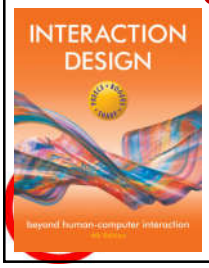
BIRZEIT UNIVERSITY

# Data analysis, interpretation and presentation

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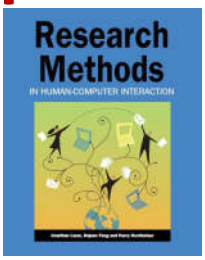


## Overview

- Quantitative and Qualitative
- Data gathered and typical initial processing
- Preparing data for statistical analysis
- Descriptive statistics
- Comparing means
  - ***t-test***
  - Analysis of variance (**ANOVA**)

# Aims

- Discuss the difference between **qualitative** and **quantitative** data and analysis.
- Enable you to analyze data gathered from:
  - Questionnaires.
  - Interviews.
  - Observation studies.
- Make you aware of software packages that are available to help your analysis.
- Identify common difficulties in data analysis, interpretation, and presentation.
- Enable you to interpret and present your findings in appropriate ways.

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# Quantitative and Qualitative

- **Quantitative** data: expressed as **numbers**.
- **Qualitative** data: difficult to measure as numbers.
- Quantitative analysis: numerical methods to discover size, magnitude, amount.
- Qualitative analysis: expresses the nature of elements and is represented as themes, patterns, stories.
- Be careful how you manipulate data and numbers!

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# Describing HCI Students?

- Height, weight, age, etc.
- Quantitative analysis:
  - 165cm tall on average.
  - 70Kg weighs on average.
  - 21 years old on average.
- Qualitative analysis: focuses on the nature of something.
  - Average student is tall, thin and young.

## Data gathered and typical initial processing

| | Usual raw data | Example qualitative data | Example quantitative data | Initial processing steps |
|---|---|---|---|---|
| Interviews | Audio recordings. Interviewer notes. Video recordings | Responses to open questions. Video pictures. Respondent's opinions | Age, job role, years of experience. Responses to closed questions | Transcription of recordings. Expansion of notes |
| Questionnaires | Written responses. Online database | Responses to open questions. Responses in 'further comments' fields. Respondent's opinions | Age, job role, years of experience. Responses to closed questions | Clean up data. Filter into different data sets |
| Observation | Observer's notes. Photographs. Audio and video recordings. Data logs. Think-aloud | Records of behavior. Description of a task as it is undertaken. Copies of informal procedures | Demographics of participants. Time spent on a task. The number of people involved in an activity | Expansion of notes. Transcription of recordings. Synchronization between data recordings |

# Preparing Data for Analysis

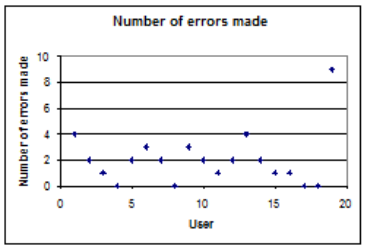
- Cleaning up data:
  - Detect errors
  - Formatting
- Coding:
  - Types of data that need to be coded
  - Be consistent
- Organizing the data:
  - Accommodate to the requirements of statistical software

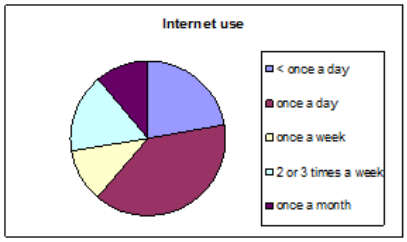
# Simple Quantitative Analysis

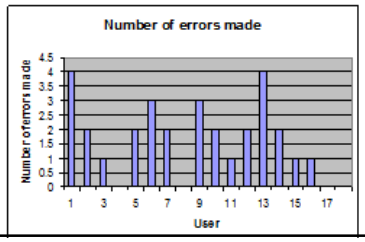
- Measures of **central tendency:**
  - **Mean**: add up values and divide by number of data points.
  - **Median**: middle value of data when ranked.
  - **Mode**: figure that appears most often in the data.
- **Percentages**
- Measures of **spread**:
  - **Range**
  - **Variance** (mean of squared distance from mean)
  - **Standard deviations** (square root of variance)

# Graphical Representations

❖ Give overview of data.



