# Two Samples *t* -Test in SAS® Studio

In this lesson, you are going to conduct an unpaired t test (a.k.a. *t* test for independent groups) that you will use to compare means between two groups. When there one continuous variable and one categorical variable with only two groups, the null hypothesis is that mean scores for group 1 and group 2 come from populations with equal means. How likely is it to get a difference of the point difference we observe with our sample if the null hypothesis were true? The answer, provided by a two-sample *t* test, is used to determine to whether reject the null to conclude that the group mean differences are statistically significant or fail to reject the null and say that there is not have enough evidence to reject a hypothesis of equality as the chance of getting the observed difference is nothing but by chance, the probability that the difference occurred by chance is higher than the traditional 5%.

There are some assumptions that need to be met before performing the two-sample t-test. One is that the values in each group are normally distributed. The other assumption is that the variances are equal in the two groups. There are tests to check this assumption and SAS Studio provides output for us to check the findings.

## Dataset Description

**For this example, you will be revisiting the BIRTH data.**

Babies with low birth weights (defined to be less than 2500 grams) are a concern because of their potential medical problems. Health researchers used this data to identify possible contributing factors to low birth weight and recommend strategies to reduce the number of low-birth-weight babies. There are 189 cases with 11 variables including:

- ID: Identification Code
- LOW: Low Birth Weight (0: birth weight>=2500g, 1: birth weight<2500g)
- AGE: Age of the Mother in Years
- LWT: Weight in Pounds at the Last Menstrual Period
- ETH: Ethnicity Category (1, 2, 3)
- SMOKE: Smoking Status During Pregnancy (1: yes, 0: no)
- PTL: History of Premature Labor (0: none, 1: one, and so on)
- HT: History of Hypertension (1: yes, 0: no)
- UI: Presence of Uterine Irritability (1: yes, 0: no)
- FTV: Number of Physician Visits During the First Trimester (0: none, 1: one, and so on)
- BWT: Birth Weight in Grams

## I. Conduct a Two-Sample *t*-Test

For this example, we will be investigating the question "Does a baby's birth weight (BWT) differ among smoking mothers versus non-smoking mothers (SMOKE)?".

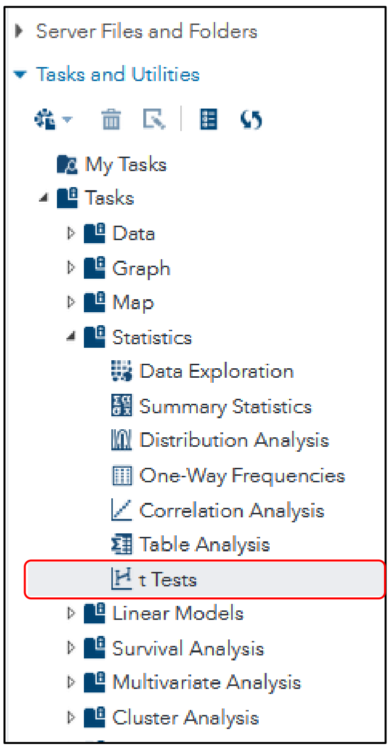
Therefore, the hypothesis statements are:

$H_0$ = The mean BWT with Non-smoking mom is equal to the mean BWT with smoking mom.

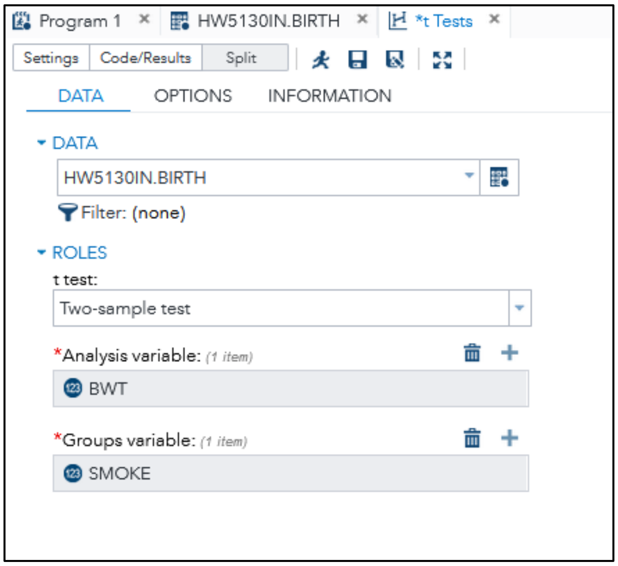
$H_A$ = The mean BWT with Non-smoking mom is not equal to the mean BWT with smoking mom.

