HHANOVA (Between Groups/Subjects)

Variance

Analysis

Narine Gevorgyan & Eric McNally

What is ANOVA?

• Like T test, compares the means of populations/groups

 Unlike T Test, ANOVA can compare two <u>or</u> <u>more</u> populations/groups

• ANOVA is part of family of F-tests, and compares means relative to variation within groups

Assumptions for ANOVA

-Normal data
distribution
-Interval Data
-Levine's test P
value .035

Normal data
distribution
Ordinal Data
Levine's test P
value .564

-Abnormal data
distribution
-Ratio Data
-Levine's test P
value .342

-Normal data distribution -Interval Data -Levine's test P

value .254

Assumptions for ANOVA

Interval or Ratio

-Normal data
distribution
-Interval Data
-Levine's test P
value .254

...

•Data must be <u>NORMAL</u>

Data





ONE-WAY ANOVA

"A one-way ANOVA is used when we have 1 IV with >3 levels, independent samples, and the same DV" -Miguel

ONE-WAY ANOVA

		Å 2	K3	504	
Part	72	86	72	76	_
ticipan	52	69	94	86	
Participant Test Scores (%)	94	71	65	69	
Score	71	92	85	74	
s (%)	82	71	73	94	

Participant Groups

- No Exercise
- Walking
- Running
- Cycling

Study testing the effect of different forms of morning exercise on cognitive function (Measured using standardized problem-solving quiz)

ONE-WAY ANOVA

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	72	86	72	76
Darticinant Test Scores (%)	52	69	94	86
+ 	94	71	65	69
n	71	92	85	74
. /0%/	82	71	73	94



More than 2 groups, T-Test CANNOT be used.

HYPOTHOSES: ANOVA VS T-TEST

<u>H° for T-Test</u>

μ¹=μ²

<u>H¹ for T-Test</u> μ¹≠μ²

<u>H° One-Way ANOVA</u> μ1 = μ2 = μ3 = μ4





WARNING ABOUT ANOVA

<u>IMPORTANT!</u> The ONE-WAY ANOVA is not intended to give details about bilateral relationships between groups.

It simply presents a boolean True/False value relating to the ANOVA null hypothesis.

Accessing One-Way ANOVA in SPSS

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Ne	ural Net <u>w</u> orks	>	
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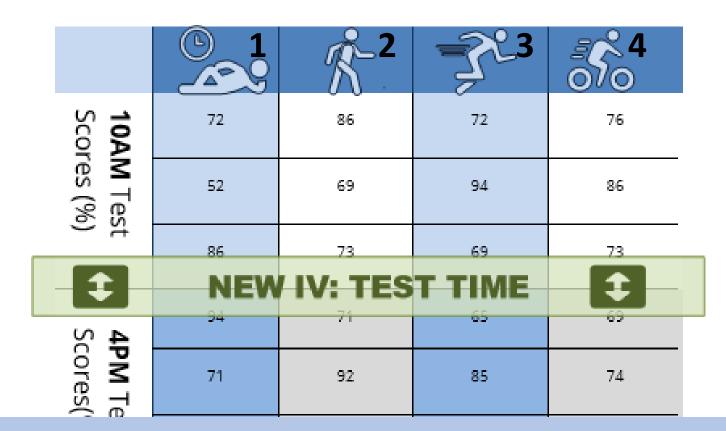
**Run any preliminary analyses needed first

**Ensure data normality

**Deal with outliers

**Ensure data is interval or ratio

When to use TWO-WAY ANOVA



In an expanded version of the study, time of day that the test is taken is also a factor. One-Way ANOVA cannot be used.

TWO-WAY ANOVA



A TWO-WAY ANOVA tests the effect of multiple groups of two independent variables on a dependent variable and on each other.

The two independent variables in a TWO-WAY ANOVA are called FACTORS. Each factor will have two or more levels within it.







Treatment groups are formed by making all possible combinations of two factors.

For example, if the first factor has 3 levels and the second factor has 2 levels, then there will be $3 \times 2=6$ different treatment groups.

