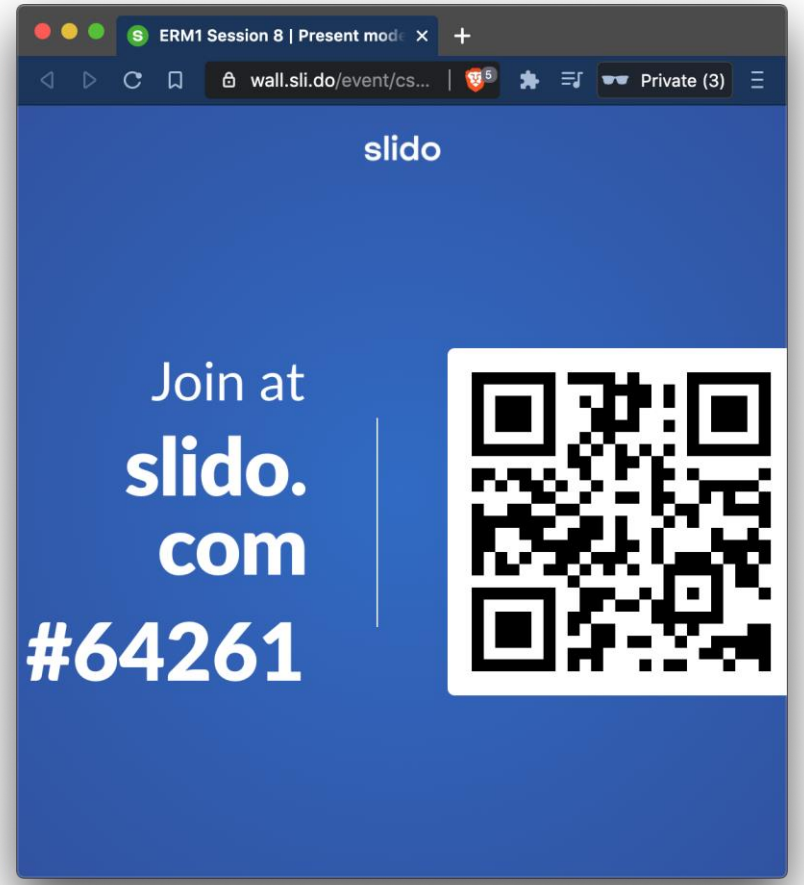
Session start question



https://app.sli.do/event/csqy6yc2

Empirical Research Methods 1

t-test for independent samples

(Or: What does beer have to do with statistics?)

Miguel Rejón,

Room 1.14

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Before we start 1/2: Info and tools

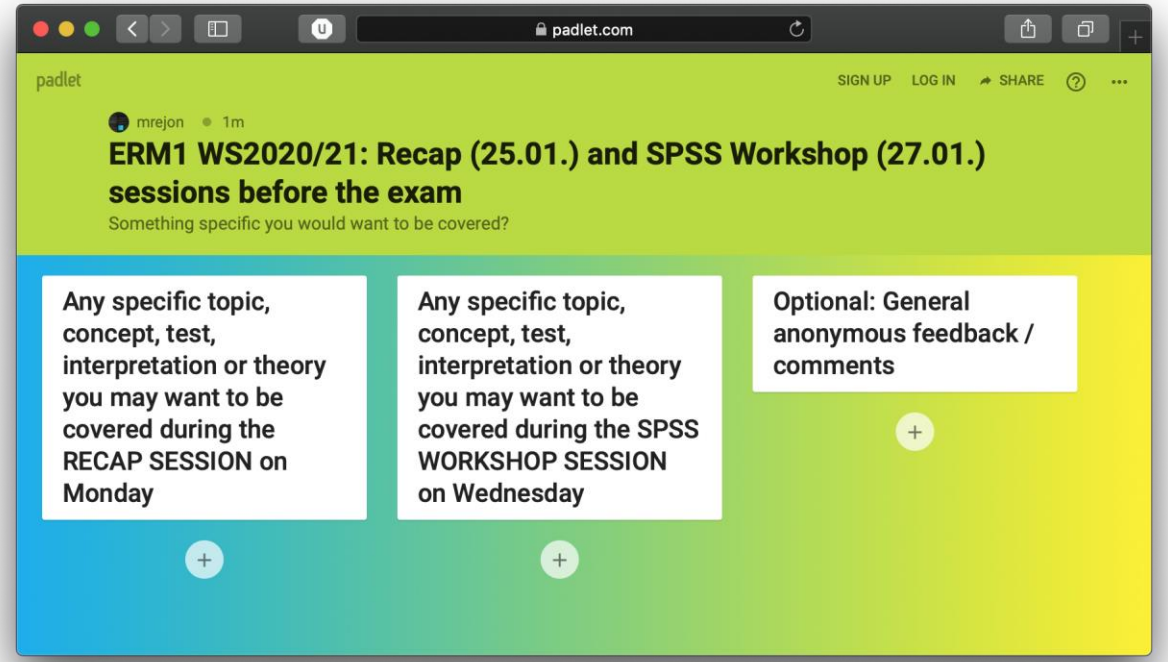
- Wheel of names: great idea! Keep using it!
- New! Slido for session start Q and Q&A at the end
- MS Teams for comments, questions, etc
- Padlet for ideas and extra anonymous feedback
- SPSS for exercise livecast

Before we start 2/2: ERM1 recap and SPSS workshop before the exam

Session	Seminar Dates (Mondays)	Seminar topic	Who presents?	First presentation draft deadline	Worksheet (WS) submission deadline	Tutorial dates (Wednesdays)
11	25.01.2021	Recap	Tutors + Miguel			27.01.2021
12	01.02.2021	Exam	everyone			03.02.2021

- Monday 25.01.: Recap session. Review of the most important seminar topics
- Wednesday 27.01.: Tutorial workshop. SPSS workshop lead by tutors
- Want to learn something specific during the Recap session or the SPSS tutorial? Write it in Padlet: https://padlet.com/mrejon/y71gbr4qt5yx720d until Wednesday 20 of Jan.

