my-ebook

Parmeshvar

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Interest: Goal Orientation Job Performance Consumer Behavior Behavioral Finance Bibiliometric Analysis Options as Derivatives Statistics Indian Knowledge System,

Orcid ID
Google Scholar
GitHub
Researcher ID
Personal Website
Youtube ID

Doing a PhD with me: README.1st

Academic Profile

Topics to be covered:

1. Basic probability theory, random variable theory (including jointly distributed RVs), probability distributions (including bivariate distributions)
2. Using Bayes' rule for statistical inference
3. An introduction to (generalized) linear models
4. An introduction to hierarchical models
5. Measurement error models
6. Mixture models
7. Model selection and hypothesis testing (Bayes factor and k-fold cross-validation)

2.1 Teaching

Science and statistics is/are one unitary thing; you cannot do one without the other. Towards this end, I teach some (in my opinion) critically important classes that provide a solid statistical foundation for doing research in cognitive science.

Courses offered:

1. Free online course, four weeks (MOOC), enrollments open: Introduction to Bayesian Data Analysis

2. Short (four-hour) tutorial on Bayesian statistics, taught at EMLAR 2022: here
3. Introduction to (frequentist) statistics
4. Introduction to Bayesian data analysis for cognitive science
5. BDA cover

2.2 Lecture notes

Download from here.

2.3 Moodle website

All communications with students in Potsdam will be done through this website. # Schedule

Week	Lecture	Main Topic	Subtopic	Video	PDF Resource
Week 2	1	Descriptive Statistics	Central Tendency	Video	Week 2.pdf
	2	Descriptive Statistics	Measure of Variability	Video	Same as above
	3	Descriptive Statistics	Describing Data	Video	Same as above
	4	Descriptive Statistics	Probability	Video	Same as above
	5	Descriptive Statistics	Distribution	Video	Same as above
Week 3	1	Descriptive Statistics	Z Table (Normal Distribution)	Video	Week 3.pdf
	2	Descriptive Statistics	Measuring Divergence	Video	Same as above
	3	Inferential Statistics	Sample and Population	Video	Same as above
	4	Inferential Statistics	Model Fit	Video	Same as above
	5	Inferential Statistics	Hypothesis and Error	Video	Same as above

Week	Lecture	Main Topic	Subtopic	Video	PDF Resource
Week 4	1	Terms of Statistics	Terms of Statistics	Video	Week 4.pdf
	2	Terms of Statistics	T-Test	Video	Same as above
	3	Terms of Statistics	T-Test in Detail	Video	Same as above
	4	ANOVA	ANOVA	Video	Same as above
Week 5	1	ANOVA	Example of ANOVA	Video	Week 5.pdf
	2	ANOVA	Types of ANOVA	Video	Same as above
	3	Correlation	Introduction to Correlation	Video	Same as above
	4	Correlation	Regression (Part 1)	Video	Same as above
	5	Correlation	Regression (Part 2)	Video	Same as above
Week 6	1	Correlation	R Script for Regression	Video	Week 6.pdf
	2	Chi Square	Chi Square	Video	Same as above
	3	Chi Square	Chi Square Test	Video	Same as above
	4	Logistic Function	Regression Function	Video	Same as above
	5	Logistic Function	Distribution	Video	Same as above
Week 7	1	Time Series	Intro to Time Series	Video	Week 7.pdf
	2	Time Series	Conditional Probability	Video	Same as above
	3	Time Series	Additional Concepts	Video	Same as above
	4	Time Series	Distribution	Video	Same as above
	5	Time Series	Poisson Distribution	Video	Same as above
	6	Index Numbers	Price & Quantity Index	Video	Same as above

Week	Lecture	Main Topic	Subtopic	Video	PDF Resource
	7	Decision Environments	Risk/Uncertainty, Bayes, Trees	Video	Same as above
	8	Time Series Analysis	Components, Trend, Seasonality	Video	Same as above
	9	Time Series Analysis	Least Squares Method	Video	Same as above
Week 8	1	Effect Size & Documentation	Package/Library	Video	Week 8.pdf
	2	Effect Size & Documentation	RStudio vs RKward	Video	Same as above
	3	Effect Size & Documentation	Flexplot	Video	Same as above
	4	Effect Size & Documentation	Functions	Video	Same as above
	5	Effect Size & Documentation	R Shiny & R Markdown	Video	Same as above
	6	Effect Size & Documentation	Application with Real Datasets	Video	Same as above
	7	Effect Size & Interpretation	Importance in Testing	Video	Same as above

Week	Lecture	Main Topic	Subtopic	Video	PDF Resource
	8	Effect Size & Interpretation	Installing dplyr, ggplot2	Video	Same as above
	9	Effect Size & Interpretation	Visual Model Interpretation	Video	Same as above
	10	Effect Size & Interpretation	Creating/Using Functions	Video	Same as above
	11	Effect Size & Interpretation	Report, Dashboard, Interactivity	Video	Same as above

3 Week 1

4 Module 1: Introduction to Statistics

4.1 Pre-Requisites

- Just an open and eager mind
- Basic understanding of Mathematics or Statistics

4.2 Agenda

- Meaning of Statistics
- Nature and Scope
- Uses of Statistics
- Limitations
- Fallacies and Misuse
- Math vs Statistics
- GUI Tools & Transition to Software-based Stats

4.3 Meaning of Statistics

Statistics is a science which provides tools for **analysis and interpretation** of raw data collected for decision-making in diverse fields.

It includes four core concepts:

- **Population** – Complete data or total group
- **Sample** – Subset of population
- **Parameter** – Numerical summary from population
- **Statistic** – Numerical summary from sample

4.4 Nature of Statistics

- Deals with **numerical facts**
- Focused on **social phenomena** and real-world data
- Organizes, classifies, and analyzes data
- Facilitates **prediction**, **interpretation**, and **decision-making**

4.5 Uses of Statistics

- Drawing representative samples
- Summarizing collected data
- Tabulation and systematic arrangement
- Group comparisons
- Determining behavioral relationships
- Estimating chance vs causation
- Application in:
  - Psychology
  - Education
  - Employment surveys
  - Market Research
  - Industrial and Organizational studies

4.6 Limitations of Statistics

- Cannot study **qualitative phenomena** without quantification
- Not applicable to individuals
- **Statistical laws are not exact**
- Does not guarantee **causal relationships**
- Vulnerable to misuse

4.7 Misuse of Statistics

- Use of extremely **small or biased** samples
- **Misleading graphs** or visual misrepresentation
- Illogical or **unexpected comparisons**

4.8 Fallacies in Statistics

Fallacies may arise from:

- Poor data collection methods
- Vague or manipulated term definitions
- Improper unit selection
- Faulty classification or grouping
- Inappropriate statistical methods

5 Module 2: Mathematics vs Statistics

Aspect	Mathematics	Statistics
Nature	Abstract, symbolic reasoning	Applied, data-based reasoning
Focus	Pure logic, proofs	Real-world data, decision-making
Techniques	Algebra, Calculus, Geometry	Probability, Hypothesis testing, Regression
Output	Theorems, functions, formulas	Inferences, predictions, summaries
Tools	Equations, graphs	Charts, tables, models

6 Module 3: Software-Based Statistical Revolution

6.1 From Paper to Code

Why shift to software?

- **Faster analysis** of massive data
- **Error-free calculations**
- **Anywhere-anytime** access
- **Cloud-based integration**
- Supports **ML/AI**, automation, and deep visualization

6.2 Popular Statistical Software

Software	Type	Use Case
R	Script	Core for academic and professional stats
RKWard	GUI	GUI wrapper for R
R Commander	GUI	Menu-based GUI for R
Rattle	GUI	Data mining toolkit in R
Excel	GUI	Basic stats with plugins
Python (pandas)	Script	Modern data science + ML

6.3 GUI vs CLI

Feature	GUI (e.g., RKWard)	Command Line (e.g., R Console)
Accessibility	User-friendly	Requires learning syntax
Speed	Slower for heavy tasks	High performance
Learning Curve	Minimal	Moderate to High
Customization	Limited	Fully scriptable
Teaching Utility	Good for beginners	Good for understanding logic

6.4 Recommended GUI Tools for R

- **RKWard**
- **Rattle**
- **R Commander**
- **R AnalyticFlow**

https://rkward.kde.org

6.5 Installing RKWard on Ubuntu

bash sudo apt install kbibtex kate libcurl4-openssl-dev libssl-dev libxml2-dev cmake sudo add-apt-repository ppa:rkward-devel/rkward-stable echo "deb https://ppa.launchpad.net/rkward-devel/rkward-stable/ubuntu jammy main" | sudo tee /etc/apt/sources.list.d/rkward.list sudo apt update sudo apt-get install rkward Awesome. Here's Part 2 of the full markdown, Lines 251–600, continuing the structured content from your Week 1 lecture.

