# COMPLETE EXAMPLE

MODERATION

**Data set:** data set 1.csv

**IVs:**

* Books – number of books a person read
* Attend – attendance in the class
* Interaction of books by attendance

**DV:**

* Grade – final course grade

**Research Question:** Is there an interaction between books and attendance in predicting final course grade?

**SPECIAL INSTRUCTIONS:**

* Centering: When working with two continuous variables in regression, you have to center them first. Centering means that you start with mean centered or z scores instead of the regular variables.
* Why? When you create an interaction, you are creating multicollinearity. Mean centering or Z-scoring helps.
  + Also, z score centering the variables creates SDs of 1 and a mean of zero.
  + When variables are NOT centered – the b/Beta values may be negative, but the slopes will look like they are positive (your figure will NOT match the values you are getting for each high and low group).
  + When variables are centered – the means are zero, so the b/Beta values will match your pictures.
* DO NOT CENTER THE DV.

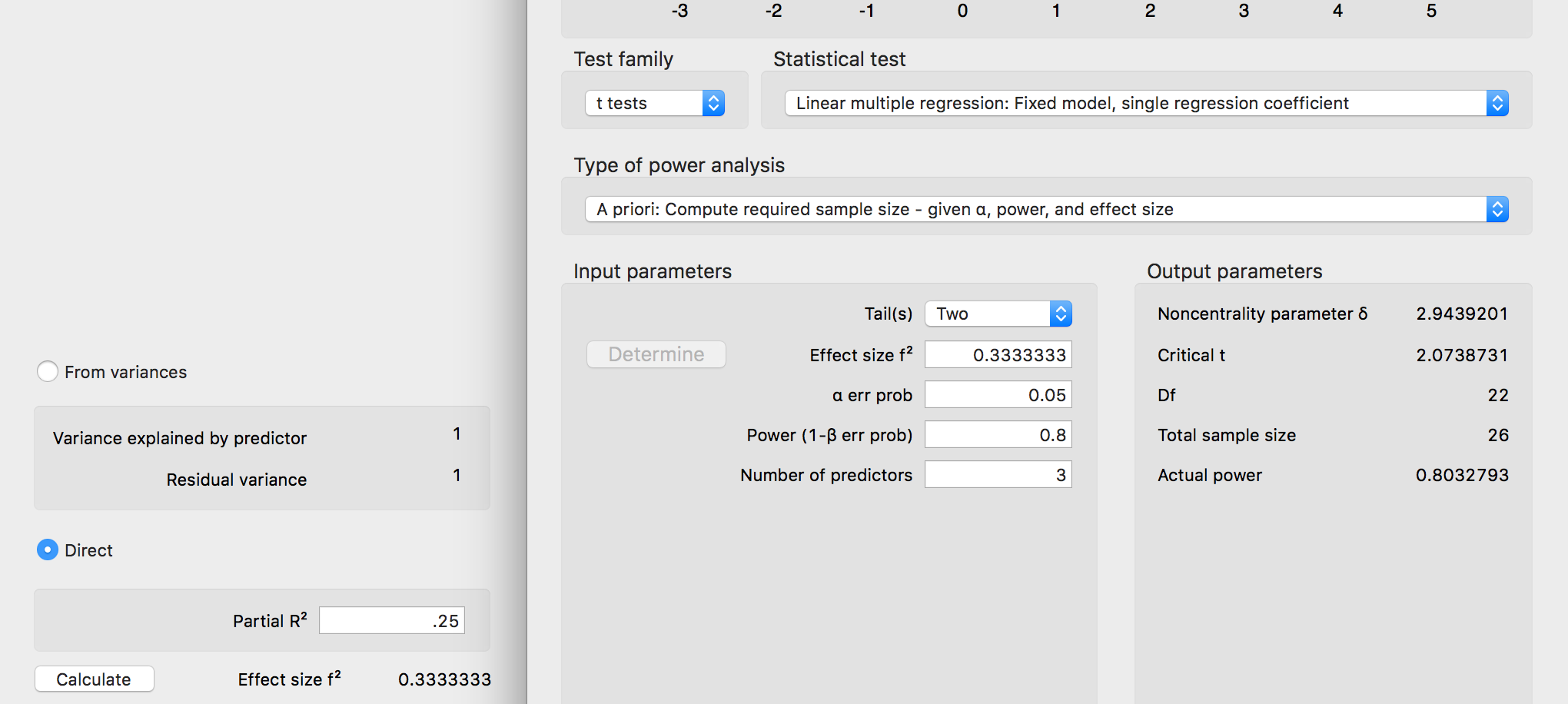
**Interaction:**

* The interaction is created by multiplying the scores of each variable together (like participant one book times participant one attendance) = participant one interaction score.
* The interaction is created after the variables are centered, so the interaction is centered as well.