Before we start 2/2: ERM1 recap and SPSS workshop before the exam



https://padlet.com/mrejon/y71gbr4qt5yx720d

Contribute until Wednesday Jan 20

Add (“+” button), comment, or like posts

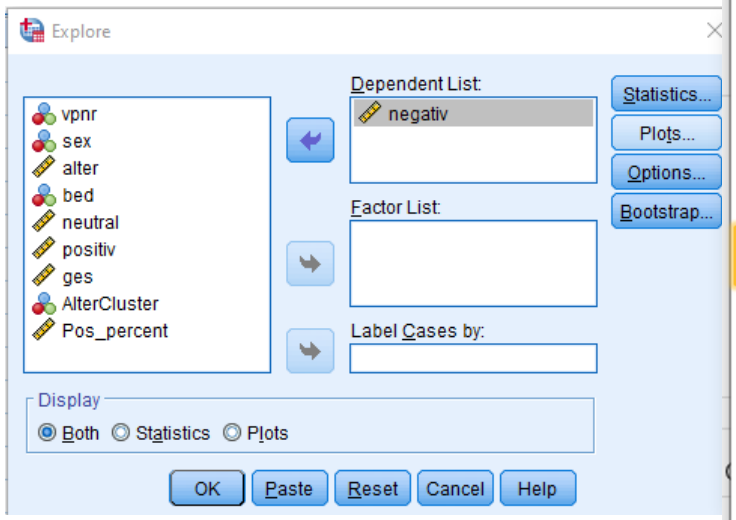
Agenda

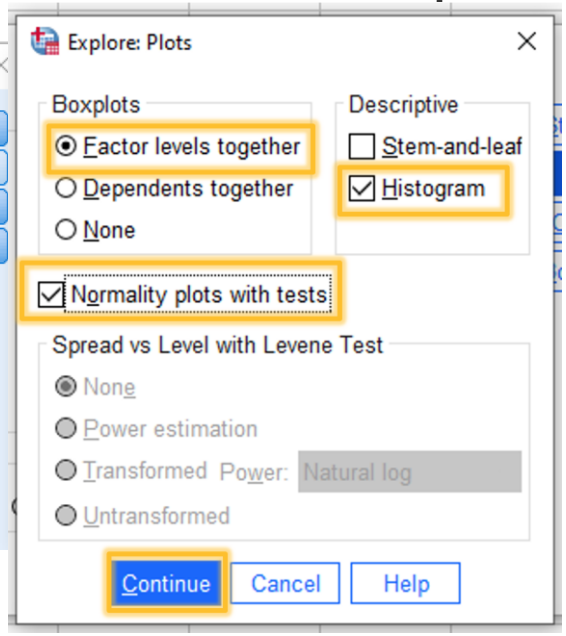
- Previously on ERM1: Normality testing
- Independent samples t-test
  - Degrees of freedom
  - T-distribution
  - T-values
- Independent samples t-test on SPSS

Previously on ERM1: Normality testing

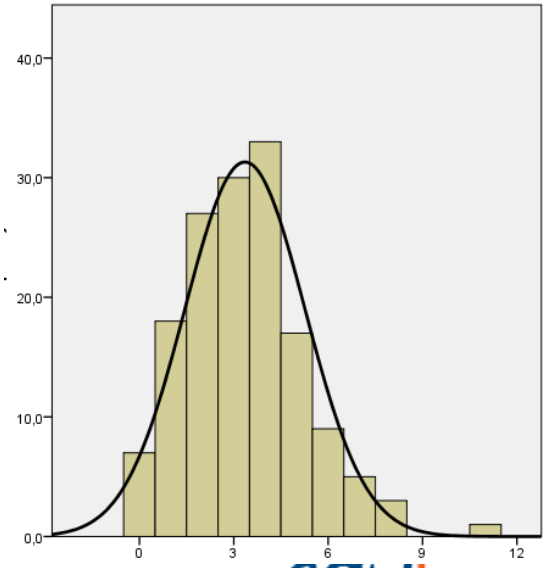
Determining normal distribution in SPSS

- Analyze → Descriptive Statistics → Explore → Plots





(Graphs > Chart Builder > Histogram)



Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
negativ	,134	150	,000	,951	150	,000

a. Lilliefors Significance Correction

Previously on ERM1: Normality testing

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
negativ	,134	150	,000	,951	150	,000

a. Lilliefors Significance Correction

Here, the Shapiro-Wilk test got a sig. value of 0.000, which means…?