ANOVA



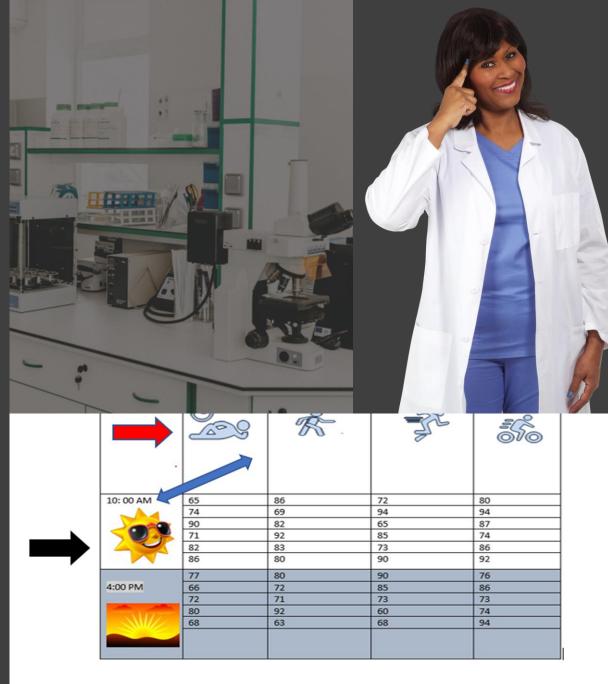
As a follow-up study, Lorraine wants to test the effect of the time of the day of the test in addition to the type of exercises performed (TWO-WAY ANOVA).

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10 AM Test Scores	52	69	94	86
ĭs ≤	86	73	69	73
4 I	94	71	65	69
4 PM Test Scores	71	92	85	74
х,	82	71	73	94

•First factor: Type of exercise assigned to the participants; levels: none, walking, running, cycling (<u>4</u> <u>levels)</u>

•Second factor: Time of the day of the test; levels: 10:00 AM and 4:00 PM (2 levels)

•Hence, Lorraine will have 4x2=8 different treatment groups





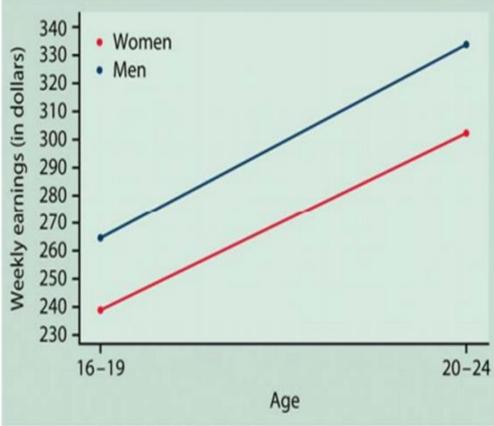
<u>Main effect</u> is the direct effect of a single factor or independent variable on the dependent variable.

Interaction effect is the combined effect of two or more factors on the dependent variable.



