

T-Tests in R

To test means of one or two groups

Lauren Kennedy

School of Psychology, University of Adelaide

2016-Version 2

1 Assumed knowledge

This guide assumes that you know what a t-test is. If you're not sure what that is see chapter 13 in Dan Navarro's Learning Statistics with R (ebook available for free here:

(<http://health.adelaide.edu.au/psychology/ccs/teaching/lsr/>).

It's important to note there are three different types of t test. This guide will go through how to do each one in R.

- A **one sample t-test** tests whether the mean of a group is equal to some constant (most often zero).
- A **two sample t-test** tests whether the mean of two different groups is the same.
- A **paired sample t-test** is for when you have two measurements from the same group of individuals.

It's also really important to note that t-tests make assumptions about your data. The t-tests in this guide are Welch t-tests. They only assume that the data are normally distributed.

If you're doing a practical, you'll need to be able to load your own data into R. If you're not sure how to do that, you can look up how to do this with the help guide on Loading your Practical Data in R.

I strongly, strongly advise that you use R Studio for all of your statistical analyses.

2 Running the test in R

We're going to run each of these tests on the some data in R. This data is already on every installation of R. It's hidden away, so you can't see it in the environment panel in Rstudio, but don't worry, it's there. To do your practicals you will need to load the practical data.

First load the lsr package. If you're on a university computer, simply type:

```
library(lsr)
```

If you're not using a university computer, you'll need to install the lsr package. See the help guide Getting Started in R for instructions on this. The lsr package contains functions that gives the outcome of your tests in a format that best suits psychology. If you use R in other disciplines, they may use the functions for t-tests that come preloaded in R.

2.1 One Sample test

To do a one sample t-test, we are going to use a data frame called women. If you type:

```
View(women) #Note View has a captial V
```

You can see what is in the data frame. The data frame women has two columns, height and weight. The columns height and weight contain the height(inches) and weight (pounds) of 15 US women. For this example we want to see if the average height of American women is different from 69.7 (the average height of an American male, according to Wikipedia). To do this we need to run a one sample t-test to test if the mean of our sample of women's heights is different from 69.7. Type (or copy and paste) the following:

```
oneSampleTTest( x=women$height , mu=69.7 )
```

This uses a function. For help with functions see the help guide "Functions in R". First we need to say **oneSamplesTTest** as it is the name of the *function*. We need **x=women\$height** as we need to specify the *continuous* variable that we are interested in. We're telling the function to look in the *dataframe* **women** and find the column **height**. The last part **mu=69.7** is what we are testing against. Mu is a fancy name for population mean. If you leave this part blank the function will test mu=0. You should get the following output:

```
One sample t-test

Data variable:  women$height

Descriptive statistics:
  height
  mean    65.000
  std dev. 4.472

Hypotheses:
  null:      population mean equals 69.7
  alternative: population mean not equal to 69.7

Test results:
  t-statistic:  -4.07
  degrees of freedom:  14
  p-value:      0.001

Other information:
  two-sided 95% confidence interval:  [62.523, 67.477]
  estimated effect size (Cohen's d):  1.051
```

There's lots of things in the output. There are descriptive statistics, a summary of the hypothesis, the t-test results, a confidence interval and an estimate of effect size. Here's how we might report it. For more information about how to interpret these findings, refer back to Chapter 13 in Learning Statistics with R.

The sample of American women heights had a mean of 65.00 inches (SD=4.47). A one sample t-test was conducted to test whether the population mean is significantly different from 69.7 inches (the mean height of American men). This test was significant ($t(14) = -4.07$, $p=.001$), with a large effect size (Cohen's $d = 1.05$). With 95% confidence the interval [62.52,67.48] contains the true mean height for American women.

2.2 Independent Samples t-test

To do an Independent Sample t-test, we're going to use another already 'hidden' data frame called sleep. If you type:

```
View(sleep) #Note View has a captial V
```

You can see what is in the data frame. The data frame `women` has three variables (because technically this is a within subjects design), but for this example we're only going to look at the first two (ignoring that a paired test should really be used). You shouldn't do this in your practicals!!! This data frame contains the results of a small randomised trial to investigate the efficacy of two interventions to improve sleep. The first column, `extra`, is the post-pre difference in sleep duration (measured in hours). The second column, `group`, is the allocated intervention, coded as 1 or 2. So the first row says the first participant received treatment 1 and had an increase of .7hours.