In this question, we have one continuous variable, BWT, and one categorical variable that has only two groups (SMOKE). Therefore, we can use the *t*-test to identify if there is a difference between these two groups.

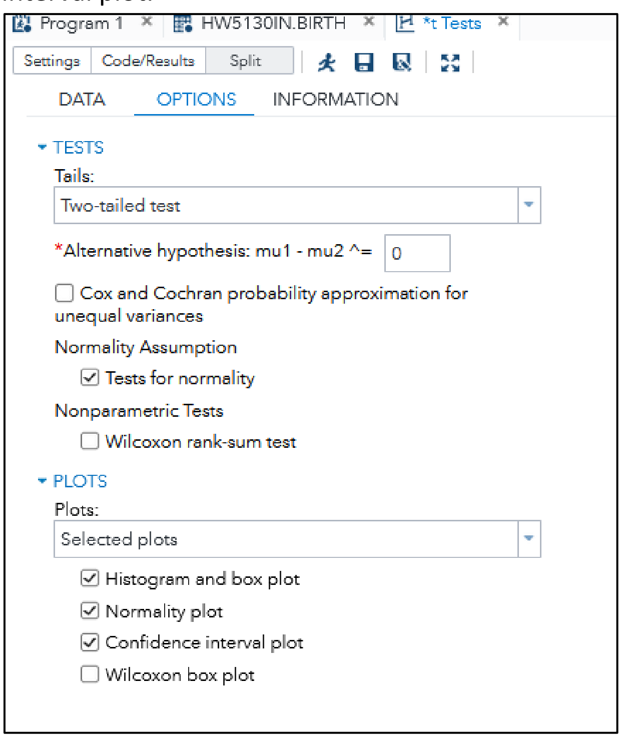
1. Expand Tasks and Utilities, expand Tasks, expand Statistics, and then select *t*-Tests.



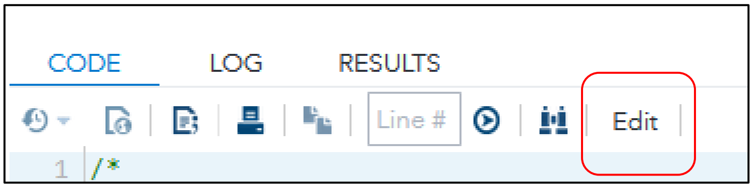
2. In the *t*-Tests window under Data, select the Birth file. Under Roles, select Two-sample test. Select BWT as the Analysis variable, and Smoke as the Groups variable.




3. Go to Options and select the two-tailed test with the alternative hypothesis that the difference between the means is 0. Since we are assessing if the assumptions necessary for a *t*-test, select test for normality. For plots, select the Histogram and box plot, Normality plot, and Confidence interval plot.



4. To add your name in the footnote, go to the code and click Edit.




5. Starting on line 30 type the following code:

```
FOOTNOTE;
FOOTNOTE1 "First and Last Name";
```

6. Run the code. The first thing that comes up in the output are the tests for Normality for Smoke = 1 and Smoke =2.

Variable: BWT (BWT)
SMOKE = 0

| Tests for Normality | | | | |
|---|---|---|---|---|
| Test | Statistic | | p Value | |
| Shapiro-Wilk | W | 0.987102 | Pr < W | 0.3436 |
| Kolmogorov-Smirnov | D | 0.060256 | Pr > D | >0.1500 |
| Cramer-von Mises | W-Sq | 0.07215 | Pr > W-Sq | >0.2500 |
| Anderson-Darling | A-Sq | 0.495093 | Pr > A-Sq | 0.2188 |

