Assignment 2 880260, 2019/20

**Due at 23:55 on Sunday, 24-11-2019**

Requirements: Assignments have to be handed in, one for each group of students. Please write all group member names with corresponding student (SNR) and administrative (ANR) numbers on the top of the first sheet that you hand in. Remember that assignments have to be typeset in English and submitted in Canvas as a single PDF file.

Always justify your answers! When asked to use R, always make sure you provide your code at the end of the assignment; the results you obtained should be reproducible.

**Exercise 1.** [10 points in total] Suicide rates among United States military veterans

The increased suicide rates among United States military veterans is a known phenomenon. News21 published data on the yearly suicide rates both of veterans and civilians for each of the 50 US states. Here we will consider the veteran suicide rate only for the years 2005 and 2011. This is the average number of suicide deaths per 100,000 people in each state's veteran population. The data you need can be found in VetSuicides\_2005.csv and VetSuicides\_2011.csv; you will need the variable vet\_rate.

(a) [1 point] Make use of plots to check normality of the data. Do you think the assumption of normality, made by the t-test, holds? Find and report the sample means. **Do you think the difference in mean suicide rates between 2005 and 2011 will be significant**?

(b) [2 points in total] Test the assumption that the **suicide rate in 2011 is larger than the suicide rate in 2005** using **a paired t test**.

\*(a) [1 point] Clearly specify the null and alternative hypothesis.

\*(b) [1 point] Report the results.

(c) [4 points in total] Perform a non-parametric bootstrap procedure on **the difference in suicide rates between 2005 and 2011** to create the bootstrap sampling distribution.

\*[1 point] Make a plot of the bootstrap distribution.

\*[1 point] Comment on the bias and shape of the bootstrap distribution.

\*[1 point] Construct the 95% bootstrap t confidence interval and the 95% bootstrap percentile interval.

\*[1 point] Comment on the use of the bootstrap t confidence interval and the bootstrap percentile interval for these data.

(d) [2 points in total] Now use a permutation test to test the assumption that -on average**- the suicide rate in 2011 is larger than in 2005**:

-[1 point] Implement the permutation test procedure and plot the resulting permutation distribution.

-[1 point] Report the permutation test estimate of the P-value.

(e) [1 point] Based on the bootstrap and permutation test results, what do you conclude about the difference in mean suicide rate between 2011 and 2005?

**Exercise 2.** Should one use a permutation test instead of Welch’s or Student’s t-test by default?

In this assignment, we focus on three hypothesis testing procedures that have been proposed for estimating and testing the difference in means between two independent samples:

\*For a first group *n*1 data are sampled from *N(µ*1*,σ²1).*

\*For a second group *n*2 data are sampled from *N(µ*2*, σ²2).*

A popular tool to assess and test the difference in means between two independent populations, is Student’s t-test. An alternative but less known tool is Welch’s t-test. Another but even less known alternative, is the permutation test. Here we will use Monte Carlo simulation to compare the three types of test procedures (Student’s t-test, Welch’s t-test, and the permutation test).

Useful reading: Delacre, Lakens, Leys (2017). Why Psychologists Should by Default Use Welch’s t-test Instead of Student’s t-test. *International review of social psychology, 30(1),* 92–101. DOI: http://doi.org/10.5334/irsp.82. (<https://www.rips-irsp.com/article/10.5334/irsp.82/>).

**Part 2[[1]](#footnote-1):** [5 points in total] **Properties of the hypothesis testing procedures for the difference in means**: Student’s t test compared to Welch’s t test compared to the permutation test.

Conduct a Monte Carlo simulation experiment to assess the control over the type I error rate and the power of the three testing procedures (Student’s t-test, Welch’s t-test, and the permutation test). Use the following values for the population parameters and sample sizes: Fix *n*2 = 100 and vary the sample size for *n*1 (*n*1=10, *n*1=100, or *n*1=200); also fix **²1=2 and vary **²2 (**²2=1, **²2=2, **²2=10); finally, fix *µ*1=0 and *µ*2=1.

1. [1 point] What is the hypothesis tested by the t-tests? And by the permutation test? Clearly specify both the null and alternative hypothesis.
2. [3 points] For each of the nine conditions, report the rejection rates of the null hypothesis for data generated 1) under the null hypothesis and 2) under the alternative hypothesis. Set *µ*2=0 under the null hypothesis and *µ*2=1 under the alternative and use a significance level of ** = 0.05 to perform the hypothesis tests. Discuss the results in terms of control over the chosen significance level and in terms of power as functions of the sample sizes and population variances.

[1 point] Often the advice is given to *always* use the permutation test instead of the t-test. Is this a good advice? Motivate your answer.

1. Part 1 was about the estimation of the standard error of the difference in means by Welch’s and Student’s t; see Assignment 1. [↑](#footnote-ref-1)