**Power:**

1. Open Gpower!
   1. Test family: t tests
   2. Statistical Test: Linear multiple regression: Fixed model, single regression coefficient
   3. Tails: two
   4. Effect size: click determine 🡪 direct 🡪 estimate partial R2 🡪 calculate and transfer to main window.
   5. Alpha = .05
   6. Power (1-beta of .20) = .80
   7. The number of predictors: 3
      1. One for X, M, and X\*M
      2. You can also include covariates.
2. Let’s estimate the following:
   1. Large effect size (*R2* = .25)
   2. Number of predictors = 3

We would need 26 people to find a large effect of the interaction.



**Output main model**

## Linear Regression

| **Model Summary** | | | | | | | | | | | | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | | **R** | | **R²** | | **Adjusted R²** | | **RMSE** | | | | **R² Change** | | **F Change** | | | | **df1** | | **df2** | | **p** | |
| 1 |  | 0.634 |  | 0.402 |  | 0.352 |  | 13.444 | | |  | 0.402 |  | 8.073 | | |  | 3 |  | 36 |  | < .001 |  |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **ANOVA** | | | | | | | | | | | | | | | | | | | | |
| **Model** | |  | | | **Sum of Squares** | | | | **df** | | **Mean Square** | | | | **F** | | **p** | | | |
| 1 |  | Regression | |  | 4377 | | |  | 3 |  | 1459.2 | | |  | 8.073 |  | < .001 | | |  |
|  |  | Residual | |  | 6506 | | |  | 36 |  | 180.7 | | |  |  |  |  | | |  |
|  |  | Total | |  | 10884 | | |  | 39 |  |  | | |  |  |  |  | | |  |
|  | | | | | | | | | | | | | | | | | | | | |

| **Coefficients** | | | | | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | |  | | **Unstandardized** | | | | | **Standard Error** | | **Standardized** | | **t** | | **p** | |
| 1 |  | intercept |  | 61.602 | | | |  | 2.319 |  |  |  | 26.570 |  | < .001 |  |
|  |  | zbooks |  | 5.951 | | | |  | 2.403 |  | 0.356 |  | 2.476 |  | 0.018 |  |
|  |  | zattend |  | 5.702 | | | |  | 2.404 |  | 0.341 |  | 2.372 |  | 0.023 |  |
|  |  | zbooks  ✻  zattend |  | 4.503 | | | |  | 2.140 |  | 0.272 |  | 2.104 |  | 0.042 |  |
|  | | | | | | | | | | | | | | | | |
| **Part And Partial Correlations** | | | | | | | |
| **Model** | |  | | **Partial** | | **Part** | |
| 1 |  | zbooks |  | 0.381 |  | 0.319 |  |
|  |  | zattend |  | 0.368 |  | 0.306 |  |
|  |  | zbooks  ✻  zattend |  | 0.331 |  | 0.271 |  |
|  | | | | | | | |

**Is the overall test significant?**

| **R² Change** | | **F Change** | | **df1** | | **df2** | | **p** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0.402 |  | 8.073 |  | 3 |  | 36 |  | < .001 |

***F*(3, 36) = 8.07, *p* < .001, *R²* = .40**

**Is the interaction significant?**

| **Coefficients** | | | | | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | |  | | **Unstandardized** | | | | | **Standard Error** | | **Standardized** | | **t** | | **p** | |
| 1 |  | intercept |  | 61.602 | | | |  | 2.319 |  |  |  | 26.570 |  | < .001 |  |
|  |  | zbooks |  | 5.951 | | | |  | 2.403 |  | 0.356 |  | 2.476 |  | 0.018 |  |
|  |  | zattend |  | 5.702 | | | |  | 2.404 |  | 0.341 |  | 2.372 |  | 0.023 |  |
|  |  | zbooks  ✻  zattend |  | 4.503 | | | |  | 2.140 |  | 0.272 |  | 2.104 |  | 0.042 |  |
|  | | | | | | | | | | | | | | | | |
| **Part And Partial Correlations** | | | | | | | |
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|  |  | zbooks  ✻  zattend |  | 0.331 |  | 0.271 |  |
|  | | | | | | | |

