Regression Vs. ANOVA: Is a main effect really a main effect?

Arthur Capelier-Mourguy

Lancaster University

17th of July 2018

Outline

Defining the problem

What you might see

We defined a regression model `Score` $\sim$ `Condition*PrePost`.

Defining the problem

What you might see

We defined a regression model

`Score` $\sim$ `Condition + PrePost + Condition:PrePost`.

Defining the problem

What you might see

We defined a regression model

`Score` $\sim$ `Condition + PrePost + Condition:PrePost`.

We found a significant main effect of Condition, with higher scores in the group A than in the group B.

Defining the problem

What you might see

We defined a regression model
`Score` $\sim$ `Condition + PrePost + Condition:PrePost`.
We found a significant main effect of Condition, with higher scores in the group A than in the group B.
[Table with parameter estimates and statistics]

Defining the problem

What you might see

We defined a regression model
`Score` $\sim$ `Condition + PrePost + Condition:PrePost`.
We found a significant main effect of Condition, with higher scores in the group A than in the group B.
[Table with parameter estimates and statistics]

- What does the regression model actually do?
- What do the parameter values in the table mean?
- What does "main effect" mean in the context of a regression?

Defining the problem

What you might see

We defined a regression model
`Score` $\sim$ `Condition + PrePost + Condition:PrePost`.
We found a significant main effect of Condition, with higher scores in the group A than in the group B.
[Table with parameter estimates and statistics]

- What does the regression model actually do?
- What do the parameter values in the table mean?
- What does "main effect" mean in the context of a regression?

All stats in R have the same syntax

What to expect from this talk?

What this talk is about

- Demonstrate how ANOVA and regression results differ
- Detail what parameters in a regression model mean and do

What to expect from this talk?

What this talk is about

- Demonstrate how ANOVA and regression results differ
- Detail what parameters in a regression model mean and do

What this talk is not about

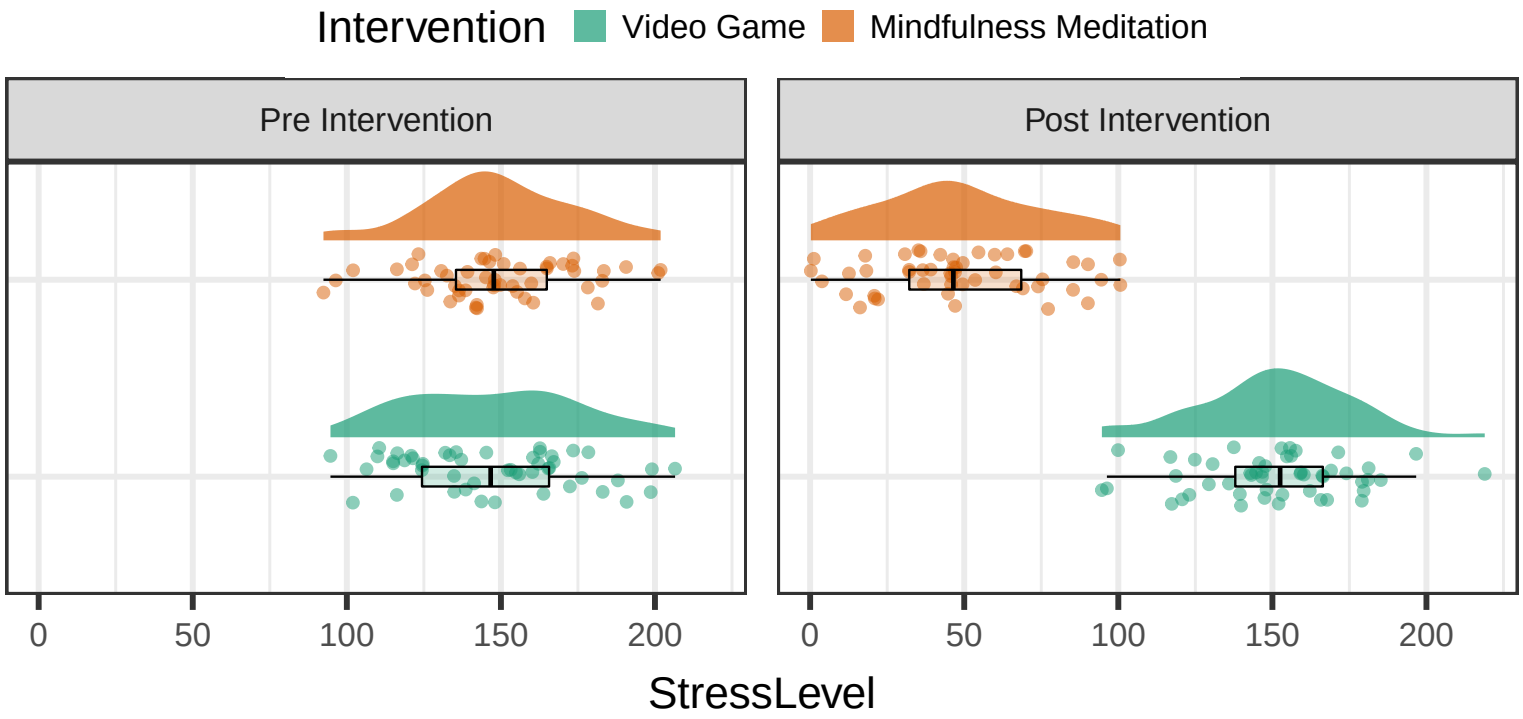
- How to use R
- How to build a good mixed-effects model
- The *p*-value debate

The simulated data

Assessing stress levels after and before a 30 minutes intervention, "mindfulness meditation" or "video games".

The simulated data

Assessing stress levels after and before a 30 minutes intervention, "mindfulness meditation" or "video games".



