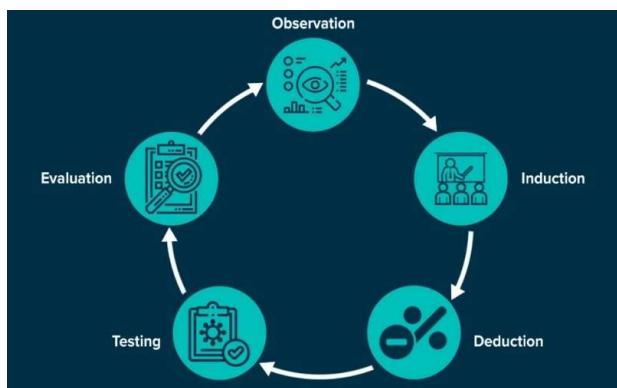


Empirical research in management and economics

Exercise

Thorsten Pachur, Linus Hof, Rebecca West,
Sebastian Hellmann, Nuno Busch

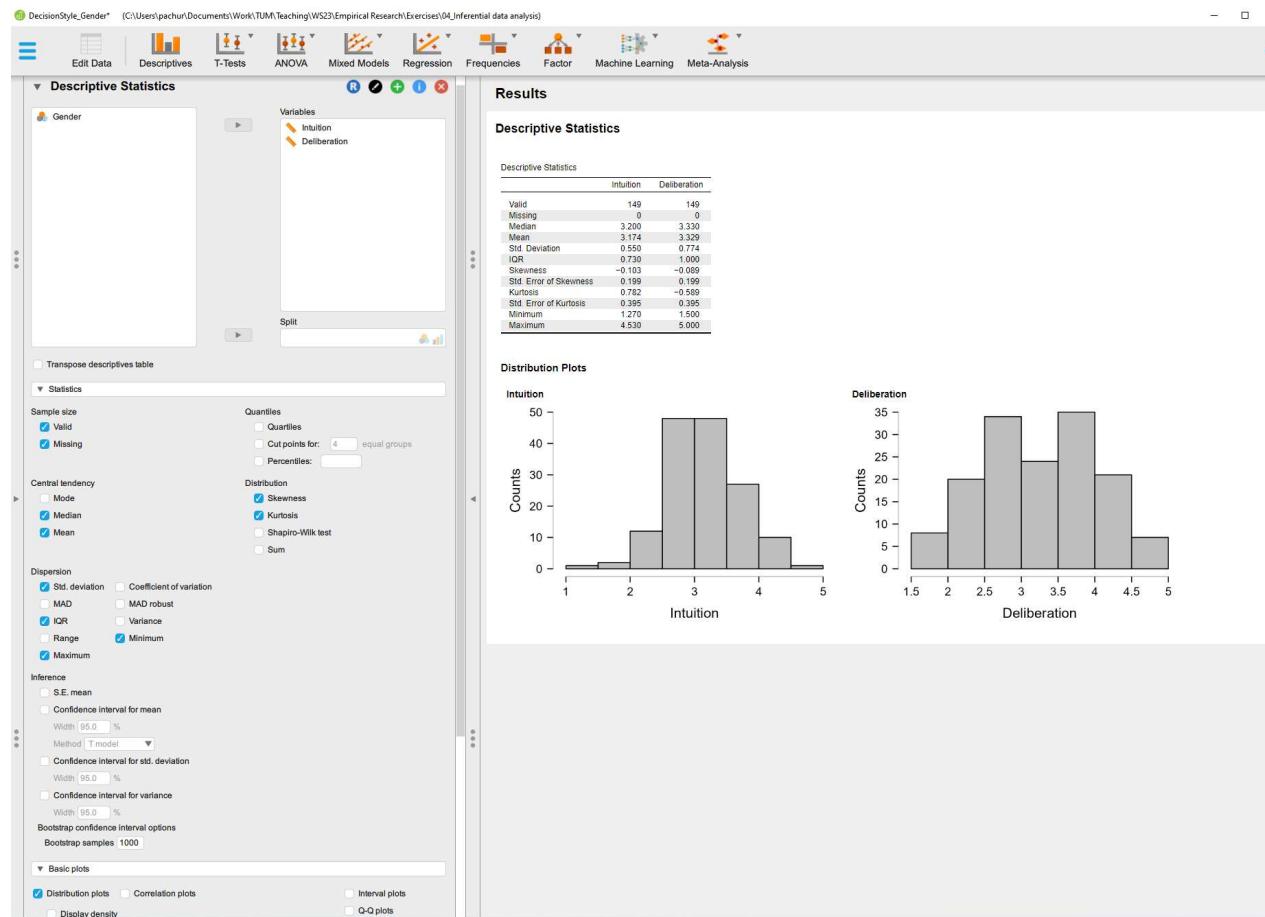
*Technical University of Munich
School of Management
Chair of Behavioral Research Methods*