**Books *b* = 5.95, *t*(36) = 2.48, *p* = .02, *pr2* = .14**

**Attend *b* = 5.70, *t*(36) = 2.37, *p* = .02, *pr2* = .14**

**Interaction *b* = 4.50, *t*(36) = 2.10, *p* = .04, *pr2* = .11**

**Simple slopes:**

1. Simple slopes are the post hoc test for a significant interaction.
   1. DO NOT think about simple slopes as creating low, average, and high groups – although the output will appear that way.
   2. What happens is that you create regressions that pretend that each person is one SD above their score (high), their current score (average), or one SD below their score (low).
      1. Remember we mean centered these scores – so the regression you ran to start is the average group.
      2. By mean centering, we are saying that the regression slopes in the main model (above) are the slopes for an average number of books and attendance.
   3. By pretending each person is one SD higher or lower than average allows us to calculate the slopes for those types of scores.
   4. Can I switch X and M? Yes – if one set of slopes makes more sense, use those. (always go with the hypothesis first).
2. Interpret the slopes:
   1. At high levels of attendance: Books ***b* = 10.45, *t*(36) = 3.20, *p* = .003, *pr2* = .22**
   2. At average levels of attendance: Books ***b* = 5.95, *t*(36) = 2.48, *p* = .02, *pr2* = .14**
   3. At low levels of attendance: Books *b* = 1.45, *t*(36) = 0.46, *p* = .65, *pr2* = .01

HIGH ATTEND

**Linear Regression**

| **Model Summary** | | | | | | | | | | | | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | | **R** | | **R²** | | **Adjusted R²** | | **RMSE** | | | | **R² Change** | | **F Change** | | | | **df1** | | **df2** | | **p** | |
| 1 |  | 0.634 |  | 0.402 |  | 0.352 |  | 13.444 | | |  | 0.402 |  | 8.073 | | |  | 3 |  | 36 |  | < .001 |  |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **ANOVA** | | | | | | | | | | | | | | | | | | | | |
| **Model** | |  | | | **Sum of Squares** | | | | **df** | | **Mean Square** | | | | **F** | | **p** | | | |
| 1 |  | Regression | |  | 4377 | | |  | 3 |  | 1459.2 | | |  | 8.073 |  | < .001 | | |  |
|  |  | Residual | |  | 6506 | | |  | 36 |  | 180.7 | | |  |  |  |  | | |  |
|  |  | Total | |  | 10884 | | |  | 39 |  |  | | |  |  |  |  | | |  |
|  | | | | | | | | | | | | | | | | | | | | |

| **Coefficients** | | | | | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | |  | | **Unstandardized** | | | | | **Standard Error** | | **Standardized** | | **t** | | **p** | |
| 1 |  | intercept |  | 67.305 | | | |  | 3.312 |  |  |  | 20.322 |  | < .001 |  |
|  |  | zbooks |  | 10.453 | | | |  | 3.271 |  | 0.626 |  | 3.195 |  | 0.003 |  |
|  |  | zattendhi |  | 5.702 | | | |  | 2.404 |  | 0.341 |  | 2.372 |  | 0.023 |  |
|  |  | zbooks  ✻  zattendhi |  | 4.503 | | | |  | 2.140 |  | 0.394 |  | 2.104 |  | 0.042 |  |
|  | | | | | | | | | | | | | | | | |
| **Part And Partial Correlations** | | | | | | | |
| **Model** | |  | | **Partial** | | **Part** | |
| 1 |  | zbooks |  | 0.470 |  | 0.412 |  |
|  |  | zattendhi |  | 0.368 |  | 0.306 |  |
|  |  | zbooks  ✻  zattendhi |  | 0.331 |  | 0.271 |  |
|  | | | | | | | |

*b* = 10.45, *t*(36) = 3.20, *p* = .003, *pr2* = .22

LOW ATTEND

## Linear Regression

| **Model Summary** | | | | | | | | | | | | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | | **R** | | **R²** | | **Adjusted R²** | | **RMSE** | | | | **R² Change** | | **F Change** | | | | **df1** | | **df2** | | **p** | |
| 1 |  | 0.634 |  | 0.402 |  | 0.352 |  | 13.444 | | |  | 0.402 |  | 8.073 | | |  | 3 |  | 36 |  | < .001 |  |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **ANOVA** | | | | | | | | | | | | | | | | | | | | |
| **Model** | |  | | | **Sum of Squares** | | | | **df** | | **Mean Square** | | | | **F** | | **p** | | | |
| 1 |  | Regression | |  | 4377 | | |  | 3 |  | 1459.2 | | |  | 8.073 |  | < .001 | | |  |
|  |  | Residual | |  | 6506 | | |  | 36 |  | 180.7 | | |  |  |  |  | | |  |
|  |  | Total | |  | 10884 | | |  | 39 |  |  | | |  |  |  |  | | |  |
|  | | | | | | | | | | | | | | | | | | | | |

