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Research Methodology and Statistics

In Sports Sciences

Research Methodology and Statistics

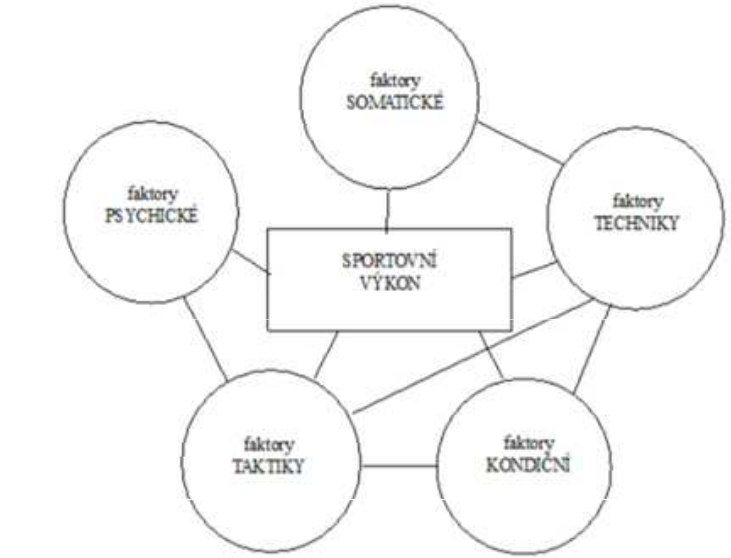
Research Methodology

Science (Benešová, 1999) - is a *systematic*, *critical* and *methodological* pursuit of true and common knowledge in a defined area of reality

Science (Ferjenčík, 2000) - is a comprehensive system of information obtained by a scientific method. Science provides guidelines for examination (methods) and an explanation of collected information (scientific theory)

Theory (Zháněl, 2014) - The primary goal of science is , i.e.an attempt to find general explanations of natural phenomena (via science research)

Examples of theory



(Dovalil et al., 2012)

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Research Methodology

Sport science – Kinesiology, Kinanthropology, Sportwissenschaft - is multidisciplinary science about human (voluntary) movement

Paradigm - a fundamental concept of a certain scientific discipline, which is considered to be exemplary. Defines proper procedures and methods, according to which rules and conventions

Methodology vs methods (Gabriel, 2011)– method is a research tool (interwiew in qualitatice study) and methodology is the justification for using this method.

- **Methodology** – the summary and study of methods, or the science of methods.
- **Method** – a tool or process for monitoring, researching, learning, exploring and achieving certain goals.
- **Methodical guidelines** – specific instructions for carrying out specific activities.

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Type of Research

Types of different research (Hendl, 2016)

Methodological study, Case study, Comparison, Correlation-predictive study, Experiment, Quasi-experiment, Evaluation, Development studies, Trend analysis, attitudes, Status, Exploration, Historical study, Modelling, Proposal and demonstration, systematic review, Meta-analysis, Theoretical studies, Analytical, Qualitative study

Types of different research (Mishra and Alok, 2017)

- Descriptive vs. analytical research
- Applied vs. fundamental research
- Conceptual vs. empirical research

Other types of research

- one-time research vs. longitudinal research
- field-setting research vs. laboratory research vs. model research
- clinical vs. diagnostic research
- case-study methods vs. exhaustively approaches
- exploratory vs. formalized research
- The objective of exploratory research (creation of hypotheses rather than their testing) vs. formalized research (specific hypotheses are tested)
- conclusion-oriented and decision-oriented research

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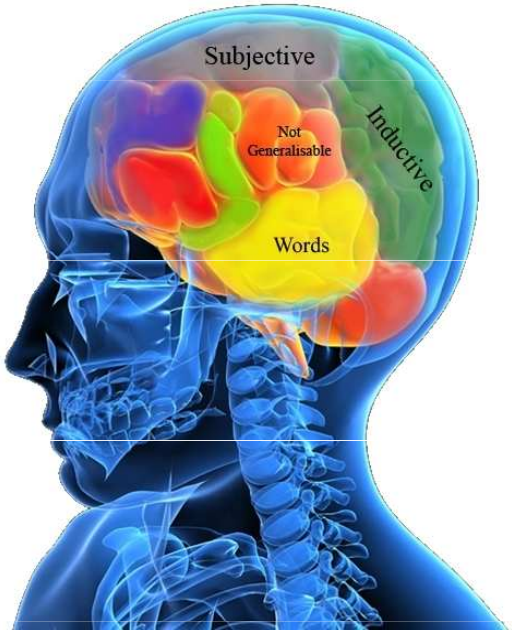
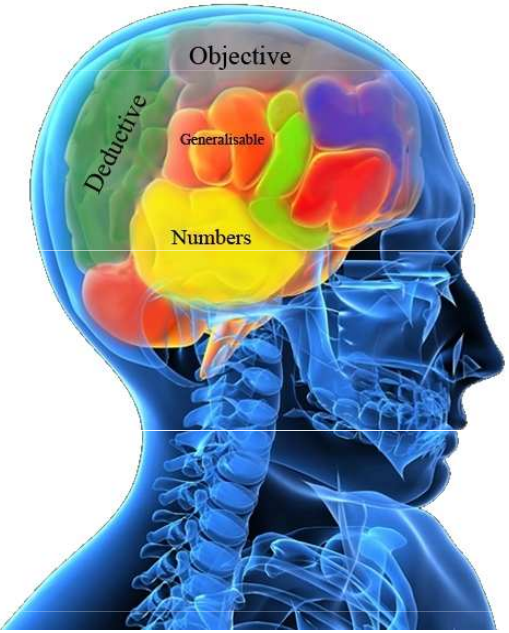
Type of Research

Qualitative research



Quantitative research



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Type of Research

Qualitative research - According of Švaříček & Šeďová et al. (2007) it is a process of examining phenomena and problems in an *authentic environment* in order to obtain a *comprehensive picture* of these *phenomena* based on *deep data* and a *specific relationship* between a researcher and a research participant. The aim of a qualitative research is to uncover and represent how people *understand*, *experience* and *create* social reality. It focuses on how individuals and/or groups *view*, *understand* and *interpret* the World (Zháněl, 2014), via *non-numerical* data.

Quantitative research - is the process of *collecting* and *analyzing numerical data*. It can be used to find *patterns* and *averages*, make *predictions*, test causal *relationships*, and *generalize* results to wider populations (Bhandari, 2021).

A common mistake: when it is relatively simple to transforming words (eg answers in a questionnaire) into numbers (occurrence) these are quantitative data

Mixed research

Hendl (2005) then talks about a combination of quantitative and qualitative methods in a single research activity when speaking of a mixed research strategy, in which the results obtained by the two strategies complement each other

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Type of *Qualitative* Research

Phenomenological method – how participant experiences, feel have opinion about a specific event or activity. It utilizes in-depth interviews, observation or survey to gather information

Grounded theory - tries to explain why a course of action evolved the way it did. Need large subject number to developer theoretical model based on existing data (DNA – genetic model)

Case study - in-depth look at one test subject (opposite of grounded theory). Various data are compiled to create a bigger conclusion

Focus groups - group of individuals who are asked questions about their opinions and attitudes towards certain fenomen

Ethnographic research - subjects are experiencing a culture that is unfamiliar to them

Type of *Quantitative* Research

Descriptive research - seeks to describe the current status of an identified variable. The researcher does not usually begin with an hypothesis, but is likely to develop one after collecting data

Correlation research - aim is to determine the extent of a relationship between two or more variables using statistical data. This type of research will recognize trends and patterns in data

Causal-Comparative/Quasi-Experimental - establish cause-effect relationships among the variables. The researcher does not randomly assign groups

Experimental Research - establish the cause-effect relationship. Subjects are randomly assigned to experimental

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Research Ethics

Most commen problems are

- Plagiarism (or wrong used of citations)
- Non-disclosure acknowledgement
- Data collection/analysis/interpretation
- Disclosure of interest; using third-party materiál

Plagiarism - It is a simple matter to follow the clear guidelines in citation that will prevent you being accused of passing off other people's work as your own (Williman, 2011)

