Research Methods:

Correlation

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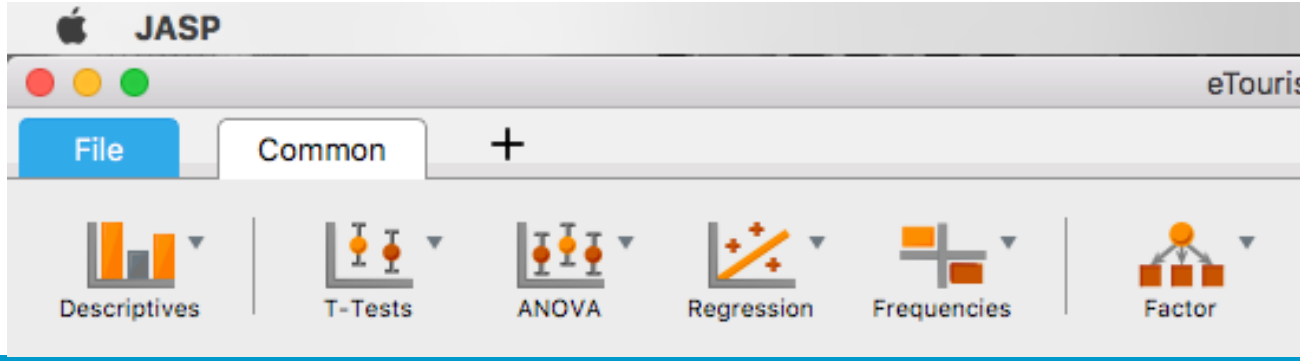
Today

- Correlation (or correlational research methods and correlational statistics)

--> procedures, coefficients, and techniques



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Learning goals (Ch. 9)

- Describe the difference between strong, moderate, and weak correlation coefficients
- Capable of visual inspection and interpretation of scatter plots (valence, form, direction and strength of the correlation)
- Understand how correlations allows for prediction

Correlation tables (example)

Table 2
Means, standard deviations and correlations (N = 493).

		M	*SD*	1	2	3	4	5	6	7
1	Gender	1.37[a]	0.49	–						
2	Age	22.13	2.15	-0.04	–					
3	Price	0.48[a]	0.50	0.01	-0.01	–				
4	Parking convenience	0.50[a]	0.50	-0.08	-0.01	-0.03	–			
5	Car Type	0.53[a]	0.50	-0.03	-0.06	0.06	0.04	–		
6	Psychological Ownership	5.72	0.97	-0.07	0.09*	-0.04	0.05	0.06	–	
7	Intention to select a shared car	0.17	1.82	0.01	-0.04	0.34**	0.19**	0.13**	0.00	–

*$p < 0.05$. **$p < 0.01$.
[a] These items take only two values.

Correlation tables (example)

Table 6
Correlations Between the BFI and the BFAS in Two Samples

	BFI					BFAS					10 aspects									
Domain	N	A	C	E	O	N	A	C	E	O	N_V	N_W	A_C	A_P	C_I	C_O	E_E	E_A	O_I	O_O
N (BFI)	—	**−.38**	**−.27**	**−.18**	**−.11**	***.75***	−.13	−.14	−.26	−.04	.67	.67	−.06	−.17	−.30	.06	−.27	−.16	−.15	.10
A (BFI)	**−.24**	—	**.25**	**.10**	**.03**	−.38	***.59***	.13	.21	.00	−.44	−.24	.45	.55	.17	.06	.38	−.04	−.02	.02
C (BFI)	**−.24**	**.38**	—	**.25**	**.15**	−.29	.18	***.71***	.33	.13	−.19	−.32	.15	.16	.65	.54	.20	.34	.27	−.07
E (BFI)	**−.33**	**.15**	**.18**	—	**.29**	−.14	.07	.21	***.76***	.17	.05	−.30	.22	−.11	.24	.12	.60	.67	.22	.06
O (BFI)	**−.13**	**.11**	**.11**	**.26**	—	−.14	.10	−.01	.35	***.77***	−.06	−.20	.25	−.09	.10	−.11	.16	.42	.64	.64
N (BFAS)	***.80***	−.34	−.33	−.26	−.15	—	**−.20**	**−.22**	**−.32**	**−.12**	.89	.89	−.09	−.25	−.41	.04	−.28	−.27	−.26	.07
A (BFAS)	−.01	***.68***	.36	.06	.09	**−.14**	—	**.18**	**.13**	**.12**	−.25	−.10	.85	.84	.18	.12	.33	−.11	−.01	.23
C (BFAS)	−.15	.24	***.77***	.08	−.04	**−.25**	**.22**	—	**.25**	**−.01**	−.13	−.26	.11	.20	.83	.84	.14	.29	.12	−.14
E (BFAS)	−.36	.31	.33	***.78***	.34	**−.33**	**.23**	**.24**	—	**.34**	−.10	−.47	.32	−.10	.35	.07	.85	.84	.40	.15
O (BFAS)	−.21	.17	.31	.22	***.67***	**−.20**	**.28**	**.19**	**.37**	—	−.04	−.18	.27	−.07	.14	−.15	.19	.38	.85	.81
Volatility (N_V)	.67	−.40	−.25	−.10	−.08	.90	−.24	−.17	−.16	−.15	—	.59	−.09	−.34	−.28	.06	−.12	−.06	−.14	.07
Withdrawal (N_W)	.76	−.20	−.34	−.38	−.19	.88	.00	−.29	−.44	−.21	.59	—	−.08	−.10	−.46	.01	−.38	−.43	−.32	.05
Compassion (A_C)	.02	.54	.32	.22	.19	−.03	.84	.18	.40	.40	−.07	.02	—	.43	.13	.05	.44	.10	.11	.35
Politeness (A_P)	−.04	.62	.28	−.12	−.04	−.20	.86	.20	.00	.08	−.32	−.02	.45	—	.18	.17	.12	−.29	−.14	.03
Industriousness (C_I)	−.32	.25	.72	.17	.04	−.42	.17	.84	.31	.23	−.28	−.49	.12	.16	—	.39	.21	.39	.31	−.09
Orderliness (C_O)	.09	.14	.55	−.05	−.11	.02	.20	.81	.07	.07	.01	.03	.17	.17	.38	—	.03	.09	−.10	−.15
Enthusiasm (E_E)	−.27	.42	.24	.69	.20	−.25	.36	.16	.88	.22	−.15	−.31	.46	.15	.20	.06	—	.43	.18	.13
Assertiveness (E_A)	−.36	.11	.34	.68	.39	−.33	.04	.25	.87	.44	−.13	−.46	.22	−.15	.34	.06	.52	—	.49	.13
Intellect (O_I)	−.37	.10	.39	.25	.46	−.37	.15	.31	.42	.82	−.25	−.41	.24	.01	.40	.10	.21	.52	—	.37
Openness (O_O)	.03	.17	.09	.09	.62	.06	.33	−.02	.18	.80	.02	.08	.42	.14	−.04	.01	.14	.17	.33	—

Note. The university sample is below the diagonal; the Eugene-Springfield community sample is above. Validity coefficients across instruments are in bold italics. Correlations among the Big Five within instrument are in bold; BFI = Big Five Inventory; BFAS = Big Five Aspect Scales; N = Neuroticism; A = Agreeableness; C = Conscientiousness; E = Extraversion; O = Openness/Intellect; subscript letters represent the first letter of the aspect.

Correlation

1.

The goals of science

Jackson (Ch. 1, mod. 1) describes 3 basic goals of scientific research:

- Description: via careful observation of behavior
- Prediction: via identification of factors impacting behavior
- Explanation: via causes and mechanisms that explain the when and why of behavior

Research methods in science

- Descriptive methods: observational, case study, survey
- Predictive methods: correlational, quasi-experimental
- Explanatory method: the experiment

The correlational method

- The correlational method is a non-experimental method
- It describes the relationship between two naturally occurring (measured) variables -> with the aim to explore if and how they are 'co-related'
- Correlation between 2 variables gives us tools to develop fairly accurate predictions

Understanding correlation coefficients

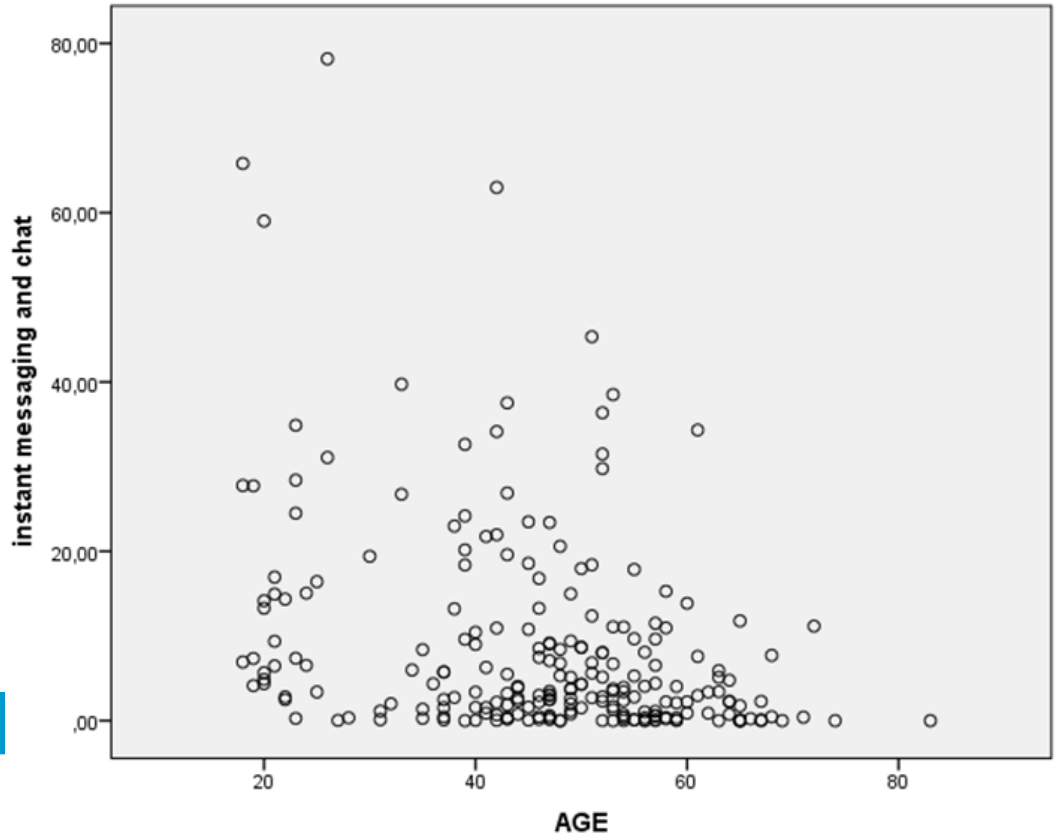
- Magnitude = an indication of the strength of the relationship between variable

