Module 6: *t* Tests

The Applied Research Center

Module 6 Overview

- Types of *t* Tests
  - One Sample *t* Test
  - Independent Samples *t* Test
  - Paired Samples *t* Test
- Examples

t-Tests

- Used for inferences concerning one or two means
- 3 main types:
  - One-sample t-test
  - Independent samples t-test
  - Paired samples t-test

One Sample t-Test

- Used to test whether the mean of single variable differs from a specified constant.
- Example
  - A researcher wants to test whether the average IQ score of a group of students differs from 100.
  - A stats professor wants to determine whether the average grade on Assignment 1 differs significantly from 23 (an A average).

One Sample t-Test

- Step 1: State the Null and Alternate Hypotheses
- Ho = The average grade on Assignment 1 is equal to 23.
- Ha = The average grade on Assignment 1 is not equal to 23.
- Is this a directional or nondirectional Ha?

One Sample t-Test (cont'd)

- Step 2: Input each student's grade into SPSS
- Step 3: Run the Analysis.
  - Analyze → Compare Means → One Sample T-test
  - Test variable = assign1
  - Test value = 23
  - Click OK

One Sample t-Test (cont'd)

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
assign1	15	21.0333	1.54072	.39781

One-Sample Test

	Test Value = 23					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
assign1	-4.944	14	.000	-1.96667	-2.8199	-1.1134

One Sample t-Test (cont' d)

- Step 4: Make a decision regarding the null
  - M = 21.03, SD = 1.54
  - t (14*) = -4.944
  - p < .001

- What is the decision regarding the null?

- *14 = df = n-1 = 15-1 = 14

One Sample t-Test (cont' d)

- Using the level of significance = .05, do we reject or fail to reject the null?
  - If $p < .05$, we reject the null
  - if $p > .05$, we fail to reject the null
- According to SPSS, $p < .001$
- $.001 < .05$, therefore, we reject the null!

One Sample t-Test (cont' d)

- Step 5: Write up your results.

- The null hypothesis stated that the average grade on Assignment 1 is equal to 23. A one sample t-test revealed that the average grade on Assignment 1 (M = 21.03, SD = 1.54) differed significantly from 23, t (14) = -4.944, p < .001. Consequently, the null hypothesis was rejected.

Independent t-Test

- The independent samples t-test is used to test comparative research questions
- That is, it tests for differences in two group means or compares means for two groups of cases.

Independent t-Test (cont' d)

- Example:

- Suppose the stats professor wanted to determine whether the average score on Assignment 1 in one stats class differed significantly from the average score on Assignment 1 in her second stats class.

Independent t-Test

- Step 1: State the Null and Alternate Hypotheses
- Ho = There is no difference between class 1 and class 2 on Assignment 1.
- Ha = There is a difference between class 1 and class 2 on Assignment 1.
- Is this a directional or nondirectional Ha?

Independent t-Test (cont'd)

- Step 2: Input each student's grade into SPSS, along with which class they are in

Grade	Class
20.00	1.00
20.50	1.00
21.00	1.00
20.50	1.00
20.00	1.00
24.50	2.00
23.50	2.00
20.00	2.00
20.00	2.00

Independent t-Test (cont' d)

- Step 3: Run the Analysis.
  - Analyze → Compare Means → Independent Samples T-test
  - Test variable = assign1
  - Grouping variable = class
  - Define Groups:
    - Type "1" next to Group 1
    - Type "2" next to Group 2
    - Click Continue
  - Click OK

Independent t-Test (cont'd)

Group Statistics

	class	N	Mean	Std. Deviation	Std. Error Mean
assign1	1.00	14	21.1786	1.48851	.39782
	2.00	13	21.9038	1.93525	.53674

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
assign1	Equal variances assumed	4.519	.044	-1.096	25	.283	-.72527	.66152	-2.08771	.637
	Equal variances not assumed			-1.086	22.530	.289	-.72527	.66810	-2.10894	.658

Independent t-Test (cont' d)

- Step 4: Make a decision regarding the null
  - Class 1 (M = 21.18, SD = 1.49)
  - Class 2 (M = 21.90, SD = 1.94)

- Which row do we look at on the output?

Independent t-Test (cont'd)

- Step 5: Levene's Test for equal variances
  - Ho = The variances of the two variables are equal.
  - Ha = The variances of the two variables are not equal.

		Levene's Test for Equality of Variances	
		F	Sig.
assign1	Equal variances assumed	4.519	.044
	Equal variances not assumed		

$p = .044$, which is <.05; Therefore, we reject the null and do not assume equal variances!

Independent t-Test (cont' d)

- Looking at the Equal variances not assumed row (the bottom row)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for		
		F	Sig.	t	df	Sig. (2-tailed)
assign1	Equal variances assumed	4.519	.044	-1.096	25	.283
	Equal variances not assumed			-1.086	22.530	.289

Independent t-Test (cont' d)

- Make a decision regarding the null
  - t (22.5) = -1.086
  - p = .289

- Using the level of significance = .05, do we reject or fail to reject the null?

