Revision section: The basics

R1.3 Confidence intervals: a way of precisely representing uncertainty

A whole range of descriptive statistics can be produced by Minitab for a variable. Below we give an example for the exam results described in Box R1.1.

MINITAB COMMANDS FOR BOX R1.1 Descriptive statistics and confidence intervals for single samples

Commands

```
%describe 'EXAMRES';
confidence 95.0.
```

Menu route

Stat > Basic Statistics > Display Descriptive Statistics

Graphs...

☑ Graphical Summary

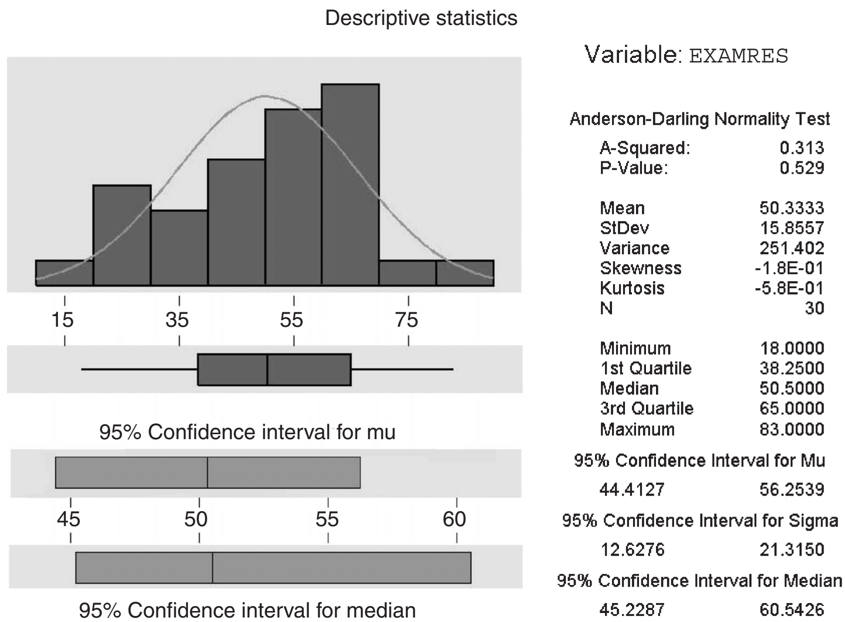
95.0 → Confidence level:

MINITAB OUTPUT FOR BOX R1.1 Descriptive statistics and confidence intervals for single samples

Descriptive Statistics: EXAMRES

```
Variable         N      Mean     Median     TrMean     StDev    SE Mean
EXAMRES         30     50.33      50.50      50.50     15.86       2.89

Variable   Minimum   Maximum         Q1         Q3
EXAMRES      18.00     83.00      38.25      65.00
```



Minitab output for Box R1.1. Confidence intervals for single samples

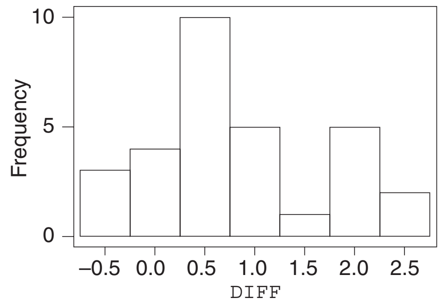
Minitab produces a wealth of information in addition to the confidence interval. However, you can see that under '95% Confidence Interval for Mu' is the same interval as that produced in Box R1.1, and calculated in the main text. Minitab has also drawn a Normal distribution with a mean and variance corresponding to our sample, and conducted a Normality test. It has also drawn a box plot, which indicates the four quartiles of the data. Confidence intervals and Normal distributions are covered in the Revision section of the main text, with Normality tests being covered in later chapters.

R1.4 The null hypothesis—taking the conservative approach

In this section, a one sample *t*-test is conducted on the data variable `DIFF`. First, a histogram of the data is plotted.

MINITAB COMMANDS FOR FIG. R1.6.

Commands	`histogram DIFF`
Menu route	Graph > Histogram `DIFF` → Graph variables, X



Minitab output for Fig. R1.6.

Then, the one sample *t*-test is conducted:

MINITAB COMMANDS FOR BOX R1.2 One sample *t*-test

Commands	`oneT DIFF;` `test 0.`
Menu route	Stat > Basic Statistics > 1-Sample t `DIFF` → Variables 0 → Test Mean:

MINITAB OUTPUT FOR BOX R1.2 One sample *t*-test

One-Sample T: `DIFF`

```
Test of mu = 0 vs mu not = 0
Variable                N          Mean        StDev       SE Mean
DIFF                   30         0.862        0.838         0.153

Variable                 95.0% CI            T             P
DIFF                 (0.549, 1.175)       5.64         0.000
```

R1.5 Comparing two means

Two sample *t*-test

The two sample *t*-test is conducted on the *squirrels* dataset. First the data are transformed to natural logarithms.