- Correlation coefficient = a measure of the degree of relationship between two sets of score. For correlation (*r*) it varies **between -1.00 and +1.00**

  - when *r* is between ±.70 and ±1.00: strong
  - when *r* is between ±.30 and ±.69: moderate
  - when *r* is between ±.00 and ±.29: none (.00) to weak

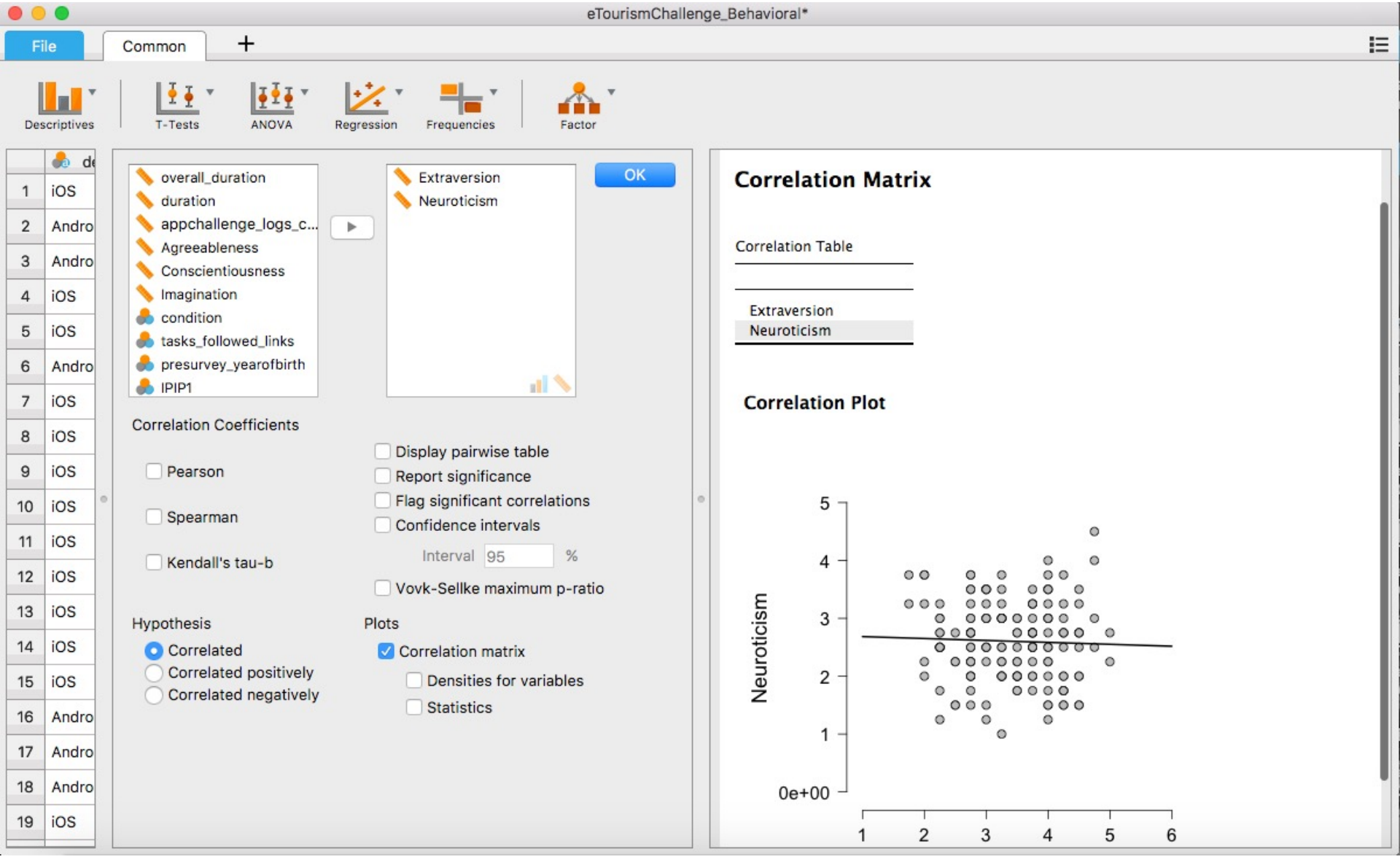
Scatterplots

- A figure that graphically represents the relationships between two variables



Note that the x-axis and y-axis could easily be reversed on the axes. This would not make a difference in interpretation.

In JASP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2
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6

Possible types of correlational relationship (I)

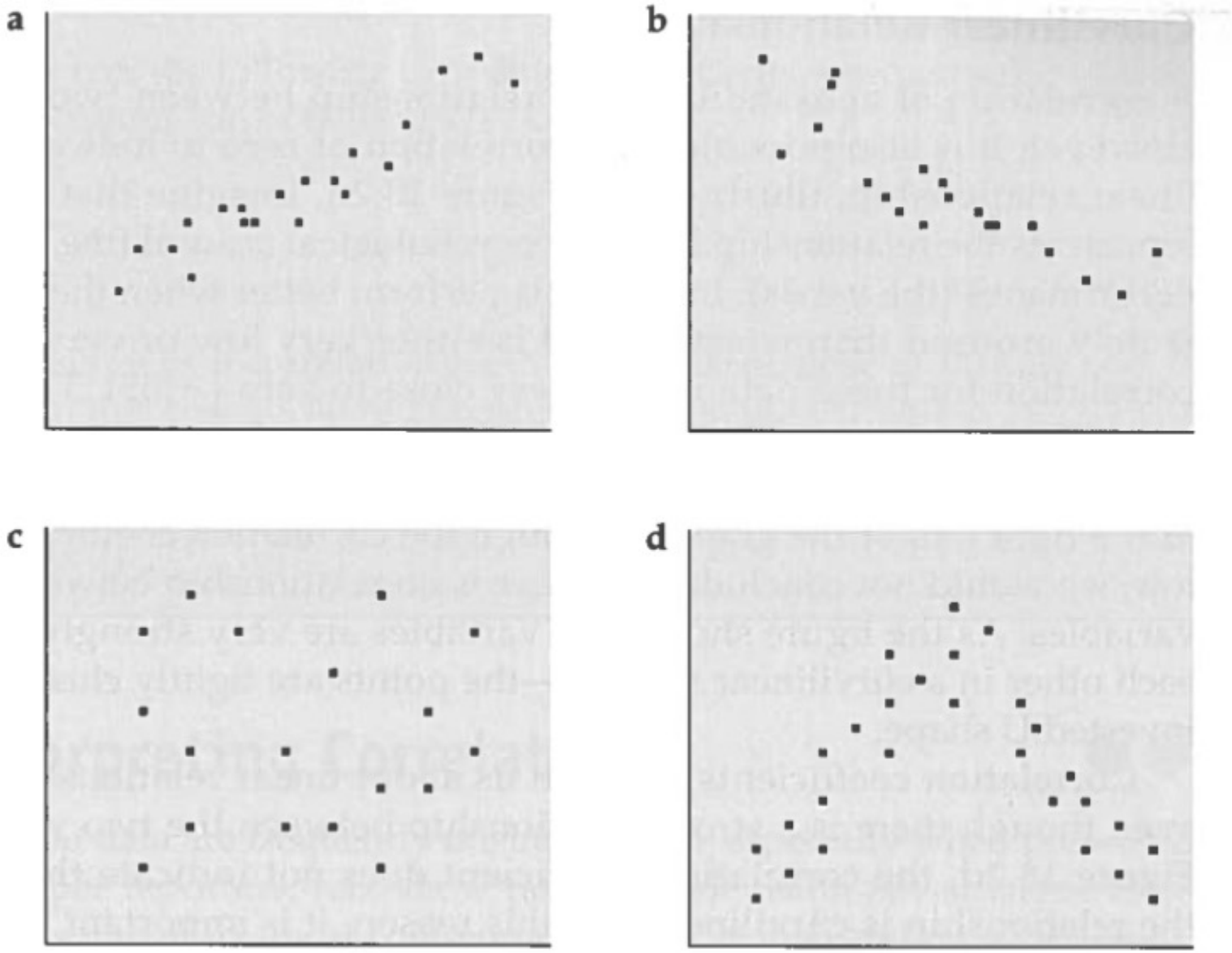
- Positive: A relationship in which the two variables move together (an in/decrease in one is related to an in/decrease in the other)
- Negative: An inverse relationship in which an in/decrease in one is related to a de/increase in the other, and v.v.

