Tutorial 4

Biological Data Analysis

Spring 2023

Outline

- Comparison between two groups
- Confidence interval
- Effect size
- Hypothesis testing

Example 1

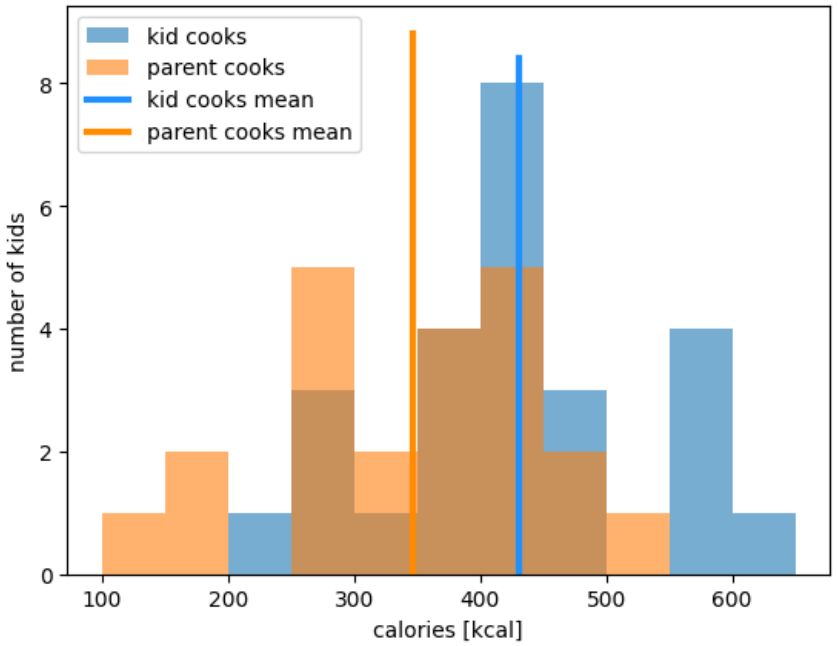
Experiment was conducted to determine effect of children participating in meal preparation on caloric intake.

Group 1: 25 children participated in meal preparation
Group 2: 22 children did not participate

Example 1

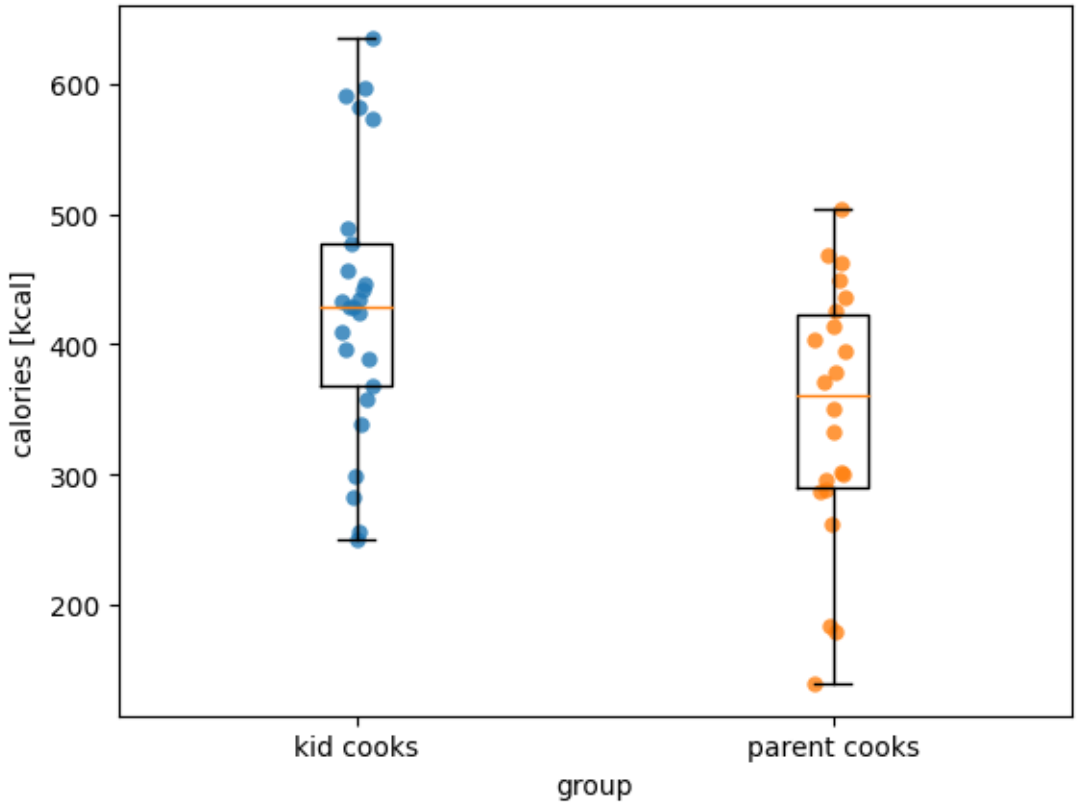
	group	calories
0	kid_cooks	435.16
1	kid_cooks	338.99
2	kid_cooks	488.73
3	kid_cooks	590.28
4	kid_cooks	582.59
5	kid_cooks	635.21
6	kid_cooks	249.86
7	kid_cooks	441.66
8	kid_cooks	572.43
9	kid_cooks	357.78
10	kid_cooks	396.79
11	kid_cooks	298.38
12	kid_cooks	282.99
...	...	...
34	parent_cooks	295.28
35	parent_cooks	139.69
36	parent_cooks	462.78
37	parent_cooks	179.59
38	parent_cooks	301.75
39	parent_cooks	436.58
40	parent_cooks	371.39
41	parent_cooks	469.02
42	parent_cooks	378.09
43	parent_cooks	287.31
44	parent_cooks	448.55
45	parent_cooks	332.64
46	parent_cooks	403.98