| **Coefficients** | | | | | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | |  | | **Unstandardized** | | | | | **Standard Error** | | **Standardized** | | **t** | | **p** | |
| 1 |  | intercept |  | 55.900 | | | |  | 3.368 |  |  |  | 16.598 |  | < .001 |  |
|  |  | zbooks |  | 1.448 | | | |  | 3.164 |  | 0.087 |  | 0.458 |  | 0.650 |  |
|  |  | zattendlo |  | 5.702 | | | |  | 2.404 |  | 0.341 |  | 2.372 |  | 0.023 |  |
|  |  | zbooks  ✻  zattendlo |  | 4.503 | | | |  | 2.140 |  | 0.372 |  | 2.104 |  | 0.042 |  |
|  | | | | | | | | | | | | | | | | |
| **Part And Partial Correlations** | | | | | | | |
| **Model** | |  | | **Partial** | | **Part** | |
| 1 |  | zbooks |  | 0.076 |  | 0.059 |  |
|  |  | zattendlo |  | 0.368 |  | 0.306 |  |
|  |  | zbooks  ✻  zattendlo |  | 0.331 |  | 0.271 |  |
|  | | | | | | | |

*b* = 1.45, *t*(36) = 0.46, *p* = .65, *pr2* = .01

1. Understand the slopes:
   1. This example:
      1. When students are going to class a lot (high attendance), each standardized book is adding points 10.45 to their grade. (a significant predictor)
      2. When students are going to class on average, each standardized book is adding 5.95 points to their grade. (a significant predictor)
      3. When students aren’t really going to class (low attendance), standardized books are adding points 1.45 to their grade. (not a significant predictor)
      4. Therefore, as attendance and books go up together, we get this additive effect to their grade.
   2. How do I know what you mean by low, average, high of the moderator?
      1. Low one SD below the mean (14.1 – 4.28 = 9.82)
      2. Average the mean (14.1)
      3. High above the mean (14.1 + 4.28 = 18.38)

## Descriptives

| **Descriptive Statistics** | | | | | |
| --- | --- | --- | --- | --- | --- |
|  | | **books** | | **attend** | |
| **Valid** |  | 40 |  | 40 |  |
| **Missing** |  | 0 |  | 0 |  |
| **Mean** |  | 2.000 |  | 14.10 |  |
| **Std. Deviation** |  | 1.432 |  | 4.278 |  |
| **Minimum** |  | 0.000 |  | 6.000 |  |
| **Maximum** |  | 4.000 |  | 20.00 |  |
|  | | | | | |

1. Create a graph (that is mostly decent):
   1. You will get a fan shaped pattern if your interaction was significant (not always like this, but a fan and NOT parallel lines).

*Figure 1*. Attendance moderating the relationship between books read and grades. Red line indicates low attendance, dashed line is average attendance, and blue line is high attendance.

**Results**

Attendance and number of books read during a semester were used to predict final class grade. Data were checked for outliers and assumptions of regression, and no violations were found. The variables were centered, and we analyzed the interaction between books and attendance predicting final class grade.

The overall model of attendance and books were significant predictors of grades, *F*(3, 36) = 8.07, *p* < .001, *R²* = .40. As a person attended more classes, their course grade increased significantly, *b* = 5.70, *t*(36) = 2.37, *p* = .02, *pr2* = .14. Students could also increase their course grades by reading more books throughout the semester, *b* = 5.95, *t*(36) = 2.48, *p* = .02, *pr2* = .14. Course grades were also predicted by the interaction between books read and attendance in the course, *b* = 4.50, *t*(36) = 2.10, *p* = .04, *pr2* = .11. Figure 1 shows the interaction between our predictors. For average attendance, there was a significant increase in grades when reading more books, *b* = 5.95. For low attendance, there was a non-significant difference in scores when reading more books, *b* = 1.45, *t*(36) = 0.46, *p* = .65, *pr2* = .01. Finally, high attending participants showed the largest increase when reading more books, *b* = 10.45*, t*(36) = 3.20*, p* = .003, *pr2* = .22.