Interpreting Main Effects and Interactions Plots

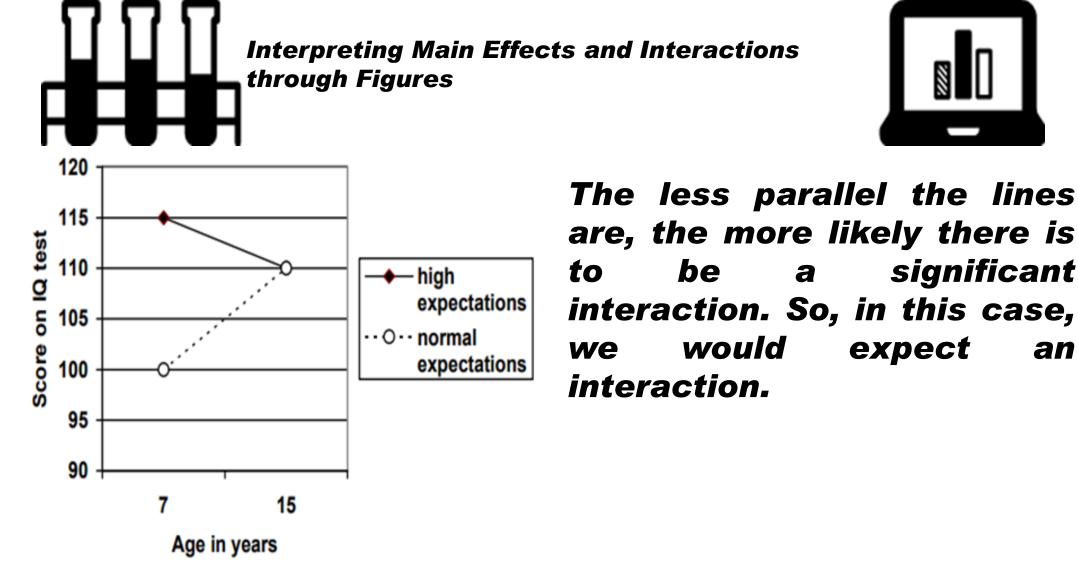




There are only two main effects that are present: an effect due to age and gender.

Parallel lines in plot usually indicate little or no interaction.

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significant

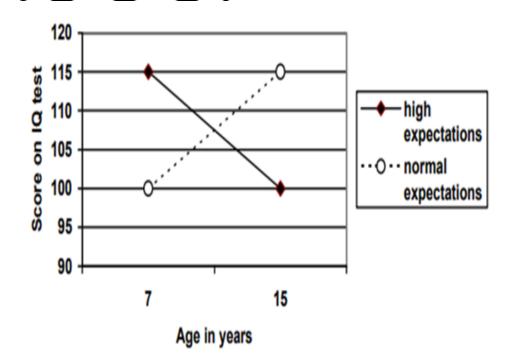
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Effects of age and teacher expectations on IQ scores

Interpreting Main Effects and Interactions through Figures





The lines are not parallel, so there is likely to be an interaction. Because the lines intersect, this type of interaction is sometimes called a cross-over interaction.

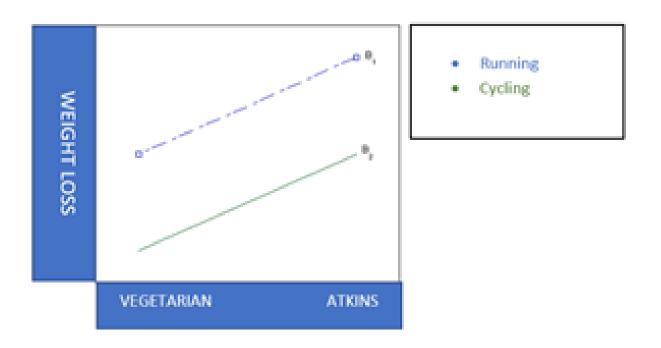
A cross-over interaction

Interpret the Following Plots: Main Effects and Interaction



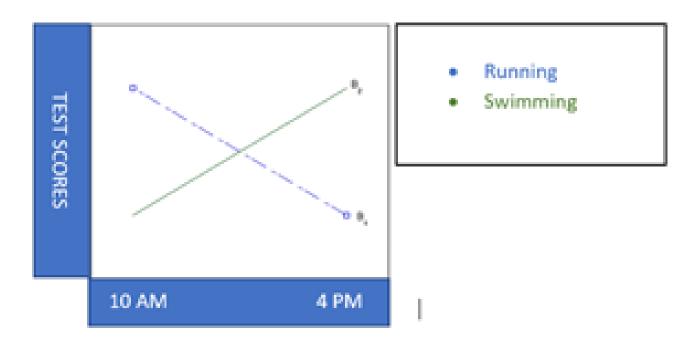
- A) Main Effect Factor Gender
- B) Main Effect Factor Season
- C) Interaction of Both Factors

Interpret the Following Plots: Main Effects and Interaction



- A) Main Effect Factor Diet
- B) Main Effect Factor Exercise
- C) Interaction of Both Factors

Interpret the Following Plots: Main Effects and Interaction



- A) Main Effect Factor Time
- B) Main Effect Factor Exercise
- C) Interaction of Both Factors



•Assumption #1: Your dependent variable should be measured at the continuous level (i.e., they are interval or ratio variables).

