

# CH. 9 – 10 $t$ -tests

- RUNNING ANALYSES USING JAMOV
- INTERPRETTING OUTPUT
- USING APA STYLE

PY 221 Statistics & Research Methods I

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# Outline for Ch. 9-10 – t-tests

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1. Independent samples t-test (for between-subjects designs)
  - How to run this using JAMOV
  - How to *interpret* JAMOV output (translate #s into words)
  - How to write up results using APA style
  
2. Paired samples t-test (for within-subjects designs)
  - How to run this using JAMOV
  - How to interpret JAMOV output
  - How to write up results using APA style

# Research Q: Does wearing an invisibility cloak lead to more mischievous behavior than not wearing an invisibility cloak?

## within-subjects design

1. All Ps go about their day, record any mischievous behavior for 1 wk.
2. Give the same people invisibility cloaks and record mischievous behavior for 1 wk.
3. Compare mischievous behavior (DV) across the "no cloak" & "cloak" weeks (IV conditions).

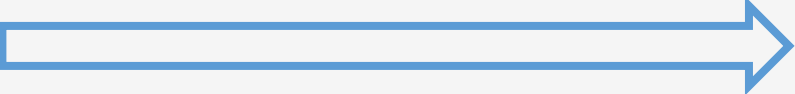
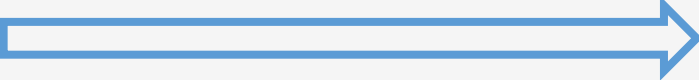
## between-subjects design

1. Give 1 group of Ps an invisibility cloak and a separate group of Ps no cloak.
2. Record mischievous behavior for all Ps across 1 wk.
3. Compare mischievous behavior (DV) across the "no cloak" & "cloak" groups (IV conditions).



# Two types of t-tests

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- **Within-subjects design**  **Paired samples t-test (repeated measures)**
  - The *same* entities are in *all* conditions
    - or entities are *paired* & complete the same measures
- **Between-subjects design**  **Independent samples t-test**
  - *Different* entities in each experimental condition
    - or different entities in each naturally-occurring group

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- How to interpret JAMOV output
- How to write up results using APA style

## 2. Paired samples t-test (for within-subjects designs)

- How to run this using JAMOV
- How to interpret JAMOV output
- How to write up results using APA style

# Independent samples t-test: Example study

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Research Question: Does wearing an invisibility cloak lead to more mischievous behavior than not wearing an invisibility cloak?

- 24 Participants, placed in an enclosed community with hidden cameras.
- Between-subjects manipulation (IV) - **whether or not wore cloak**
  - 12 Ps given an invisibility cloak.
  - 12 Ps not given an invisibility cloak.
- Outcome variable (DV) – **mischievous behavior**
  - measured how many mischievous acts Ps performed in a week

## 1. What is the null hypothesis?

There are no differences in mischievousness between those who wear and do not wear an invisibility cloak. (OR There is no effect of our cloak manipulation on mischievous behavior.)  $H_0: \mu_{\text{Cloak}} = \mu_{\text{NoCloak}}$

## 2. Let's set $\alpha = .05$

# Independent samples t-test: How to run in JAMOV

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## Layout of your data file












**Each participant will have data for two variables:**

- **1 variable for IV** (*Cloak* will be variable name).
  - Each P has either "No Cloak" or "Cloak" as their data
- **1 variable for DV** (*Mischief* will be variable name)
  - Captures the # of mischievous acts for each P

