***EXAMPLE 2*** **An Outlier's Effect**

Our bodies have a natural electrical field that is known to help heal wounds. Does changing the field strength slow healing? A series of experiments with newts investigated this question. In one experiment, the two hind limbs of 12 newts were assigned at random to either experimental or control groups. The electrical field in the experimental limbs was reduced to zero by applying a voltage. The control limbs were left alone. Here are the rates at which new cells closed a razor cut in each limb, in micrometers per hour.

| Newt | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Control Limb | 36 | 41 | 39 | 42 | 44 | 39 | 39 | 56 | 33 | 20 | 49 | 30 |
| Experimental Limb | 28 | 31 | 27 | 33 | 33 | 38 | 45 | 25 | 28 | 33 | 47 | 23 |

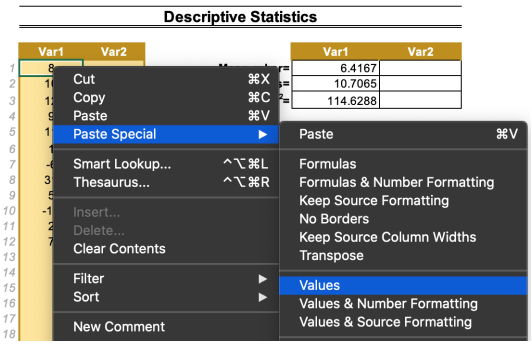
Click on *Hypothesis for Two Samples - Matched Pairs* and enter the data into var1 and var2.

| | Var1 | Var2 | Difference |
|---|---|---|---|
| 1 | 36 | 28 | 8 |
| 2 | 41 | 31 | 10 |
| 3 | 39 | 27 | 12 |
| 4 | 42 | 33 | 9 |
| 5 | 44 | 33 | 11 |
| 6 | 39 | 38 | 1 |
| 7 | 39 | 45 | -6 |
| 8 | 56 | 25 | 31 |
| 9 | 33 | 28 | 5 |
| 10 | 20 | 33 | -13 |
| 11 | 49 | 47 | 2 |
| 12 | 30 | 23 | 7 |
| 13 | | | |

The obvious outlier is pair #8 with a difference of 31. A stem and leaf plot also shows this:

```
−1 | 3
 0 | 6
 0 | 12579
 1 | 012
 2 |
 3 | 1
```

Let's see if there is a second outlier. Highlight the *Difference* column, and right click Copy. Click **Index** and then on the *Descriptive Statistics* page. Right click on **var1** #1 and select **Paste Special ▸ Values.**




We now have the descriptive statistics and the values that are outliers.

**Descriptive Statistics**

| | Var1 | Var2 |
|---|---|---|
| 1 | 8 | |
| 2 | 10 | |
| 3 | 12 | |
| 4 | 9 | |
| 5 | 11 | |
| 6 | 1 | |
| 7 | -6 | |
| 8 | 31 | |
| 9 | 5 | |
| 10 | -13 | |
| 11 | 2 | |
| 12 | 7 | |
| 13 | | |
| 14 | | |
| 15 | | |
| 16 | | |
| 17 | | |
| 18 | | |
| 19 | | |
| 20 | | |
| 21 | | |
| 22 | | |
| 23 | | |
| 24 | | |
| 25 | | |
| 26 | | |

| | Var1 | Var2 |
|---|---|---|
| Mean x-bar= | 6.4167 | |
| Sample st.dev. s= | 10.7065 | |
| Sample Variance $s^2$= | 114.6288 | |
| | | |
| Population st. dev. σ= | 10.2507 | |
| Population Variance $\sigma^2$= | 105.0764 | |
| | | |
| | *Five Number Summary* | |
| Min= | -13 | |
| Q1= | 1.25 | |
| Med= | 7.5 | |
| Q3= | 10.75 | |
| Max= | 31 | |
| | | |
| Mode= | #N/A | |
| | | |
| | | |
| | | |
| Skewness= | 0.4419 | |
| | | |
| Percentile= | 40% | 45% |
| | 5.4 | |
| | | |
| Outliers | ≤ -13 | |
| | ≥ 25 | |

