

Now let's run the 1-way ANOVA using the *aov* function (part of base R). We are going to assign it to a variable we are calling *model*.

```
> model <- aov(Ability ~ Condition, data = cond)
> anova(model)
Analysis of Variance Table

Response: Ability
          Df  Sum Sq Mean Sq F value    Pr(>F)
Condition  2 103.872   51.936   297.05 < 2.2e-16 ***
Residuals 42   7.343    0.175
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Here's the output we get – the F value is the ratio of systematic variance to unsystematic variation. It is the Mean SS of Condition divided by Mean Residual SS.

To get the Mean Square values we divide the Sum of Squares by the associated degrees of freedom (e.g.,  $7.343 / 42 = 0.175$ ).

The ANOVA tells us we have an effect somewhere of Condition, but we don't yet know which level of this factor differs from which other level(s).

We need to conduct post hoc tests to figure this out. We can conduct both Bonferroni and Tukey pairwise comparisons using the *emmeans* function - Bonferroni is slightly more conservative than Tukey.

```
> emmeans(model, pairwise ~ Condition, adjust = "Bonferroni")
```

```
$emmeans
```

Condition	emmean	SE	df	lower.CL	upper.CL
Water	5.165081	0.1079627	42	4.947204	5.382959
Single Espresso	6.985001	0.1079627	42	6.767124	7.202879
Double Espresso	8.886287	0.1079627	42	8.668409	9.104164

```
Confidence level used: 0.95
```

```
$contrasts
```

contrast	estimate	SE	df	t.ratio	p.value
Water - Single Espresso	-1.819920	0.1526824	42	-11.920	<.0001
Water - Double Espresso	-3.721205	0.1526824	42	-24.372	<.0001
Single Espresso - Double Espresso	-1.901285	0.1526824	42	-12.453	<.0001

```
P value adjustment: bonferroni method for 3 tests
```