RESEARCH METHODOLOGY

[PT 309]

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LECTURE NOTES FOR 3rD GRADE BPT STUDENTS

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HYPOTHESIS FORMULATION AND TESTING, AND PROBABILITY DISTRIBUTION

LECTURE OUTLINE

- Learning objectives
- Hypothesis
  - Definition
  - Types of hypothesis
  - Hypothesis testing
- Probability distribution
  - Nominal
  - Skewed
- Review
- Reading resources/additional materials

RESEARCH METHODOLOGY

LEARNING OBJECTIVES

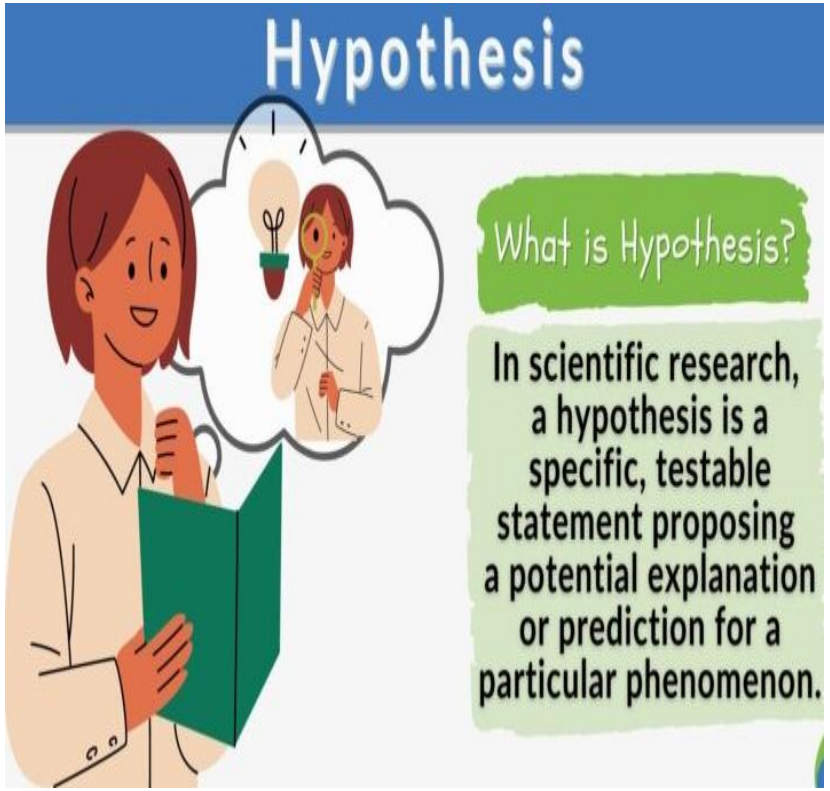
- Define and discuss different types of hypothesis.
- Formulate hypotheses for hypothesis testing.
- Conduct hypothesis tests using appropriate statistical methods.
- Understand various types of probability distributions (e.g., normal, binomial).

RESEARCH METHODOLOGY

Hypothesis

What is hypothesis?

- A hypothesis is a **testable statement** or **assumption** about the relationship between variables that can be investigated using research methods & statistical analysis.
- Provides a clear direction for research & guides statistical analysis.
- It defines what the study aims to prove or disprove
- Example: "Patients who receive education & exercise therapy for knee OA will show greater improvement in pain & function compared to those who receive education only"



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Hypothesis

Types of hypothesis

Alternative hypothesis (H_1)

- Definition: states that there is an effect or difference between groups or variables.
- Example:
  - "Physiotherapy treatment **improves** knee function in patients with ACL injuries"
  - "There will **be a significant difference** in knee pain between physiotherapy treatment and paracetamol in patients with knee OA"

Null hypothesis (H_0)

- Definition: states that there is no effect or no difference between groups or variables.
- It is the opposite of the null hypothesis & assumes any observed effect is due to chance.
- Example: "
  - "Physiotherapy treatment will have **no significant effect** in knee function before & after treatment in patients with ACL injuries"
  - "There will be **no significant difference** in knee function between physiotherapy treatment and paracetamol in patients with knee OA"

RESEARCH METHODOLOGY

Hypothesis

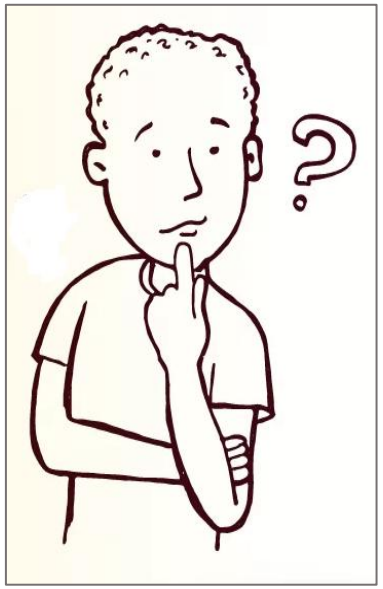
Formulating hypothesis

Step 1: identifying the research questions (define research question)

- What are you trying to investigate?
- Example:
  - "Does physiotherapy improve mobility in elderly patients with hip fractures? "
  - "Is physiotherapy treatment more effective at improving knee pain compared to paracetamol in patients with knee OA?"

Step 2: Conduct a literature review (search)

- Identify gaps in knowledge, trends, and evidence that guide hypothesis formulation.
- Example:
  - Literature shows mixed results regarding the efficacy of physiotherapy on post-fracture rehabilitation among elderly patients.

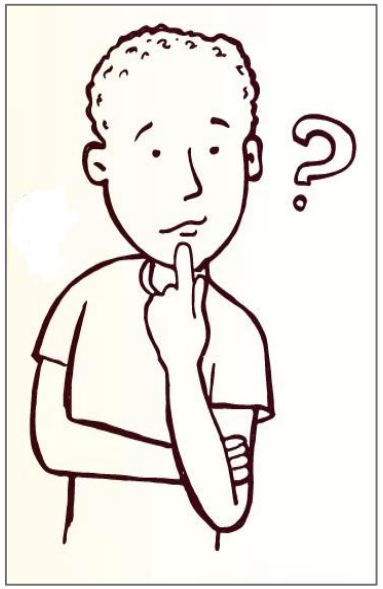


Hypothesis

Formulating hypothesis

Step 3: Define variables

- **Independent Variable (IV)**: The factor you manipulate
- Example:
  - Type of physiotherapy treatment (e.g., strength exercises, balance training).
  - Paracetamol
- **Dependent Variable (IV)**: The outcome you measure
- Example:
  - Mobility or gait speed improvement (e.g. 10-Meter Walk Test, TUG)
  - Knee pain: (e.g. Knee Injury and Osteoarthritis Outcome Score [KOOS]), VAS



Step 4: Develop the hypothesis

- Example:
  - "Elderly patients with post-fracture receiving balance training + strength exercise will show greater improvement in mobility compared to those receiving only strength exercise".

