314.00  $53626
2 Aaron, Pe... ASSISTANT STAT... A29045    States Atto... 09/25/2... $74000.00  $73000
```

```
any(is.na(Sal$Name)) # are there any NAs?
```

```
[1] FALSE
```

Recoding Variables

Example of Recoding

For example, let's say gender was coded as Male, M, m, Female, F, f. Using Excel to find all of these would be a matter of filtering and changing all by hand or using if statements.

In `dplyr` you can use the `recode` function:

```
data = data %>%  
  mutate(gender = recode(gender, M = "Male", m = "Male", M = "Male"))
```

or use `ifelse`:

```
data %>%  
  mutate(gender = ifelse(gender %in% c("Male", "M", "m"),  
                          "Male", gender))
```

Example of Cleaning: more complicated

Sometimes though, it's not so simple. That's where functions that find patterns come in very useful.

```
table(gender)
```

```
gender
```

F	FeMAle	FEMALE	Fm	M	Ma	mAle	Male	MaLe	MALE	Man
80	88	76	87	99	76	84	83	79	93	84
Woman										
71										

Example of Cleaning: more complicated

```
table(gender)
```

```
gender
female Female      fm   male   Male
      164      151    87    339    259
```


Strings functions

Splitting/Find/Replace and Regular Expressions

- R can do much more than find exact matches for a whole string
- Like Perl and other languages, it can use regular expressions.
- What are regular expressions?
 - Ways to search for specific strings
 - Can be very complicated or simple
 - Highly Useful - think “Find” on steroids

A bit on Regular Expressions

- <http://www.regular-expressions.info/reference.html>
- They can use to match a large number of strings in one statement
- `.` matches any single character
- `*` means repeat as many (even if 0) more times the last character
- `?` makes the last thing optional
- `^` matches start of vector `^a` - starts with "a"
- `$` matches end of vector `b$` - ends with "b"

The **stringr** package

The `stringr` package:

- Makes string manipulation more intuitive
- Has a standard format for most functions
 - the first argument is a string like first argument is a `data.frame` in `dplyr`
- We will not cover `grep` or `gsub` - base R functions
 - are used on forums for answers
- Almost all functions start with `str_*`

Let's look at modifier for **stringr**

?modifiers

- `fixed` - match everything exactly
- `regex` - default - uses **regular expressions**
- `ignore_case` is an option to not have to use `tolower`

Substring and String Splitting

- `str_sub(x, start, end)` - substrings from position start to position end
- `str_split(string, pattern)` - splits strings up - returns list!

```
library(stringr)
x <- c("I really", "like writing", "R code programs")
y <- str_split(x, " ") # returns a list
y
```

```
[[1]]
[1] "I"      "really"
```

```
[[2]]
[1] "like"   "writing"
```

```
[[3]]
[1] "R"      "code"   "programs"
```

Using a fixed expression

One example case is when you want to split on a period ".". In regular expressions . means **ANY** character, so

```
str_split("I.like.strings", ".")
```

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

```
str_split("I.like.strings", fixed("."))
```

```
[[1]]  
[1] "I"      "like"    "strings"
```

Let's extract from **y**

```
y[[2]]
```

```
[1] "like"      "writing"
```

```
sapply(y, dplyr::first) # on the fly
```

```
[1] "I"        "like" "R"
```

```
sapply(y, nth, 2) # on the fly
```

```
[1] "really"    "writing" "code"
```

```
sapply(y, last) # on the fly
```

```
[1] "really"    "writing" "programs"
```


Separating columns based on a separator

- From `tidyr`, you can split a data set into multiple columns:

```
df = tibble(x = c("I really", "like writing", "R code programs"))
```

```
df %>% separate(x, into = c("first", "second", "third"))
```

Warning: Expected 3 pieces. Missing pieces filled with `NA` in 2 rows [1, 2].

```
# A tibble: 3 x 3
  first second third
<chr> <chr>  <chr>
1 I      really <NA>
2 like   writing  <NA>
3 R      code   programs
```

Separating columns based on a separator

- From `tidyr`, you can split a data set into multiple columns:

```
df = tibble(x = c("I really", "like writing", "R code programs"))
```

```
df %>% separate(x, into = c("first", "second"))
```

Warning: Expected 2 pieces. Additional pieces discarded in 1 rows [3].