ANOVA and regression results

ANOVA and regression results

ANOVA results

`aov(StressLevel ~ Intervention*PrePost)`

Parameter	Sum Square	F value	$Pr(>\mathrm{F})$
Intervention	114381	164.8	$< 2e{-}16$
PrePost	185059	266.7	$< 2e{-}16$
Intervention:PrePost	102808	148.2	$< 2e{-}16$

ANOVA and regression results

ANOVA results

`aov(StressLevel ~ Intervention*PrePost)`

Parameter	Sum Square	F value	$Pr(>\mathrm{F})$
Intervention	114381	164.8	$< 2e{-}16$
PrePost	185059	266.7	$< 2e{-}16$
Intervention:PrePost	102808	148.2	$< 2e{-}16$

Regression results

`lm(StressLevel ~ Intervention*PrePost)`

Parameter	Estimate	Std. Error	t value	$Pr(>\|t\|)$
(Intercept)	147.305	3.674	40.099	$< 2e{-}16$
Intervention	1.801	5.195	0.347	0.729
PrePost	3.553	5.195	0.684	0.495
Intervention:PrePost	-104.193	7.347	-14.182	$< 2e{-}16$

ANOVA and regression results

ANOVA results

`aov(StressLevel ~ Intervention*PrePost)`

Parameter	Sum Square	F value	$Pr(>\mathrm{F})$
Intervention	114381	164.8	$< 2e{-}16$
PrePost	185059	266.7	$< 2e{-}16$
Intervention:PrePost	102808	148.2	$< 2e{-}16$

Regression results

`lm(StressLevel ~ Intervention*PrePost)`

Parameter	Estimate	Std. Error	t value	$Pr(>\|t\|)$
(Intercept)	147.305	3.674	40.099	$< 2e{-}16$
InterventionMeditation	1.801	5.195	0.347	0.729
PrePostPost Intervention	3.553	5.195	0.684	0.495
Intervention:PrePost	-104.193	7.347	-14.182	$< 2e{-}16$

Graphically understanding the regression results

$$Stress = 147.5 + 2 \times Int + 3.5 \times PrPo - 104 \times Int \times PrPo$$

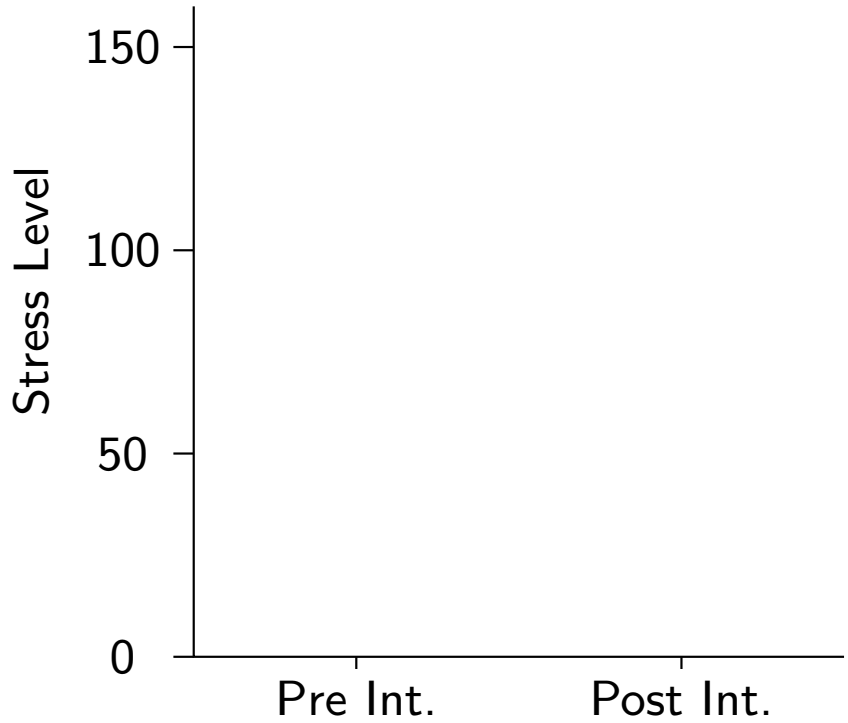
$$Int = \begin{cases} 0 \text{ if Video Game} \\ 1 \text{ if Meditation} \end{cases}, \quad PrPo = \begin{cases} 0 \text{ if Pre Intervention} \\ 1 \text{ if Post Intervention} \end{cases}$$

Graphically understanding the regression results

$$Stress = 147.5 + 2 \times Int + 3.5 \times PrPo - 104 \times Int \times PrPo$$

$$Int = \begin{cases} 0 \text{ if Video Game} \\ 1 \text{ if Meditation} \end{cases}, \quad PrPo = \begin{cases} 0 \text{ if Pre Intervention} \\ 1 \text{ if Post Intervention} \end{cases}$$

For Video Game Pre Int., $Stress = 147.5 + 2 \times 0 + 3.5 \times 0 - 104 \times 0 \times 0$