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Hypothesis

Hypothesis testing process

Step 1: State the hypothesis

- H_0: No effect or difference
- H_1: There is an effect or difference

Step 2: Choose significance level (alpha [α])

- Common value: α = 0.05 (5% risk of a Type I error)

Step 3: Select the statistical test

- Choose based on data type & study design
  - T-test: for comparing two groups.
  - ANOVA: for comparing more than two groups.
  - Chi-square: for categorical data
  - Example:
    - A t-test might be used to compare mobility improvement between two physiotherapy interventions.

Hypothesis

Hypothesis testing process

Step 5: Collect and analyze data

- Gather data from participants & use the appropriate test to analyze results.
- H_1: There is an effect or difference

Step 6: Make a decision

- **Reject H_0 (failed to accept the null hypothesis)** if p-value < α (evidence supports H_1).
- **Fail to reject H_0** if p-value ≥ α (insufficient evidence for H_1).

Example:

Hypothesis: There will be no significant difference in mobility between balance + strength exercise and strength in elderly patients with post-fracture after 8 weeks treatment

Alpha level: 0.05 (P < 0.05)

Test statistics: Independent t-test

Observed t-value and P-value for mobility score: t = 25.815, P = 0.001

Decision: Since the observed P-value is less than 0.05 Alpha level, I therefore failed to accept the null hypothesis (reject H_0)

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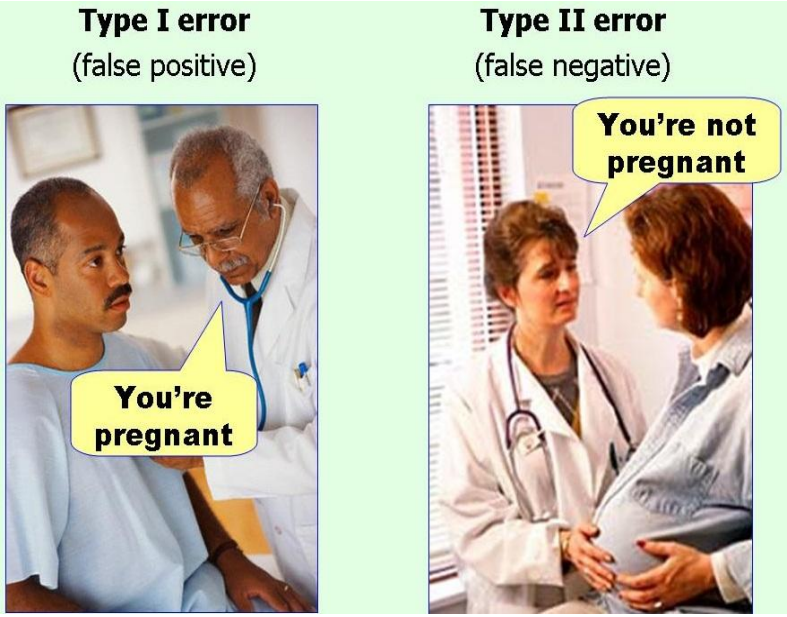
Hypothesis

Type I Error (False positive)

- Rejecting H_0 when it is actually true (incorrectly claiming a result exists).
- This can be problematic, especially in medicine or legal systems.
- Example:
  - A medical test wrongly detects a disease in a healthy person.
  - Concluding that no treatment improves mobility when it doesn't.

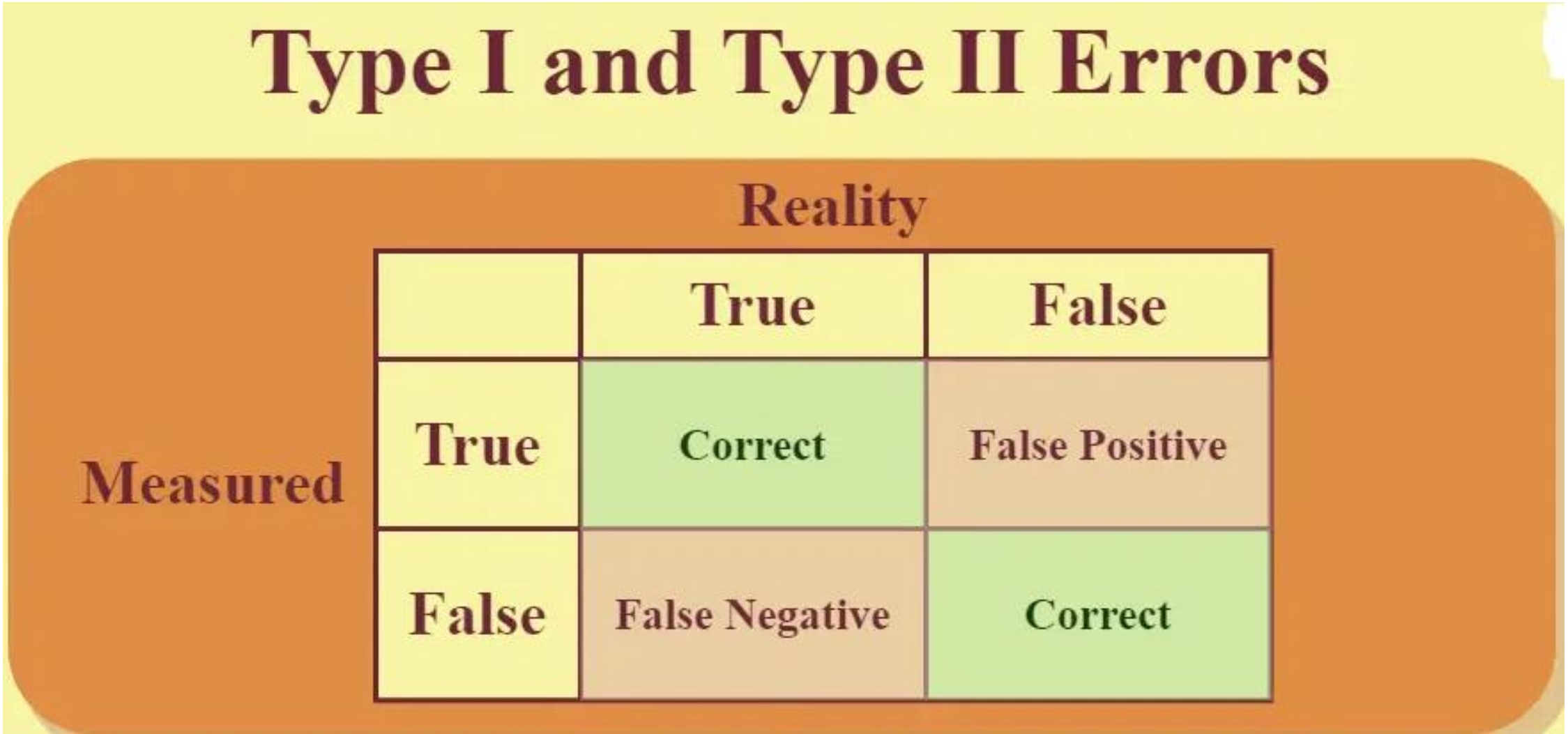
Type II Error (False negative)

