ADS2 Practical 13: Comparing multiple groups using simulation

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Work through this guide alone or in groups. Facilitators are here to help. The time it takes to complete this practical can vary between individuals - this is OK. Do not worry if you do not finish within the session.

Learning Objectives

- Design and interpret a simulation-based hypothesis test
- Use a simulation-based test to compare more than two means

Introduction to the dataset

In this practical, we are looking at a study where two different drugs against chronic pain (creatively named "Drug A" and "Drug B") were tested. In addition, there is a control group that was given a Placebo.

Chronic pain patients were randomly assigned to one of three groups (Placebo, Drug A, Drug B). They were treated for 2 weeks, and then their relative pain levels were assessed through a medical questionnaire (zero means average compared to other adults in the same age range, positive values mean more pain, negative values mean less pain).

If we had just one drug and one control group, we could easily do a t-test. But now we are comparing three different groups, so things are a tad more complicated.

Today, we are going to just answer the first question: Is there any difference at all between those three groups or are they all the same?

Looking at the dataset

Import the drug trial dataset into a data frame called trial

Let's have a look first: Plot the data in some useful format
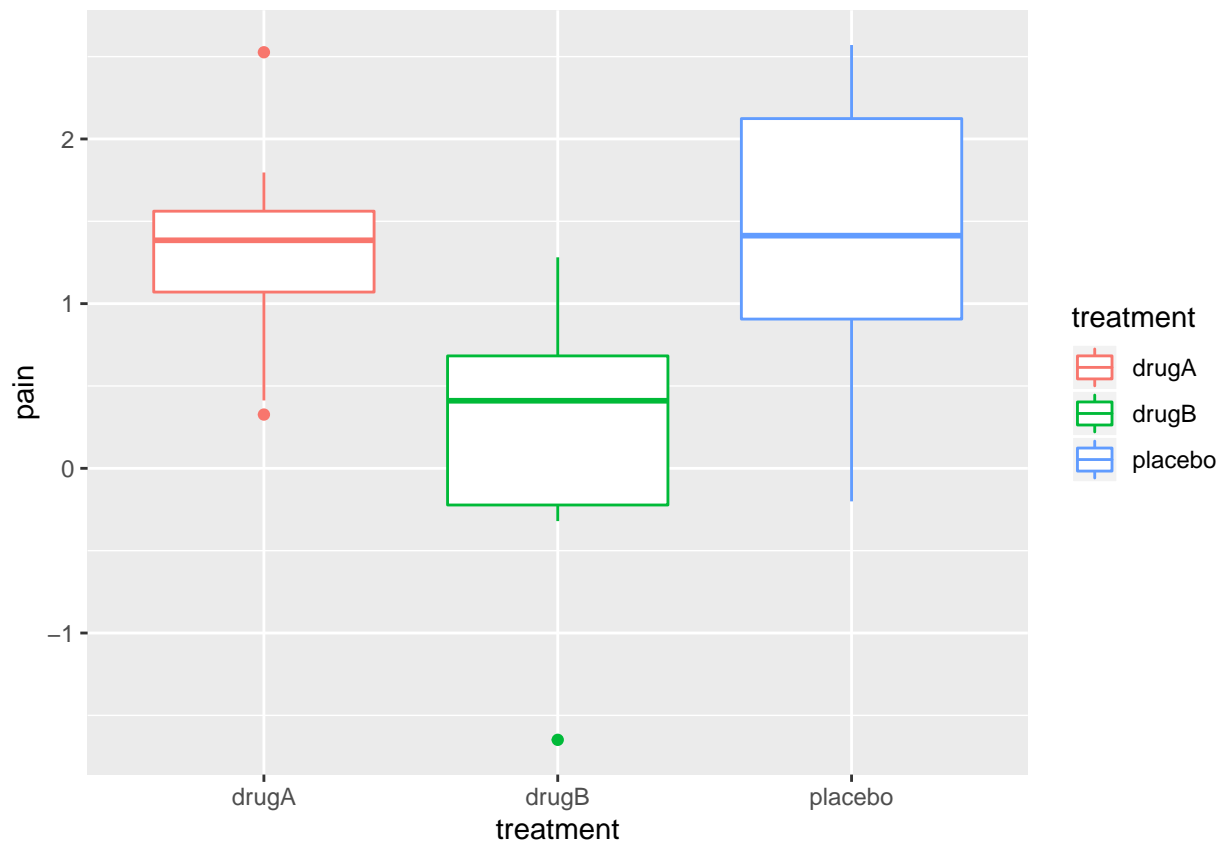
Reminding ourselves of H0 and HA

Are those groups the same or are they different? What are the Null and Alternative Hypotheses?

H0: _____Those groups are the same._____

HA: _____Those groups are different._____

Looking back to the lecture, one way to think about it is this: If you draw two data points at random from different groups, would they be more different from each other than if you draw two data points at random from the same group? Re-formulate H0 and HA with this in mind:

H0: _____Two points from different groups are as different as from the same group._____

HA: _____Two points from different groups are more different than from the same group._____

Getting a sense of variability

Let's try this first. Draw one sample data point at random. Draw another one from *within* the same treatment group. Compute the (absolute) difference between the two.

