WEEK ONE OF QUARTER FOUR

Hypothesis Testing

TESTS ABOUT MEANS

Prepared for B2026 by MJ Ayaay, VC Chua, LD Estonilo

Welcome to the FINAL QUARTER!

What to expect this quarter?

One major topic: Hypothesis tests

Two individual, in-class LAs: Week 3 and Week 5

Oral Project Report by Week 6.

Written Project Report by Week 7.

Welcome to the

FINAL QUARTER!

What to expect:

Please work on the project ASAP.

You need to consult with your teacher before you collect data.

Seek help regarding the project if you need to.

WEEK ONE OF QUARTER FOUR

Lesson Outline

In this lesson, students should be able to:

- Recall previously-defined concepts in hypothesis testing
- Understand the p-value method
- Identify the appropriate test for one or two means
- Use Jamovi to employ tests for one mean and tests for two independent means

RECALL

Hypothesis testing

What is a statistical hypothesis?

A **STATISTICAL HYPOTHESIS** is a hypothesis that is testable on the basis of observed data modelled (or assumed) as the realized values taken about a collection of random variables.

STUART A., ORD K., ARNOLD S. (1999), KENDALL'S ADVANCED THEORY OF STATISTICS: VOLUME 2A—CLASSICAL INFERENCE & THE LINEAR MODEL

RECALL

Hypothesis testing

What are the two types of statistical hypothesis?

The **NULL HYPOTHESIS** (H_0), is a (negative) statement about a population parameter that is assumed to be true.

An **ALTERNATIVE HYPOTHES** is (H_a) is a statement that directly contradicts a null hypothesis by stating that that the actual value of a population parameter is less than, greater than, or not equal to the value stated in the null hypothesis.

RECALL

Hypothesis testing

What is the significance level, α, in the context of hypothesis testing?

It is the probability of committing a TYPE 1 ERROR: rejecting a true null hypothesis.

It is also the probability that the event could have occurred by chance. It essentially sets our **level of reasonable doubt**.

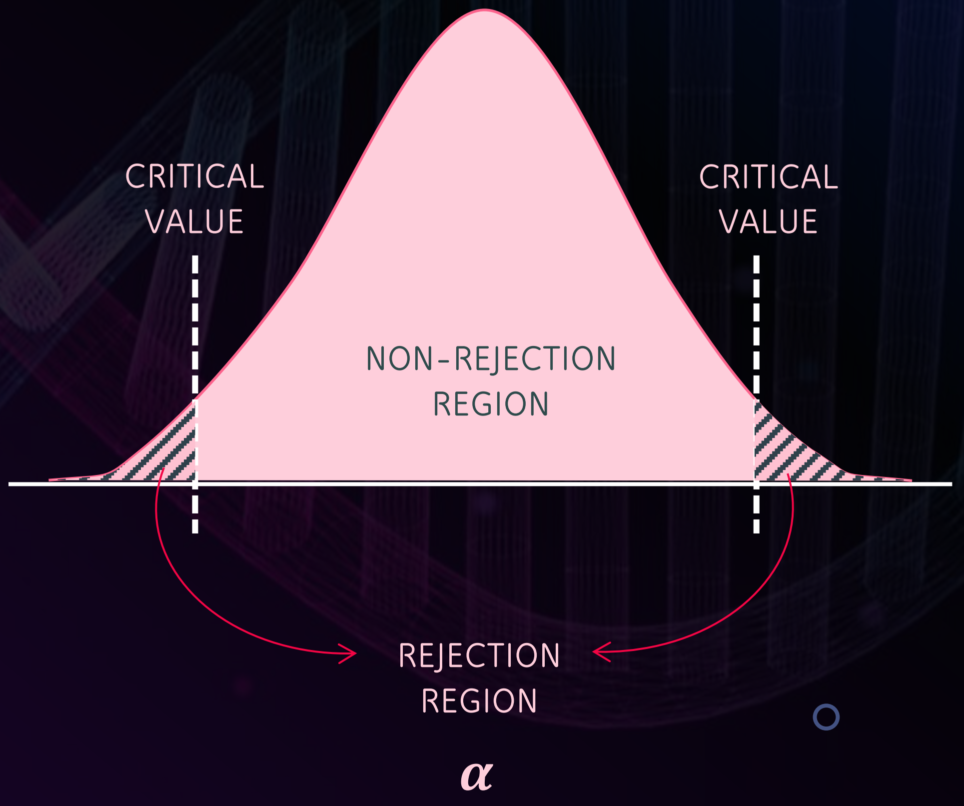
If we set α to be low, we will have a harder time rejecting the null hypothesis, and a high α makes it easier to reject the null hypothesis

RECALL

Hypothesis testing

The significance level divides the distribution into two regions.

If the distribution score of the sample falls into the rejection region, then the null hypothesis is rejected.



BASIC STEPS IN

Hypothesis testing

1. Identify and define the parameter(s) or relationship between variables being tested
2. State the null and alternative hypotheses
3. Set the level of significance (typically 0.1, 0.05, or 0.01)
4. Gather data, then check if it is unlikely to appear if the null hypotheses were true
5. Decide whether to reject the null or not
6. State the appropriate conclusion

EXAMPLE OF
Hypothesis testing

1. Identify and define the parameter(s) or relationship between variables being tested
2. State the null and alternative hypotheses
3. Set the level of significance (typically 0.1, 0.05, or 0.01)

Suppose you want to prove that a diet leads to weight loss in guinea pigs. Suppose the average weight of the population of guinea pigs is known to be 1kg. Fifteen guinea pigs are used for this investigation.

Since you want to see a decrease in the average weight, the set μ=average weight of guinea pigs given the new diet.

H_0: $\mu = 1$; H_1: $\mu < 1$

Set the level of significance, α=0.05. This should lead to the identification of the rejection region.

1. Identify and define the parameter(s) or relationship between variables being tested

   Since you want to see a decrease in the average weight, the set μ=average weight of guinea pigs given the new diet.

2. State the null and alternative hypotheses

   $H_0\colon \mu = 1; \qquad H_1\colon \mu < 1$

3. Set the level of significance (typically 0.1, 0.05, or 0.01)

   Set the level of significance, α=0.05. This should lead to the identification of the rejection region.

4. Gather data, then check if it is unlikely to appear if the null hypotheses were true

   Feed the guinea pigs with the supposed diet, and check the average weight after the diet.

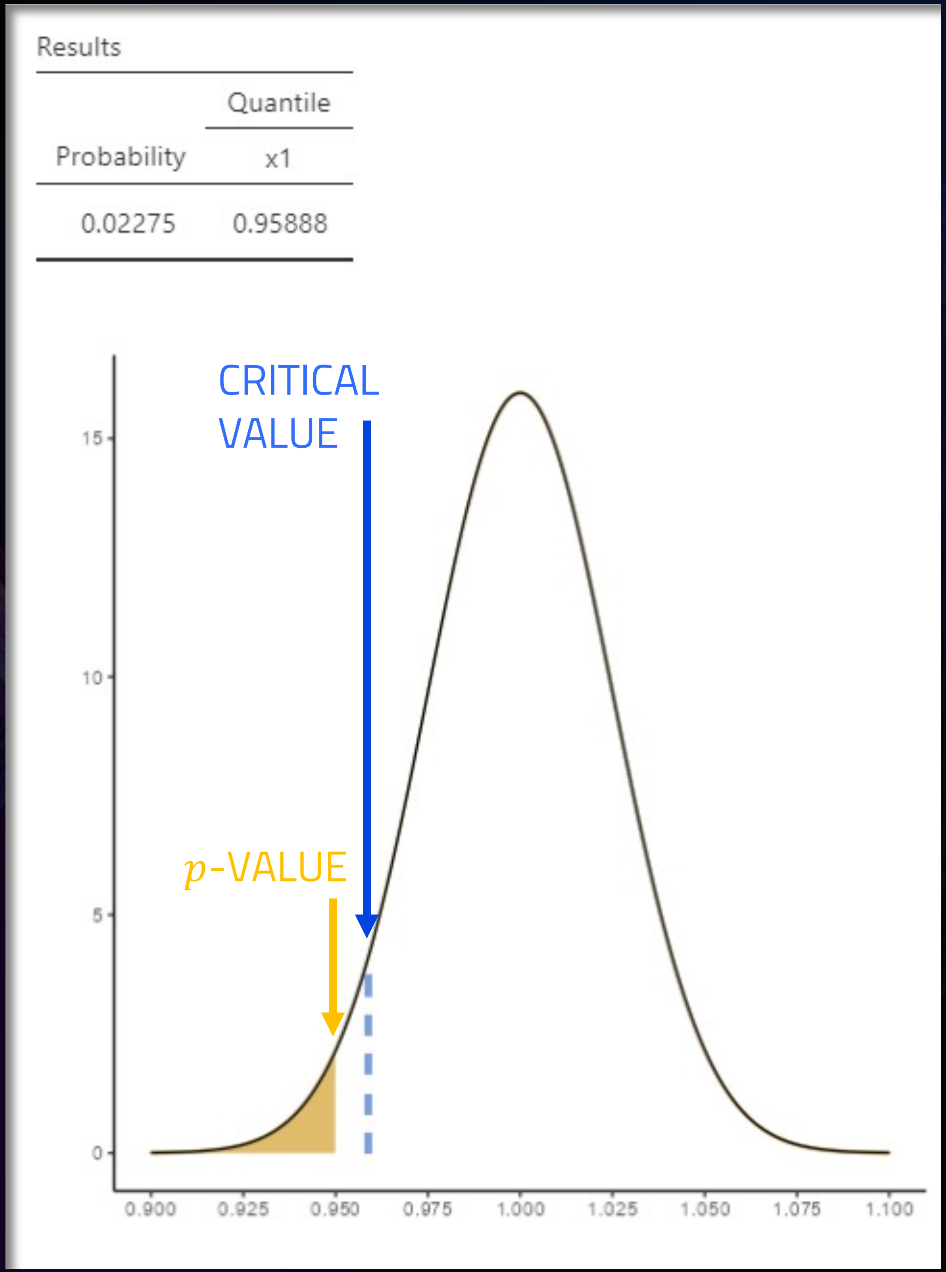
5. Decide whether to reject the null or not