- Failing to reject H_0 when it is false (missing a real effect).
- This could be harmful, for example, failing to diagnose a treatable disease.
  - Example:
    - A medical test failing to detect a dx when actually present.
    - Failing to detect a significant improvement in mobility from physiotherapy when it actually exists.



Hypothesis

Errors associated with results of experiment



Hypothesis

Probability value (P-value)

What is P-value?

- A p-value is a number describing the likelihood of obtaining the observed data under the H_0 of a statistical test.
- Provide the smallest level of significance at which the H_0 would be rejected.
- A smaller p-value means stronger evidence in favor of the alternative hypothesis.
- Often set at 0.05, indicating there is less than a 5% probability the null is correct.

Interpretation:

- When $P < 0.05$: Reject H_0 (statistically significant result).
- When $P \geq 0.05$: Fail to reject H_0 (no statistically significant result).

Example:

- If the p-value for a t-test comparing two physiotherapy treatments is 0.03, the H_0 is rejected & concluded that the treatments significantly differ in effectiveness.

Probability distribution

Recap on descriptive statistics

- **Descriptive statistics** are concerned with describing the characteristics of frequency distributions.
- Where is the center?
- What is the range?
- What is the shape [of the distribution]?

Frequency Table Test Scores

Observation (scores)	Frequency (# occurrences)
65	1
70	2
75	3
80	4
85	3
90	2
95	1

What is the range of test scores?

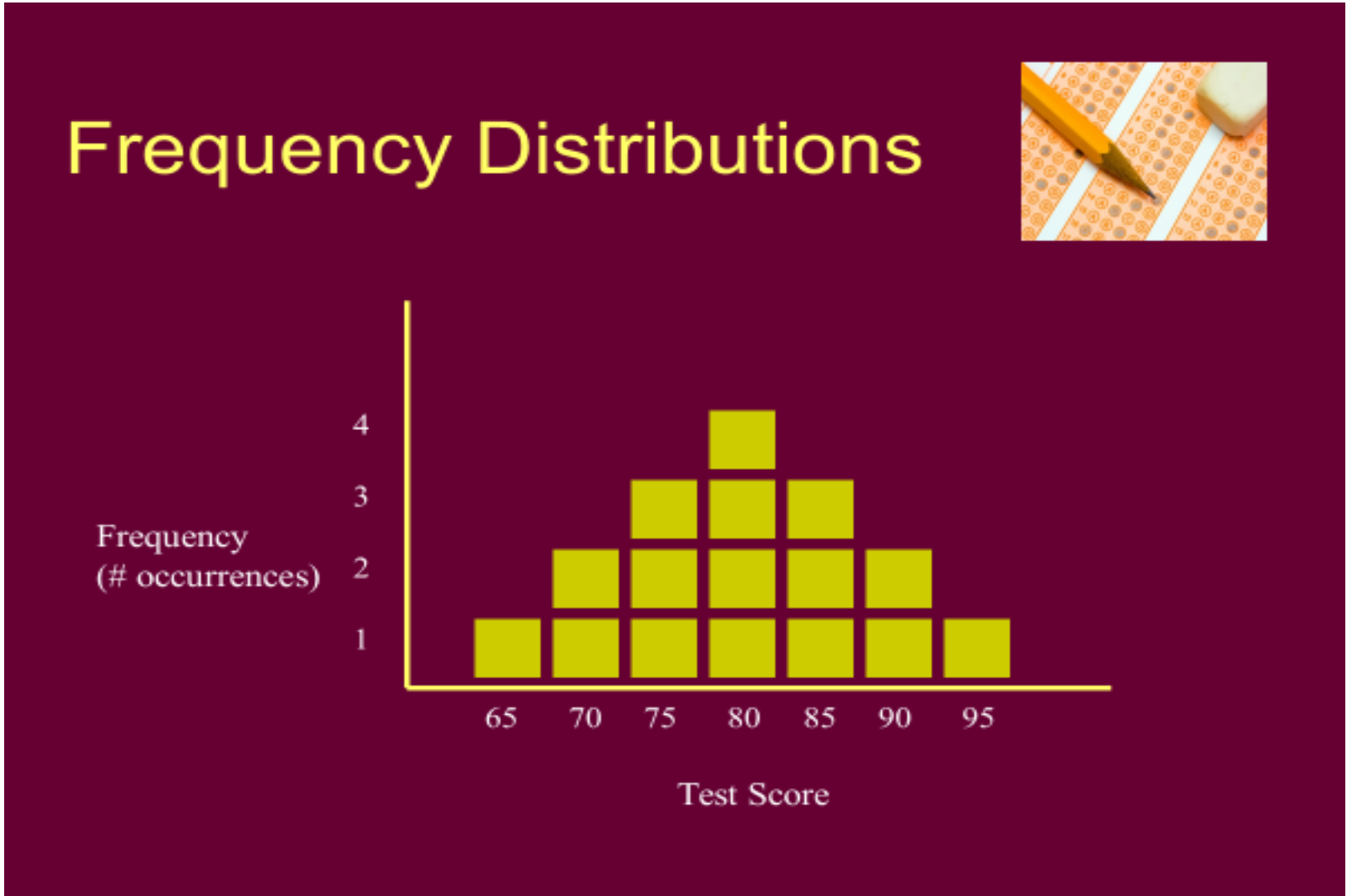
A: 30 (95 minus 65)

When calculating mean, one must divide by what number?