The H0 of the Shapiro-Wilk test states that the data is normally distributed, therefore with a sig. = 0.000 we reject the H0.

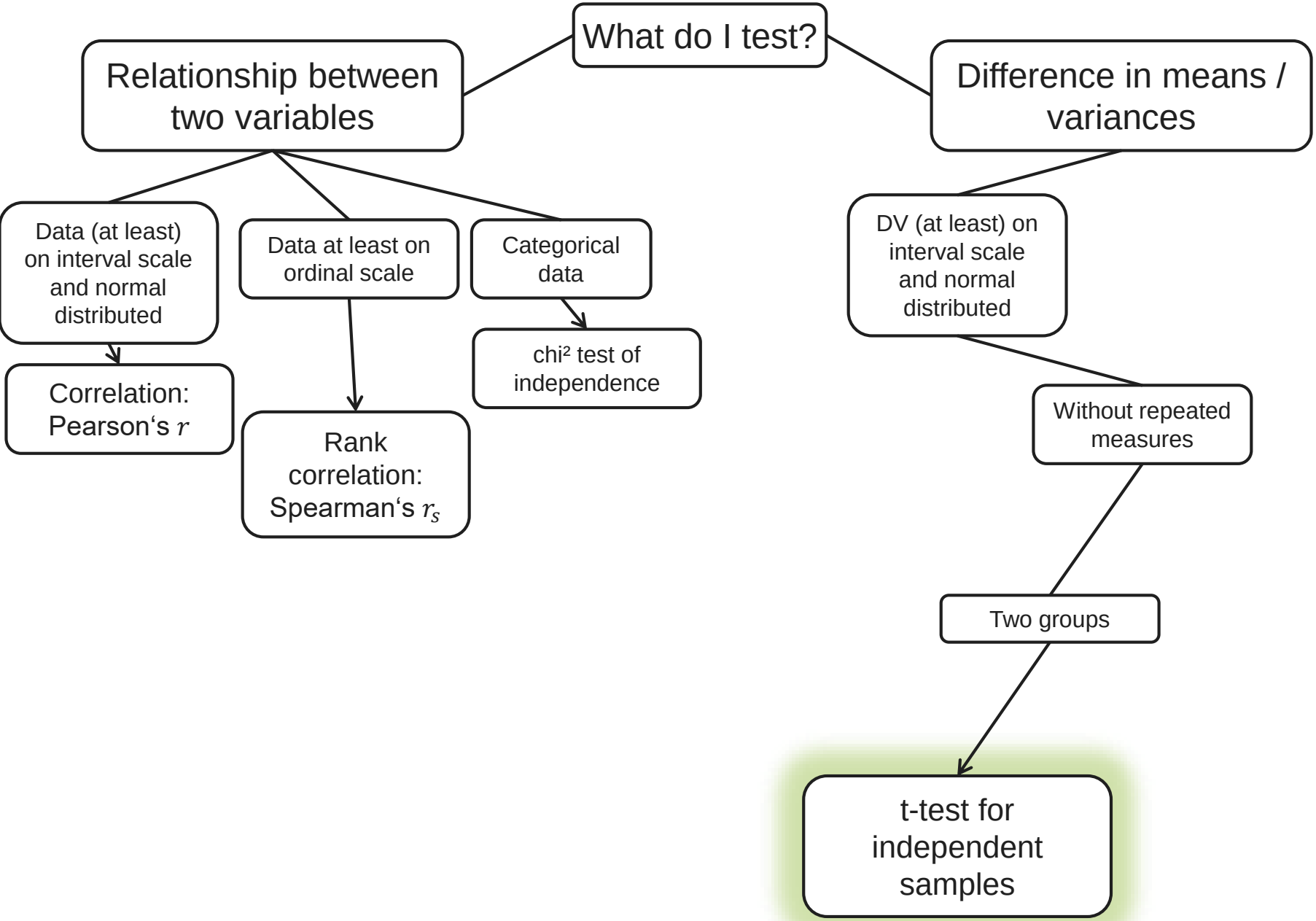
Therefore, our data is NOT normally distributed

Remember: 1) This is a normality test, 2) We don't always want to reject the H0

Previously on ERM1: Normality testing

According to the S-W test, the data is not normally distributed, what now?

- If $n \geq 30$: carry on
- If $n < 30$: do a data transformation (beware!) or use a non-parametric test (specially when other parametric assumptions are also violated)
- All in all: T and F families of tests are robust enough to handle non-normal distributions. Ideally, try to always have a $n \geq 30$


What do I test?
Relationship between two variables
Difference in means / variances
Data (at least) on interval scale and normal distributed
Data at least on ordinal scale
Categorical data
DV (at least) on interval scale and normal distributed
Correlation: Pearson‘s r
Rank correlation: Spearman‘s r_s
chi² test of independence
Without repeated measures
Two groups
t-test for independent samples

Degrees of Freedom and the t distribution

- df = degrees of freedom = How many values can I vary?
- “Degrees of freedom (df) of an estimate is the number of **independent pieces of information that went into calculating the estimate**. It’s not quite the same as the number of items in the sample. In order to get the df for the estimate, you have to subtract 1 from the number of items.” (Glen, n.d., para 1)
- “In statistics, the degrees of freedom (DF) indicate the **number of independent values that can vary** in an analysis without breaking any constraints.” (Frost, 2020, para. 1)
- “Degrees of freedom are often broadly defined as the **number of "observations"** (pieces of information) in the data that are **free to vary when estimating statistical parameters**.” (Minitab Blog Editor, 2016, para. 9)