7 Module 4: Understanding Variables

7.1 What is a Variable?

A **variable** is a characteristic or attribute that can assume different values across individuals or items.

In statistics, variables are categorized for analysis and measurement.

7.1.1 R Definition:

In R, variables are containers for data, created by assignment:

```
x <- 10
name <- "Harsh"
flag <- TRUE

Classification of Variables

A. Qualitative (Categorical)

Type    Description Example

Nominal Categories without order    Gender (Male, Female)
Ordinal Categories with a meaningful order  Education Level (UG, PG)


B. Quantitative (Numerical)

Type    Description Example

Discrete    Countable numbers   No. of students
Continuous  Infinite values in a range  Height, Weight


Statistical Data Types (Scale of Measurement)

Data Type   Description Examples

Nominal Categories with no order    Blood group (A, B, AB, O)
Ordinal Ranked categories   Satisfaction (Low, Med, High)
```

```
Interval    Numeric scale with no true zero Temperature in Celsius
Ratio   Numeric scale with true zero    Income, Weight, Age

Data Types in R

R Type  Description Example Code

Numeric Real numbers    x <- 15.3
Integer Whole numbers   y <- as.integer(10)
Complex Real + imaginary    z <- 2+3i
Character   Text strings    c <- "hello"
Logical Boolean values  b <- TRUE
Factor  Categorical encoding    factor(c("yes", "no", "yes"))


# Examples in R
x <- 15.6
y <- as.integer(18)
z <- 7 + 5i
c <- "I am OK"
b <- TRUE


Module 5: Data Structures in R

Vectors

A vector is a one-dimensional array of elements.

vec1 <- c(5, 2, 3, 7, 8, 9, 1, 4, 10, 15)

Matrices

Two-dimensional arrays of rows and columns.

mat <- matrix(1:9, nrow=3, ncol=3)

Arrays

Multidimensional generalization of matrices.

arr <- array(1:24, dim=c(3,4,2))

Lists

Collection of different types of elements.
```

```
mylist <- list(name="Alice", age=30, scores=c(89,90))

Data Frames

Tabular data (like a spreadsheet), each column can have a different type.

df <- data.frame(ID=1:3, Name=c("A", "B", "C"), Score=c(85, 90, 95))

Factors

Used for categorical variables.

gender <- factor(c("Male", "Female", "Male"))

Module 6: Descriptive Statistics

Descriptive statistics summarize and simplify data.

Central Tendency

Measure Formula Meaning

Mean    $\bar{x} = \frac{\sum x_i}{n}$  Average
Median  Middle value in sorted data Central observation
Mode    Most frequent value Most common observation


Dispersion Measures

Measure Formula Purpose

Range   $Range = Max - Min$ Spread of data
Variance    $s^2 = \frac{\sum (x_i - \bar{x})^2}{n - 1}$    Spread from mean
Standard Deviation  $s = \sqrt{Variance}$   Average distance from mean


Example in R

x <- c(10, 20, 30, 40, 50)
mean(x)
median(x)
var(x)
sd(x)

Module 7: Inferential Statistics

Inferential stats allow us to make conclusions about populations using samples.
```

```
Key Concepts

Hypothesis Testing: Assesses assumptions about a population.

Confidence Intervals: Estimate population parameters within a range.

Significance Levels ( ): Commonly 0.05 or 5%

P-Value: Probability of observing the data assuming the null is true.


Hypothesis Types

Type    Description

Null Hypothesis No difference / no effect
Alternative There is a difference / effect


R Examples

t.test(x)                 # One-sample t-test
t.test(x, y)              # Two-sample t-test

Module 8: Visualizing Data

Data visualization helps uncover patterns and insights.

Boxplot

Shows 5-number summary

Identifies outliers


boxplot(x)

Histogram

Frequency distribution of continuous data


hist(x)

Pie Chart

Shows proportion in categories
```

```
slices <- c(10, 12, 4, 16, 8)
labels <- c("A", "B", "C", "D", "E")
pie(slices, labels=labels)

Scatter Plot

Relationship between two variables


plot(x, y)

Ogive (Cumulative Frequency)

# Create cumulative frequency table manually

Module 9: Spreadsheet Basics

Spreadsheets like Excel or Google Sheets are entry points for data work.

Key Features:

Rows → Observations

Columns → Variables

Supports sorting, filtering

Built-in formulas: =SUM(), =AVERAGE(), etc.

Spreadsheets vs R

Feature Spreadsheet (Excel, GSheets)    R / RKWard

Cost    Usually licensed    Free and open source
Flexibility Limited to GUI formulas Full programming capability
Graphics    Basic    Advanced (ggplot2)
Reproducibility Low High (script-based)

Module 10: Command Line vs GUI

Command Line (R Console)

# Windows Command Line
cd ..
mkdir new_folder
dir
```

```
R Console Commands

getwd()
setwd("path")
install.packages("ggplot2")
library(ggplot2)

GUI (RKWard)

Point-and-click interface

No coding needed

View script history and console

Menu for graphs, models, tables

Learning Resources:

Books

Mohanty, B., & Misra, S. (2016). Statistics for Behavioural and Social Sciences

Pandya et al. (2018). Statistical Analysis in Simple Steps using R

Field, A. P. et al. (2012). Discovering Statistics using R

Harris, J. K. (2019) . Statistics with R: Solving Problems using Real-World Data

## Utilizing Statistical Methods for Decision Making

- Use statistical evidence to guide business strategies.
- Make informed policy decisions based on empirical data.
- Report findings clearly for transparency and comprehension.

## Summary

The "Basic Statistics Using GUI-R (RK Ward)" course equips learners with the foundational and 

## Key Takeaways

- Proficiency in defining and using variables and data types.
- Capability to import and manipulate data in RKWard.
- Understanding of basic statistical practices and their applications.
- Skill in visualizing data for effective communication of results.

## Websites
```

```
https://rkward.kde.org
https://r4stats.com
https://cran.r-project.org









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8 Week 2

9 Introduction

9.1 Purpose of the eBook

This eBook is designed as a complete beginner-to-intermediate guide for understanding the foundational concepts of statistics. It aims to bridge theoretical knowledge and practical application using RKWard (a GUI for R). Readers will be introduced to descriptive and inferential statistics, probability theory, and probability distributions with ample examples and exercises.

9.2 Who Should Read This?

- Undergraduate students
- MBA and management students
- Data analysis beginners
- Professionals dealing with data

9.3 What You'll Learn

- Data classification and types
- Descriptive statistics: central tendency and variability
- Basic probability and events
- Probability distributions: Bernoulli, Binomial, and Normal
- Use of RKWard in statistical analysis

---

10 1. Fundamentals of Statistics

10.1 1.1 What is Statistics?

Statistics is the science of collecting, organizing, analyzing, and interpreting data to make informed decisions. It involves both **theoretical** (mathematical) and **applied** approaches to understanding uncertainty and variability in real-world phenomena.

10.2 1.2 Key Objectives

- Summarizing large datasets effectively
- Estimating population parameters
- Testing hypotheses
- Making predictions and decisions under uncertainty

10.3 1.3 Types of Statistics

- **Descriptive Statistics:** Deals with the presentation and summarization of data.
- **Inferential Statistics:** Draws conclusions about populations based on sample data.

---

11 2. Types of Data

11.1 2.1 Classification of Data

Type	Example	Description
Qualitative	Gender, Nationality	Non-numeric labels
Quantitative	Height, Age	Numeric values
Discrete	No. of Children	Countable numbers
Continuous	Temperature, Weight	Infinite values in a range

11.1.1 2.1.1 Qualitative (Categorical) Data

- **Nominal:** No inherent order (e.g., religion, marital status).
- **Ordinal:** Natural order (e.g., customer satisfaction: Poor, Average, Good).

11.1.2 2.1.2 Quantitative (Numerical) Data

- **Discrete:** Integers; e.g., number of books.
- **Continuous:** Measurable; e.g., weight in kilograms.

---

12 3. Descriptive Statistics

12.1 3.1 Measures of Central Tendency

12.1.1 3.1.1 What is Central Tendency?

Central tendency refers to the center or middle of a dataset. It's the value that best represents the entire distribution.

12.1.2 3.1.2 Characteristics of a Good Measure

- Rigidly defined
- Easy to understand
- Takes all data into account
- Amenable to algebraic treatment
- Stable under sampling
- Minimally affected by outliers (except mean)

12.2 3.2 The Mean

12.2.1 3.2.1 Definition

