

# How to Run a One Sample t-test in Stata: A Step-by-Step Guide

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The One Sample t-test is a fundamental statistical procedure used extensively across various disciplines, from social sciences to engineering, to determine if the mean of a single population is significantly different from a known or hypothesized value. Before diving into the practical execution in Stata, it is essential to grasp the theoretical basis: we are testing the observed sample mean against a specific benchmark, allowing researchers to draw robust inferences about the entire population.

To successfully perform a One Sample t-test in Stata, the process involves standard steps: loading the data, specifying the variable of interest, and defining the hypothesized population mean (often denoted as  $\mu_0$ ). The resulting output provides crucial metrics, including the **t-statistic**, the associated degrees of freedom, and the critical p-value. These elements collectively inform the decision regarding the null hypothesis, thereby establishing the statistical significance of the findings.

## Introduction to the One Sample t-Test

A One Sample t-test is a parametric hypothesis test that examines whether the mean of a single population differs significantly from a predetermined constant. This test is appropriate when the population standard deviation is unknown (which is usually the case in real-world research) and the sample size is relatively small, although it performs well even with larger samples. Researchers must ensure that the data meet the underlying assumptions of the t-test, primarily that the data are randomly sampled and approximately normally distributed. Violations of these assumptions, especially major deviations from normality in small samples, might necessitate the use of non-parametric alternatives.

The core utility of this test lies in its ability to validate assumptions or benchmarks. For instance, a quality control team might use it to check if the average weight of a product batch meets the specified industry standard, or educators might test if student performance scores align with the national average. By comparing the observed sample mean ( $\bar{x}$ ) to the hypothesized population mean ( $\mu_0$ ), we quantify the difference relative to the variability within the sample. This comparison yields the t-statistic, which serves as the measure of how many standard errors the sample mean is away from the hypothesized value.

## The Core Hypothesis: Null vs. Alternative

Every hypothesis test is built upon two competing statements: the null hypothesis ( $H_0$ ) and the alternative hypothesis ( $H_a$  or  $H_1$ ). The null hypothesis assumes no effect or no difference, stating that the population mean is exactly equal to the hypothesized value ( $\mu = \mu_0$ ). Conversely, the alternative hypothesis posits that the population mean is different from the hypothesized value. This alternative can be two-sided ( $\mu \neq \mu_0$ ) or one-sided ( $\mu$

$\mu_0$ ), depending on the specific research question being addressed.

The choice between a one-sided or two-sided test is crucial as it affects the resulting p-value and, consequently, the conclusion. A two-sided test checks for differences in either direction, dividing the significance level ( $\alpha$ ) across both tails of the t-distribution. A one-sided test, used when researchers have a directional prediction, concentrates all of  $\alpha$  in one tail. The decision to reject the null hypothesis hinges on comparing the calculated p-value to the chosen significance level (commonly  $\alpha = 0.05$ ). If  $p < \alpha$ , we reject  $H_0$ , concluding that there is sufficient evidence of a difference, thus achieving statistical significance.

## Case Study: Investigating Automobile MPG in Stata

To illustrate the practical application of the one sample t-test, we will use a common scenario involving vehicle efficiency data. Researchers are interested in determining if the average fuel efficiency of automobiles in a specific population meets a benchmark of 20 miles per gallon (mpg). They have collected a representative sample consisting of 74 cars and intend to conduct a one sample t-test to rigorously assess whether the true average mpg ( $\mu$ ) differs statistically from the target value of 20.