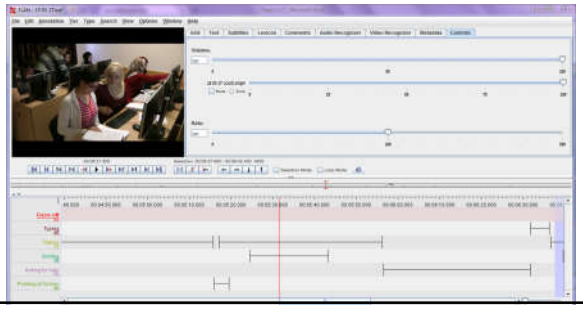




# Simple Qualitative Analysis

- **Recurring patterns or themes**
  - Emergent (تنشئ) from data, dependent on observation framework if used.
- **Categorizing data**
  - Categorization scheme may be emergent or pre-specified.
- **Looking for critical incidents**
  - Helps to focus in on key events.

# Tools to Support Data Analysis

- **Spreadsheet** – simple to use, basic graphs.
- **Statistical packages**, e.g. SPSS.
- Qualitative data analysis tools:
  - Categorization and theme-based analysis
  - Quantitative analysis of text-based data



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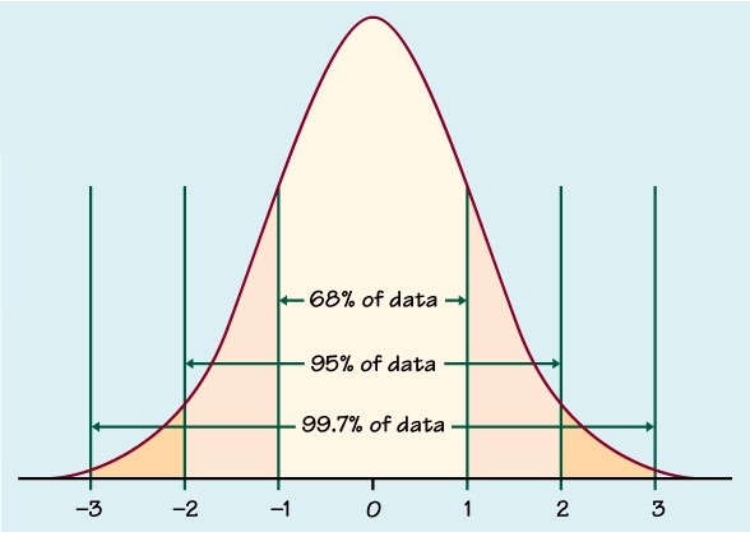
# Normal Distribution Curve



# Comparing Means

- In multiple conditions studies, the goal is to find out whether there is any difference between the conditions.
- The significance test will suggest the probability of the observed difference occurring by chance.
- If the probability fairly low (<5%), we can claim with high **confidence** that difference is due to difference in **independent variables.**

# Comparing Means

- ***t*-test** a simplified analysis of variance involving only 2 conditions.
- **ANOVA**: more than two conditions.

| Experiment design | Independent variables (IV) | Conditions for each IV | Types of test |
|---|---|---|---|
| Between-group | 1 | 2 | Independent-samples *t* test |
| | 1 | 3 or more | One-way ANOVA |
| | 2 or more | 2 or more | Factorial ANOVA |
| Within-group | 1 | 2 | Paired-samples *t* test |
| | 1 | 3 or more | Repeated measures ANOVA |
| | 2 or more | 2 or more | Repeated measures ANOVA |
| Between- and within-group | 2 or more | 2 or more | Split-plot ANOVA |

Commonly used significance tests for comparing means and their application context

# Comparing Means: Example

- Suppose you want to investigate whether the use of specific word-prediction software has an impact on typing speed?
- Null hypothesis?

