What are the differences between one-tailed and two-tailed tests?

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A one-tailed test is a statistical hypothesis test in which the alternative hypothesis is directional, meaning it specifies a difference or relationship in a specific direction. This type of test is used to determine if a sample data supports the hypothesis that the population parameter is either greater than or less than a specific value. On the other hand, a two-tailed test is a statistical hypothesis test in which the alternative hypothesis is non-directional, meaning it does not specify a difference or relationship in a specific direction. This type of test is used to determine if a sample data supports the hypothesis that the population parameter is different from a specific value, regardless of the direction. The main difference between one-tailed and two-tailed tests lies in the way the alternative hypothesis is formulated, and this can have an impact on the interpretation of the results. In general, a one-tailed test is used when there is a specific hypothesis or prediction about the direction of the relationship, while a two-tailed test is used when there is no specific prediction or when both directions of the relationship are of interest. Ultimately, the choice between a one-tailed and two-tailed test depends on the research question and the specific hypothesis being tested.

FAQ: What are the differences between one-tailed and two-tailed tests?

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When you conduct a test of statistical significance, whether it is from a correlation, an ANOVA, a regression or some other kind of test, you are given a p-value somewhere in the output. If your test statistic is symmetrically distributed, you can select one of three alternative hypotheses. Two of these correspond to one-tailed

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tests and one corresponds
to a two-tailed test. However, the
p-value presented is (almost always) for a two-tailed test. But how do
you choose which test?
Is the p-value appropriate for your test? And, if it is not, how can you
calculate the correct p-value for your test given the p-value in your
output?

What is a two-tailed test?

First let's start with the meaning of a two-tailed test. If you are using a
significance level of 0.05, a two-tailed test allots half of your alpha to
testing the statistical significance in one direction and half of your alpha to
testing statistical significance in the other direction. This means that
.025 is in each tail of the distribution of your test statistic. When using a
two-tailed test, regardless of the direction of the relationship you

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hypothesize, you are testing for the possibility of the relationship in both directions. For example, we may wish to compare the mean of a sample to a given value x using a t-test. Our null hypothesis is that the mean is equal to x. A two-tailed test will test both if the mean is significantly greater than x and if the mean significantly less than x. The mean is considered significantly different from x if the test statistic is in the top 2.5% or bottom 2.5% of its probability distribution, resulting in a p-value less than 0.05.

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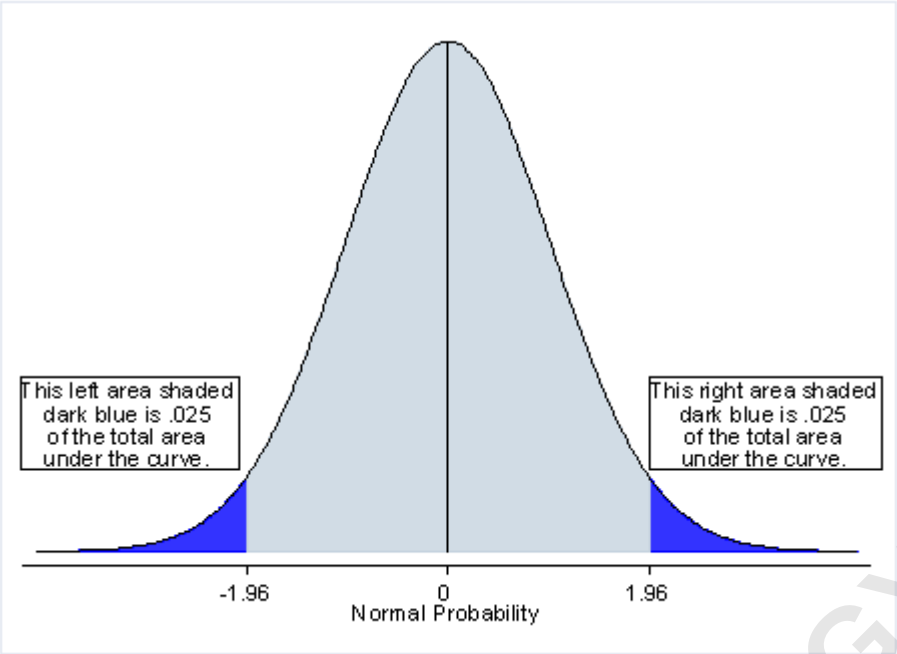

What is a one-tailed test?

Next, let's discuss the meaning of a one-tailed test. If you are using a significance level of .05, a one-tailed test allots all of your alpha to testing the statistical significance in the one direction of interest. This means that .05 is in one tail of the distribution of your test statistic. When using a one-tailed test, you are testing for the possibility of the relationship in one direction and completely disregarding the possibility of a relationship in the

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other direction. Let's return to our example comparing the mean of a
sample to a given value x using a t-test. Our null hypothesis is
that the mean is equal to x. A one-tailed test will test either if the
mean is significantly greater than x or if the mean is significantly less
than x, but not both. Then, depending on the chosen tail, the mean is
significantly greater than or less than x if the test statistic is in the
top 5% of its probability distribution or bottom 5% of its probability
distribution, resulting in a p-value less than 0.05. The one-tailed test provides more power to detect an effect
in one direction by not testing the effect in the other direction. A discussion
of when this is an appropriate option follows.