MINITAB COMMANDS TO TRANSFORM DATA

Commands

```
name C3 = 'LMALE'
let LMALE = LOGE(MALE)
name C4 = 'LFEM'
let LFEM = LOGE(FEMALE)
```

Menu route

Calc > Calculator
`LMALE` → Store result in variable
`LOGE(MALE)` → Expression

Calc > Calculator
`LFEM` → Store result in variable
`LOGE(FEMALE)` → Expression

Both the raw data and the logged data are plotted—but here we just show how to do this for the logged data. The midpoint/cutpoint command allows you to specify the bar divisions, and so ensure the two histograms are plotted on the same X scale.

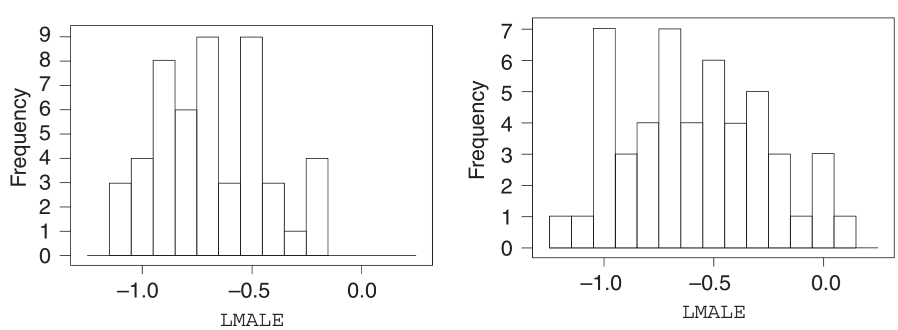
MINITAB COMMANDS FOR FIG. R1.7 Histograms of Logs of body mass of male and female squirrels

Commands

```
histogram LMALE LFEM;
midpoint -1.2:0.2/0.1;
```

Menu route

Graph > Histogram
`LMALE` → Graph variables, X row 1
`LFEM` → Graph variables, X row 2
Options...
⊙ Midpoint/cutpoint positions
-1.2:0.2/0.1 → Midpoint/cutpoint positions



Minitab output for Fig. R1.7. Histograms of Logs of body mass of male and female squirrels.

Finally, the two sample *t*-test. In this case, as in the main text, we have used the 'pooled' method to calculated the standard errors. In other words, we have assumed that one error variance can be estimated for the two samples.

MINITAB COMMANDS FOR BOX R1.6 Two sample *t*-test

Commands
```
twosample LMALE LFEM;
pooled.
```

Menu route: Stat > Basic Statistics > 2-sample *t*
- ⊙ Samples in different columns
- LMALE → First:
- LFEM → Second:
- ☑ Assume equal variances

MINITAB OUTPUT FOR BOX R1.6 Two sample *t*-test

```
Two-Sample T-Test and CI: LMALE, LFEM
Two-sample T for LMALE vs LFEM

                  N           Mean          StDev          SE Mean
LMALE            50         -0.579          0.325            0.046
LFEM             50         -0.688          0.245            0.035

Difference = mu LMALE - mu LFEM
Estimate for difference: 0.1092
95% CI for difference: (-0.0050, 0.2234)
T-Test of difference = 0 (vs not =): T-Value = 1.90 P-Value = 0.061 DF = 98
Both use Pooled StDev = 0.288
```

One and two tailed tests

To convert a two tailed to a one tailed test requires an additional command, as shown below:

MINITAB COMMANDS FOR BOX R1.9 A one-tailed two sample *t*-test of the logs of squirrel body masses

Commands
```
twosample LMALE LFEM;
pooled;
alternative 1.
```

Menu route	Stat > Basic Statistics > Two sample *t* ⦿ Samples in different columns `LMALE` → First: `LFEM` → Second: ☑ Assume equal variances Options... Alternative ▼ greater than

MINITAB OUTPUT FOR BOX R1.9 A one-tailed two sample t-test of the logs of squirrel body masses

```
Two-Sample T-Test and CI: LMALE, LFEM
Two-sample T for LMALE vs LFEM

             N      Mean     StDev   SE Mean
LMALE       50    -0.579     0.325     0.046
LFEM        50    -0.688     0.245     0.035

Difference = mu LMALE - mu LFEM
Estimate for difference: 0.1092
95% lower bound for difference: 0.0136
T-Test of difference = 0 (vs >): T-Value = 1.90
P-Value = 0.030 DF = 98
Both use Pooled StDev = 0.288
```

In this case we were using the command ‘alternative 1’ because our alternative hypothesis was that `LMALE` was greater than `LFEM`. However, we could just as easily have had the alternative hypothesis that `LMALE` was less than `LFEM`, in which case we could have used the command ‘alternative −1’. However, having noted the direction of the difference (`LMALE > LFEM`), then the test would most definitely not be significant in the other direction! Our one-tailed test has converted an insignificant *p*-value into a significant one—but see main text for a health warning!