**There is no significant difference in the task completion time between individuals who use the word-prediction software and those who do not use the word-prediction software.**

# Comparing 2 means: *t*-test

- **Independent-samples *t*-test**: between-group design

| Group | Participants | Task completion time | Coding |
|---|---|---|---|
| No prediction | Participant 1 | 245 | 0 |
| No prediction | Participant 2 | 236 | 0 |
| No prediction | Participant 3 | 321 | 0 |
| No prediction | Participant 4 | 212 | 0 |
| No prediction | Participant 5 | 267 | 0 |
| No prediction | Participant 6 | 334 | 0 |
| No prediction | Participant 7 | 287 | 0 |
| No prediction | Participant 8 | 259 | 0 |
| With prediction | Participant 9 | 246 | 1 |
| With prediction | Participant 10 | 213 | 1 |
| With prediction | Participant 11 | 265 | 1 |
| With prediction | Participant 12 | 189 | 1 |
| With prediction | Participant 13 | 201 | 1 |
| With prediction | Participant 14 | 197 | 1 |
| With prediction | Participant 15 | 289 | 1 |
| With prediction | Participant 16 | 224 | 1 |

Sample data for independent-samples *t* test.

# Independent-samples *t*-test

- SPSS results summary:
  - If we run an Independent-samples ***t*-test** a value called ***t* value** is returned.
  - For previous example: ***t*** value is **2.169**, which is higher than the t value for the specific degree of freedom (**df=15**) at the **95%** confidence interval.
  - This suggests that there is significant difference in the task completion time between the groups.

# Comparing 2 means: *t*-test

- **Paired-sample *t*-test**: within-group design

| Participants | No prediction | With prediction |
|---|---|---|
| Participant 1 | 245 | 246 |
| Participant 2 | 236 | 213 |
| Participant 3 | 321 | 265 |
| Participant 4 | 212 | 189 |
| Participant 5 | 267 | 201 |
| Participant 6 | 334 | 197 |
| Participant 7 | 287 | 289 |
| Participant 8 | 259 | 224 |

Sample data for paired-samples *t* test.

## Two-tailed vs. one-tailed *t*-test

- In some studies the hypothesis indicates the direction of the difference.
- Hypothesis: users who use word-prediction software can type faster than those who do not.
- In these cases, **one tailed *t*-test** is more appropriate.
- A ***t*** value that is **>90%** confidence interval suggests that the **null hypothesis** is false, and the difference is significant.

## Comparing 2 or more means: Analysis of variance (ANOVA)

- ANOVA tests returns a value called **F**
- Also called ***F*-test**
- **One-way ANOVA**: for between-group design and only one independent variable with 3 or more conditions.

| Group | Participants | Task completion time | Coding |
|---|---|---|---|
| Standard | Participant 1 | 245 | 0 |
| Standard | Participant 2 | 236 | 0 |
| Standard | Participant 3 | 321 | 0 |
| : | | | |
| Standard | Participant 7 | 287 | 0 |
| Standard | Participant 8 | 259 | 0 |
| Prediction | Participant 9 | 246 | 1 |
| Prediction | Participant 10 | 213 | 1 |
| : | | | |
| Prediction | Participant 15 | 289 | 1 |
| Prediction | Participant 16 | 224 | 1 |
| Speech-based dictation | Participant 17 | 178 | 2 |
| Speech-based dictation | Participant 18 | 289 | 2 |
| : | | | |
| Speech-based dictation | Participant 23 | 267 | 2 |
| Speech-based dictation | Participant 24 | 197 | 2 |

Sample data for one-way ANOVA test.

# One-way ANOVA

❖SPSS results summary:

| Source | Sum of squares | df | Mean square | *F* | Significance |
|---|---|---|---|---|---|
| Between-group | 7842.250 | 2 | 3921.125 | 2.174 | 0.139 |
| Within-group | 37880.375 | 21 | 1803.827 | | |

Result of the one-way ANOVA test.

❖ The calculated value **2.174** is lower than the value at the **95%** confidence → no significant difference among the 3 conditions.