```
# A tibble: 3 x 2
  first second
  <chr> <chr>
1 I      really
2 like   writing
3 R      code
```

Separating columns based on a separator

- `extra = "merge"` will not drop data. Also, you can specify the separator

```
df = tibble(x = c("I really", "like. _writing R. But not", "R code programs"))
```

```
df %>% separate(x, into = c("first", "second", "third"), extra = "merge")
```

Warning: Expected 3 pieces. Missing pieces filled with `NA` in 1 rows [1].

```
# A tibble: 3 x 3
  first second  third
<chr> <chr>    <chr>
1 I      really  <NA>
2 like   writing R. But not
3 R      code    programs
```

Separating columns based on a separator

- `extra = "merge"` will not drop data. Also, you can specify the separator

```
df %>% separate(x, into = c("first", "second", "third"),  
               extra = "merge", sep = " ")
```

Warning: Expected 3 pieces. Missing pieces filled with `NA` in 1 rows [1].

```
# A tibble: 3 x 3  
  first second  third  
  <chr> <chr>    <chr>  
1 I      really  <NA>  
2 like.  _writing R. But not  
3 R      code    programs
```

'Find' functions: **stringr**

`str_detect`, `str_subset`, `str_replace`, and `str_replace_all` search for matches to argument pattern within each element of a character vector: they differ in the format of and amount of detail in the results.

- `str_detect` - returns TRUE if pattern is found
- `str_subset` - returns only the strings which pattern were detected
 - convenient wrapper around `x[str_detect(x, pattern)]`
- `str_extract` - returns only strings which pattern were detected, but ONLY the pattern
- `str_replace` - replaces pattern with replacement the first time
- `str_replace_all` - replaces pattern with replacement as many times matched

'Find' functions: Finding Logicals

These are the indices where the pattern match occurs:

```
head(str_detect(Sal$Name, "Rawlings"))
```

```
[1] FALSE FALSE FALSE FALSE FALSE FALSE
```

'Find' functions: Finding Indices

These are the indices where the pattern match occurs:

```
which(str_detect(Sal$Name, "Rawlings"))
```

```
[1] 10256 10257 10258
```

Showing difference in `str_extract`

`str_extract` extracts just the matched string

```
ss = str_extract(Sal$Name, "Rawling")  
head(ss)
```

```
[1] NA NA NA NA NA NA
```

```
ss[ !is.na(ss) ]
```

```
[1] "Rawling" "Rawling" "Rawling"
```


'Find' functions: finding values, **stringr** and **dplyr**

```
str_subset(Sal$Name, "Rawlings")
```

```
[1] "Rawlings,Kellye A"          "Rawlings,Paula M"  
[3] "Rawlings-Blake,Stephanie C"
```

```
Sal %>% filter(str_detect(Name, "Rawlings"))
```

```
# A tibble: 3 x 7
```

	Name <chr>	JobTitle <chr>	AgencyID <chr>	Agency <chr>	HireDate <chr>	AnnualSalary <chr>	GrossPay <chr>
1	Rawlings,Ke...	EMERGENCY D...	A40302	M-R Info Te...	01/06/2...	\$48940.00	\$73356
2	Rawlings,Pa...	COMMUNITY A...	A04015	R&P-Recreat...	12/10/2...	\$19802.00	\$10443
3	Rawlings-Bl...	MAYOR	A01001	Mayors Offi...	12/07/1...	\$167449.00	\$16524

Using Regular Expressions

- Look for any name that starts with:
 - Payne at the beginning,
 - Leonard and then an S
 - Spence then capital C

```
head(str_subset( Sal$Name, "^Payne.*"), 3)
```

```
[1] "Payne El,Boaz L"      "Payne El,Jackie"  
[3] "Payne Johnson,Nickole A"
```

```
head(str_subset( Sal$Name, "Leonard.?S"))
```

```
[1] "Payne,Leonard S"      "Szumlanski,Leonard S"
```

```
head(str_subset( Sal$Name, "Spence.*C.*"))
```

```
[1] "Spencer,Charles A"  "Spencer,Clarence W" "Spencer,Michael C"
```

Showing difference in `str_extract` and `str_extract_all`

`str_extract_all` extracts all the matched strings - `\\d` searches for DIGITS/numbers