A: 16 (total # occurrences)

Probability distribution

Recap on descriptive statistics



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Probability distribution

Normally distributed curve

- Also known as a Gaussian distribution, is a **bell-shaped curve** that represents a normal distribution in statistics.
- The **bell-shaped** means the curve rises to a peak at the mean & tapers off symmetrically toward both extremes (left & right).
- Most of the data (i.e. mean, median, & mode) coincide at the center of the curve.
- Mean = Median = Mode

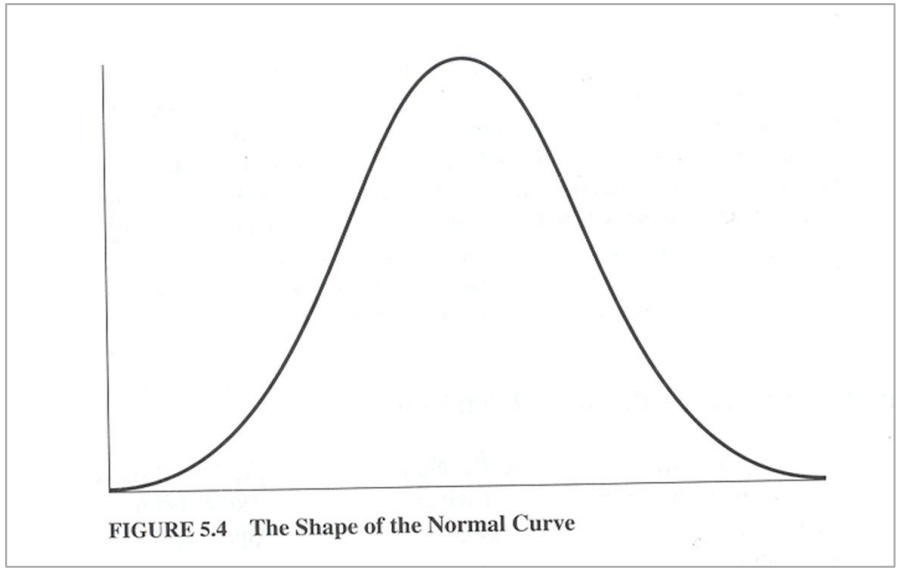
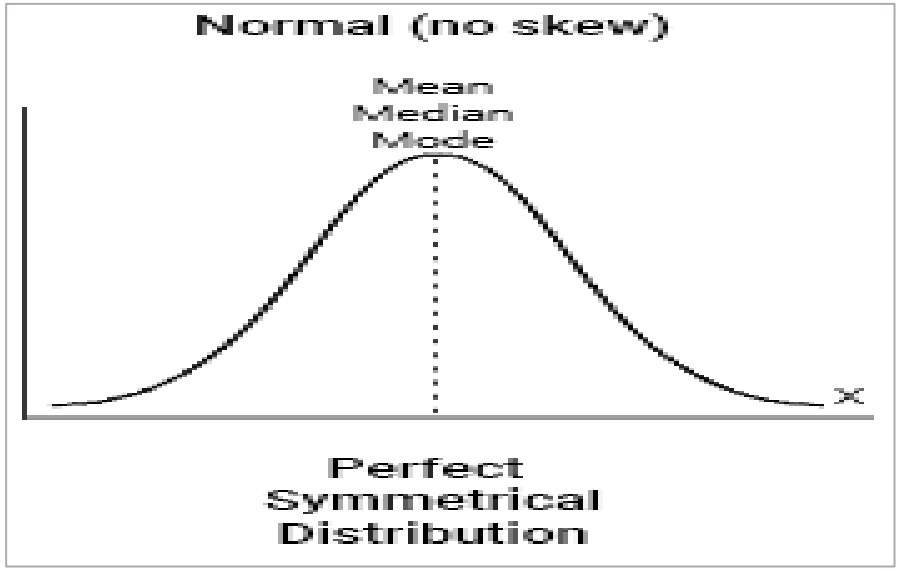


