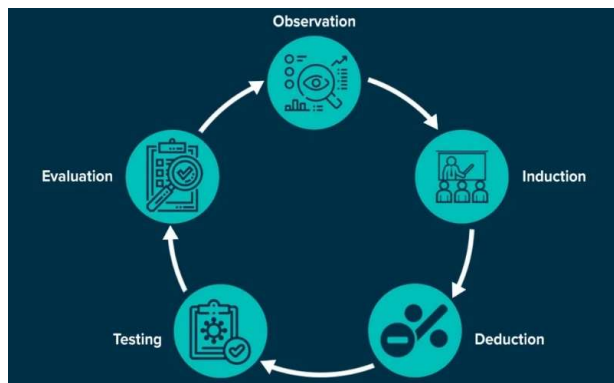


# *Empirical research in management and economics*

## Exercise

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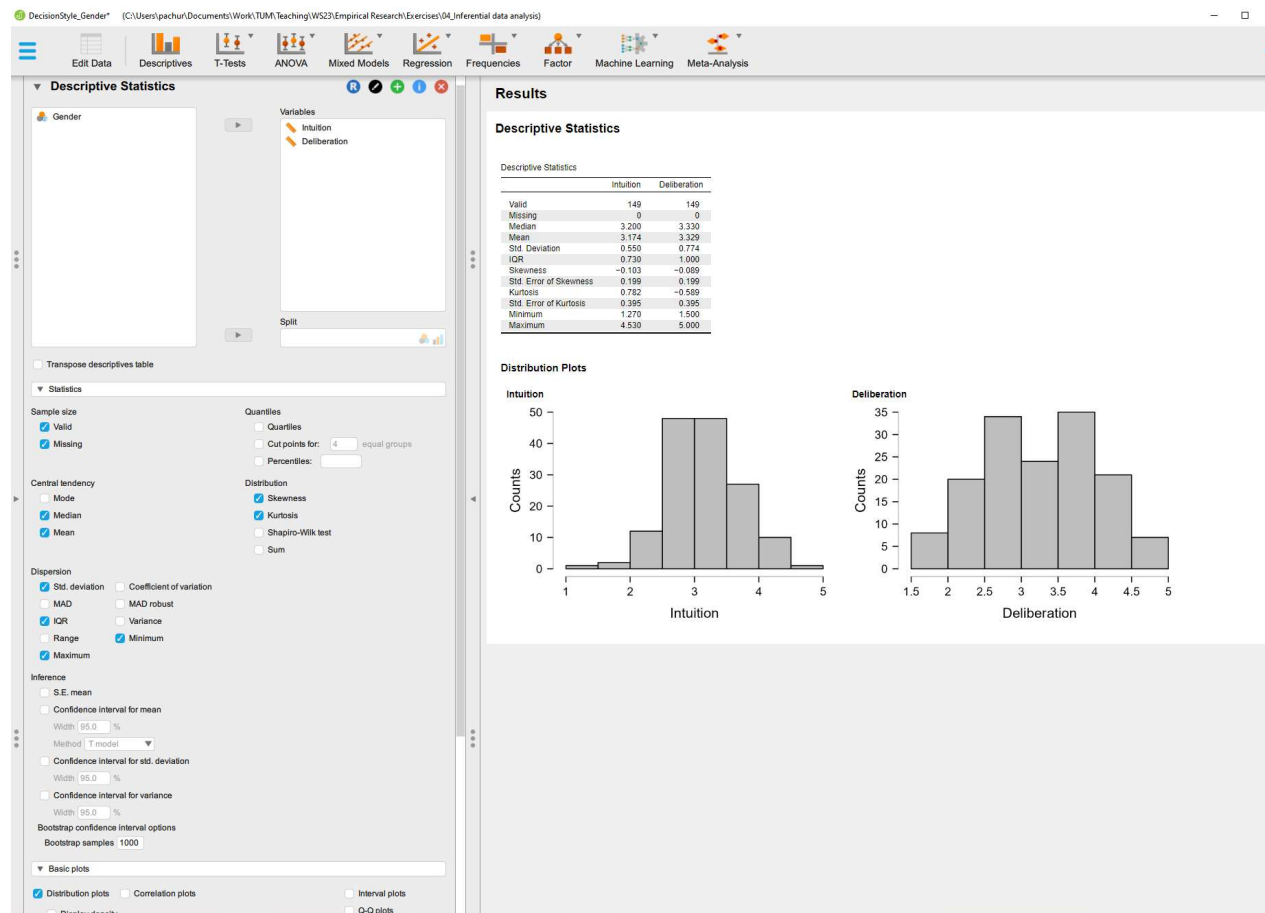
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School of Management  
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# *Exercise 1: t-test*