```
head(str_extract(Sal$AgencyID, "\\d"))
```

```
[1] "0" "2" "6" "9" "4" "9"
```

```
head(str_extract_all(Sal$AgencyID, "\\d"), 2)
```

```
[[1]]  
[1] "0" "3" "0" "3" "1"
```

```
[[2]]  
[1] "2" "9" "0" "4" "5"
```

Showing difference in `str_replace` and `str_replace_all`

`str_replace_all` extracts all the matched strings

```
head(str_replace(Sal$Name, "a", "j"))
```

```
[1] "Airon, Patricia G"      "Airon, Petra L"        "Abjineh, Yohannes T"  
[4] "Abbene, Anthony M"     "Abbey, Emmjnuel"       "Abbott-Cole, Michelle"
```

```
head(str_replace_all(Sal$Name, "a", "j"), 2)
```

```
[1] "Airon, Pjtricij G" "Airon, Petrj L"
```

Replace

Let's say we wanted to sort the data set by Annual Salary:

```
class(Sal$AnnualSalary)
```

```
[1] "character"
```

```
head(Sal$AnnualSalary, 4)
```

```
[1] "$55314.00" "$74000.00" "$64500.00" "$46309.00"
```

```
head(as.numeric(Sal$AnnualSalary), 4)
```

Warning in head(as.numeric(Sal\$AnnualSalary), 4): NAs introduced by coercion

```
[1] NA NA NA NA
```

R didn't like the \$ so it thought turned them all to NA.

Replacing and substituting

Now we can replace the \$ with nothing (used `fixed("$")` because \$ means ending):

```
Sal = Sal %>% mutate(  
  AnnualSalary = str_replace(AnnualSalary, fixed("$"), ""),  
  AnnualSalary = as.numeric(AnnualSalary)  
) %>%  
  arrange(desc(AnnualSalary))
```

Pasting strings with `paste` and `paste0`

Paste can be very useful for joining vectors together:

```
paste("Visit", 1:5, sep = "_")
```

```
[1] "Visit_1" "Visit_2" "Visit_3" "Visit_4" "Visit_5"
```

```
paste("Visit", 1:5, sep = "_", collapse = " ")
```

```
[1] "Visit_1 Visit_2 Visit_3 Visit_4 Visit_5"
```

```
paste("To", "is going be the ", "we go to the store!", sep = "day ")
```

```
[1] "Today is going be the day we go to the store!"
```

```
# and paste0 can be even simpler see ?paste0  
paste0("Visit", 1:5)
```

```
[1] "Visit1" "Visit2" "Visit3" "Visit4" "Visit5"
```

Uniting columns based on a separator

- From `tidyr`, you can unite:

```
df = tibble(id = rep(1:5, 3), visit = rep(1:3, each = 5))
```

```
df %>% unite(col = "unique_id", id, visit, sep = "_")
```

```
# A tibble: 15 x 1
```

```
  unique_id
```

```
  <chr>
```

```
1 1_1
2 2_1
3 3_1
4 4_1
5 5_1
6 1_2
7 2_2
8 3_2
9 4_2
10 5_2
11 1_3
12 2_3
13 3_3
14 4_3
15 5_3
```


Uniting columns based on a separator

- From `tidyr`, you can unite:

```
df = tibble(id = rep(1:5, 3), visit = rep(1:3, each = 5))
```

```
df %>% unite(col = "unique_id", id, visit, sep = "_", remove = FALSE)
```

```
# A tibble: 15 x 3
  unique_id    id visit
  <chr>      <int> <int>
1 1_1          1     1
2 2_1          2     1
3 3_1          3     1
4 4_1          4     1
5 5_1          5     1
6 1_2          1     2
7 2_2          2     2
8 3_2          3     2
9 4_2          4     2
10 5_2         5     2
11 1_3          1     3
12 2_3          2     3
13 3_3          3     3
14 4_3          4     3
15 5_3          5     3
```

Paste Depicting How Collapse Works

```
paste(1:5)
```

```
[1] "1" "2" "3" "4" "5"
```

```
paste(1:5, collapse = " ")
```

```
[1] "1 2 3 4 5"
```

Useful String Functions

Useful String functions

- `toupper()`, `tolower()` - uppercase or lowercase your data:
- `str_trim()` (in the `stringr` package) or `trimws` in base
 - will trim whitespace
- `nchar` - get the number of characters in a string

Sorting characters

- `sort` - reorders the data - characters work, but not correctly
- `rank` - gives the rank of the data - ties are split
- `order` - gives the indices, if subset, would give the data sorted
 - `x[order(x)]` is the same as sorting