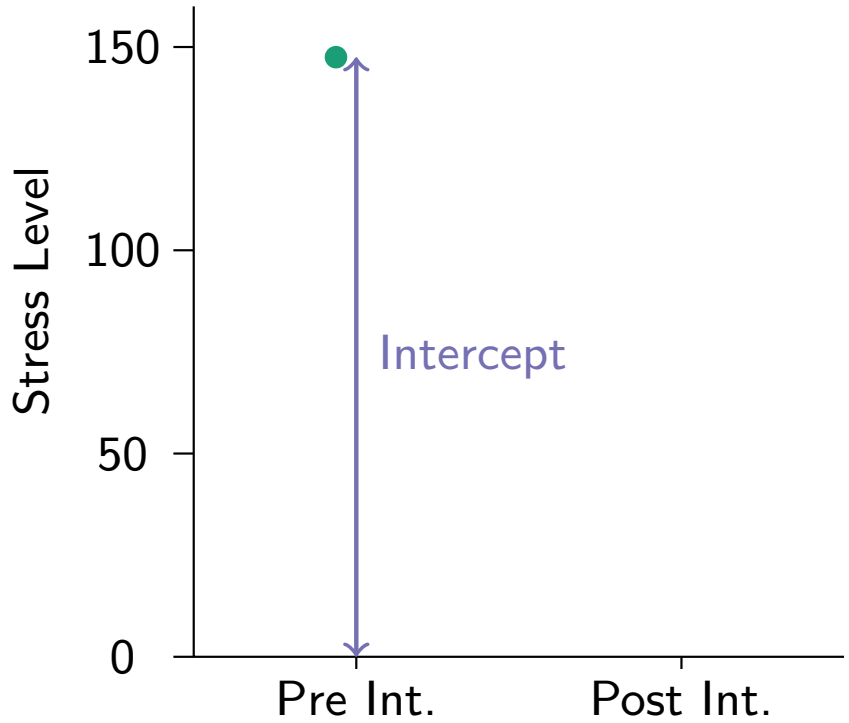


Graphically understanding the regression results

$$Stress = 147.5 + 2 \times Int + 3.5 \times PrPo - 104 \times Int \times PrPo$$

$$Int = \begin{cases} 0 \text{ if Video Game} \\ 1 \text{ if Meditation} \end{cases}, \quad PrPo = \begin{cases} 0 \text{ if Pre Intervention} \\ 1 \text{ if Post Intervention} \end{cases}$$

For Video Game Pre Int., $Stress = 147.5$

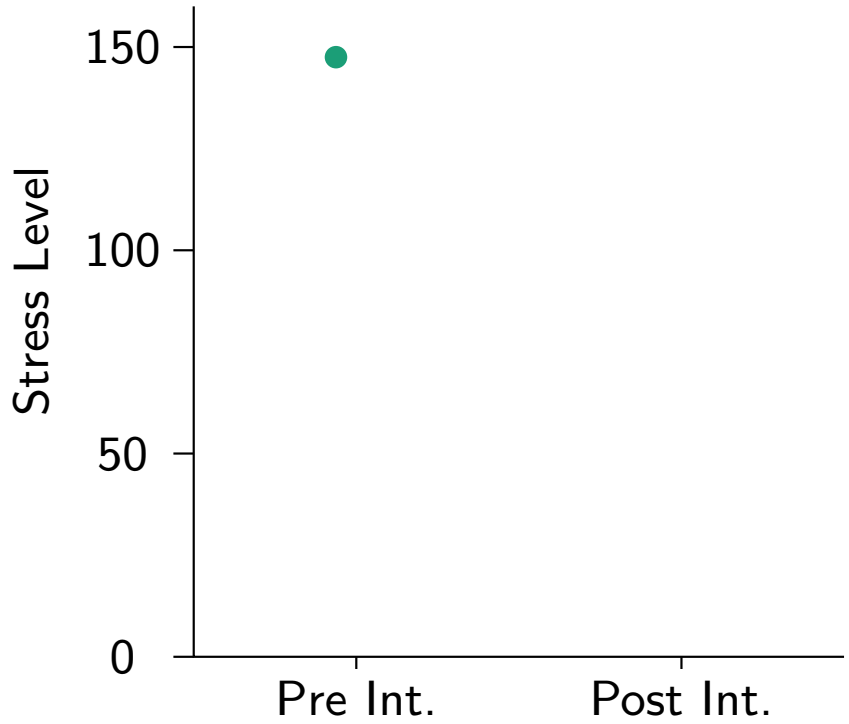


Graphically understanding the regression results

$$Stress = 147.5 + 2 \times Int + 3.5 \times PrPo - 104 \times Int \times PrPo$$

$$Int = \begin{cases} 0 \text{ if Video Game} \\ 1 \text{ if Meditation} \end{cases}, \quad PrPo = \begin{cases} 0 \text{ if Pre Intervention} \\ 1 \text{ if Post Intervention} \end{cases}$$

For Meditation Pre Int., $Stress = 147.5 + 2 \times 1 + 3.5 \times 0 - 104 \times 1 \times 0$

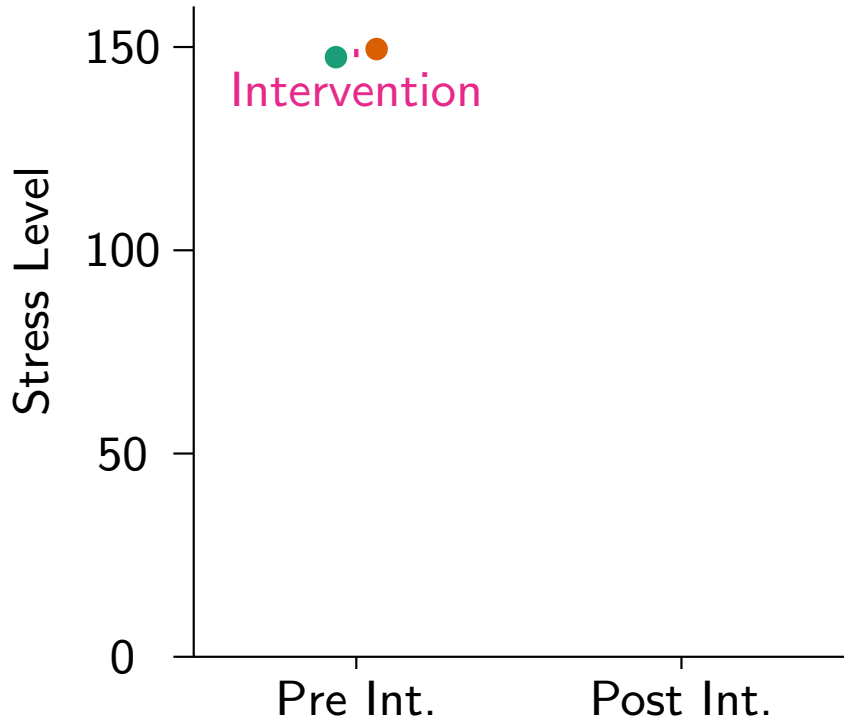


Graphically understanding the regression results

$$Stress = 147.5 + 2 \times Int + 3.5 \times PrPo - 104 \times Int \times PrPo$$

$$Int = \begin{cases} 0 \text{ if Video Game} \\ 1 \text{ if Meditation} \end{cases}, \quad PrPo = \begin{cases} 0 \text{ if Pre Intervention} \\ 1 \text{ if Post Intervention} \end{cases}$$

