# Complete Example (Between Subjects – Factorial)

New to this section:

* Levene’s Test: as with one-way ANOVAs, you will get a Levene’s test for homogeneity. Unlike Mauchly’s test for repeated measures, you get one test examining the variances by condition.
* Main effects: interpreting each IV on its own, ignoring the effect of the other IVs.
* Interaction: interpreting the IVs together, seeing if the conditions are significantly different OR if the pattern of data across levels is different for the other IV.

Chart of ANOVA Analysis:

|  |  |  |  |
| --- | --- | --- | --- |
|  | ANOVA | | |
|  | Main Effect | Main Effect | Interaction |
| If levels > 2  And significant | Independent t-test  Bonferroni correction | Independent t-test  Bonferroni correction | SPLIT one IV column  Independent t-test  Bonferroni correction |
| If levels = 2 | Interpret means | Interpret means |

If the interaction is significant, often people ignore any analyses with the main effects:

* This procedure reduces Type 1 error because you are running less post hoc tests.
* You are interested in the interaction anyway, so why only interpret one variable at a time?

We looked at two years worth of athletic spending data for five different sports. Are there differences across sports and years in spending?

**Datafile:** bn 2 anova.csv

**IVs:**

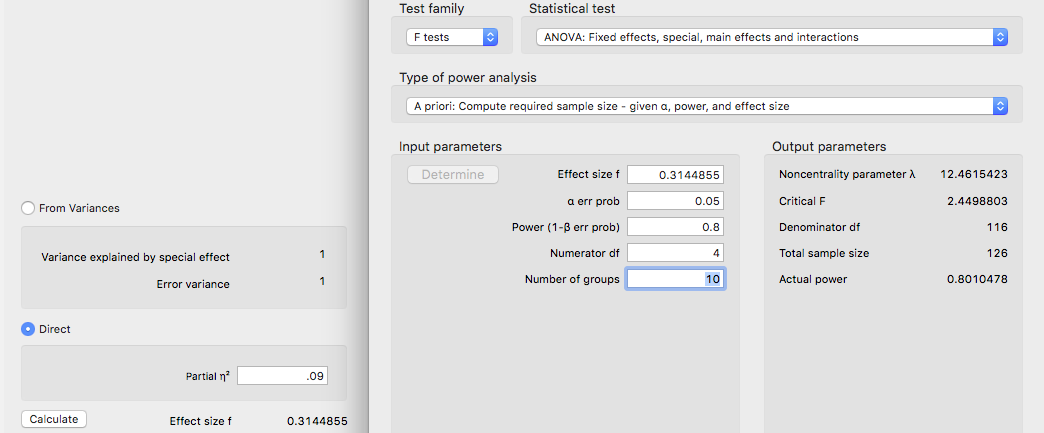
* Years:
  + Levels: 2007 versus 2008
* Type of Sport:
  + Levels: Basketball, baseball, volleyball, football, soccer

**DV:**

* Money: Spending transactions for each individual sport, represented in dollar amounts.

**Power:**

1. Open Gpower!
   1. Test family: F-test
   2. Statistical Test: ANOVA fixed effect, special, main effects and interactions
   3. Estimate an effect size: click determine 🡪 click direct 🡪 use eta square sizes you think might be accurate, remember small, medium, and large estimates from the notes.
   4. Alpha = .05
   5. Power (1-beta .20) = .80
   6. Numerator df:
      1. For main effects: number of levels – 1
      2. For interactions: (number of levels – 1)\*(number of levels – 1)
      3. Generally, you want to estimate based on interactions because that’s the purpose of the experiment.
   7. Number of groups:
      1. For the main effects: number of levels
      2. For the interactions: number of conditions
2. Let’s estimate the following:
   1. Medium effect size (eta = .09)
   2. Interaction component (2-1)\*(5-1)
   3. Conditions from our current study (2\*5)
3. Says we needed to run 126 people to find a significant effect with a small effect size.



Write Up Example:

**Results**

Monthly budget transactions were examined to determine if type of sport spending (Baseball, Basketball, Football, Soccer, and Volleyball) changed over a two year period (2007, 2008). Data were screened for assumptions (linearity, homogeneity, normality, outliers), and several problems were found with linearity, homogeneity, and outliers. While Levene’s test indicated a potential problem with homogeneity (*F*(9, 18250) = 266.50, *p* < .001) the large sample size may have influenced this factor and a residual plot showed homogeneous groups. Several outliers were found with high standardized z-scores (*n* = 223), which were excluded for analyses after determining the data was correct.