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Research Ethics

General Principles

- The health of my patient will be my first consideration
- Physician must promote and safeguard the health, well-being and rights of patients
- … never take precedence over the rights and interests of individual research subjects
- researcher protect the life, health, dignity, integrity, right to self-determination, privacy, and confidentiality of personal information of research subjects
- …

Helsinki Declaration

- Adopted by the 18th The World Medical Association (WMA) General Assembly, Helsinki, Finland, June 1964
- Statement of ethical principles for medical research involving human subjects, including research on identifiable human material and data

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The Research Hypotheses

Hypotheses are statements that relate to the existence of the relationship between variables or prediction of defined variables using other variables (Zháněl, 2014)

- Without hypothesis the research in unfoucussed
- Hypothesis is necesarry link between theory and investigation

Sources of hypothesis

- Theory and studies (literature research)
- Observation (from own practice / experience)
- Intuition (less then theory and observation)
- Culture (behavior or beliefs of social, ethnic or age group)
- New trend (possible future experience)

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The Research Hypotheses

Working hypothesis – not very specific, they can be easily modified, used with insufficient data; example: Chocolates before training ensures maximum performance

Descriptive hypothesis – variable can be situation, event, organization, person, group, object

- Relation hypothesis (describes relationship – positive, negative or casual – between two variables) example: Children from higher incomes families spend more times at leisure physical activities
- Formalised hypothesis (cause and effect relationship between independent and dependent variable) example: If families have higher incomes, than they spend more money on leisure physical activities

Types of research hypotheses

Null hypothesis (H_0) – predicts that there is no relationship between two variables;

Alternative hypothesis (H_a/H_1) – the opposite statement than H_0. For acceptance of H_a, H_0 must be rejected first.

1. Directional (left or right tailed test) – hypothesis in which we can predict effect (positive/negative) of one variable on others. Example: Girls are more flexible than boys
2. Non-directional (two tailed test) – hypothesis in which we cannot predict effect, but stat a relationship between variables (we do not know what kind of difference); example: there will be a difference in the performance of experimental and control groups

(Zháněl, 2014; Cauvery et al., 2010)

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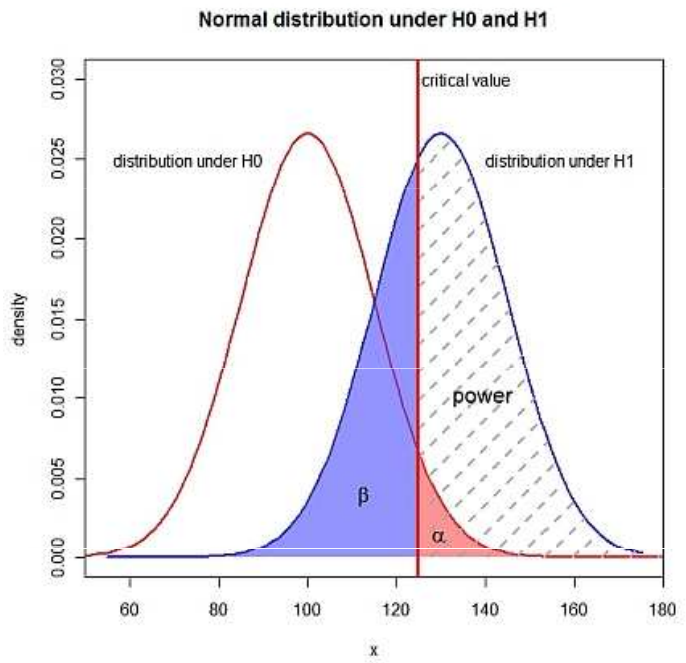
The Research Hypotheses



Rejecting the null hypothesis

		Actual Value (reality)	
		Positive	Negative
Conclusion from hypothesis test	Positive	Positive Positive == TRUE Positive (Power, 1 – β)	Negative Positive == **FALSE Positive**, *Type I Error (α)*
	Negative	Positive Negative == **FALSE Negative** *Type II Error (β)*	Negative Negative == TRUE Negative

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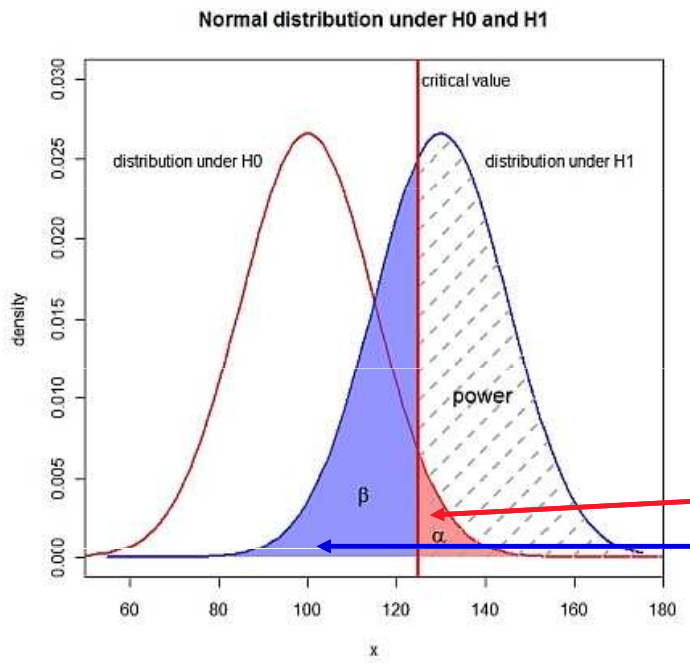
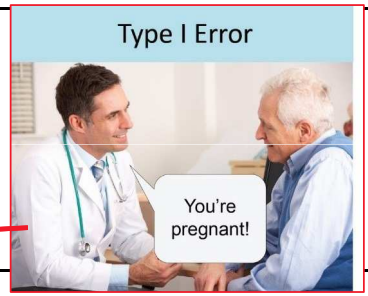
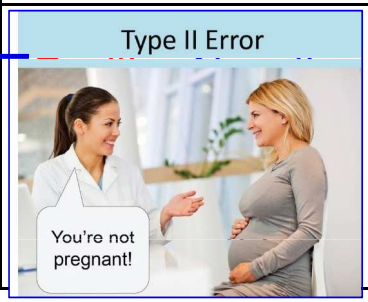
The Research Hypotheses



Rejecting the null hypothesis

		Actual Value (reality)	
		Positive	Negative
Conclusion from hypothesis test	Positive	Correct	
	Negative		Correct

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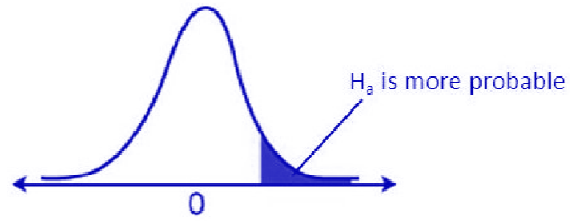
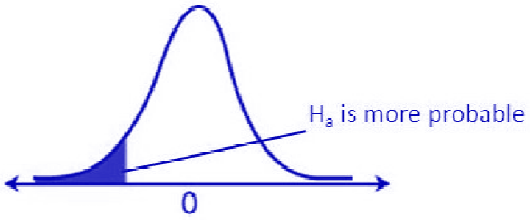
The Research Hypotheses

Rejecting the null hypothesis



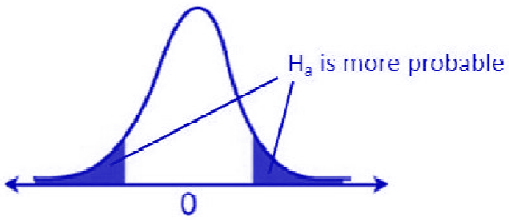
Right-tail test

$H_a: \mu > \text{value}$



Left-tail test

$H_a: \mu < \text{value}$



Two-tail test

$H_a: \mu \neq \text{value}$

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Sampling

- The study of the total population **is not possible** and it is **impracticable**.
- The practical limitation *cost*, *time*, and *other factors* which are usually operative in the situation, stand in the way of *studying the total population*
- Sampling is the process of *selecting a few* (a sample) from a bigger group (the sampling population) to become the basis for estimating or predicting the prevalence of an unknown piece of information, situation, or outcome regarding the bigger group

Basically we have two types of sample:

- *Random sample*
- *Non-random sample*

(Singh, 2006; Kumar, 2011)