- Start JASP and open dataset “DecisionStyle\_Gender.csv”
  - Scores of  $N = 149$  (female and male) students on the intuitive decision style scale and on the deliberate decision style scale
- Do a descriptive data analysis
  - Central tendency, dispersion, distribution
  - Basic plots: Distribution plots
    - Describe the results for the different variables
- Do an inferential data analysis (independent samples t-test)
  - Do females and males differ in their decision style preference? Also compute the effect size.
  - Assume you wanted to test the hypothesis that females have a stronger preference for intuition than males. How would you need to adjust the analysis?

# Inferential data analysis



# Inferential data analysis

DecisionStyle\_Gender (autosaved) (C:\Users\pachur\Documents\Work\TUM\Teaching\WS23\Empirical Research\Exercises\05\_Inferential data analysis I)

DecisionStyle\_Gender (C:\Users\pachur\Documents\Work\TUM\Teaching\WS23\Empirical Research\Exercises\05\_Inferential data analysis I)

Gender Intuition Deliberation

	Gender	Intuition	Deliberation
1	Female	3.67	2.67
2	Female	3.53	2.5
3	Female	3.53	1.67
4	Female	3	4.5
5	Female	3	3.67
6	Female	3.07	3.17
7	Female	3.93	4.67
8	Female	3.4	2.83
9	Female	3.53	2.5
10	Female	3.4	3.5
11	Female	2.47	2.5
12	Female	3.4	4.33
13	Female	3.93	4.17
14	Male	3.07	3.67
15	Male	3.33	1.67
16	Female	2.73	3
17	Female	4.2	3
18	Male	3.4	2.83
19	Female	3	3.67
20	Female	2.6	2.83
21	Female	3.4	2.67
22	Female	3	2.83
23	Male	3.27	3.17

**Independent Samples T-Test**

Dependent Variables: Intuition, Deliberation

Grouping Variable: Gender

Tests: ☒ Student, ☐ Welch, ☐ Mann-Whitney

Alternative Hypothesis: ☒ Group 1 ≠ Group 2, ☐ Group 1 > Group 2, ☐ Group 1 < Group 2

Assumption Checks: ☒ Normality, ☒ Equality of variances, ☐ Brown-Forsythe, ☐ Levene's, ☐ Q-Q plot residuals

Missing Values: ☒ Exclude cases per dependent variable, ☐ Exclude cases listwise

Additional Statistics: ☐ Location parameter, ☐ Confidence interval 95%, ☒ Effect size, ☐ Cohen's d, ☐ Glass' delta, ☐ Hedges' g, ☐ Confidence interval 95%, ☒ Descriptives, ☐ Vovk-Sellke maximum p-ratio

Plots: ☒ Descriptives plots, ☐ Confidence interval 95%, ☐ Horizontal display, ☐ Raincloud plots, ☐ Bar plots, ☐ Confidence interval 95%, ☐ Standard error, ☐ Fix horizontal axis to 0

**Results**

**Independent Samples T-Test**

	t	df	p	Cohen's d	SE Cohen's d
Intuition	-1.495	147	.137	-0.254	0.177
Deliberation	-2.317	147	.022	-0.408	0.179

Note: Student's t-test.

**Assumption Checks**

Test of Normality (Shapiro-Wilk)

Residuals	W	p
Intuition	0.987	.192
Deliberation	0.986	.128

Note: Significant results suggest a deviation from normality.