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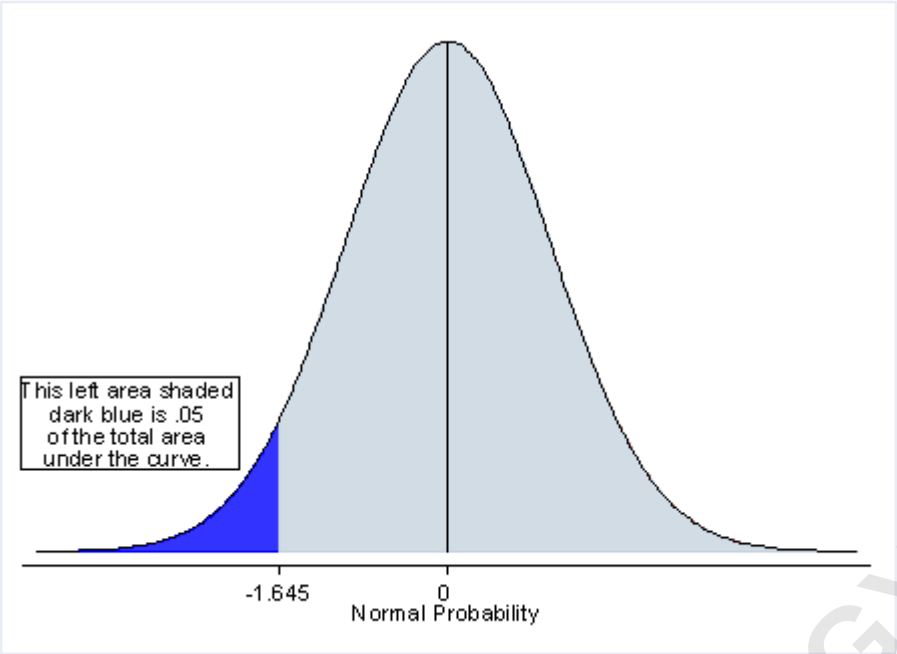

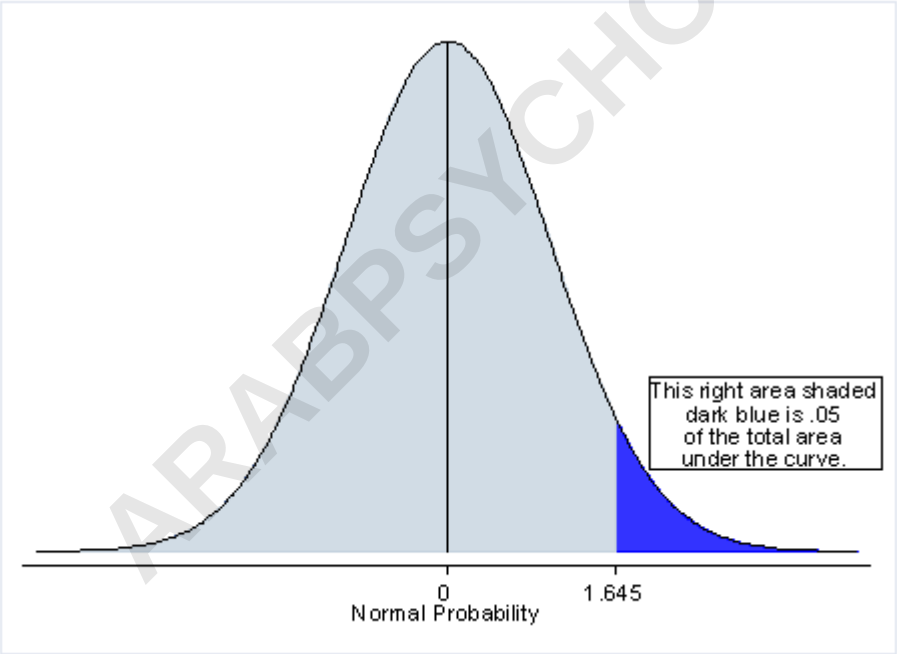

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When is a one-tailed test appropriate?

Because the one-tailed test provides more power to

detect an effect, you may
be tempted to use a one-tailed test whenever you have a hypothesis about the
direction of an effect. Before doing so, consider the consequences of missing an
effect in the other direction. Imagine you have developed a new drug that
you believe is an improvement over an existing drug. You wish to maximize
your ability to detect the improvement, so you opt for a one-tailed test. In
doing so, you fail to test for the possibility that the new drug is less
effective than the existing drug. The consequences in this example are
extreme, but they illustrate a danger of inappropriate use of a one-tailed test.