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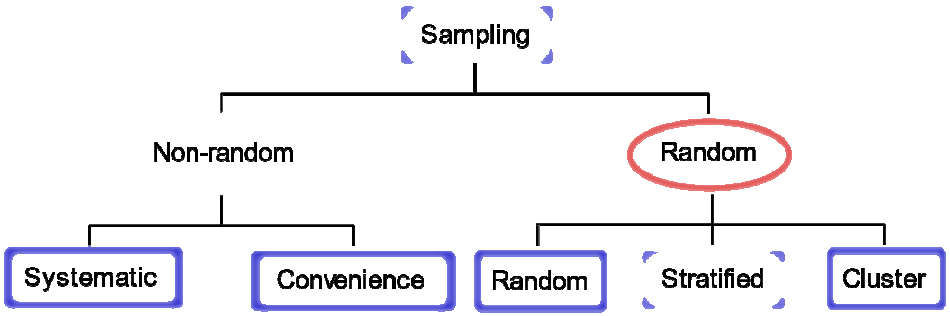
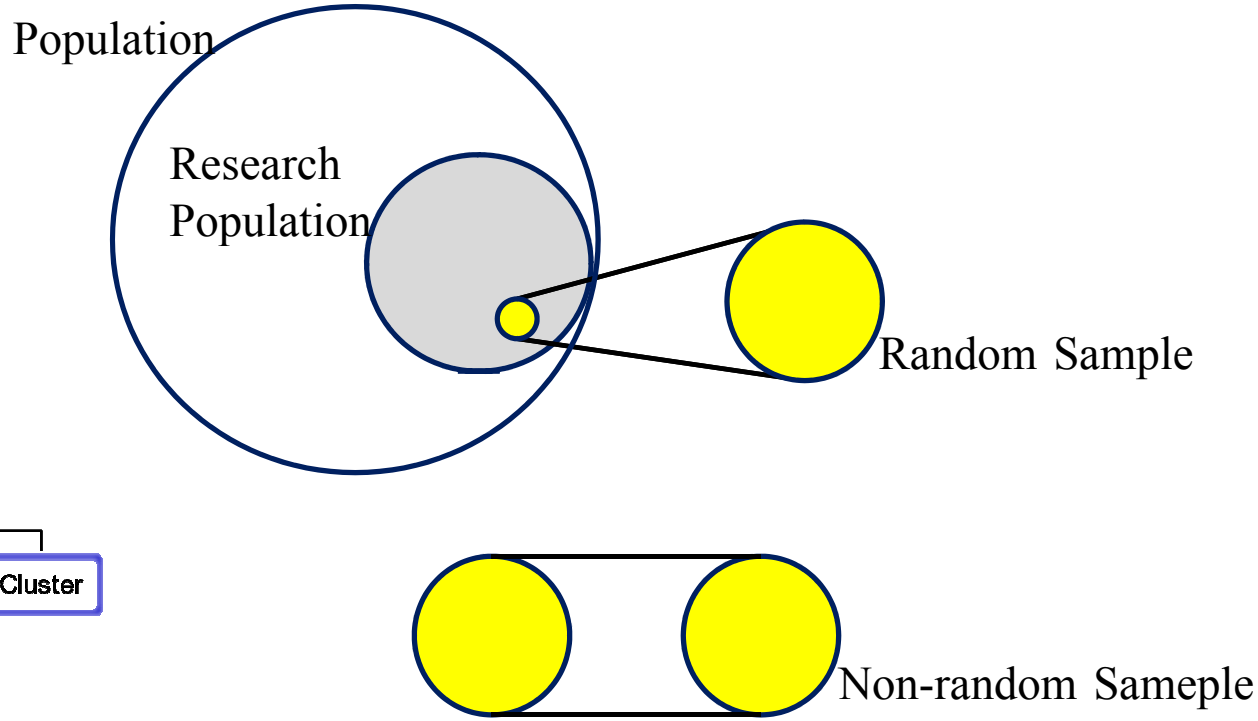
Sampling





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Statistical Analysis

Statistical analysis is the science of collecting data and uncovering patterns and trends

note: you <u>cannot</u> only accept H_0 (only **reject** or **fail to reject**), after rejecting H_0, we can add „we can accept H_a

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Characteristics of a Good Test

Reliability is consistency, dependence or trust

measurement reliability is the consistency with which a test yields the same result in measuring whatever it does measure

Example 1: If after first test mean score is 80, and after one week we used same test on same sample and the mean score is:

- 80 = test provided stable and dependent results
- 102 = test results are not consistent

Example 2: how two different teachers will evaluate the same test results

Reliability, Validity, Objectivity and Usability

Types of reliability testing methods:

- Test-retest method (the same test over time)
- Interrater method (the same test conducted by different people)
- Parallel forms method (different version of a test which are designed to be equivalent)
- Split-half method (same test divides into two equivalent values)
- Internal consistency method (correlation between multiple items in a test that are intended to measure the same construct)

Methods of determining reliability

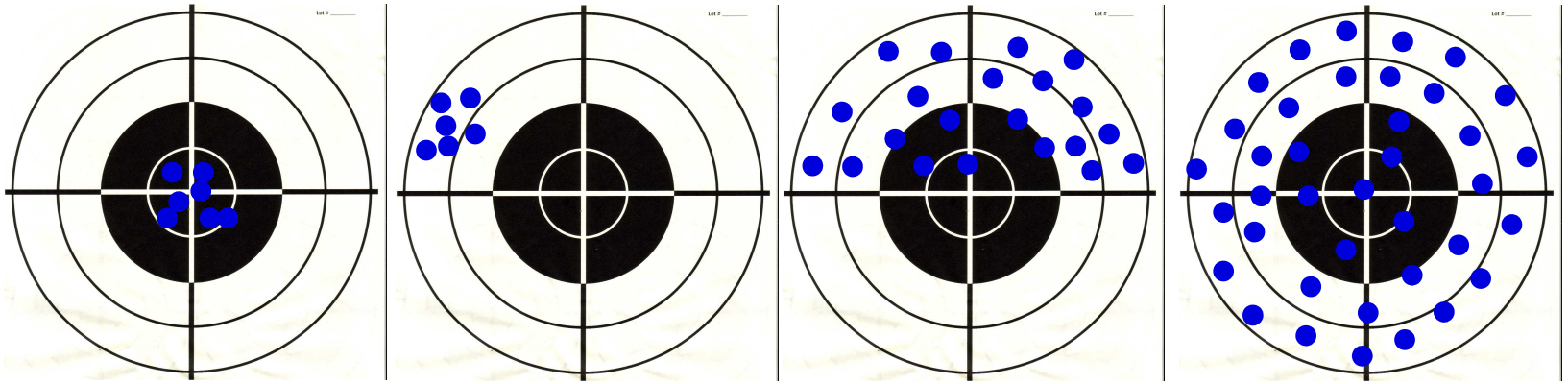
- *Intraclass Correlation Coefficient* (ICC) - defines a measure's ability to discriminate among subjects
- *Standard Error of Measurement* (SEM) - quantifies error in the same units as the original measurement

(Gronlund and Linn, 1995; Ebel and Frisbie, 1991)

Research Methodology and Statistics

Characteristics of a Good Test Reliability, **Validity**, Objectivity and Usability

- It means to what extent the **test measures that**, what the test maker **intends to measure**
  - means *truthfulness* of a test
- Validity do not have different types. It is a unitary concept, based on various types of evidence



Both Reliable and Valid | Reliable but not Valid | Neither reliable or valid | Not Reliable but Valid

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Research Methodology and Statistics

Characteristics of a Good Test

Reliability, Validity, **Objectivity** and Usability

The extent to which the instrument is *free from personal error* (personal bias), that is subjectivity on the part of the scorer (Good, 1973)

a test is considered objective when it makes for the *elimination* of the *scorer's personal opinion* and *bias judgement*

It affects both validity and reliability of test scores

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Research Methodology and Statistics

Characteristics of a Good Test

- The test must have *practical value* from time, economy, and administration point of view
- Practical considerations *cannot be neglected*

Reliability, Validity, Objectivity and **Usability**

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Variable Types and Scaling

Research variables are things you *measure*, *manipulate* and *control* in statistics and research

