Practical Exercises for **Exercise Collection**

Sonja Hartnack, Terence Odoch & Muriel Buri

October 2018

Exercise 1

- Open R Studio
- Open a new R-Script
- Load data set `chickwts`
- Do summary statistic (numerically and graphically)
- 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

- Create a data frame with 3 columns.

Exercise 3

- Install package `MASS`.
- Load data set `bacteria`.
- Describe in your own words what the data set `bacteria` contains.
- Do summary statistic (numerically and graphically).
- 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.fac` 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 `perulung_ems` and `ToothGrowth` data set.

Exercise 9A: Plausibility Checks

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

Exercise 9B: Missing Values

- Check out the difference between the different missing values
- Create a vector with missing values and determine the mean and median
- If `x = c(22,3,7,NA,NA,67)` what will be the output for the R statement `length(x)`?
- If `x = c(NA,3,14,NA,33,17,NA,41)` which line of R code removes all occurrences of NA in x.
- If `y = c(1,3,12,NA,33,7,NA,21)` what R statement will replace all occurrences of NA with 11?
- If `x = c(34,33,65,37,89,NA,43,NA,11,NA,23,NA)` then what will count the number of occurrences of NA in `x`?
- Create a vector and find the number of missing values and their position
- Now, create the vector `x2` and assess the difference to `x1`.
- What is the meaning of "NA" versus "NaN"?
- Replace the missing values in `x1` with a 0, and check that no NAs are present try two different commands to coerce the NAs into 0.

Exercise 10

- 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.
- Detect the errors in the imported data set `water_errors.csv` in R.
- Find possible solutions in R how to handle these challenges.
- Do all variables have the correct data type (numeric, integer, factor)? - If not, do correct / define them.

Exercise 11

- Apply the two-sided two sample t-test to suitable variables of the data set `ToothGrowth`.
- Interpret the results.
- Apply the two-sided t-test to the `perulung_ems` data set

Exercise 12

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

Exercise 13A: Outside plot frame

- Type `demo(graphics)` in your console and press enter. This command shows you a nice demonstration of possible R graphics.
- Change the x-axis and y-axis labelling of a boxplot plotting the `len` variable of the `ToothGrowth` data set.
- How do you set a main title for your above plot?
- What does the following command do?
- 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.
- 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?
- Label the x-axis of the following plot with "Vitamin C in μg". Use the greek letter for μ.
- Read `http://www.statmethods.net/advgraphs/parameters.html`.

Exercise 13B: Inside the square of the plot

- Type `demo(graphics)` in your console and press enter.
- Add a legend to the following barplot. Are there several different solutions for this?
- Add a density line to this histogram.
- Add a **dotted red** linear regression line to the following plot.
- Color the points in the following plot according to the `sex` variable.
- Add two linear regression lines separately for `female` and `male`to the following plot.
- Color the points in the following plot according to the `supp` variable. Use different point characters (`pch`) based on the `supp` variable.
- Read `http://www.statmethods.net/advgraphs/parameters.html`.

Exercise 14

- Load the below data set and for further information check the command `?water`.
- Try to plot the variables `mortality` against `hardness` from the `water` data set.

- Add a main title to the above plot (`mortality` against `hardness`).
- Change the ...
  1. font size of the axis annotation
  2. font size of the x- and y-axis labels
  3. the point sizes within the plot

  ... of the above plot (`mortality` against `hardness`).
- 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?
- 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`).
- Add a legend to the above plot so that you can easily differentiate the locations (`North` or `South`) of the observations.
- Do a barplot of the variable `location` from the `water` data set.
- ADDITIONAL: Try if any of these following plotting functions can be applied to the data sets `perulung` or `ToothGrowth`.

Exercise 15

- Download the .R file `ANOVA_with_chickwts.R` from the switch drive and have another look on how we applied the anova to the `chickwts` data set.
- Load the `ToothGrowth` data set into R and encode the numeric variable `dose` as a factor variable. Define the new factor variable as `dose.fac` with the three levels `low`, `med` and `high` and add it to the data frame of `ToothGrowth`.
- Visualize the variable `len` per `dose` level in a boxplot.
- 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

- 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.
- 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

- Load the `ToothGrowth` data set and run the following four linear regression models.
- Have a look at the summary of these models.
- How do you interpret the model coefficients?
- Which model is best?

Exercise 18

- 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.
- Check the underlying model assumptions.
- Add an interaction term between `hardness` and `location` to the above estimated multiple linear regression model.
- Interpret the interaction coefficient `hardness:locationSouth`.
- Check the underlying model assumptions.
- Which one is the better model? With or without the interaction term?
- 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

- 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.

- Encode the numeric variable `antibodies` as a factor with levels 0 and 1.
- Make a crosstable with the risk factor `exposure` and `antibodies`.
- 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.
- Create a subset for `male` and `female` based on the variable `gender`.
- Repeat the crosstable, Chi-squared test, Fisher's exact test and a logistic regression (`glm`) for the subsets **separately**.
- 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?)
- Fit a logistic regression model (`glm`) with `exposure` and `gender` as explanatory variables.
- **SPECIAL FOR GUMA**: Is `exposure` being from an urban area a risk factor?