•Assumption #2: Your two independent variables should each consist of two or more categorical, independent groups

•Assumption #3: You should have independence of observations



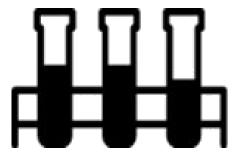


•Assumption #4: There should be no significant outliers.

•Assumption #5: Your dependent variable should be approximately normally distributed for each combination of the groups of the two independent variables

•Assumption #6:

There needs to be homogeneity of variances for each combination of the groups of the two independent variables.

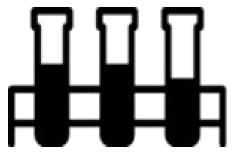


HYPOTHESES



- Ho1:The sample means of the first factor are equal.
- Ho2:The sample means of the second factor are equal.

 Ho3: There is no interaction between the two factors.



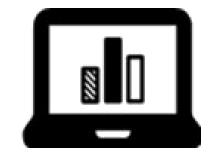
TWO-WAY ANOVA IN SPSS



Lorraine wants to conduct a research study to see if the individual's weight is affected by the type of the diet and the type of the exercise.

In order to find out, 180 participants were randomly assigned to one of the three types of diet (None, Vegetarian and Atkins) and three types of exercises (None, 30 min a day and 60 min. a day)

HYPOTHESES



H0= The means of all diet groups are equal H1=The mean of at least one diet group is different.

H0= The means of the exercise groups are equal H1=The means of the exercise groups are different.

H0= There is no interaction between the diet and exercise

H1=There is an interaction between the diet and exercise





•First factor: Type of the exercise assigned to the participants; levels: none, 30 min a day, 60 min a day <u>(3 levels)</u>

•Second factor: Type of the diet assigned to the participants; levels: None, Vegetarian and Atkins <u>(3 levels)</u>

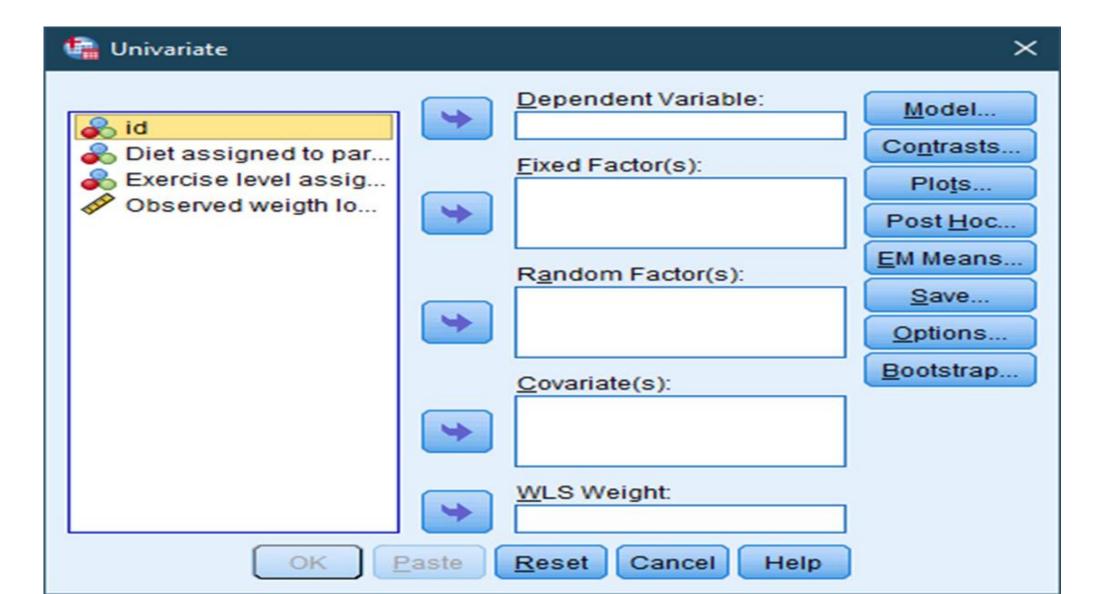
•Hence, Lorraine will have 3x3=9 different treatment groups