For Meditation Pre Int., $Stress = 147.5 + 2$

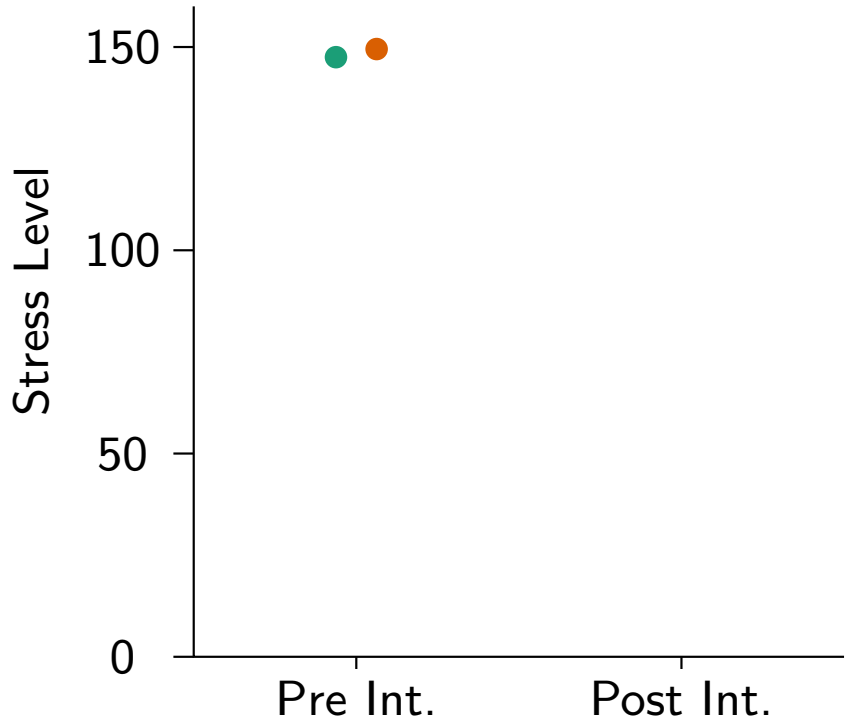


Graphically understanding the regression results

$$Stress = 147.5 + 2 \times Int + 3.5 \times PrPo - 104 \times Int \times PrPo$$

$$Int = \begin{cases} 0 \text{ if Video Game} \\ 1 \text{ if Meditation} \end{cases}, \quad PrPo = \begin{cases} 0 \text{ if Pre Intervention} \\ 1 \text{ if Post Intervention} \end{cases}$$

For Video Game Post Int., $Stress = 147.5 + 2 \times 0 + 3.5 \times 1 - 104 \times 0 \times 1$

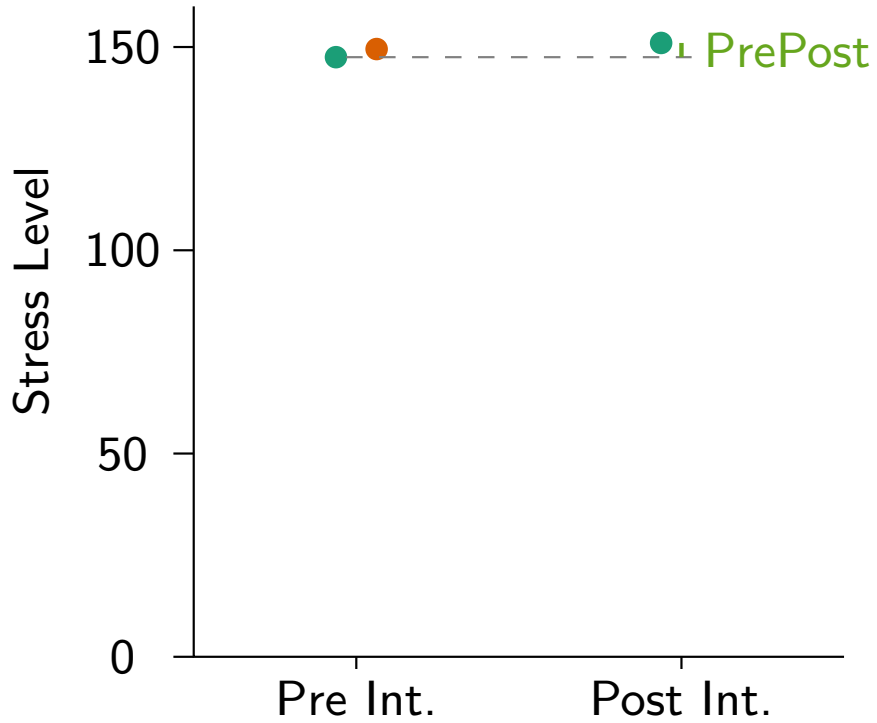


Graphically understanding the regression results

$$Stress = 147.5 + 2 \times Int + 3.5 \times PrPo - 104 \times Int \times PrPo$$

$$Int = \begin{cases} 0 \text{ if Video Game} \\ 1 \text{ if Meditation} \end{cases}, \quad PrPo = \begin{cases} 0 \text{ if Pre Intervention} \\ 1 \text{ if Post Intervention} \end{cases}$$