Possible types of correlational relationship (II)

- No relationship: The relationship between two variables is (close to) zero, and data points are scattered in random fashion

- Curvilinear: Variables increase together up to a point and then, as one continues to increase, the other decreases. A curvilinear relationship between two variables also is summarized in a correlation coefficient (close to) zero (but there is a relationship!)

Example



Misinterpreting correlations (Ia)

- The most common mistake = interpret the observed relationship (the correlation) as a causal relationship
- Causality = the assumption that a correlation indicates a causal relationship between the two variables
- The correlation coefficient indicates that two variables 'move together', not that a change in Var. 1 will cause a change in Var. 2

Misinterpreting correlations (Ib)

- Directionality = the inference made with respect to the direction of a relationship between two variables
- Again, the correlation coefficient indicates that two variables 'move together', not that a ± change in Var. 1 will cause a ± change in Var. 2
- You cannot draw causality-based conclusions from correlational data!

Misinterpreting correlations (II)

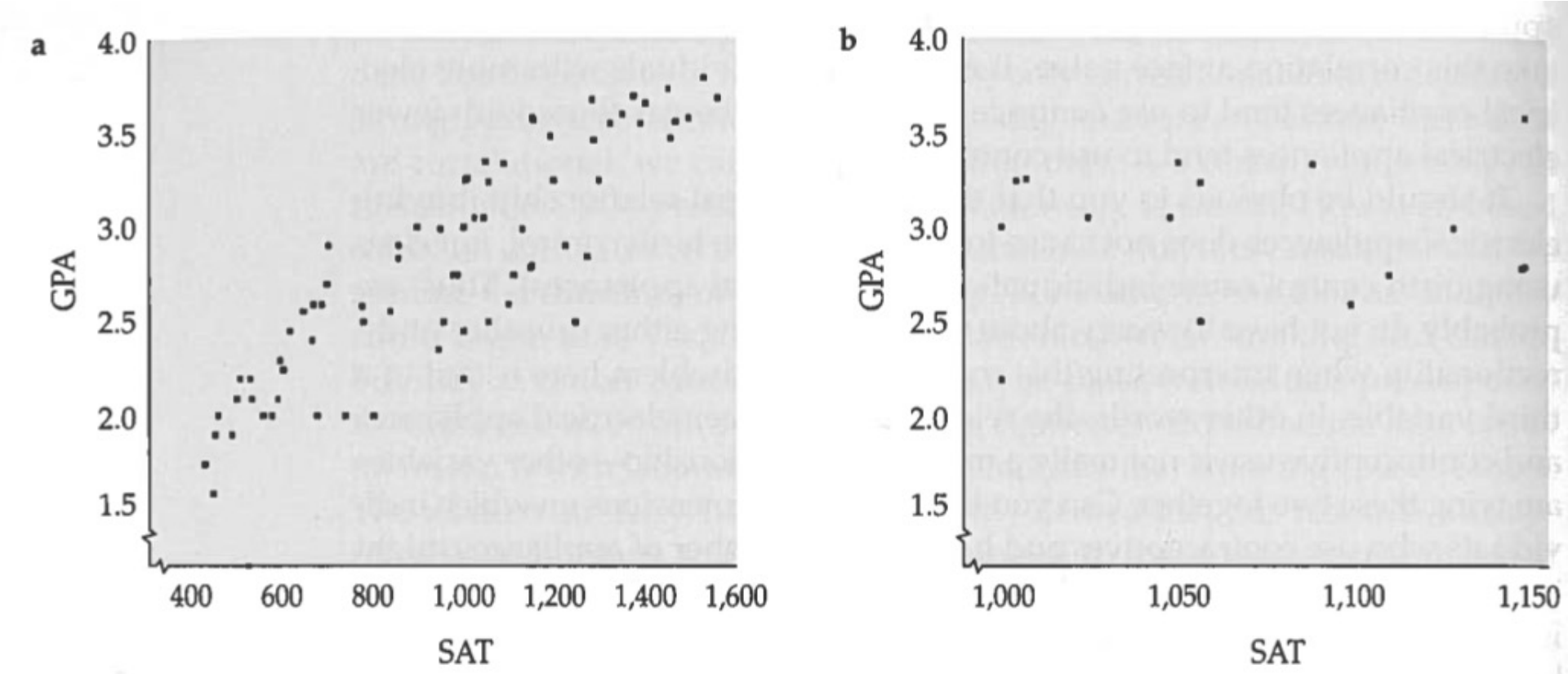
- The third-variable problem = the problem of a correlation between two variables being dependent on another (third) variable

- You can statistically control for the third-variable problem using a procedure called partial correlation:

  - Measuring three variables, then remove the effect of the third variable from the correlation of the remaining two variables

Misinterpreting correlations (III)

- Restrictive range = A variable does not vary enough, and it is therefore impossible to observe a relationship



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Misinterpreting correlations (IV)

- Curvilinear relationships = A partial relationship exists between two variables, but this relationship is cancelled out in the other half of the curve
- The correlation coefficient would be .00 or close to .00
- You would erroneously conclude that no correlation existed!

Correlation and prediction

- **Correlation≠ Causality**. Still, correlation indicates that when one variable is present at a certain level, the second variable *may / tend to** also be present at a certain level
  - * NOTE the phrasing / vocabulary here!
- Thus, you may observe (linear) trends, but must acknowledge that not all cases will fit in – there will be outliers / exceptions

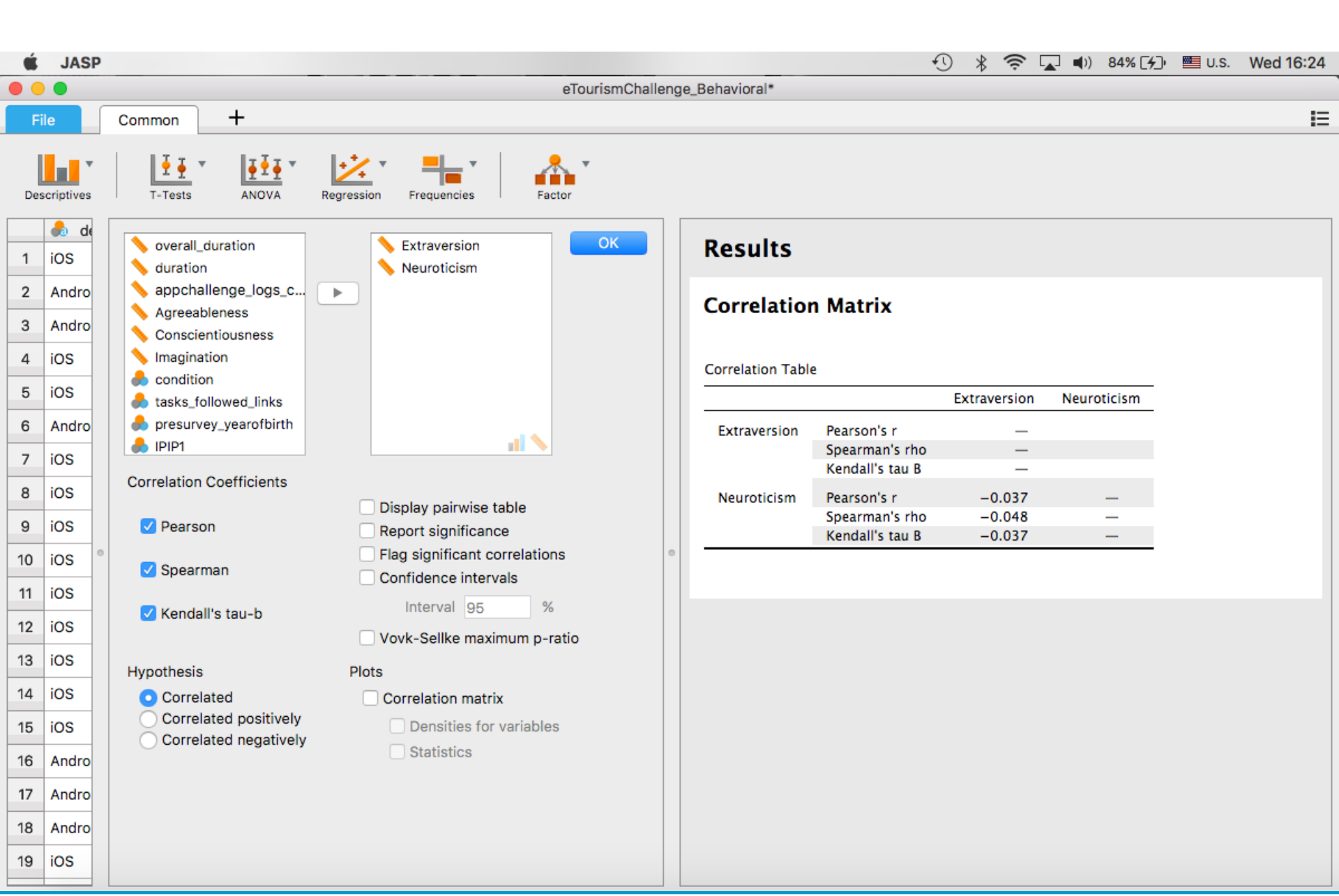
Recall: The goals of science

Jackson (Ch. 1, mod. 1) describes 3 basic goals of scientific research:

- Description: via careful observation of behavior
- Prediction: via identification of factors impacting behavior
- Explanation: via causes and mechanisms that explain the when and why of behavior

