Research methods are simply various ways of conducting research into a specific subject (e.g. data gathering through diaries, questionnaires or interviews).

Research methods aim to solve some problem related to the research task (data gathering, analysis, evaluation etc.).

Methodology is the study of how research is done, how we find out about things, and how knowledge is gained. A methodology involves the use of methods, tools, techniques or processes that need to be performed in order to accomplish a specific research task.

Methodology is about principles that guide our research practices and paves the way to correct implementation of research methods, sort of a guide book.

Methodology therefore explains why we're using certain methods or tools in our research.
Design Methods - Review

John Chris Jones uses the following items to describe a design method:

- **Title** - The title of the method. Should make clear what the method is about.
- **Aims** - Describes what the results of this method are in a single sentence.
- **Outline** - Brief description of the steps and action involved in this design method.
- **Examples** - Several examples showing the design method in action.
- **Comments** - Brief assessment of the effectiveness and usability of the method, including application in practice.
- **Application** - Kinds of situation in which this method can be used.
- **Learning** - How easy is it to learn and use this method.
- **Time and cost** - How much time is needed to carry out this method, and what are the associated costs.
- **References** - References to e.g. original publications, and other relevant publications.
Participatory Design

- **Title** - PD.
- **Knowledge production** – working with users on a team gives input that would not be otherwise possible – involves mutual learning and thus new knowledge for researchers.
- **Outline** - Brief description of concepts, methods, tools or techniques involved.
- **Examples** - Examples showing how this design methodology works.
- **Application** – Steps in implementing this methodology.
- **References** - References to e.g. original publications, and other relevant publications.
User Centered Design

- **Title** - UCD.
- **Knowledge production** – focus on users and what they do (not only say), empathy as a central tenant.
- **Outline** - Brief description of concepts, methods, tools or techniques involved.
- **Examples** - Examples showing how this design methodology works.
- **Application** – Steps in implementing this methodology.
- **References** - References to e.g. original publications, and other relevant publications.
HCI Research

- Methods and methodologies borrowed from different fields: psychology, design, human factors etc.
- No unifying theories
Inherent conflicts in HCI

- HCI research is complex
- There often is not one optimal solution
- There are trade-offs and multiple stakeholders with conflicting goals
  - Users prefer consistency over change even when innovation is a buzzword
  - HCI research can be hard to cost-justify
Communicating your ideas

- Not only should you be familiar with methods in HCI, but you may need to become somewhat familiar with research methods from different disciplines, as dictated by a particular research question you are working on.

- Know what the “sensitive spots” are from other disciplines.

- You need to communicate your results in a way that others can understand.

- Be prepared to answer: “why did we use method X instead of methods Y or Z?”
Data Collection: Triangulation

- No data collection method will be perfect
- It is important to have multiple researchers, using multiple methods, investigating the same phenomenon
- We call this triangulation
- One paper ≠ scientific truth
- Different researchers, different methods, all coming to the same conclusion, THAT’S when you find consensus
Measurement in HCI

There are many different approaches to measurement

- The traditional measurements are:
  - Task performance, time performance, and user satisfaction

Those measurements do not accurately measure:
- Why people no longer use an interface
- Use for enjoyment
- Use of technology in public spaces also culture
- Emotion and trust
Newer forms of measurement

- A feeling of community?
- Emotion?
- Enjoyment?
- Physiological measures (EEG, EMG)?
- Satisfaction from accomplishments in gaming or in virtual worlds?
- Ease of use and enjoyment of new forms of technology can be challenging to measure
Chapter 2 – Experimental Research
Overview

- Types of behavioral research
- Research hypotheses
- Basics of experimental research
- Significance tests
- Errors
- Limitations of experimental research
What is Empirical Research?

Empirical research is...

- observation-based investigation seeking to discover and interpret facts, theories, or laws (relating to humans interacting with computers)
Why do Empirical Research?

- We conduct empirical research to...
  - Answer (and raise!) questions about new or existing user interface designs or interaction techniques
  - Develop or explore models that describe or predict behavior (e.g., of humans interacting with computers, mobile tech etc.)
How do we do Empirical Research?