Distribution of data in two groups and mean values



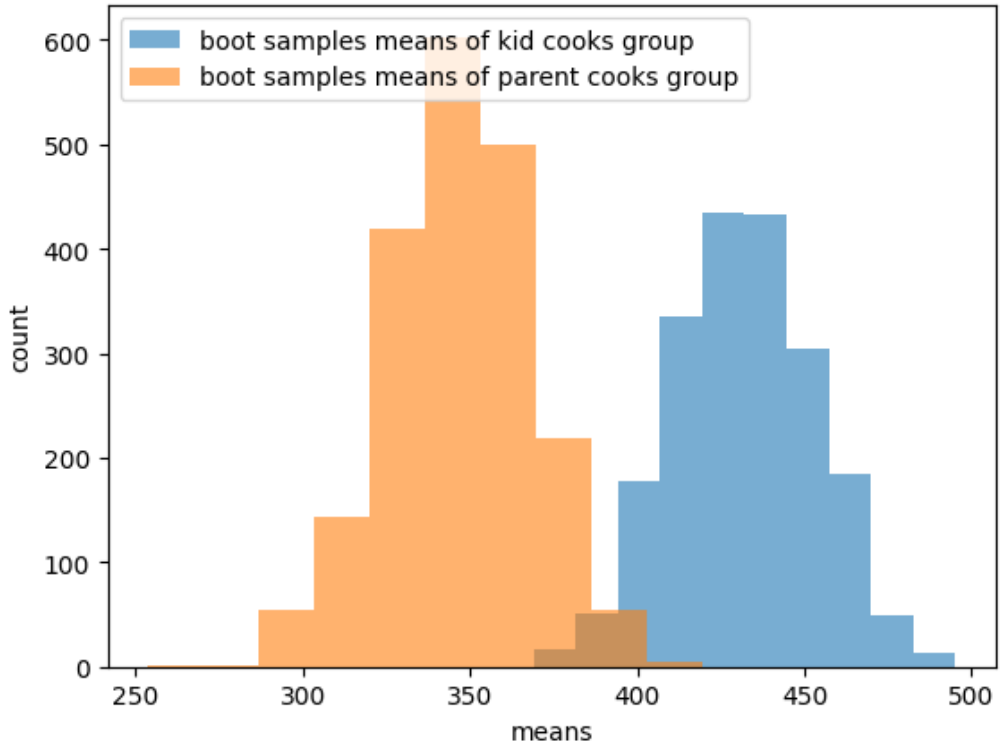
Example 1

Boxplot presentation of data in two groups



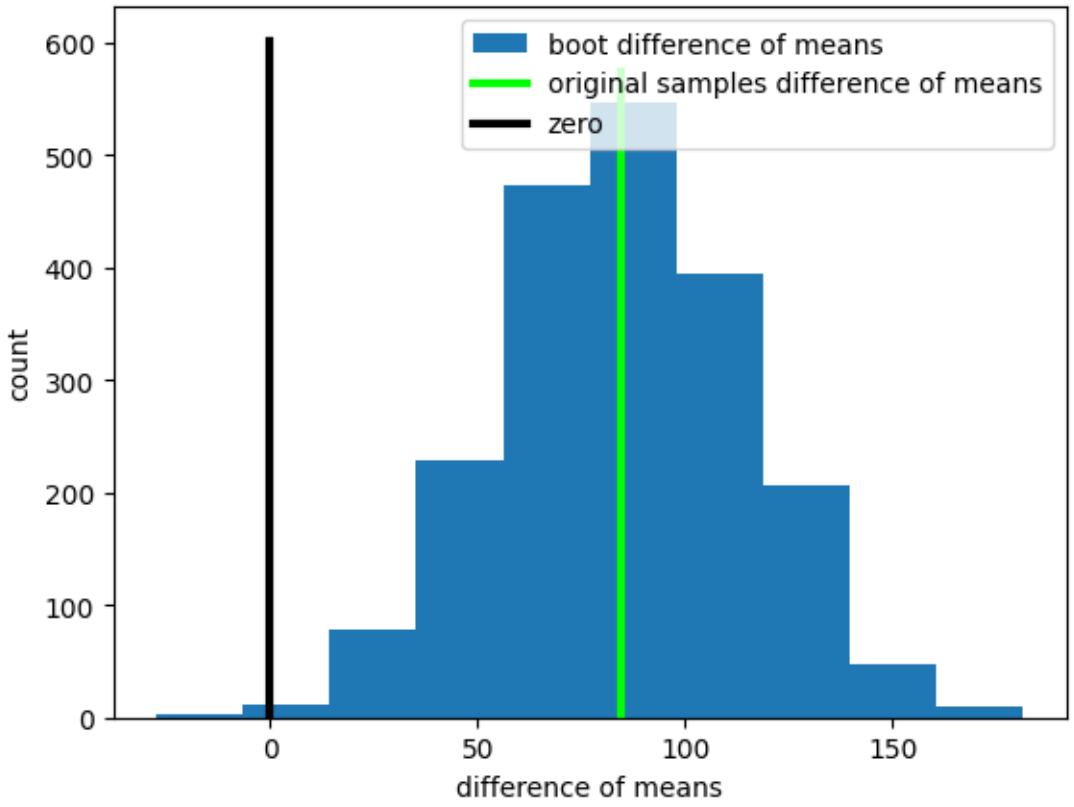
Example 1

Create bootstrap sample using non-parametric bootstrap unpaired