   Check if the average weight is in the rejection region. In such case, the null is rejected, and it is concluded that the diet is effective.

6. State the appropriate conclusion

   If on the other hand the mean weight is NOT in the rejection region, it is concluded that there is insufficient evidence to show that the diet works.

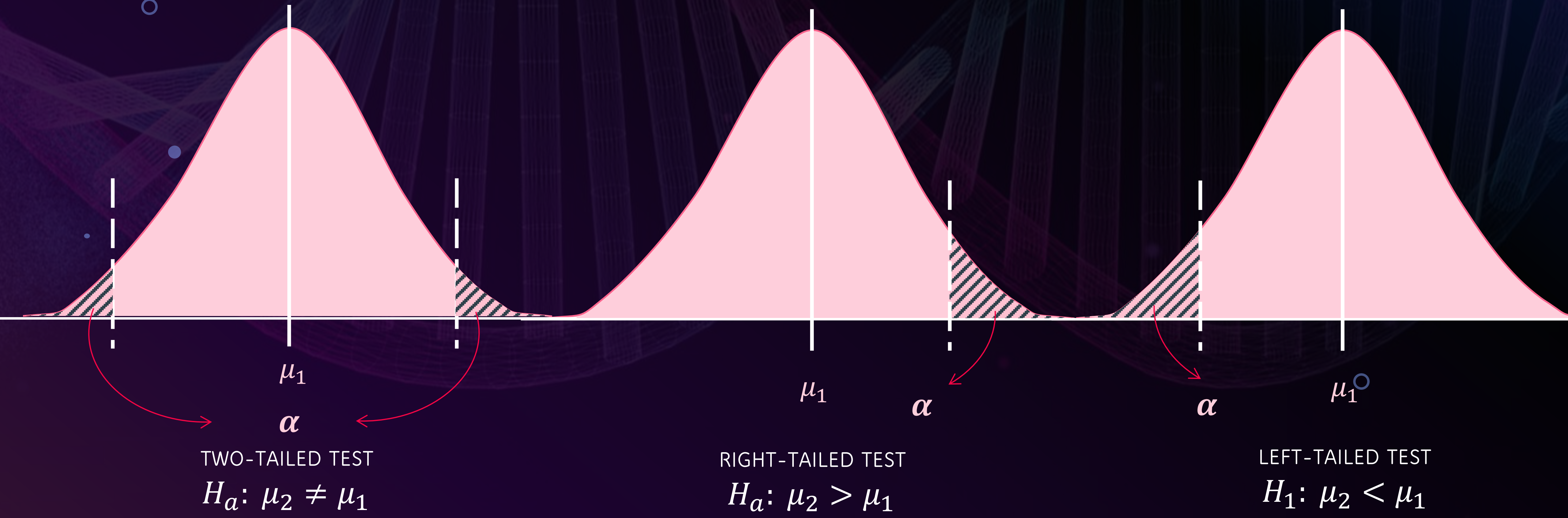
1. Identify and define the parameter(s) or relationship between variables being tested
2. State the null and alternative hypotheses
3. Set the level of significance (typically 0.1, 0.05, or 0.01)
4. Gather data, then check if it is unlikely to appear if the null hypotheses were true
5. Decide whether to reject the null or not
6. State the appropriate conclusion



Hypothesis testing

THE p-VALUE

Calculated from the appropriate statistical test, the p-value is the probability that you have found a particular set of observations if the null hypothesis were true.



Hypothesis testing

THE p-VALUE

- Calculated from the appropriate statistical test, the p-value is the probability that you have found a particular set of observations if the null hypothesis were true.

  You can use the p-value as an alternative in checking whether to reject the null hypothesis or not.

  If the p-value is less than or equal to α then the null hypothesis is rejected. **WHY?**

Hypothesis testing

THE p-VALUE

- Calculated from the appropriate statistical test, the p-value is the probability that you have found a particular set of observations if the null hypothesis were true.

  You can use the p-value as an alternative in checking whether to reject the null hypothesis or not.

  If the p-value is less than or equal to α then the null hypothesis is rejected. **WHY?**

When the p-value is small, then the chance that the sample appears is very small, if the null hypothesis were true.

This then leads us to **doubt the validity of the null hypothesis**.

Hypothesis testing

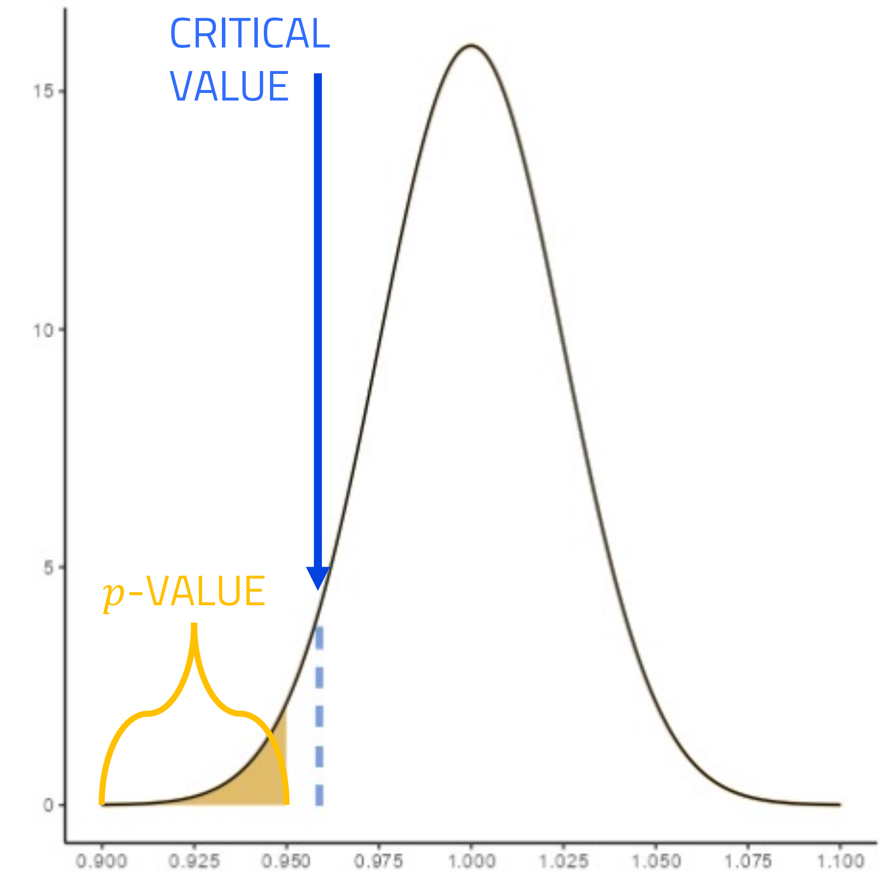
THE p-VALUE

- When the p-value is less than or equal to α it places the sample in the rejection region.