	None	Vegetarian	Atkins
None	20	20	20
30 min a day	20	20	20
60 min a day	20	20	20

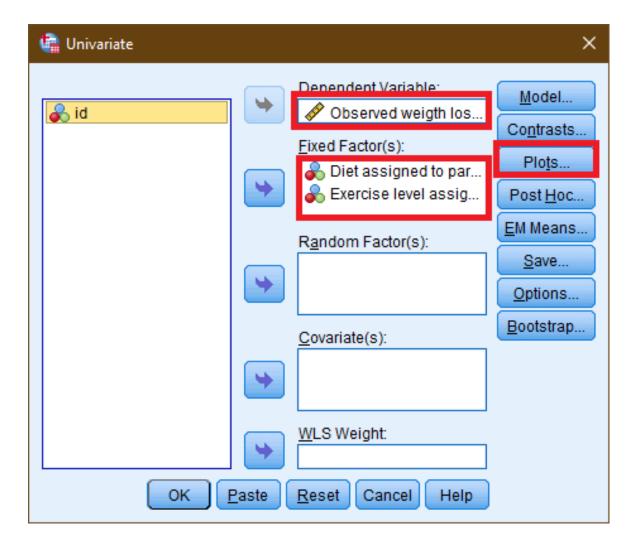
1. Analyze >> General Linear Model >> Univariate...

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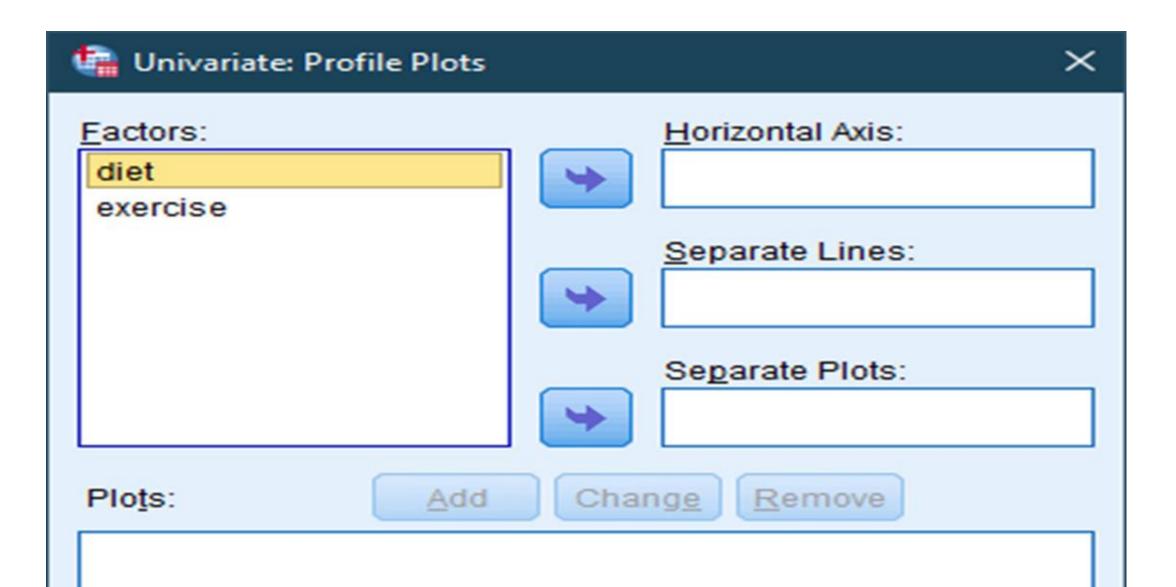
2. You will be presented with the "UNIVARIATE", as shown below:



3. Add "Weight loss" into the "Dependent Variable" and Diet and Exercise into the "Fixed Factor(s)". After click on <u>**Plots**</u>



4. You'll be presented with the "Univariate: Profile Plots" window, as shown below:



5. Transfer "Diet" and "Exercise" to the "Horizontal Axis" and "Separate lines". Click on "Continue" and then you'll be returned to the Univariate dialogue box.