For Video Game Post Int., $Stress = 147.5 + 3.5$

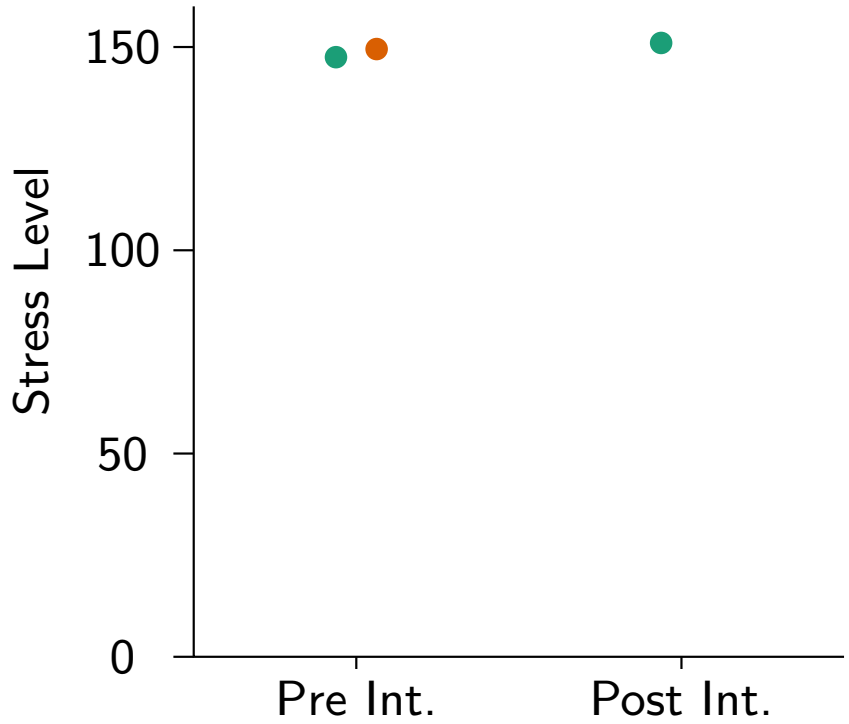


Graphically understanding the regression results

$$Stress = 147.5 + 2 \times Int + 3.5 \times PrPo - 104 \times Int \times PrPo$$

$$Int = \begin{cases} 0 \text{ if Video Game} \\ 1 \text{ if Meditation} \end{cases}, \quad PrPo = \begin{cases} 0 \text{ if Pre Intervention} \\ 1 \text{ if Post Intervention} \end{cases}$$

For Meditation Post Int., $Stress = 147.5 + 2 \times 1 + 3.5 \times 1 - 104 \times 1 \times 1$

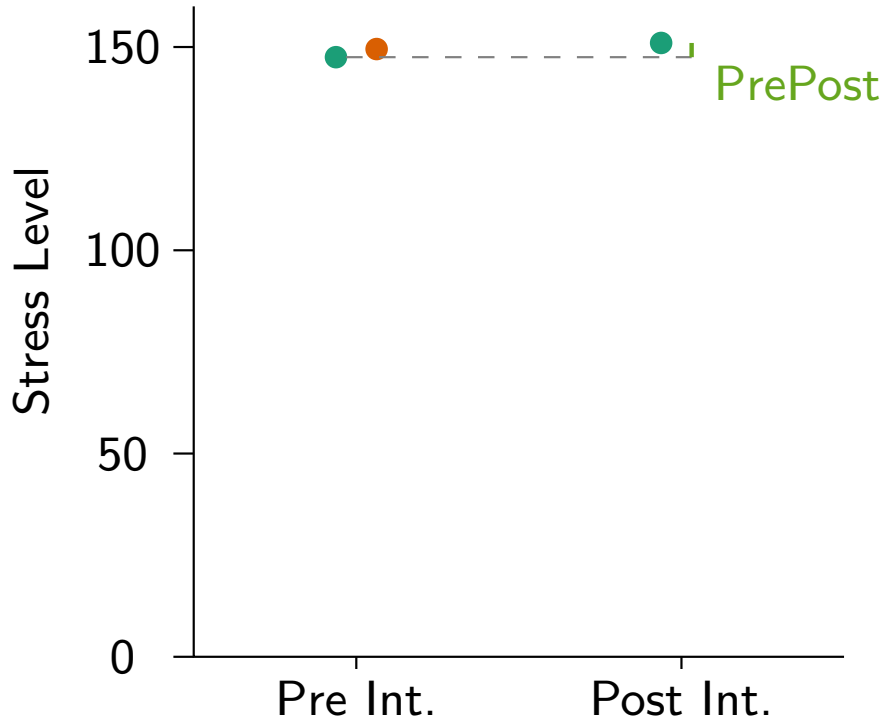


Graphically understanding the regression results

$$Stress = 147.5 + 2 \times Int + 3.5 \times PrPo - 104 \times Int \times PrPo$$

$$Int = \begin{cases} 0 \text{ if Video Game} \\ 1 \text{ if Meditation} \end{cases}, \quad PrPo = \begin{cases} 0 \text{ if Pre Intervention} \\ 1 \text{ if Post Intervention} \end{cases}$$