Degrees of Freedom and the t distribution

- t distribution:
  - Similar shape as a normal distribution
  - Used when we compare 2 means but don't know a) the population standard deviation (σ) and/ or b) have a sample ≤ 30. (Either of these which happen very often!)
  - Thicker tails for accommodating more variation
  - Required: mean, variance and degrees of freedom

Degrees of Freedom and the t distribution

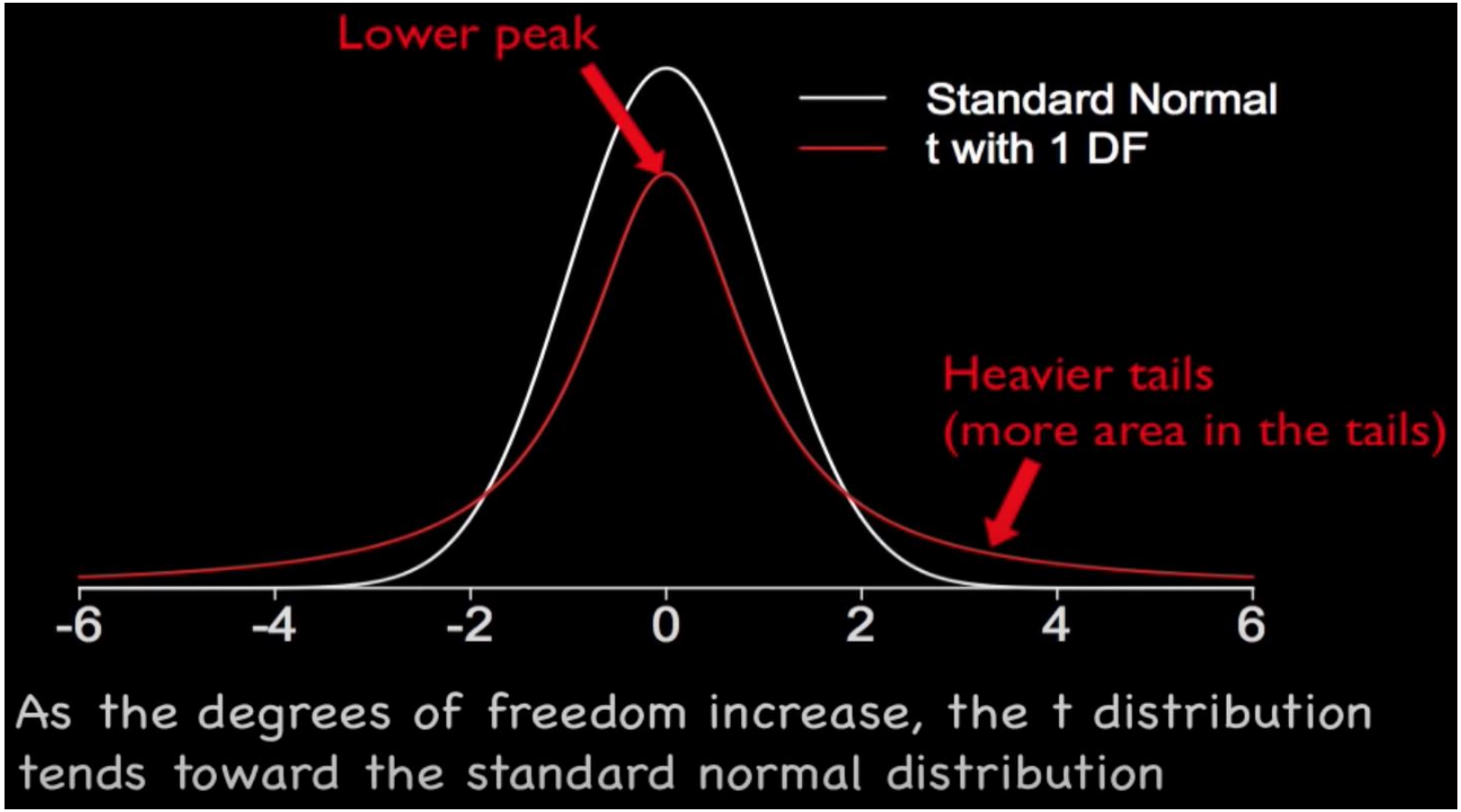


Image source: https://www.youtube.com/watch?v=Uv6nGIgZMVw

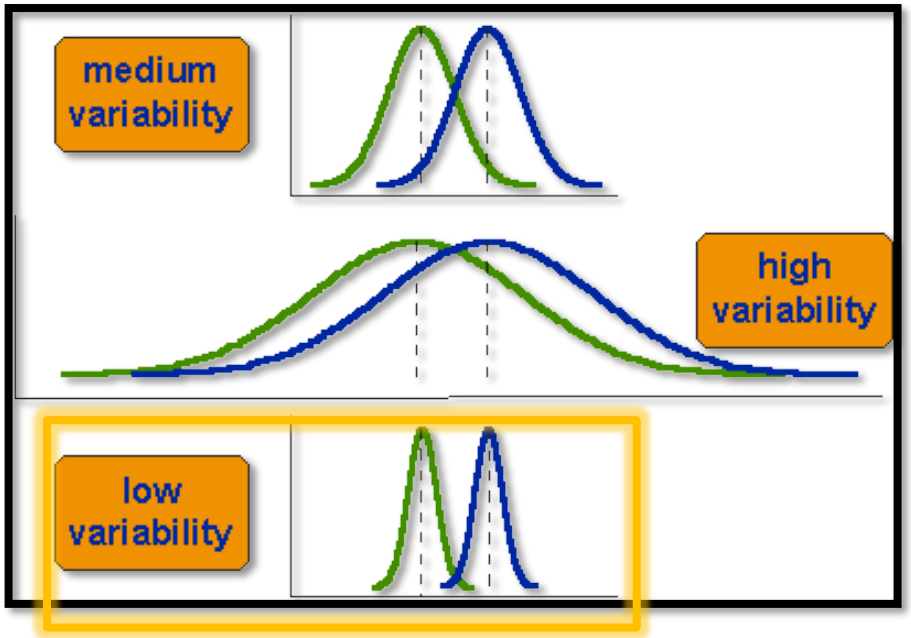
Student‘s t?

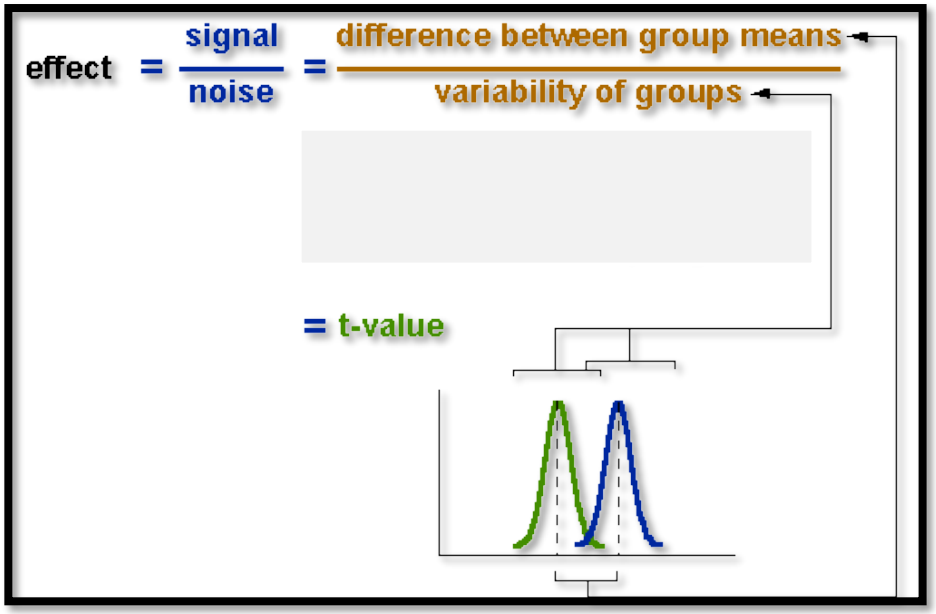
- Student’s t statistic, Student’s t distribution, Student’s t-test
- The t distribution is named after William Gosset who used the pseudonym “Student” for publishing