– Person, place, thing, idea, …

Other variables: Intervening (mediator) variables, Moderating (moderator) variables, Extraneous variables, Quantitative (numerical) variables, Qualitative (categorical) variables, Composite variables

Research Variables

The most common types of variable

- *Independent variable* (IV) - is a singular characteristic that the other variables in your experiment cannot change, but IV can change other variables
  - *Age* (eating or exercise habits are not changing your biological age, but you will not lift same weight as senior)
- *Dependent variable* (DV) - relies on and can be changed by other components, IV can influence DV, DV can't influence IV. Researchers goals are **determine what makes** the dependent variable change and **how**.
  - *A grade on exam* (it depends on factors as how much your slept or how long you studied, but your test does not affect the time you spent studying)
- *Control (controlling)* variables - are constant and do not change during a study, they have no effect on other variables.
  - If we are investigating how much your slept (IV) effect a grade on exam (DV), we need to control *time spent learning*, the same *level of students* and more

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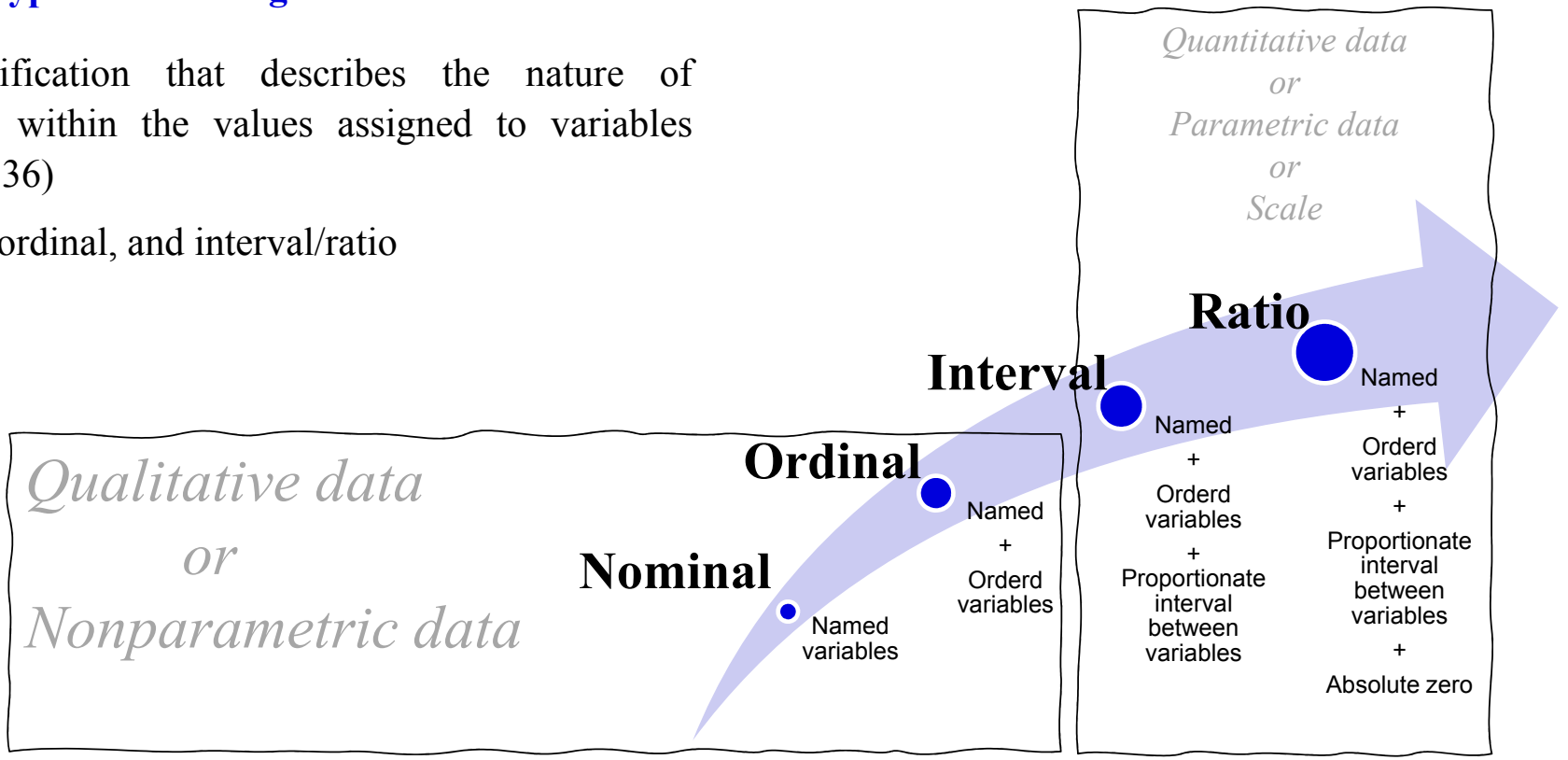
Variable Types and Scaling

is a classification that describes the nature of information within the values assigned to variables (Stevens, 1936)

– nominal, ordinal, and interval/ratio

Levels of Measurement



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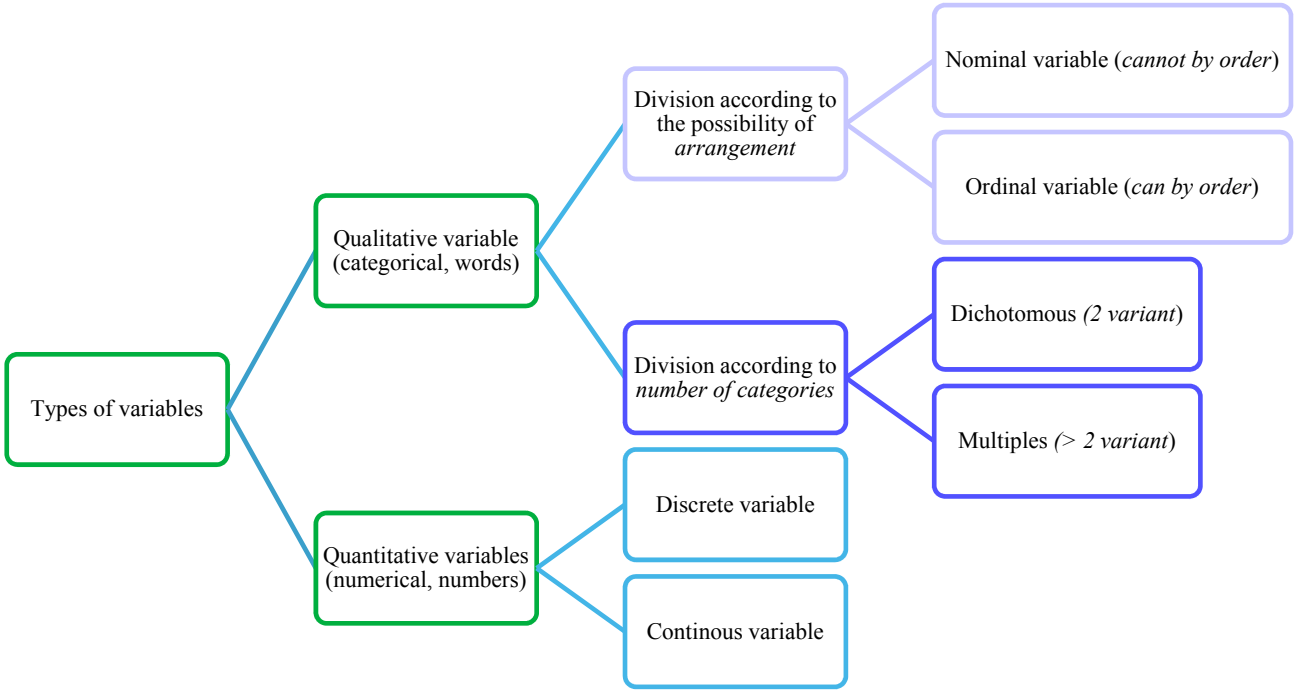
Variable Types and Scaling

Levels of Measurement

Levels of Measurement (Scale of Measure) are *Nominal, Ordinal, Interval, Ratio*



(Litschmannová, 2011)