On the bottom we see it appears 31 and –13 are both outliers. Let's conduct the hypothesis tests on all the data, and then again removing the outliers one by one. Click **Index**, and back to *Hypothesis for Two Samples - Matched Pairs.*

**All Data**

Hypothesis test set-up: $\begin{cases} H_o : \mu_d = 0 \\ H_1 : \mu_d > 0 \end{cases}$ claim

Hypothesis Test for Matched Pairs Using Data

| | Var1 | Var2 | Difference |
|---|---|---|---|
| 1 | 36 | 28 | 8 |
| 2 | 41 | 31 | 10 |
| 3 | 39 | 27 | 12 |
| 4 | 42 | 33 | 9 |
| 5 | 44 | 33 | 11 |
| 6 | 39 | 38 | 1 |
| 7 | 39 | 45 | -6 |
| 8 | 56 | 25 | 31 |
| 9 | 33 | 28 | 5 |
| 10 | 20 | 33 | -13 |
| 11 | 49 | 47 | 2 |
| 12 | 30 | 23 | 7 |
| 13 | | | |
| 14 | | | |

| | |
|---|---|
| Sample Difference Mean= | 6.4167 |
| Standard Deviation= | 10.7065 |
| Variance= | 114.6288 |
| Sample Size= | 12 |
| Degrees of Freedom= | 11 |
| Hypothesized Difference= | 0 |
| Type: | Ha: μd > 0 |
| t-statistic= | 2.0761 |
| P-Value= | 0.0311 |

With $P-$value = 0.0311 there is some evidence at the $\alpha = 0.05$ level that $\mu_d > 0$.

**Removing $x$ = 31** (Delete out either the var1 or var2 data values)

Hypothesis Test for Matched Pairs Using Data

| | Var1 | Var2 | Difference |
|---|---|---|---|
| 1 | 36 | 28 | 8 |
| 2 | 41 | 31 | 10 |
| 3 | 39 | 27 | 12 |
| 4 | 42 | 33 | 9 |
| 5 | 44 | 33 | 11 |
| 6 | 39 | 38 | 1 |
| 7 | 39 | 45 | -6 |
| 8 | | | |
| 9 | 33 | 28 | 5 |
| 10 | 20 | 33 | -13 |
| 11 | 49 | 47 | 2 |
| 12 | 30 | 23 | 7 |
| 13 | | | |
| 14 | | | |

| | |
|---|---|
| Sample Difference Mean= | 4.1818 |
| Standard Deviation= | 7.7565 |
| Variance= | 60.1636 |
| Sample Size= | 11 |
| Degrees of Freedom= | 10 |
| Hypothesized Difference= | 0 |
| Type: | Ha: μd > 0 |
| t-statistic= | 1.7881 |
| P-Value= | 0.0520 |

Now we have $P-$value = 0.052, so not enough evidence at $\alpha = 0.05$

**Removing Both Outliers**

Hypothesis Test for Matched Pairs Using Data

| | Var1 | Var2 | Difference |
|---|---|---|---|
| 1 | 36 | 28 | 8 |
| 2 | 41 | 31 | 10 |
| 3 | 39 | 27 | 12 |
| 4 | 42 | 33 | 9 |
| 5 | 44 | 33 | 11 |
| 6 | 39 | 38 | 1 |
| 7 | 39 | 45 | -6 |
| 8 | | | |
| 9 | 33 | 28 | 5 |
| 10 | | | |
| 11 | 49 | 47 | 2 |
| 12 | 30 | 23 | 7 |
| 13 | | | |
| 14 | | | |

| | |
|---|---|
| Sample Difference Mean= | 5.9000 |
| Standard Deviation= | 5.5468 |
| Variance= | 30.7667 |
| Sample Size= | 10 |
| Degrees of Freedom= | 9 |
| Hypothesized Difference= | 0 |
| Type: | Ha: μd > 0 |
| t-statistic= | 3.3637 |
| P-Value= | 0.0042 |

With $P-$value = 0.0042 we have strong evidence that $\mu_d > 0$.