

# Practical Exercises for **Exercise Collection**

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## Exercise 1

- (a) Open R Studio
- (b) Open a new R-Script
- (c) Load data set `chickwts`
- (d) Do summary statistic (numerically and graphically)
- (e) For advanced R users: Try an anova (are the assumptions fulfilled?) and a Tukey-Anscombe plot.  
Try a histogram with a density line on top. ...

## Exercise 2

- (a) Create a data frame with 3 columns.

## Exercise 3

- (a) Install package `MASS`.
- (b) Load data set `bacteria`.
- (c) Describe in your own words what the data set `bacteria` contains.
- (d) Do summary statistic (numerically and graphically).
- (e) Select only observations collected during the second week.

## Exercise 4

What is conceptionally the difference between the bracket types `[...]` and `(...)`?

```
chickwts[, 2]  
summary(aov(weight ~ feed, data = chickwts))
```

## Exercise 5

- How many levels has the factor variable `trt` from `bacteria`?
- Define a new variable `trt.new` in which you combine the levels `drug` and `drug+` into one single level and label it as `treated`. The new variable `trt.new` should in the end have two levels: `placebo` and `treated`.
- Do summary statistics for `placebo` and `treated` group.

## Exercise 6

- Load data set `ToothGrowth`.
- Do summary statistic (numerically and graphically).
- Define additional column `dose.factor` by converting the numeric variable `dose` into a factor variable.
- Are the tooth length measurements normally distributed within the treatment (`supp`: `VC` or `OJ`) and within in the different doses (`dose`: 0.5, 1, 2)?

## Exercise 7

- Import the data set `perulung_ems.csv` (taken from Kirkwood and Sterne, 2nd edition) into R.  
Data from a study of lung function among children living in a deprived suburb of Lima, Peru.  
Variables:
  - `fev1`: in liter, "Forced Expiratory Volume in 1 second" measured by a spirometer. This is the maximum volume of air which the children could breath out in 1 second
  - `age`: in years
  - `height`: in cm
  - `sex`: 0 = girl, 1 = boy
  - `respsymp`: respiratory symptoms experienced by the child over the previous 12 months
- What *delimiter* do you need to choose?
- Do all variables have the correct data type (numeric, integer, factor)? If not, do correct and / or define them.
- Check for heteroscedascity or homogeneity of variances

## Exercise 8

Apply the summary statistics to the `perlung_ems` and `ToothGrowth` data set.

## Exercise 9A: Plausibility Checks

- (a) What can go wrong?
- (b) Identify different strategies for spotting these potential errors.
  - Logical errors
  - Spelling mistakes
- (c) Import the data set `bacteria_plausibility_check.csv` to R.
- (d) Detect the **six** errors in the imported data set `bacteria_plausibility_check.csv` in R.
- (e) Find possible solutions in R how to handle these challenges.
- (f) Do all variables have the correct data type (numeric, integer, factor)? - If not, do correct / define them.

## Exercise 9B: Missing Values

- (a) Check out the difference between the different missing values.

```
y1 <- c(2, 4, 3, NA, 6, 1)
y2 <- c("diseased", "healthy", NA, "NA")
y3 <- c(1, "NA", 0, 1, NaN)
#
is.na(y1)
which(is.na(y1))
is.na(y2)
which(is.na(y2))
is.na(y3)
which(is.na(y3))
is.nan(y3)
```

- (b) Create a vector with missing values and determine the mean and median.
- (c) If `x = c(22,3,7,NA,NA,67)` what will be the output for the R statement `length(x)`?

- (d) If  $x = c(\text{NA}, 3, 14, \text{NA}, 33, 17, \text{NA}, 41)$  which line of R code removes all occurrences of NA in  $x$ .
- (e) If  $y = c(1, 3, 12, \text{NA}, 33, 7, \text{NA}, 21)$  what R statement will replace all occurrences of NA with 11?
- (f) If  $x = c(34, 33, 65, 37, 89, \text{NA}, 43, \text{NA}, 11, \text{NA}, 23, \text{NA})$  then what will count the number of occurrences of NA in  $x$ ?
- (g) Create the vector  $x1$ . Then, find again the number of missing values and their position.

```
x1 <- c(rnorm(10,5,2), NA, 5:12, NA, 6, 7.5, NA)
```

- (h) Now, create the vector  $x2$  and assess the difference to  $x1$ .

```
x2 <- c(rnorm(10,5,2), NA, 5:12, NA, 6, 7.5, NA, log(-2))
```

- (i) What is the meaning of "NA" versus "NaN"?
- (j) Replace the missing values in  $x1$  with a 0. Check then that the NAs are no longer present. Try two different commands to coerce the NAs into 0.