- Gosset worked for the Guiness brewery and was interested in applying statistics to develop better beers
- The t-test we use nowadays builds on his (and others’) work

t-value. What's it?

- Result from conducting a t-test → "provides" a p-value which is what we use to determine statistical significance
- Result of comparing 2 means relative to their variability → t-value formula is a ratio
- A t-test and its t-value will allow us to determine if, by comparing their means (relative to their variability ;-)), if **2 groups** are different

t-value. Signal and noise





Variability = spread

Same difference between the 2 means

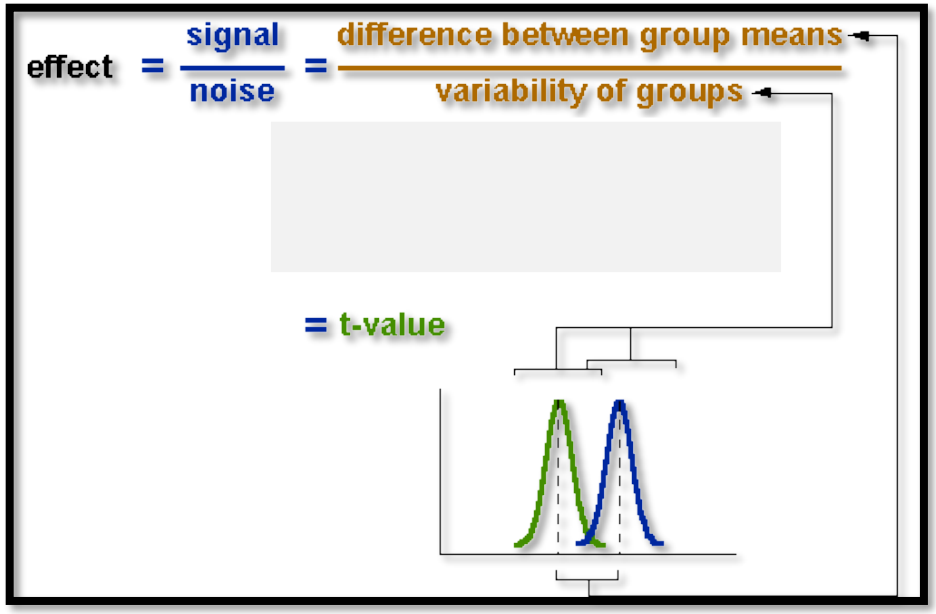
Effect = t-value

Numerator: the strength of the “signal”; the raw difference (or delta (Δ)) of the means ($\overline{x}$; μ)