FIGURE 5.4 The Shape of the Normal Curve



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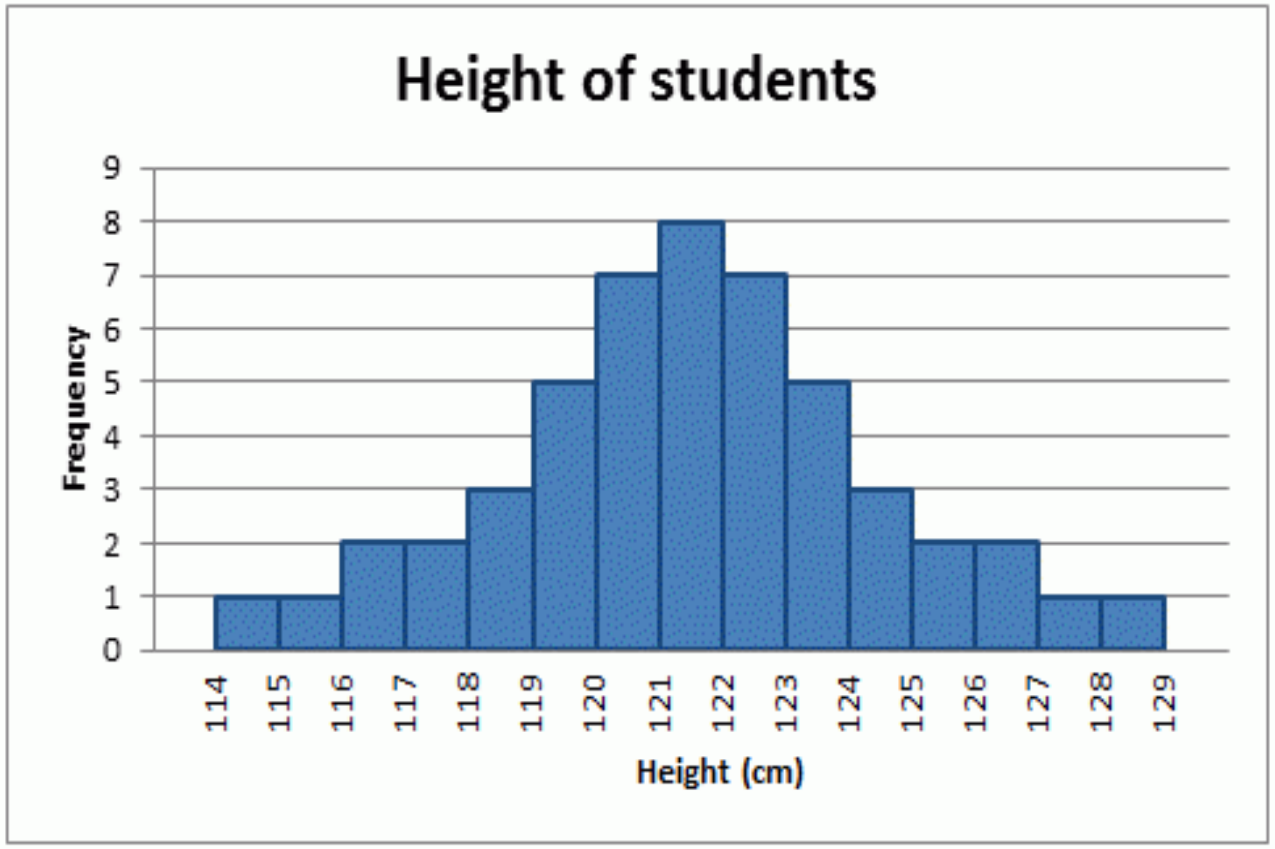
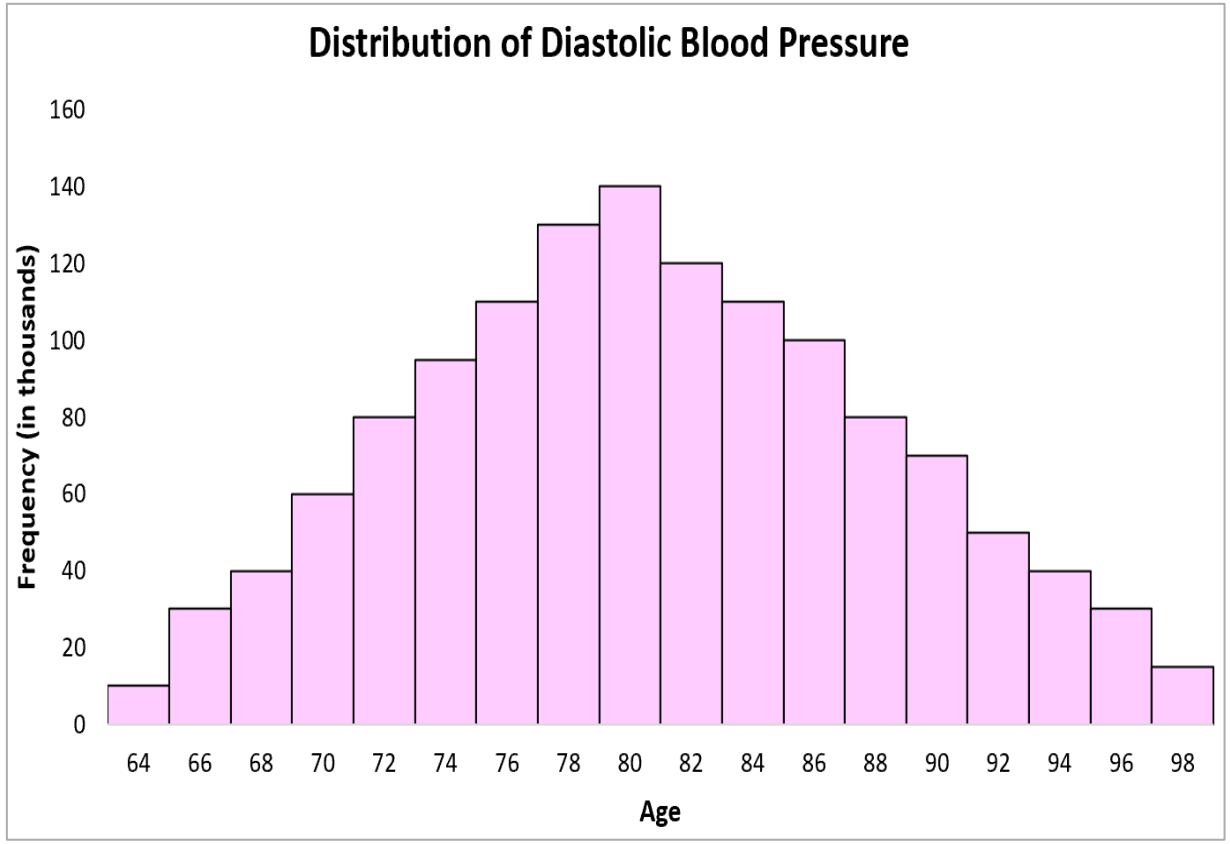
Probability distribution