## Exercise 10

- (a) Import the data set `water_errors.csv` to R: A data frame with 61 observations on the following 6 variables.
- **location**: a factor with levels `North` and `South` indicating whether the town is as north as Derby.
  - **town**: the name of the town.
  - **mortality**: averaged annual mortality per 100.000 male inhabitants.
  - **hardness**: calcium concentration (in parts per million).
  - **smoker**: If there are any smokers living in town.
  - **num.of.cig**: In case, smokers live in town, what number of cigarettes do they smoke per day.
- (b) Detect the errors in the imported data set `water_errors.csv` in R.
- (c) Find possible solutions in R how to handle these challenges.
- (d) Do all variables have the correct data type (numeric, integer, factor)? - If not, do correct / define them.

## Exercise 11

- (a) Load the data set `ToothGrowth` within R and apply the two-sided two sample t-test to suitable variables of the data set.

```
data(ToothGrowth)
```

- (b) Interpret the results.
- (c) Read in the data set `perulung_ems` and apply the two-sided t-test to suitable variables of the `perulung_ems` data set and interpret the results.

## Exercise 12

- (a) Apply the Chi-square test and the fisher exact test to the whole `bacteria` data set.
- (b) Apply the Chi-square test and the fisher exact test to the subset of `bacteria` containing only the observations taken in week 2 (cf. Exercise 3). Are there any issues?
- (c) Repeat this exercise by using the (previously defined) combined `trt.new` variable (cf. Exercise 5) with the two levels `treated` and `drug`.
- (d) Could you also obtain the odds ratios?
- (e) Try also a logistic regression in R. Ask Google for help!

## Exercise 13A: Outside plot frame

- (a) Type `demo(graphics)` in your console and press enter. This command shows you a nice demonstration of possible R graphics.

```
# After the demonstration us the following commands:  
dev.off()  
par(mfrow=c(1,1))
```

- (b) Change the x-axis and y-axis labelling of a boxplot plotting the `len` variable of the `ToothGrowth` data set.

```
data("ToothGrowth")  
boxplot(ToothGrowth$len)
```

- (c) How do you set a main title for your above plot?
- (d) What does the following command do?

```
par(mfrow=c(2,2))
```

- (e) We have six different feed types in `chickwts`. Try to plot two separate boxplots for `casein` and `horsebean` and set the same minimum and maximum for the y-axis. Use the function `subset` for doing so.
- (f) How do you enlarge the font size of the axis as well as the axis labels of the following plot with the `perulung` data set?

```
lung <- read.csv("perulung_ems.csv", sep=";")
par(mfrow=c(1,1))
plot(lung$fev1, lung$height)
```

- (g) Label the x-axis of the following plot with "Vitamin C in  $\mu\text{g}$ ". Use the greek letter for  $\mu$ .

```
plot(ToothGrowth$dose, ToothGrowth$len)
```

- (h) Read <http://www.statmethods.net/advgraphs/parameters.html>.

## Exercise 13B: Inside the square of the plot

- (a) Type `demo(graphics)` in your console and press enter. This command shows you a nice demonstration of possible R graphics.

```
# After the demonstration us the following commands:
dev.off()
par(mfrow=c(1,1))
```

- (b) Add a legend to the following barplot. Are there several different solutions for this?

```
library("MASS")
data("bacteria")
barplot(prop.table(table(bacteria$y, bacteria$trt),margin=1),
        beside=FALSE, ylim = c(0,0.8))
```

(c) Add a density line to this histogram.

```
hist(ToothGrowth$len, prob = TRUE, col = "grey", ylim = c(0, 0.05))
```

(d) Add a **dotted red** linear regression line to the following plot.

```
plot(lung$height, lung$fev1)
```

(e) Color the points in the following plot according to the `sex` variable.

```
plot(lung$height, lung$fev1)
```

(f) Add two linear regression lines separately for `female` and `male` to the following plot.

```
plot(lung$height, lung$fev1)
```

(g) Color the points in the following plot according to the `supp` variable. Use different point characters (`pch`) based on the `supp` variable.

```
plot(ToothGrowth$len, ToothGrowth$dose)
```

(h) Read <http://www.statmethods.net/advgraphs/parameters.html>.