Denominator: the surrounding noise, i.e. the variability, in the data

Images source: http://www.socialresearchmethods.net/kb/statsimp.php

t-value. The ratio of signal and noise



- The bigger the signal (i.e. the means Δ) and the smaller the noise (i.e. the variability), the more likely that the **groups** are significantly different

Images source: http://www.socialresearchmethods.net/kb/statsimp.php

t-value. Spooky math formulas

Type	T-statistic	Degrees of freedom
One-sample t-test	$t = \frac{m - \mu}{s/\sqrt{n}}$	$df = n - 1$
Paired t-test	$t = \frac{m}{s/\sqrt{n}}$	$df = n - 1$
Independent samples t-test	$t = \frac{m_A - m_B}{\sqrt{\frac{S^2}{n_A} + \frac{S^2}{n_B}}}$	$df = n_A + n_B - 2$

Formulas source: http://www.sthda.com/english/wiki/t-test-formula

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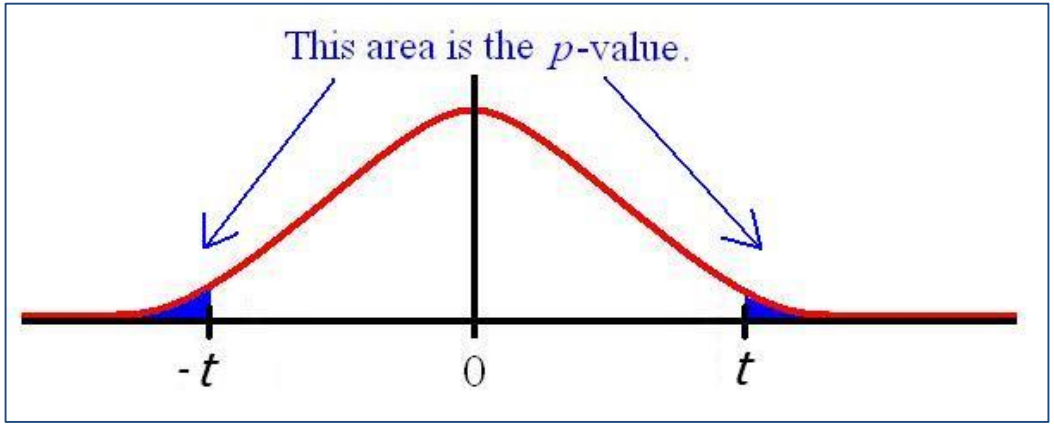
t-value. Final steps

- Set an α (e.g. 0.05) and determine the df to determine the critical t-value (t_{crit})
- Compare the t_{crit} with the t-value (t_{emp}) obtained from the formula
- If [$t_{emp} > t_{crit}$], then our t-value is “unlikely enough” and we reject H0



Student's t, t, t: Distribution, value, test. Recap

- T-Distribution: Similar as a standard normal distribution but with thicker tails to accommodate dispersion (a.k.a. uncertainty)
- T-Value: result of a t-test which will allow us to obtain a p-value and determine statistically significant results
- T-test: parametric test that compares the means of 2 groups to determine if the **groups** are different