For Meditation Post Int., $Stress = 147.5 + 2 + 3.5 - 104$

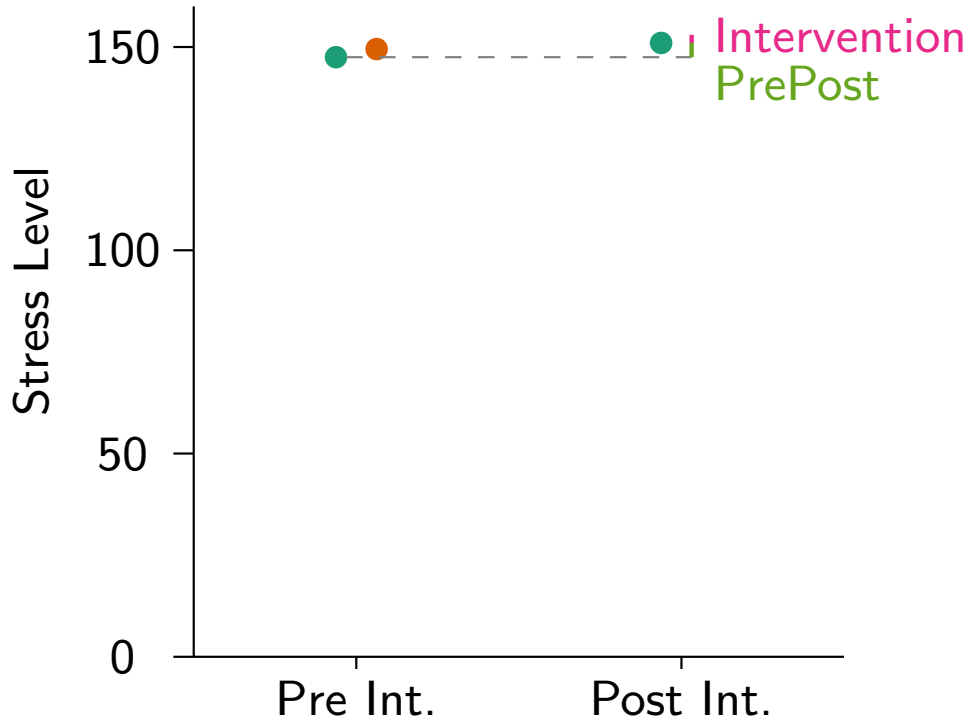


Graphically understanding the regression results

$$Stress = 147.5 + 2 \times Int + 3.5 \times PrPo - 104 \times Int \times PrPo$$

$$Int = \begin{cases} 0 \text{ if Video Game} \\ 1 \text{ if Meditation} \end{cases}, \quad PrPo = \begin{cases} 0 \text{ if Pre Intervention} \\ 1 \text{ if Post Intervention} \end{cases}$$

For Meditation Post Int., $Stress = 147.5 + 2 + 3.5 - 104$

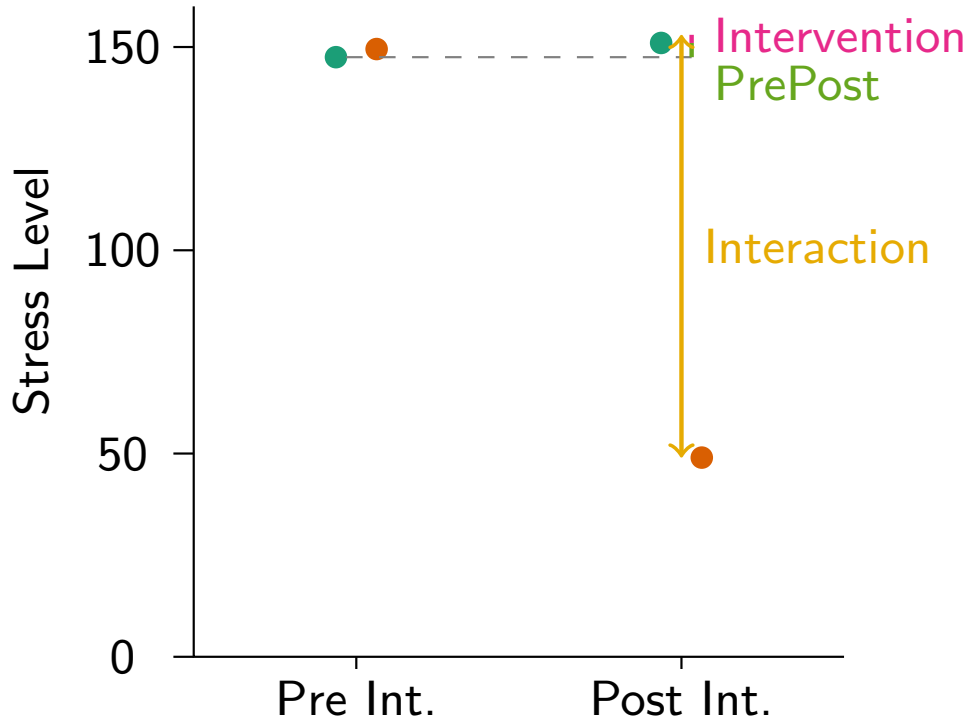


Graphically understanding the regression results

$$Stress = 147.5 + 2 \times Int + 3.5 \times PrPo - 104 \times Int \times PrPo$$

$$Int = \begin{cases} 0 \text{ if Video Game} \\ 1 \text{ if Meditation} \end{cases}, \quad PrPo = \begin{cases} 0 \text{ if Pre Intervention} \\ 1 \text{ if Post Intervention} \end{cases}$$

For Meditation Post Int., $Stress = 147.5 + 2 + 3.5 - 104$



Impact of the choice of reference levels

Impact of the choice of reference levels

Let's redefine Intervention: 0 = Meditation, 1 = Video Game.

Impact of the choice of reference levels

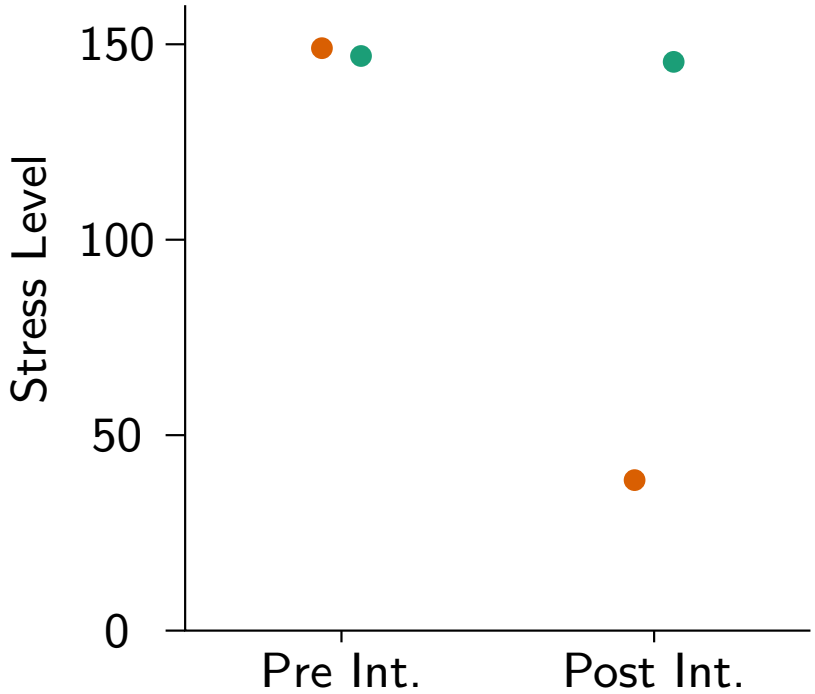
Let's redefine Intervention: 0 = Meditation, 1 = Video Game.