```
sort(c("1", "2", "10")) # not sort correctly (order simply ranks the data)
```

```
[1] "1"  "10" "2"
```

```
order(c("1", "2", "10"))
```

```
[1] 1 3 2
```

```
x = rnorm(10)
x[1] = x[2] # create a tie
rank(x)
```

```
[1] 2.5 2.5 10.0 7.0 4.0 1.0 8.0 5.0 9.0 6.0
```

Lab Part 3

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Comparison of **stringr** to base R -
not covered

Splitting Strings

Substringing

Very similar:

Base R

- `substr(x, start, stop)` - substrings from position start to position stop
- `strsplit(x, split)` - splits strings up - returns list!

stringr

- `str_sub(x, start, end)` - substrings from position start to position end
- `str_split(string, pattern)` - splits strings up - returns list!

Splitting String: base R

In base R, `strsplit` splits a vector on a string into a list

```
x <- c("I really", "like writing", "R code programs")  
y <- strsplit(x, split = " ") # returns a list  
y
```

```
[[1]]  
[1] "I"      "really"
```

```
[[2]]  
[1] "like"   "writing"
```

```
[[3]]  
[1] "R"      "code"   "programs"
```

Showing difference in `str_extract` and `str_extract_all`

`str_extract_all` extracts all the matched strings - `\\d` searches for DIGITS/numbers

```
head(str_extract(Sal$AgencyID, "\\d"))
```

```
[1] "2" "9" "6" "2" "0" "0"
```

```
head(str_extract_all(Sal$AgencyID, "\\d"), 2)
```

```
[[1]]  
[1] "2" "9" "0" "0" "1"
```

```
[[2]]  
[1] "9" "9" "3" "9" "0"
```

'Find' functions: base R

`grep`: `grep`, `grepl`, `regexpr` and `gregexpr` search for matches to argument pattern within each element of a character vector: they differ in the format of and amount of detail in the results.

`grep(pattern, x, fixed=FALSE)`, where:

- `pattern` = character string containing a regular expression to be matched in the given character vector.
- `x` = a character vector where matches are sought, or an object which can be coerced by `as.character` to a character vector.
- If `fixed=TRUE`, it will do exact matching for the phrase anywhere in the vector (regular find)

'Find' functions: stringr compared to base R

Base R does not use these functions. Here is a "translator" of the `stringr` function to base R functions

- `str_detect` - similar to `grepl` (return logical)
- `grep(value = FALSE)` is similar to `which(str_detect())`
- `str_subset` - similar to `grep(value = TRUE)` - return value of matched
- `str_replace` - similar to `sub` - replace one time
- `str_replace_all` - similar to `gsub` - replace many times

Important Comparisons

Base R:

- Argument order is `(pattern, x)`
- Uses option `(fixed = TRUE)`

`stringr`

- Argument order is `(string, pattern)` aka `(x, pattern)`
- Uses function `fixed(pattern)`

'Find' functions: Finding Indices

These are the indices where the pattern match occurs:

```
grep("Rawlings", Sal$Name)
```

```
[1]      9  6854 13284
```

```
which(grepl("Rawlings", Sal$Name))
```

```
[1]      9  6854 13284
```

```
which(str_detect(Sal$Name, "Rawlings"))
```

```
[1]      9  6854 13284
```

'Find' functions: Finding Logicals

These are the indices where the pattern match occurs:

```
head(grepl("Rawlings", Sal$Name))
```

```
[1] FALSE FALSE FALSE FALSE FALSE FALSE
```

```
head(str_detect(Sal$Name, "Rawlings"))
```

```
[1] FALSE FALSE FALSE FALSE FALSE FALSE
```


'Find' functions: finding values, base R

```
grep("Rawlings", Sal$Name, value=TRUE)
```

```
[1] "Rawlings-Blake, Stephanie C" "Rawlings, Kellye A"  
[3] "Rawlings, Paula M"
```

```
Sal[grep("Rawlings", Sal$Name), ]
```

```
# A tibble: 3 x 7
```

	Name	JobTitle	AgencyID	Agency	HireDate	AnnualSalary	GrossPay
	<chr>	<chr>	<chr>	<chr>	<chr>	<dbl>	<chr>
1	Rawlings-Bl...	MAYOR	A01001	Mayors Offi...	12/07/1...	167449	\$16524
2	Rawlings, Ke...	EMERGENCY D...	A40302	M-R Info Te...	01/06/2...	48940	\$73356
3	Rawlings, Pa...	COMMUNITY A...	A04015	R&P-Recreat...	12/10/2...	19802	\$10443

Showing difference in `str_extract`

`str_extract` extracts just the matched string