The arithmetic mean is the sum of all values divided by the number of values.

12.2.2 3.2.2 Formula

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

12.2.3 3.2.3 Properties of Mean

- Uses all data values
- Affected by extreme values
- The sum of deviations from the mean is zero

12.2.4 3.2.4 Example

Data: 10, 15, 20, 25, 30
Mean $= (10 + 15 + 20 + 25 + 30)/5 = 20$

12.3 3.3 The Median

12.3.1 3.3.1 Definition

The median is the value separating the higher half from the lower half of a data sample.

12.3.2 3.3.2 Calculation

- Odd number of items: Middle value
- Even number of items: Average of the two middle values

12.3.3 3.3.3 Properties

- Not influenced by extreme values
- Best for skewed data

12.3.4 3.3.4 Example

Data: 4, 6, 9, 12, 15, 21, 33
Median = 12 (middle value)

12.4 3.4 The Mode

12.4.1 3.4.1 Definition

The mode is the value that appears most frequently in a dataset.

12.4.2 3.4.2 Characteristics

- Can be used for categorical data
- Dataset can be unimodal, bimodal, or multimodal
- May not exist if all values are unique

12.4.3 3.4.3 Example

Data: 4, 4, 6, 8, 9, 10, 4
Mode = 4

12.5 3.5 Comparison Table

Measure	Use Case	Affected by Outliers	Mathematical Use
Mean	Symmetric distributions	Yes	High
Median	Skewed distributions	No	Moderate
Mode	Categorical variables	No	Low

---

13 4. Measures of Variability

13.1 4.1 Why Measure Variability?

While central tendency summarizes data, variability tells us how spread out the data is. It's essential in determining consistency and reliability.

13.2 4.2 Range

13.2.1 4.2.1 Definition

The difference between the maximum and minimum values.

$$\text{Range} = x_{\max} - x_{\min}$$

13.2.2 4.2.2 Example

Data: 12, 14, 17, 19, 23
Range = 23 - 12 = 11

13.2.3 4.2.3 Limitations

- Ignores distribution shape
- Extremely sensitive to outliers

13.3 4.3 Quartiles and Interquartile Range

13.3.1 4.3.1 Quartiles

- Q1 (25th percentile): Lower quartile
- Q2 (50th percentile): Median
- Q3 (75th percentile): Upper quartile

13.3.2 4.3.2 Formula for Position

$$Q_k = \frac{k(n+1)}{4}$$

13.3.3 4.3.3 IQR Formula

$$IQR = Q3 - Q1$$

13.3.4 4.3.4 Example

Data: 12, 30, 45, 57, 70
Q1 = 30, Q3 = 57 → IQR = 27

13.4 4.4 Variance

13.4.1 4.4.1 Concept

Variance is the average of the squared differences from the Mean.

13.4.2 4.4.2 Formulas

Population Variance:

$$\sigma^2 = \frac{1}{N} \sum (x_i - \mu)^2$$

Sample Variance:

$$s^2 = \frac{1}{n-1} \sum (x_i - \bar{x})^2$$

13.5 4.5 Standard Deviation

13.5.1 4.5.1 Concept

Standard deviation is the square root of variance. It provides a measure of spread in the same units as the data.

$$s = \sqrt{s^2}$$

13.5.2 4.5.2 Properties

- Same unit as original data
- Measures how far values deviate from the mean
- Widely used in most statistical computations

13.6 4.6 Coefficient of Variation (CV)

13.6.1 4.6.1 Definition

The ratio of the standard deviation to the mean, expressed as a percentage. Used to compare variability between datasets with different units.

$$CV = \left(\frac{s}{\bar{x}}\right) \times 100\%$$

13.6.2 4.6.2 Example

Dataset A: Mean = 100, SD = 10 → CV = 10%
Dataset B: Mean = 50, SD = 5 → CV = 10%

13.7 4.7 Moment-Based Measures

- First Moment (about mean): 0 (since $\sum(x - \bar{x}) = 0$)
- Second Moment: Variance
- Third Moment: Skewness
- Fourth Moment: Kurtosis

---

14 5. Probability Fundamentals

14.1 5.1 Introduction to Probability

Probability is the mathematical framework for quantifying uncertainty. It helps us estimate how likely an event is to occur.

14.2 5.2 Key Definitions

- **Experiment:** A process that leads to an outcome.
- **Outcome:** The result of an experiment.
- **Sample Space (Ω):** All possible outcomes.
- **Event:** A subset of the sample space.

14.3 5.3 Types of Events

Event Type	Description
Independent	Occurrence of one does not affect the other
Dependent	One affects the outcome of another
Mutually Exclusive	Cannot occur together
Exhaustive	Includes all possible outcomes

14.4 5.4 Classical Probability

Used when all outcomes are equally likely.

Formula:

$$P(A) = \frac{\text{Number of favorable outcomes}}{\text{Total outcomes in } \Omega}$$

Example: Rolling a fair die
P(rolling a 3) = 1/6

14.5 5.5 Probability Rules

14.5.1 Rule 1: Non-Negativity

$$0 \leq P(A) \leq 1$$

14.5.2 Rule 2: Total Probability

$$P(\Omega) = 1$$

14.5.3 Rule 3: Complement Rule

$$P(A^c) = 1 - P(A)$$

14.5.4 Rule 4: Addition Rule

If A and B are mutually exclusive:

$$P(A \cup B) = P(A) + P(B)$$

Otherwise:

$$P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

14.5.5 Rule 5: Multiplication Rule

- For independent events:

$$P(A \cap B) = P(A) \cdot P(B)$$

14.6 5.6 Conditional Probability

Formula:

$$P(A|B) = \frac{P(A \cap B)}{P(B)}$$

---

15 6. Discrete Probability Distributions

15.1 6.1 Bernoulli Distribution

- One trial, two outcomes (success/failure).
- Success = 1, Failure = 0

$$P(X = x) = p^x (1-p)^{1-x}, \quad x \in \{0, 1\}$$

- Mean = p
- Variance = $p(1-p)$

15.1.1 Example:

Flip a fair coin → p = 0.5
Mean = 0.5, Variance = 0.25

15.2 6.2 Binomial Distribution

- Series of n independent Bernoulli trials
- Number of successes x out of n trials

Formula:

$$P(X = x) = \binom{n}{x} p^x (1-p)^{n-x}$$

- Mean: $\mu = np$
- Variance: $\sigma^2 = np(1-p)$

15.2.1 Example:

Flip a coin 5 times (p = 0.5)
P(X = 3) = $\binom{5}{3}(0.5)^3(0.5)^2 = 10 \cdot 0.125 \cdot 0.25 = 0.3125$

---

16 7. Continuous Distributions

16.1 7.1 Normal Distribution

The most important continuous distribution in statistics.

Properties:

- Bell-shaped and symmetric
- Defined by mean ( ) and variance (^{2})
- Total area under the curve = 1

Probability Density Function (PDF):

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$$

16.1.1 Empirical Rule:

- 68% of values lie within ± 1
- 95% within ± 2
- 99.7% within ± 3

16.2 7.2 Standard Normal Distribution

A normal distribution with:

- Mean = 0
- Standard deviation = 1

Z-score Formula:

$$Z = \frac{X-\mu}{\sigma}$$

16.2.1 Example:

If $\mu = 100$, $\sigma = 15$, and $X = 130$
Then $Z = \frac{130-100}{15} = 2$

17 8. Visualizing Data

17.1 8.1 Frequency Distribution

Class Interval	Frequency
0–10	3
11–20	7
21–30	9
31–40	6

17.2 8.2 Histogram

A bar chart representing the frequency distribution of numerical data.

Use Case: Visualize shape (e.g., normal, skewed)

17.3 8.3 Boxplot (Box-and-Whisker Plot)

Shows:

- Minimum
- Q1
- Median
- Q3
- Maximum
- Outliers (as dots)

Helps identify skewness and outliers quickly.

17.4 8.4 Scatter Plot

Used to study the relationship between two quantitative variables.

18 9. Practical Applications

18.1 9.1 Business Use Cases

- Retail: Analyze sales patterns
- Healthcare: Patient outcome probabilities
- Finance: Stock volatility (using SD, CV)

18.2 9.2 Education and Research

- Student test scores: Use mean, SD, and percentile ranking
- Experiment analysis: Use Z-scores and Normal Distribution

---

19 10. Using RKWard

19.1 10.1 What is RKWard?

A graphical frontend for the R programming language designed for statistical analysis and data visualization.

19.2 10.2 Installation Guide

1. Download R from CRAN
2. Install RKWard from rkward.kde.org
3. Start RKWard and begin with menu-driven tasks

19.3 10.3 Sample RKWard Activities

19.3.1 Calculate Mean and SD

- Load dataset
- Click *Statistics* → *Descriptive Statistics*
- Choose variables and click *OK*

19.3.2 Visualize Histogram

- Click *Graphics* → *Histogram*
- Select variable and customize bins

19.4 10.4 Using R Code in RKWard

```
data <- c(12, 15, 17, 18, 21)
mean(data)
sd(data)
hist(data)

## Summary

This eBook provided a deep dive into basic statistics including:

Data types and classification
Central tendency and variability
Probability theory and rules
Discrete and continuous distributions
Visual interpretation and real-world applications
GUI-based statistical analysis using RKWard




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20 Week 3

21 Introduction

21.1 Importance of Statistics

Statistics is a powerful tool used across disciplines — from economics and psychology to biology, data science, and machine learning. It enables:

- Interpretation of data
- Generalization from samples to populations
- Hypothesis testing and decision-making
- Prediction and modeling

Understanding statistics is essential for anyone involved in **empirical research**, **policy making**, **data-driven decision-making**, or **scientific inquiry**.