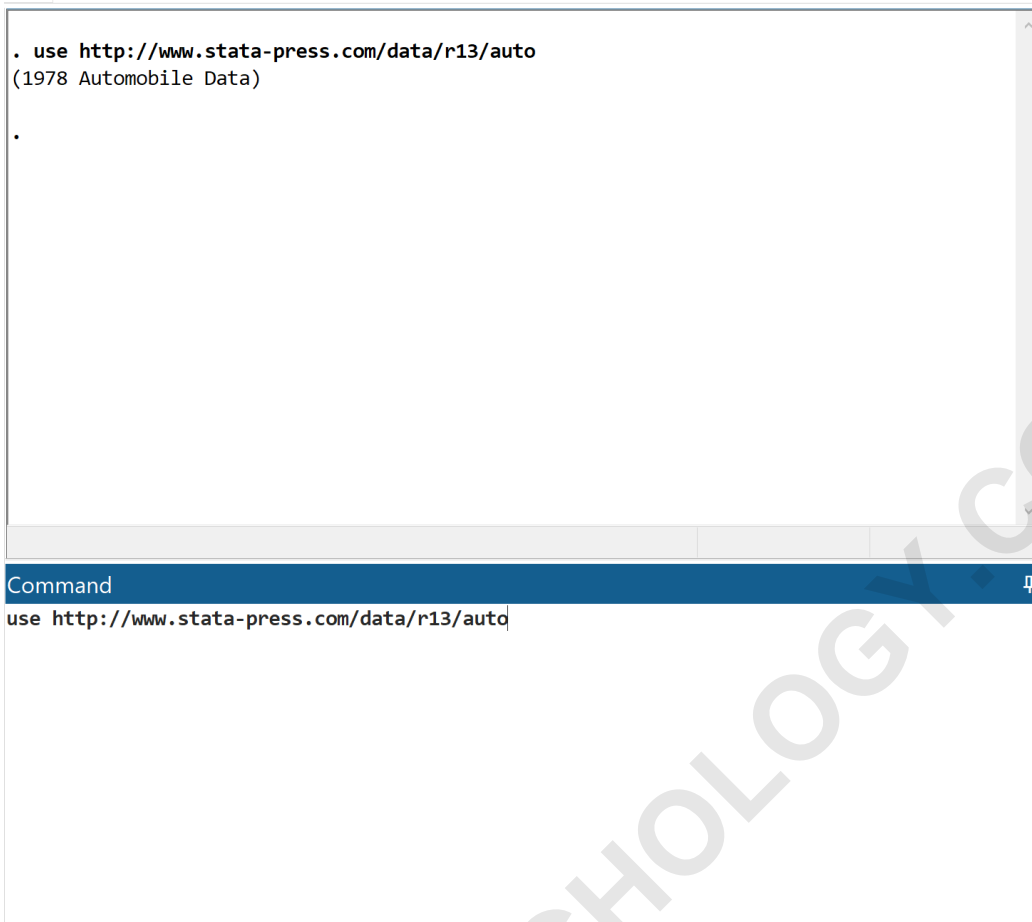
In this scenario, our hypotheses are formally defined as follows: the null hypothesis ( $H_0$ ) states that the true population mean mpg is 20 ( $\mu = 20$ ). The alternative hypothesis ( $H_a$ ), reflecting the general interest in knowing if the average is different from 20, is two-sided: the true population mean mpg is not equal to 20 ( $\mu \neq 20$ ). We will proceed using the statistical software Stata to manage the data and perform the calculations necessary to test this claim.

### Step 1: Preparing and Loading the Dataset

The initial step in any data analysis workflow in Stata is to load the relevant data into the active session. For this specific example, we utilize a built-in dataset commonly used for demonstrations, accessible directly via a URL. To load this dataset, type the following command precisely into the Stata Command window and execute it by pressing Enter. This constitutes the first concrete step in our analysis:

```
use http://www.stata-press.com/data/r13/auto
```

Upon execution, Stata confirms that the dataset, which contains information on 74 automobiles, has been successfully loaded into memory. This step is crucial, as all subsequent statistical operations will reference variables within this loaded dataset. It is good practice to ensure the data is loaded correctly before proceeding to data inspection or analysis.



```
. use http://www.stata-press.com/data/r13/auto
(1978 Automobile Data)

.

Command
use http://www.stata-press.com/data/r13/auto
```

## Step 2: Inspecting the Raw Data Structure

Before running the formal test, it is highly recommended to inspect the raw structure of the data to verify variable names, identify potential data entry errors, and understand the range of values. In Stata, this can be achieved interactively through the graphical user interface (GUI). Navigate to the top menu bar and select **Data > Data Editor > Data Editor (Browse)**. This action opens a read-only viewer displaying all the variables and observations.

While the dataset contains various details about the 74 cars (such as make, weight, and price), our focus for the One Sample t-test is exclusively on the miles per gallon variable, designated as **mpg**. Reviewing this column ensures that the variable is correctly formatted (numeric) and that the data appears reasonable. This visual confirmation step is vital for ensuring data integrity and minimizing analytical errors later on.