A 2X5 between subjects ANOVA was analyzed on year and transaction type. Both main effects of year (*F*(1, 18250) = 49.29, *p* < .001, *η²* = .002) and type of sport (*F*(4, 18250) = 580.40, *p* < .001, *η²* = .11) were significant. The interaction between year and transaction type was not significant, *F*(4, 18250) = 3.47, *p* = .008, *η²* = .001. Figure 1 shows the interaction. (\*\*normally here you’d talk about the significant main effects post hoc only\*\*). Independent *t*-tests with a Bonferroni correction were performed to examine if average budgets had decreased across time. Baseball decreased spending by about $12 dollars from 2007 to 2008 (*t*(3100) = 2.39, *p* < .001, *d* = 0.09), while Football decreased by about $22 dollars from 2007 to 2008 (*t*(4417) = 5.01 *p* < .001, *d* = 0.15).

(\*\*\* you would go on and talk about all the different comparisons\*\*\*)

*Figure 1.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Basketball | Baseball | Football | Soccer | Volleyball |
| 2007 |  |  |  |  |  |
| 2008 |  |  |  |  |  |

Rules for across or down:

* Go with the hypothesis (do what your advisor wants)
* Split by the larger variable 🡪 analyze by the smaller one (always make smaller number of total comparisons, which is less type 1 error)

DOWN: 5 comparisons

For basketball: 2007 v 2008

For baseball: 2007 v 2008

For football: 2007 v 2008

For soccer: 2007 v 2008

For volleyball: 2007 v 2008

ACROSS: 20 comparisons!

For 2007:

1. Basket v base
2. Basket v foot
3. Basket v soccer
4. Basket v vb
5. Base v foot
6. Base v soccer
7. Base vb
8. Foot v soccer
9. Foot v vb
10. Soccer v vb

For 2008:

1. Basket v base
2. Basket v foot
3. Basket v soccer
4. Basket v vb
5. Base v foot
6. Base v soccer
7. Base vb
8. Foot v soccer
9. Foot v vb
10. Soccer v vb

**Results**

**ANOVA**

| **ANOVA - money** | | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cases** | | **Sum of Squares** | | **df** | | **Mean Square** | | **F** | | **p** | | **η²** | |
| year |  | 1.676e +6 |  | 1 |  | 1.676e +6 |  | 49.289 |  | < .001 |  | 0.002 |  |
| type |  | 7.893e +7 |  | 4 |  | 1.973e +7 |  | 580.398 |  | < .001 |  | 0.113 |  |
| year ✻ type |  | 472148 |  | 4 |  | 118037 |  | 3.472 |  | 0.008 |  | 0.001 |  |
| Residual |  | 6.204e +8 |  | 18250 |  | 33997 |  |  |  |  |  |  |  |
|  | | | | | | | | | | | | | |
| *Note.*  Type III Sum of Squares | | | | | | | | | | | | | |

Year, *F*(1, 18250) = 49.29, *p* < .001, *η²* = .002

Type, *F*(4, 18250) = 580.40, *p* < .001, *η²* = .11

Interaction, *F*(4, 18250) = 3.47, *p* = .008, *η²* = .001

**Assumption Checks**

| **Test for Equality of Variances (Levene's)** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **F** | | **df1** | | **df2** | | **p** | |
| 266.5 |  | 9 |  | 18250 |  | < .001 |  |
|  | | | | | | | |

Levene’s is significant, *F*(9, 18250) = 266.50, *p* < .001

**Post Hoc Tests**

| **Post Hoc Comparisons - type** | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  | | **Mean Difference** | | **SE** | | **t** | | **p tukey** | |
| Baseball |  | Basketball |  | 37.73 |  | 4.539 |  | 8.312 |  | < .001 |  |
|  |  | Football |  | -141.88 |  | 4.323 |  | -32.821 |  | < .001 |  |
|  |  | Soccer |  | -95.32 |  | 4.646 |  | -20.516 |  | < .001 |  |
|  |  | Volleyball |  | -41.16 |  | 4.422 |  | -9.308 |  | < .001 |  |
| Basketball |  | Football |  | -179.60 |  | 4.163 |  | -43.146 |  | < .001 |  |
|  |  | Soccer |  | -133.05 |  | 4.498 |  | -29.582 |  | < .001 |  |
|  |  | Volleyball |  | -78.88 |  | 4.265 |  | -18.494 |  | < .001 |  |
| Football |  | Soccer |  | 46.55 |  | 4.279 |  | 10.879 |  | < .001 |  |
|  |  | Volleyball |  | 100.72 |  | 4.034 |  | 24.966 |  | < .001 |  |
| Soccer |  | Volleyball |  | 54.17 |  | 4.379 |  | 12.369 |  | < .001 |  |
|  | | | | | | | | | | | |