21.2 Overview of Topics

This book covers:

- Population vs Sample
- Hypotheses and Errors
- Descriptive vs Inferential Statistics
- Data Types (R + Theoretical)
- Sampling Techniques
- Normal Distribution
- Linear and Logistic Regression
- GUI-based R interfaces: RKWard, Rcmdr, Rattle
- Fallacies and misuse in statistics
- Graphical Methods
- R programming constructs for statistics

---

22 Understanding Populations and Samples

22.1 Population

The complete set of all units of interest. Examples:

- All students in India
- All electric cars in the U.S.

22.2 Sample

A **subset of the population**, selected for analysis. Goal: represent the population accurately.

22.3 Why Use Samples?

- More practical and cost-efficient
- Enables faster analysis
- Allows estimation and inference

22.4 Relation Between Population & Sample

Population → Sample → Statistic → Inference → Population Parameter

---

23 Hypotheses and Errors

23.1 Hypothesis Defined

A hypothesis is a testable assumption about a population.

23.1.1 Null Hypothesis (H_0)

- No difference or effect
- Example: H_0: “ $= 100$”

23.1.2 Alternative Hypothesis (H_A)

- A difference or effect exists
- Example: H_A: “ 100”

23.2 Types of Errors

Error Type	Description
Type I Error	Rejecting H_0 when it’s true (false positive)
Type II Error	Failing to reject H_0 when it’s false (false neg)

23.3 Significance Level ( )

The probability of making a Type I error — commonly set to **0.05 (5%)**

---

24 Inferential Statistics

24.1 Purpose

- Estimate unknown population parameters
- Test hypotheses
- Predict outcomes

24.2 Common Techniques

- t-test
- z-test
- ANOVA
- Chi-square
- Regression

24.3 Sampling Techniques

24.3.1 1. Simple Random Sampling

Every unit has equal probability.

24.3.2 2. Systematic Sampling

Pick every kth element.

24.3.3 3. Stratified Sampling

Subdivide population into strata (e.g. age groups), then sample from each.

24.3.4 4. Cluster Sampling

Randomly choose entire groups (e.g. schools, cities).

24.4 Central Limit Theorem (CLT)

If $n > 30$, the distribution of sample means approximates a **normal distribution** even if the original population is not normal.

Formula:

$$Z = \frac{\bar{X} - \mu}{\sigma/\sqrt{n}}$$

25 Descriptive Statistics

25.1 Measures of Central Tendency

25.1.1 Mean

$$\bar{x} = \frac{\sum x_i}{n}$$

25.1.2 Median

Middle value in an ordered dataset.

25.1.3 Mode

Most frequent value.

25.2 Measures of Dispersion

25.2.1 Range

$$Range = Max - Min$$

25.2.2 Variance

$$s^2 = \frac{\sum (x_i - \bar{x})^2}{n - 1}$$

25.2.3 Standard Deviation

$$s = \sqrt{s^2}$$

25.3 Measures of Shape

- **Skewness**: Degree of asymmetry
- **Kurtosis**: Peakedness of distribution

26 Graphical Methods

26.1 Histogram

r hist(data$height, col="blue", main="Height Distribution") Boxplot

boxplot(data$score\ data$group) Scatter Plot

plot(data$x, data$y, col="red") Ogive (Cumulative Frequency Plot)

Built using cumulative frequency of class intervals.

26.2 R Data Types and Structures

Basic Data Types

x <- 12.5 # numeric y <- as.integer(5) # integer z <- 4 + 3i # complex name <- "Ravi" # character flag <- TRUE # logical Vectors

v <- c(1, 2, 3) Matrices

m <- matrix(1:9, nrow=3, byrow=TRUE) Data Frame

df <- data.frame(Name=c("A", "B"), Score=c(89, 94)) Lists

lst <- list(id=101, name="John", marks=c(78, 82)) Factors

gender <- factor(c("Male", "Female", "Male")) Statistical Fallacies

What are Fallacies?

Fallacies occur when conclusions are drawn based on flawed statistical reasoning.

Common Fallacies

Improper Sampling Misleading Graphs Ambiguous Term Definitions Ignoring Confounding Variables Assuming Correlation Implies Causation Misuse of Statistics

Examples of Misuse

Using biased samples Cherry-picking data Using 3D pie charts to exaggerate results Misrepresenting scale in graphs

26.3 Comparing R vs Excel vs GUI-R (RKWard)

Feature	R (Script)	Excel	RKWard GUI
Usability	Medium	Easy	Easy
Flexibility	High	Low-Medium	Medium
Statistical Power	Very High	Low	High
Graphics	ggplot2	Basic	ggplot2 supported
Reproducibility	High	Low	High

26.4 Installing RKWard (Ubuntu)

$sudoaptinstallkbibtexkatelibcurl4-openssl-devlibssl-devlibxml2-devcmakesudoadd-apt-repositoryppa: rku$

26.5 Teaching Tools in RKWard

$install.packages(c("R2HTML","car","e1071","Hmisc","plyr","ggplot2","prob","ez","multcomp","remotes"),de$

26.6 GUI-Based Statistical Tools

RKWard – KDE interface for R Rcmdr – Classic R Commander GUI Rattle – Data mining GUI in R R AnalyticFlow – Flow-based programming for statistics

27 Linear Regression in R

27.1 What is Linear Regression?

Linear regression models the relationship between a **dependent variable (Y)** and one or more **independent variables (X)**.

27.1.1 Simple Linear Regression Equation:

$$Y = \beta_0 + \beta_1 X + \epsilon$$

Where:

- Y is the dependent variable
- X is the independent variable
- β_0 is the intercept
- β_1 is the slope
- ϵ is the error term

27.2 Code Example

r # Load data data(mtcars)

28 Fit model

model <- lm(mpg ~ wt, data=mtcars)

29 Summary

summary(model)

29.1 Adjusted R-squared

Penalizes the number of predictors to avoid overfitting.

AIC & BIC

AIC: Akaike Information Criterion BIC: Bayesian Information Criterion Lower values of AIC/BIC → better model fit (with penalty for complexity).

29.2 Normal Distribution

Key Properties

Symmetrical, bell-shaped curve Mean = Median = Mode Total area under curve = 1 Empirical Rule: 68% within ±1 SD 95% within ±2 SD 99.7% within ±3 SD

Example: Given: Mean = 70, SD = 5, X = 75

z <- (75 - 70) / 5 # Result: 1.0 Z-Table Usage

Find the area under the curve to the left of the z-score Useful for probability and percentile ranking

29.3 Data Import Techniques

CSV Import in R

df <- read.csv("data.csv", header=TRUE) head(df) Excel Import (using readxl)

install.packages("readxl") library(readxl)

df <- read_excel("data.xlsx")

29.4 Working with the RKWard Interface

Sections: Console – Run R code Script Editor – Write reusable code Workspace – View loaded variables Teaching Tab – Education-focused modules

29.5 Spreadsheet Concepts

Structure

Component |Description Rows |Individual observations Columns |Variables Cells |Data points Header Row| Variable names