# Factorial ANOVA

- For between-group design
- 2 or more independent variables involved
- Data layout: table 4.9

| | Standard | Prediction | Speech |
|---|---|---|---|
| Transcription | Group 1 | Group 2 | Group 3 |
| Composition | Group 4 | Group 5 | Group 6 |

A between-group factorial design with two independent variables.

| Task type | Entry method | Participant number | Task time | Task type coding | Entry method coding |
|---|---|---|---|---|---|
| Transcription | Standard | Participant 1 | 245 | 0 | 0 |
| Transcription | Standard | Participant 2 | 236 | 0 | 0 |
| Transcription | Standard | Participant 3 | 321 | 0 | 0 |
| ... | ... | ... | ... | ... | ... |
| Transcription | Prediction | Participant 9 | 246 | 0 | 1 |
| Transcription | Prediction | Participant 10 | 213 | 0 | 1 |
| Transcription | Prediction | Participant 11 | 265 | 0 | 1 |
| ... | ... | ... | ... | ... | ... |
| Transcription | Speech-based dictation | Participant 17 | 178 | 0 | 2 |
| Transcription | Speech-based dictation | Participant 18 | 289 | 0 | 2 |
| Transcription | Speech-based dictation | Participant 19 | 222 | 0 | 2 |
| ... | ... | ... | ... | ... | ... |
| Composition | Standard | Participant 25 | 256 | 1 | 0 |
| Composition | Standard | Participant 26 | 269 | 1 | 0 |
| Composition | Standard | Participant 27 | 333 | 1 | 0 |
| ... | ... | ... | ... | ... | ... |
| Composition | Prediction | Participant 33 | 265 | 1 | 1 |
| Composition | Prediction | Participant 34 | 232 | 1 | 1 |
| Composition | Prediction | Participant 35 | 254 | 1 | 1 |
| ... | ... | ... | ... | ... | ... |
| Composition | Speech-based dictation | Participant 41 | 189 | 1 | 2 |
| Composition | Speech-based dictation | Participant 42 | 321 | 1 | 2 |
| Composition | Speech-based dictation | Participant 43 | 202 | 1 | 2 |
| ... | ... | ... | ... | ... | ... |

Table 4.9 Sample data for the factorial ANOVA test.

# Factorial ANOVA

❖ SPSS summary results

| Source | Sum of square | Df | Mean square | *F* | Significance |
|---|---|---|---|---|---|
| Task type | 2745.188 | 1 | 2745.188 | 1.410 | 0.242 |
| Entry method | 17564.625 | 2 | 8782.313 | 4.512 | 0.017 |
| Task*entry | 114.875 | 2 | 57.437 | 0.030 | 0.971 |
| Error | 81751.625 | 42 | 1946.467 | | |

**Table 4.10** Result of the factorial ANOVA test.

➔ no significant difference regarding task type.

➔ These is significant difference regarding used entry method.

# Repeated measures ANOVA

❖For within-group design

❖Can investigate one or more variables

❖One-way repeated measures ANOVA

| | Standard | Prediction | Speech |
|---|---|---|---|
| Participant 1 | 245 | 246 | 178 |
| Participant 2 | 236 | 213 | 289 |
| Participant 3 | 321 | 265 | 222 |
| Participant 4 | 212 | 189 | 189 |
| Participant 5 | 267 | 201 | 245 |
| Participant 6 | 334 | 197 | 311 |
| Participant 7 | 287 | 289 | 267 |
| Participant 8 | 259 | 224 | 197 |

Sample data for one-way repeated measures ANOVA.

# Repeated measures ANOVA

❖ One-way repeated measures ANOVA summary report:

| Source | Sum of square | Df | Mean square | *F* | Significance |
|---|---|---|---|---|---|
| Entry method | 7842.25 | 2 | 3921.125 | 2.925 | 0.087 |
| Error | 18767.083 | 14 | 1340.506 | | |

**Table 4.12** Result of the one-way repeated measures ANOVA test.

➔ no significant difference between the three text entry methods.

# Repeated measures ANOVA

❖ Two-way repeated measures ANOVA experiment design:

| | Standard | Prediction | Speech |
|---|---|---|---|
| Transcription | Group 1 | Group 1 | Group 1 |
| Composition | Group 1 | Group 1 | Group 1 |

Experiment design of a two-way, repeated measures ANOVA.