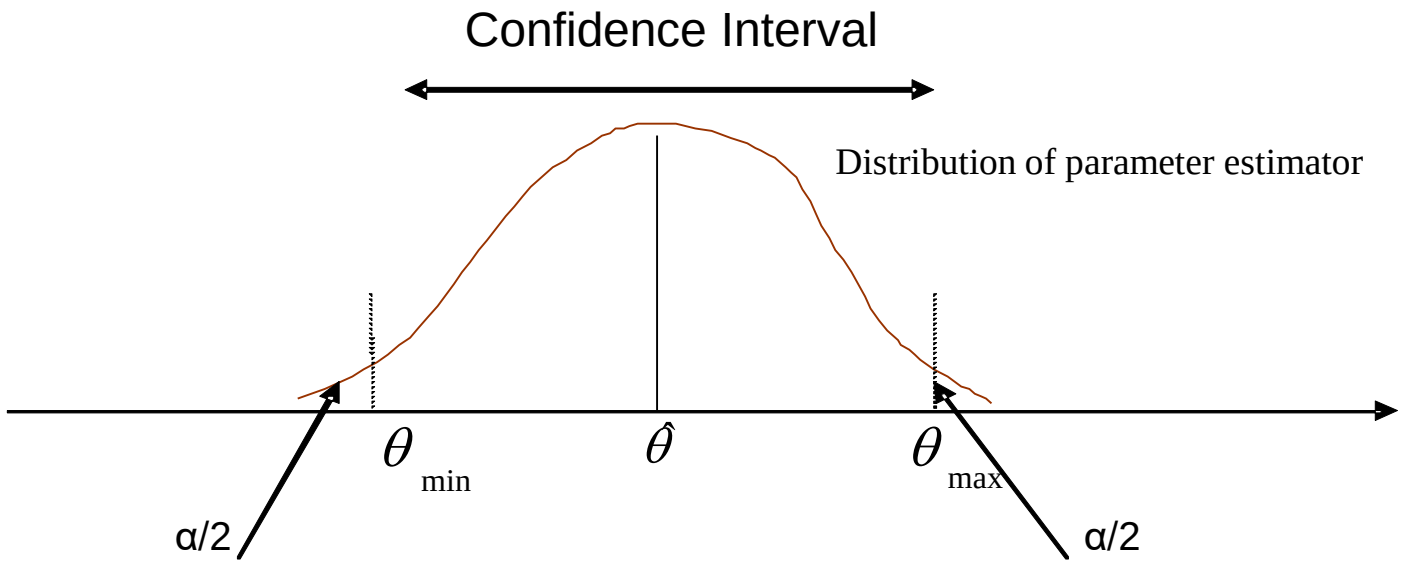
Example 1

Difference of means



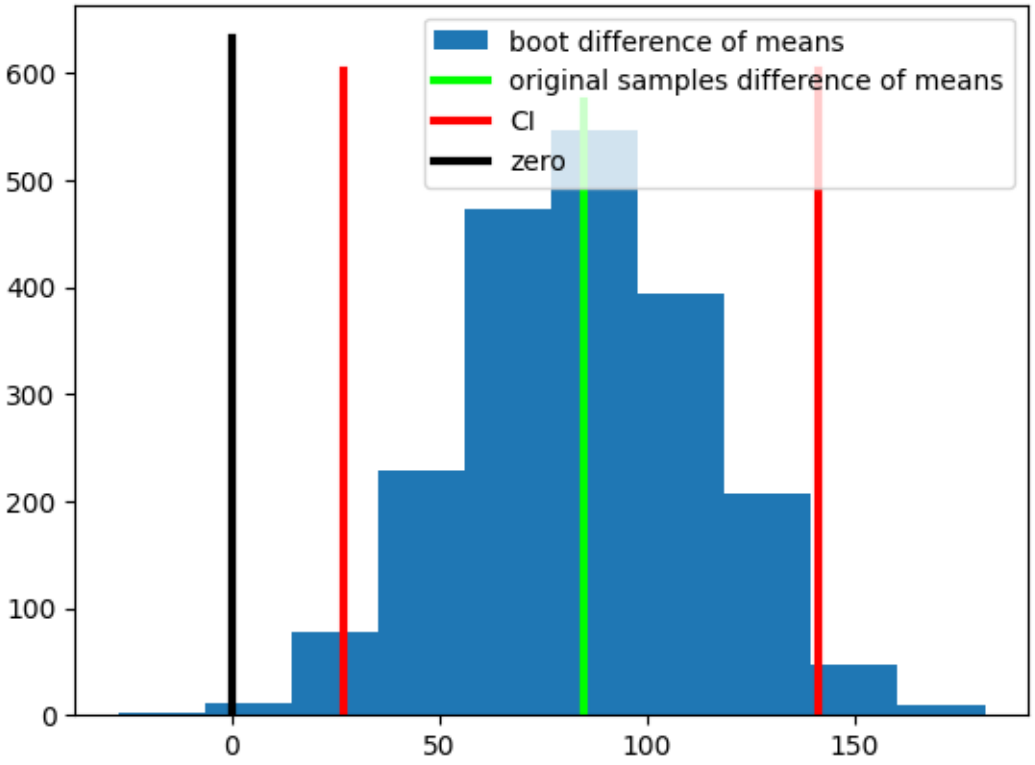
Confidence Interval

- A range with 100(1-α)% of estimator distribution
- Probability that the real population parameter is outside the CI range is low