Parameter	Estimate	Std. Error	t value	$Pr(>\|t\|)$
(Intercept)	149.106	3.674	40.589	$< 2e{-}16$
InterventionVideo Game	-1.801	5.195	-0.347	0.729
PrePostPost Intervention	-100.640	5.195	-19.372	$< 2e{-}16$
Intervention:PrePost	104.193	7.347	14.182	$< 2e{-}16$

Impact of the choice of reference levels

Let's redefine Intervention: 0 = Meditation, 1 = Video Game.

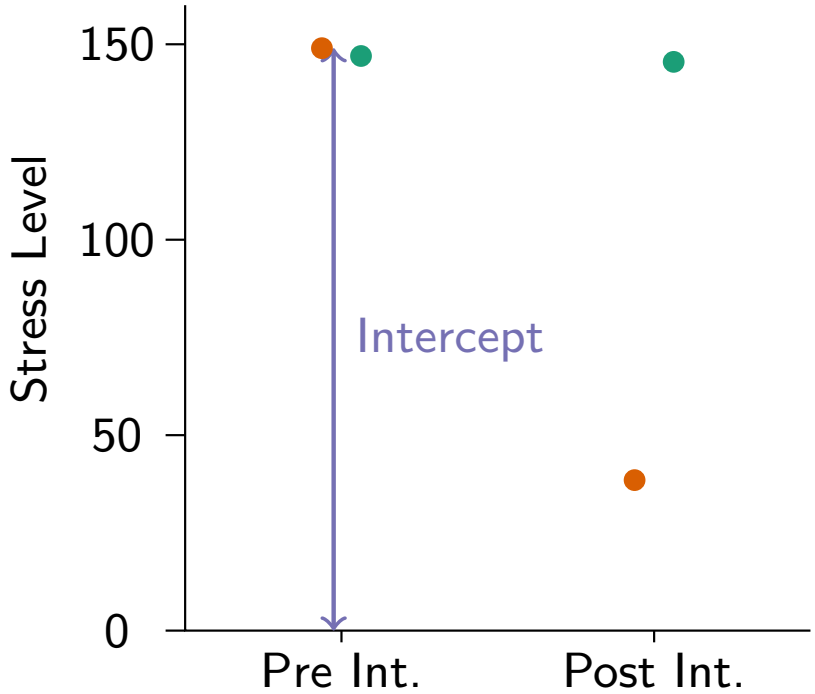
Parameter	Estimate	Std. Error	t value	$Pr(>\|t\|)$
(Intercept)	149.106	3.674	40.589	$< 2e{-}16$
InterventionVideo Game	-1.801	5.195	-0.347	0.729
PrePostPost Intervention	-100.640	5.195	-19.372	$< 2e{-}16$
Intervention:PrePost	104.193	7.347	14.182	$< 2e{-}16$



Impact of the choice of reference levels

Let's redefine Intervention: 0 = Meditation, 1 = Video Game.

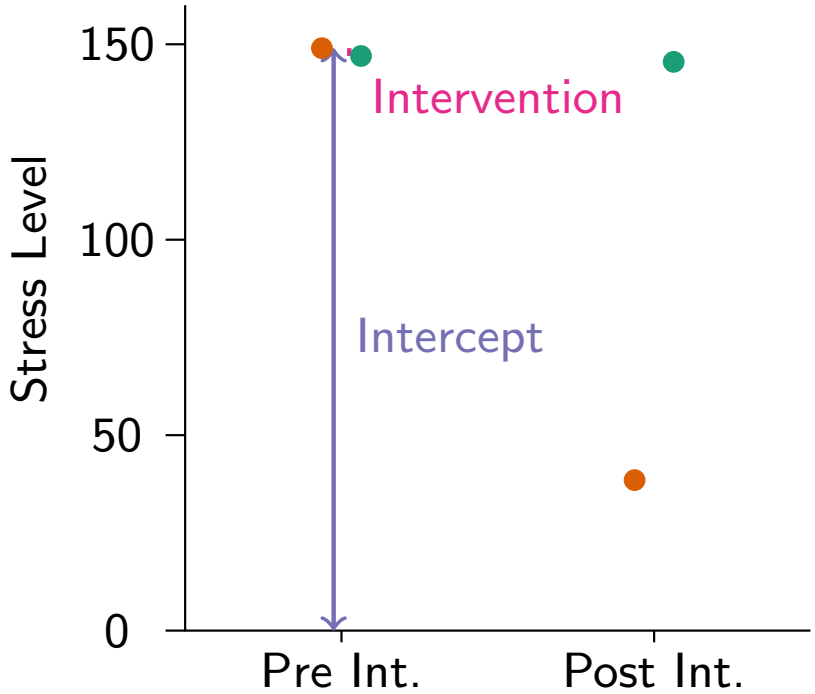
Parameter	Estimate	Std. Error	t value	$Pr(>\|t\|)$
(Intercept)	149.106	3.674	40.589	$< 2e{-}16$
InterventionVideo Game	-1.801	5.195	-0.347	0.729
PrePostPost Intervention	-100.640	5.195	-19.372	$< 2e{-}16$
Intervention:PrePost	104.193	7.347	14.182	$< 2e{-}16$



Impact of the choice of reference levels

Let's redefine Intervention: 0 = Meditation, 1 = Video Game.