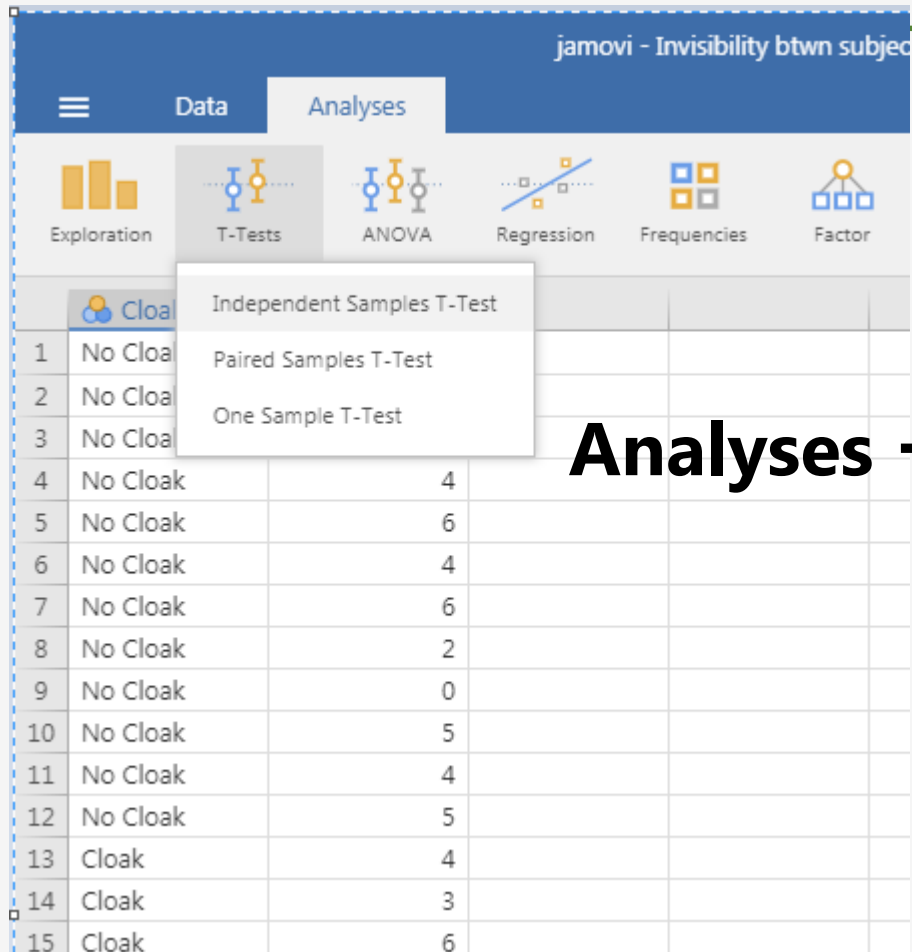
# Independent samples t-test: How to run in JAMOVİ

jamovi - Invisibility btwn subjects

	Data	Analyses
 Paste Clipboard	 Edit	 Setup  Compute  Transform Variables  Add  Delete
	 Cloak	 Mischief
1	No Cloak	3
2	No Cloak	1
3	No Cloak	5
4	No Cloak	4
5	No Cloak	6
6	No Cloak	4
7	No Cloak	6
8	No Cloak	2
9	No Cloak	0
10	No Cloak	5
11	No Cloak	4
12	No Cloak	5
13	Cloak	4
14	Cloak	3
15	Cloak	6
16	Cloak	6
17	Cloak	8
18	Cloak	5
19	Cloak	5
20	Cloak	4
21	Cloak	2
22	Cloak	5
23	Cloak	7
24	Cloak	5



# Independent samples t-test: How to run in JAMOV



The screenshot shows the JAMOVI software interface. The 'Data' tab is active, and the 'Analyses' menu is open. The 'Independent Samples T-Test' option is selected. The data table below shows two groups: 'No Cloak' and 'Cloak'.

	Cloak			
1	No Cloak			
2	No Cloak			
3	No Cloak			
4	No Cloak	4		
5	No Cloak	6		
6	No Cloak	4		
7	No Cloak	6		
8	No Cloak	2		
9	No Cloak	0		
10	No Cloak	5		
11	No Cloak	4		
12	No Cloak	5		
13	Cloak	4		
14	Cloak	3		
15	Cloak	6		

**Analyses → T-Tests → Independent Samples T-Test**

# Independent samples t-test: How to run in JAMOVI

Put outcome variable (DV) into  
"Dependent Variables" box.

Put predictor variable (IV) into  
"Grouping Variable" box.