🕼 Univariate: Profile Plots	×
Eactors:	Horizontal Axis:
diet exercise	✓ exercise
	Separate Lines:
	🤟 diet
	Segarate Plots:
	•
Plots: Add	Change Remove
Chart Type:	
Line Chart	
Bar Chart	
Error Bars	
Include Error bars	
Confidence Interval	(95.0%)
Standard Error	Multiplier: 2
Include reference line fo	r grand mean
🛅 Y axis starts at 0	
Continue	Cancel Help

6. Click on "Post Hoc"

🤹 Univariate		×
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7.Transfer the factors to the "Post Hoc Tests for", after check "Tukey" >>Continue, which will bring you back to "Univariate" window

🔹 Univariate:	Post Hoc Multiple Cor	mparisons for Observed Means X
<u>Factor(s):</u> diet exercise		Post Hoc Tests for: diet exercise
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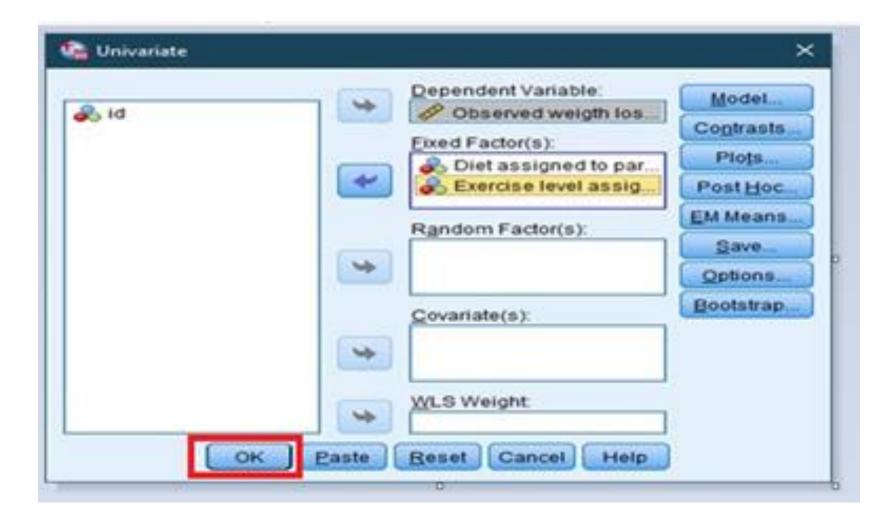
8. Click on the "Options"

👫 Univariate		×
	Dependent Variable: Observed weigth Eixed Factor(s): Diet assigned to Exercise level as Random Factor(s):	Ios Model Ios Contrasts par Plots Ssig Post Hoc EM Means Save
OK	Covariate(s):	<u>Options</u> <u>B</u> ootstrap Help

9. "Options" >> "Descriptive Statistics" >> "Estimates of effect size" >> "Homogeneity tests" >> Continue>>OK

ia Univariate: Options	×
┌ Display	
Descriptive statistics	✓ Homogeneity tests
Estimates of effect size	Spread vs. level plot
Observed power	Residual plot
Parameter estimates	Lack of fit
Contrast coefficient matrix	General estimable function
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Modified Breusch-Pagan test	📃 F test
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Significance le <u>v</u> el: .05 Confidence in Continue Cancel	tervals are 95.0 % Help

10. You will be back to "Univariate" window again. Click "OK" to run the analysis.



TESTS OF BETWEEN SUBJECT EFFECTS



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Dependent Variable:	Observed weight loss in kilos over last 2 months									
	Type III Sum of									
Source	Squares	df	Mean Square	F	Sig.					
Corrected Model	1905.037#	8	238.130	27.647	.000					
Intercept	3624.868	1	3624.868	420.844	.000					
diet	363.904	þ	181.952	21.124	.000					
exercise	1508.859	2	754.429	87.589	.000					
diet * exercise	32.274	4	8.069	.937	.444					
Error	1472.879	171	8.613							
Total	7002.784	180								
Corrected Total	3377.916	179								