# Repeated measures ANOVA

Two-way repeated measures ANOVA data layout:

| | Transcription | | | Composition | | |
|---|---|---|---|---|---|---|
| | Standard | Prediction | Speech | Standard | Prediction | Speech |
| Participant 1 | 245 | 246 | 178 | 256 | 265 | 189 |
| Participant 2 | 236 | 213 | 289 | 269 | 232 | 321 |
| Participant 3 | 321 | 265 | 222 | 333 | 254 | 202 |
| Participant 4 | 212 | 189 | 189 | 246 | 199 | 198 |
| Participant 5 | 267 | 201 | 245 | 259 | 194 | 278 |
| Participant 6 | 334 | 197 | 311 | 357 | 221 | 341 |
| Participant 7 | 287 | 289 | 267 | 301 | 302 | 279 |
| Participant 8 | 259 | 224 | 197 | 278 | 243 | 229 |

**Table 4.14** Sample data for two-way, repeated measures ANOVA test.

# Repeated measures ANOVA

❖ Two-way repeated measures ANOVA summary report:

| Source | Sum of square | df | Mean square | *F* | Significance |
|---|---|---|---|---|---|
| Task type | 2745.187 | 1 | 2745.187 | 14.217 | 0.007 |
| Error (task type) | 1351.646 | 7 | 193.092 | | |
| Entry method | 17564.625 | 2 | 8782.313 | 2.923 | 0.087 |
| Error (entry method) | 42067.708 | 14 | 3004.836 | | |
| Task type * entry method | 114.875 | 2 | 57.438 | 0.759 | 0.486 |
| Error (task type * entry method) | 1058.792 | 14 | 75.628 | | |

**Table 4.15** Result of the two-way, repeated measures ANOVA test.

# Split-plot ANOVA

- Involves both between-group and within-group factors
- Experiment design:

| | Keyboard | Prediction | Speech |
|---|---|---|---|
| Transcription | Group 1 | Group 1 | Group 1 |
| Composition | Group 2 | Group 2 | Group 2 |

**Table 4.16** Split-plot experiment design.

# Split-plot ANOVA data layout

| Task type | Participant number | Task type coding | Standard | Prediction | Speech |
|---|---|---|---|---|---|
| Transcription | Participant 1 | 0 | 245 | 246 | 178 |
| Transcription | Participant 2 | 0 | 236 | 213 | 289 |
| Transcription | Participant 3 | 0 | 321 | 265 | 222 |
| Transcription | Participant 4 | 0 | 212 | 189 | 189 |
| Transcription | Participant 5 | 0 | 267 | 201 | 245 |
| Transcription | Participant 6 | 0 | 334 | 197 | 311 |
| Transcription | Participant 7 | 0 | 287 | 289 | 267 |
| Transcription | Participant 8 | 0 | 259 | 224 | 197 |
| Composition | Participant 9 | 1 | 256 | 265 | 189 |
| Composition | Participant 10 | 1 | 269 | 232 | 321 |
| Composition | Participant 11 | 1 | 333 | 254 | 202 |
| Composition | Participant 12 | 1 | 246 | 199 | 198 |
| Composition | Participant 13 | 1 | 259 | 194 | 278 |
| Composition | Participant 14 | 1 | 357 | 221 | 341 |
| Composition | Participant 15 | 1 | 301 | 302 | 279 |
| Composition | Participant 16 | 1 | 278 | 243 | 229 |

**Table 4.17** Sample data for the split-plot ANOVA test.

# Split-plot ANOVA Summary Report

| Source | Sum of square | df | Mean square | $F$ | Significance |
|---|---|---|---|---|---|
| Task type | 2745.187 | 1 | 2745.187 | 0.995 | 0.335 |
| Error | 38625.125 | 14 | 2758.937 | | |

**Table 4.18** Results of the split-plot test for the between-group variable.

| Source | Sum of square | df | Mean square | $F$ | Significance |
|---|---|---|---|---|---|
| Entry method | 17564.625 | 2 | 8782.313 | 5.702 | 0.008 |
| Entry method * task type | 114.875 | 2 | 57.437 | 0.037 | 0.963 |
| Error (entry method) | 43126.5 | 28 | 1540.232 | | |

**Table 4.19** Results of the split-plot test for the within-group variable.

# Presenting the Findings

- Only make claims that your data can support.
- The best way to present your findings depends on the audience, the purpose, and the data gathering and analysis undertaken.
- Graphical representations may be appropriate for presentation.
- Other techniques are:
  - Notations, e.g. UML
  - Using stories, e.g. to create scenarios
  - Summarizing the findings