Correlation coefficients

2a.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Densities for variables
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Extraversion
Neuroticism
Pearson's r
Spearman's rho
Kendall's tau B
−0.037
−0.048
−0.037

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Learning goals

- Describe when it is appropriate to use the Pearson correlation coefficient, and the Spearman correlation coefficient or Kendall's tau-b (the latter one is "slides only")

- Interpret these correlation coefficients in JASP output form

The correlational method

- The correlational method describes the relationship between two naturally occurring (measured) variables -> with the aim to explore if and how they are 'co-related'

- Correlation between 2 variables gives us tools to develop fairly accurate predictions

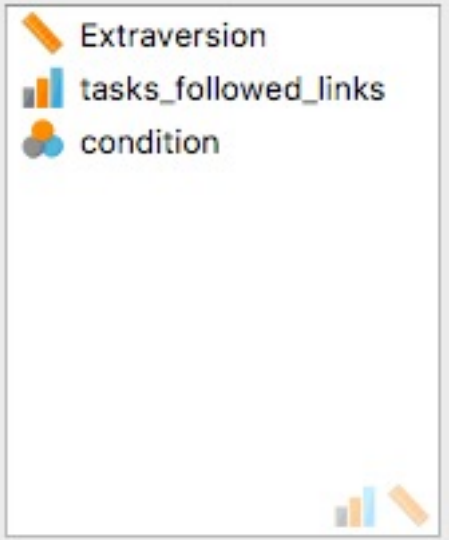
Scales of measurement (Ch. 1)

- **Nominal scale** = a scale in which objects or individuals are broken into categories that have no numerical properties
- **Ordinal scale** = a scale in which objects or individuals are categorized, and those categories for a rank order
- **Interval scale** = a scale in which the units of measurement (intervals) between the numbers on a scale are all equal in size (and with an absolute zero for **ratio scales** --> the absence of the variable being measured

Scales of measurement

FEATURES OF SCALES OF MEASUREMENT

	SCALE OF MEASUREMENT			
	Nominal	**Ordinal**	**Interval**	**Ratio**
Examples	Ethnicity Religion Sex	Class rank Letter grade	Temperature (Fahrenheit and Celsius) Many psychological tests	Weight Height Time
Properties	Identity	Identity Magnitude	Identity Magnitude Equal unit size	Identity Magnitude Equal unit size Absolute zero
Mathematical Operations	None	Rank order	Add Subtract Multiply Divide	Add Subtract Multiply Divide
Typical Statistics Used	Mode Chi-square	Mode Median Wilcoxon tests	Mode Median Mean *t* test ANOVA	Mode Median Mean *t* test ANOVA



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Pearson's *r*

- Pearson's product-moment correlation coefficient (Pearson's *r*) = the most commonly used correlation coefficient
- Suits **variables at the interval and ratio scale**
- Interpretation: *r* between **-1.00 and + 1.00** (none, weak, moderate, strong)

Calculating Pearson's *r* (step 1)

- Raw scores are converted into *z* scores (the number of standard deviation units a raw score is above / below the mean):

$$Z = \frac{x - \mu}{\sigma}$$

X = each individual score

μ = the population mean

σ = the population standard deviation

Calculating Pearson's *r* (step 2)

Calculate the cross-products (multiplication) of all the individual *z* scores for both variables. Enter the cross-product of the *z* scores into the formula for Pearson's *r*:

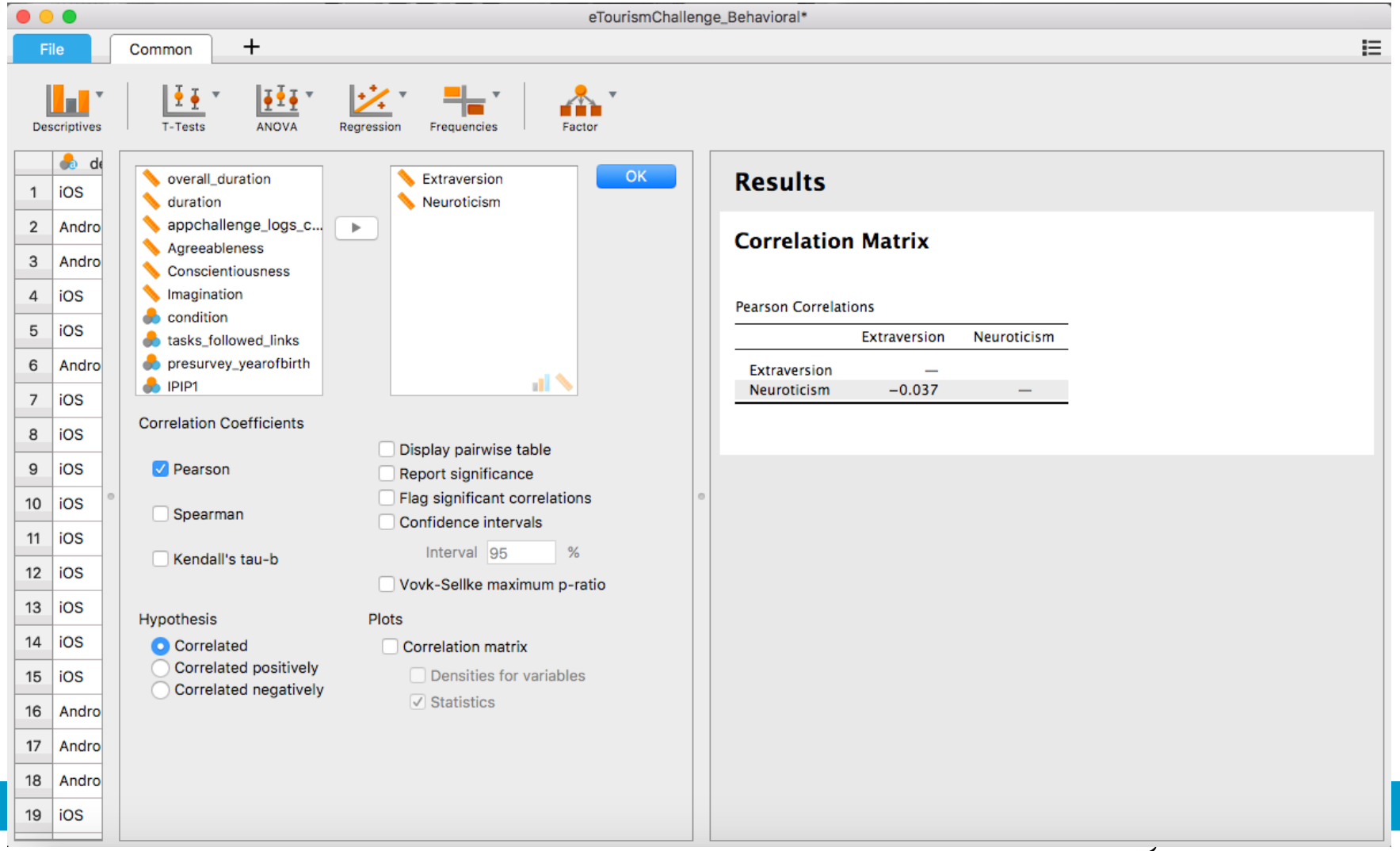
$$r = \frac{\sum Z_X Z_Y}{N}$$

Z_x = the z score for variable *x* for each individual

Z_y = the z score for variable *y* for each individual

N = the number of individuals in the sample

In JASP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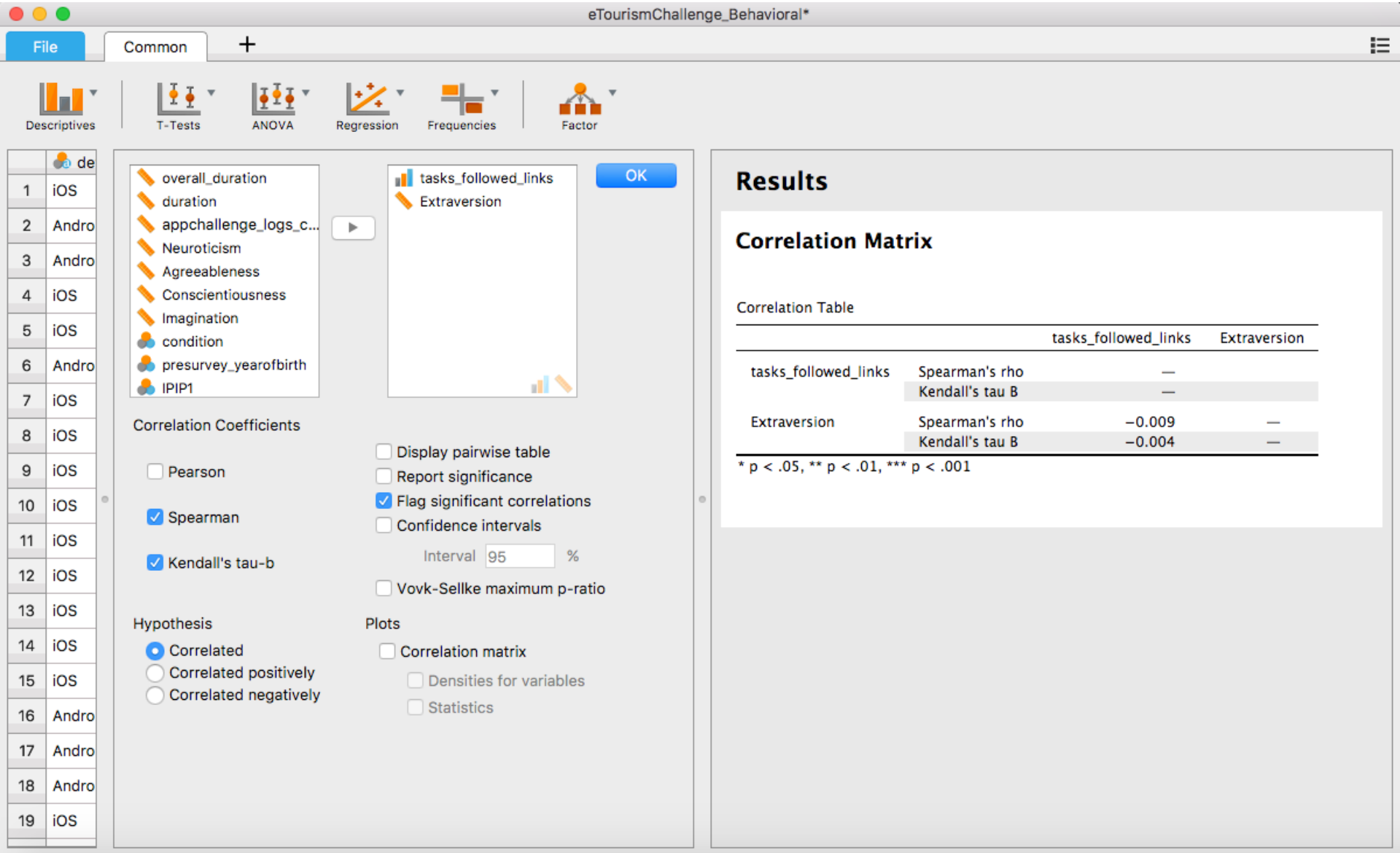
−0.037

