Unpaired sample t-test

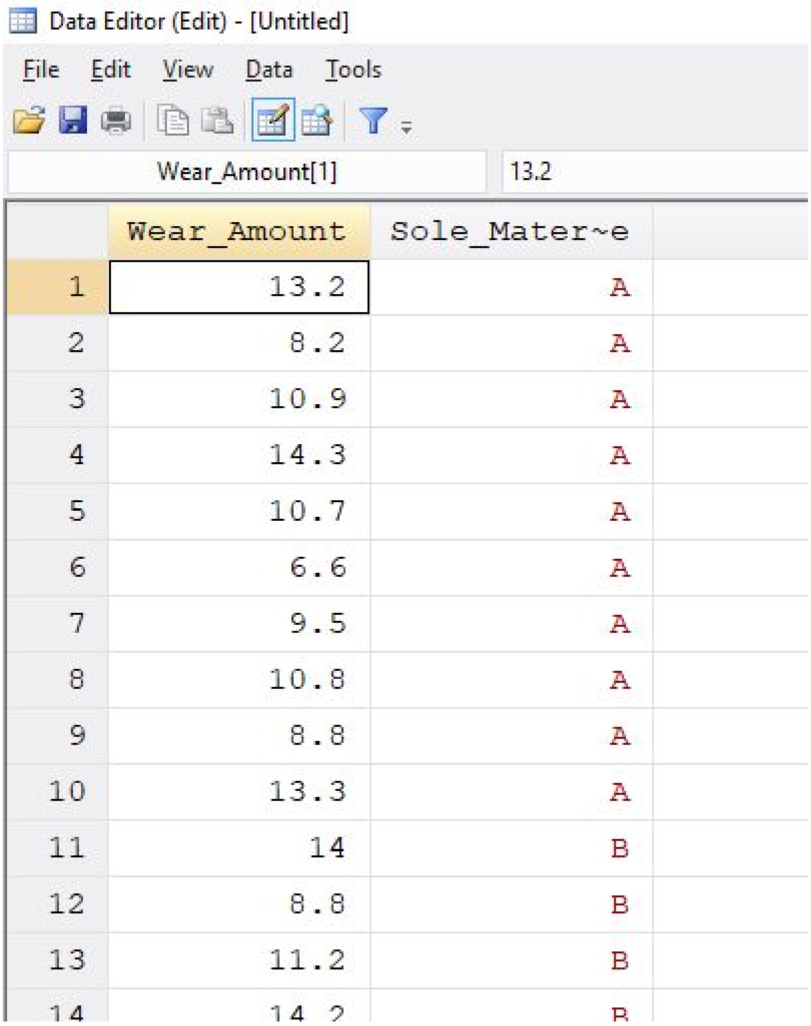
An Independent Samples t-test compares the means for two groups.

Here we will use a sample dataset, we have 1 categorical (factor) variable which is Sole_Material_Type. And we have 1 quantitative variable which is Wear_Amount.

Load data

.import excel "student_t_test\data\t-test2.xls", sheet("Independent-sample t-test") firstrow

//Browse the imported dataset
.Browse



Data Editor (Edit) - [Untitled]

File Edit View Data Tools

Wear_Amount[1] 13.2

	Wear_Amount	Sole_Mater~e
1	13.2	A
2	8.2	A
3	10.9	A
4	14.3	A
5	10.7	A
6	6.6	A
7	9.5	A
8	10.8	A
9	8.8	A
10	13.3	A
11	14	B
12	8.8	B
13	11.2	B
14	14.2	B

Let’s summarize data

```
. summarize Wear_Amount if Sole_Material_Type=="A"

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
 Wear_Amount |         10       10.63    2.451326        6.6       14.3

. summarize Wear_Amount if Sole_Material_Type=="B"

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
 Wear_Amount |         10       11.04    2.518465        6.4       14.2
```

As seen above, the mean of wear amount for type A sole is 10.63 and that for type B is 11.04.

Question
Is there a statistically significant difference between A and B on their Wear_Amount?