Normally distributed curve

Examples of normal distributed data





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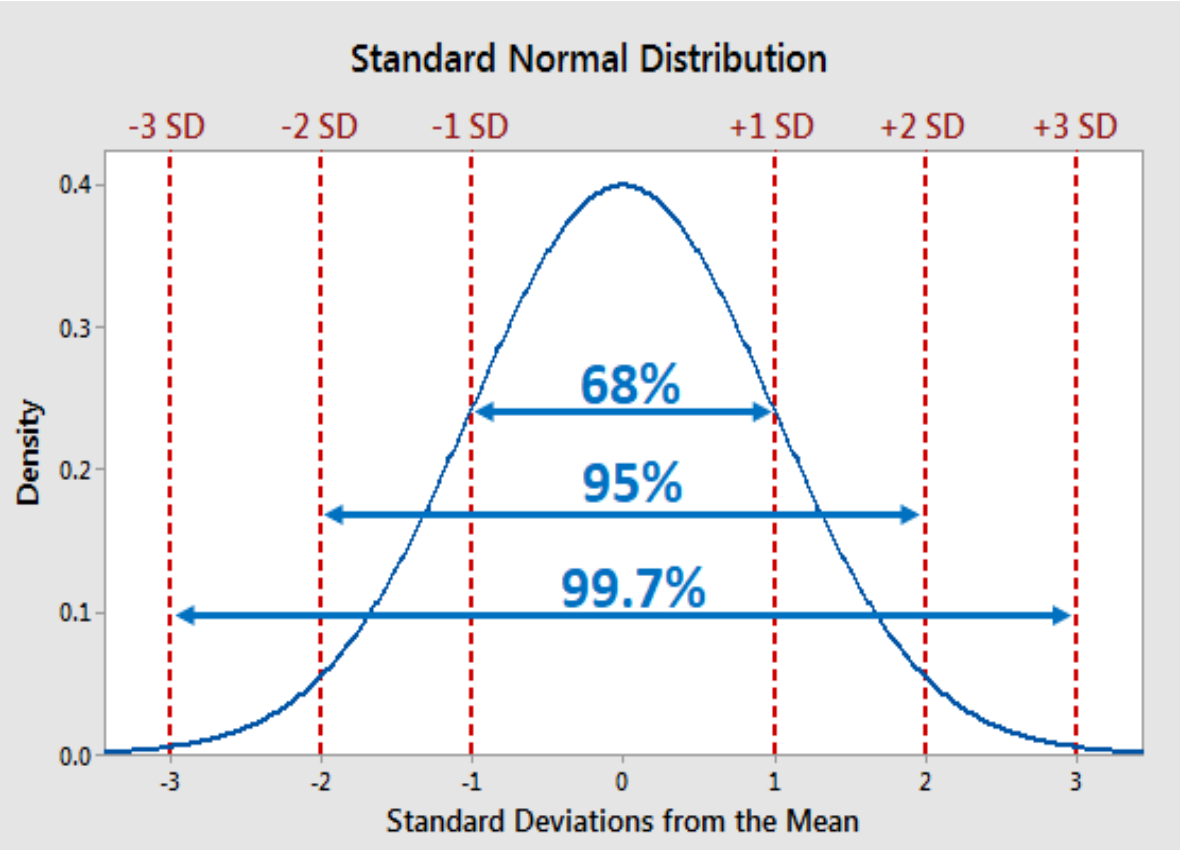
Probability distribution

Normally distributed curve

Empirical rule

- Also known as the **68 95 99 rule**, states that for normal distributions;
  - About 68% of data falls within 1 SD of the mean
  - About 95% of data falls within 2 SD of the mean
  - About 99.7% of data falls within 3 SD of the mean



Standard deviation (SD)

- A measure of how spread out or how much the values in a data set vary from the average (mean).
- **Low SD** means the values are close to the mean, so the data is less spread out.
- **High SD** means the values are more spread out from the mean, showing more variation in the data. It is not reliable.

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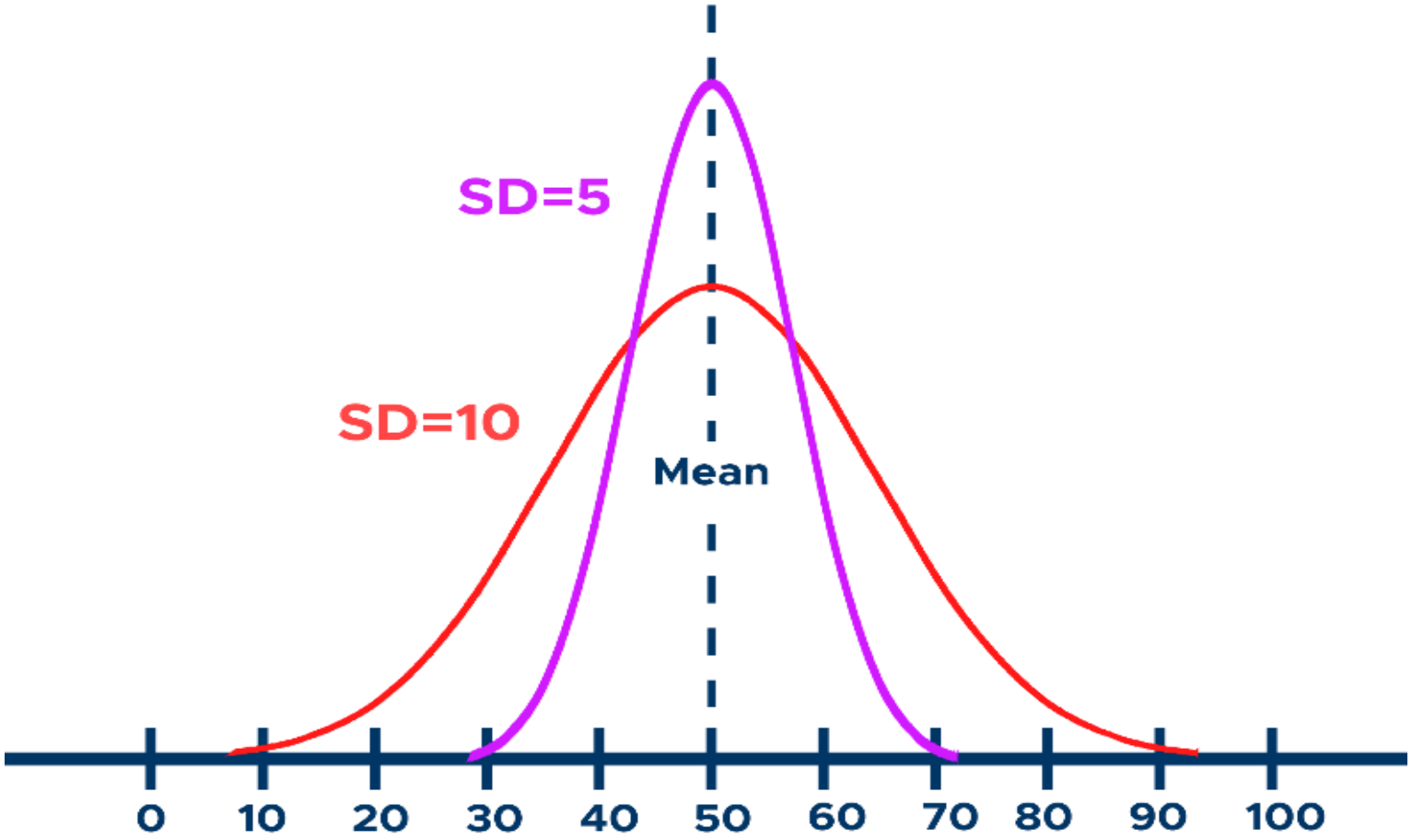
Probability distribution