Variable: BWT (BWT)
SMOKE = 1

| Tests for Normality | | | | |
|---|---|---|---|---|
| Test | Statistic | | p Value | |
| Shapiro-Wilk | W | 0.982771 | Pr < W | 0.4103 |
| Kolmogorov-Smirnov | D | 0.068722 | Pr > D | >0.1500 |
| Cramer-von Mises | W-Sq | 0.04179 | Pr > W-Sq | >0.2500 |
| Anderson-Darling | A-Sq | 0.309712 | Pr > A-Sq | >0.2500 |

The output provides several tests for normality, all of which compare the scores in the sample to a normally distributed set of scores with the same mean and standard deviation using the null hypothesis that “the sample distribution is normal”. All of these tests resulted in *p* values greater than the standard level of 0.05. Therefore, we failed to reject the null hypothesis and determine that it is appropriate to treat this distribution as if it were normally distributed:

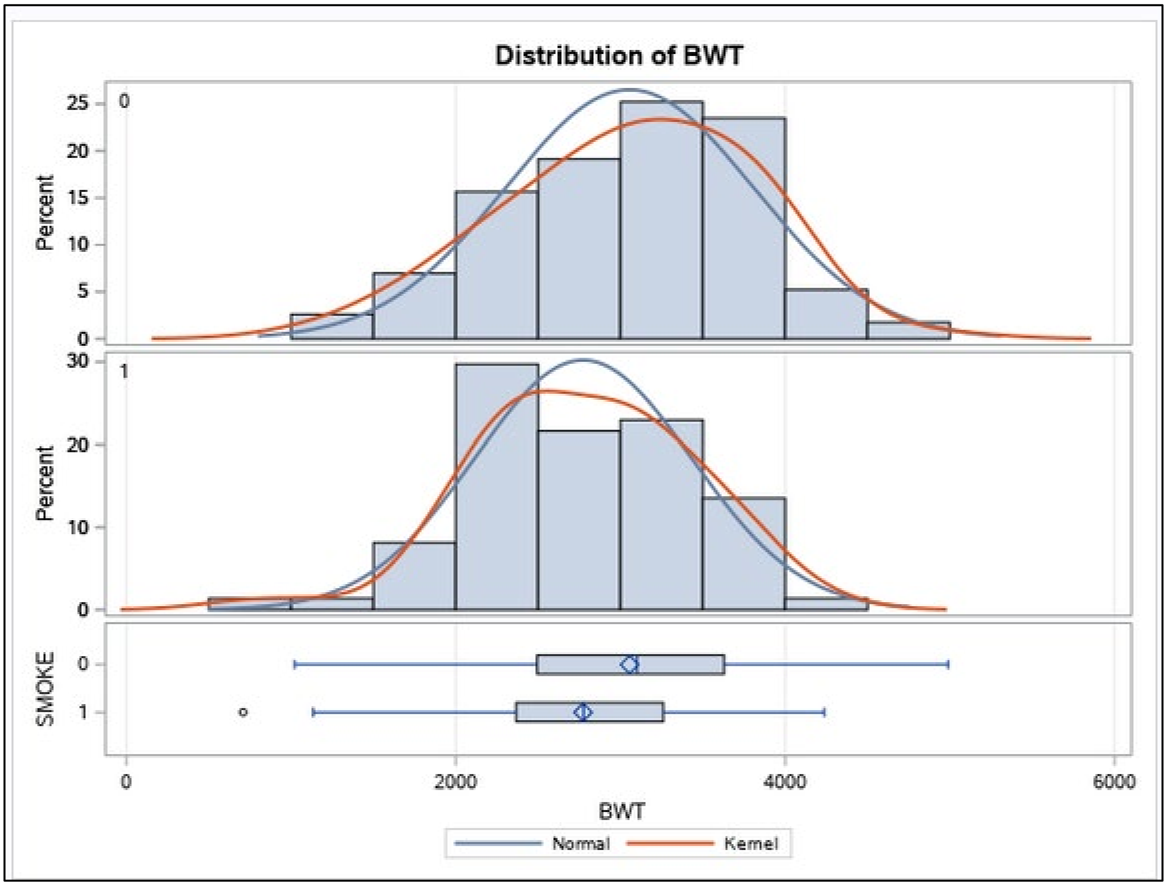
**The Shapiro-Wilk test** is based on the correlation between the data and the corresponding normal scores and provides better power when compared to the Kolmogrov-Smirnov test. Power is the most frequent measure of the value of a test for normality because it describes the ability to detect whether a sample comes from a non-normal distribution.