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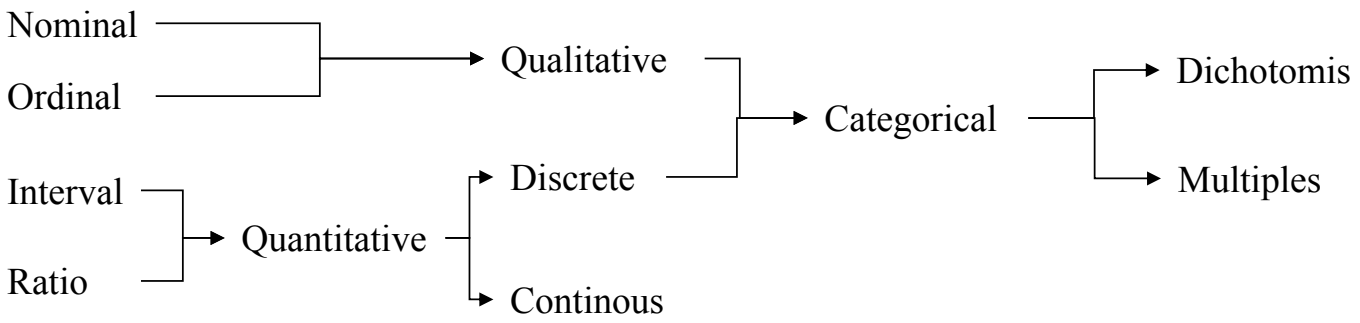
Variable Types and Scaling — Levels of Measurement

Levels of Measurement (Scale of Measure) are *Nominal, Ordinal, Interval, Ratio*



(Řezanková et al., 2017)

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Research Methodology and Statistics

Descriptive Statistic

1. Measures of Distribution or Frequency
2. Measures of Central Tendency
3. Measures of Dispersion or Variation
4. Measures of Position

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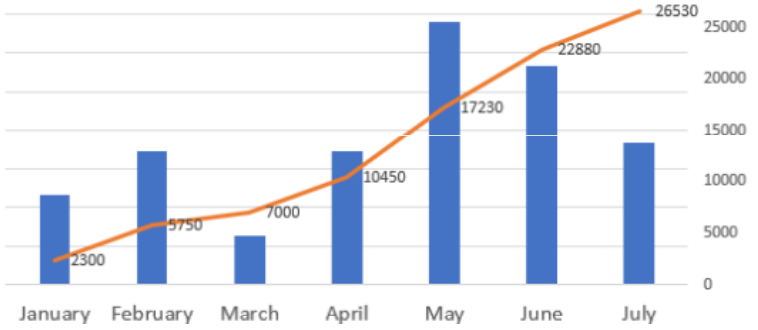
Descriptive Statistic

Measures of Distribution or Frequency

- a graph or data set organized to show the frequency of occurrence of each possible outcome of a repeatable event observed many times
- compare one part of the distribution to another part of the distribution
- *Count, Percent, Frequency*

My Classmate's Favorite Colors		
Color Choices	**Tally Marks**	**Frequency**
Red	𝍸	4
Blue	𝍸 ||	7
Yellow	𝍸	5
Orange	||	2

Weight (Kg)	Frequency	Cumulative Frequency
0 up to 20	2	2
20 up to 40	7	9
40 up to 60	12	21
60 up to 80	6	27
80 up to 100	3	30



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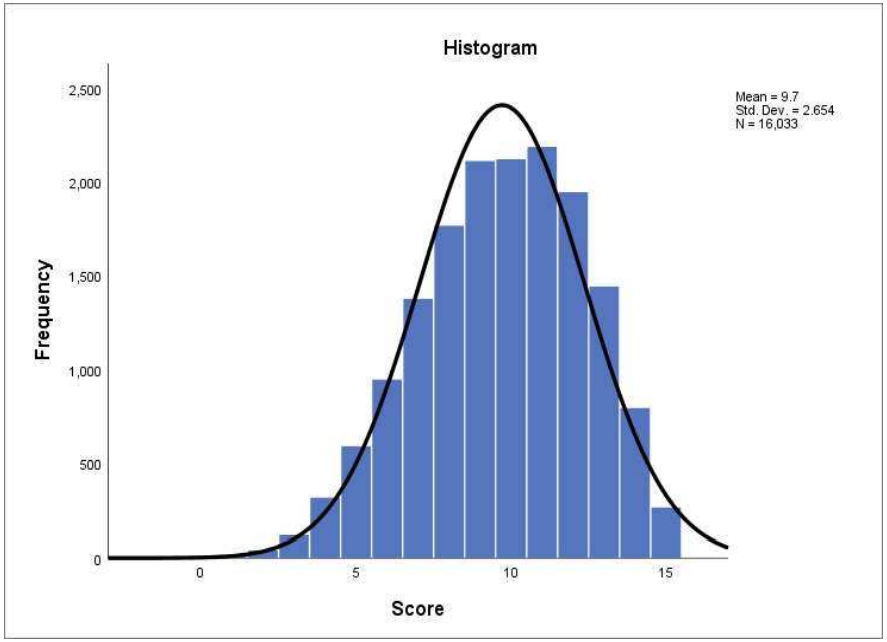
Descriptive Statistic Measures of Distribution or Frequency

- a graph or data set organized to show the frequency of occurrence of each possible outcome of a repeatable event observed many times
- compare one part of the distribution to another part of the distribution
- *Count, Percent, Frequency*



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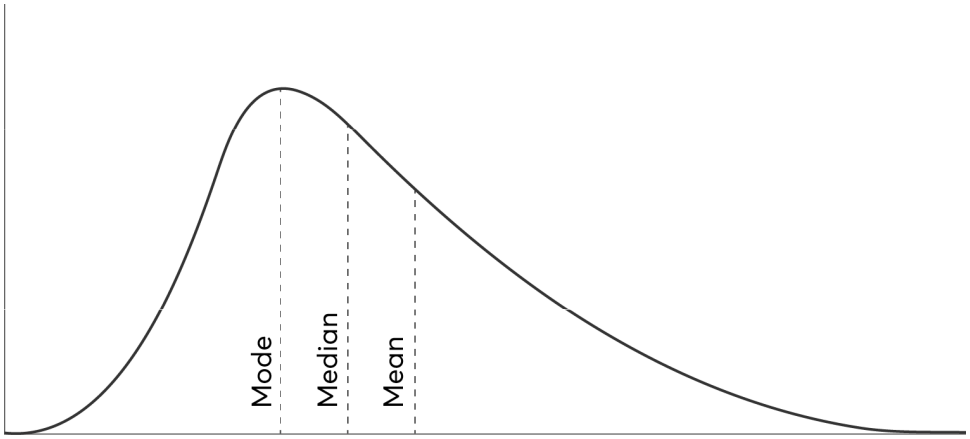
Descriptive Statistic Measures of Central Tendency

is defined as the number used to represent the center or middle of a set of data values

- *Mean, Median, Mode*



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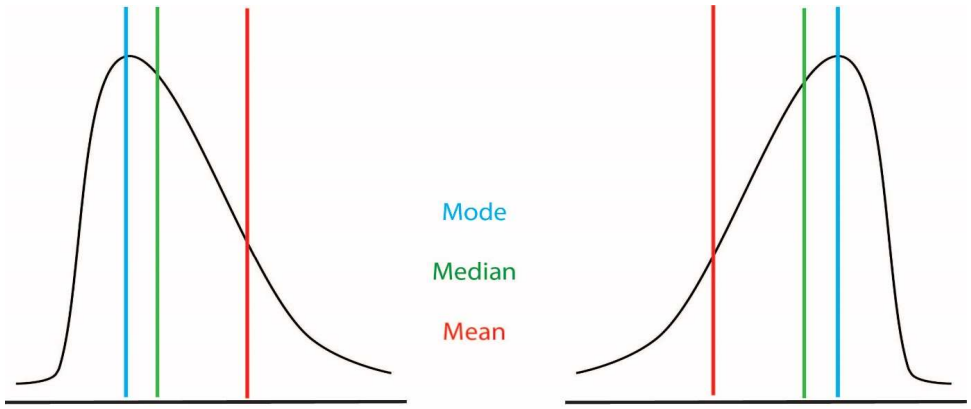
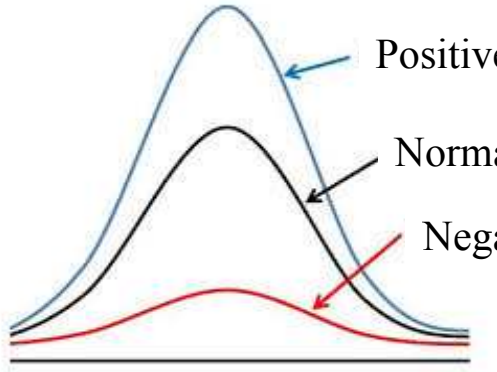
Descriptive Statistic Measures of Central Tendency