29.6 Advantages

Easy data entry Visual inspection Good for small datasets

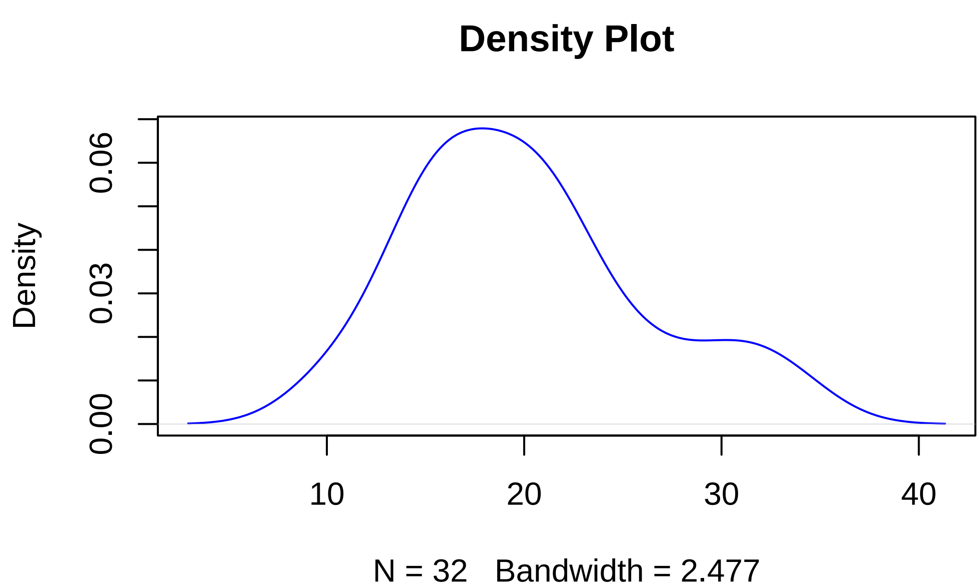
29.7 Limitations

Limited statistical functionality Hard to reproduce Error-prone for large datasets

29.8 Advanced Plots and Techniques

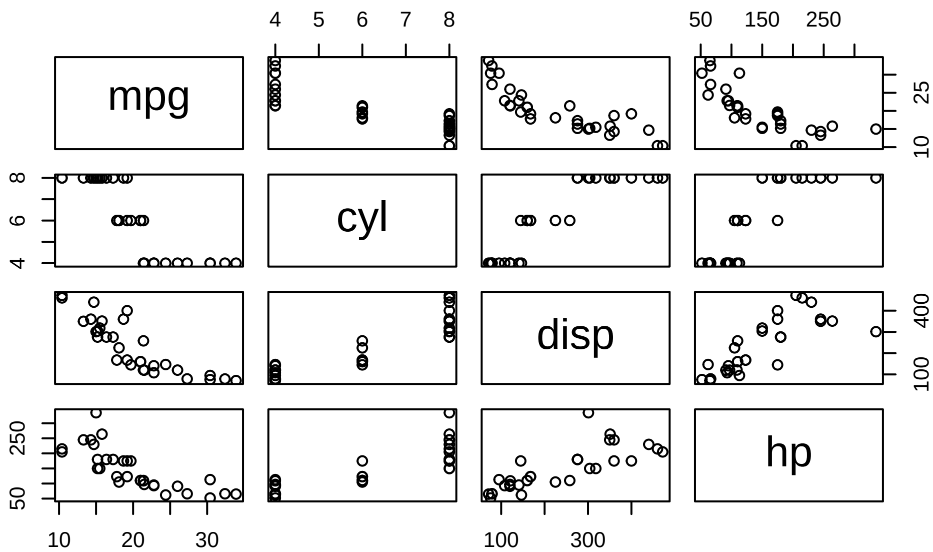
Density Plot

```r
plot(density(mtcars$mpg), main="Density Plot", col="blue")
```



Pair Plot

```r
pairs(mtcars[, 1:4])
```



Correlation Matrix

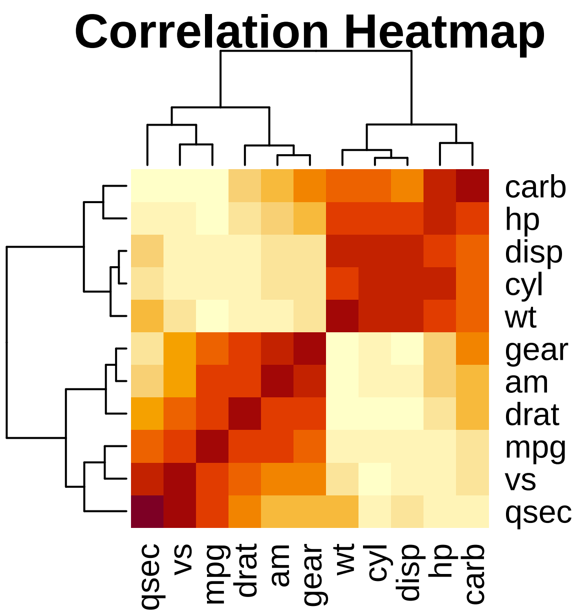
```r
cor(mtcars)
```

```
            mpg        cyl       disp         hp        drat         wt
mpg   1.0000000 -0.8521620 -0.8475514 -0.7761684  0.68117191 -0.8676594
cyl  -0.8521620  1.0000000  0.9020329  0.8324475 -0.69993811  0.7824958
disp -0.8475514  0.9020329  1.0000000  0.7909486 -0.71021393  0.8879799
hp   -0.7761684  0.8324475  0.7909486  1.0000000 -0.44875912  0.6587479
drat  0.6811719 -0.6999381 -0.7102139 -0.4487591  1.00000000 -0.7124406
wt   -0.8676594  0.7824958  0.8879799  0.6587479 -0.71244065  1.0000000
qsec  0.4186840 -0.5912421 -0.4336979 -0.7082234  0.09120476 -0.1747159
vs    0.6640389 -0.8108118 -0.7104159 -0.7230967  0.44027846 -0.5549157
am    0.5998324 -0.5226070 -0.5912270 -0.2432043  0.71271113 -0.6924953
gear  0.4802848 -0.4926866 -0.5555692 -0.1257043  0.69961013 -0.5832870
carb -0.5509251  0.5269883  0.3949769  0.7498125 -0.09078980  0.4276059
            qsec         vs          am       gear        carb
mpg   0.41868403  0.6640389  0.59983243  0.4802848 -0.55092507
cyl  -0.59124207 -0.8108118 -0.52260705 -0.4926866  0.52698829
disp -0.43369788 -0.7104159 -0.59122704 -0.5555692  0.39497686
hp   -0.70822339 -0.7230967 -0.24320426 -0.1257043  0.74981247
drat  0.09120476  0.4402785  0.71271113  0.6996101 -0.09078980
wt   -0.17471588 -0.5549157 -0.69249526 -0.5832870  0.42760594
qsec  1.00000000  0.7445354 -0.22986086 -0.2126822 -0.65624923
vs    0.74453544  1.0000000  0.16834512  0.2060233 -0.56960714
```

```
am   -0.22986086  0.1683451  1.00000000  0.7940588  0.05753435
gear -0.21268223  0.2060233  0.79405876  1.0000000  0.27407284
carb -0.65624923 -0.5696071  0.05753435  0.2740728  1.00000000
```

Heatmap

```r
heatmap(cor(mtcars), main="Correlation Heatmap")
```



29.9 Common R Packages for Statistics

Package |Purpose ggplot2 |Data visualization dplyr |Data manipulation tidyr |Data tidying Hmisc |Misc stats functions car |Regression diagnostics e1071 |Skewness/kurtosis, ML tools psych |Psychological statistics shiny |Interactive apps caret |Classification and regression

29.10 Introduction to Command Line

29.11 Windows Terminal

$$cd..mkdirmy_projectdir$$

Linux Terminal

$$cd\ mkdirstats_projectls - l$$

29.12 Git + R Project Example

$$gitinitgitclonehttps://github.com/username/project.git$$

29.13 R Script Template for Analysis

$$ # Load packages library(ggplot2) library(dplyr)

30 Load data

df <- read.csv("dataset.csv")

31 Descriptive stats

summary(df) sd(df$Score)

32 Histogram

ggplot(df, aes(x=Score)) + geom_histogram(bins=10, fill="skyblue")

33 Linear regression

model <- lm(Score ~ StudyHours, data=df) summary(model)

34 Scatter plot with regression line

ggplot(df, aes(x=StudyHours, y=Score)) + geom_point() + geom_smooth(method="lm") $$ ## Fallacies and Bias: Real-World Cautions

Examples of Statistical Abuse

Cherry-picking data Data dredging (p-hacking) Using relative risk without absolute context Non-random sampling Ethics in Data Analysis

Be transparent Document sources Disclose methodology Avoid overstating conclusions

34.1 Future Applications of Statistics

Real-World Domains

Healthcare: Drug effectiveness, diagnostics Economics: Forecasting, policy evaluation Sociology: Survey analysis Sports: Performance analytics AI/ML: Predictive modeling, optimization Next Steps

Learn tidyverse ecosystem Explore machine learning in R Build Shiny dashboards Get familiar with reproducible research using Quarto

34.2 Practice Challenges

1. Load and summarize data

Load mtcars or your own dataset Use summary(), mean(), sd() 2. Create 3 different plots

Histogram Boxplot by group Scatter plot with trend line 3. Build a regression model

Identify predictor and outcome Use lm() and summary() 4. Explore a GUI like RKWard or Rcmdr

34.3 Key Takeaways

Statistics supports informed decision-making. R and its GUI frontends offer flexibility + power. Understand theory → then automate with code. Avoid fallacies by following robust methods. Visuals are crucial: plot early, plot often.