Click the checkboxes for:

- Mean difference
  - Confidence interval 95%
- Effect size
- Descriptives

The screenshot shows the JAMOVI software interface with the 'Analyses' tab selected. The 'Independent Samples T-Test' dialog box is open. The 'Dependent Variables' box contains 'Mischief'. The 'Grouping Variable' box contains 'Cloak'. In the 'Tests' section, 'Student's' is selected. In the 'Additional Statistics' section, 'Mean difference', 'Confidence interval 95%', 'Effect size', and 'Descriptives' are all checked. The 'Hypothesis' section shows 'Group 1 ≠ Group 2' selected. The 'Missing values' section shows 'Exclude cases analysis by analysis' selected. The 'Assumption Checks' section has 'Homogeneity test', 'Normality test', and 'Q-Q plot' all unchecked. Red boxes highlight the 'Additional Statistics' and 'Descriptives' sections.

jamovi - Invisibility btwn subjects

Analyses

Exploration T-Tests ANOVA Regression Frequencies Factor

Independent Samples T-Test

Dependent Variables

Mischief

Grouping Variable

Cloak

Tests

☒ Student's

☐ Bayes factor

Prior 0.707

☐ Welch's

☐ Mann-Whitney U

Hypothesis

☒ Group 1 ≠ Group 2

☐ Group 1 > Group 2

☐ Group 1 < Group 2

Missing values

☒ Exclude cases analysis by analysis

☐ Exclude cases listwise

Additional Statistics

☒ Mean difference

☒ Confidence interval 95 %

☒ Effect size

☐ Confidence interval 95 %

☒ Descriptives

☐ Descriptives plots

Assumption Checks

☐ Homogeneity test

☐ Normality test

☐ Q-Q plot

# Outline for Ch. 9-10 – t-tests

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## 1. Independent samples t-test (for between-subjects designs)

- How to run this using JAMOV
- **How to interpret JAMOV output**
- How to write up results using APA style

## 2. Paired samples t-test (for within-subjects designs)

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# Independent samples t-test: How to interpret JAMOVl output

## Independent Samples T-Test

Independent Samples T-Test

							95% Confidence Interval		
							Lower	Upper	Cohen's d
Mischief	Student's t	-1.71	22.00	0.101	-1.25	0.73	-2.76	0.26	-0.70

Group Descriptives

		N	Mean	Median	SD	SE
Mischief	No Cloak	12	3.75	4.00	1.91	0.55
	Cloak	12	5.00	5.00	1.65	0.48

# Independent Samples T-Test: How to interpret output

## Independent Samples T-Test

test  
statistic,  $t$

degrees of freedom,  
needed for APA write-up

p-value associated with  
your test statistic

		Statistic		df	p	Mean difference	SE difference	95% Confidence Interval		Cohen's d
								Lower	Upper	
Mischief	Student's t	-1.71		22.00	0.101	-1.25	0.73	-2.76	0.26	-0.70

Recall – Null Hypothesis tested when using a t-test

There are no differences in mischievousness between those who wear and do not wear an invisibility cloak. (OR There is no effect of our cloak manipulation on mischievous behavior.)

$$H_0: \mu_{\text{Cloak}} = \mu_{\text{NoCloak}} \text{ OR } H_0: \mu_{\text{Cloak}} - \mu_{\text{NoCloak}} = 0$$

**Remember STEP 4 of NHST is to make the decision, by examining p-value, and comparing to  $\alpha = .05$ .**

*Is  $p < .05$ ? → Reject the null hypothesis (null *not* credible)*

*Is  $p \geq .05$ ? → Retain the null hypothesis (null is credible)*

# Independent samples t-test: How to interpret output

The difference in the mean # of mischievous acts, btwn the cloak & no-cloak groups (*aka*, the difference score)

CI surrounding the mean difference

Effect size (typically only reported if null is rejected)

Independent Samples T-Test

		Statistic	df	p	Mean difference	SE difference	95% Confidence Interval		Cohen's d
							Lower	Upper	
Mischief	Student's t	-1.71	22.00	0.101	-1.25	0.73	-2.76	0.26	-0.70

**Examine the 95% confidence interval (CI) for the mean difference.**

*If CI does not contain zero → reject null (mean difference is unlikely to be 0)*

*If CI contains zero → retain null (mean difference btwn groups may be 0)*

# Independent samples t-test: How to interpret output

## Step 4 of NHST – Make the decision

We *retain* the null hypothesis. We cannot conclude that there is an effect of wearing an invisibility cloak on mischievous behavior.