Right or Positive **skew**

Left or Negative **skew**



Positive **kurtosis** or Leptokurtic

Normal **kustosis** or Mesokurtic

Negative **kurtosis** or platykurtic

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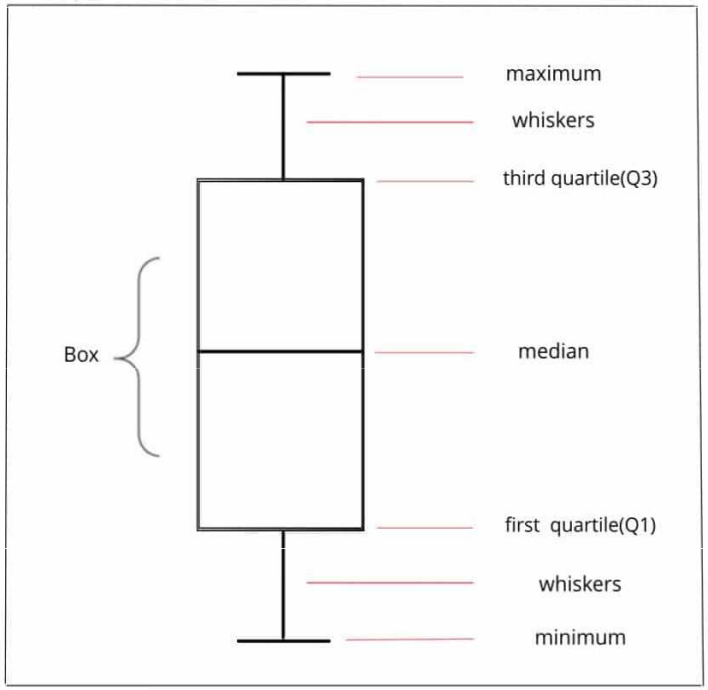
Descriptive Statistic

Measures of Dispersion or Variation

how far apart data points lie from each other and from the center of a distribution (mean±SD)

- **Range, IQR, Standard Deviation, Variance**
  - *Range* (R) = $x_{Max} - x_{min}$
  - *Interquartile range (IQR)* = $Q_3 - Q_1$
  - *Standard deviation* (SD, s) is the average amount of variability in your dataset
    - s = sample standart diviation
    - σ = population standard deviation
  - *Variance* (s^2) is the average of squared deviations from the mean
    - To get variance, square the standard deviation (s)
    - s^2 = sample variance
    - σ^2 = population variance



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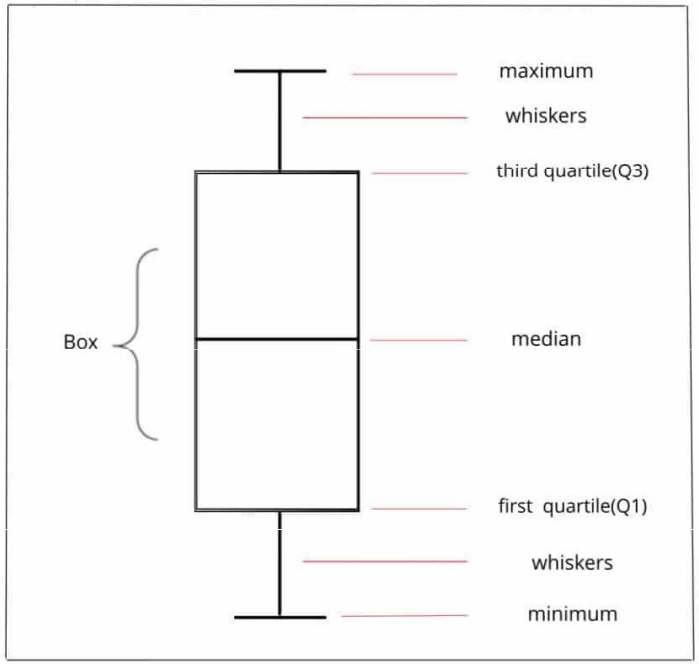
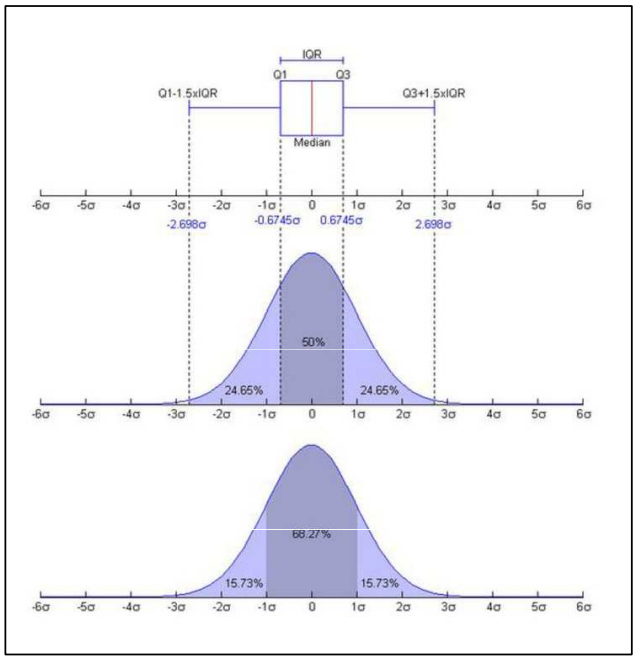
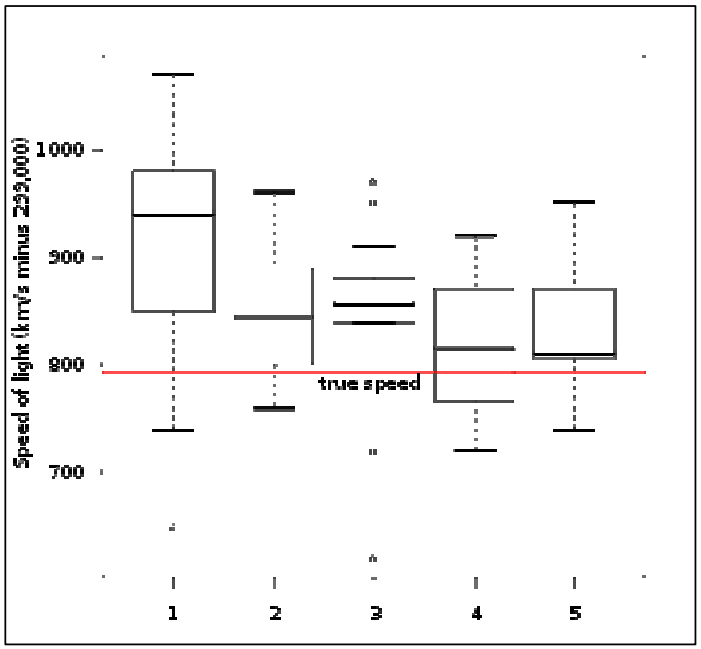
Descriptive Statistic Measures of Dispersion or Variation