35 Week 4

36 Introduction

This eBook is a comprehensive companion to the course *Basic Statistics using GUI-R (RKWard)*. It includes foundational theory, practical examples, and step-by-step explanations, with integrated GUI-R usage.

37 Course Overview

37.1 Course Name

Basic Statistics using GUI-R (RKWard)

37.2 Instructor Profile

Dr. Harsh Pradhan is Assistant Professor at the Institute of Management Studies, Banaras Hindu University.
Faculty Profile

37.3 Learning Objectives

- Understand core concepts in statistics
- Apply t-tests and ANOVA using real data
- Compute confidence intervals and test statistics
- Use GUI-R (RKWard) for statistical analysis

38 Chapter 1: Fundamental Concepts

38.1 Descriptive Statistics

38.1.1 Central Tendency

- **Mean**
- **Median**
- **Mode**

38.1.2 Dispersion

- **Range**
- **Variance**
- **Standard Deviation**

38.1.2.1 Example:

```r
data <- c(4, 8, 6, 5, 3)
mean(data)
```

```
[1] 5.2
```

```r
median(data)
```

```
[1] 5
```

```r
sd(data)
```

```
[1] 1.923538
```

38.2 Standard Error

$$SE = \frac{s}{\sqrt{n}}$$

Small SE = sample mean is a good estimate of the population mean.

38.3 Central Limit Theorem

For $n > 30$, sampling distribution of the mean approximates normal:

$$\bar{X} \sim \mathcal{N}(\mu, \frac{\sigma}{\sqrt{n}})$$

38.4 Confidence Intervals

$$CI = \bar{x} \pm Z \cdot \frac{s}{\sqrt{n}}$$

Interpret 95% CI as: 95 of 100 such intervals would contain the true mean.

39 Chapter 2: Estimation

39.1 Types of Estimates

Type	Description	Example
Point Estimate	Single value	Sample mean
Interval Estimate	Range + confidence	Confidence Int

39.2 Parameter vs Statistic

Term	Description
Parameter	Value from population (e.g., μ)
Statistic	Value from sample (e.g., $\bar{x}$)

40 Chapter 3: Hypothesis Testing

- **Null Hypothesis (H_0)**: No effect
- **Alternative Hypothesis (H_1)**: Some effect
- **Type I Error**: Reject H_0 when true
- **Type II Error**: Fail to reject H_0 when false

41 Chapter 4: Student's T-Test

41.1 Types

Test Type	Description
One-Sample	Compare sample to fixed value
Independent	Compare two unrelated groups
Paired	Compare two related groups

41.2 One-Sample T-Test Example

```r
data <- c(22, 24, 27, 26, 28, 23, 25, 29, 21, 26, 24, 27)
t.test(data, mu = 25)
```

```
	One Sample t-test

data:  data
t = 0.2363, df = 11, p-value = 0.8175
alternative hypothesis: true mean is not equal to 25
95 percent confidence interval:
 23.61427 26.71906
sample estimates:
mean of x
 25.16667
```

41.3 Test Statistic

$$t = \frac{\bar{x} - \mu}{SE}$$

41.4 Degrees of Freedom

$$df = n - 1$$

41.5 Decision Rule

Compare calculated t to table value. If $|t| > t_{critical}$, reject H_0.

41.6 T-Test in GUI-R

1. Import data
2. Choose T-Test
3. Define groups
4. Run & interpret output

42 Chapter 5: ANOVA

42.1 Purpose

Used when comparing means across 3+ groups.

42.1.1 One-Way ANOVA Formula

$$F = \frac{MS_{between}}{MS_{within}}$$

Where:

- $MS_{between} = \frac{SS_{between}}{df_{between}}$
- $MS_{within} = \frac{SS_{within}}{df_{within}}$

42.1.2 Assumptions

- Normality
- Homogeneity of variance
- Independence

42.1.3 Example Table

Group	Mean	Var	n
A	5.5	1.5	30
B	7.1	2.0	30
C	6.8	1.8	30

42.2 Post-Hoc Tests

Run if ANOVA is significant to locate pairwise differences.

42.3 ANOVA in GUI-R

1. Load data
2. Choose "One-Way ANOVA"
3. Define groups
4. Interpret output

43 Chapter 6: GUI-R Workflow

1. **Import Data** (CSV, Excel)
2. **Choose Test** (T-Test, ANOVA, etc.)
3. **Run** the analysis
4. **Interpret** the output
5. **Export** the results or visualizations

44 Chapter 7: Advanced Concepts

44.1 Variance Partitioning

$$\text{Total Variance} = \text{Explained Variance} + \text{Unexplained Variance}$$

Explained Terms	Unexplained Terms
Systematic	Random
Predictive	Error
Deterministic	Noise

44.2 Degrees of Freedom

For equation $x + y + z = 3$, if 2 values are known, third is fixed.
Hence, $df = n - k$ where $n =$ total variables, $k =$ constraints.

44.3 Chi-Square and F Distribution

- **Chi-Square**: Categorical variable comparison
- **F-Distribution**: Used in ANOVA, variance testing

44.4 Univariate, Bivariate, Multivariate

Type	Variables	Example
Univariate	1	Height
Bivariate	2	Height vs Weight
Multivariate	>2	Study w/ Age, Gender, Income

44.5 Parametric Test Assumptions

- Interval/Ratio DV
- Random Sampling
- Normality
- Equal Variances

If assumptions violated $\rightarrow$ use non-parametric test.

44.6 Effect Size

$$\text{Effect Size} = \frac{|\mu_1 - \mu_2|}{\sigma}$$

Used for comparison across studies.

44.7 Power of a Test

$$\text{Power} = 1 - \beta$$

Higher power $\rightarrow$ lower chance of Type II error
Power increases with sample size, effect size

45 Conclusion

Statistics is the language of data. GUI-R makes statistical tools accessible for everyone. This book empowers you to analyze data effectively using t-tests, ANOVA, and confidence intervals in a GUI environment.

46 References

- Pradhan, H. (2023). *Basic Statistics using GUI-R (RKWard)*
- Field, A. (2013). *Discovering Statistics Using R.*
- https://methods.sagepub.com

47 Chapter 8: Advanced T-Test Applications

47.1 Paired Sample T-Test

Used when the same group is measured twice (e.g., before and after).

47.1.1 Example:

```r
before <- c(80, 82, 79, 84, 88)
after <- c(78, 81, 76, 83, 86)
t.test(before, after, paired = TRUE)
```

```

	Paired t-test

data:  before and after
t = 4.8107, df = 4, p-value = 0.008581
alternative hypothesis: true mean difference is not equal to 0
95 percent confidence interval:
 0.7611494 2.8388506
sample estimates:
mean difference 
            1.8 
```

47.2 Independent Samples T-Test

Compare means of two unrelated groups.

```r
group1 <- c(85, 90, 88, 92, 87)
group2 <- c(80, 83, 85, 84, 82)
t.test(group1, group2)
```

```

	Welch Two Sample t-test

data:  group1 and group2
t = 3.7755, df = 7.226, p-value = 0.006537
```

```
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 2.114814 9.085186
sample estimates:
mean of x mean of y
     88.4      82.8
```

47.3 One-Sample T-Test with GUI-R

- Import dataset
- Use 'Descriptive Statistics' to check mean
- Navigate to 'T-Test' → 'One Sample'
- Input hypothesized mean and run

48 Chapter 9: More on Confidence Intervals

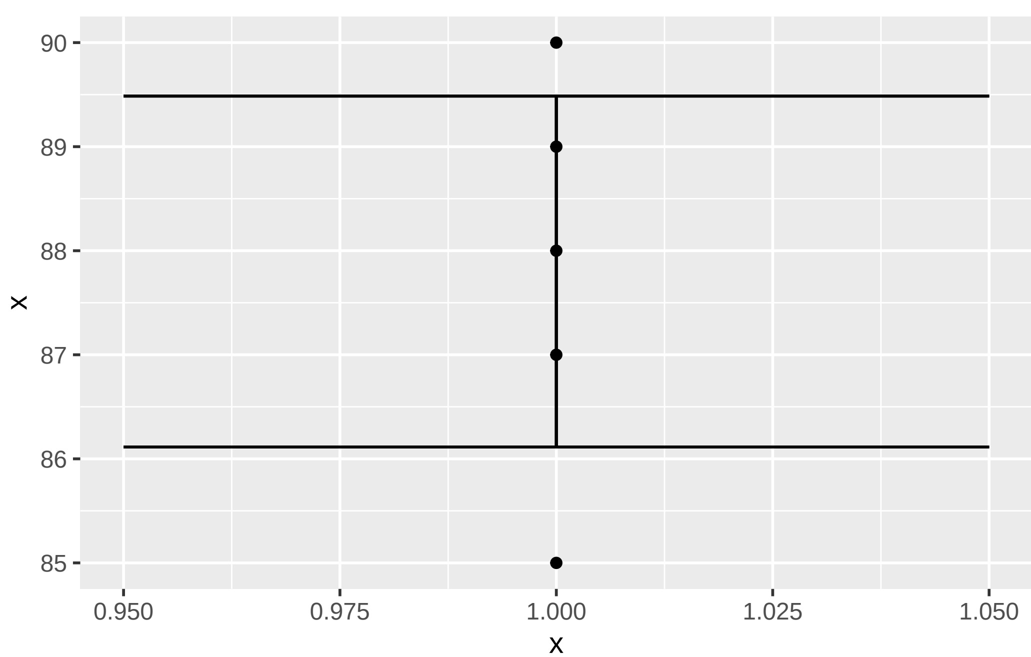
48.1 Visualizing Confidence Intervals in R

```
x <- c(88, 90, 85, 87, 89)
mean_x <- mean(x)
se <- sd(x) / sqrt(length(x))
ci_lower <- mean_x - 1.96 * se
ci_upper <- mean_x + 1.96 * se
c(ci_lower, ci_upper)
```

```
[1] 86.11394 89.48606
```