t-test exercise 1

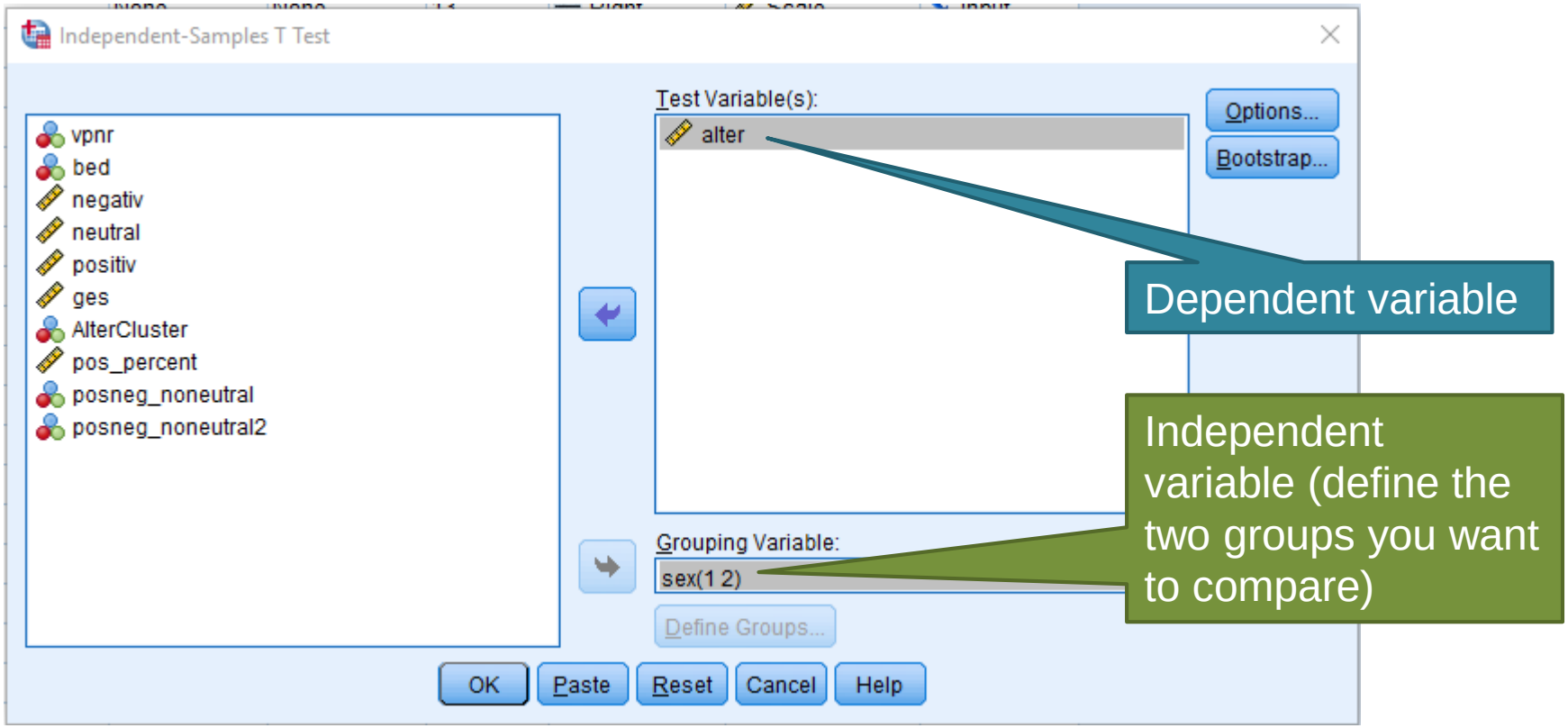
Using Beispieldatensatz(a.k.a. ExSh_9_Beispieldatensatz_A3), test the following hypothesis:

There is a difference in age depending on the gender.

I will do it live.

t-test exercise 1

Analyze > Compare means > Independent-samples t test



t-test exercise 1

DV

IV

Group Statistics

	sex	N	Mean	Std. Deviation	Std. Error Mean
alter	maennlich	52	22,54	2,477	,344
	weiblich	98	21,51	3,374	,341

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
alter	Equal variances assumed	,306	,581	1,937	148	,055	1,028	,531	-,021	2,077
	Equal variances not assumed			2,125	133,057	,035	1,028	,484	,071	1,985

Homogeneity of variances is given*

t-value / df / significance (p)

There was no sign. difference regarding age depending on participants‘ sex: t (148) = 1.937, p = .055

*If the Levene test becomes significant, the homogeneity is not given and you need to read the results from the row “equal variances not assumed“

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t-test exercise 2

Describe an experimental situation which would require an independent samples t-test and another which would require a one-sample t-test

Define, RQ (or QQ), H0 and H1, state if your H1 is directional or not, sample size

t-test exercise 3

Report the results:

Group Statistics

	AlterCluster	N	Mean	Std. Deviation	Std. Error Mean
pos_percent	up to 19 years	25	34,6838	9,23946	1,84789
	20-29 years	123	33,4802	16,90847	1,52459

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
pos_percent	Equal variances assumed	6,964	,009	,345	146	,731	1,20362	3,48908	-5,69201	8,09924
	Equal variances not assumed			,502	62,130	,617	1,20362	2,39563	-3,58499	5,99222

There was no sign. difference regarding “pos_percent” depending on participants‘ age cluster: t (62) = .502, p = .617

t-test exercise 4

Report the results:

Group Statistics

	bed	N	Mean	Std. Deviation	Std. Error Mean
ges	strukturell	50	7,20	3,162	,447
	emotional	50	12,02	4,206	,595

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
ges	Equal variances assumed	4,273	,041	-6,477	98	,000	-4,820	,744	-6,297	-3,343
	Equal variances not assumed			-6,477	90,979	,000	-4,820	,744	-6,298	-3,342

There was a sign. difference regarding “ges” depending on the experimental condition (strukturell vs. emotional): t (91) = -6.477, p = .000

t-test exercise 5

Report the results:

Group Statistics

	bed	N	Mean	Std. Deviation	Std. Error Mean
pos_percent	strukturell	50	36,0633	20,33905	2,87638
	emotional	50	35,4023	12,30672	1,74043

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
pos_percent	Equal variances assumed	8,148	,005	,197	98	,845	,66106	3,36194	-6,01060	7,33273
	Equal variances not assumed			,197	80,639	,845	,66106	3,36194	-6,02860	7,35073

There was no sign. difference regarding “pos_percent” depending on the experimental condition (strukturell vs. emotional): t (81) = .197, p = .845

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Stephanie Glen. (n.d.). *Degrees of Freedom: What are they?*. Retrieved from https://www.statisticshowto.com/probability-and-statistics/hypothesis-testing/degrees-of-freedom/

Further reads

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https://blog.minitab.com/blog/statistics-and-quality-data-analysis/what-is-a-t-test-and-why-is-it-like-telling-a-kid-to-clean-up-that-mess-in-the-kitchen