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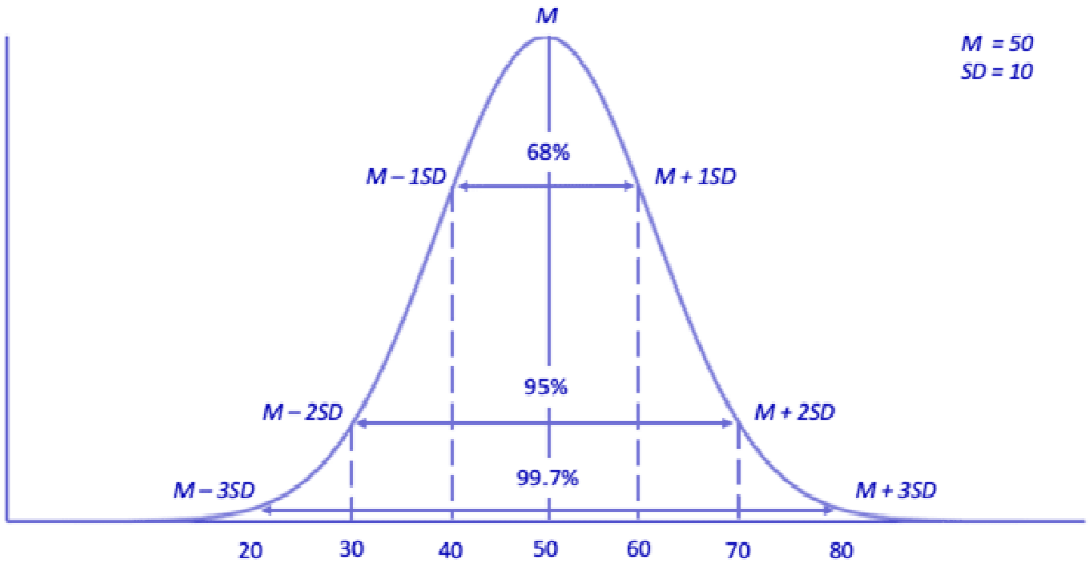
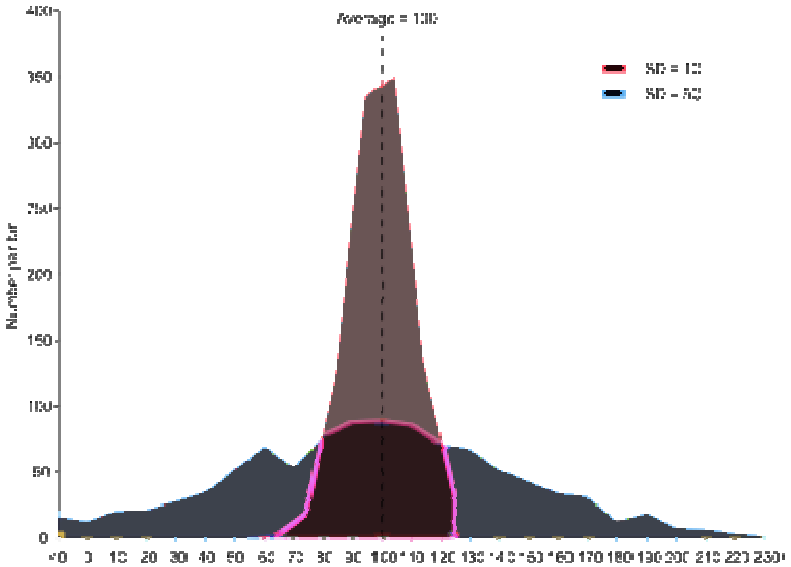
Descriptive Statistic Measures of Dispersion or Variation





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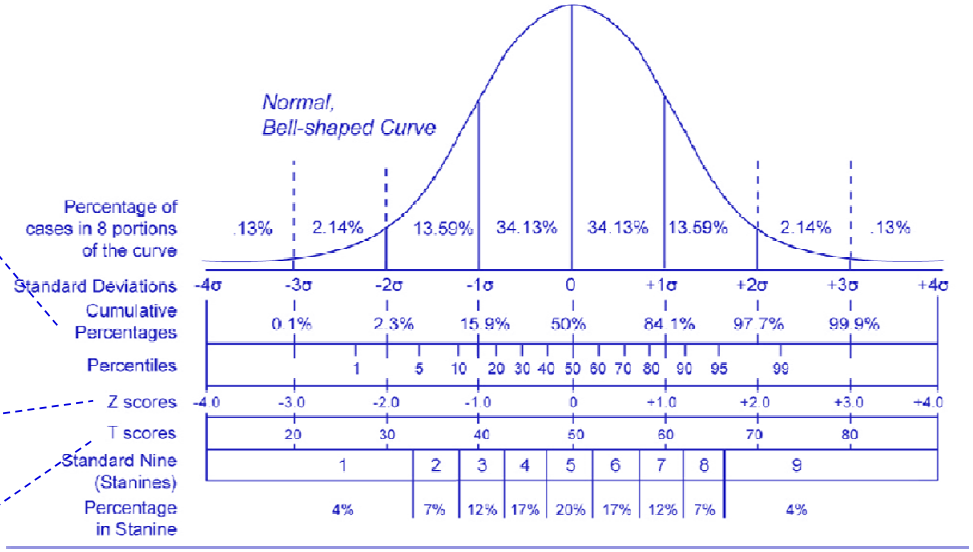
Descriptive Statistic

Measures of Position

Determines the position of a single value in relation to other values in a sample or a population data set.

- **Quantiles (Percentile, Decile, Quartile), Outliers, standard scores**
  - *Percentile* (P_i)= divide a rank-ordered data set (from the smallest to the largest) into 100 equal parts
  - *Decile* - divide a rank-ordered data set into ten equal parts
  - *Quartiles* (Q_i) - divide a rank-ordered data set into four equal parts
    - $Q_1 = P_{25}$, $Q_2 = P_{50}$ = median
  - *Standard scores*: raw scores that, for ease of interpretation, are converted to a common scale of measurement, or z distribution
    - *z-Score* indicates how many standard deviations an element is from the mean
    - *t-score* enables you to take an individual score and transform it into a standardized form, which helps you to compare scores.



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Research Methodology and Statistics

Inferential or Analytical Statistic

- Inferential statistics takes data from a sample and makes inferences about the larger population from which the sample was drawn
- the goal of inferential statistics is to *draw conclusions* from a *sample* and *generalize* them to a *population*

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Research Methodology and Statistics

Inferential or Analytical Statistic

Hypothesis (or Predictions) Testing

- Comparison tests
  - t-test, ANOVA, Mann-Whitney U test, Wilcoxon test, Kruskal-Wallis H test
- Correlation tests
  - Pearson's r, Spearman's rho, Chi square test
- Regression tests
  - Simple linear regression, Multiple linear regression, …

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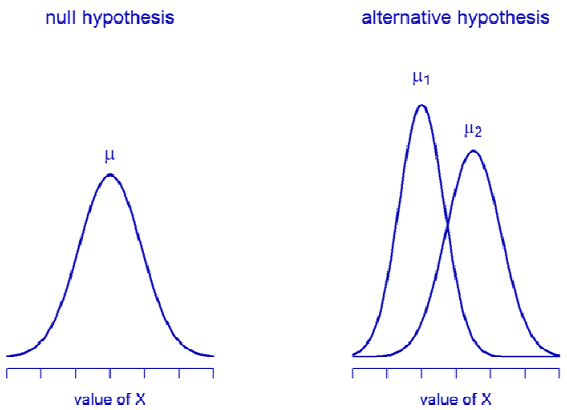

Hypothesis (or Predictions) Testing

For Choosing adequate Comparasion test You need to know:

- Which test answer the research question (*Validity*)
- *Scales of measurement*
  - Nominal, Ordinal, Interval, Ratio data
  - Binary, Multiple, Discrete Continuous data
  - Binary, Nominal, Ordinal, Discrete, Continuous data
- *Parametric* or *nonparametric* data
  - using the normal distribution test (just for quantitative data)
- *Paired* (repeated measurements) or *independent* (unpaired) sample

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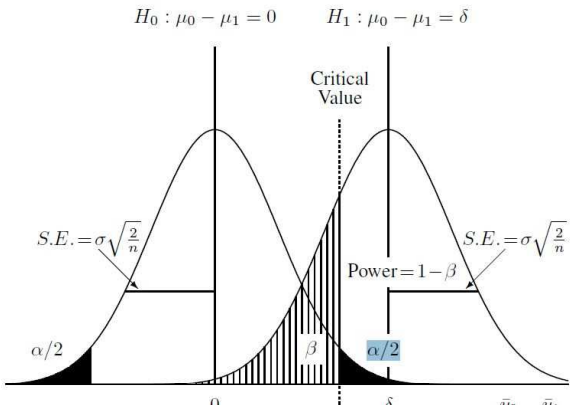