**Marginal Means**

| **Marginal Means - year** | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **year** | | **Marginal Mean** | | **SE** | | **Lower CI** | | **Upper CI** | |
| 2007 |  | 287.0 |  | 1.899 |  | 283.3 |  | 290.7 |  |
| 2008 |  | 267.6 |  | 1.998 |  | 263.7 |  | 271.5 |  |
|  | | | | | | | | | |

| **Marginal Means - type** | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **type** | | **Marginal Mean** | | **SE** | | **Lower CI** | | **Upper CI** | |
| Baseball |  | 229.2 |  | 3.314 |  | 222.7 |  | 235.7 |  |
| Basketball |  | 191.5 |  | 3.102 |  | 185.4 |  | 197.5 |  |
| Football |  | 371.1 |  | 2.776 |  | 365.6 |  | 376.5 |  |
| Soccer |  | 324.5 |  | 3.257 |  | 318.1 |  | 330.9 |  |
| Volleyball |  | 270.3 |  | 2.928 |  | 264.6 |  | 276.1 |  |
|  | | | | | | | | | |

| **Marginal Means - year ✻ type** | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **year** | | **type** | | **Marginal Mean** | | **SE** | | **Lower CI** | | **Upper CI** | |
| 2007 |  | Baseball |  | 235.6 |  | 4.582 |  | 226.7 |  | 244.6 |  |
|  |  | Basketball |  | 197.6 |  | 4.268 |  | 189.2 |  | 205.9 |  |
|  |  | Football |  | 389.6 |  | 3.848 |  | 382.1 |  | 397.2 |  |
|  |  | Soccer |  | 335.5 |  | 4.452 |  | 326.7 |  | 344.2 |  |
|  |  | Volleyball |  | 276.6 |  | 4.033 |  | 268.7 |  | 284.5 |  |
| 2008 |  | Baseball |  | 222.7 |  | 4.788 |  | 213.3 |  | 232.1 |  |
|  |  | Basketball |  | 185.3 |  | 4.502 |  | 176.5 |  | 194.2 |  |
|  |  | Football |  | 352.5 |  | 4.002 |  | 344.7 |  | 360.3 |  |
|  |  | Soccer |  | 313.6 |  | 4.754 |  | 304.2 |  | 322.9 |  |
|  |  | Volleyball |  | 264.0 |  | 4.245 |  | 255.7 |  | 272.4 |  |
|  | | | | | | | | | | | |

**Descriptives**

| **Descriptives - money** | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **year** | | **type** | | **Mean** | | **SD** | | **N** | |
| 2007 |  | Baseball |  | 235.6 |  | 153.0 |  | 1619 |  |
|  |  | Basketball |  | 197.6 |  | 121.3 |  | 1866 |  |
|  |  | Football |  | 389.6 |  | 254.6 |  | 2296 |  |
|  |  | Soccer |  | 335.5 |  | 201.8 |  | 1715 |  |
|  |  | Volleyball |  | 276.6 |  | 167.5 |  | 2090 |  |
| 2008 |  | Baseball |  | 222.7 |  | 147.7 |  | 1483 |  |
|  |  | Basketball |  | 185.3 |  | 112.4 |  | 1677 |  |
|  |  | Football |  | 352.5 |  | 236.0 |  | 2123 |  |
|  |  | Soccer |  | 313.6 |  | 194.3 |  | 1504 |  |
|  |  | Volleyball |  | 264.0 |  | 161.9 |  | 1887 |  |
|  | | | | | | | | | |

Separate out the files!

No correction for type 1 error. Independent t … so what do I do to correct?

Bonferroni alpha / number of comparisons … .05 / 5 = new alpha or criterion = .01

If found p is less than .01, then it’s significant.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Split Group | Group 1 | Group 2 | Comparison | *d* |
| Basketball | 2007  M = 197.6  SD =121.3  N = 1866 | 2008  M = 185.3  SD = 112.4  N = 1677 | *t*(3541) = 3.10, *p* = .002  SIGNIFICANT | *d* = 0.10 |
| Baseball | 2007  M = 235.6  SD = 153  N = 1619 | 2008  M = 222.7  SD = 147.7  N = 1483 | *t*(3100) = 2.39, *p* = .017  NOT | *d =* 0.09 |
| Football | 2007  M = 389.6  SD = 254.6  N = 2296 | 2008  M = 352.5  SD = 236  N = 2123 | *t*(4417) = 5.01, *p* < .001  SIGNIFICANT | *d* = 0.15 |
| Soccer | 2007  M = 335.5  SD = 201.8  N = 1715 | 2008  M = 313.6  SD = 194.3  N = 1504 | *t*(3217) = 3.12, *p* = .002  SIGNIFICANT | *d* = 0.11 |
| Volleyball | 2007  M = 276.6  SD = 167.5  N = 2090 | 2008  M = 264  SD =161.9  N = 1887 | *t*(3975) = 2.41, *p* = .016  NOT | *d* = 0.08 |