## Exercise 14

(a) Load the below data set and for further information check the command `?water`.

```
# install.packages("HSAUR3")  
library("HSAUR3")  
data("water")  
str(water)  
head(water)  
summary(water)
```

(b) Try to plot the variables `mortality` against `hardness` from the `water` data set.

(c) Add a main title to the above plot (`mortality` against `hardness`).

- (d) Change the ...
- (a) font size of the axis annotation
  - (b) font size of the x- and y-axis labels
  - (c) the point sizes within the plot
- ... of the above plot (mortality against hardness).
- (e) Looking at the above plot: Do you think the two variables `hardness` and `mortality` correlate? What function do you use to find out the correlation coefficient? Do they have a positive or a negative correlation coefficient? How do you interpret the correlation coefficient in your own words?
- (f) In the `water` data set, can you graphically find out if there is a difference between the the two variables `hardness` and `mortality` conditional on the `location` (`North`, `South`).
- (g) Add a legend to the above plot so that you can easily differentiate the locations (`North` or `South`) of the observations.
- (h) Do a barplot of the variable `location` from the `water` data set.
- (i) ADDITIONAL: Try if any of these following plotting functions can be applied to the data sets `perulung` or `ToothGrowth`.

## Exercise 15

- (a) Open the .R file `ANOVA_with_chickwts.R` from your RCourse folder and have another look on how we applied the anova to the `chickwts` data set. Check line for line.
- (b) Load the `ToothGrowth` data set into R and encode the numeric variable `dose` as a factor variable. Define the new factor variable as `dose.factor` with the three levels `low`, `med` and `high` and add it to the data frame of `ToothGrowth`.

```
data(ToothGrowth)
```

- (c) Visualize the variable `len` per `dose.factor` level in a boxplot.
- (d) With the help of the R-commands written in the `ANOVA_with_chickwts.R` file, apply a analysis of variance (ANOVA) to the data set `ToothGrowth`



## Exercise 16

- (a) Download the .R file LM\_with\_water.R from the switch drive and have another look on how we applied the linear model to the water data set.
- (b) Reuse these commands to fit a simple as well as multiple linear regression model to the data set of perulung\_ems. Use fev1 as your response variable  $y$ .

## Exercise 17

- (a) Load the ToothGrowth data set and run the following four linear regression models.

```
data(ToothGrowth)
ToothGrowth$dose.factor <- factor(ToothGrowth$dose, levels = c(0.5, 1.0, 2.0),
                                  labels = c("low", "med", "high"))
mod1 <- lm(len ~ dose.factor, data = ToothGrowth)
mod2 <- lm(len ~ supp, data = ToothGrowth)
mod3 <- lm(len ~ dose.factor + supp, data = ToothGrowth)
mod4 <- lm(len ~ dose.factor*supp, data = ToothGrowth)
```

- (b) Have a look at the summary of these models.
- (c) How do you interpret the model coefficients?
- (d) Which model is best?

## Exercise 18

- (a) Load the water data set and fit a multiple linear regression model. Use mortality as your response variable and add hardness and location as an explanatory variable.
- (b) Check the underlying model assumptions.
- (c) Add an interaction term between hardness and location to the above estimated multiple linear regression model.
- (d) Interpret the interaction coefficient hardness:locationSouth.
- (e) Check the underlying model assumptions.
- (f) Which one is the better model? With or without the interaction term?
- (g) How to derive confidence intervals for the regression coefficient of hardness and location?

## Exercise 19

**Hypothetical example** - from Kirkwood and Sterne, Medical Statistics, 2nd ed., p. 177

- (a) Read in the data set `lepto`. This study presents a serology survey of leptospira sero-prevalence in rural and urban areas of the west indies.
- (b) Encode the numeric variable `antibodies` as a factor with levels 0 and 1.
- (c) Make a crosstable with the risk factor `exposure` and `antibodies`.
- (d) Run a Chi-squared test, a Fisher's exact test and a logistic regression (`glm`) to assess if the `exposure` (living in rural vs. urban areas) is a risk factor.
- (e) Create a subset for male and female based on the variable `gender`.
- (f) Repeat the crosstable (2-by-2 table), Chi-squared test, Fisher's exact test and a logistic regression (`glm`) for the subsets **separately**.
- (g) Does the conclusion of your research question change with the analysis of the subsets? (Research question: Is the `exposure` (rural and urban areas) a risk factor?)
- (h) Fit a logistic regression model (`glm`) with `exposure` and `gender` as explanatory variables.