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https://statisticsbyjim.com/hypothesis-testing/t-tests-t-values-t-distributions-probabilities/

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https://www.youtube.com/watch?v=Uv6nGIgZMVw

Further reads

https://statisticsbyjim.com/hypothesis-testing/degrees-freedom-statistics/

https://support.minitab.com/en-us/minitab-express/1/help-and-how-to/basic-statistics/inference/supporting-topics/tests-of-means/types-of-t-tests/

https://blog.minitab.com/blog/statistics-and-quality-data-analysis/what-is-a-t-test-and-why-is-it-like-telling-a-kid-to-clean-up-that-mess-in-the-kitchen

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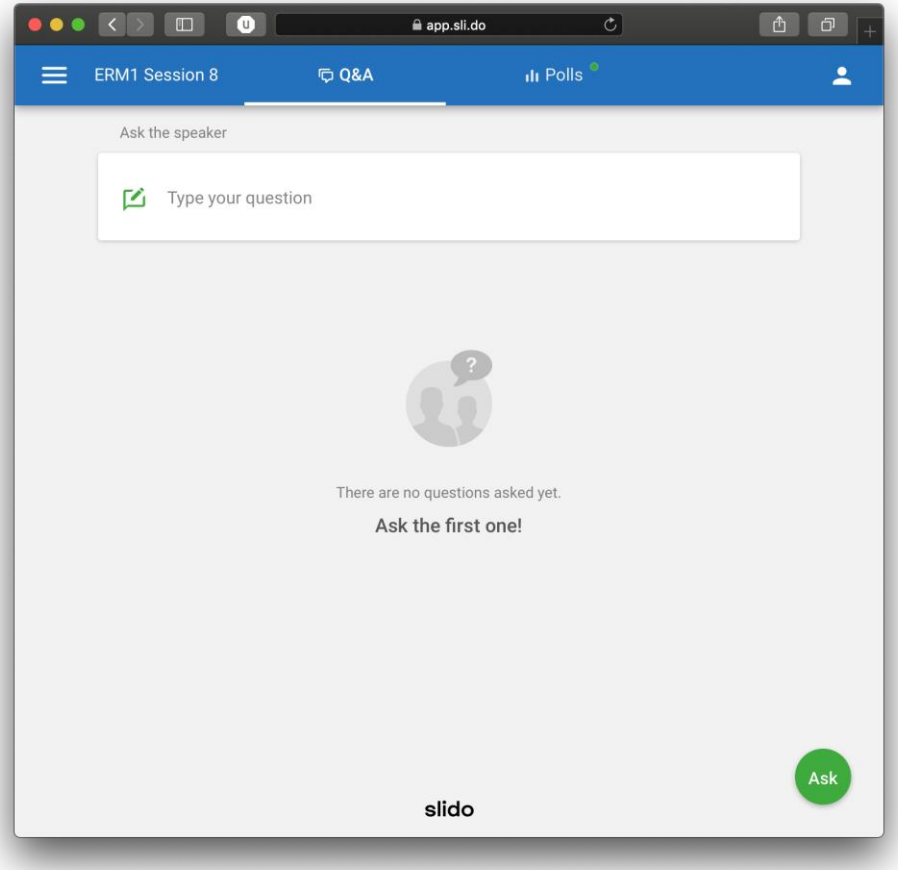
https://www.real-statistics.com/students-t-distribution/t-distribution-basic-concepts/

Q&A: today‘s topic; ERM1 in general



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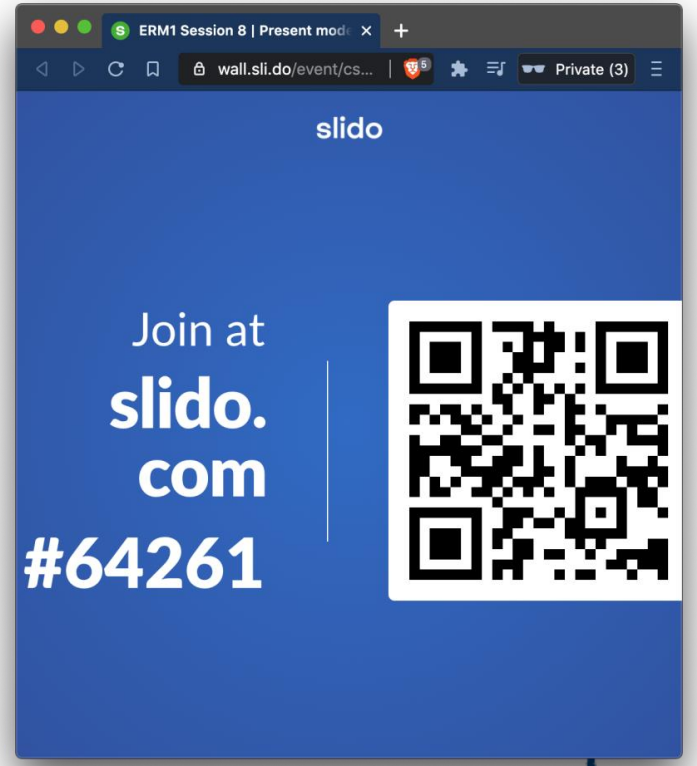

WEBCAMS ON FOR THE GOODBYE!