- We conduct empirical research through...
- a program of inquiry conforming to the scientific method (a body of techniques for investigating phenomena and acquiring new knowledge, as well as for correcting and integrating previous knowledge. It is based on gathering observable, empirical, measurable evidence, subject to the principles of reasoning. (wikipedia)
- Part of it is behavioral research: how something behaves in relation to something else
## Types of Behavioral Research

<table>
<thead>
<tr>
<th>Type of Research</th>
<th>Focus</th>
<th>General Claims</th>
<th>Typical Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descriptive</td>
<td>Describe a situation or a set of events</td>
<td>X is happening</td>
<td>Observations, field studies, focus groups, interviews</td>
</tr>
<tr>
<td>Relational</td>
<td>Identify relations between multiple variables</td>
<td>X is related to Y</td>
<td>Observations, field studies, surveys</td>
</tr>
<tr>
<td>Experimental</td>
<td>Identify causes of a situation or a set of events</td>
<td>X is responsible for Y</td>
<td>Controlled experiments</td>
</tr>
</tbody>
</table>

*Table 2.1 Relationship between descriptive research, relational research, and experimental research.*
Experimental Research
(quantitative research methods)

Applied in social sciences, as well as natural sciences as traditionally

https://www.youtube.com/watch?v=TYlh4MkcfJA (Asch Experiment – Conformity)

https://www.youtube.com/watch?v=yr5cjyokVUs (Milgram Experiment – Authority)

It is the best way to establish causal relationships between two or more variables

(cause $\rightarrow$ effect)

This is done by forming and testing hypothesis
Research hypotheses

- An experiment normally starts with a research hypothesis.
- A hypothesis is a precise problem statement that can be directly tested through an empirical investigation. It is a supposition or proposed explanation made on the basis of limited evidence as a starting point for further investigation.
- Compared with a theory, a hypothesis is a smaller, more focused statement that can be examined by a single experiment.
- Compared to a problem statement, it is more specific, in particular with respect to what is measured.
You observe the growth of a plant over time.

The growth of the plant depends on the water it is given, the temperature, the light.

How would you set up an experiment that tells you what are the ideal conditions at your place to make the plant thrive? (you may need lots of plants and you may set up the experiment in different ways)
Independent variables (IV) refer to the factors that the researchers are interested in studying or the possible "cause" of the change in the dependent variable.

IV is independent of a participant’s behavior (i.e., there is nothing a participant can do to influence an independent variable. Examples:

- Technology: interface, device, feedback mode, visual layout etc.
- People: gender, age, expertise etc.
- Context of use: social status, physical status etc.

IV and factor are synonymous terms.
Dependent variables (DV) refer to the outcome or effect that the researchers are interested in and measuring.

DV is dependent on a participant’s behavior or the changes in the IVs (examples: completion time, speed, accuracy, error rate, throughput, target re-entries, retries, key actions, outcome for elderly vs. youngsters, etc).

DV is usually the outcomes that the researchers need to measure.

It is nice to give a name to the dependent variable, separate from its units (e.g., “Text Entry Speed” is a dependent variable with units “words per minute”).

Research hypotheses
Example of a hypothesis

Hypothesis can be understood as

- A statement of the predicted or expected relationship between at least two variables
- A provisional answer to a research question.

It needs to

- define the variables involved
- define a relationship between variables

Example:

- Question: How does having information on the context of a caller affect whether the receiver picks up the call?
- Hypothesis: Receivers will be more likely to pick up a call when they have information of their callers’ context than they will be when they do not.
Properties a hypothesis should have

- Testable: The means for manipulating the variables and/or measuring the outcome variable must potentially exist.

- Falsifiable: Must be able to disprove the hypothesis with data.

- Parsimonious: Should be stated in simplest adequate form.

- Precise: Should be specific (operationalized).

- Useful:
  - Relate to existing theories and/or “point” toward new theories.
  - It should lead to studies beyond the present one (often hard to determine in advance).
Hypotheses in an experiment

- Null hypothesis $H_0$: typically states that there is no difference between experimental treatments.
- Alternative hypothesis $H_a$: a statement that is mutually exclusive with the null hypothesis.
- The goal of an experiment is to find statistical evidence to refute or nullify the null hypothesis in order to support the alternative hypothesis.
- A hypothesis should specify the independent variables and dependent variables.
Components of experiment

- Treatments, or conditions: the different techniques, devices, or procedures that we want to compare.

- Units: the objects to which we apply the experiment treatments. In HCI research, the units are normally human subjects with specific characteristics, such as gender, age, or computing experience.

- Assignment method: the way in which the experimental units are assigned different treatments.

https://www.youtube.com/watch?v=lgs7d5saFFc (The Lady tasting the tea - Fisher)
Other variables

- Control variables - What is held constant
- Random variables
  What is allowed to vary randomly
- Confounding variable
  What correlates with the independent + dependent variable
Basics of experimental research

Relationships

- **Causal**
  One variable depends on and is affected by the other

- **Correlational**
  Two variables are affected by a third variable in the same direction
Randomization: the random assignment of treatments to the experimental units or participants

In a totally randomized experiment, no one, including the investigators themselves, is able to predict the condition to which a participant is going to be assigned

Methods of randomization
- Software driven randomization
- Random tables
- Tossing the coin or dice
- ‘Drawing out of the hat’
Basics of experimental research

Experimental Design

- Correlational research
- Quasi-experimental research
- Experimental research
Correlational design

- For studies examining the relationships between variables such as personality traits, work habits, gender, etc., the hypothesis is a specific statement about relationships.