  Thus, we conclude that the null hypothesis should be rejected.

Results

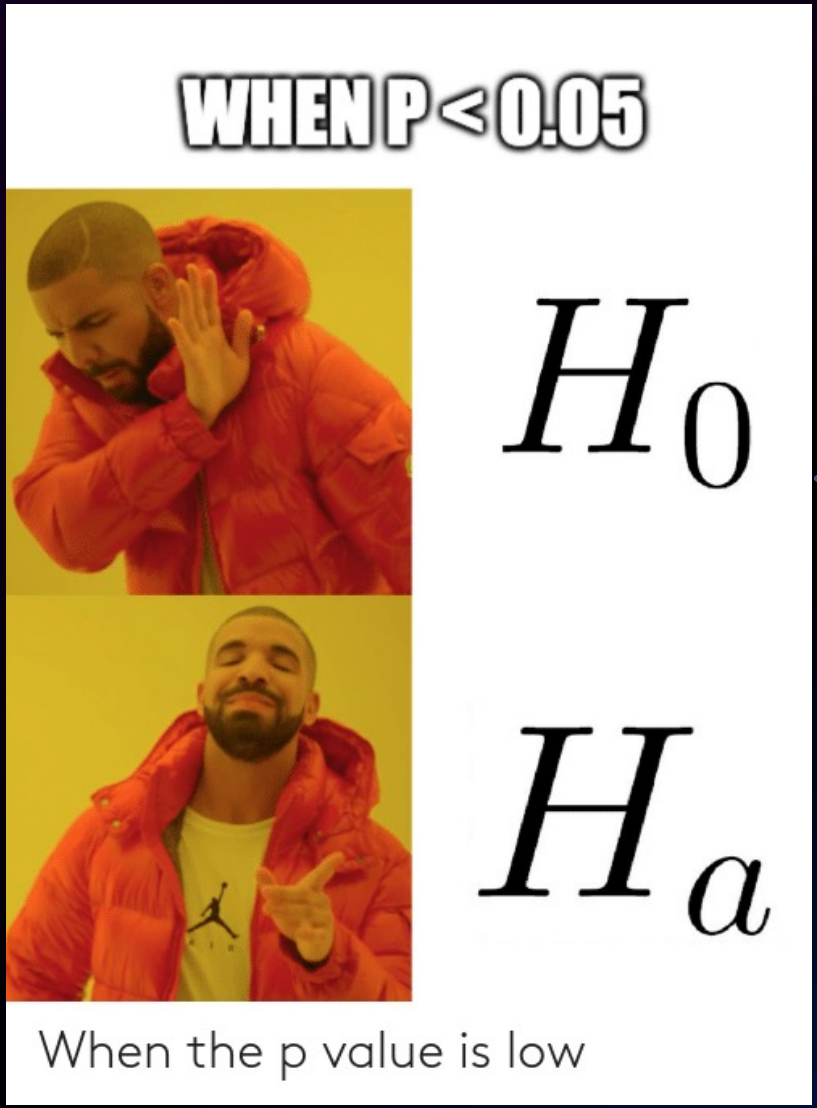
	Quantile
Probability	x1
0.02275	0.95888



The p-value


THAT MOMENT WHEN..
YOUR P VALUE IS LESS THAN .05
P > 0.05
GAME OVER, TRY AGAIN


p = 0.02
!
p < 0.05
inhales
THUS THE NULL HYPOTHESIS IS REJECTED AND THE OBSERVED DIFFERENCES CANNOT BE ATTRIBUTED TO CHANCE ALONE


WHEN P < 0.05
H_0
H_a
When the p value is low

BASIC STEPS IN HYPOTHESIS TESTING USING THE p-VALUE

1. Identify and define the parameter(s) or relationship between variables being tested
2. State the null and alternative hypotheses
3. Set the level of significance (typically 0.1, 0.05, or 0.01)
4. Collect data and compute the p-value
5. Compare the p-value and α then decide whether to reject the null hypothesis or not.
6. State the appropriate conclusion

Statistical Tests ABOUT MEANS

1. Test for a single mean
2. Test for comparing two means from independent groups
3. Test for comparing means from related groups (Week 2)

Testing for A SINGLE MEAN

Used when you want to compare the mean to a particular value

For example, in the tooth growth dataset, if you want to check if guinea pigs had an average growth rate that exceeds 15 mm at 5% level of significance.

You can also use this to test if the average screen time of students is above a set limit, for example 5 hours a day.

Tests for
A SINGLE MEAN

1. one-sample t-test
2. one-sample Wilcoxon test

ASSUMPTIONS & CONDITIONS

t-test for one sample

1. **RANDOM SAMPLE**
   The sample must have been randomly chosen.

2. **INDEPENDENCE**
   The data from one individual is not affected by that of another individual.

3. **ABSENCE OF OUTLIERS**
   There should not be any significant outliers

4. **NORMALITY**
   The variable should be approximately normally distributed.

ASSUMPTIONS & CONDITIONS

t-test for one sample

1. **RANDOM SAMPLE**
   The sample must have been randomly chosen.

2. **INDEPENDENCE**
   The data from one individual is not affected by that of another individual.

The first two conditions depend on how data was collected.

ASSUMPTIONS & CONDITIONS
t-test for one sample

These other two conditions need to be tested.

3. **ABSENCE OF OUTLIERS**
   There should not be any significant outliers

4. **NORMALITY**
   The variable should be approximately normally distributed.

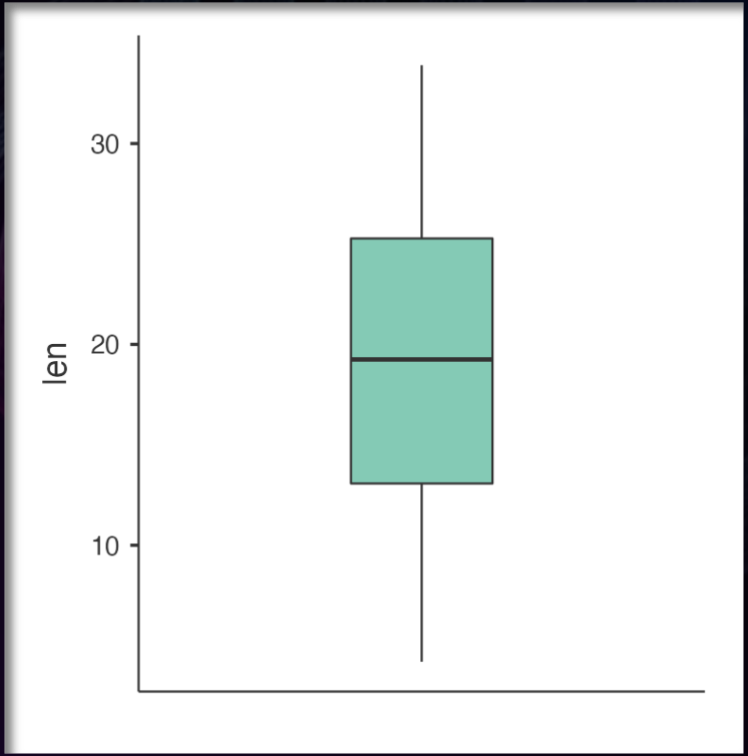
ASSUMPTIONS & CONDITIONS
t-test for one sample

3 **ABSENCE OF OUTLIERS**

There should not be any significant outliers

How do we check if a dataset has outliers?

We can generate and examine the box plot of the dataset for outliers.



ASSUMPTIONS & CONDITIONS

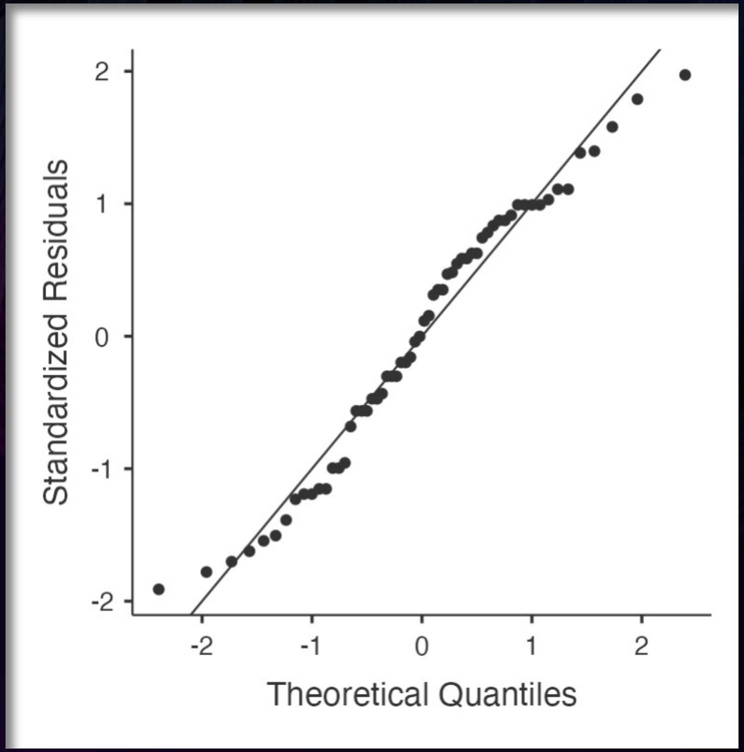
t-test for one sample

4 NORMALITY

The variable should be approximately normally distributed.