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

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

Independent Samples T-Test

Dependent Variables: Intuition, Deliberation

Grouping Variable: Gender

Tests: Student (checked), Welch, Mann-Whitney

Alternative Hypothesis: Group 1 ≠ Group 2

Assumption Checks: Test of Normality (Shapiro-Wilk), Test of Equality of Variances (Brown-Forsythe)

Plots: Descriptives plots, Bar plots

Descriptives

Group	N	Mean	SD	SE	Coefficient of variation	
Intuition	Female	102	3.128	0.587	0.056	0.181
Intuition	Male	47	3.273	0.502	0.073	0.153
Deliberation	Female	102	3.230	0.765	0.076	0.237
Deliberation	Male	47	3.542	0.757	0.110	0.214

Results

Independent Samples T-Test

	t	df	p	Cohen's d	SE Cohen's d
Intuition	-1.496	147	.137	-0.264	0.177
Deliberation	-2.317	147	.022	-0.408	0.179

Note: Student's t-test.

Assumption Checks

Test of Normality (Shapiro-Wilk)

Residual	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)

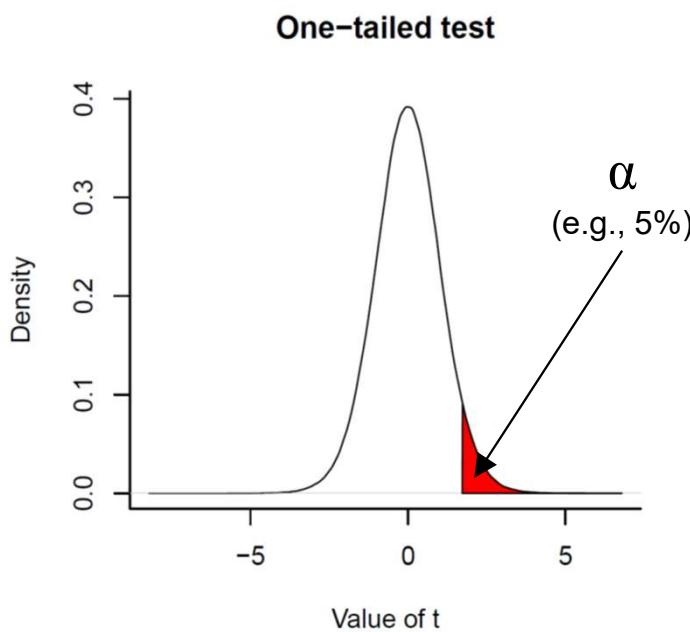
	F	df ₁	df ₂	p
Intuition	0.637	1	147	.426
Deliberation	0.452	1	147	.502