Our question here is pretty simple. We want to know whether the two interventions had the same or a different effect on average. To do this we need to run an Independent Samples t-test to test if the population mean of change from intervention 1 is different intervention 2. Type (or copy and paste) the following:

```
independentSamplesTTest(formula = extra~group, data=sleep)
```

As before, this uses a function. First we need to say `independentSamplesTTest` as it is the name of the *function*. We need `extra` as it is the name of the *continuous* variable that we are interested in. We need `group` as it is the *nominal* variable that you are interested in comparing across. The symbol between the `extra` and `group` is called a *tilda* and is found (on my keyboard at least) in the top left hand corner of your keyboard, before the 1. The `data=sleep` part tells the function what the *dataframe* is called. Here it's the `sleep` dataframe. You should get the following output:

```
Welch's independent samples t-test

Outcome variable:  extra
Grouping variable:  group

Descriptive statistics:
      1      2
mean  0.750 2.330
std dev. 1.789 2.002

Hypotheses:
null:      population means equal for both groups
alternative: different population means in each group

Test results:
t-statistic:  -1.861
degrees of freedom:  17.776
p-value:  0.079

Other information:
two-sided 95% confidence interval:  [-3.365, 0.205]
estimated effect size (Cohen's d):  0.832
```

Here's how we might report it. For more information about how to interpret these findings, refer back to Chapter 13 in Learning Statistics with R.

Twenty individuals were randomly assigned to either intervention 1 or intervention 2. Intervention 1 produced a mean sleep difference of .75 hours (SD=1.79), whilst intervention 2 produced a mean sleep difference of 2.33 hours (SD=2.00). A Welch independent samples t-test was not significant ($t(17.78) = -1.86, p=.079$), although the effect size was large (Cohen's $d = 0.83$). With 95% confidence, the interval $[-3.37, 0.21]$ contains the true difference between the means of these two groups.

2.3 Paired Samples t-tests

2.3.1 What does your data look like?

There are two ways your data can be organised in an R data-frame when you need to do a Paired Samples t-test. These are known as long and wide forms.

Long form means that *each row* in the data represents one *observation* for each individual. Wide form means the *each row* in the data frame represents *one individual*. The easiest way to check this is to ask whether an individual is represented by more than one row of the data frame. If they are, then you have long form data. If each individual is represented by a single row, then it's most likely your data are in *wide* form. There's lots of reasons why people prefer one over the other, but it's important to note that it **ONLY** changes the code you use to calculate the test, **NOT** the results of the test.

We're going to manipulate a data-frame so we can demonstrate the paired samples t-test. For your practicals you should identify the format of your data and use the corresponding section to help you run the corresponding test.

2.3.2 Paired Samples t-test with long form data

To do a Paired Samples t-test, we're going to use the same 'hidden' dataframe sleep. In the previous example we ignored the last column. That's because the last analysis wasn't quite right. This dataset was actually between subjects. Each of the 10 participants received both intervention 1 and then intervention 2 (or vice versa). The third column, ID, identifies which individual is which by their id number. As before the first column, extra, is the post-pre difference in sleep duration (measured in hours). The second column, group, is the allocated intervention, coded as 1 or 2. The third column is the amount of sleep the participant gained in that particular intervention. So the first row says the first participant received treatment 1 and had an increase of .7hours.

Our question here is the same as before. We want to know whether the two interventions had the same or a different effect on average, but this time to take into account of the paired samples design. To do this we need to run an Paired Samples t-test to test if the population mean of change from intervention 1 is different intervention 2. Type (or copy and paste) the following:

```
pairedSamplesTTest(formula = extra ~ group, data=sleep, id='ID')
```

Again this uses a different function. First we need to say **pairedSamplesTTest** as it is the name of the *function*. The formula is the same as the independent samples t-test. We need **extra** as it is the name of the *continuous* variable that we are interested in. We need **group** as it is the *nominal* variable that you are interested in comparing across. The **data=sleep** part tells the function what the *dataframe* is called. Here it's the sleep dataframe. We also have another part to the function. This is the **id='ID'**, which is new. This is specific to a paired samples t-test, it tells the model which individuals match.