How do we know if the distribution is approximately normal?

Visually, we can study what is referred to as a **QUANTILE-QUANTILE (Q-Q) PLOT**

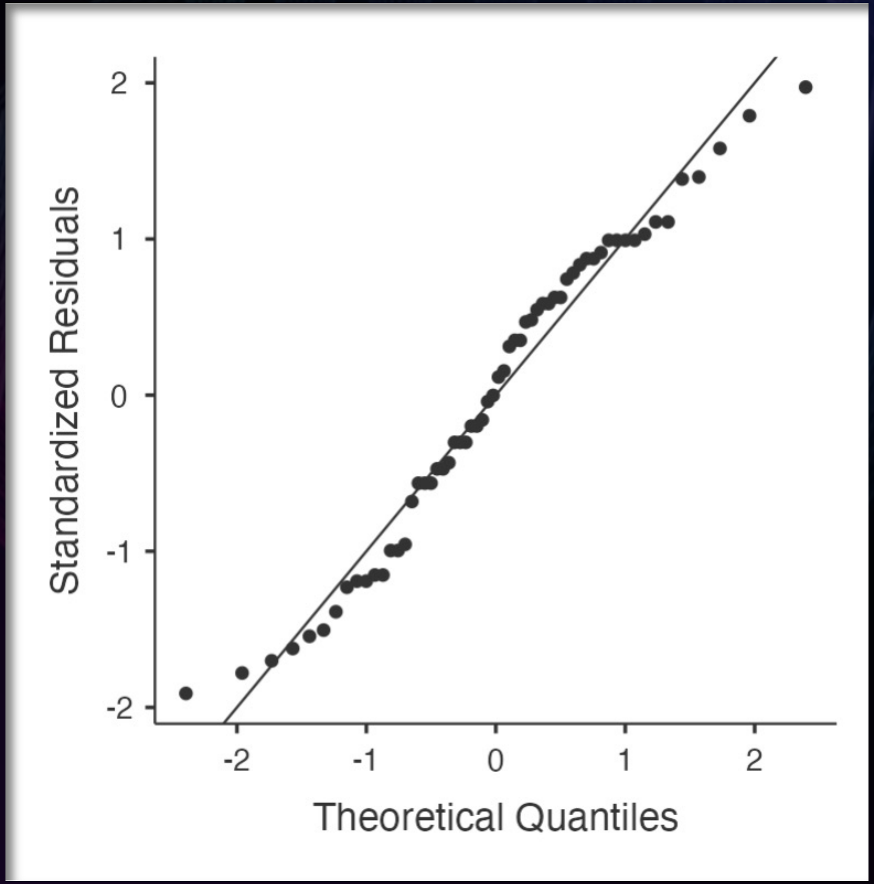


ASSUMPTIONS & CONDITIONS
t-test for one sample

How do we know if the distribution is approximately normal?

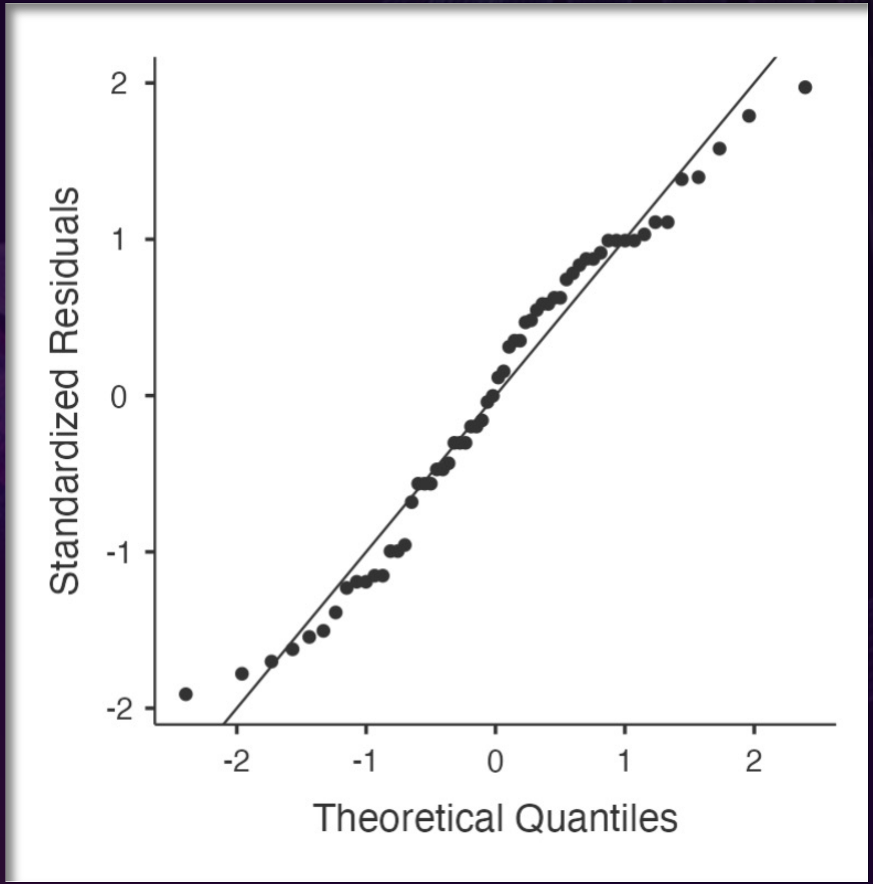
Visually, we can study what is referred to as a **QUANTILE-QUANTILE (Q-Q) PLOT**

- The Q-Q plot compares the quantiles of a theoretical distribution (e.g., normal) to the quantiles of a distribution of interest.



ASSUMPTIONS & CONDITIONS

t-test for one sample

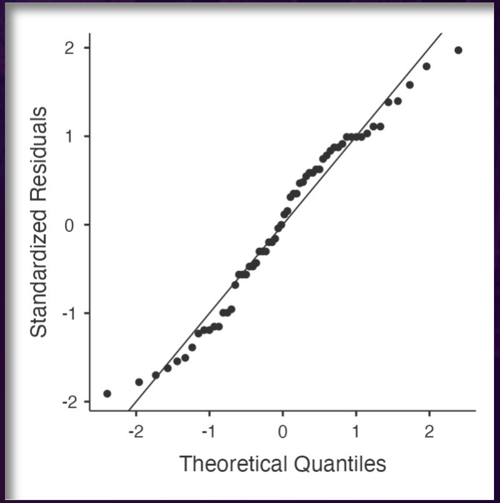


If the data is normally distributed, the points in a Q-Q plot will lie on a straight diagonal line.

Conversely, the more the points in the plot deviate significantly from a straight diagonal line, the less likely the set of data follows a normal distribution.