So when is a one-tailed test appropriate? If you consider the consequences of
missing an effect in the untested direction and conclude that they are
negligible and in no way irresponsible or unethical, then you can proceed with a

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one-tailed test. For example, imagine again that you have developed a new drug.
It is cheaper than the existing drug and, you believe, no less effective.
In testing this drug, you are only interested in testing if it less effective
than the existing drug. You do not care if it is significantly more
effective. You only wish to show that it is not less effective. In this
scenario, a one-tailed test would be appropriate.

When is a one-tailed test NOT appropriate?

Choosing a one-tailed test for the sole purpose of attaining significance is
not appropriate. Choosing a one-tailed test after running a two-tailed
test that failed to reject the null hypothesis is not appropriate, no matter how
"close" to significant the two-tailed test was. Using statistical tests
inappropriately can lead to invalid results that are not replicable and highly
questionable-a steep price to pay for a significance star

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in your results
table!

Deriving a one-tailed test from two-tailed output

The default among statistical packages performing tests is to report two-tailed
p-values. Because the most commonly used test statistic distributions
(standard normal, Student's t) are symmetric about zero, most one-tailed
p-values can be derived from the two-tailed p-values.

Below, we have the output from a two-sample t-test in Stata. The test
is comparing the mean male score to the mean female score. The null
hypothesis is that the difference in means is zero. The two-sided
alternative is that the difference in means is not zero. There are two
one-sided alternatives that one could opt to test instead: that the male score
is higher than the female score (diff > 0) or that the female score is

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higher than the male score (diff < 0). In this instance, Stata presents results for all
three alternatives. Under
the headings Ha: diff < 0 and Ha: diff > 0 are the results for the one-tailed
tests. In the middle, under the heading Ha: diff != 0 (which
means that the difference is not equal to 0), are the results for the two-tailed test.

Two-sample t test with equal variances

Group | Obs Mean Std. Err. Std. Dev.
---+---
male | 91 50.12088 1.080274 10.30516 47.97473 52.26703
female | 109 54.99083 .7790686 8.133715 53.44658 56.53507
---+---
combined | 200 52.775 .6702372 9.478586 51.45332 54.09668
---+---
diff | -4.869947 1.304191 -7.441835 -2.298059

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Degrees of freedom: 198

Ho: mean(male) - mean(female) = diff = 0

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0

t = -3.7341 t = -3.7341 t = -3.7341

P < t = 0.0001 P > |t| = 0.0002 P > t = 0.9999

Note that the test statistic, -3.7341, is the same for all of these tests.

The two-tailed p-value is P > |t|. This can be rewritten as P(>3.7341) + P(<

-3.7341). Because the t-distribution is symmetric about zero, these two

probabilities are equal: P > |t| = 2 * P(< -3.7341). Thus, we can

see that the two-tailed p-value is twice the one-tailed p-value for the

alternative hypothesis that (diff < 0). The other one-tailed alternative

hypothesis has a p-value of P(>-3.7341) = 1-(P<-3.7341) = 1-0.0001 = 0.9999.

So, depending on the direction of the one-tailed hypothesis, its p-value is

either 0.5*(two-tailed p-value) or 1-0.5*(two-tailed p-value) if the test

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statistic symmetrically distributed about zero.

In this example, the two-tailed p-value suggests rejecting the null
hypothesis of no difference. Had we opted for the one-tailed test of (diff > 0),
we would fail to reject the null because of our choice of tails.

The output below is from a regression analysis in Stata. Unlike the example
above, only the two-sided p-values are presented in this output.

```
Source | SS df MS Number of obs = 200
-------------+------------------------------ F( 2, 197) = 46.58
Model | 7363.62077 2 3681.81039 Prob > F = 0.0000
Residual | 15572.5742 197 79.0486001 R-squared = 0.3210
-------------+------------------------------ Adj R-squared = 0.3142
Total | 22936.195 199 115.257261 Root MSE = 8.8909
------------------------------------------------------------------------------
socst | Coef. Std. Err. t P>|t|
-------------+----------------------------------------------------------------
```

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science | .2191144 .0820323 2.67 0.008 .0573403 .3808885
math | .4778911 .0866945 5.51 0.000 .3069228 .6488594
_cons | 15.88534 3.850786 4.13 0.000 8.291287 23.47939

For each regression coefficient, the tested null hypothesis is that the
coefficient is equal to zero. Thus, the one-tailed alternatives are that
the coefficient is greater than zero and that the coefficient is less than zero.
To get the p-value for the one-tailed test of the variable science having a
coefficient greater than zero, you would divide the .008 by 2, yielding .004
because the effect is going in the predicted direction. This is P(>2.67). If you
had made your prediction in the other direction (the opposite direction of the
model effect), the p-value would have been 1 - .004 = .996. This is
P(<2.67). For all three p-values, the test statistic is 2.67.

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