Test of Equality of Variances (Brown-Forsythe)

	F	df1	df2	p
Intuition	0.637	1	147	.426
Deliberation	0.452	1	147	.502

**Descriptives**

Group Descriptives

	Group	N	Mean	SD	SE	Coefficient of variation
Intuition	Female	102	3.128	0.567	0.056	0.181
	Male	47	3.273	0.502	0.073	0.153
Deliberation	Female	102	3.230	0.765	0.076	0.237
	Male	47	3.542	0.757	0.110	0.214

**Descriptives Plots**

Intuition

Deliberation

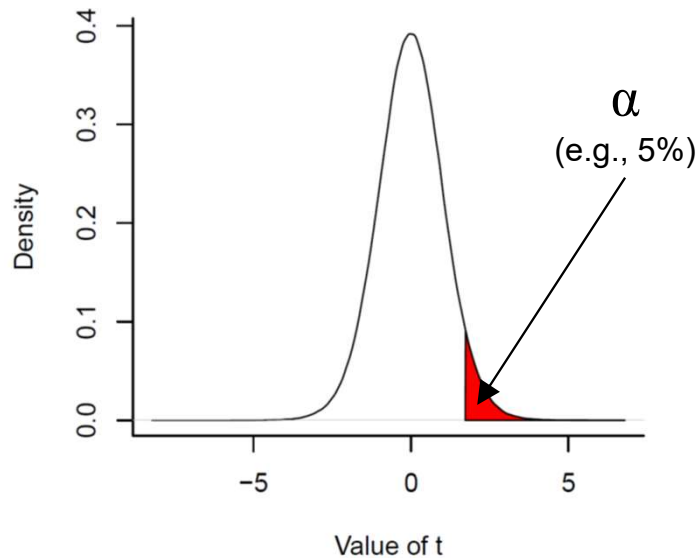
Gender

The test of normality and the test of equality of variances should be nonsignificant, meaning that the assumptions of normality and equal variances are not violated.

# Two-tailed vs. one-tailed test

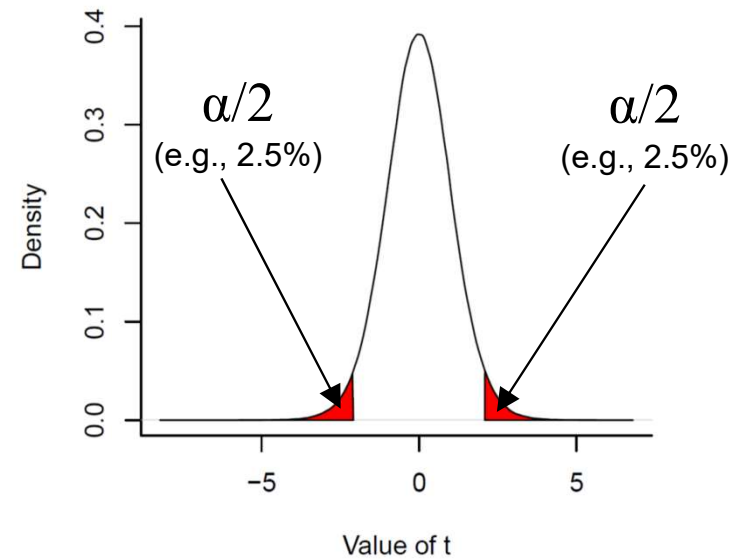
Directional hypothesis  
(e.g.,  $M_{X1} > M_{X2}$ )

One-tailed test



Non-directional hypothesis  
(i.e.,  $M_{X1} \neq M_{X2}$ )

Two-tailed test



## *Exercise II: ANOVA*

- A health maintenance organization orders weekly medical supplies for its four clinics from five different suppliers. Delivery times (in days) for 4 recent weeks are in the file “Delivery.csv”. Open the file.
- Test whether there are main effects for the factors “Clinics” and “Supplier”—that is, whether delivery times differ between the four clinics and between the different supplies—and also test whether there is an interaction between the two factors.
  - Factorial ANOVA (2 factors, with 4 and 5 levels, respectively)
  - Also compute effect sizes

Delivery (C:\Users\pachur\Documents\Work\TUM\Teaching\WS23\Empirical Research\Exercises\04\_Inf