Tests of Between-Subjects Effects

a. R Squared = .564 (Adjusted R Squared = .544)

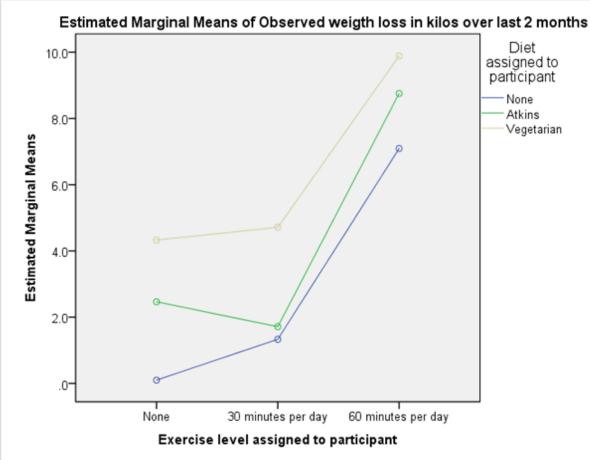
Main Effects for Diet F (2, 171) = 21.124, p = .000

Main effects for Exercise F (2, 171) = 87, 589, p = .000

No interaction between diet and exercise F(4, 171) = .937, p = .444

TWO-WAY ANOVA OUTPUT:





Each line rises steeply between 30 to 60 minutes of exercise per day.

A vegetarian diet resulted in more weight loss than the other diets.

Both diet and exercise seem to have a *main effect* on weight loss.

Since these lines look pretty similar, the plot doesn't show much of an interaction effect.

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MULTIPLE COMPARISONS



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Multiple Comparisons

Dependent Variable: Observed weight loss in kilos over last 2 months

Tukey HSD

(I) Exercise level assigned to participant	(J) Exercise level assigned to participant	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
None	30 minutes per day	289	.5358	.852	-1.556	.978
	60 minutes per day	-6.281*	.5358	.000	-7.548	-5.014
30 minutes per day	None	.289	.5358	.852	978	1.556
	60 minutes per day	-5.992*	.5358	000	-7.259	-4.725
60 minutes per day	None	6.281*	.5358	.000	5.014	7.548
	30 minutes per day	5.992*	.5358	000	4.725	7.259

Based on observed means.

The error term is Mean Square(Error) = 8.613.

*. The mean difference is significant at the 0.05 level.

The difference in weight loss between no exercise and 30 minutes is 0.29 kg.

The difference between no exercise and 60 min exercise is very big, about 6.28 kg. Also, p value shows that the difference is statistically significant.

Retrieved from https://www.spss-tutorials.com/spss-two-way-anova-basics-tutorial/

References

Two-way ANOVA in SPSS Statistics. (n.d.). Retrieved December 12, 2020, from <u>https://statistics.laerd.com/spss-tutorials/two-way-anova-using-spss-statistics.php</u>