- When we observe an increase in X then we will also observe an increase (or decrease) in Y.

- Example questions:
  - Is there a relationship between smoking and lung cancer?
  - Is there a relationship between anxiety and test-taking performance?

- Correlation does NOT imply causation.
Quasi-experiment design

- Used when randomization is impossible and/or impractical
- Separate participants based on some characteristic
- No random assignment
  E.g., Gender, occupation, verbal ability
- Possible questions
  Do people with high verbal ability learn new languages faster
True experiment design

- Studies in which variables are manipulated and outcomes measured, units assignment randomized and the hypothesis is a cause and effect statement
- Y will occur, when X is manipulated (a change in X, causes Y)

Examples

- Students will remember more items from a word list if they learn the list in the quiet, rather than in the presence of intense music
- Reading speed (words/minute) will change when font size is manipulated, such that reading speed will increase as font size is increased from 4 point to 20 point, but reading speed will decrease as font size is increased above 20 point
Significance tests

A method for testing a hypothesis about population, using data obtained from a sample of population.
When to do significance testing?

When the values of the members of the comparison groups are all known, you can directly compare them and draw a conclusion. No significance test is needed since there is no uncertainty involved.

When the population is large, we can only sample a sub-group of people from the entire population. Significance tests allow us to determine how confident we are that the results observed from the sampling population can be generalized to the entire population.
Examples

Significance testing

- Mental health is better at higher level of socioeconomic status
- People who use 'cool' technologies are more creative
- If school children have sugar for lunch (cakes), they are hyperactive during the subsequent hours.
Significance tests

Steps

Create the hypothesis
\((H_0 \text{ and } H_a)\)

Set criteria for decision
(usually, significance is set to 5%, when the probability of obtaining a sample mean is less than 5%, the \(H_0\) is rejected)

Compute the test statistics
(usually using SPSS or like)

Make a decision

Oslo, 15/09/16
What types of errors can be made?

All significance tests are subject to the risk of Type I and Type II errors.

- A **Type I error** (also called an \( \alpha \) error or a "false positive") refers to the mistake of rejecting the null hypothesis when it is true and should not be rejected.

- A **Type II error** (also called a \( \beta \) error or a "false negative") refers to the mistake of not rejecting the null hypothesis when it is false and should be rejected.
Errors

What types of errors can be made?

All significance tests are subject to the risk of Type I and Type II errors.

- **A Type I error** (also called an \( \alpha \) error or a "false positive". \( \alpha \) is a probability of making a Type I error, often set to 0.05) refers to the mistake of rejecting the null hypothesis when it is true and should not be rejected.

- **A Type II error** (also called \( \beta \) error or a "false negative". \( \beta \) is a probability of making error of type II) refers to the mistake of not rejecting the null hypothesis when it is false and should be rejected.

<table>
<thead>
<tr>
<th>Decision</th>
<th>Truth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do not reject null</td>
<td>Null hypothesis: OK</td>
</tr>
<tr>
<td></td>
<td>Alternative hypothesis: TYPE II ERROR</td>
</tr>
<tr>
<td>Reject null</td>
<td>Null hypothesis: TYPE I ERROR</td>
</tr>
<tr>
<td></td>
<td>Alternative hypothesis: OK</td>
</tr>
</tbody>
</table>
Minimize chance of Type I error...

- ... by making significance level $\alpha$ small.
- Common values are $\alpha = 0.01, 0.05, \text{ or } 0.10$.
- “How small” depends on seriousness of Type I error.
- Decision is not a statistical one but a practical one.
Test power

The statistical power of a test, defined as $1 - \beta$, refers to the probability of successfully rejecting a null hypothesis when it is false and should be rejected.

- The farther apart the actual mean is from the mean specified in the null hypothesis, the higher the power.
- The higher the significance level $\alpha$, the higher the power.
- The smaller the standard deviation, the higher the power.
- The larger the sample, the higher the power.

Goal is to maximize the power....
Limitations of Experimental Research

- Experimental research requires well-defined, testable hypotheses that consist of a limited number of dependent and independent variables.

- Experimental research requires strict control of factors that may influence the dependent variables.

- Lab-based experiments may not be a good representation of users’ typical interaction behavior.
That is it for today!