### Independent Samples T-Test

Independent Samples T-Test

$p = .101$ , which is  
> .05 (our alpha)  
→ retain null

Our 95% CI  
contains 0 → retain  
null hypothesis

		→ retain null					95% Confidence Interval		
		Statistic	df	p	Mean difference	SE difference	Lower	Upper	Cohen's d
Mischief	Student's t	-1.71	22.00	0.101	-1.25	0.73	-2.76	0.26	-0.70

*Recall* – Null Hypothesis: There is no effect of our cloak manipulation on mischievous behavior.  $H_0: \mu_{\text{Cloak}} = \mu_{\text{NoCloak}}$  OR  $H_0: \mu_{\text{Cloak}} - \mu_{\text{NoCloak}} = 0$

# Independent samples t-test: How to interpret output

Sample size per group/condition

Mean score on DV/outcome for Ps in one condition

SE for each condition/group of the predictor (IV).  
(We report these along w/the means...)

Group Descriptives

	Group	N	Mean	Median	SD	SE
Mischief	No Cloak	12	3.75	4.00	1.91	0.55
	Cloak	12	5.00	5.00	1.65	0.48

outcome variable (DV)

groups/conditions/levels of the predictor variable (IV)

Mean score on DV/outcome for Ps in other condition



# Independent samples t-test: How to interpret output

N = 12 Ps in no cloak cond.  
N = 12 Ps in cloak condition

Mean # of mischievous  
acts performed by Ps  
NOT wearing cloak

## Group Descriptives

	Group	N	Mean	Median	SD	SE
Mischief	No Cloak	12	3.75	4.00	1.91	0.55
	Cloak	12	5.00	5.00	1.65	0.48

DV = # of  
mischievous  
acts

IV = whether or not  
cloak is worn

Mean # of mischievous  
acts performed by Ps  
wearing cloak

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# Writing up results of independent t-tests using APA style

While on average, participants given a cloak of invisibility appeared to engage in more acts of mischief ( $M = 5.00$ ,  $SE = 0.48$ ) than those not given a cloak ( $M = 3.75$ ,  $SE = 0.55$ ), this difference was not significant,  $t(22) = -1.71$ ,  $p = .10$ , 95% CI [-2.76, 0.26].

If there was a significant difference between the groups, you'd add a statement about effect size (Cohen's  $d$ ).

riptives

Group	N	Mean	Median	SD	SE
No Cloak	12	3.75	4.00	1.91	0.55
Cloak	12	5.00	5.00	1.65	0.48

Independent Samples T-Test

							95% Confidence Interval		Cohen's d
		Statistic	df	p	Mean difference	SE difference	Lower	Upper	
Mischief	Student's t	-1.71	22.00	0.101	-1.25	0.73	-2.76	0.26	-0.70

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2. **Paired samples t-test (for within-subjects designs)**
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  - How to interpret JAMOV output
  - How to write up results using APA style

# Paired samples t-test: Example study

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Research Question: Are invisible people mischievous?

