Introduction to Hypothesis Testing

# Overview

Hypothesis testing is a statistical method that allows you to make inferences or draw conclusions about a population based on sample data. It is used to determine whether there is enough evidence to reject a null hypothesis.

# Key Concepts

## Hypothesis

Null Hypothesis (H₀): A statement of no effect or no difference, which serves as the default assumption.  
Alternative Hypothesis (H₁ or Ha): A statement that contradicts the null hypothesis, indicating the presence of an effect or difference.

## Significance Level (α)

The probability of rejecting the null hypothesis when it is true (Type I error).  
Common significance levels are 0.05, 0.01, and 0.10.

## P-Value

The probability of obtaining a test statistic at least as extreme as the one observed, assuming the null hypothesis is true.  
If the p-value is less than the significance level (α), the null hypothesis is rejected.

## Test Statistic

A standardized value used to determine the p-value. Examples include the z-score, t-score, and chi-square statistic.

## Decision Rule

Based on the p-value and significance level, decide whether to reject or fail to reject the null hypothesis.

# Steps in Hypothesis Testing

## State the Hypotheses

Formulate the null hypothesis (H₀) and the alternative hypothesis (H₁).

## Choose the Significance Level (α)

Decide on the significance level for the test.

## Collect Data and Compute Test Statistic

Gather sample data and calculate the appropriate test statistic.

## Determine the P-Value

Use the test statistic to find the p-value.

## Make a Decision

Compare the p-value with the significance level and decide whether to reject or fail to reject the null hypothesis.

## Draw a Conclusion

Interpret the results in the context of the research question.

# Types of Hypothesis Tests

## One-Sample Tests

Used to compare the sample mean to a known value or population mean.  
Example: One-sample t-test.

## Two-Sample Tests

Used to compare the means of two independent samples.  
Example: Two-sample t-test (independent t-test).

## Paired Sample Tests

Used to compare means from the same group at different times.  
Example: Paired t-test.

## Proportion Tests

Used to compare sample proportions to a known proportion or between groups.  
Example: Z-test for proportions.

## Chi-Square Tests

Used to test relationships between categorical variables.  
Example: Chi-square test of independence.

# Example: One-Sample t-Test

## State the Hypotheses

H₀: The population mean is equal to a specified value (μ = μ₀).  
H₁: The population mean is not equal to the specified value (μ ≠ μ₀).

## Choose the Significance Level (α)

α = 0.05.

## Collect Data and Compute Test Statistic

Calculate the sample mean (X̄), sample standard deviation (s), and sample size (n).  
Compute the t-statistic:  
t = (X̄ - μ₀) / (s / √n)

## Determine the P-Value

Use the t-distribution to find the p-value associated with the computed t-statistic.

## Make a Decision

If p-value < 0.05, reject H₀.  
If p-value ≥ 0.05, fail to reject H₀.

## Draw a Conclusion

Based on the decision, conclude whether there is enough evidence to reject the null hypothesis in the context of the research question.

# Importance of Hypothesis Testing

Provides a structured framework for making decisions based on data.  
Helps in understanding the relationships and differences between variables.  
Widely used in scientific research, business, medicine, and various other fields.