Alternative correlation coefficients

- Spearman's rank-order correlation coefficient = The correlation coefficient (rho) used when one or more of the variables is measured on an ordinal (ranking) scale -> **between -1.00 and + 1.00**

- Kendall's tau-b = A non-parametric correlation coefficient similar to Spearman's, used for small data sets with large numbers of tied ranks (many scores have the same rank) -> **between -1.00 and + 1.00**

In JASP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Spearman's rho
Kendall's tau B
−0.009
−0.004
* p < .05, ** p < .01, *** p < .001

Other alternatives (book)

- **Point-biserial correlation** = the correlation coefficient used when you have one variable on a nominal scale and another variable at the interval / ratio scale

- **Phi coefficient** = the correlation coefficient used when both variables are nominal

Ergo

- You must be careful to check the scale of measurement of the two variables you wish to compare

- ...As the type of correlation coefficient you select depends on this!

Correlation and significance testing

2b.

Correlation and significance testing

- Apart from looking at the valence and magnitude of a correlation coefficient, we can also check whether it is statistically significant or not

- **H_0** = the true population correlation coefficient is zero (so, not related)
- **H_a** = the observed correlation is not equal to zero (hence they are related)

(NOTE this is for a two-tailed test)

Correlation and significance testing (2)

- Your book provides a table where you can manually inspect the critical values for one-tailed / two-tailed tests, and see whether you have statistical significance (also see slides on Probability & Hypothesis Testing)

- JASP can do this automatically for you --> when you select that option

Example

- Let's explore the following:

This app came with a survey, in which participants provided scores on two variables: Behavioral Inhibition (BIS) Anxiety (BIS_Anxiety) and FFFS_Fear).

- How do these two sub-dimensions correlate?

Question 1

- BIS_Anxiety and FFFFS-Fear were measured on a 4-point Likert scale; (*not at all*) to (*very much so*)
  - Which correlation coefficients are we going to select?
  - And why?

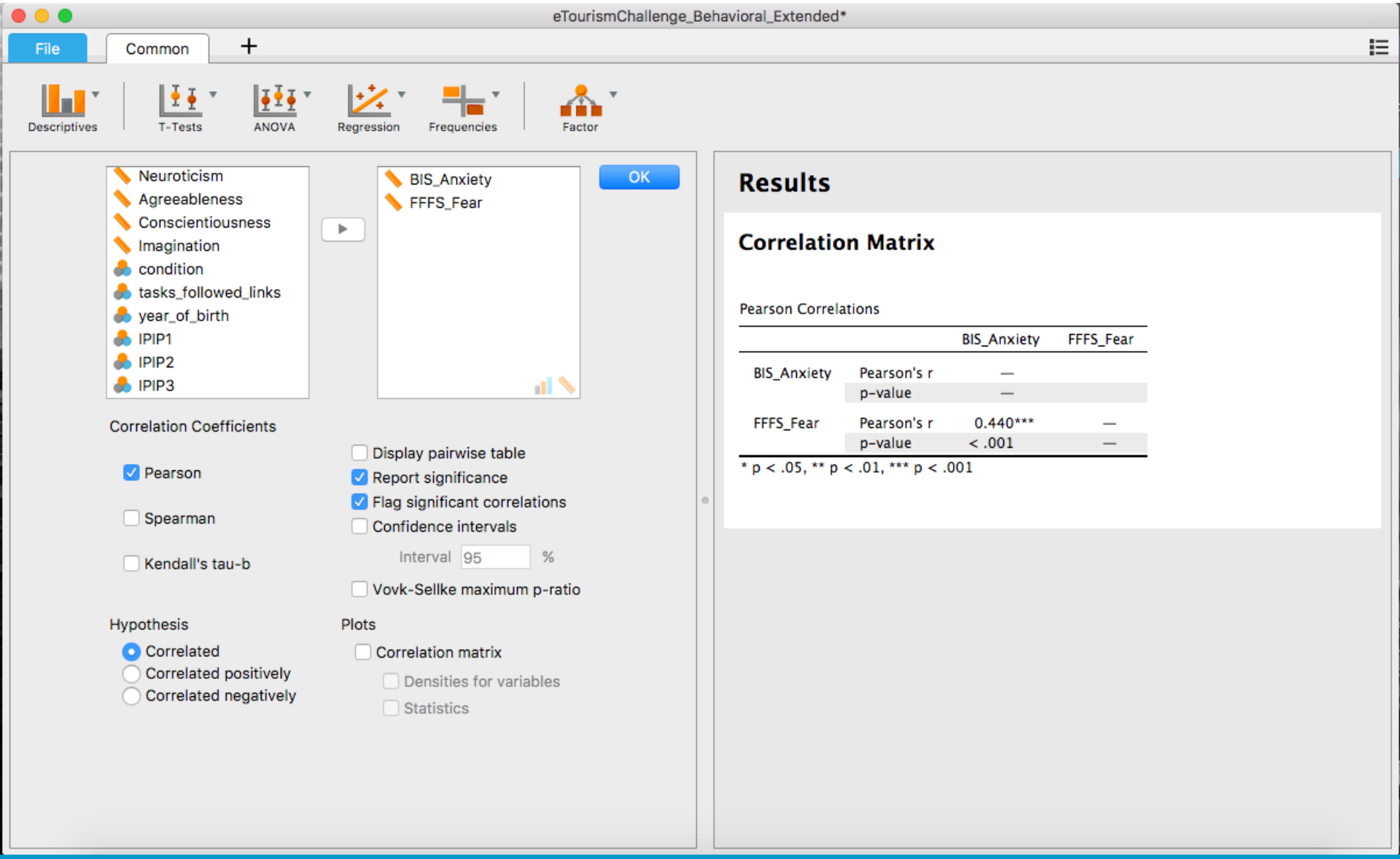
Question 1

- BIS_Anxiety and FFFFS-Fear were measured on a 4-point Likert scale; (*not at all*) to (*very much so*)
  - Which correlation coefficients are we going to select?
  - And why?

Answer: Both are interval scales. In JASP this is indicated with the "ruler"-icon. Hence, we go for the Pearson coefficient.

Question 2

- Do BIS_Anxiety and FFFFS-Fear correlate with each other?
  - If so, how, and to what extent?
  - And why?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BIS_Anxiety Pearson's r —
p-value —
FFFS_Fear Pearson's r 0.440*** —
p-value < .001 —
* p < .05, ** p < .01, *** p < .001