Hypothesis
H0: There's no difference in Wear_Amount between A and B
Ha: There's a statistically significant difference in Wear_Amount between A and B

The level of significance
alpha = 0.05

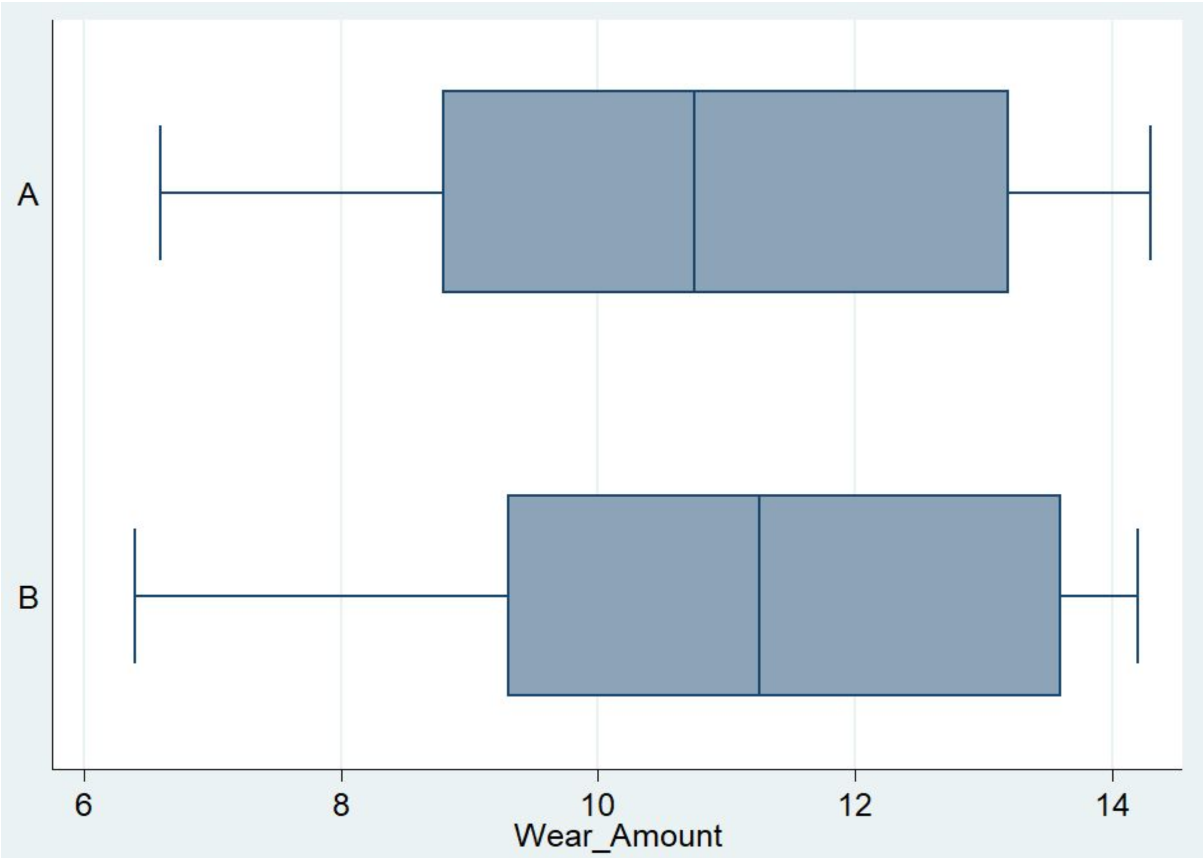
Assumptions
Determine if data meets requirements to perform an independent samples t-test.

Assumption #1: Your dependent variable should be measured on a continuous scale.
Assumption #2: Your independent variable should consist of two categorical, independent groups.
Assumption #3: You should have independence of observations.
Assumption #4: There should be no significant outliers.
Assumption #5: Your dependent variable should be approximately normally distributed for each group of the independent variables.
Assumption #6: There needs to be homogeneity of variances.

CHECK FOR OUTLIERS

Check outliers by plotting a boxplot

. graph hbox Wear_Amount, over(Sole_Material_Type)



As seen from the above boxplot we don't have outliers from either of the groups A and B.

<u>NORMALITY TEST</u>

Normality Law test using Skewness Kurtosis test for normality

H0: The data follows a normal distribution.

Ha: The data does not follow a normal distribution.

```
. sktest Wear_Amount if Sole_Material_Type=="A"

                    Skewness/Kurtosis tests for Normality
                                                          ------ joint ------
    Variable |        Obs  Pr(Skewness)  Pr(Kurtosis) adj chi2(2)   Prob>chi2
-------------+---------------------------------------------------------------
 Wear_Amount |         10      0.9784        0.6027        0.27         0.8730

. sktest Wear_Amount if Sole_Material_Type=="B"

                    Skewness/Kurtosis tests for Normality
                                                          ------ joint ------
    Variable |        Obs  Pr(Skewness)  Pr(Kurtosis) adj chi2(2)   Prob>chi2
-------------+---------------------------------------------------------------
 Wear_Amount |         10      0.5688        0.8643        0.34         0.8418
```