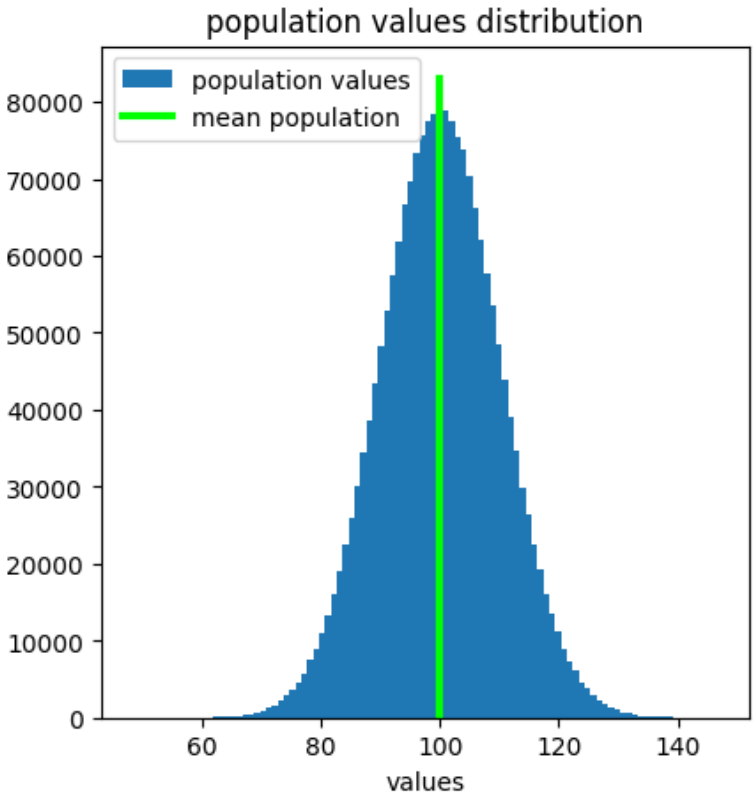


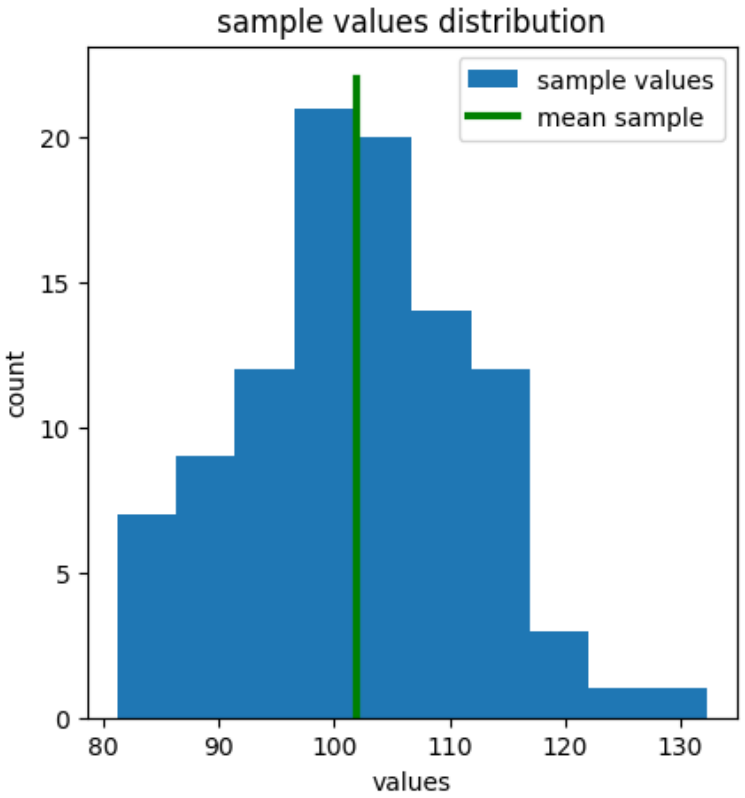
Example 1

95% Confidence Interval = (26.92814954545 , 141.2248704545)