Draw a third point from a different treatment group. Compute the (absolute) difference *between* the first and the third. We are plotting this here just for illustration purposes, but you don't need to.

```
## [1] "Difference within group:  0.0189399014881749"
```

```
## [1] "Difference between groups:0.431085028135568"
```
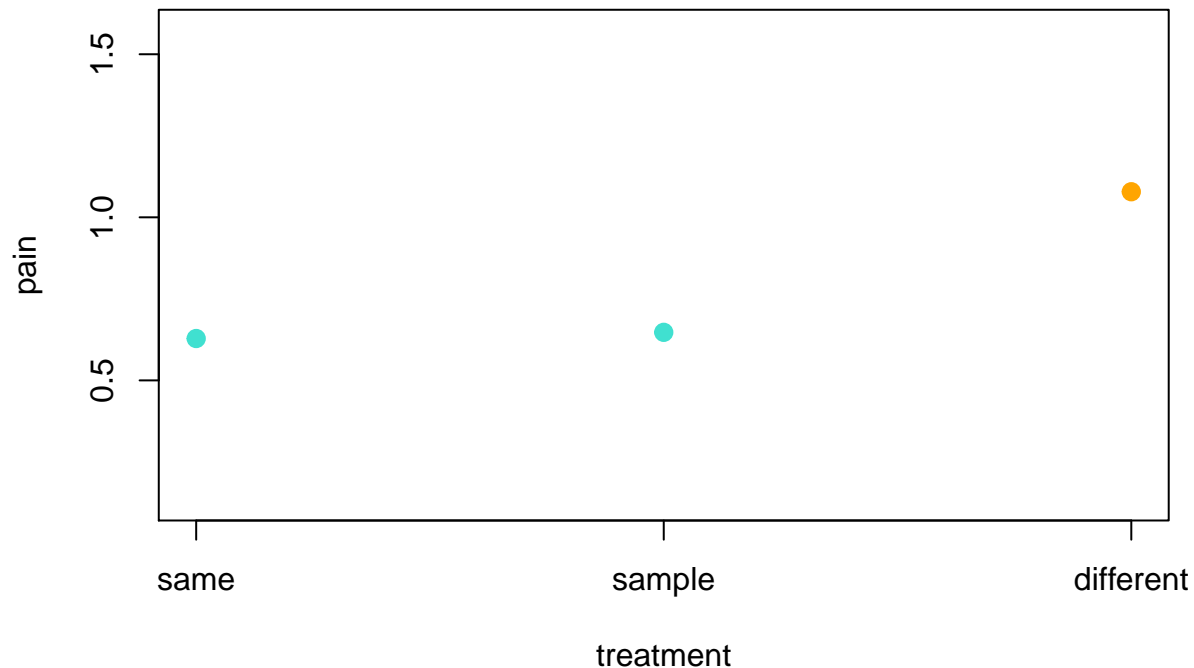
Useful R concepts for this part of the practical:

- *sample*()
- *dataframe*[*row, column*]
- *dataframe*[−*row, column*]
- *abs*()

Here is some pseudocode that may be helpful:

```
# separate data into three treatment groups

# randomly draw one data point from one of the groups

# read out pain index

# randomly draw another data point from the same group
# (but not the same data point)

# compute (absolute) difference

# pick a random data point from a different treatment group

# compute (absolute) difference
```
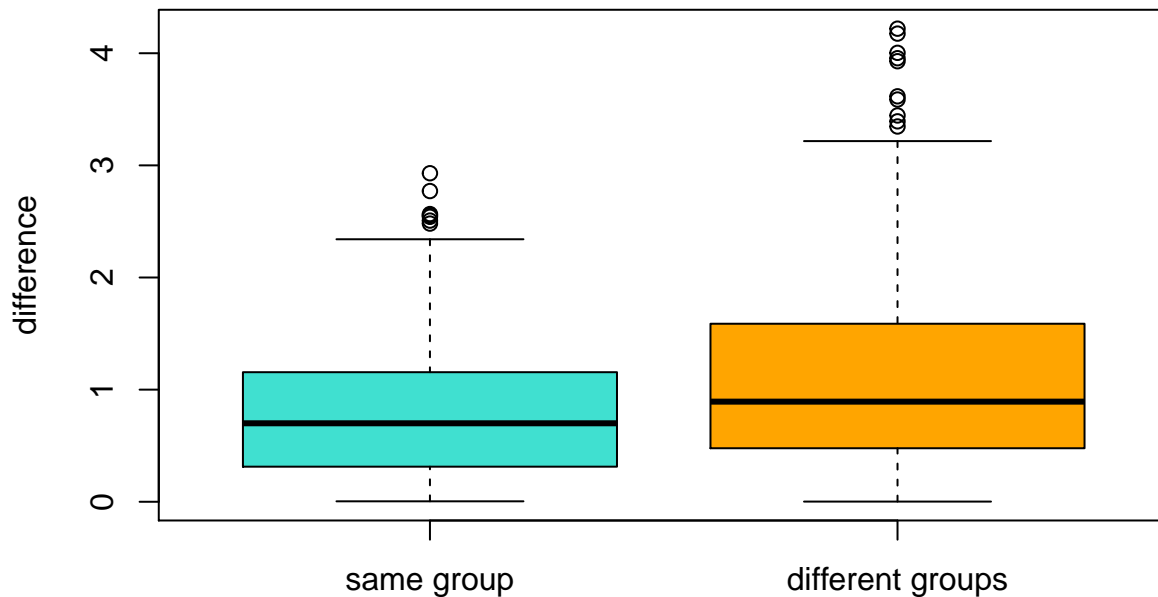
We can actually do this systematically: Compare every data point to every other data point, and record the absolute distance between them (keeping track of whether the data points were from the same or different treatment groups).