ASSUMPTIONS & CONDITIONS

t-test for one sample



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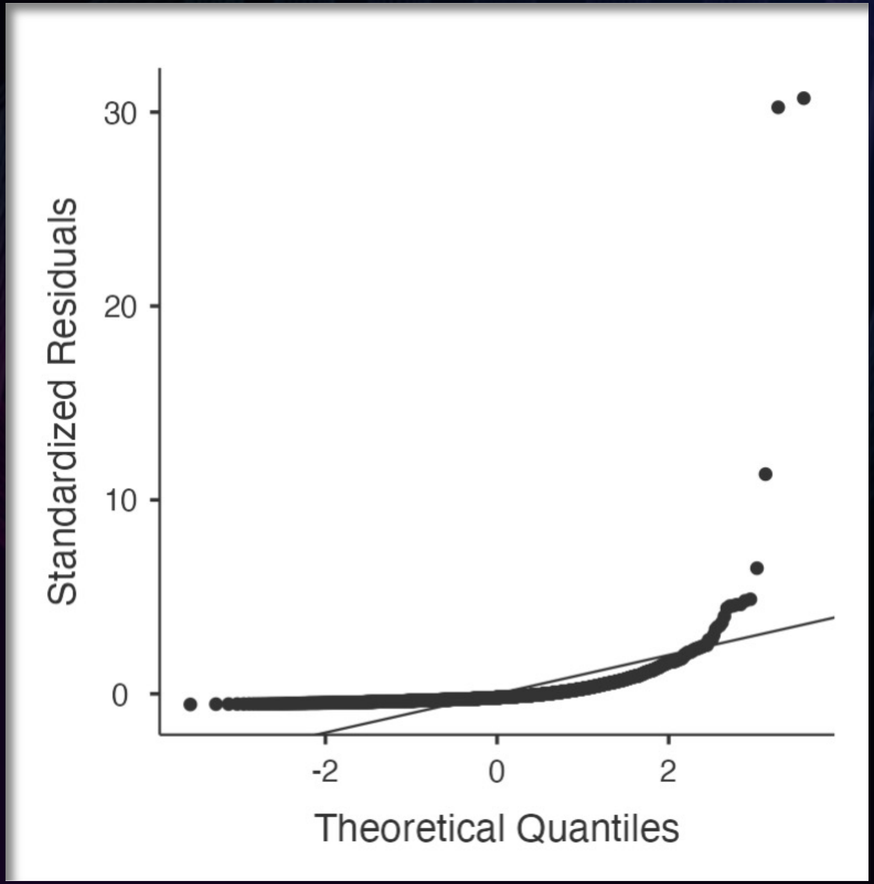
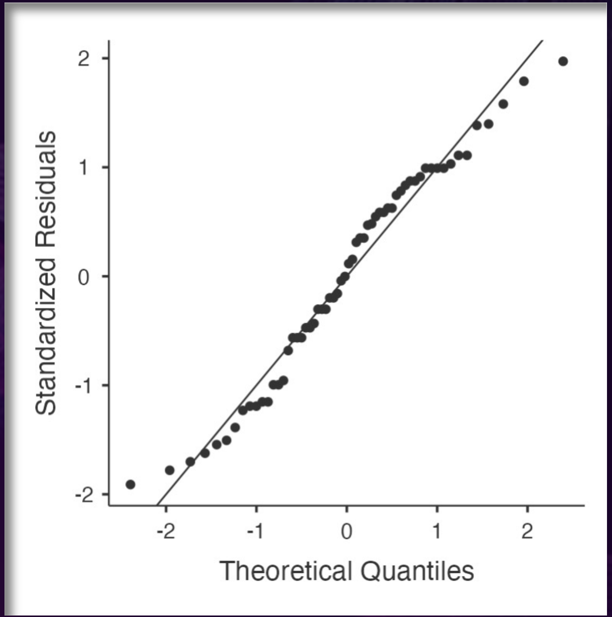
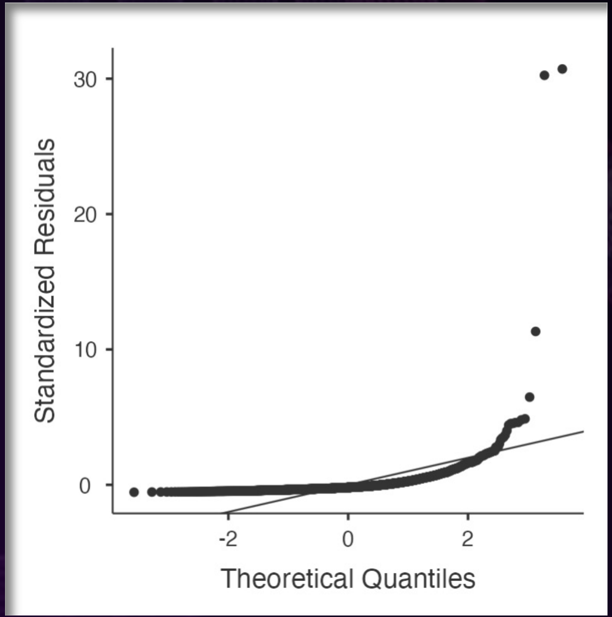


ASSUMPTIONS & CONDITIONS
t-test for one sample





Because it is just a visual check, examining the plot to determine the assumption of normality is somewhat subjective and is **not an air-tight proof**.

Read more about Q-Q plots **here**.

ASSUMPTIONS & CONDITIONS
Tests of Normality

A normality test determines whether a sample data has been drawn from a normally distributed population.

The null hypothesis is data are taken from a normally distributed population.

What p-value do we want as result of the normality test to establish the condition of normality?

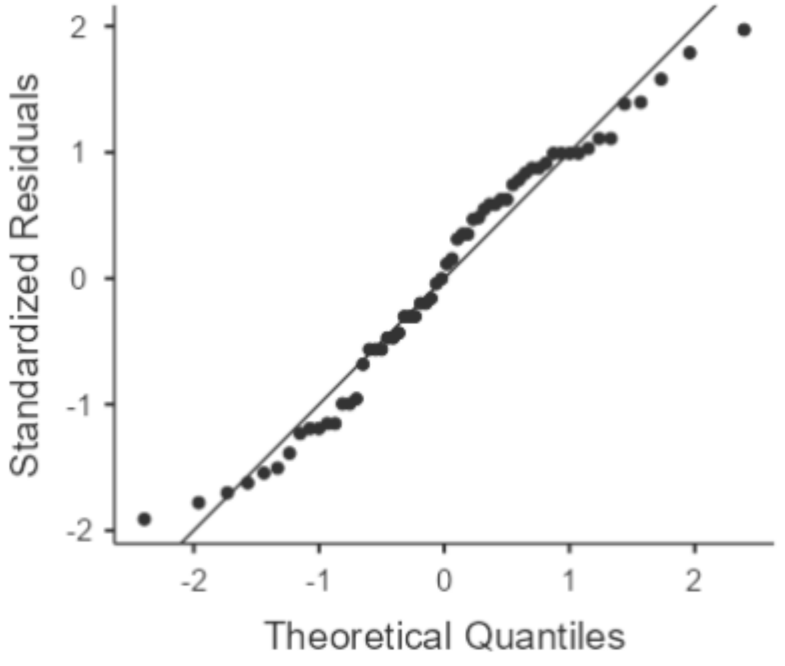
This is a test in which we want to RETAIN the null hypothesis because that means that the data from a normally distributed population. Thus, we want $p > \alpha$.

Tests of Normality

		statistic	p
len	Shapiro-Wilk	0.96743	0.10910
	Kolmogorov-Smirnov	0.09709	0.62369
	Anderson-Darling	0.64705	0.087090

Note. Additional results provided by *moretests*

Q-Q plots



ASSUMPTIONS & CONDITIONS

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Note. Additional results provided by *moretests*

Use **SHAPIRO-WILK TEST** if sample size is less than 50. Use **KOLMOGOROV-SMIRNOV TEST** if sample size is at least 50 .

For this dataset, the sample size is 60, so use the Kolmogorov-Smirnov test.

At $\alpha = 0.05$, a Kolmogorov-Smirnov test indicates that the tooth length of the population guinea pigs is not different from a normal distribution ($D(60) = 0.0971, p = 0.6237$).

ASSUMPTIONS & CONDITIONS

Tests of Normality

Tests of Normality

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significance level normality test

At $\alpha = 0.05$, a Kolmogorov-Smirnov test indicates that the tooth length of the population guinea pigs is not different from a normal distribution ($D(60) = 0.0971, p = 0.6237$).

sample size test statistic p-value

TESTING FOR A SINGLE MEAN
t-test for one sample

1. Identify and define the parameter(s) or relationship between variables being tested.
2. State the null and alternative hypotheses.
3. Set the level of significance (typically 0.1, 0.05, or 0.01) .
4. Determine the appropriate test and check the assumptions then, compute the p-value.

Consider the tooth growth dataset containing the length of odontoblasts of a sample of 60 guinea pigs. At 5 percent significance level, check the claim that the length of odontoblasts of guinea pigs given Vitamin C (either in the form of a supplement or orange juice) exceeds 15 mm.

Let μ be the **mean length** of the population of guinea pigs given Vitamin C.

$H_0: \mu = 15$ and $H_1: \mu > 15$

Set $\alpha = 0.05$

We want to compare a single mean with some value. Checking the conditions for a t-test of a single mean:

We assume that the guinea pigs were randomly sampled. Since the Vitamin C was administered per individual guinea pig, we can assume independence.