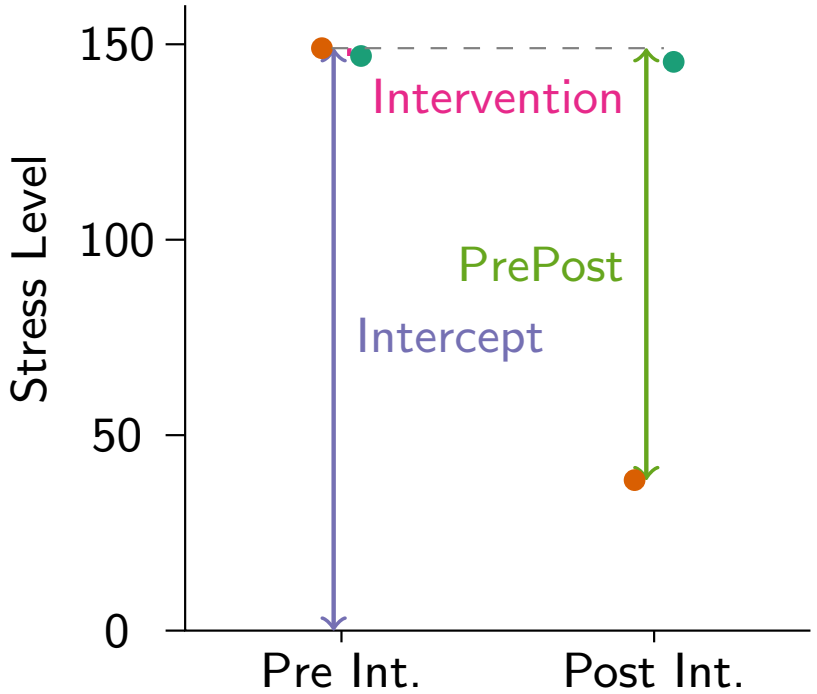
Parameter	Estimate	Std. Error	t value	$Pr(>\|t\|)$
(Intercept)	149.106	3.674	40.589	$< 2e{-}16$
InterventionVideo Game	-1.801	5.195	-0.347	0.729
PrePostPost Intervention	-100.640	5.195	-19.372	$< 2e{-}16$
Intervention:PrePost	104.193	7.347	14.182	$< 2e{-}16$



Impact of the choice of reference levels

Let's redefine Intervention: 0 = Meditation, 1 = Video Game.

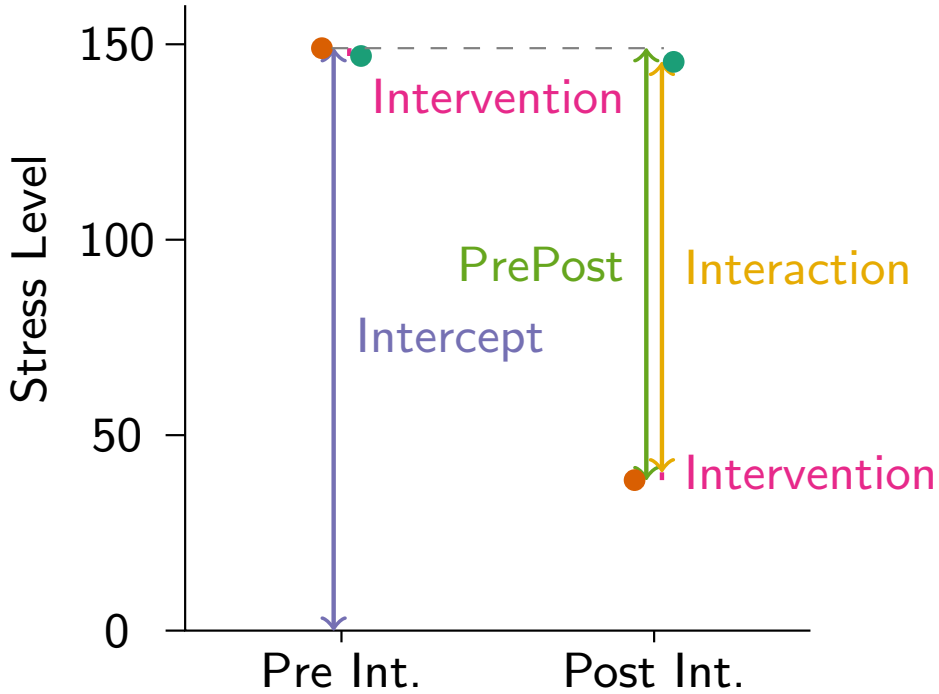
Parameter	Estimate	Std. Error	t value	$Pr(>\|t\|)$
(Intercept)	149.106	3.674	40.589	$< 2e{-}16$
InterventionVideo Game	-1.801	5.195	-0.347	0.729
PrePostPost Intervention	-100.640	5.195	-19.372	$< 2e{-}16$
Intervention:PrePost	104.193	7.347	14.182	$< 2e{-}16$



Impact of the choice of reference levels

Let's redefine Intervention: 0 = Meditation, 1 = Video Game.

Parameter	Estimate	Std. Error	t value	$Pr(>\|t\|)$
(Intercept)	149.106	3.674	40.589	$< 2e{-}16$
InterventionVideo Game	-1.801	5.195	-0.347	0.729
PrePostPost Intervention	-100.640	5.195	-19.372	$< 2e{-}16$
Intervention:PrePost	104.193	7.347	14.182	$< 2e{-}16$



Changes to the simulated data

Regression results

Graphically understanding the regression results

The experiment in a nutshell

Something

What's the take home message?