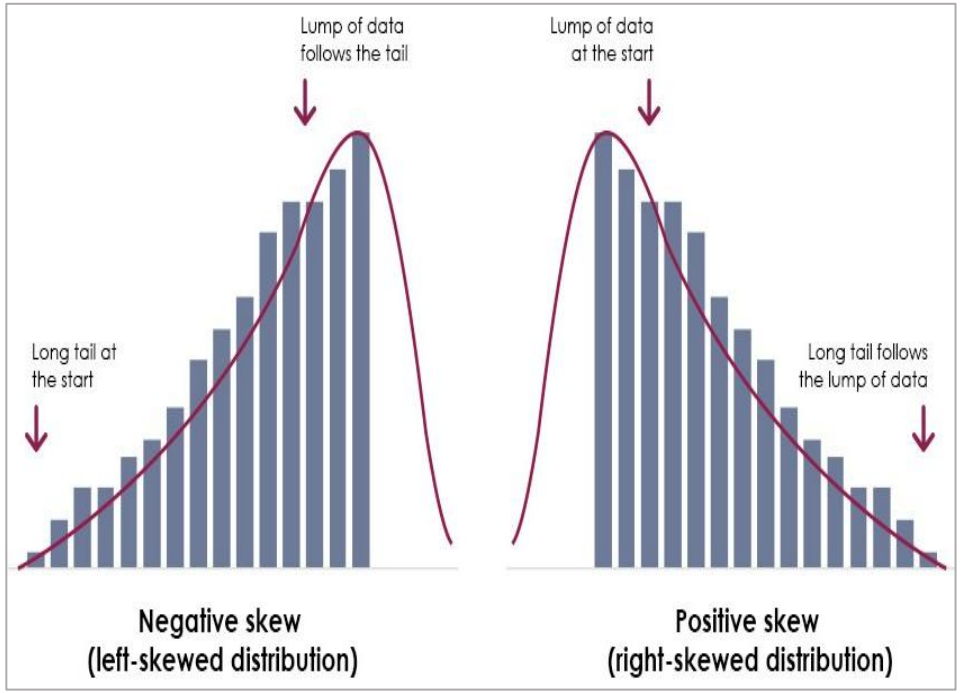
Normally distributed curve



Probability distribution

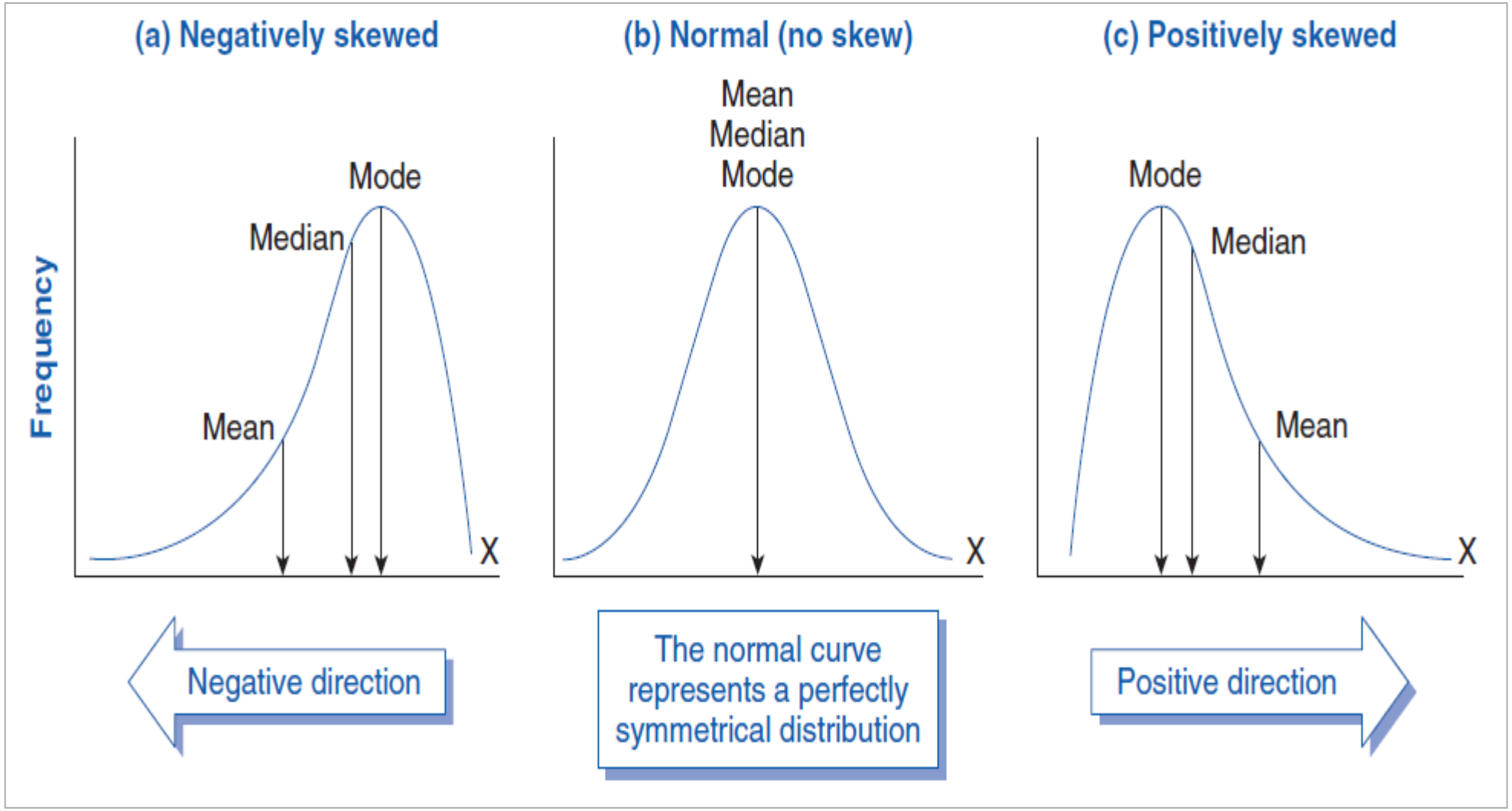
Skewed distribution

- A probability distribution in which the data is not symmetrically distributed & is unevenly spread to one side of the mean.
- One tail ("skewed" side) is longer or more spread out than the other, creating an asymmetry.
- It can be:
  - **Right-skewed (positively skewed) distribution**
    - The right tail (higher values) is longer or more stretched out than the left tail.
    - Mode>Medium>Mean
  - **Left-skewed (negatively skewed) distribution**
    - The left tail (lower values) is longer or more stretched out than the right tail.
    - Mean< Medium<Mode



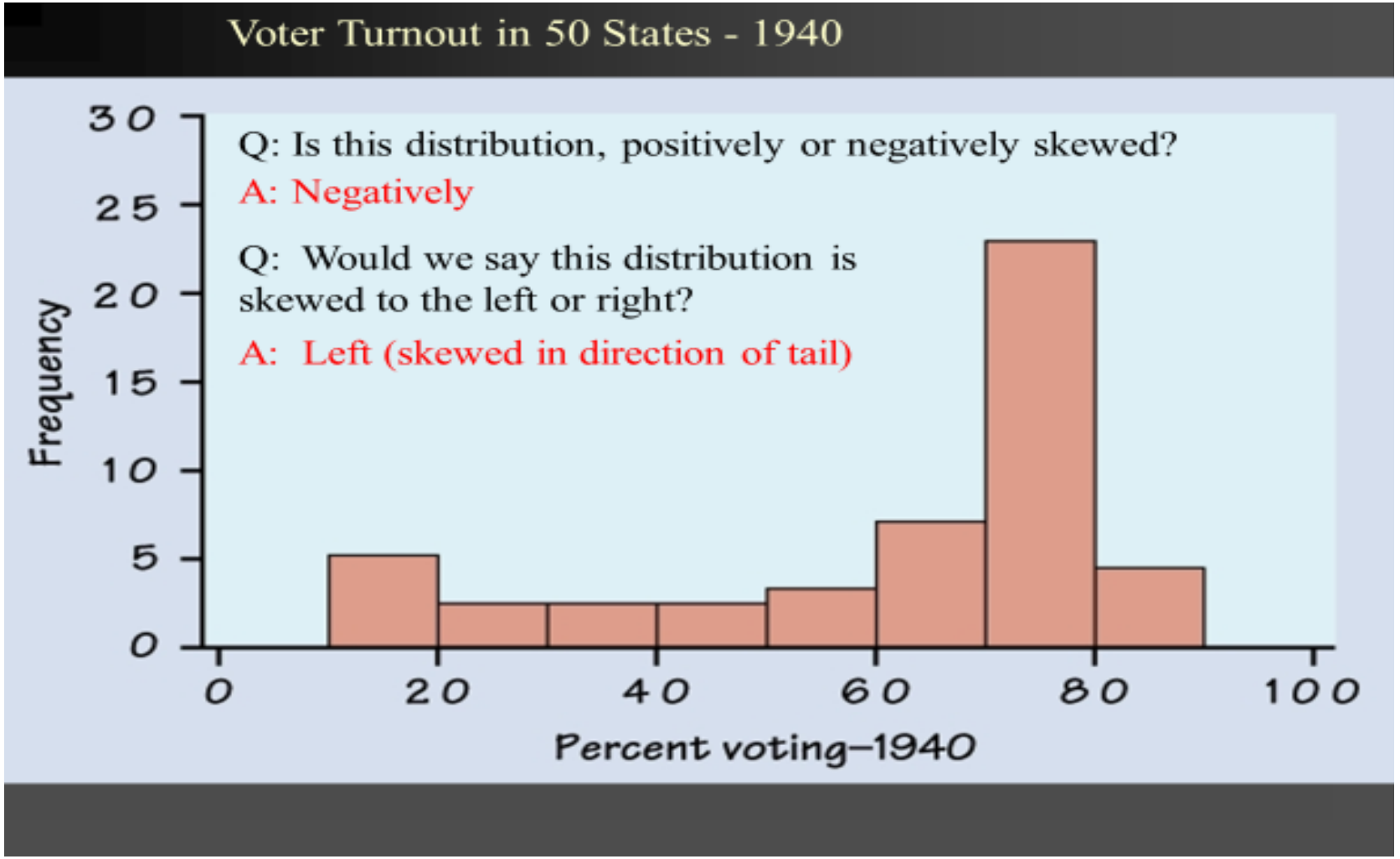
Probability distribution

Skewed distribution



Probability distribution

Skewed distribution



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Probability distribution

Normality assessment of data (using SPSS)

1. Visual methods

- Using methods like histogram & Boxplots
- What to check:
  - Symmetry (bell-shaped curves)
  - Extremes points

NB: Presence of symmetrical, bell-shaped curves, & absence of extremes points suggest normally distributed data

2. Statistical methods

1. **Kolmogorov-Smirnov Test**
   - Use for larger sample size ≥ 50
   - P > 0.05 = suggest normally distributed data as not significant variations in the sample.
2. **Shapiro-Wilk Test**
   - Use for small sample size ≤ 50, though can be also use for large sample
   - P > 0.05 = suggest normally distributed data as not significant variations in the sample.

RESEARCH METHODOLOGY

REVIEW

OTHER READING SOURCES

TEXT

1. *Kumar, R. (2011). Research methodology: A step-by-step guide for beginners (3rd ed.). Sage Publications.*
2. *Kothari, C. R. (2019). Research methodology: Methods and techniques (4th ed.). New Age International.*
3. *Walliman, N. (2011). Research methods: The basics (1st ed.). Routledge.*

THANKS FOR LISTENING