Descriptives Plots

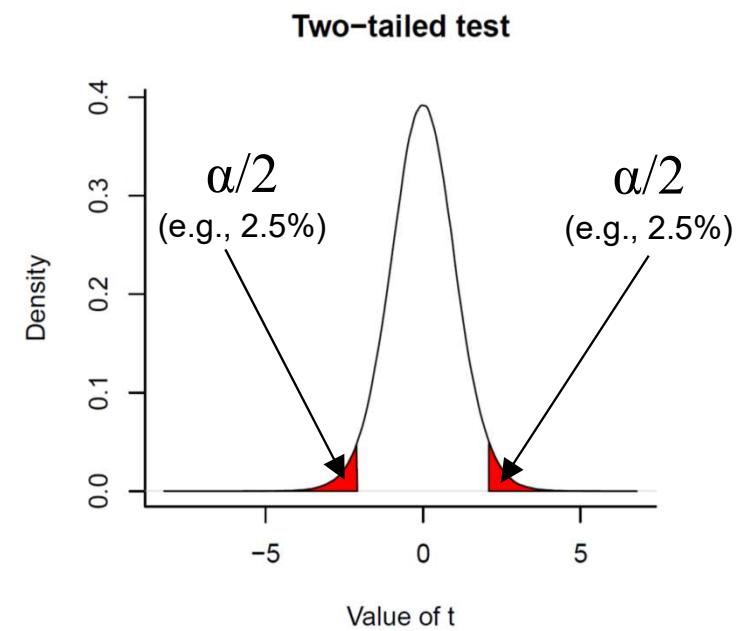
The test of normality and the test of equality of variances should be nonsignificant, meaning that the assumptions of normality and equal variances are not violated.

Two-tailed vs. one-tailed test

Directional hypothesis
(e.g., $M_{X_1} > M_{X_2}$)



Non-directional hypothesis
(i.e., $M_{X_1} \neq M_{X_2}$)



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

ANOVA

Dependent Variable: Delivery Times

Fixed Factors: Supplier, Clinic

ANOVA - Delivery Times

Cases	Sum of Squares	df	Mean Square	F	p	η^2	ω^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

Clinic

- Clinic A
- Clinic B
- Clinic C
- Clinic D

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)

Display

- Descriptive statistics
- Estimates of effect size
 - ω^2
 - partial ω^2
 - η^2
 - partial η^2
- Confidence intervals 95 %
- Vovk-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
- 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	η^2	ω^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	.304

Marginal Means

Marginal Means - Supplier

Supplier	Marginal Mean	95% CI for Mean Difference	Lower	Upper	SE
Supplier 1	11.125	9.009	12.341	0.558	
Supplier 2	10.188	9.071	11.304	0.558	
Supplier 3	9.563	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	Lower	Upper	SE
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)

The screenshot shows a software interface for 'LectureSurvey' with a survey form and a sidebar. The survey form contains 23 rows of data, each with a question and a response. The sidebar on the right is titled 'Classical' and includes options for 'Binomial Test', 'Multinomial Test', 'Contingency Tables' (which is circled in red), and 'Log-Linear Regression'. Below these are sections for 'Bayesian' tests: 'Binomial Test', 'A/B Test', 'Multinomial Test', 'Informed Multinomial Test', 'Informed Multi-Binomial Test', 'Contingency Tables', and 'Log-Linear Regression'. A note at the top of the sidebar says 'Please indicate your prior experience regarding statistical software.' with a list of options: 'no previous experience with statistical software.', 'previously used R.', and 'previously used other statistical software (e.g., SPSS, S...)'.

	What's your Master's program?	What is your previous experience with and interest in empirical research methods?
1	Master in Management	This is my first class on empirical research methods but I find ...
2	Master in Consumer Science	I have taken a class on empirical research methods previously but I ...
3	Master in Management	This is my first class on empirical research methods and I do not ...
4	Master in Management	This is my first class on empirical research methods but I find ...
5	Master in Management	This is my first class on empirical research methods but I find ...
6	Master in Management	I have taken a class on empirical research methods previously but I ...
7	Master in Management	This is my first class on empirical research methods and I do not ...
8	Master in Management	This is my first class on empirical research methods but I find ...
9	Master in Management	This is my first class on empirical research methods but I find ...
10	Master in Management	This is my first class on empirical research methods but I find ...
11	Master in Management and Technology	This is my first class on empirical research methods but I find ...
12	Master in Management	This is my first class on empirical research methods but I find ...
13	Master in Management	This is my first class on empirical research methods and I do not ...
14	Other	This is my first class on empirical research methods but I find ...
15	Master in Management	This is my first class on empirical research methods but I find ...
16	Master in Management	I have taken a class on empirical research methods previously but I ...
17	Master in Management and Technology	I have taken a class on empirical research methods previously but I ...
18	Master in Management	I have taken a class on empirical research methods previously but I ...
19	Master in Management and Technology	This is my first class on empirical research methods but I find ...
20	Master in Management	This is my first class on empirical research methods but I find ...
21	Other	This is my first class on empirical research methods but I find ...
22	Master in Management	I have taken a class on empirical research methods previously but I ...
23	Master in Management	This is my first class on empirical research methods but I find ...