Plot using `ggplot2`:

```
library(ggplot2)
df <- data.frame(x = x)
ggplot(df, aes(y = x, x = 1)) +
  geom_point() +
  geom_errorbar(aes(ymin = ci_lower, ymax = ci_upper), width = 0.1)
```



49 Chapter 10: Robust ANOVA Models

49.1 Two-Way ANOVA

Examines the effect of two categorical independent variables on a continuous dependent variable.

```
# Sample dataset for demonstration
dataset <- data.frame(
  score = c(85, 90, 88, 92, 87, 80, 83, 85, 84, 82),
  gender = rep(c("Male", "Female"), each = 5),
  teaching_method = rep(c("A", "B"), times = 5)
)
aov_result <- aov(score ~ gender * teaching_method, data = dataset)
summary(aov_result)
```

```
                       Df Sum Sq Mean Sq F value  Pr(>F)
gender                  1  78.40   78.40  23.718 0.00279 **
teaching_method         1   6.02    6.02   1.820 0.22598
gender:teaching_method  1  18.15   18.15   5.491 0.05759 .
Residuals               6  19.83    3.31
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

49.2 Repeated Measures ANOVA

Use when the same subjects are used for each treatment.

```
# Sample repeated measures data in long format
data_long <- data.frame(
  id = rep(1:5, each = 3),
  condition = rep(c("A", "B", "C"), times = 5),
  score = c(85, 88, 90, 80, 82, 85, 78, 80, 83, 90, 92, 95, 88, 90, 91)
)
library(ez)
ezANOVA(data = data_long, dv = .(score), wid = .(id), within = .(condition))
```

```
Warning: Converting "id" to factor for ANOVA.
```

```
Warning: Converting "condition" to factor for ANOVA.
```

```
$ANOVA
     Effect DFn DFd        F            p p<.05       ges
2 condition   2   8 88.22222 3.539139e-06     * 0.1479687

$`Mauchly's Test for Sphericity`
     Effect         W         p p<.05
2 condition 0.5555556 0.4140867

$`Sphericity Corrections`
     Effect       GGe        p[GG] p[GG]<.05       HFe        p[HF] p[HF]<.05
2 condition 0.6923077 9.135419e-05         * 0.9411765 6.568851e-06         *
```

50 Chapter 11: Effect Size Measures

50.1 Cohen's d

$$d = \frac{\bar{x}_1 - \bar{x}_2}{s_p}$$

Where s_p is the pooled standard deviation.

50.1.1 R Example

```r
library(effsize)
cohen.d(group1, group2)
```

```
Cohen's d

d estimate: 2.387848 (large)
95 percent confidence interval:
    lower     upper
0.4791634 4.2965327
```

50.2 Eta-Squared (η^2)

Used for ANOVA:

$$\eta^2 = \frac{SS_{between}}{SS_{total}}$$

51 Chapter 12: Statistical Assumptions Checking

51.1 Normality

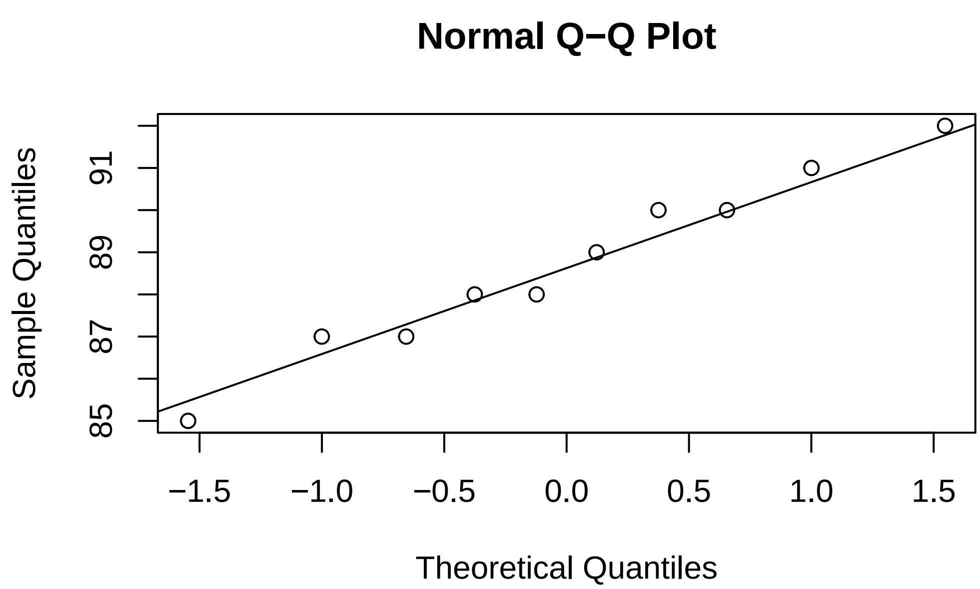
Use Shapiro-Wilk test:

```
# Sample data frame for normality test
data <- data.frame(variable = c(88, 90, 85, 87, 89, 91, 92, 88, 90, 87))
shapiro.test(data$variable)
```

```

	Shapiro-Wilk normality test

data:  data$variable
W = 0.97743, p-value = 0.95
```

Visualize:

```
qqnorm(data$variable)
qqline(data$variable)
```



51.2 Homogeneity of Variance

Use Levene's Test:

```r
# Sample data frame for Levene's Test
data <- data.frame(
  variable = c(88, 90, 85, 87, 89, 91, 92, 88, 90, 87),
  group = rep(c("A", "B"), each = 5)
)
library(car)
```

```
Loading required package: carData
```

```r
leveneTest(variable ~ group, data = data)
```

```
Warning in leveneTest.default(y = y, group = group, ...): group coerced to
factor.
```

```
Levene's Test for Homogeneity of Variance (center = median)
      Df F value Pr(>F)
group  1  0.0769 0.7885
       8
```

52 Chapter 13: Non-Parametric Alternatives

52.1 Wilcoxon Signed Rank Test

```r
wilcox.test(before, after, paired = TRUE)
```

```
Warning in wilcox.test.default(before, after, paired = TRUE): cannot compute
exact p-value with ties


	Wilcoxon signed rank test with continuity correction

data:  before and after
V = 15, p-value = 0.05676
alternative hypothesis: true location shift is not equal to 0
```

52.2 Mann-Whitney U Test

```r
wilcox.test(group1, group2)
```

```
Warning in wilcox.test.default(group1, group2): cannot compute exact p-value
with ties