	Delivery Times	Supplier	Clinic
14	10	Supplier 1	Clinic D
15	10	Supplier 1	Clinic D
16	13	Supplier 1	Clinic D
17	14	Supplier 2	Clinic A
18	9	Supplier 2	Clinic A
19	14	Supplier 2	Clinic A
20	11	Supplier 2	Clinic A
21	9	Supplier 2	Clinic B
22	9	Supplier 2	Clinic B
23	7	Supplier 2	Clinic B
24	8	Supplier 2	Clinic B
25	8	Supplier 2	Clinic C
26	9	Supplier 2	Clinic C
27	11	Supplier 2	Clinic C
28	12	Supplier 2	Clinic C
29	8	Supplier 2	Clinic D
30	13	Supplier 2	Clinic D
31	9	Supplier 2	Clinic D
32	12	Supplier 2	Clinic D
33	10	Supplier 3	Clinic A
34	15	Supplier 3	Clinic A
35	10	Supplier 3	Clinic A
36	7	Supplier 3	Clinic A

Delivery\* (C:\Users\pachur\Documents\Work\TUM\Teaching\WS23\Empirical Research\Exercises\05\_inferential data analysis II)

**ANOVA**

Dependent Variable: Delivery Times

Fixed Factors: Supplier, Clinic

Display: ☐ Descriptive statistics, ☒ Estimates of effect size ( $\omega^2$ ,  $\eta^2$ ), ☐ Confidence intervals, ☐ Volk-Selike maximum p-ratio

Model:

Assumption Checks: ☒ Homogeneity tests

Homogeneity corrections: ☒ None, ☐ Brown-Forsythe, ☐ Welch

Q-Q plot of residuals: ☐

Contrasts:

Order Restricted Hypotheses:

Post Hoc Tests:

Descriptives Plots:

Factors:

Horizontal Axis: Supplier

Separate Lines: ☒

Separate Plots: ☐

Display: ☒ Error bars, ☒ Confidence interval, ☐ Standard error

**Results**

**ANOVA**

ANOVA - Delivery Times

Cases	Sum of Squares	df	Mean Square	F	p	$\eta^2$	$\omega^2$
Supplier	104.42	4	26.106	5.239	.001	0.187	0.150
Clinic	51.35	3	17.117	3.435	.022	0.092	0.065
Supplier * Clinic	102.77	12	8.565	1.719	.085	0.184	0.076
Residuals	299.00	60	4.983				

Note. Type III Sum of Squares

**Descriptives**

Descriptives plots

Assumption Checks

Test for Equality of Variances (Levene's)

F	df1	df2	p
1.093	19.00	60.00	.381



Delivery\* (C:\Users\pachur\Documents\Work\TUM\Teaching\WS25\Empirical Research\Exercises\05\_Inferential data analysis II)

Menu: Edit Data | Descriptives | T-Tests | ANOVA | Mixed Models | Regression | Frequencies | Factor | Machine Learning | Meta-Analysis | Power | Process | Reliability

**Display**

- ☐ Descriptive statistics
- ☒ Estimates of effect size
  - ☒  $\omega^2$  ☐ partial  $\omega^2$
  - ☒  $\eta^2$  ☐ partial  $\eta^2$
- ☐ Confidence intervals 95 %
- ☐ Vovk-Sellke maximum p-ratio

**Model**

**Assumption Checks**

- ☒ Homogeneity tests
- Homogeneity corrections
  - ☒ None ☐ Brown-Forsythe ☐ Welch
- ☐ Q-Q plot of residuals

**Contrasts**

**Order Restricted Hypotheses**

**Post Hoc Tests**

**Descriptives Plots**

**Factors**

Horizontal Axis: Supplier

Separate Lines: Clinic

Separate Plots:

**Display**

- ☒ Error bars
  - ☐ Confidence interval 95 %
  - ☐ Standard error

**Bar Plots**

**Raincloud Plots**

**Marginal Means**

Supplier \* Clinic

Supplier

Clinic

From 1000 bootstraps

Compare marginal means to 0

Confidence interval adjustment: None

**Results**

**ANOVA**

ANOVA - Delivery Times

Cases	Sum of Squares	df	Mean Square	F	p	$\eta^2$	$\omega^2$
Supplier	104.42	4	26.106	5.239	.001	0.187	0.150
Clinic	51.35	3	17.117	3.435	.022	0.092	0.065
Supplier * Clinic	102.77	12	8.565	1.719	.085	0.184	0.076
Residuals	299.00	60	4.983				