	make	price	mpg	rep78	headroom	trunk	weight	length	turn	displacement	gear_ratio	foreign
1	AMC Concord	4,099	22	3	2.5	11	2,930	186	40	121	3.58	Domestic
2	AMC Pacer	4,749	17	3	3.0	11	3,350	173	40	258	2.53	Domestic
3	AMC Spirit	3,799	22	.	3.0	12	2,640	168	35	121	3.08	Domestic
4	Buick Century	4,816	20	3	4.5	16	3,250	196	40	196	2.93	Domestic
5	Buick Electra	7,827	15	4	4.0	20	4,080	222	43	350	2.41	Domestic
6	Buick LeSabre	5,788	18	3	4.0	21	3,670	218	43	231	2.73	Domestic
7	Buick Opel	4,453	26	.	3.0	10	2,230	170	34	304	2.87	Domestic
8	Buick Regal	5,189	20	3	2.0	16	3,280	200	42	196	2.93	Domestic
9	Buick Riviera	10,372	16	3	3.5	17	3,880	207	43	231	2.93	Domestic
10	Buick Skylark	4,082	19	3	3.5	13	3,400	200	42	231	3.08	Domestic
11	Cad. Deville	11,385	14	3	4.0	20	4,330	221	44	425	2.28	Domestic
12	Cad. Eldorado	14,500	14	2	3.5	16	3,900	204	43	350	2.19	Domestic
13	Cad. Seville	15,906	21	3	3.0	13	4,290	204	45	350	2.24	Domestic
14	Chev. Chevette	3,299	29	3	2.5	9	2,110	163	34	231	2.93	Domestic
15	Chev. Impala	5,705	16	4	4.0	20	3,690	212	43	250	2.56	Domestic
16	Chev. Malibu	4,504	22	3	3.5	17	3,180	193	31	200	2.73	Domestic
17	Chev. Monte Carlo	5,104	22	2	2.0	16	3,220	200	41	200	2.73	Domestic
18	Chev. Monza	3,667	24	2	2.0	7	2,750	179	40	151	2.73	Domestic
19	Chev. Nova	3,955	19	3	3.5	13	3,430	197	43	250	2.56	Domestic
20	Dodge Colt	3,984	30	5	2.0	8	2,120	163	35	98	3.54	Domestic
21	Dodge Diplomat	4,010	18	2	4.0	17	3,600	206	46	318	2.47	Domestic
22	Dodge Magnum	5,886	16	2	4.0	17	3,600	206	46	318	2.47	Domestic
23	Dodge St. Regis	6,342	17	2	4.5	21	3,740	220	46	225	2.94	Domestic
24	Ford Fiesta	4,389	28	4	1.5	9	1,800	147	33	98	3.15	Domestic
25	Ford Mustang	4,187	21	3	2.0	10	2,650	179	43	140	3.08	Domestic
26	Linc. Continental	11,497	12	3	3.5	22	4,840	233	51	400	2.47	Domestic
27	Linc. Mark V	13,594	12	3	2.5	18	4,720	230	48	400	2.47	Domestic
28	Linc. Versailles	13,466	14	3	3.5	15	3,830	201	41	302	2.47	Domestic
29	Merc. Bobcat	3,829	22	4	3.0	9	2,580	169	39	140	2.73	Domestic
30	Merc. Cougar	5,379	14	4	3.5	16	4,060	221	48	302	2.75	Domestic
31	Merc. Marquis	6,165	15	3	3.5	23	3,720	212	44	302	2.26	Domestic
32	Merc. Monarch	4,516	18	3	3.0	15	3,370	198	41	250	2.43	Domestic
33	Merc. XR-7	6,303	14	4	3.0	16	4,130	217	45	302	2.75	Domestic

### Step 3: Executing the t-Test Using Stata's GUI

With the data loaded and inspected, the next phase is to execute the One Sample t-test. The most intuitive way for new users to perform this analysis is through Stata's menu system. Begin by navigating the top menu: **Statistics > Summaries, tables, and tests > Classical tests of hypotheses > t test (mean-comparison test)**. This sequence opens the dedicated dialogue box for mean comparison tests.

Within the dialogue box, ensure that the radio button for **One-sample** test is selected, confirming our objective of comparing a single sample mean against a constant. For the **Variable name** dropdown, select **mpg**. Critically, in the field labeled **Hypothesized mean**, input the value of **20**, as this is the benchmark against which we are testing the population mean. Lastly, the **Confidence level** setting allows adjustment of the desired level of certainty for the confidence interval; the default setting of 95% corresponds to a statistical significance level ( $\alpha$ ) of 0.05. After configuring these parameters, clicking **OK** executes the test and generates the detailed statistical

output.

The screenshot shows the Stata dialog box for running a t-test. The window title is "ttest - t tests (mean-comparison tests)". The "Main" tab is selected, and the "by/if/in" sub-tab is active. In the "t tests" section, the "One-sample" option is selected. In the "One-sample mean-comparison test" section, the "Variable name:" is set to "mpg" and the "Hypothesized mean:" is set to "20". The "Confidence level" is set to "95". At the bottom of the dialog, there are buttons for "?", a refresh icon, a save icon, "OK", "Cancel", and "Submit".