- 12 Participants
- Placed participants in an enclosed community with hidden cameras.
- Within-subjects manipulation (IV) – **whether or not wore cloak**
  - For 1<sup>st</sup> week, Ps' were not given any sort of cloak.
  - For 2<sup>nd</sup> week, all Ps were given an invisibility cloak.
- Outcome (DV) – **mischievous behavior**
  - measured how many mischievous acts Ps performed when wearing cloak and when not wearing cloak

## 1. What is the null hypothesis?

There is no effect of our cloak manipulation on mischievous behavior.

$$H_0: \mu_{\text{Cloak}} = \mu_{\text{NoCloak}} \text{ OR } H_0: \mu_{\text{Cloak}} - \mu_{\text{NoCloak}} = 0$$

## 2. Let's set our significance level, $\alpha$ , at .05.

# Paired samples t-test: How to run in JAMOVI

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## Layout of your data file

**Each participant will have data for two variables:**

- 1 variable that captures the # of mischievous acts the P committed the week that the P ***was not wearing a cloak*** (*No\_Cloak* will be variable name.)
- 1 variable that captures the # of mischievous acts the P committed the week that the P ***was wearing a cloak*** (*Cloak* will be variable name.)

### ***Recall* INDEPENDENT SAMPLES T-TEST**

**Each participant will have data for two variables:**

1 variable for IV.

Each P had cloak or no cloak as data

1 variable for DV

Captures the # of mischievous acts for each P

# Paired samples t-test: How to run

jamovi - Invisibility

Data Analyses

Paste Clipboard Edit Setup Compute Transform Variables Add Delete Filters Rows Add Delete

	No_Cloak	Cloak				
1	3	4				
2	1	3				
3	5	6				
4	4	6				
5	6	8				
6	4	5				
7	6	5				
8	2	4				
9	0	2				
10	5	5				
11	4	7				
12	5	5				

Data format for within-subjects design  
(You have *pairs* of scores for each P.)

jamovi - Invisibility btwn subjects

Data Analyses

Data format for between-subjects design

Paste Clipboard Edit Setup Compute Transform Variables Add Delete

	Cloak	Mischief				
1	No Cloak	3				
2	No Cloak	1				
3	No Cloak	5				
4	No Cloak	4				
5	No Cloak	6				
6	No Cloak	4				
7	No Cloak	6				
8	No Cloak	2				
9	No Cloak	0				
10	No Cloak	5				
11	No Cloak	4				
12	No Cloak	5				
13	Cloak	4				
14	Cloak	3				
15	Cloak	6				
16	Cloak	6				
17	Cloak	8				
18	Cloak	5				
19	Cloak	5				
20	Cloak	4				
21	Cloak	2				
22	Cloak	5				
23	Cloak	7				
24	Cloak	5				

# Paired samples t-test: How to run in JAMOVI

The screenshot shows the JAMOVI software interface. The 'Analyses' tab is selected, and the 'T-Tests' icon is highlighted. A dropdown menu is open, showing three options: 'Independent Samples T-Test', 'Paired Samples T-Test', and 'One Sample T-Test'. The 'Paired Samples T-Test' option is highlighted. Below the menu, a data table is visible with 12 rows and 3 columns. The first column contains row numbers 1 through 12. The second column contains values: 4, 6, 4, 6, 2, 0, 5, 4, 5. The third column contains values: 6, 8, 5, 5, 4, 2, 5, 7, 5.

1		
2		
3		
4	4	6
5	6	8
6	4	5
7	6	5
8	2	4
9	0	2
10	5	5
11	4	7
12	5	5

**Analyses → T-Tests → Paired-Samples T-Test**



# Paired samples t-test: How to run in JAMOVI

Click your two variables over into the top row of the Paired Variables box, side by side.

Click the checkboxes for:

- Mean difference
  - Confidence interval 95%
- Effect size
- Descriptives

The screenshot shows the JAMOVI software interface with the 'Analyses' tab selected. The 'Paired Samples T-Test' dialog box is open. In the 'Paired Variables' section, 'No\_Cloak' and 'Cloak' are listed side-by-side. The 'Tests' section has 'Student's' checked, with a 'Prior' value of 0.707. The 'Hypothesis' section has 'Measure 1 ≠ Measure 2' selected. The 'Missing values' section has 'Exclude cases analysis by analysis' selected. The 'Additional Statistics' section, highlighted with a red box, has 'Mean difference', 'Confidence interval' (set to 95%), 'Effect size', and 'Descriptives' (also highlighted with a red box) all checked. The 'Assumption Checks' section has 'Normality test' and 'Q-Q Plot' unchecked.