Basketball

# Results

## T-Test

| **Independent Samples T-Test** | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **t** | | **df** | | **p** | | **Cohen's d** | |
| money |  | 3.104 |  | 3541 |  | 0.002 | ᵃ | 0.104 |  |
|  | | | | | | | | | |
| Note.  Student's T-Test. | | | | | | | | | |
| ᵃ Levene's test is significant (p < .05), suggesting a violation of the equal variance assumption | | | | | | | | | |

### Descriptives

| **Group Descriptives** | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **Group** | | **N** | | **Mean** | | **SD** | | **SE** | |
| money |  | 2007 |  | 1866 |  | 197.6 |  | 121.3 |  | 2.809 |  |
|  |  | 2008 |  | 1677 |  | 185.3 |  | 112.4 |  | 2.745 |  |
|  | | | | | | | | | | | |

Baseball

# Results

## T-Test

| **Independent Samples T-Test** | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **t** | | **df** | | **p** | | **Cohen's d** | |
| money |  | 2.385 |  | 3100 |  | 0.017 |  | 0.086 |  |
|  | | | | | | | | | |
| Note.  Student's T-Test. | | | | | | | | | |

### Descriptives

| **Group Descriptives** | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **Group** | | **N** | | **Mean** | | **SD** | | **SE** | |
| money |  | 2007 |  | 1619 |  | 235.6 |  | 153.0 |  | 3.803 |  |
|  |  | 2008 |  | 1483 |  | 222.7 |  | 147.7 |  | 3.836 |  |
|  | | | | | | | | | | | |

Football

# Results

## T-Test

| **Independent Samples T-Test** | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **t** | | **df** | | **p** | | **Cohen's d** | |
| money |  | 5.014 |  | 4417 |  | < .001 | ᵃ | 0.151 |  |
|  | | | | | | | | | |
| Note.  Student's T-Test. | | | | | | | | | |
| ᵃ Levene's test is significant (p < .05), suggesting a violation of the equal variance assumption | | | | | | | | | |

### Descriptives

| **Group Descriptives** | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **Group** | | **N** | | **Mean** | | **SD** | | **SE** | |
| money |  | 2007 |  | 2296 |  | 389.6 |  | 254.6 |  | 5.313 |  |
|  |  | 2008 |  | 2123 |  | 352.5 |  | 236.0 |  | 5.123 |  |
|  | | | | | | | | | | | |

Soccer

# Results

## T-Test

| **Independent Samples T-Test** | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **t** | | **df** | | **p** | | **Cohen's d** | |
| money |  | 3.124 |  | 3217 |  | 0.002 |  | 0.110 |  |
|  | | | | | | | | | |
| Note.  Student's T-Test. | | | | | | | | | |

### Descriptives

| **Group Descriptives** | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **Group** | | **N** | | **Mean** | | **SD** | | **SE** | |
| money |  | 2007 |  | 1715 |  | 335.5 |  | 201.8 |  | 4.874 |  |
|  |  | 2008 |  | 1504 |  | 313.6 |  | 194.3 |  | 5.011 |  |
|  | | | | | | | | | | | |

Volleyball

# Results

## T-Test

| **Independent Samples T-Test** | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **t** | | **df** | | **p** | | **Cohen's d** | |
| money |  | 2.409 |  | 3975 |  | 0.016 |  | 0.076 |  |
|  | | | | | | | | | |
| Note.  Student's T-Test. | | | | | | | | | |

### Descriptives

| **Group Descriptives** | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **Group** | | **N** | | **Mean** | | **SD** | | **SE** | |
| money |  | 2007 |  | 2090 |  | 276.6 |  | 167.5 |  | 3.663 |  |
|  |  | 2008 |  | 1887 |  | 264.0 |  | 161.9 |  | 3.727 |  |
|  | | | | | | | | | | | |

While there are new options for effect size in JASP, those work for one-way tests or main effects only. You could still calculate Cohen’s d as described here.