

JMP INTRO® Lab Activities

Lab Activity – Hypothesis Testing – Matched Pairs t -test

Data Set: THERM.jmp

A health care center recently purchased a new eardrum probe thermometer, which provides an easier way to measure patients' temperatures than the standard oral mercury thermometer. The nurses suspected, however, that the new device gave readings that were consistently higher than with the old method. To test this, readings were taken on some patients twice, once with the eardrum probe and the other with the oral thermometer. The patients were chosen randomly from the population of patients who visit the health care center.

Open JMP INTRO, and from the **JMP Starter** menu, select **Open Data Table**. Open the THERM.jmp file. Readings taken with the standard oral thermometer are recorded in the **Oral** column, and readings taken with the new eardrum probe thermometer are recorded in the **Tympanic** column. Choose **Analyze** ® **Distribution** using both **Oral** and **Tympanic** as the **Y,Columns** variables. To compare the two distributions more easily, you can select **Uniform Scaling** from the red triangle menu of **Distributions** in the pop-up window.

Create a new column to represent the difference between the two temperature measurements. Label the column **Difference**. To calculate the differences in JMP INTRO, select the **Difference** column by clicking on the column heading. Then, from the menu bar, choose **Cols** ® **Formula**. In the pop-up window, click on the variable name **Tympanic**, then **-**, then the variable name **Oral**. This enters the formula for the difference. Click **OK**. Look at the distribution of the differences to see if the conditions for using the t test are reasonable by choosing **Analyze** ® **Distribution** for the new variable **Difference**. Conduct a hypothesis test on the differences by selecting **Test Mean** from the red triangle menu for **Differences**. Enter the correct hypothesized mean for the hypothesis of interest.

Using your results from JMP INTRO, carry out a complete hypothesis test using one of the commonly used significance levels. Include assumptions, hypotheses, sample statistic values, test statistic and p-value, and conclusions in the context of the problem. Include a discussion of why a matched pairs design was appropriate for this problem. Include graphical displays for temperatures for both types of thermometers and for the difference in temperatures. Include JMP INTRO output for the hypothesis test results, with the correct p-value circled. Explain how you chose the proper p-value for this test.

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Teacher Notes

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Data Set: THERM.jmp

Objectives:

- Gain familiarity with some of the basic operational tools of JMP INTRO.
- Use JMP INTRO to conduct a hypothesis test for a comparison of two means for dependent samples (matched pairs).
- Create a word processing document, incorporating displays from JMP INTRO.

Time Required: 30 minutes

Materials:

- Hypothesis Testing – Matched Pairs t -test student activity directions
- THERM.jmp data set

Note 1: THERM.jmp is a data set that is not included in the Sample Data folder for JMP INTRO. This data set can, however, be downloaded from SAS. Refer to the Teacher Notes from Hypothesis Testing – Two-Sample t -test for information on how to retrieve these data files.

Note 2: The THERM.jmp data set already has a column for the differences in temperature readings between the two types of thermometers. Eliminate this column from the data set, and resave with the same name or a different name for student use.

Prerequisites:

- Students should have basic knowledge of how to use JMP INTRO.
- Students should have experience conducting tests of hypothesis by hand and/or with graphing calculators for a matched pairs design.
- Students should have experience writing conclusions in the context of the problem for hypothesis tests.

JMP INTRO Notes:

- JMP INTRO includes an extensive online help system. It contains a table of contents and/or can be used to search for a specific topic. In addition, JMP INTRO has context sensitive help. You can access it by selecting the help tool (?) from the tools toolbar and clicking inside a data table or report. JMP INTRO opens help specific to the clicked-on item.
- To enter the formula for the differences column, students on PC compatible computers may alternately right click on the **Difference** column header and choose **Formula**. The formula would be entered in the same manner.

- JMP-INTRO also features a “Matched Pairs” analysis. To use this analysis, rather than create a **Difference** column, go to **Analyze** ® **Matched Pairs**. Both **Oral** and **Tympanic** should be entered as **Y, Paired Response** variables. The resulting display should provide the same results for the matched pairs test described in the student activity.