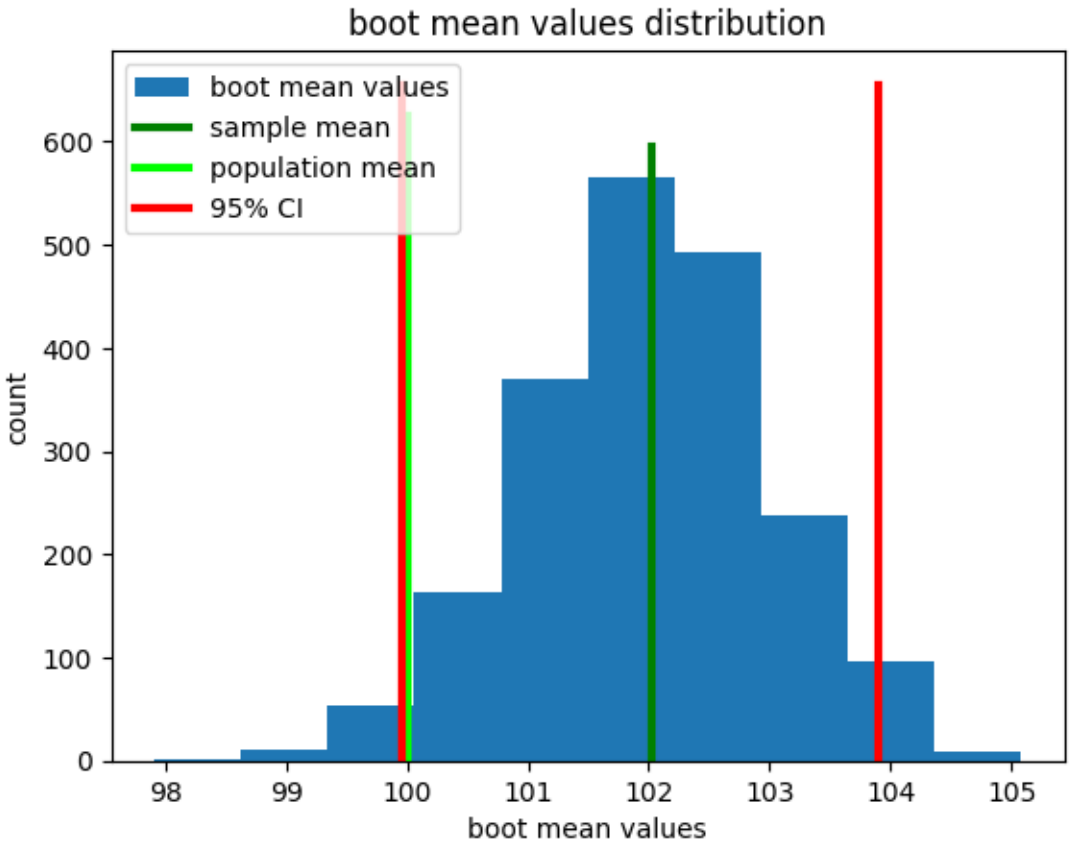
Simulation: Confidence Interval





Simulation: Confidence Interval

Confidence interval of mean estimator from one sample using bootstrap



Effect size

Difference between means normalized by common SD

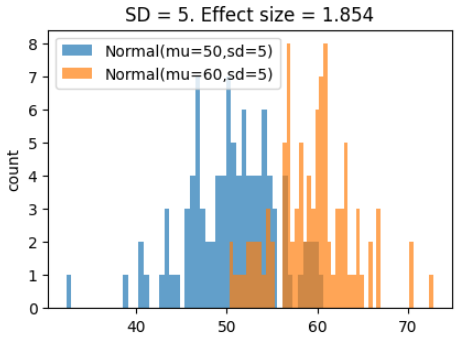
Cohen's d

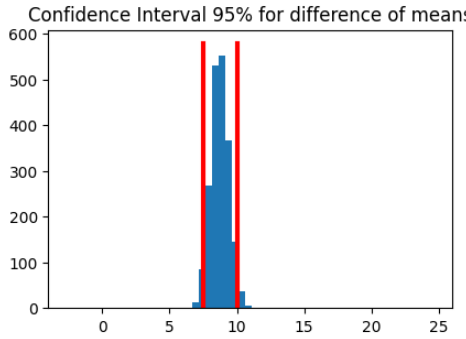
$$\frac{\overline{X}_1 - \overline{X}_2}{s_{comb}}$$

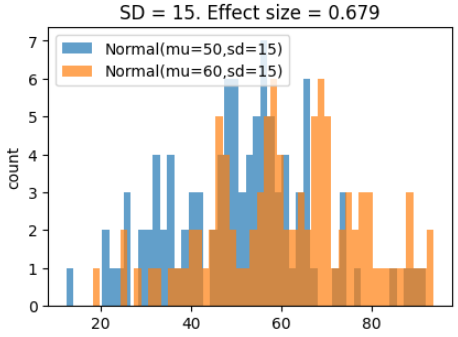
$$s_{comb} = \sqrt{\frac{(N_1 - 1)s_1^2 + (N_2 - 1)s_2^2}{N_1 + N_2 - 2}}$$

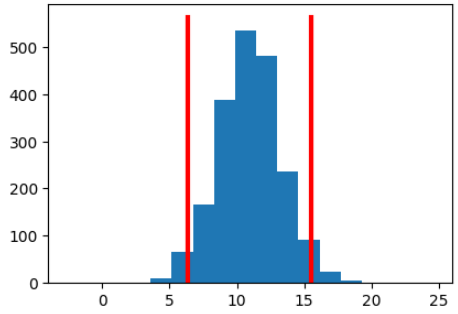
	Small	**Medium**	**Large**
Effect size	0.2	0.5	0.8

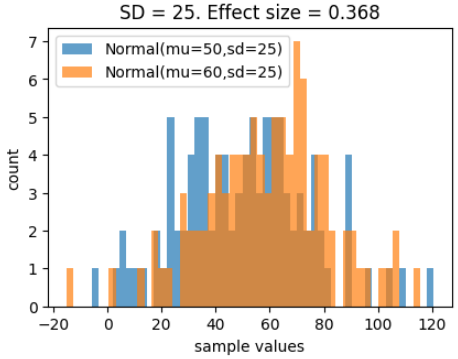
Simulation: significance of spread on CI and effect size