TESTING FOR A SINGLE MEAN

t-test for one sample

Consider the tooth growth dataset containing the length of odontoblasts of a sample of 60 guinea pigs. At 5 percent significance level, check the claim that the length of odontoblasts of guinea pigs given Vitamin C (either in the form of a supplement or orange juice) exceeds 15 mm.

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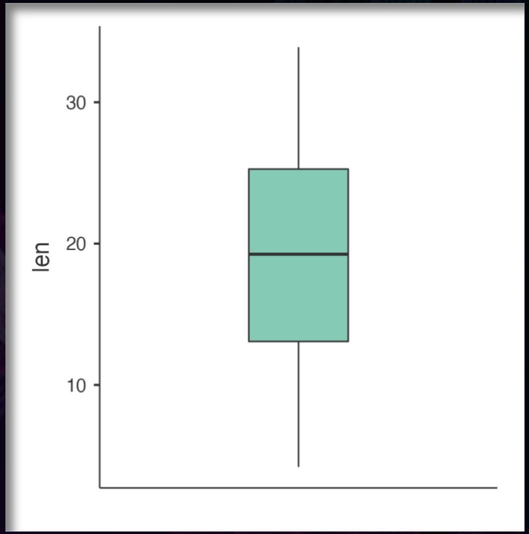

Both conditions regarding outliers and normality are satisfied by the data.

Tests of Normality

		statistic	p
len	Shapiro-Wilk	0.96743	0.10910
	Kolmogorov-Smirnov	0.09709	0.62369
	Anderson-Darling	0.64705	0.087090

Note. Additional results provided by *moretests*

TESTING FOR A SINGLE MEAN

t-test for one sample

1. Identify and define the parameter(s) or relationship between variables being tested.
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Consider the tooth growth dataset containing the length of odontoblasts of a sample of 60 guinea pigs. At 5 percent significance level, check the claim that the length of odontoblasts of guinea pigs given Vitamin C (either in the form of a supplement or orange juice) exceeds 15 mm.

Let μ be the **mean length** of the population of guinea pigs given Vitamin C.

$H_0: \mu = 15$ and $H_1: \mu > 15$

Set $\alpha = 0.05$

All assumptions and conditions of the t-test for one sample are met by the data.

One Sample T-Test

		Statistic	df	p
len	Student's t	3.8615	59.0000	1.412e–4

Note. H_a $\mu > 15$

TESTING FOR A SINGLE MEAN
t-test for one sample

5. Compare the p-value and α then decide whether to reject the null hypothesis or not.
6. State the appropriate conclusion.

Since $p < 0.05$, we reject H_0.

A t-test for one sample was conducted at $\alpha = 5\%$ and it was found that the mean length of odontoblasts of guinea pigs given Vitamin C supplements is significantly greater than 15 mm ($t(59) = 3.8615, p < 0.01$).

Consider the tooth growth dataset containing the length of odontoblasts of a sample of 60 guinea pigs. At 5 percent significance level, check the claim that the length of odontoblasts of guinea pigs given Vitamin C (either in the form of a supplement or orange juice) exceeds 15 mm.

Let μ be the **mean length** of the population of guinea pigs given Vitamin C.

H_0: $\mu = 15$ and H_1: $\mu > 15$

Set $\alpha = 0.05$

All assumptions and conditions of the t-test for one sample are met by the data.

One Sample T-Test

		Statistic	df	p
len	Student's t	3.8615	59.0000	1.412e–4

Note. H_a $\mu > 15$

EXAMPLE: Testing for A SINGLE MEAN

Dolan, Oort, Stoel, and Wicherts (2009) published a dataset on the Big 5 personality traits of 500 first year Dutch, psychology students. One of the dimensions of personality is called **Openness to Experience** which refers to one's willingness to try new things as well as engage in imaginative and intellectual activities. It includes the ability to "think outside of the box." The mean score can range from 1 to 5.

Suppose that another study determined that the mean openness score of first year Filipino psychology students is 3.84. **Is there a significant difference in the openness index between Dutch and Filipino psychology students? Test at $\alpha = 0.05$.**

WEEK ONE OF QUARTER FOUR

Hypothesis Testing

TESTS ABOUT MEANS

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WEEK ONE OF QUARTER FOUR

Lesson Outline

In this lesson, students should be able to:

- Recall previously-defined concepts in hypothesis testing
- Understand the p-value method
- Identify the appropriate test for one or two means
- Use Jamovi to employ tests for one mean and tests for two independent means

BASIC STEPS IN HYPOTHESIS TESTING

USING THE p-VALUE

1. Identify and define the parameter(s) or relationship between variables being tested
2. State the null and alternative hypotheses
3. Set the level of significance (typically 0.1, 0.05, or 0.01)
4. Collect data and compute the p-value
5. Compare the p-value and α then decide whether to reject the null hypothesis or not.
6. State the appropriate conclusion

Tests for
A SINGLE MEAN

1. one-sample t-test
2. one-sample Wilcoxon test

ASSUMPTIONS & CONDITIONS

t-test for one sample

1 RANDOM SAMPLE
The sample must have been randomly chosen.

2 INDEPENDENCE
The data from one individual is not affected by that of another individual.

3 ABSENCE OF OUTLIERS
There should not be any significant outliers

4 NORMALITY
The variable should be approximately normally distributed.

EXAMPLE: Testing for A SINGLE MEAN

Extraversion reflects the tendency and intensity to which someone seeks interaction with their environment, particularly socially. It encompasses the comfort and assertiveness levels of people in social situations.

Determine at $\alpha = 0.05$ if the extraversion index of first year Psychology students in the Netherlands in 2008 is significantly less than 3.50.

Testing for
A SINGLE MEAN

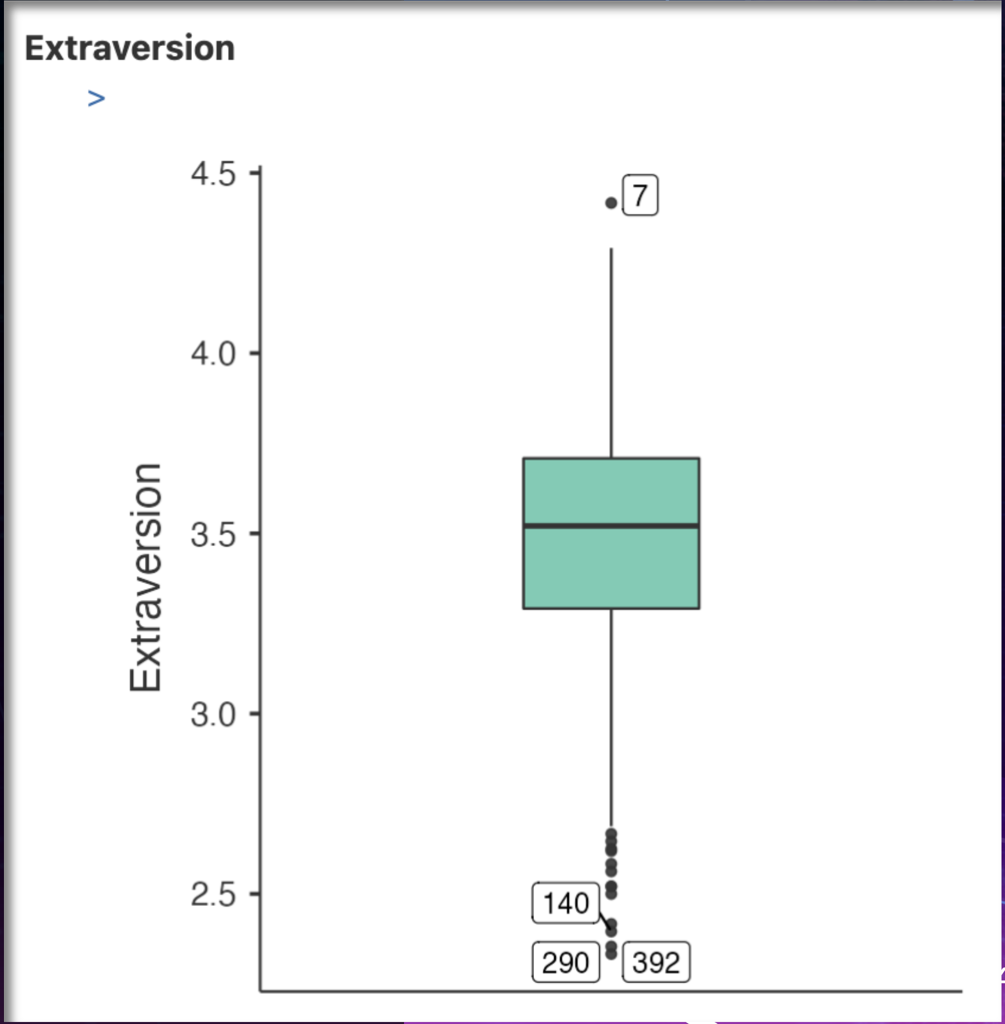
What if any of the assumptions is/are NOT fulfilled by the dataset?