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

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

Contingency Tables

Rows: What is your previous experience with and interest in empirical research methods? (What is your previous experience w... Please indicate your prior experien...)

Columns: What's your Master's program? (What's your Master's program?)

Counts: Layer 1

What is your previous experience with and interest in empirical research methods?

	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 Expected count: 10.24	Count: 13.00 Expected count: 22.52	Count: 10.00 Expected count: 9.10	Count: 6.00 Expected count: 6.14	Count: 48.00 Expected count: 48.00
I have taken a class on empirical research methods previously but I do not remember much.	Count: 14.00 Expected count: 14.29	Count: 31.00 Expected count: 31.44	Count: 15.00 Expected count: 12.70	Count: 7.00 Expected count: 8.57	Count: 67.00 Expected count: 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 Expected count: 4.48	Count: 11.00 Expected count: 9.85	Count: 3.00 Expected count: 3.98	Count: 4.00 Expected count: 2.69	Count: 21.00 Expected count: 21.00
This is my first class on empirical research methods but I find the topic interesting.	Count: 9.00 Expected count: 16.00	Count: 44.00 Expected count: 35.19	Count: 12.00 Expected count: 14.22	Count: 10.00 Expected count: 9.60	Count: 75.00 Expected count: 75.00
Total	Count: 45.00 Expected count: 45.00	Count: 99.00 Expected count: 99.00	Count: 40.00 Expected count: 40.00	Count: 27.00 Expected count: 27.00	Count: 211.00 Expected count: 211.00

Chi-Squared Tests

	Value	df	p
χ^2	19.47	9	.021
N	211		

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

Nominal

	Value*
Phi-coefficient	NaN
Cramer's V	0.175

*Phi coefficient is only available for 2 by 2 contingency Tables

Contingency Tables

Please indicate your prior experience regarding statistical software

	Master in Consumer Science	Master in Management	Master in Management and Technology	Other	Total
I have no previous experience with statistical software.	Count: 11.00 Expected count: 18.13	Count: 51.00 Expected count: 39.88	Count: 13.00 Expected count: 16.11	Count: 10.00 Expected count: 10.88	Count: 85.00 Expected count: 85.00
I have previously used JASP.	Count: 2.00 Expected count: 1.71	Count: 5.00 Expected count: 3.75	Count: 1.00 Expected count: 1.52	Count: 0.00 Expected count: 1.02	Count: 8.00 Expected count: 8.00
I have previously used R.	Count: 15.00 Expected count: 16.42	Count: 29.00 Expected count: 36.13	Count: 19.00 Expected count: 14.60	Count: 14.00 Expected count: 9.85	Count: 77.00 Expected count: 77.00
I have previously used both R and JASP.	Count: 4.00 Expected count: 2.56	Count: 4.00 Expected count: 5.63	Count: 3.00 Expected count: 2.27	Count: 1.00 Expected count: 1.54	Count: 12.00 Expected count: 12.00
I have previously used other statistical software (e.g., SPSS, STATA).	Count: 13.00 Expected count: 6.18	Count: 10.00 Expected count: 13.61	Count: 4.00 Expected count: 5.50	Count: 2.00 Expected count: 3.71	Count: 29.00 Expected count: 29.00
Total	Count: 45.00 Expected count: 45.00	Count: 99.00 Expected count: 99.00	Count: 40.00 Expected count: 40.00	Count: 27.00 Expected count: 27.00	Count: 211.00 Expected count: 211.00

Chi-Squared Tests

	Value	df	p
χ^2	24.21	12	.019
N	211		

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

Nominal

	Value*
Phi-coefficient	NaN
Cramer's V	0.196

*Phi coefficient is only available for 2 by 2 contingency