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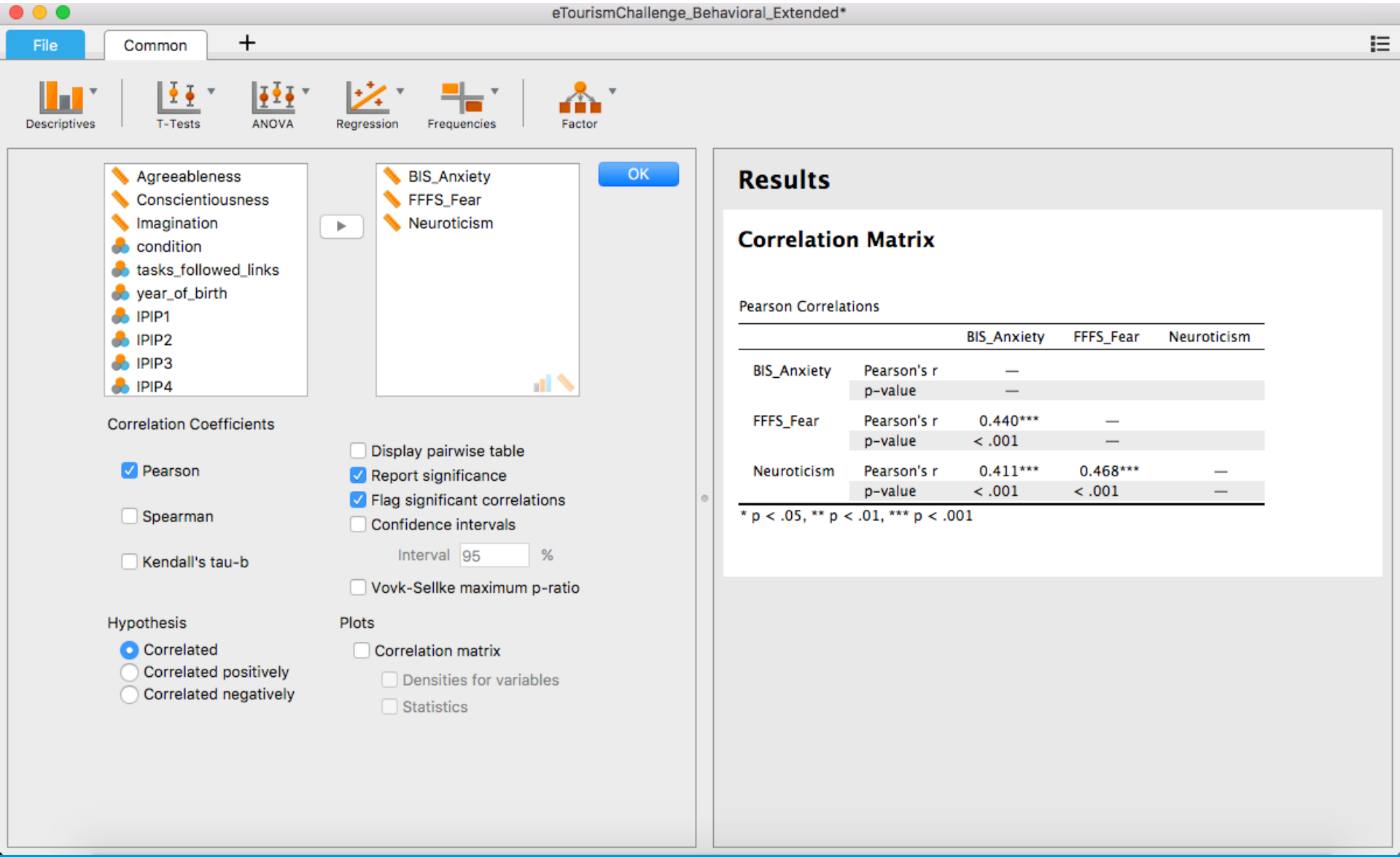
Interpretation

- Pearson's $r = 0.44$, $p < .001$
  - --> we reject H_0 that the variables are not related, and we accept H_a (that they are related), instead!

Question 3

- Let's explore the following:
  - We have our sub-dimensions (BIS_Anxiety and FFFS_Fear)
  - We also have a Big Five personality test result: Extraversion, Agreeableness, Conscientiousness, Neuroticism, Imagination
- **Theory claims associations between BIS_Anxiety, FFFS_Fear, and Neuroticism**
- Does a correlation analysis show this?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Pearson Correlations
BIS_Anxiety Pearson's r — p-value —
FFFS_Fear Pearson's r 0.440*** p-value < .001 —
Neuroticism Pearson's r 0.411*** 0.468*** p-value < .001 < .001 —
* p < .05, ** p < .01, *** p < .001

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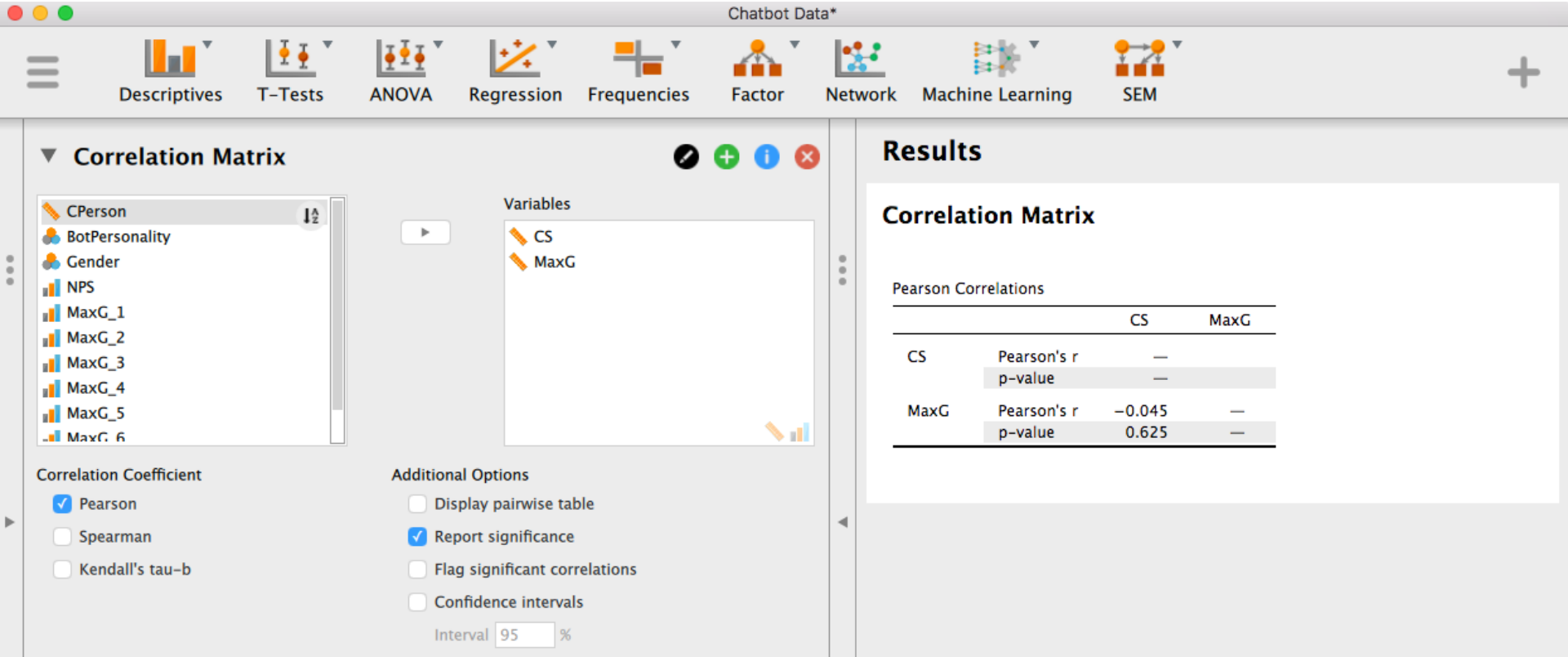
Question 3: Answer

- Answer:

- The Pearson's $r = 0.41$ for BIS Anxiety-Neuroticism; and $r = 0.47$ for FFFS_Fear-Neuroticism. This indicates correlations with moderate strength in both cases.
- Also, in both cases, this correlations are highly significant, with p-values < 0.001.
  - --> we reject H_0 that the variables are not related, and we accept H_a (that they are related), instead!

Another example (different variables)

- Do the variables MaxG and CS correlate?

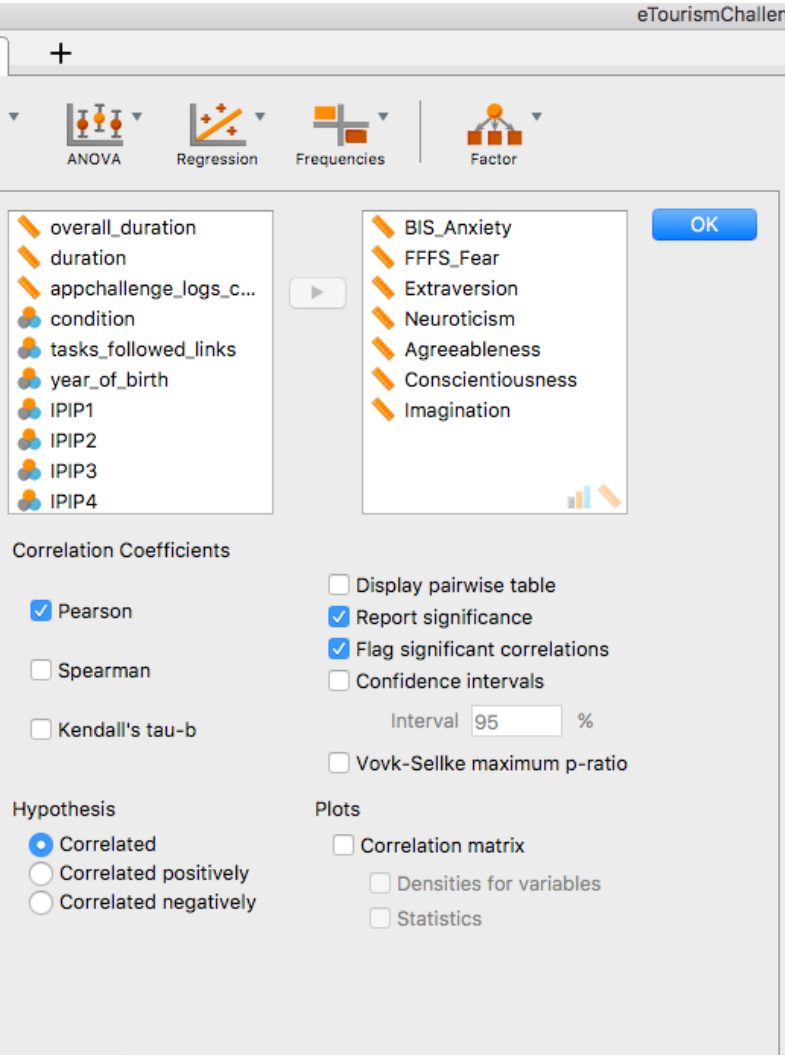


Interpretation

- Pearson's $r = -0.045$, $p = .625$
  - --> we reject H_a (that they are related), and we accept H_0 that the variables are not related, instead!