Normality Law test using Shapiro-Wilk W test for normal data

H0: The data follows a normal distribution.
Ha: The data does not follow a normal distribution.

```
. swilk Wear_Amount if Sole_Material_Type=="A"

                   Shapiro-Wilk W test for normal data

    Variable |        Obs       W           V         z       Prob>z
-------------+------------------------------------------------------
 Wear_Amount |         10    0.96240      0.579    -0.888    0.81286

. swilk Wear_Amount if Sole_Material_Type=="B"

                   Shapiro-Wilk W test for normal data

    Variable |        Obs       W           V         z       Prob>z
-------------+------------------------------------------------------
 Wear_Amount |         10    0.94815      0.799    -0.376    0.64665
```

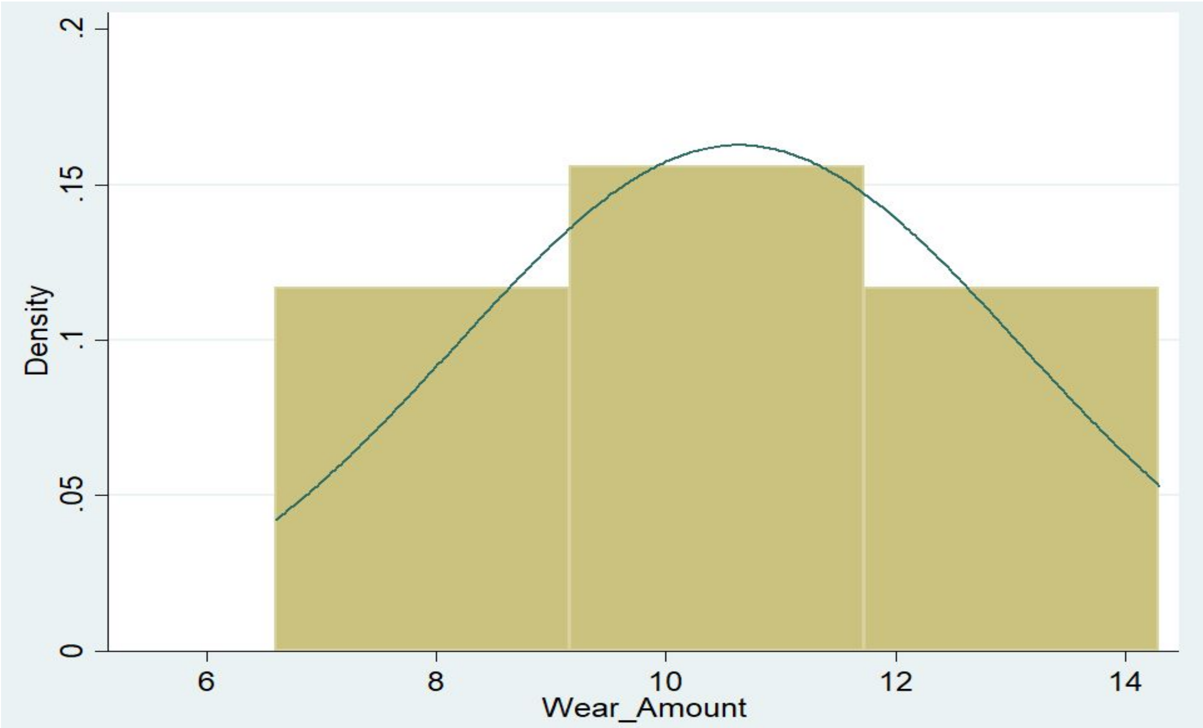
Normality Law test using Shapiro-Francia W' test for normal data

H0: The data follows a normal distribution.
Ha: The data does not follow a normal distribution.