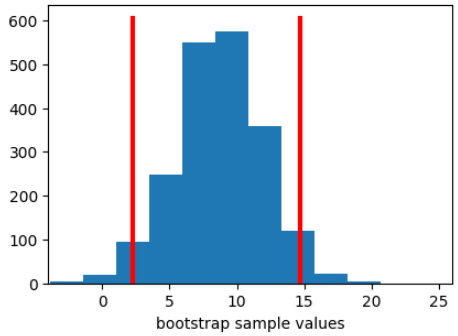






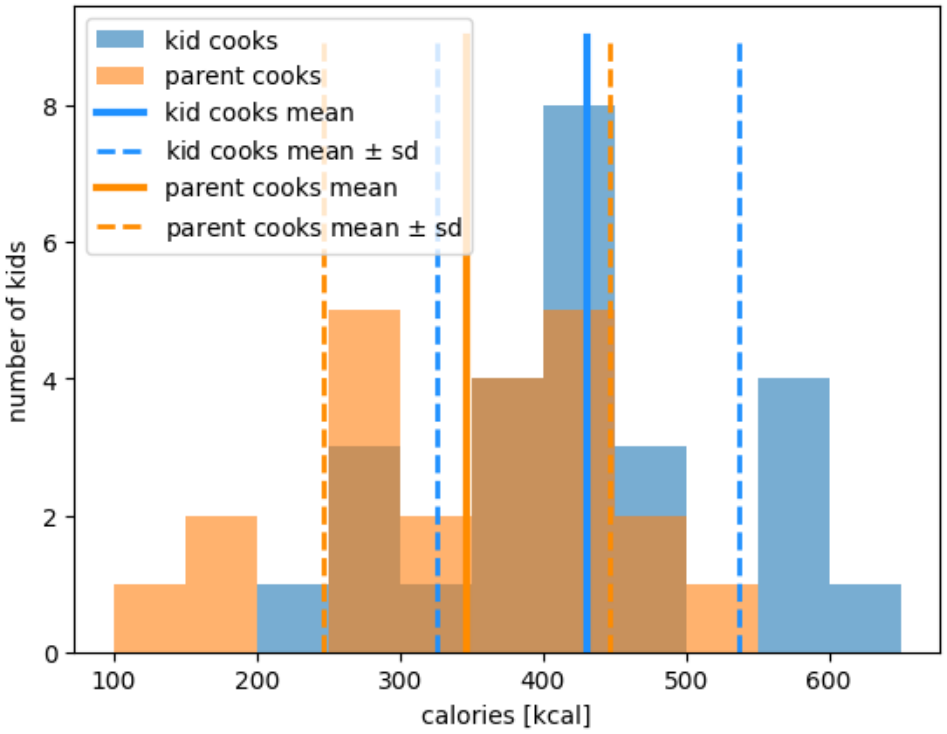






Exercise 1

effect size = 0.8225 large effect



Hypothesis testing

To prove a certain assertion:

- Population mean is higher/lower than zero (comparison of population with single number)
- Means of two populations are different

Sample the population, estimate the parameter, define and compare two models:

- **Null Model (Null Hypothesis)**: assertion that we want to prove is false
- **Effects Model (Alternative Hypothesis)**: assertion is true

Hypothesis testing algorithm

Assume the Null Model is true

Try to reject the Null Model using the data

If the Null Model is rejected -> assume the Effects Model is true -> assertion is true (probability that assertion is not true is low)

If the Null Model is not rejected -> do not assume the Effects Model is true -> no conclusion about the assertion

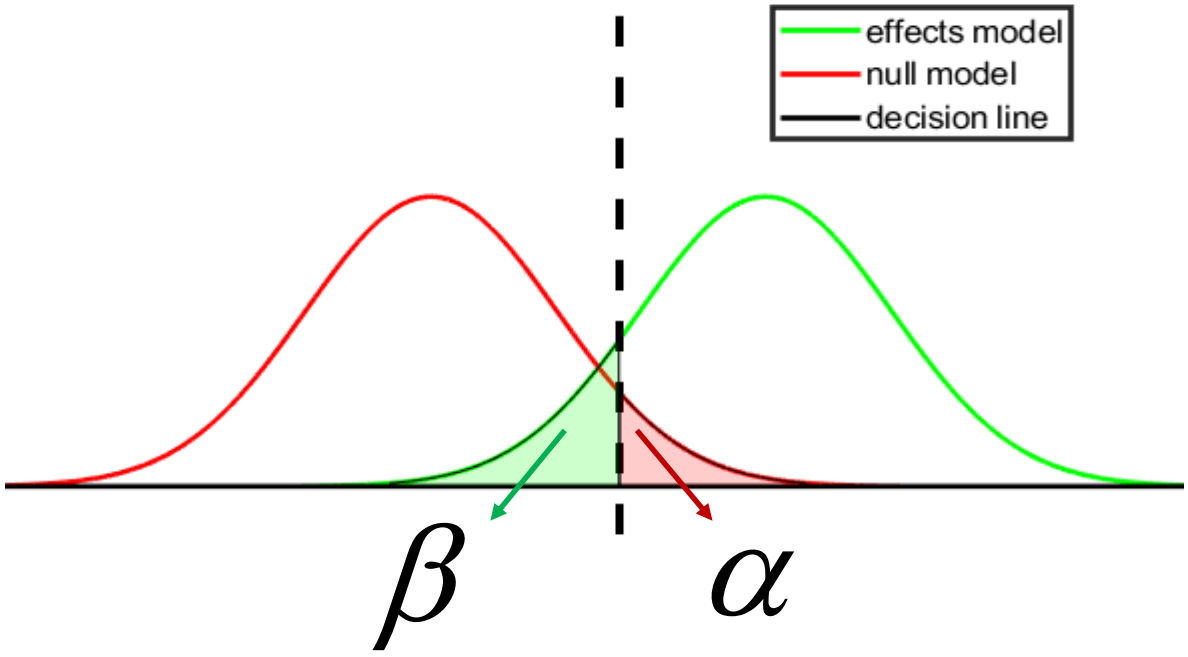
Null Model is never accepted

Errors in Hypothesis Testing

Alpha Error – Type I error - rejection of correct Null Model (conclusions about the existing effect are not correct)

Alpha error - Test significance (p-value is compared to alpha)

Beta Error – Type II error - failing to reject the incorrect Null Model (miss the real existing effect)



Confidence interval and Hypothesis testing

- Statistical question: what is the probability of getting a null model value if the population has the same distribution as the sample

- What is the probability of getting a value as the Null Model (or more extreme) from the estimator distribution we found using bootstrap

Exercise 1

Define wanted alpha error – 0.05

Sum number of extreme samples (difference of means smaller than 0)