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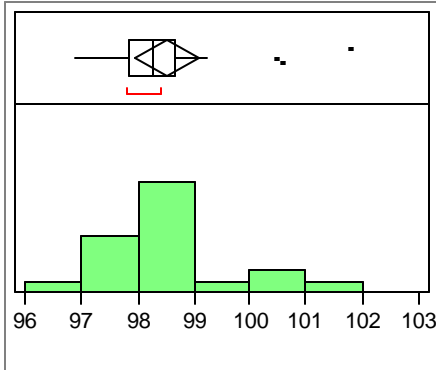
Answer Key

The following are suggested answers for Hypothesis Testing – Matched Pairs *t*-test.

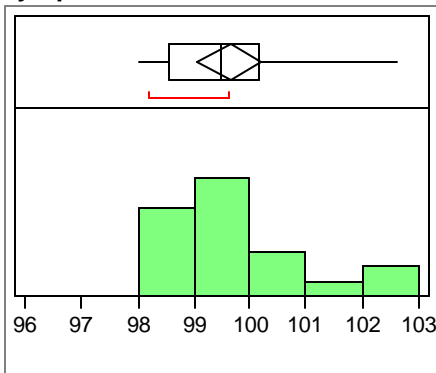
Graphical Displays of Temperatures for Both Types of Thermometers:

Distributions

Oral



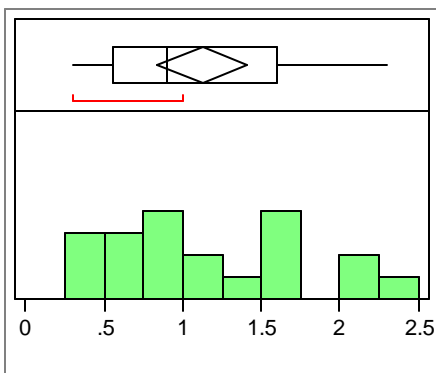
Tympanic



Graphical Display of the Differences in Temperatures:

Distributions

Differences



Summary Statistics for the Difference in Temperatures:

Quantiles

100.0%	maximum	2.3000
99.5%		2.3000
97.5%		2.3000
90.0%		2.1800
75.0%	quartile	1.6000
50.0%	median	0.9000
25.0%	quartile	0.5500
10.0%		0.4000
2.5%		0.3000
0.5%		0.3000
0.0%	minimum	0.3000

Moments

Mean	1.12
Std Dev	0.6237408
Std Err Mean	0.1394727
upper 95% Mean	1.4119197
lower 95% Mean	0.8280803
N	20

Hypothesis Test Results:

Test Mean=value

Hypothesized Value	0
Actual Estimate	1.12
df	19
Std Dev	0.62374

	t Test
Test Statistic	8.0302
Prob > t	<.0001
Prob > t	<.0001
Prob < t	1.0000

The circled p-value was chosen because we had a one-sided greater than alternative hypothesis.

A matched pairs design is appropriate for this test because we do not have two independent samples of temperatures for the two thermometers.

Assumptions: We have a random sample of patients. Although the distribution of the temperature differences appears to be slightly skewed right, there are no outliers in the distribution. With a sample of size 20, it is reasonable to use the *t* procedure.

Hypotheses: $H_o : m_b = 0$ The two thermometers produce equivalent temperature readings. (The difference between the temperature readings of the two thermometers is zero.)

$H_a : m_b > 0$ The new eardrum thermometer produces temperature readings higher than the oral thermometer.

Test Mechanics:
$$t = \frac{\bar{x}_D}{\frac{s}{\sqrt{n}}} = \frac{1.12}{\frac{0.62374}{\sqrt{20}}} = 8.03$$

$$p < 0.0001$$

Conclusion: At the $\alpha = 0.05$ level, because $p < 0.0001 < 0.05$, we can reject the null hypothesis. We have evidence that the new eardrum probe thermometer produces temperature readings that are higher than the standard oral mercury thermometer on average.