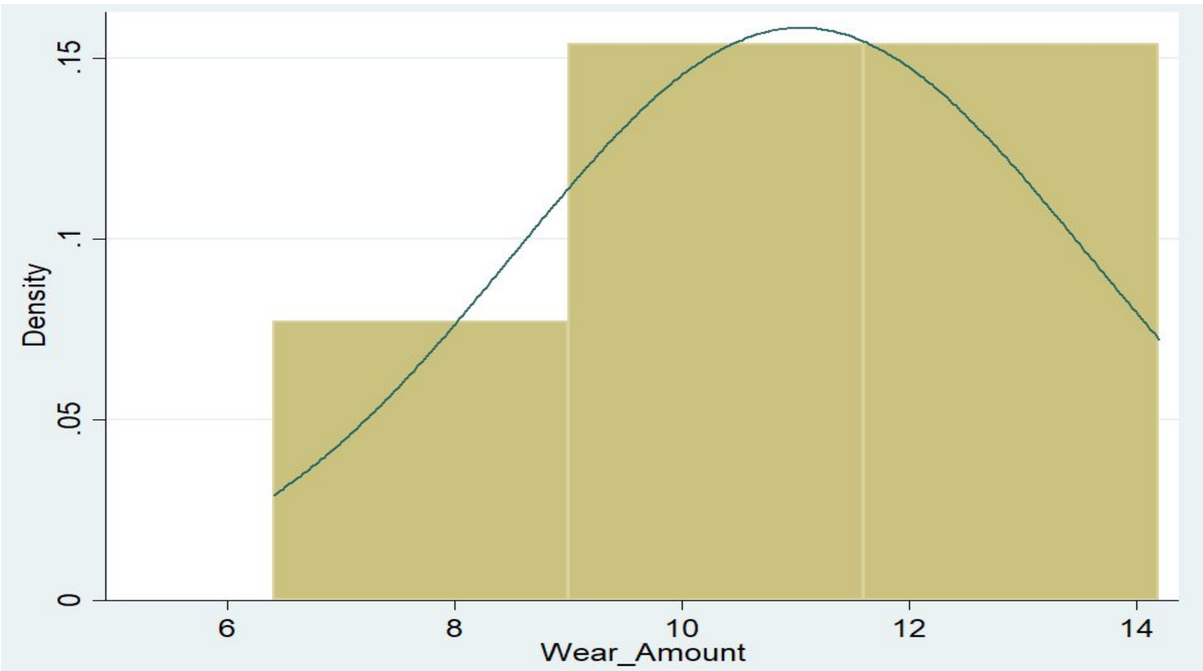
```
. sfrancia Wear_Amount if Sole_Material_Type=="A"

                  Shapiro-Francia W' test for normal data

    Variable |       Obs       W'          V'        z       Prob>z
-------------+-----------------------------------------------------
 Wear_Amount |        10    0.97022      0.498    -1.211    0.88698

. sfrancia Wear_Amount if Sole_Material_Type=="B"

                  Shapiro-Francia W' test for normal data

    Variable |       Obs       W'          V'        z       Prob>z
-------------+-----------------------------------------------------
 Wear_Amount |        10    0.95685      0.722    -0.566    0.71421
```

As you see in all the above 3 tests (off course you don't need all the 3), they all are NOT significant and so we have no evidence to reject the H0, that states that the data follow a normal distribution. We can plot a histogram to visualize;

```
. histogram Wear_Amount if Sole_Material_Type=="A", normal
(bin=3, start=6.6, width=2.5666667)
```




```
. histogram Wear_Amount if Sole_Material_Type=="B", normal
(bin=3, start=6.4, width=2.6)
```



Homogeneity of variances

We will use the command ‘robvar’ to obtain our test of equality of variance

```
. robvar Wear_Amount , by( Sole_Material_Type )

Sole_Materi |        Summary of Wear_Amount
    al_Type |        Mean   Std. Dev.       Freq.
------------+------------------------------------
          A |       10.63   2.4513262          10
          B |       11.04   2.5184651          10
------------+------------------------------------
      Total |      10.835   2.4279675          20

W0  =  0.01894809   df(1, 18)     Pr > F = 0.89204353

W50 =  0.01126581   df(1, 18)     Pr > F = 0.91664483

W10 =  0.00981664   df(1, 18)     Pr > F = 0.92217066
```

LEVENE and BROWN-FORSYTHE tests are obtained using the command robvar. These are good choices especially when assumption of normality is in question..

- W_0 = Levene test.
- W_50 = Forsythe-Browne modification of Levene test (mean is replaced by median).
- W_10 = Fosythe-Browne modification of Levene test (mean is replaced by 10% trim).

As seen from the above results, Levene’s test for homogeneity of variance is not significant which indicates that the groups have approximately equal variances.

Unpaired Sample T-test

With all data requirements for unpaired Sample T-test satisfied, let us not run the test.

```
. ttest Wear_Amount, by(Sole_Material_Type)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       A |      10       10.63    .7751774    2.451326    8.876427    12.38357
       B |      10       11.04    .7964086    2.518465    9.238399     12.8416
---------+--------------------------------------------------------------------
combined |      20      10.835      .54291    2.427968    9.698676    11.97132
---------+--------------------------------------------------------------------
    diff |                -.41    1.111381               -2.744924    1.924924
------------------------------------------------------------------------------
    diff = mean(A) - mean(B)                                      t =  -0.3689
Ho: diff = 0                                     degrees of freedom =       18

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.3582         Pr(|T| > |t|) = 0.7165          Pr(T > t) = 0.6418
```

Interpretation

An unpaired sample t-test was used to analyze the wear amount of shoe sole type to test if there was a significant difference. The wear amount of type B was higher (11.04 ± 2.52 units) compared to type A wear amount (10.63 ± 2.45 units), but this difference was NOT statistically significant ($t(9)=-0.37$, $p= 0.0.716$) of 0.41 units, so we fail to reject the null hypothesis.