Paired Samples T-Test

Paired Variables

No\_Cloak Cloak

Tests

☒ Student's  
☐ Bayes factor  
Prior 0.707  
☐ Wilcoxon rank

Hypothesis

☒ Measure 1 ≠ Measure 2  
☐ Measure 1 > Measure 2  
☐ Measure 1 < Measure 2

Missing values

☒ Exclude cases analysis by analysis  
☐ Exclude cases listwise

Additional Statistics

☒ Mean difference  
☒ Confidence interval 95 %  
☒ Effect size  
☐ Confidence interval 95 %  
☒ Descriptives  
☐ Descriptives plots

Assumption Checks

☐ Normality test  
☐ Q-Q Plot

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2. **Paired samples t-test (for within-subjects designs)**
  - How to run this using JAMOV
  - **How to interpret JAMOV output**
  - How to write up results using APA style

# Paired samples t-test: How to interpret output

## Paired Samples T-Test

*Recall* – Null hypothesis: There is no effect of our cloak manipulation on mischievous behavior.  $H_0: \mu_{\text{Cloak}} - \mu_{\text{NoCloak}} = 0$

Paired Samples T-Test

Paired Samples T-Test										
								95% Confidence Interval		
		statistic	df	p	Mean difference	SE difference	Lower	Upper	Cohen's d	
No_Cloak	Cloak	Student's t	-3.80	11.00	0.003	-1.25	0.33	-1.97	-0.53	-1.10

Descriptives

	N	Mean	Median	SD	SE
No_Cloak	12	3.75	4.00	1.91	0.55
Cloak	12	5.00	5.00	1.65	0.48

### Step 4 – Make the decision.

**Examine p-value, and compare to  $\alpha = .05$ .**

*Is  $p < .05$ ? → Reject the null hypothesis*

*Is  $p \geq .05$ ? → Retain the null hypothesis*

**Examine CI for the mean difference.**

*If CI does not contain zero → reject null*

*If CI contains zero → retain null*

# Independent samples t-test: How to interpret output

## Step 4 of NHST – Make the decision

We *reject* the null hypothesis. We conclude that there *is* an effect of wearing an invisibility cloak on mischievous behavior.

### Paired Samples T-Test

Paired Samples T-Test

$p = .003$ , which is  
< .05 (our alpha)  
→ reject null

Our 95% CI  
does not  
contain 0 →  
reject null.

							95% Confidence Interval			
			statistic	df	p	Mean difference	SE difference	Lower	Upper	Cohen's d
No_Cloak	Cloak	Student's t	-3.80	11.00	0.003	-1.25	0.33	-1.97	-0.53	-1.10

*Recall* – Null hypothesis: There is no effect of our cloak manipulation on mischievous behavior.  $H_0: \mu_{\text{Cloak}} - \mu_{\text{NoCloak}} = 0$

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2. **Paired samples t-test (for within-subjects designs)**
  - How to run this using JAMOV
  - How to interpret JAMOV output
  - **How to write up results using APA style**

# Writing up results of paired t-tests using APA style

On average, when people wore a cloak of invisibility, they engaged in significantly more acts of mischief ( $M = 5.00$ ,  $SE = 0.48$ ), than when they did not wear a cloak ( $M = 3.75$ ,  $SE = 0.55$ ),  $t(11) = -3.80$ ,  $p = .003$ , 95% CI [-1.97, -0.53]. This difference represented a large effect,  $d = 1.10$ .

## Paired Samples T-Test

### Paired Samples T-Test

							95% Confidence Interval			
			statistic	df	p	Mean difference	SE difference	Lower	Upper	Cohen's d
No_Cloak	Cloak	Student's t	-3.80	11.00	0.003	-1.25	0.33	-1.97	-0.53	-1.10

### Descriptives

	N	Mean	Median	SD	SE
No_Cloak	12	3.75	4.00	1.91	0.55
Cloak	12	5.00	5.00	1.65	0.48