Independent t-Test (cont' d)

- Remember
  - If $p < .05$, we reject the null
  - if $p > .05$, we fail to reject the null

- According to SPSS, $p = .289$

- $.289 > .05$, therefore, we fail to reject the null!!

Independent t-Test (cont' d)

- Step 5: Write up your results.

- The null hypothesis stated that there is no difference between class 1 and class 2 on Assignment 1. An independent samples t-test revealed that the average grades on Assignment 1 did not differ significantly from Class 1
(M = 21.18, SD = 1.49) to Class 2 (M = 21.90, SD = 1.94), t (22.5) = -1.086, p = .289. Consequently, the researcher failed to reject the null hypothesis.

Paired Samples t-Test

- Used to compare the means of two variables for a single group.
- The procedure computes the differences between values of the two variables for each case and tests whether the average differs from 0.

Paired Samples t-Test

- Example
  - A researcher wanted to know the effects of a reading program. The researcher gave the students a pretest, implemented the reading program, then gave the students a post test.

Paired Samples t-Test

- Step 1: State the Null and Alternate Hypotheses
- Ho = There is no difference in students' performance between the pretest and the posttest.
- Ha = Students will perform better on the posttest than on the pretest.
- Is this a directional or nondirectional Ha?

NOTE for One-tailed Tests!!

- Remember when we have a directional hypothesis, we conduct a one-tailed test.
- When we have a non-directional hypothesis, we conduct a two-tailed test.
- SPSS (unless given the choice) automatically runs a 2-tailed test, IF you have a directional alternate hypothesis (and a 2-tailed test was run), you MUST divide the p-value by 2 to obtain the correct p-value!

Paired Samples t-Test

- Step 2: Set up data

Pre	Post
20.00	25.00
21.00	24.00
19.00	23.00
18.00	22.00
20.00	24.00
21.00	25.00

Paired Samples *t*-Test

- Step 3: Analyze the Results
- Analyze → Compare Means → Paired Samples t-Test
- Paired variables: pre--post

Paired Samples *t*-Test (cont'd)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	pre	19.8333	6	1.16905	.47726
	post	23.8333	6	1.16905	.47726

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	pre - post	-4.00000	.63246	.25820	-4.66372	-3.33628	-15.492	5	.000

Paired Samples *t*-Test (cont'd)

- Step 4: Make a decision regarding the null
  - Pretest (M = 19.83, SD = 1.17)
  - Posttest (M = 23.83, SD = 1.17)
  - t (5) = -15.49
  - p < .001 (two-tailed)

- What is the decision regarding the null?

Paired Samples *t*-Test (cont'd)

- We have a directional alternate, therefore we have to divide the p-value by 2.

Paired Samples Test

red Differences					
	95% Confidence Interval of the Difference				
Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
.25820	-4.66372	-3.33628	-15.492	5	.000

Paired Samples *t*-Test (cont'd)

- .000/2 = 0
- $p < .001$
- What is the decision regarding the null?

Paired Samples *t*-Test (cont'd)

- Using the level of significance = .05, do we reject or fail to reject the null?
  - If p < .05, we reject the null
  - if p > .05, we fail to reject the null
- According to SPSS, $p < .001$
- .001 < .05, therefore, we reject the null!

Paired Samples *t*-Test (cont'd)

- Step 5: Write up your results.

- The null hypothesis stated that there is no difference in students' performance between the pretest and the posttest. A paired samples t-test revealed that students scored significantly higher on the posttest ($M = 23.83$, $SD = 1.17$) than they did on the pretest ($M = 19.83$, $SD = 1.17$), $t\ (5) = -15.49$, $p < .001$. Consequently, the null hypothesis was rejected.

Directional Hypothesis Example

- Suppose:
  - H_a = Class 1 will score higher on Assignment 3 than Class 2.
  - → Must be based on literature (or prior data/test scores).
- Run everything the same, only difference is final p-value!
- According to SPSS, p = .289/2=.145
- → still fail to reject the null!

Another Example

- If H_a = Class 1 will score higher on Assignment 3 than Class 2.
- And SPSS reported a p-value of .08. When.08/2 = .04, which IS significant; in this case, we would reject the null!

Module 6 Summary

- Types of *t* Tests
  - One Sample *t* Test
  - Independent Samples *t* Test
  - Paired Samples *t* Test
- Examples

Review Activity

- Please complete the review activity at the end of the module.
- All modules build on one another. Therefore, in order to move onto the next module you must successfully complete the review activity before moving on to next module.
- You can complete the review activity and module as many times as you like.

Upcoming Modules

- Module 1: Introduction to Statistics
- Module 2: Introduction to SPSS
- Module 3: Descriptive Statistics
- Module 4: Inferential Statistics
- Module 5: Correlation
- Module 6: *t*-Tests
- Module 7: ANOVAs
- Module 8: Linear Regression
- Module 9: Nonparametric Procedures