Divide by the number of samples

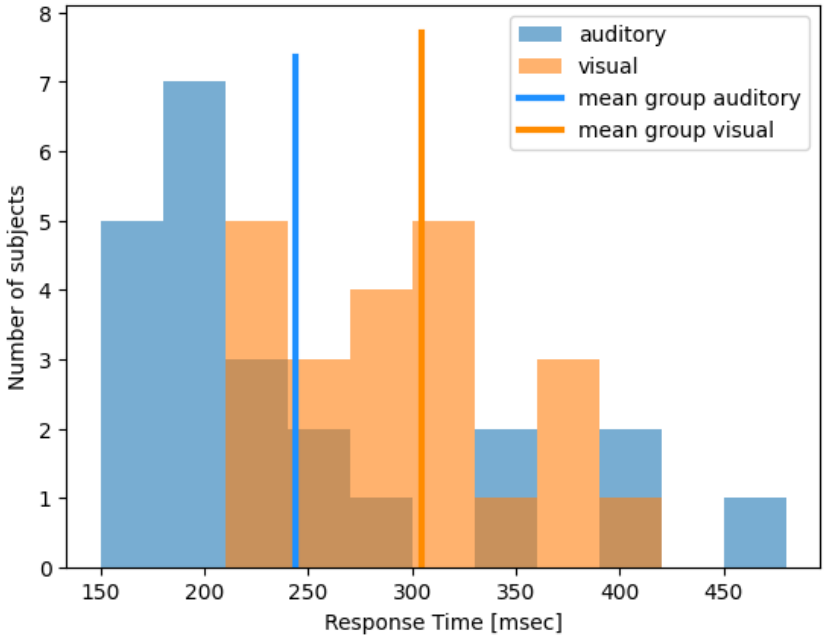
Compare to alpha error

```
p-value = 0.002
p_value<alpha_error? True
```

Null model rejected

Exercise 2

Data – reaction time to two types of stimuli: auditory and visual. 23 subjects reacted to both stimuli



Is there a difference between the reaction types in different conditions?

Exercise 2

Null Model: there is no difference between the conditions

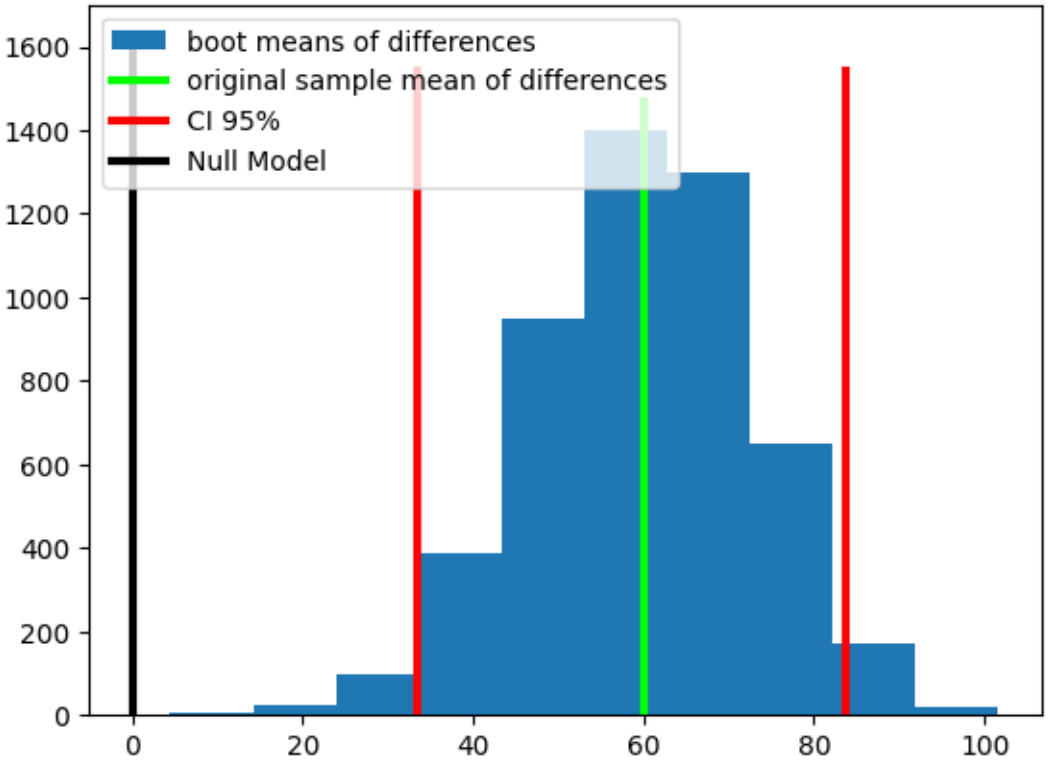
Effects Model: there is a difference between the condition

Statistic: mean of differences between two groups

Significance level: alpha = 0.05

Exercise 2

Non-parametric bootstrap paired



Exercise 2

Calculate significance (p-value) and effect size

```
p-value = 0.0
p_value<alpha_error? True
```

Reject the null model and accept effects model

```
effect size = 0.7652
```

Medium effect

Exercise 3

In an experiment to test the effect of ginkgo biloba on memory. 203 subjects were randomly assigned to take ginkgo biloba supplements or a placebo and took a memory test. 99 took the supplement and 104 – the placebo.

Does ginko supplement has an effect on memorization abilities?

Exercise 3

Null Model: supplement has no effect on memory

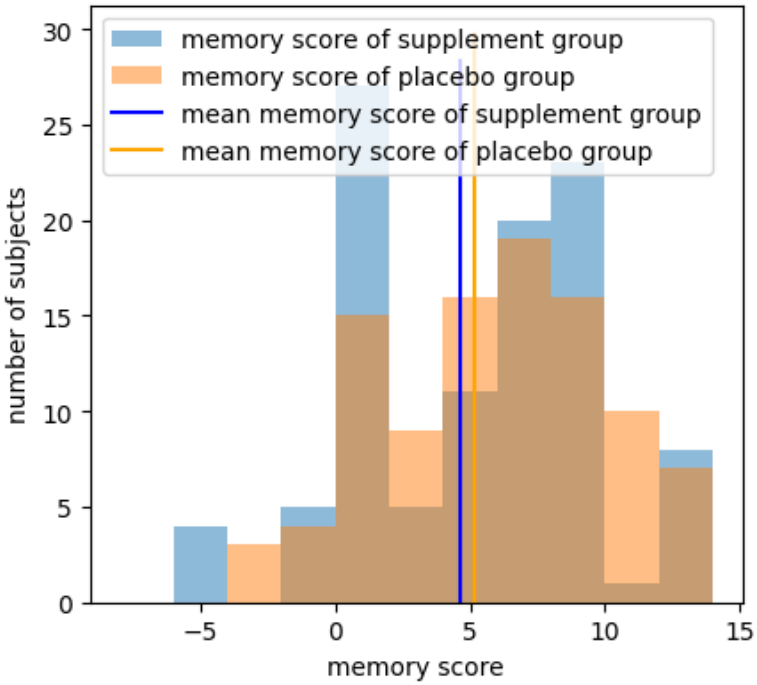
Effects Model: supplement has an effect on memory