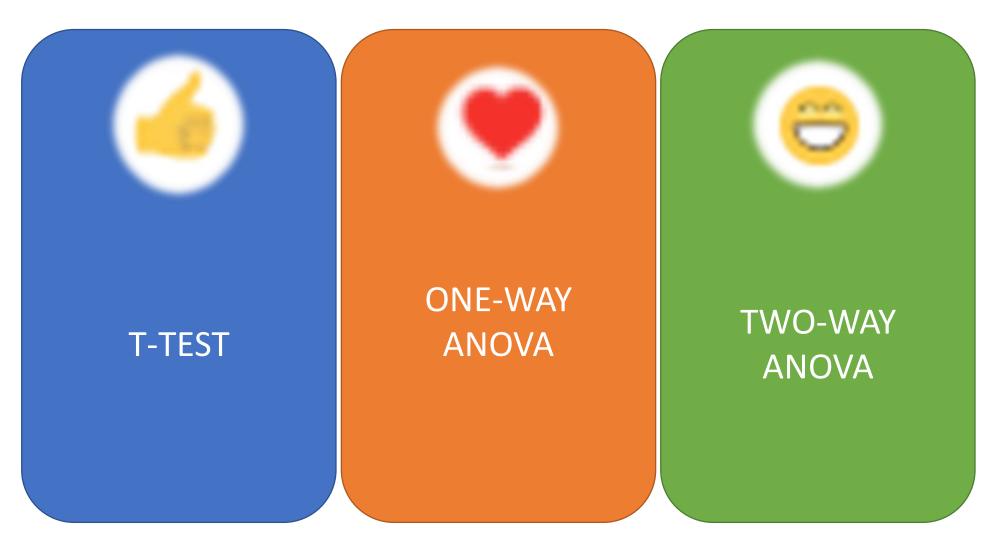
ANOVA Test: Definition, Types, Examples. (2020, September 17). Retrieved December 12, 2020, from https://www.statisticshowto.com/probability-and-statistics/hypothesis-testing/anova/

MacKenzie, R. (2018, July 23). One-Way vs Two-Way ANOVA: Differences, Assumptions and
Hypotheses.RetrievedDecember12,2020,fromhttps://www.technologynetworks.com/informatics/articles/one-way-vs-two-way-anova-
definition-differences-assumptions-and-hypotheses-30655312,2020,from

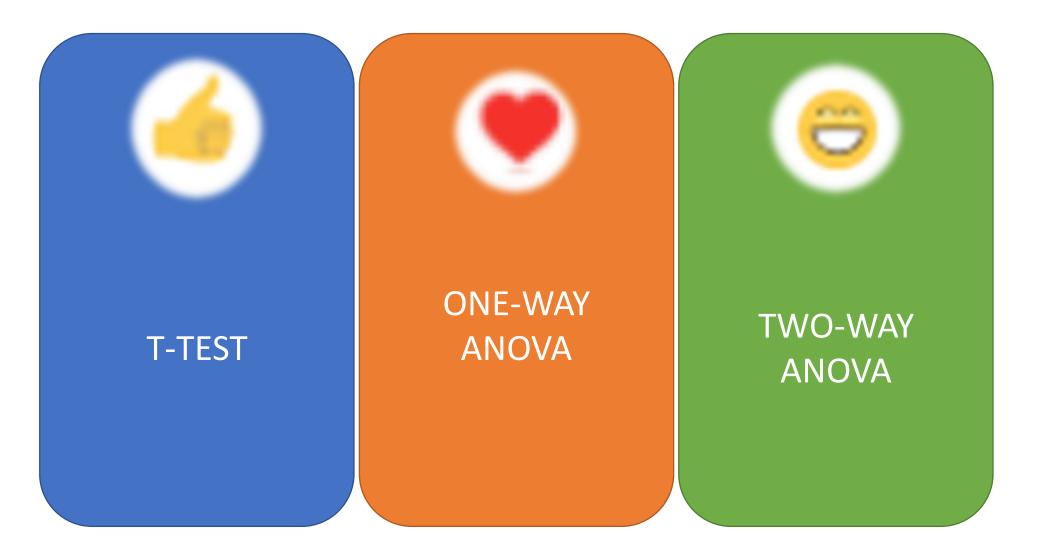
SPSS Two Way ANOVA – Basics Tutorial. (n.d.). Retrieved December 12, 2020, from https://www.spss-tutorials.com/spss-two-way-anova-basics-tutorial/

Musadoto Follow. (2017, November 16). 2 way ANOVA(Analysis Of VAriance. Retrieved December 12, 2020, from https://www2.slideshare.net/musadoto/2-way-anovaanalysis-of-variance?from_action=save

For a study testing three different fertilizers and their effects on the same type of plant, which test would be used to compare the means of the three groups?



Which test would you use for a study testing average running speed of people wearing two different types of shoes?



Which test would you use for a study testing the effect of yoga and tai chi on the blood pressure depending on the time of the day?