## Understanding the t-Test Output

The results window in Stata provides a concise summary table followed by the three possible hypothesis test outcomes (two-tailed and two one-tailed tests). Interpreting this output requires careful attention to each statistic provided. The summary section details the characteristics of the sample used in the analysis:

**Obs:** This denotes the number of observations ( $n$ ), which is **74**, representing the total number of cars in the sample.

**Mean:** This is the calculated sample mean ( $\bar{x}$ ) for mpg. In this specific output, the mean mpg is reported as **21.2973** miles per gallon.

**Std. Err:** The Standard Error of the Mean, which estimates the variability of the sample mean if the sampling process were repeated. It is calculated as the standard deviation divided by the square root of the sample size:  $\text{Std Err} = \sigma / \sqrt{n} = 5.785503 / \sqrt{74} \approx 0.6725511$ .

**Std. Dev:** The standard deviation of the mpg variable, which measures the dispersion of the data around the sample mean. Here, it is **5.785503**.

**95% Conf. Interval:** The 95% confidence interval for the true population mean ( $\mu$ ). We are 95% confident that the true average mpg for the population falls within the range (19.9569, 22.63769).

Below the summary statistics, Stata reports the actual test results: the calculated t-statistic and the degrees of freedom. The t-statistic, denoted by **t**, quantifies the difference between the sample mean and the hypothesized mean in standard error units. It is calculated as:  $t = (\bar{x} - \mu_0) / \text{Std Err} = (21.2973 - 20) / 0.6725511 \approx 1.9289$ . The degrees of freedom (df) for a one sample t-test are calculated simply as  $n-1$ , which in this case is  $74 - 1 = 73$ .

One-sample t test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]
mpg	74	21.2973	.6725511	5.785503	19.9569 22.63769

mean = mean(mpg) t = 1.9289  
 Ho: mean = 20 degrees of freedom = 73

Ha: mean < 20  
 Pr(T < t) = 0.9712

Ha: mean != 20  
 Pr(|T| > |t|) = 0.0576

Ha: mean > 20  
 Pr(T > t) = 0.0288

## Interpreting the Statistical Significance

The most critical part of the output is the bottom section, which provides the p-values corresponding to the three possible alternative hypotheses. Since our initial research question was whether the true average mpg is 20 or not (a two-sided test), we must look at the results for  $H_a: \text{mean} \neq 20$ . This two-tailed test is located in the center of the output table. The calculated p-value for this test is **0.0576**.

We compare this p-value (0.0576) against our predetermined significance level ( $\alpha = 0.05$ ). Since  $0.0576$  is greater than  $0.05$ , we do not meet the threshold required to reject the null hypothesis ( $H_0$ ). Therefore, based on the collected sample of 74 cars, we conclude that there is insufficient evidence, at the 5% statistical significance level, to assert that the true population mean mpg is different from 20 mpg. Although the sample mean (21.2973) is numerically higher than 20, the difference is not large enough, relative to the data variability, to be deemed statistically significant.

## Alternative Method: Using the Stata Command Line

While the graphical user interface is excellent for beginners, experienced Stata users often prefer the command line for efficiency and reproducibility. The equivalent command to perform the one sample t-test used in the previous steps is highly succinct and easy to recall. The general syntax requires the command `ttest`, followed by the variable name, and then the option `==` followed by the hypothesized mean value.

For our specific case study testing the mpg against a hypothesized mean of 20, the command is:

```
ttest mpg == 20
```

Executing this single line of code in the Command window will produce the exact same output generated by navigating the menus, confirming the t-statistic of 1.9289 and the two-tailed p-value of 0.0576. Using command syntax is the preferred method for constructing reproducible do-files, ensuring that analyses can be easily shared and validated by others.

## Step 4: Reporting the Findings

The final and crucial step in any statistical analysis is clearly and accurately reporting the findings in a format that conveys the methodology and conclusions to the relevant audience. When reporting a One Sample t-test, standard conventions require including the test statistic (t), the degrees of freedom (df), and the exact p-value. The context, including the sample size and the hypothesized value, must also be clearly stated.

The following is an example of how the results from our automobile mpg analysis should be summarized in a formal report, adhering to statistical reporting standards:

A One Sample t-test was conducted on a sample of 74 automobiles to evaluate whether the true population mean miles per gallon (mpg) differed significantly from the hypothesized value of 20 mpg.

Results showed that the true population mean was **not** different than 20 mpg ( $t(73) = 1.9289$ ,  $p = .0576$ ) at a significance level of 0.05. Consequently, we failed to reject the null hypothesis.

A 95% confidence interval for the true population mean resulted in the interval of (19.9569, 22.63769). Since this confidence interval includes the hypothesized value of 20, this finding reinforces the conclusion that the evidence for a significant difference is insufficient.