Note: Type III Sum of Squares

**Descriptives**

**Assumption Checks**

Test for Equality of Variances (Levene's)

F	df1	df2	p
1.093	10.00	60.00	.354

**Marginal Means**

Marginal Means - Supplier

Supplier	Marginal Mean	95% CI for Mean Difference			SE
		Lower	Upper		
Supplier 1	11.125	10.009	12.241	0.558	
Supplier 2	10.188	9.071	11.304	0.558	
Supplier 3	9.553	8.446	10.679	0.558	
Supplier 4	8.750	7.634	9.866	0.558	
Supplier 5	12.000	10.884	13.116	0.558	

Marginal Means - Clinic

Clinic	Marginal Mean	95% CI for Mean Difference			SE
		Lower	Upper		
Clinic A	10.750	9.752	11.748	0.499	
Clinic B	10.650	9.652	11.648	0.499	
Clinic C	10.950	9.952	11.948	0.499	
Clinic D	8.950	7.952	9.948	0.499	

Useful for interpreting the main effects!



# *Exercise III: Chi-square test*

Dataset "LectureSurvey.csv"

→ Experience with statistical software and experience with and interest in empirical research methods for students from different Master's programs

Inferential data analysis

Chi-square test

- Does experience with statistical software differ across the different Master's programs? Also compute the effect size.
- Does experience with and interest in empirical research methods differ across the different Master's programs? Also compute the effect size.

# Inferential data analysis

LectureSurvey\* (C:\Users\pachur\Documents\Work\TUM\Teaching\WS23\Empirical Research\Exercises\04\_Inferential data analysis)

Edit Data | Descriptives | T-Tests | ANOVA | Mixed Models | Regression | Frequencies | Factor | Machine Learning | Meta-Analysis

	What's your Master's program?	What is your previous experience with and interest in empirical research methods?	Please indicate your prior experience regarding statistical software.
1	Master in Management	This is my first class on empirical research methods but I find ...	no previous experience with statistical software.
2	Master in Consumer Science	I have taken a class on empirical research methods previously bu...	previously used R.
3	Master in Management	This is my first class on empirical research methods and I do no...	no previous experience with statistical software.
4	Master in Management	This is my first class on empirical research methods but I find ...	no previous experience with statistical software.
5	Master in Management	This is my first class on empirical research methods but I find ...	no previous experience with statistical software.
6	Master in Management	I have taken a class on empirical research methods previously bu...	no previous experience with statistical software.
7	Master in Management	This is my first class on empirical research methods and I do no...	previously used R.
8	Master in Management	This is my first class on empirical research methods but I find ...	no previous experience with statistical software.
9	Master in Management	This is my first class on empirical research methods but I find ...	no previous experience with statistical software.
10	Master in Management	This is my first class on empirical research methods but I find ...	previously used other statistical software (e.g., SPSS, S...
11	Master in Management and Technology	This is my first class on empirical research methods but I find ...	I have previously used R.
12	Master in Management	This is my first class on empirical research methods but I find ...	I have previously used R.
13	Master in Management	This is my first class on empirical research methods and I do no...	I have no previous experience with statistical software.
14	Other	This is my first class on empirical research methods but I find ...	I have previously used R.
15	Master in Management	This is my first class on empirical research methods but I find ...	I have no previous experience with statistical software.
16	Master in Management	I have taken a class on empirical research methods previously bu...	I have no previous experience with statistical software.
17	Master in Management and Technology	I have taken a class on empirical research methods previously bu...	I have previously used other statistical software (e.g., SPSS, S...
18	Master in Management	I have taken a class on empirical research methods previously bu...	I have previously used R.
19	Master in Management and Technology	This is my first class on empirical research methods but I find ...	I have no previous experience with statistical software.
20	Master in Management	This is my first class on empirical research methods but I find ...	I have previously used other statistical software (e.g., SPSS, S...
21	Other	This is my first class on empirical research methods but I find ...	I have previously used other statistical software (e.g., SPSS, S...
22	Master in Management	I have taken a class on empirical research methods previously bu...	I have no previous experience with statistical software.
23	Master in Management	This is my first class on empirical research methods but I find ...	I have no previous experience with statistical software.