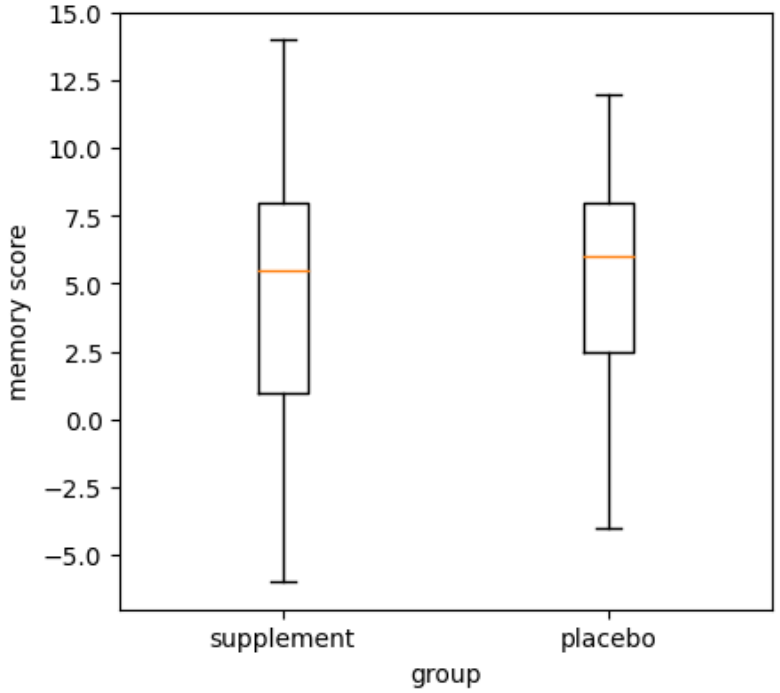
Statistic: difference between the means of two groups

Significance level: 0.05

Exercise 3

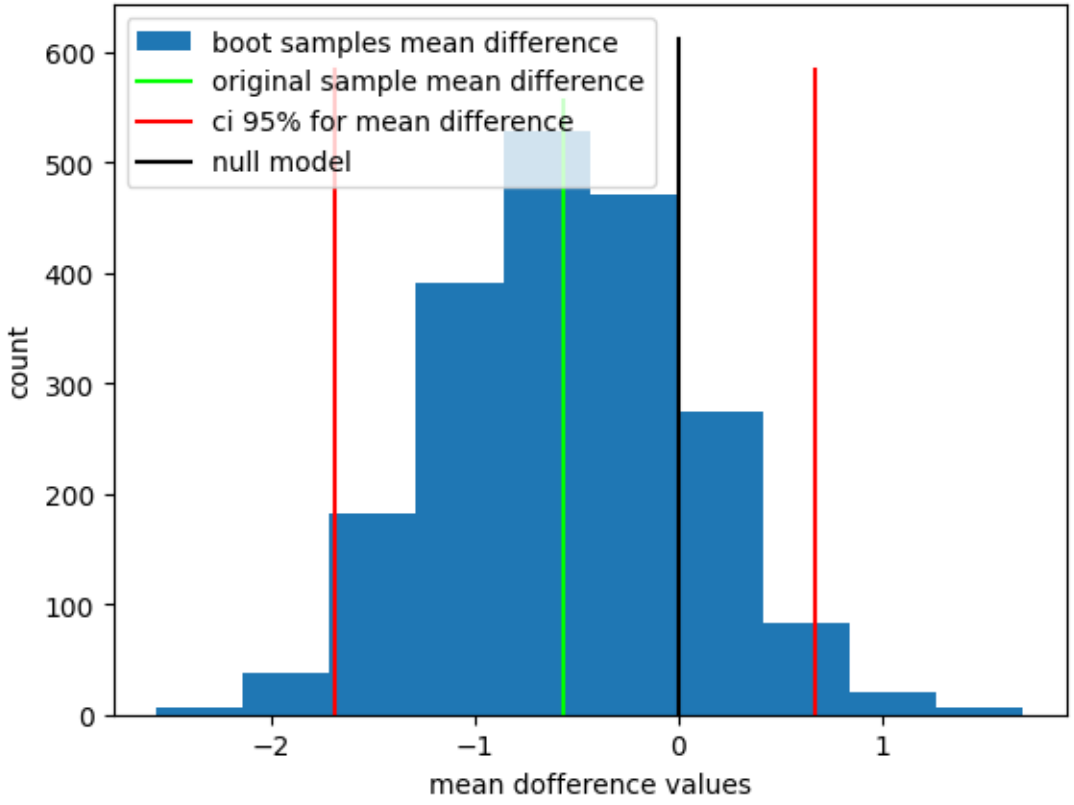
Present using histogram and boxplot





Exercise 3

Non-parametric bootstrap unpaired



Exercise 3

Calculate significance (p-value) and effect size

```
p-value = 0.186
p_value<alpha_error? False
```

Failed to reject the null model

```
effect size = -0.131
```

Small effect