You should get the following output:

```
Paired samples t-test

Outcome variable:  extra
Grouping variable:  group
ID variable:      ID

Descriptive statistics:
              1      2 difference
mean      0.750 2.330    -1.580
std dev.  1.789 2.002     1.230

Hypotheses:
null:      population means equal for both measurements
alternative: different population means for each measurement

Test results:
t-statistic:  -4.062
degrees of freedom:  9
p-value:      0.003

Other information:
```

```
two-sided 95% confidence interval: [-2.46, -0.7]
estimated effect size (Cohen's d): 1.285
```

2.3.3 Paired Samples t-test with wide form data

Getting the data in the right form Now we're going to change the sleep dataframe to wide form so we can repeat the analysis with a different format of data. You need to copy and paste the following code to this. In your practicals you shouldn't need to do this, so don't worry too much about how this code works (if you ever need to do such a manipulation there are many more elegant methods).

```
sleep.wide <- data.frame( ID=1:10, group1=sleep$extra[1:10], group2=sleep$extra[11:20])
```

If you type the following you can see our new data frame called textitsleep.wide

```
View(sleep.wide) #Note View has a captial V
```

The first column, extra, is the participant's ID number. Now the second column, *group1* shows the average increase in hours slept for each participant in treatment 1. The third column, *group2* shows the average increase in hours slept for each participant in treatment 2. Notice that before, each participant was represented by multiple rows. Now each participant is represented by a single row.

As before, we need to run an Paired Samples t-test to test if the population mean of change from intervention 1 is different intervention 2. Type (or copy and paste) the following:

```
pairedSamplesTTest(formula = ~ group1+ group2, data=sleep.wide
```

This uses the same **pairedSamplesTTest** function as before. However the formula is the different to the first paired samples t-test. We need **group1** as it is the name of the *continuous* variable values from group 1. We need **group2** as it is the *continuous* variable values from the second group, group 2 that you are interested in comparing across. The **data=sleep.wide** part tells the function what the *dataframe* where those variables are stored is called. We also lose the **id='ID'** input, which we used with our first paired samples t-test. We now assume that any values on the same row are from the same individual. You should get the following output:

```
Paired samples t-test
Variables:  group1 , group2
Descriptive statistics:
      group1 group2 difference
mean      0.750 2.330    -1.580
std dev.  1.789 2.002     1.230
Hypotheses:
null:      population means equal for both measurements
alternative: different population means for each measurement
Test results:
t-statistic: -4.062
degrees of freedom: 9
p-value: 0.003
Other information:
two-sided 95% confidence interval: [-2.46, -0.7]
estimated effect size (Cohen's d): 1.285
```

2.3.4 Writing it up

Two differently formatted data-frames, with different commands that *both run the same test*. Here's how we might report it. For more information about how to interpret these findings, refer back to Chapter 13 in Learning Statistics with R.

Ten individuals received intervention 1 or intervention 2 in a random order. On average the difference in mean increased sleep hours between intervention 1 and intervention 2 was -1.58 (SD=1.23), indicating that participants slept more on average after intervention 2. A paired samples t-test indicated this difference was significant ($t(9) = -4.062, p=.003$), with a large effect size (Cohen's $d = 1.29$). With 95% confidence, the interval [-2.46, -.7] contains the true difference between the means of these two groups. This indicates that the second intervention is most effective at increasing the number of hours slept.

When you write up your t-test, you don't need to follow these examples exactly. However there are a few important points you should cover. It may look like a lot, but if you look back at the examples in this guide, you can see how we can cover these points with relatively few words.

- First you need to describe the sample. Here we are looking at means, so we describe the mean and standard deviation of each sample.
- Refer to your statistical test with its full and proper name.
- Identify the variables you used in the statistical test by name (not by the shorthand we use in the dataframes in R).
- Include your stat block
- Interpret your statistical test (Was it significant? Was it not Significant?) Explain what this means for the data (Do the two groups have the same mean or a different mean?)
- Interpret the direction of your t-test. Was Group A on average larger than Group B on the variable of interest?
- Report a measure of effect size (Cohen's d)
- Interpret the effect size. Is it large? Is it small?
- Report the confidence interval. Remember to use square brackets.
- Interpret the confidence interval. What does it mean?

3 Conclusion

In this guide you learnt how to implement three functions from the `lsr` package in R to run three different sorts of t-tests. They were a One Sample t-test, a Welch Independent Samples t-test and a Paired t-test. You used long form data to do so.