**The Kolmogrov-Smirnov test** is an empirical distribution function in which the theoretical cumulative distribution function of the test distribution is contrasted with the empirical distribution function of the data. This test is highly sensitive to extreme values and tends to have lower power. This test is not recommended when parameters are estimated from the data, regardless of sample size.

**The Cramér-von Mises's test** is an empirical distribution function omnibus test for the composite hypothesis of normality. It uses the summed squared differences between observed and expected cumulative proportions as the test statistic.

**<u>The Anderson–Darling tes</u>**t is a statistical test of whether a given sample of data is drawn from a given probability distribution. When applied to testing whether a normal distribution adequately describes a set of data, it is one of the most powerful statistical tools for detecting most departures from normality.

7. The determination that this data can be treated as if it were normally distributed after evaluating the histograms. Here, we see that the histograms of the data are relatively close to the normal distribution, shown with the blue curved line.



8. The results from the two-samples *t*-test are shown below.

| SMOKE | Method | N | Mean | Std Dev | Std Err | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| 0 | | 115 | 3055.0 | 752.4 | 70.1625 | 1021.0 | 4990.0 |
| 1 | | 74 | 2773.2 | 660.1 | 76.7322 | 709.0 | 4238.0 |
| Diff (1-2) | Pooled | | 281.7 | 717.8 | 107.0 | | |
| Diff (1-2) | Satterthwaite | | 281.7 | | 104.0 | | |

| SMOKE | Method | Mean | 95% CL Mean | | Std Dev | 95% CL Std Dev | |
|---|---|---|---|---|---|---|---|
| 0 | | 3055.0 | 2916.0 | 3193.9 | 752.4 | 666.1 | 864.6 |
| 1 | | 2773.2 | 2620.3 | 2926.2 | 660.1 | 568.2 | 787.7 |
| Diff (1-2) | Pooled | 281.7 | 70.6927 | 492.7 | 717.8 | 651.8 | 798.7 |
| Diff (1-2) | Satterthwaite | 281.7 | 76.4668 | 487.0 | | | |

| Method | Variances | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|
| Pooled | Equal | 187 | 2.63 | 0.0092 |
| Satterthwaite | Unequal | 170 | 2.71 | 0.0074 |

Equality of Variances

| Method | Num DF | Den DF | F Value | Pr > F |
|---|---|---|---|---|
| Folded F | 114 | 73 | 1.30 | 0.2290 |

Under the null that the mean group differences is zero, we have an observed 281.7 differences between newborns with non-smoking moms (SMOKE=0) vs with smoking counterparts (SMOKE=1).

How likely to get this 281.7 differences in our sample while the true difference is 0, when the null is correct? We need standard error of our point estimate, sample mean differences. We have two numbers for this: 107 with Pooled method (under the assumption of equal group variances) and 104 with Satterthwaite method under the assumption of unequal group variances.

As for the t-statistics, we have two numbers: 2.63 under Pool method and 2.71 underSatterthwaite method under the assumption of unequal group variances. Which one to choose? It does not matter in our case as both t-values are high with *p*-values less than indicating that the group differences we observe (281.7) cannot be just by chance if the null was true. Technically, you would need to check the test of equal variance result to decide whether you will use the Pooled or Satterthwaite *t*-values. According to the equal variance test, under the null, variances are equal, and our test has a *p* value of 0.2290 which is higher than 0.05, so it is not significant. It means it is very likely to have the observed variance differences while they are same in the population. Therefore, we will use pooled *t*- test results based on the equality of variance test.

The pooled *t* value is 2.63 and *p* value is 0.0092, which is less than 0.05. Therefore, our test statistics is statistically significant. We reject the null and conclude that:

> "Yes, baby's birth weight (BWT) differs among smoking mothers versus non-smoking mothers (SMOKE)."