**Classical**  
 Binomial Test  
 Multinomial Test  
 Contingency Tables  
 Log-Linear Regression  
**Bayesian**  
 Binomial Test  
 A/B Test  
 Multinomial Test  
 Informed Multinomial Test  
 Informed Multi-Binomial Test  
 Contingency Tables  
 Log-Linear Regression

	Rows
	What is your previous experience w... Please indicate your prior experien...
	<b>Columns</b> What's your Master's program?
	<b>Counts</b> <input type="text"/>
	<b>Layers</b> Layer 1

☒  $\chi^2$  ☐ Odds ratio (2x2 only)

☐  $\chi^2$  continuity correction ☐ Log Odds Ratio

☐ Likelihood ratio Confidence interval  %

☐ Vovk-Sellke maximum p-ratio Alt. Hypothesis (Fisher's exact test)

☐ Group one  $\neq$  Group two

☐ Group one  $>$  Group two

☐ Group one  $<$  Group two

☐ Contingency coefficient

☒ Phi and Cramer's V

☐ Lambda

☐ Gamma

☐ Kendall's tau-b

<b>Counts</b>	<b>Residuals</b>
<input checked="" type="checkbox"/> Observed	<input type="checkbox"/> Unstandardized
<input checked="" type="checkbox"/> Expected	<input type="checkbox"/> Pearson
	<input type="checkbox"/> Standardized (adjusted Pearson)
<b>Percentages</b>	<b>Margin</b>
<input type="checkbox"/> Row	<input checked="" type="checkbox"/> Show totals
<input type="checkbox"/> Column	
<input type="checkbox"/> Total	
<b>Options</b>	

## Options

What is your previous experience with and interest in empirical research methods?	What's your Master's program?					
	Master in Consumer Science	Master in Management	Master in Management and Technology	Other	Total	
I have taken a class on empirical research methods previously and I remember quite a bit.	Count	19.00	13.00	10.00	6.00	48.00
	Expected count	10.24	22.52	9.10	6.14	48.00
I have taken a class on empirical research methods previously but I do not remember much.	Count	14.00	31.00	15.00	7.00	67.00
	Expected count	14.29	31.44	12.70	8.57	67.00
This is my first class on empirical research methods and I do not really know why I should need to know about empirical research methods.	Count	3.00	11.00	3.00	4.00	21.00
	Expected count	4.48	9.85	3.98	2.69	21.00
This is my first class on empirical research methods but I find the topic interesting.	Count	9.00	44.00	12.00	10.00	75.00
	Expected count	16.00	35.19	14.22	9.60	75.00
Total	Count	45.00	99.00	40.00	27.00	211.00
	Expected count	45.00	99.00	40.00	27.00	211.00

	Value	df	p
X <sup>2</sup>	19.47	9	.021
N	211		

Note. Continuity correction is available only for 2x2 tables.

	Value*
Phi-coefficient	NaN
Cramer's V	0.175

Contingency Tables ▼

Please indicate your prior experience regarding statistical software.	What's your Master's program?					Total
	Master in Consumer Science	Master in Management	Master in Management and Technology	Other		
I have no previous experience with statistical software.	Count	11.00	51.00	13.00	10.00	85.00
	Expected count	18.13	39.88	16.11	10.88	85.00
I have previously used JASP.	Count	2.00	5.00	1.00	0.00	8.00
	Expected count	1.71	3.75	1.52	1.02	8.00
I have previously used R.	Count	15.00	29.00	19.00	14.00	77.00
	Expected count	16.42	36.13	14.60	9.85	77.00
I have previously used both R and JASP.	Count	4.00	4.00	3.00	1.00	12.00
	Expected count	2.58	5.63	2.27	1.54	12.00
I have previously used other statistical software (e.g., SPSS, STATA).	Count	13.00	10.00	4.00	2.00	29.00
	Expected count	6.18	13.61	5.50	3.71	29.00
Total	Count	45.00	99.00	40.00	27.00	211.00
	Expected count	45.00	99.00	40.00	27.00	211.00

	Value	df	p
X <sup>2</sup>	24.21	12	.019
N	211		

Note. Continuity correction is available only for 2x2 tables.

	Value*
Phi-coefficient	NaN
Cramer's V	0.196