Tests of Normality

		statistic	p
Extraversion	Shapiro-Wilk	0.9862	1.091e–4
	Kolmogorov-Smirnov	0.0537	0.1119
	Anderson-Darling	1.8204	1.170e–4

Note. Additional results provided by *moretests*

The distribution of extraversion indices among first year Dutch psychology students in 2008 does not fulfill the condition regarding outliers.



Parametric and Nonparametric Tests

PARAMETRIC STATISTICS are based on assumptions about the distribution of population from which the sample was taken.

NONPARAMETRIC STATISTICS are not based on assumptions. That is, the data can be collected from a sample that does not follow a specific distribution.

Parametric tests are, in general, more powerful than nonparametric tests. Nonparametric tests are used in cases where parametric tests are not appropriate. **When at least one of the assumptions of a parametric test is not fulfilled by the distribution, we use a nonparametric equivalent.**

WILCOXON SIGNED RANKS TEST

This non-parametric test is appropriate to use when testing for a single mean when there are outliers in the distribution.

What parameter is tested (used as basis for comparison) in this test?

The test uses the median as a measure of center because the median is not susceptible to outliers.

TESTING FOR A SINGLE MEDIAN
WILCOXON SIGNED RANKS TEST

This non-parametric test is appropriate to use when testing for a single mean when there are outliers in the distribution.

What parameter is tested (used as basis for comparison) in this test?

The test uses the median as a measure of center because the median is not susceptible to outliers.

TESTING FOR A SINGLE MEAN
WILCOXON SIGNED RANKS TEST

1. Identify and define the parameter(s) or relationship between variables being tested.
2. State the null and alternative hypotheses.
3. Set the level of significance (typically 0.1, 0.05, or 0.01) .
4. Determine the appropriate test and compute the p-value.
5. Compare the p-value and α then decide whether to reject the null hypothesis or not.
6. State the appropriate conclusion.

Determine at $\boldsymbol{\alpha}$=**0.05** if the extraversion index of first year Psychology students in the Netherlands in 2008 is significantly less than 3.50.

Let η be the **median extraversion index** of first year Dutch Psychology students in 2008.

$H_0: \eta = 3.5$ and $H_1: \eta < 3.5$

Set $\alpha = 0.05$

After failing one of the conditions for the appropriate parametric test, we want to compare the median of a distribution with some value.

One Sample T-Test

		Statistic	p
Extraversion	Wilcoxon W	59065.0000	0.4553

Note. H_a $\mu < 3.5$

TESTING FOR A SINGLE MEAN
WILCOXON SIGNED RANKS TEST

1. Identify and define the parameter(s) or relationship between variables being tested.
2. State the null and alternative hypotheses.
3. Set the level of significance (typically 0.1, 0.05, or 0.01) .
4. Determine the appropriate test and compute the p-value.
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Determine at $\boldsymbol{\alpha}=\mathbf{0.05}$ if the extraversion index of first year Psychology students in the Netherlands in 2008 is significantly less than 3.50.

Let η be the **median extraversion index** of first year Dutch Psychology students in 2008.

$H_0\colon \eta = 3.5$ and $H_1\colon \eta < 3.5$

Set $\alpha = 0.05$

After failing one of the conditions for the appropriate parametric test, we want to compare the median of a distribution with some value.

Since $p > 0.05$, we fail to reject H_0.

A Wilcoxon Signed Ranks Test found at $\alpha = 5\%$ that the extraversion index of first year Dutch Psychology students is not significantly different from 3.50 ($\mathrm{W} = 59065, p = 0.4553$).

TESTING FOR A DIFFERENCE
BETWEEN TWO INDEPENDENT MEANS

t-test for two independent samples

Used when you want to compare the means of two **DISTINCT** groups from each other

For example, in the tooth growth dataset, you may want to compare the tooth length between guinea pigs that took supplements vs. those that drank orange juice.

TESTING FOR A DIFFERENCE BETWEEN TWO INDEPENDENT MEANS

t-test for two independent samples

1. Identify and define the parameters being tested.
2. State the null and alternative hypotheses.
3. Set the level of significance
4. Determine the appropriate test, check assumptions, and compute the p-value.
5. Compare the p-value and α then decide whether to reject the null hypothesis or not.
6. State the appropriate conclusion.

Sixty guinea pigs were given one of two forms (supplement and orange juice) of Vitamin C. At $\alpha = 0.05$, determine if there is a significant difference between the tooth length of guinea pigs that took supplements vs. those that drank orange juice.

Let μ_s be the mean tooth length of guinea pigs who took supplements and μ_j be the mean tooth length of guinea pigs who drank orange juice.

$H_0: \mu_s = \mu_j$ and $H_1: \mu_s \neq \mu_j$

Set $\alpha = 0.05$

Let us check if assumptions of the t-test for two independent samples is satisfied.

ASSUMPTIONS & CONDITIONS

t-test for two independent samples

1. **RANDOM SAMPLE**
   The sample must have been randomly chosen.

2. **INDEPENDENCE**
   The data from one individual is not affected by that of another individual.

3. **ABSENCE OF OUTLIERS**
   There should not be any significant outliers

4. **NORMALITY**
   The variable should be approximately normally distributed.

5. **HOMOGENEITY OF VARIANCE**
   The variances of the quantitative variable in both groups must be equal.

ASSUMPTIONS & CONDITIONS

t-test for two independent samples

1. **RANDOM SAMPLE**
   The sample must have been randomly chosen.
   Determined by data collection process.

2. **INDEPENDENCE**
   The data from one individual is not affected by that of another individual.
   Determined by data collection process.

3. **ABSENCE OF OUTLIERS**
   There should not be any significant outliers
   Check using box plot.

4. **NORMALITY**
   The variable should be approximately normally distributed.
   Check at $\alpha = 0.05$ using appropriate normality test.

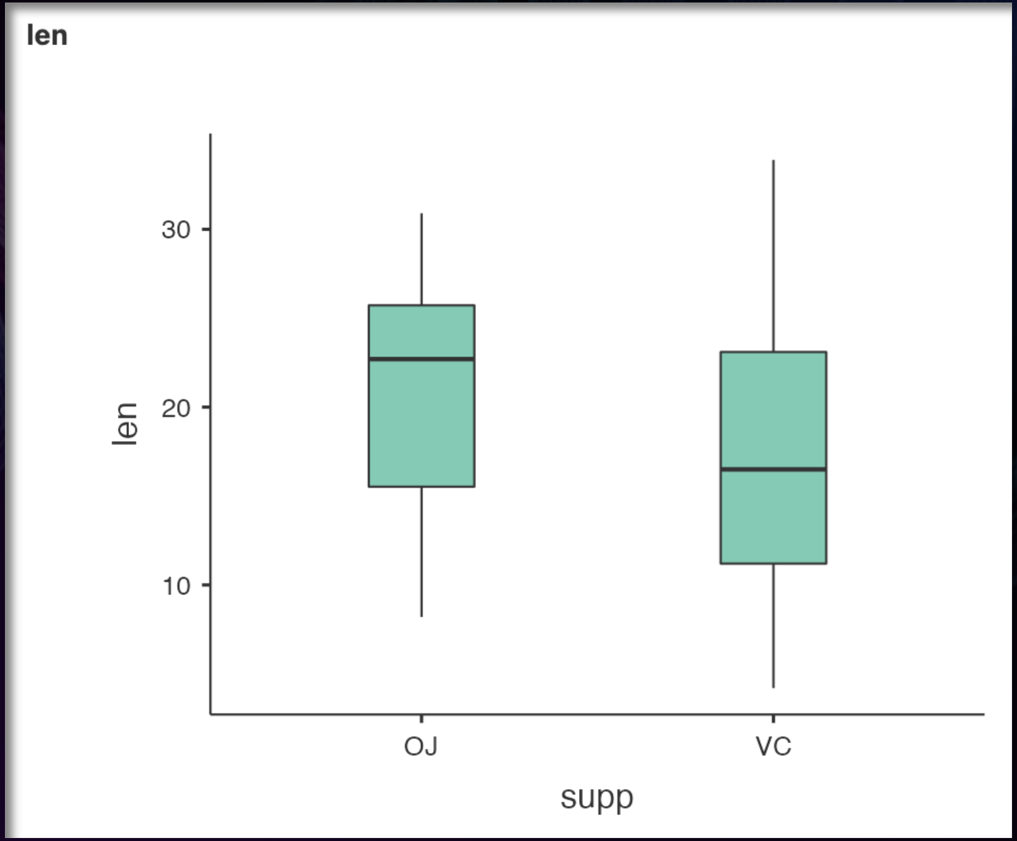
5. **HOMOGENEITY OF VARIANCE**
   The variances of the quantitative variable in both groups must be equal.
   Check at $\alpha = 0.05$ using
   Levene's Test of Equality of Variance