Since we have a relatively small sample, this can easily be done using a double loop. *How many absolute distances do we have to compute?*

Do they look the same, do they look different? If we compare the means, we get

```
## [1] 0.8088831
```

for the distances between data points within the same groups and

```
mean(diffs)
```

```
## [1] 1.081275
```

for the distances between data points in different groups

The difference between those means is 0.2723916

Is this a small difference or a large one?

Run a simulation-based test

Recall the simulation-based version of a t-test you ran a few weeks ago. The central premise was this: We want to know what things would look like if the Null Hpyothesis was true. In order to do that, we run the experiment many times, assuming H0 is true.

If the H0 is true, then labels do not matter. So, we can simulate H0 being true by randomly re-assigning labels. In this case, we have three labels ("placebo", "drugA", "drugB") to re-assign, but other than that, the principle is the same.

(Running this 1000 times will likely take a few minutes. Run the loop fewer times at first in order to test your code and convince yourself that you are doing the right thing)

```
# repeat 1000 times:
  # re-assign labels randomly
  # compute all absolute distances between samples from within the same treatment group and between dif
  # compute the mean of distances for "same" and "different"
  # compute and record the (absolute) difference between means

# the distribution of the 1000 differences between means is your Null distribution
```

Null distribution
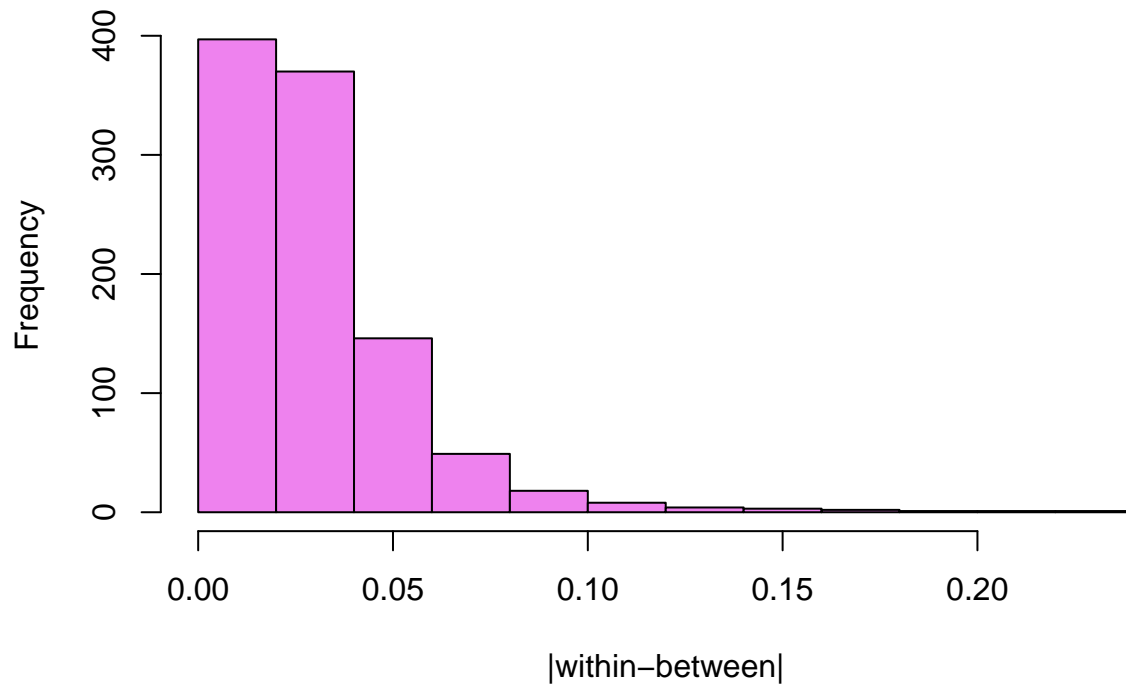
Compute a p value and interpret your result

You have your Null Distribution, you have your original value. What do you do now? And what do you conclude? Be very careful to relate this back to your original Hypotheses.

Also, what information do you think is still missing?

What's next?

This test has shown us that there is a difference, i.e. not all groups are the same. But are they all different? Or is it just one that's different from the other two?

Now that you know there *is* a difference, you may be tempted to run t-tests to compare each individual pair of groups.

But remember what we said in lecture about the problem with false-positive rates when we do that.

Roughly, can you think of a way out of this problem?

(We will discuss this in more detail in next week's lecture!)