Question 4

- Let's explore the following:
  - We have our sub-dimensions (BIS_Anxiety and FFFS_Fear)
  - We also have the Big Five sub-dimensions: Extraversion, Agreeableness, Conscientiousness, Neuroticism, Imagination
- **How do the two BIS dimensions (BIS_Anxiety, FFFS_Fear) and all five dimensions of the Big Five relate to each other?**
- Let's build a bigger correlation table and interpret it



Imagination	Pearson's r	−0.088	−0.024	−0.067	0.187*	0.160*
	p-value	0.274	0.764	0.405	0.019	0.045

* p < .05, ** p < .01, *** p < .001

Correlation Matrix

Pearson Correlations

		BIS_Anxiety	FFFS_Fear	Extraversion	Neuroticism	Agreeableness
BIS_Anxiety	Pearson's r	—				
	p-value	—				
FFFS_Fear	Pearson's r	0.440***	—			
	p-value	< .001	—			
Extraversion	Pearson's r	−0.026	−0.029	—		
	p-value	0.743	0.716	—		
Neuroticism	Pearson's r	0.411***	0.468***	−0.037	—	
	p-value	< .001	< .001	0.644	—	
Agreeableness	Pearson's r	0.160*	0.113	0.267***	−0.018	—
	p-value	0.046	0.162	< .001	0.820	—
Conscientiousness	Pearson's r	0.042	−0.007	−0.037	−0.017	0.009
	p-value	0.603	0.928	0.644	0.833	0.915
Imagination	Pearson's r	−0.088	−0.024	0.187*	−0.067	0.160*
	p-value	0.274	0.764	0.019	0.405	0.045

* p < .05, ** p < .01, *** p < .001

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Correlation Matrix

Pearson Correlations

		BIS_Anxiety	FFFS_Fear	Extraversion	Neuroticism	Agreeableness	Conscientiousness	Imagination
BIS_Anxiety	Pearson's r	—						
	p-value	—						
FFFS_Fear	Pearson's r	0.440***	—					
	p-value	< .001	—					
Extraversion	Pearson's r	−0.026	−0.029	—				
	p-value	0.743	0.716	—				
Neuroticism	Pearson's r	0.411***	0.468***	−0.037	—			
	p-value	< .001	< .001	0.644	—			
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	p-value	0.603	0.928	0.644	0.833	0.915	—	
Imagination	Pearson's r	−0.088	−0.024	0.187*	−0.067	0.160*	0.107	—
	p-value	0.274	0.764	0.019	0.405	0.045	0.184	—

* p < .05, ** p < .01, *** p < .001

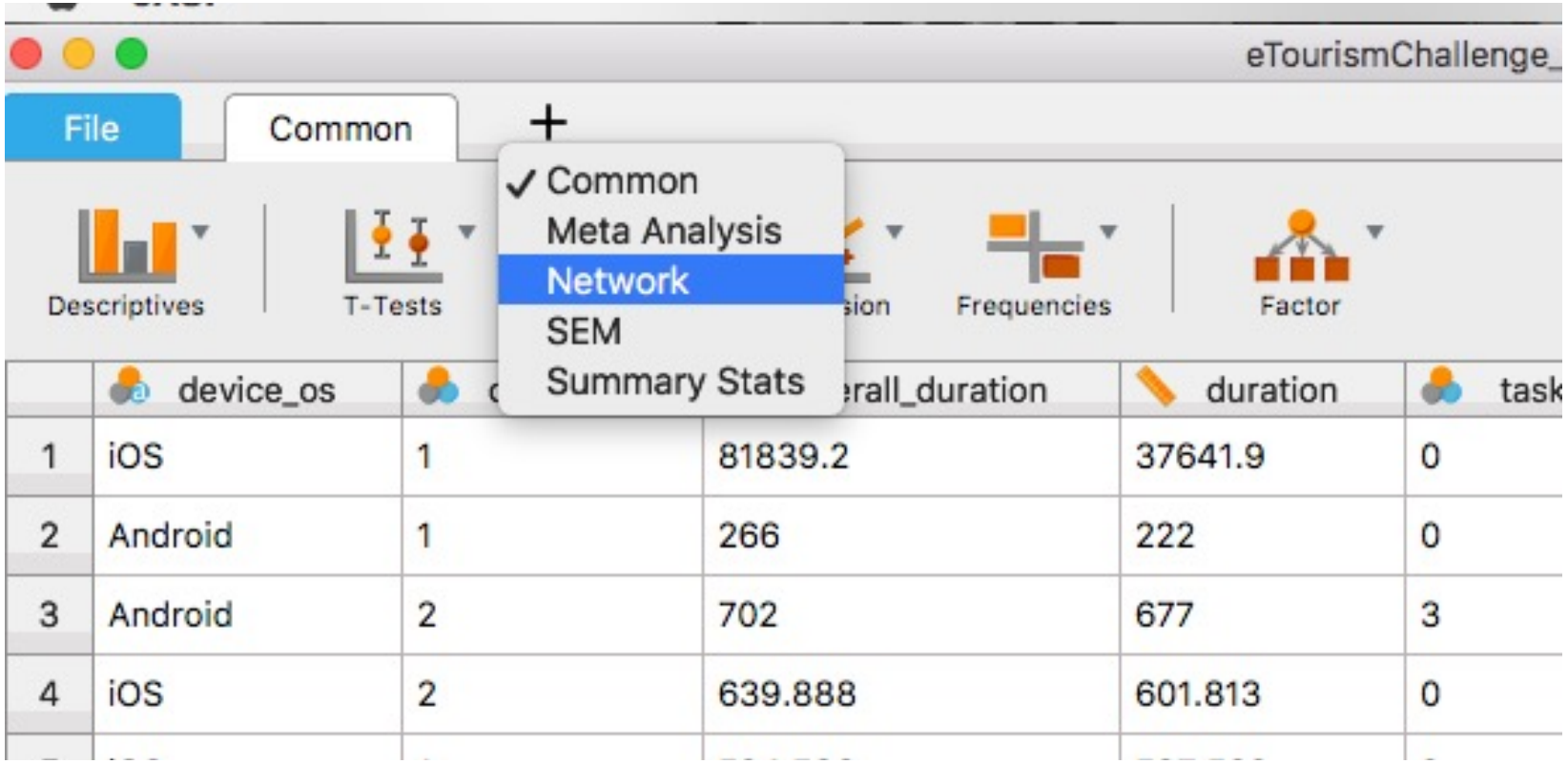
Interpretation

- The two main patterns are:

- We see highly significant – positive – correlations of moderate strength between Neuroticism, BIS-Anxiety and FFFS-Fear -> they move together such that low scores link with low scores, and high scores link with high scores.

- Agreeableness and Extraversion (two social components of the Big Five) also move together, in weak, positive, but significant manner

A cool feature in JASP (not in the exam)



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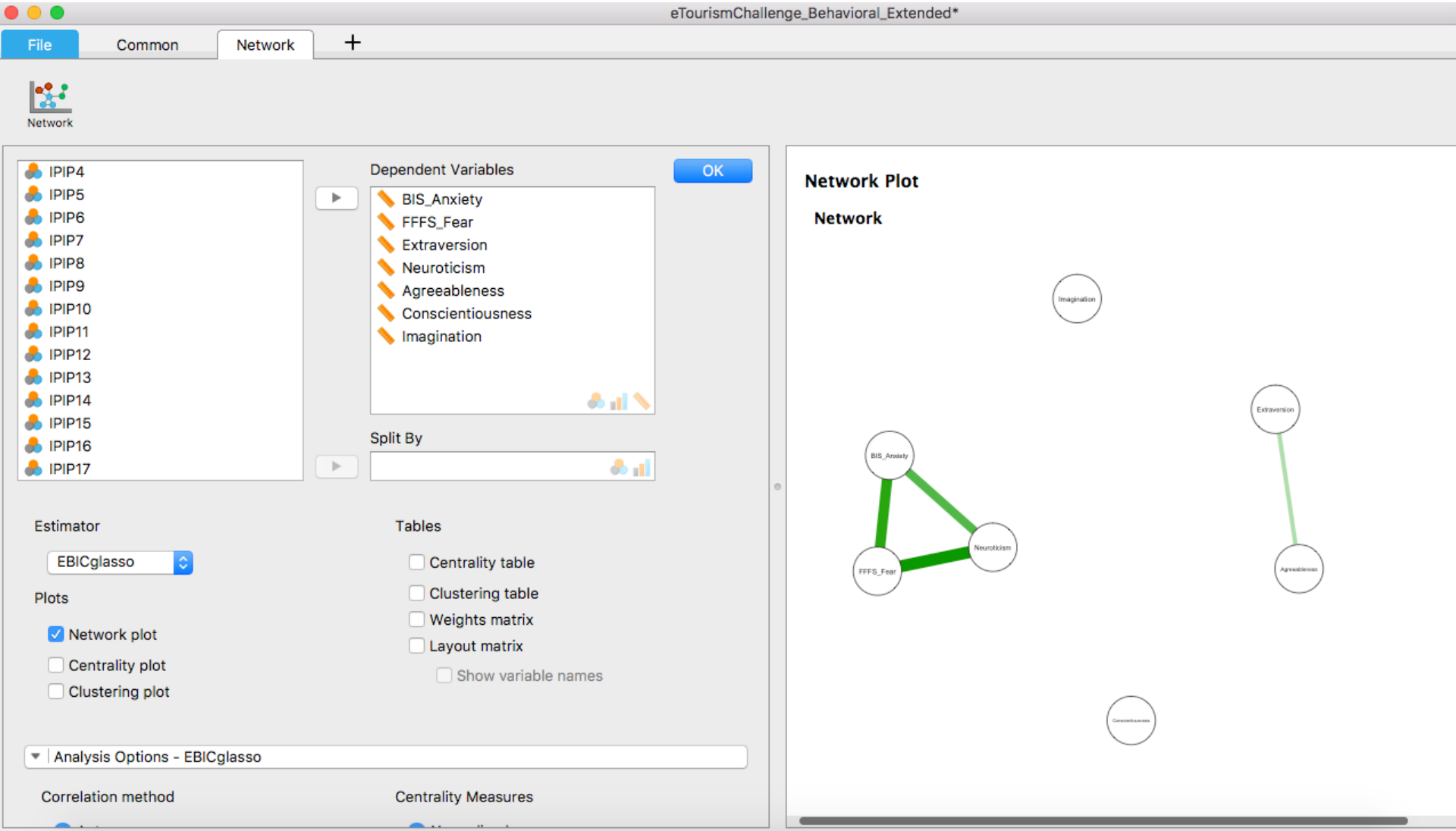
eTourismChallenge_Behavioral_Extended*
File
Common
Network
Network
IPIP4
IPIP5
IPIP6
IPIP7
IPIP8
IPIP9
IPIP10
IPIP11
IPIP12
IPIP13
IPIP14
IPIP15
IPIP16
IPIP17
Dependent Variables
BIS_Anxiety
FFFS_Fear
Extraversion
Neuroticism
Agreeableness
Conscientiousness
Imagination
OK
Split By
Estimator
EBICglasso
Plots
Network plot
Centrality plot
Clustering plot
Tables
Centrality table
Clustering table
Weights matrix
Layout matrix
Show variable names
Analysis Options - EBICglasso
Correlation method
Centrality Measures
Network Plot
Network
Imagination
BIS_Anxiety
Extraversion
FFFS_Fear
Neuroticism
Agreeableness
Conscientiousness