ASSUMPTIONS & CONDITIONS
t-test for two independent samples

3 ABSENCE OF OUTLIERS

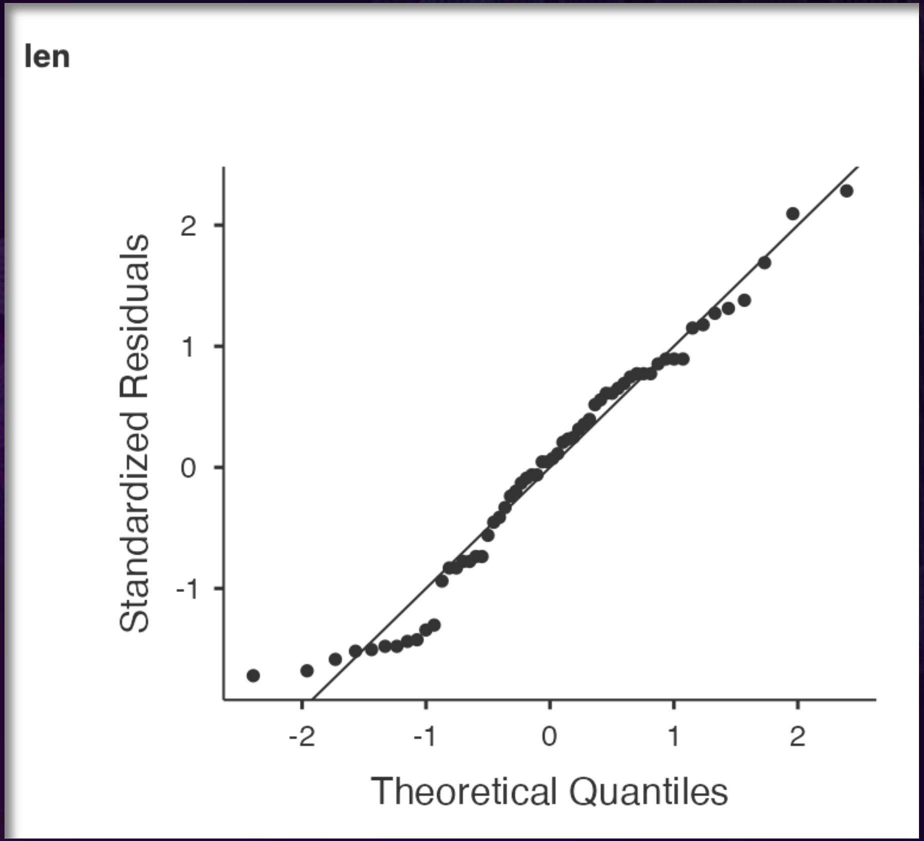
There should not be any significant outliers

Check using box plot.



ASSUMPTIONS & CONDITIONS

t-test for two independent samples



4

NORMALITY

The variable should be approximately normally distributed.

Check at $\alpha = 0.05$ using appropriate normality test.

Tests of Normality

		statistic	p
len	Shapiro-Wilk	0.9695	0.1378
	Kolmogorov-Smirnov	0.0870	0.7543
	Anderson-Darling	0.5145	0.1850

Note. Additional results provided by *moretests*

ASSUMPTIONS & CONDITIONS

t-test for two independent samples

Homogeneity of Variances Tests

		F	df	df2	p
len	Levene's	1.0973	1	58	0.2992
	Variance ratio	0.6386	29	29	0.2331

Note. Additional results provided by *moretests*

5 HOMOGENEITY OF VARIANCE

The variances of the quantitative variable in both groups must be equal.

Check at $\alpha = 0.05$ using

Levene's Test of Equality of Variance

The Levene's test tests the claim (H_0) that there is no significant difference in the variances in both groups (i.e., the variances are equal).

To use the t-test, we must NOT reject the null hypothesis to show that the variances are equal.

TESTING FOR A DIFFERENCE BETWEEN TWO INDEPENDENT MEANS

t-test for two independent samples

1. Identify and define the parameters being tested.
2. State the null and alternative hypotheses.
3. Set the level of significance
4. Determine the appropriate test, check assumptions, and compute the p-value.
5. Compare the p-value and α then decide whether to reject the null hypothesis or not.
6. State the appropriate conclusion.

Sixty guinea pigs were given one of two forms (supplement and orange juice) of Vitamin C. At $\alpha = 0.05$, determine if there is a significant difference between the tooth length of guinea pigs that took supplements vs. those that drank orange juice.

Let μ_s be the mean tooth length of guinea pigs who took supplements and μ_j be the mean tooth length of guinea pigs who drank orange juice.

$H_0: \mu_s = \mu_j$ and $H_1: \mu_s \neq \mu_j$

Set $\alpha = 0.05$

All assumptions of the t-test for two independent samples are satisfied by the data.

Independent Samples T-Test

		Statistic	df	p
len	Student's t	1.9153	58.0000	0.06039

Note. H_a $\mu_{OJ} \neq \mu_{VC}$

TESTING FOR A DIFFERENCE BETWEEN TWO INDEPENDENT MEANS

t-test for two independent samples

5 Compare the p-value and α then decide whether to reject the null hypothesis or not.

6 State the appropriate conclusion.

Since $p > 0.05$, we fail to reject H_0.

A t-test for two independent samples was conducted at $\alpha = 5\%$ and it was found that there is not enough evidence to support that the mean length of odontoblasts of guinea pigs given Vitamin C supplements is significantly different from the mean length of odontoblasts of those given with orange juice ($t(58) = 1.9153, p = 0.0604$).

Sixty guinea pigs were given one of two forms (supplement and orange juice) of Vitamin C. At $\alpha = 0.05$, determine if there is a significant difference between the tooth length of guinea pigs that took supplements vs. those that drank orange juice.

Let μ_s be the mean tooth length of guinea pigs who took supplements and μ_j be the mean tooth length of guinea pigs who drank orange juice.

H_0: $\mu_s = \mu_j$ and H_1: $\mu_s \neq \mu_j$

Set $\alpha = 0.05$

All assumptions of the t-test for two independent samples are satisfied by the data.

Independent Samples T-Test

		Statistic	df	p
len	Student's t	1.9153	58.0000	0.06039

Note. H_a $\mu_{OJ} \neq \mu_{VC}$

TESTING FOR A DIFFERENCE
BETWEEN TWO INDEPENDENT MEANS/MEDIANS

NONPARAMETRIC TESTS

What if any of the assumptions is/are NOT fulfilled by the dataset?

1. **WELCH'S TEST** is a test of means that assumes normality but not equal variances. Use this when the distribution fails the Levene's test.

2. **MANN-WHITNEY U TEST** is a test of medians that assumes equal variances but not normality. Use this when the distribution fails the normality test.

EXAMPLE: Testing for TWO INDEPENDENT MEANS

A study was conducted by Ryan, Wilde, and Crist (2013) on the hostility of 92 individuals to different types of insects classified according to digustingness and frighteningness.

Determine if there is a significant difference in the mean (or median) hostility rating for LDLF insects between male and female respondents. Set the level of significance to 0.05.

EXAMPLE: Testing for

TWO INDEPENDENT MEANS

Determine if the mean (or median) hostility rating for HDLF insects of males is significantly greater than the hostility rating of the same insects of the females. Set the level of significance to 0.1.

EXAMPLE:

TESTING FOR TWO MEANS

Drunk driving is one of the main causes of car accidents. Interviews with drunk drivers who were involved in accidents and survived revealed that one of the main problems is that drivers do not realize that they are impaired.

A random sample of 20 drivers was chosen, and their reaction times in an obstacle course were measured before and after drinking two beers. At α=0.05, determine if the difference in the reaction time before and after drinking two cans of beer is significant .

University of Florida, Biostatistics Open Learning Textbook (accessed 13 April 2023) Paired Samples.