```
ss = str_extract(Sal$Name, "Rawling")  
head(ss)
```

```
[1] NA NA NA NA NA NA
```

```
ss[ !is.na(ss) ]
```

```
[1] "Rawling" "Rawling" "Rawling"
```

Showing difference in `str_extract` and `str_extract_all`

`str_extract_all` extracts all the matched strings

```
head(str_extract(Sal$AgencyID, "\\d"))
```

```
[1] "2" "9" "6" "2" "0" "0"
```

```
head(str_extract_all(Sal$AgencyID, "\\d"), 2)
```

```
[[1]]
```

```
[1] "2" "9" "0" "0" "1"
```

```
[[2]]
```

```
[1] "9" "9" "3" "9" "0"
```

Using Regular Expressions

- Look for any name that starts with:
 - Payne at the beginning,
 - Leonard and then an S
 - Spence then capital C

```
head(grep("^Payne.*", x = Sal$Name, value = TRUE), 3)
```

```
[1] "Payne,James R" "Payne,Karen V" "Payne,Jasman T"
```

```
head(grep("Leonard.?S", x = Sal$Name, value = TRUE))
```

```
[1] "Szumlanski,Leonard S" "Payne,Leonard S"
```

```
head(grep("Spence.*C.*", x = Sal$Name, value = TRUE))
```

```
[1] "Spencer,Michael C" "Spencer,Clarence W" "Spencer,Charles A"
```

Using Regular Expressions: **stringr**

```
head(str_subset( Sal$Name, "^Payne.*"), 3)
```

```
[1] "Payne,James R" "Payne,Karen V" "Payne,Jasman T"
```

```
head(str_subset( Sal$Name, "Leonard.?S"))
```

```
[1] "Szumlanski,Leonard S" "Payne,Leonard S"
```

```
head(str_subset( Sal$Name, "Spence.*C.*"))
```

```
[1] "Spencer,Michael C" "Spencer,Clarence W" "Spencer,Charles A"
```

Replace

Let's say we wanted to sort the data set by Annual Salary:

```
class(Sal$AnnualSalary)
```

```
[1] "numeric"
```

```
sort(c("1", "2", "10")) # not sort correctly (order simply ranks the data)
```

```
[1] "1"  "10" "2"
```

```
order(c("1", "2", "10"))
```

```
[1] 1 3 2
```

Replace

So we must change the annual pay into a numeric:

```
head(Sal$AnnualSalary, 4)
```

```
[1] 238772 211785 200000 192500
```

```
head(as.numeric(Sal$AnnualSalary), 4)
```

```
[1] 238772 211785 200000 192500
```

R didn't like the \$ so it thought turned them all to NA.

`sub()` and `gsub()` can do the replacing part in base R.

Replacing and subbing

Now we can replace the \$ with nothing (used `fixed=TRUE` because \$ means ending):

```
Sal$AnnualSalary <- as.numeric(gsub(pattern = "$", replacement="",  
                                   Sal$AnnualSalary, fixed=TRUE))  
Sal <- Sal[order(Sal$AnnualSalary, decreasing=TRUE), ]  
Sal[1:5, c("Name", "AnnualSalary", "JobTitle")]
```

```
# A tibble: 5 x 3  
  Name                AnnualSalary JobTitle  
  <chr>                <dbl> <chr>  
1 Mosby, Marilyn J    238772 STATE'S ATTORNEY  
2 Batts, Anthony W    211785 Police Commissioner  
3 Wen, Leana          200000 Executive Director III  
4 Raymond, Henry J    192500 Executive Director III  
5 Swift, Michael      187200 CONTRACT SERV SPEC II
```


Replacing and subbing: **stringr**

We can do the same thing (with 2 piping operations!) in dplyr

```
dplyr_sal = Sal
dplyr_sal = dplyr_sal %>% mutate(
  AnnualSalary = AnnualSalary %>%
    str_replace(
      fixed("$"),
      "") %>%
    as.numeric() %>%
    arrange(desc(AnnualSalary))
check_Sal = Sal
rownames(check_Sal) = NULL
all.equal(check_Sal, dplyr_sal)
```

```
[1] TRUE
```

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