Hypothesis (or Predictions) Testing

Example of Comparison Tests

- Suitable tests for *nominal* data
  - odds ratio test,
- Suitable tests for *ordinal* data
  - Chi-square test (goodness of fit, homogeneity and independence)
- Suitable tests for *interval* and *Ratio* data (Scale data)
  - *t*-test (one sample, two independent/paired sample; for one or two sample)
  - ANOVA test (also for repeated measurements; for three or more sample)

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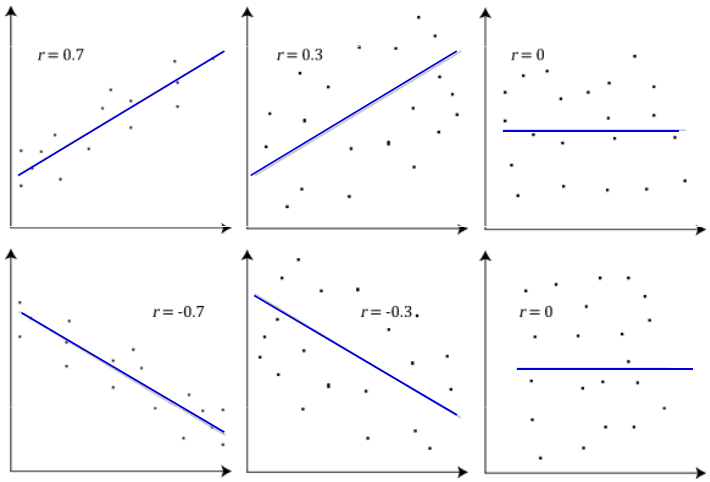

Hypothesis (or Predictions) Testing

- Pearson's *r*
  - parametric, quantitative data
- Spearman's *rho*
  - nonparametric, quantitative which are handled like qualitative data
- Chi-square test (χ^2)
  - qualitative data
- Dimension reduction techniques
  - *Factor analysis* (use when you assume association if you want to understand the latent factors)
  - *Principal Component Analysis* (seeks to identify, to predict using the factors, PCA)

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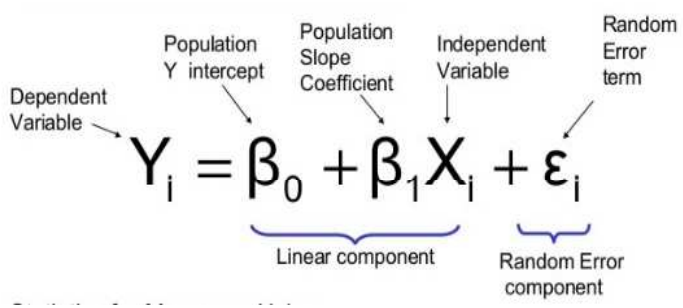
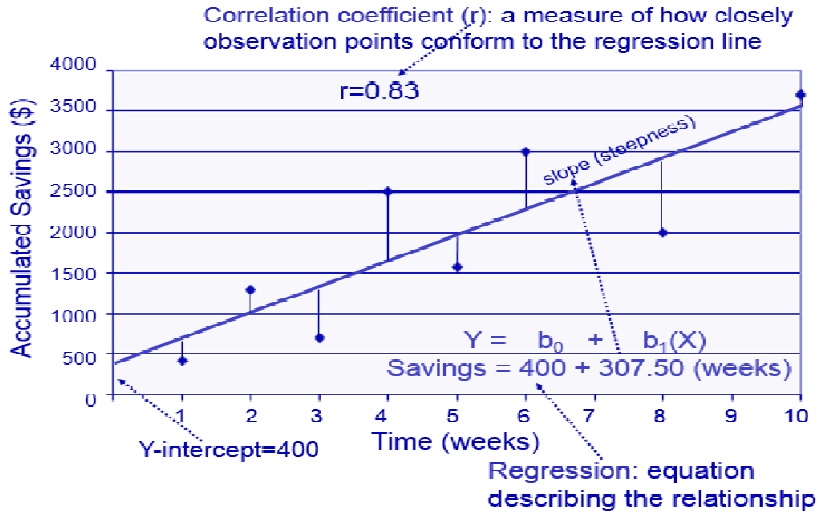


Hypothesis (or Predictions) Testing

- **Simple linear regression** (1 metric IV; 1 metric DV)
- Multiple linear regression (2+ metric IV; metric DV)
- Logistic regression (1 any IV; 1 binary variable)



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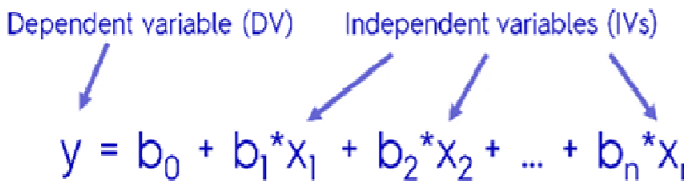

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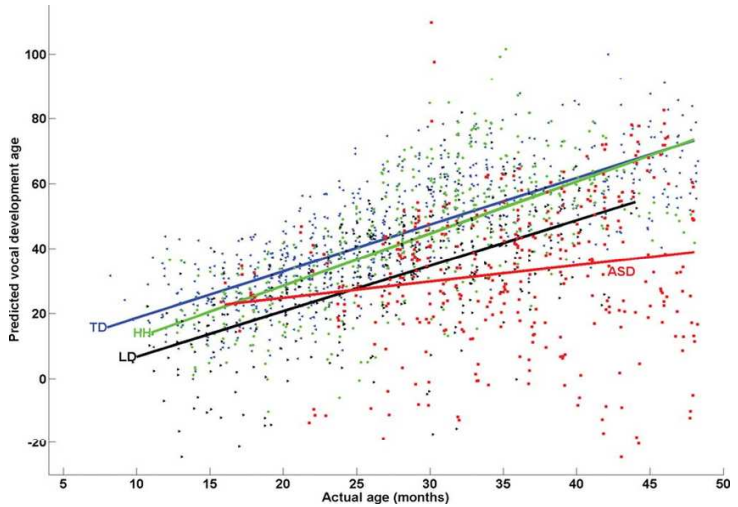

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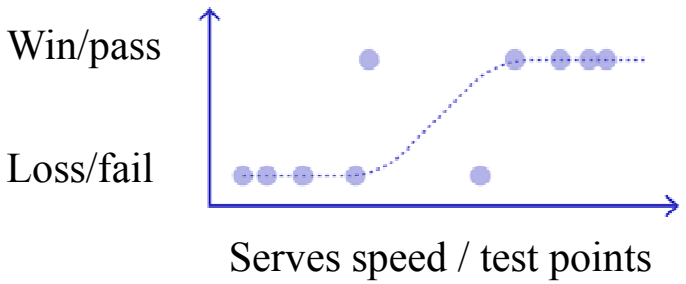

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Research Methodology and Statistics

The Effect size

- Is a *quantitative measure* of *the magnitude* of the experimental effect
- Is considered an *essential complement* of the *statistical significance test*, because it allows to know the relevance of the difference and discerning between the statistical significance of a test and its practical importance.
- The effect size allows to make comparisons between the statistical significant differences from groups with a very *different number* of items, and studying groups from *different scientific works* (meta-analysis)
- Effect size hepl undestend *the magnitude of differences* found (statistical signifikance examines whether the findings are likely to be *due to chance*)

Most common effect size tests

- Cohen's *d* (Effect size index *d*)
  - Appropriate to campared two means (*t*-test)
  - Small (*d* = 0.2; 58%*), Medium (*d* = 0.5; 69%*), Large (*d* = 0.8; 79%)
- Pearson correlation (*r*)
- Confidence interval (CI)
  - is a range of values that you can be (95%) certain contains the true mean of the population.
  - there are variants of 90 % CI, 95% CI, 99% CI
  - *Cohen's d* [95% CI] = *d* [lower bound; higher bound] = 0.9 [0.12; 1.52]
- Odds ratio test (OR)
  - For 2x2 table, (AD) / (BC)
  - Example for OR (95% CI): 2.1 (2.0 to 2.2)
- Others Effect size tests
  - Epsilon-squared (ε^2), Cohen's ω (ω), Eta-squared (η^2), Cramer's V (V), Effect size Phi (φ), Relative risk or risk ratio (RR), Coefficient of determination (r^2), Common Language Effect Size (CLES), ...

*Procentige of control group below the mean of experimental group

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