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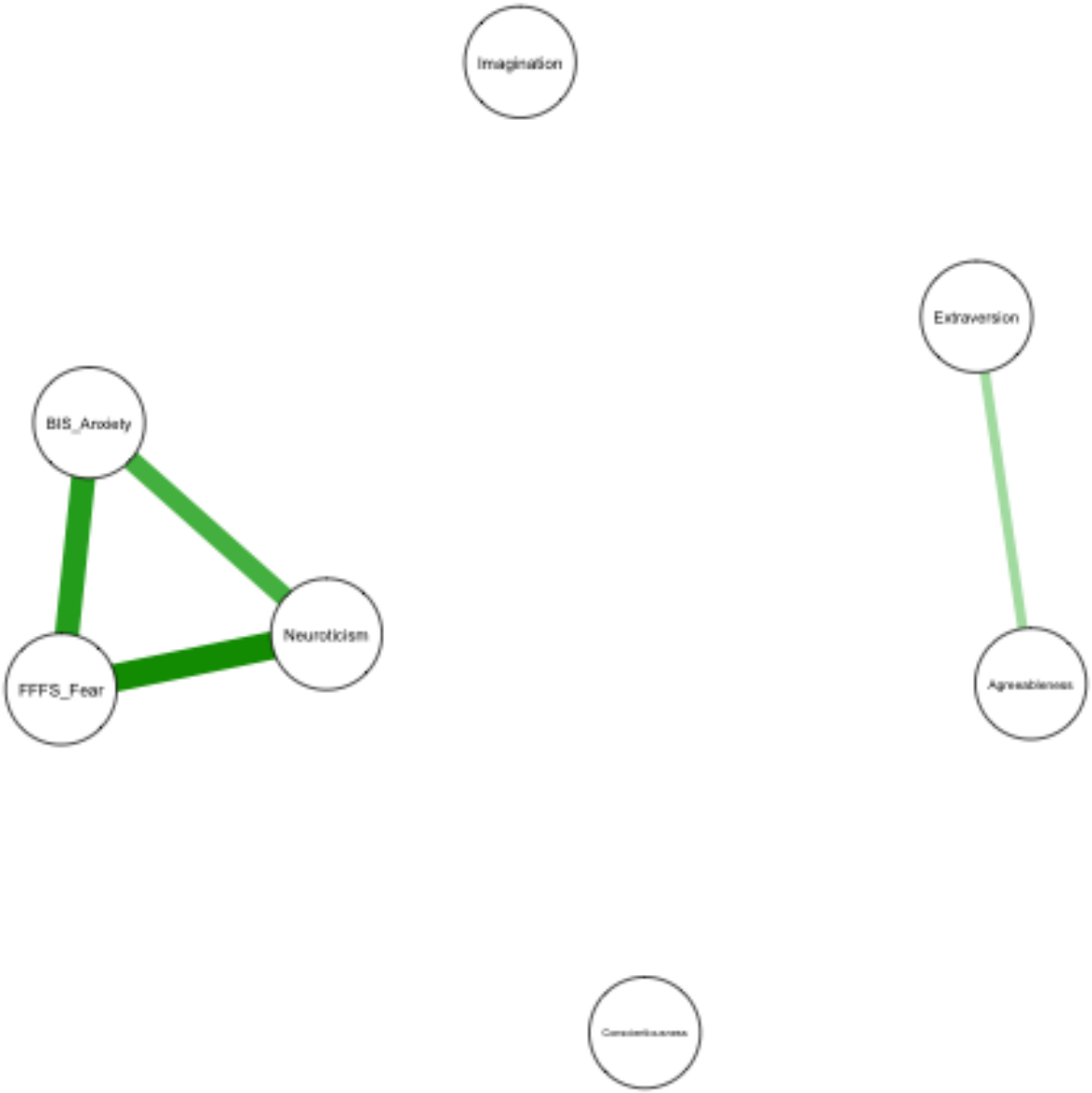

NOTE that this network graph visually confirms / illustrates what we stated for the correlation matrix: two main patterns.

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Bigger network plots

Network Plot ▼

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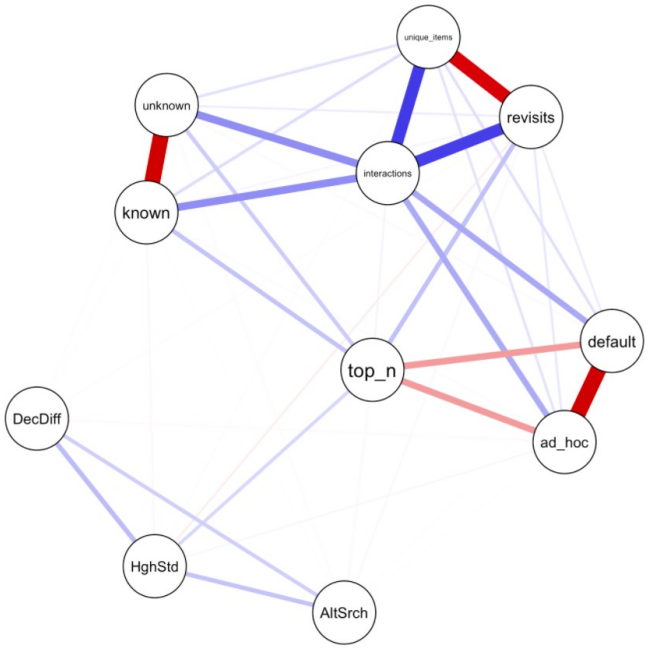

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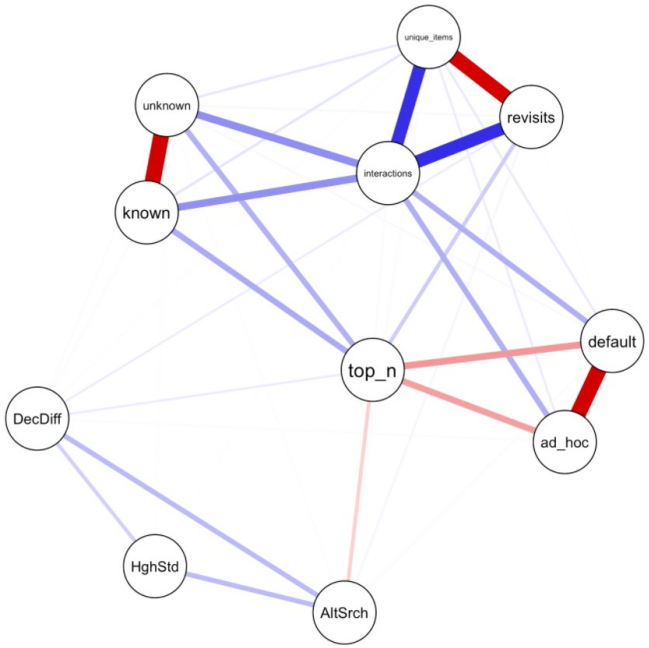

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In conclusion

3.

Learning goals (I)

- Describe the difference between strong, moderate, and weak correlation coefficients
- Capable of visual inspection and interpretation of scatter plots (valence, form, direction and strength of the correlation)
- Understand how correlations allows for prediction

Learning goals (II)

- Describe when it is appropriate to use the Pearson correlation coefficient, and when the Spearman correlation coefficient or Kendall's tau-b should be used (the latter one is "slides only")

- Interpret these correlation coefficients in JASP output form