	Wilcoxon rank sum test with continuity correction

data:  group1 and group2
W = 24.5, p-value = 0.01597
alternative hypothesis: true location shift is not equal to 0
```

52.3 Kruskal-Wallis Test

Non-parametric alternative to ANOVA.

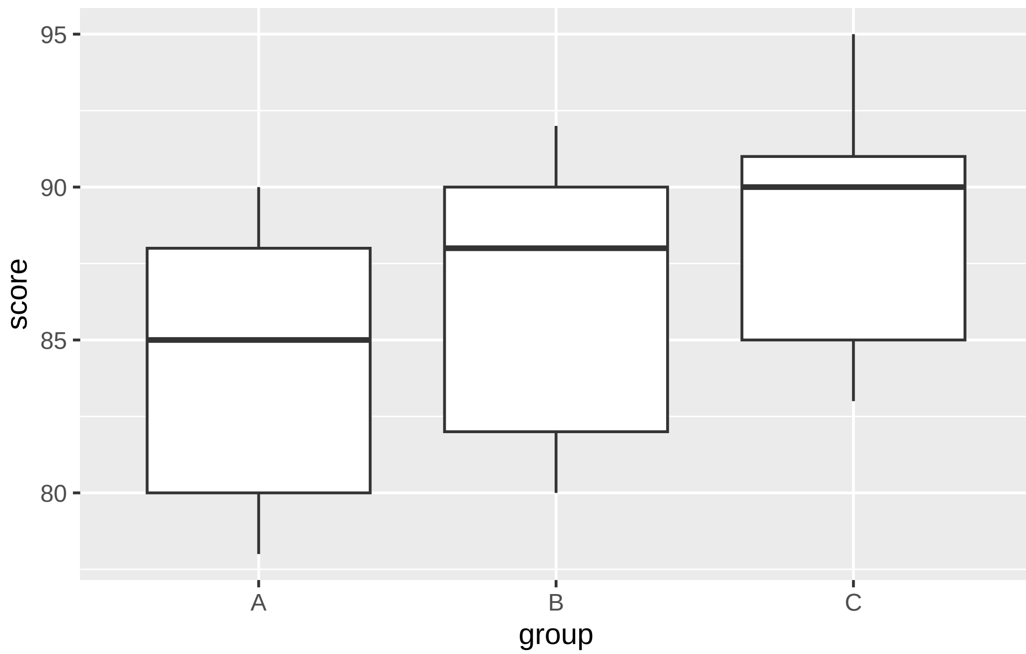
```r
# Sample data frame for Kruskal-Wallis Test
data <- data.frame(
  score = c(85, 88, 90, 80, 82, 85, 78, 80, 83, 90, 92, 95, 88, 90, 91),
  group = rep(c("A", "B", "C"), times = 5)
)
kruskal.test(score ~ group, data = data)
```

```

	Kruskal-Wallis rank sum test

data:  score by group
Kruskal-Wallis chi-squared = 2.2329, df = 2, p-value = 0.3274
```

53 Chapter 14: Visualizing Statistical Results

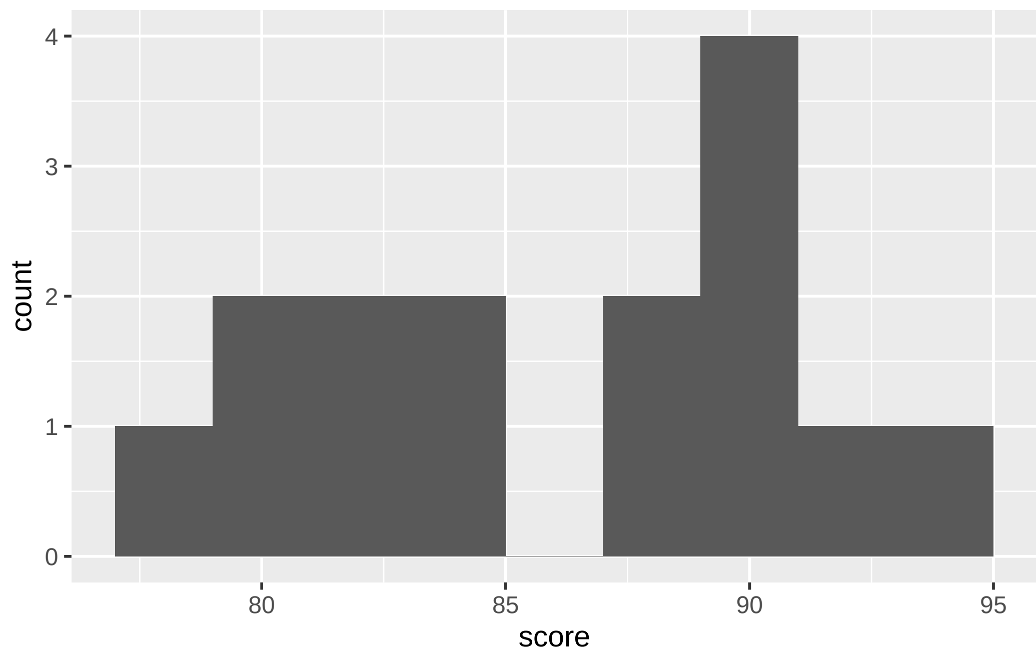
53.1 Boxplots

```r
ggplot(data, aes(x = group, y = score)) +
  geom_boxplot()
```



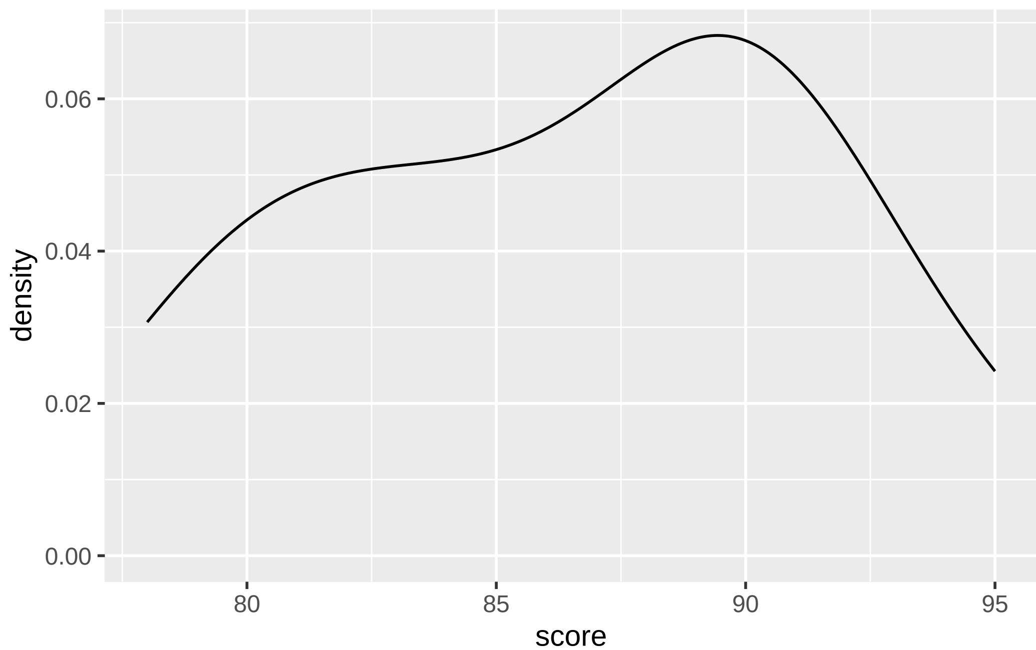
53.2 Histograms

```r
ggplot(data, aes(x = score)) +
  geom_histogram(binwidth = 2)
```



53.3 Density Plot

```
ggplot(data, aes(x = score)) +
  geom_density()
```



54 Chapter 15: RKWard (GUI-R) Tips

- Use menu-based analysis for beginners
- Save and export plots easily
- Integrate with R scripts for reproducibility

54.1 Summary: Basic Statistics using GUI-R (RKWard)

This eBook, authored by Dr. Harsh Pradhan (Assistant Professor at the Institute of Management Studies, Banaras Hindu University), serves as a comprehensive guide to understanding and applying basic statistical concepts, particularly in the GUI-based software RKWard (GUI-R).

Key Highlights: 1. Descriptive Statistics Covers measures of central tendency (mean, median, mode) and variability (range, variance, standard deviation). Introduces standard error and its role in estimating population parameters. 2. Inferential Statistics Introduces the Central Limit Theorem and how it forms the foundation for many statistical techniques. Confidence intervals are explained both theoretically and with practical calculations. 3. T-Tests (Student's t) Explains one-sample, independent-sample, and paired-sample t-tests. Includes step-by-step computation and GUI-R implementation. Includes interpretation of p-values, degrees of freedom, and test statistics. 4. Analysis of Variance (ANOVA) Covers one-way, two-way, and repeated measures ANOVA. Focuses on the F-statistic, assumptions, and post-hoc analyses. Discusses partitioning of variance into systematic and unsystematic components. 5. Effect Size and Statistical Power Introduces Cohen's d, eta-squared, and power analysis. Emphasizes that statistical significance does not always imply practical importance. 6. Assumption Testing Tests for normality (Shapiro-Wilk, QQ plot). Tests for homogeneity of variance (Levene's test). Highlights when to use non-parametric alternatives. 7. Non-Parametric Tests Introduces Wilcoxon signed-rank, Mann-Whitney U, and Kruskal-Wallis tests as robust alternatives to parametric methods. 8. Data Visualization in R Demonstrates use of boxplots, histograms, and density plots using ggplot2. Provides example R code for reproducibility. 9. GUI-R (RKWard) Usage Offers practical steps for using GUI-R for all statistical techniques covered. Designed to bridge the gap for learners unfamiliar with command-line R.